Indian J Physiol Pharmacol 2000; 44 (1): 92–96

TASK RELATED CHANGES IN ERP *AUDITORY VS VISUAL TASKS*

VINEET SAHAI*, O. P. TANDON AND S. S. SIRCAR

Department of Physiology,
UCMS and GTB Hospital,
Shahdara, Delhi – 110 095

(Received on July 17, 1999)

Abstract : P3 component of event related potentials have been studied in relaxed state of mind. Changes in P3 latency and amplitude are expected if measured after a rigorous mental exercise. The event related potentials (ERP) were measured in 20 normal male subjects aged between 18 and 22 years. ERP was recorded twice in each subject before and after the administration of a mental task. The *auditory mental task* comprised of repeating in reverse order string of random digits read out to the subject at a uniform speed of 1 per second. The *visual task* comprised reading laterally inverted type written text. Each subject had to undergo 2 sessions in separate sittings. The latency and amplitude of P300 recorded before and after the task were compared statistically using Students' unpaired t-test. There was significant increase in P3 latency following both visual and auditory tasks (auditory task: before 330 ± 24.43 msec and after 342.9 ± 27.66 msec, similarly visual task: before 333.2 ± 26.66 msec and after 345.65 ± 26.56 msec). All other ERP waves latency and amplitude changes were insignificant.

Key words : event-related potentials mental tasks P300

INTRODUCTION

Event related potential (ERP) is an endogenous long latency evoked potential related to aspects of cognitive processing. Endogenous ERPs are not markedly affected by changes in physical parameters of the stimulus, such as intensity and frequency. There are several subject characteristics that may affect P300. These include age of the subject (1–4), level of attention during ERP recording (5), time of day (6), the regency of food (6), body temperature (6), menstrual cycle (7), relative difficulty of P3 task (8–11), drug intake (12–16) and fitness (17). In all the work done so far, the electrophysiological measurements have been made when the subjects were in a relaxed state of mind. We have proposed a modification, by measuring the parameters after an intense mental exercise. We wanted to establish whether given mental task would bring changes in ERP and whether visual and auditory tasks have different effects on ERP. In the present study, we have analyzed the task related amplitude and latency changes in ERP.

*Corresponding Author

METHODS

The present study was carried out in Department of Physiology, University College of Medical Sciences, Shahdara, Delhi. It was conducted over a period of nine months, starting July 1997.

A total of 20 male subjects in the age group of 18 to 20 yrs were selected from the first year medical students who had volunteered for the study. Each subject had similar socio-economic status, was well versed in English and included in the study after a detailed physical, ENT, ophthalmoscopic examination and exclusion of cases having history of

(a) acute and chronic systemic disease,

(b) Psychiatric illness and

(c) Recent intake of drugs

The subject was briefed about the test procedure. He was made to sit on a chair comfortably in a soundproof air-conditioned room. SMP4100 auditory/visual stimulator and MEB5200. NeuropackII evoked potential recorder was used for auditory ERP recording. Standard auditory 'Odd ball' paradigm was used. In this paradigm the subject was presented binaurally with headphones a sequence of two distinguishable sound click stimuli, one occurred frequently (frequent stimulus-non-target stimulus) and other infrequently (rare stimulus-target stimulus). The subject was asked to respond by pressing a button using his preferred hand whenever a rare stimulus was presented. The cerebral response obtained was recorded on the screen of the evoked potential recorder.

The electrode recording sites on the scalp were cleaned with spirit and skin pure. Electrolyte paste (Elefix) was applied and Ag/AgCl disc electrodes were placed as per 10–20 International System of electrode placement :

Active electrode (–): Vertex (Cz), Midline Parietal (Pz)

Reference electrode (+) : Both ears connected (A1+A2)

Grounding electrode : Forehead