Differences in P300 (P3) Topography in Younger and Older Adult Subjects

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ABSTRACT. I studied topographical differences in the P300 (P3) component in younger and older adult groups using a t-statistic significance probability map (t-SPM, Duffy et al. 1981[1]). The P3 mean latencies and amplitudes in the younger and older adults were 337.5±27.6 msec and 13.6±4.1 μ V, and 363.8±32.2 msec and 12.1±4.1 μ V respectively. Analysis of P3 topography revealed a statistically significant lower P3 amplitude in the occipitotemporal region in the older adult group. These results may support a frontal shift of P3 distribution in the aged.

Key words: event-related potential — P300 (P3) — topography

Somatosensory evoked potentials (SEP), auditory evoked potentials (AEP) and visual evoked potentials (VEP) are stimulus-related potentials. Event-related potentials (ERP), on the other hand, are long duration potentials and include the N100(N1), P200 (P2), N200 (N2), P300 (P3) and N400 (N4) components. These potentials provide a non-invasive means for evaluating the activity of the human brain as it perceives stimuli, makes decisions and controls behavior. The P3 wave is defined as the first positive wave or wave complex after 250 msec and is the most useful one for clinical application. Age-related changes in the latency and amplitude of the P3 wave have been previously reported.[2] Regarding P3 scalp distribution in aging, however, only a few studies have been done.[3,4] Recently, event-related potential mapping have been increasingly applied to the evaluation of higher brain function in schizophrenia,[5,6] Alzheimer disease,[7] cerebrovascular desease[7] and Parkinson disease.[8] In those studies, however, the aging effect on P3 distribution does not seem to have been adequately considered. The aim of this study was to elucidate topographical regional differences in P3 in younger and older adult groups, using an auditory oddball paradigm.

METHODS

Subjects: Twenty neurologically and audiologically normal young adults (6 women and 14 men; mean age 24.1 yrs; range 22-27 yrs) and 20 older adults (14 women and 6 men; mean age 56.9 yrs; range 49-64 yrs) were examinated in this study.

Task: The oddball paradigm was used. The auditory stimulus was a pure tone delivered binaurally through headphones at an intensity of 60 dBnHL and

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a frequency of 1KHz for the frequent tone (80%) or 2KHz (20%) for the target tone. The tones were presented in a random series once every 2 sec. The subjects were told to keep their eyes open and mentally count the target stimuli. Then they reported the total counts (20) following the trial sequence. The counting error in both groups did not exceed ±10% of the real number of tones.

Recording : All subjects were seated in a comfortable reclining chair. They were instructed to look at a target. EEG activity was recorded from 19 scalp electrode sites (F7, T3, T5, Fp1, F3, C3, P3, O1, Fz, Cz, Pz, Fp2, F4, C4, P4, O2, F8, T4 and T6) according to the international 10-20 electrode system using an ECI electro-cap. Linked earlobes served as the reference. All electrode impedances were ≦ 5K Ω. Evoked responses to the rare stimuli were filtered with a bandpass 0.53-60Hz and averaged. Trials on which the EOG or EEG exceeded ±100 μ V were automatically rejected. Data from two trials were obtained consecutively and stored. Averages of EEG were processed by the Signal Processor DP1200 (NEC, Sanei). From 40 trials in each group, a grand average of topographic mappings was calculated.

RESULTS

The P3 mean latency and amplitude in the younger and older adults were 337.5±27.6 msec and 13.6±4.1 μ V and 363.8±32.2 msec and 12.1±4.1 μ V, respectively. The recurrent curve of the P3 latency was 311.6+1.0 msec/year and that of the P3 amplitude was 13.8-0.03 μ V/year. Averaged P3 peaks and the distribution on the scalp were determined in the younger adults (Fig 1) and

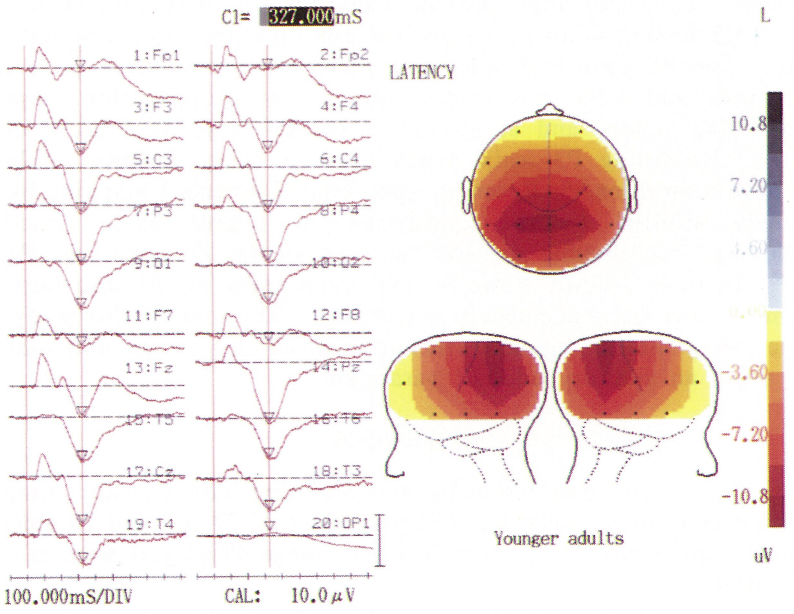

Fig 1. P3 in the younger adult group (grand average).
P3 latency and amplitude were 337.5±27.6 msec and 13.6±4.1 μ V.

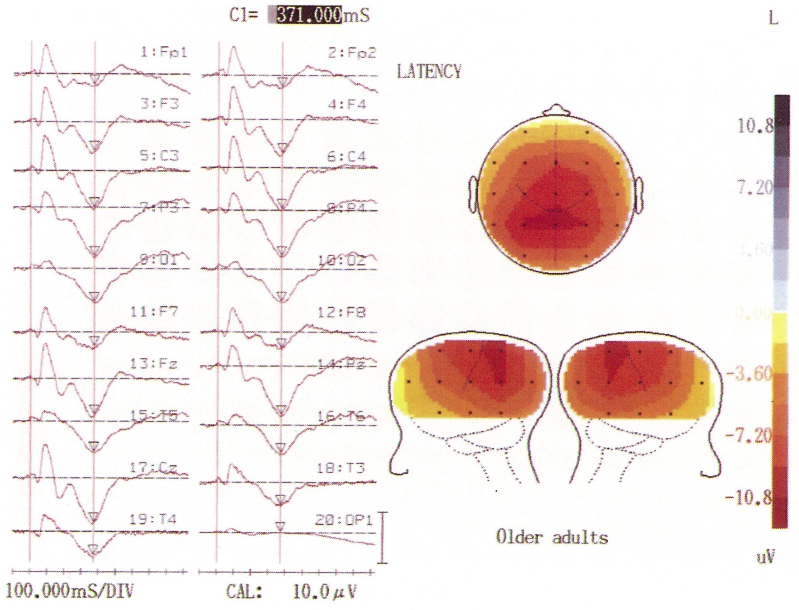

Fig 2. P3 in the older adult group (grand average).
The P3 duration and amplitude were 363.8±32.2 msec and 12.1±4.1 μ V.

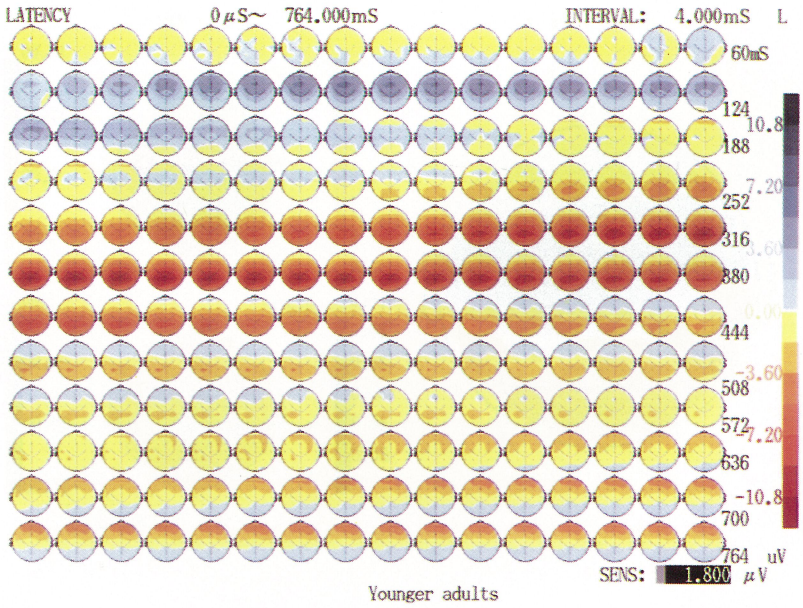

Fig 3. Serial multiple map demonstration in the younger adult group (grand average).
The P3 wave appeared between 248 to 380 msec.

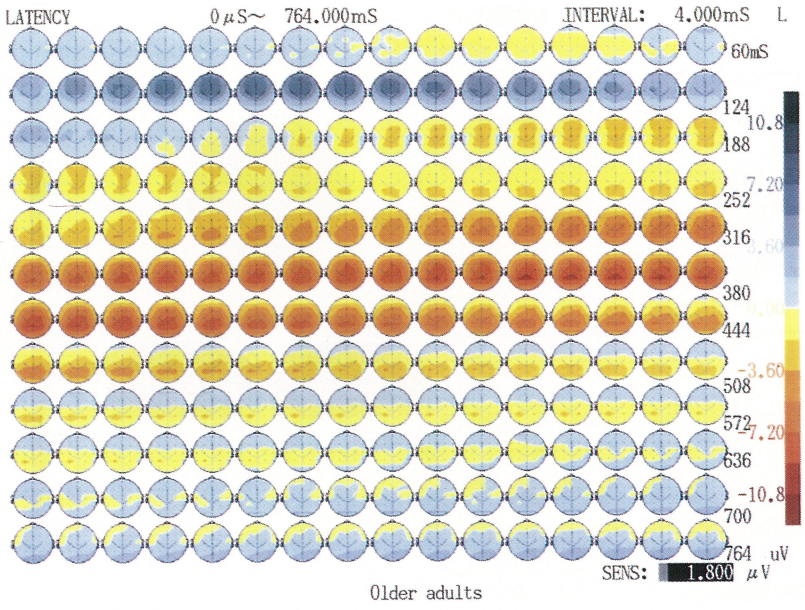

Fig 4. Serial multiple map demonstration in older adult group (grand average). P3 wave was shown between 320 to 416 msec.

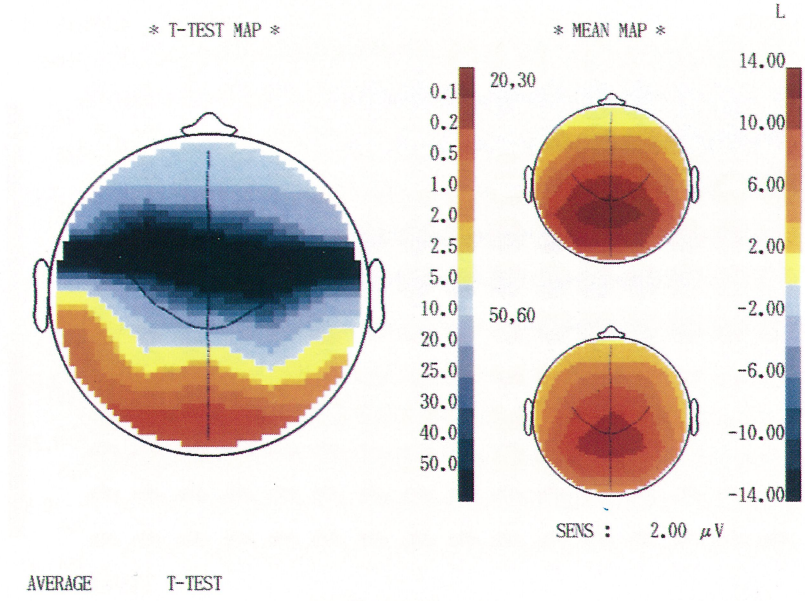

Fig 5. The difference in topograms between the two groups.
A stastistically significant lower P3 amplitude was observed ($p<0.05$) in the occipitotemporal region in the older group.

older adults (Fig 2), respectively. Then, 192 topograms were made in a series from 0 msec to 764 msec, with 4 msec intervals in the two groups using the Topography No. 601 system (NEC, Sanei) (Fig 3. 4). From at serial multiple map demonstration (0-764 msec) in each group, P3 wave was noted from 248 msec to 380 msec in the younger group and from 320 msec to 416 msec in older group. It was clearly delayed evolution and a shorter duration in the older adult group. The differences in P3 topography between the two groups were evaluated using t-SPM to determine the area of maximal statistic separation. Analysis of the P3 topography at peak latency using t-SPM showed a statistically significant lower P3 amplitude in the occipitotemporal region in the older adult group (Fig 5). The results may suggest a frontal shift of P3 distribution in the older subjects.

DISCUSSION

The P300 or P3 component has been applied as a measurement tool for the evaluation of cognitive capability in normal and clinical subjects.[9] The P3 wave has been related to many aspects of human information processing. The simplest paradigm for recording this component requires the subject to focus their attention on a train of regularly occurring stimuli in order to detect occasional targets that differ from the standard stimuli by some simple physical characteristic. This has often been called the oddball paradigm. The auditory oddball paradigm adopted in this study was found to be very useful to detect the P3 peak and its scalp distribution. Regarding age-related changes in P3, Goodin[2] initially reported that the P3 wave of the evoked potential to detect auditory signals was longer in latency in older subjects than in younger ones. Enoki[10] reported that duration and amplitude of the P3 wave was shortest at age 15. As for the effects of development and aging in humans, the latency of P3 was found to decrease rapidly as age increased until age 16 (-9.43 msec/year), and then it gradually become prolonged from age 17 years of age (+1.43 msec/year).

The amplitude of P3, on the other hand, tended to be larger in adolescent subjects than in subjects of other age groups, but the difference was not stastistically significant. Increase of the amount of myelin lipids and myelination in central nervous system may possibly continue into the fourth or fifth postnatal year,[11] but myelination of the association cortex is not completed until puberty.[12] Cognitive function or development of P3 wave may be related to the myelinating process of association cortex. In this study, P3 showed longer latency and lower amplitude in the older adult group. The recurrent curve of the P3 latency was 311.6+1.0 msec/year, and the P3 amplitude was 13.8-0.03 μ V/year. Based on the difference in topography between the two groups measured by t-SPM, it was demonstrated that a statistically significant lower P3 amplitude ($P<0.05$) in the occipito-temporal region in the older adult group. A change in P3 scalp distribution in aging was reported by Pfefferbaum *et al.*[4] They showed that an apparent P3 frontal shift was due to a relatively decreased P3 amplitude in the parietal region. Mullis *et al*[13] reported that the P3 amplitude increased in the frontal region and decreased in the occipital region with aging. The reason for the frontal

shift of P3 peak distribution is not clear, but this phenomenon might suggest relatively higher frontal activity in the aged. Recently P3 studies have been applied to schizophrenia,[6] degenerative brain lesions,[14] cortical and subcortical dementia[7] and gender differences.[15] The age-related serial multiple map demonstration in this study may provide more useful information regarding these pathological states.

CONCLUSION

1. I reported differences in the P300 (P3) topography of younger and older adults.
2. The P3 mean latency and amplitude in younger and older adults were 337.5±27.6 msec and 13.6±4.1 μ V, and 363.8±32.2 msec and 12.1±4.1 μ V respectively.
3. Analysis of P3 topography showed a statistically significant lower P3 amplitude in the occipitotemporal region in the older adult group.
4. Recognition of age-related changes in P3 topography is basically important in the evaluation pathological processes.

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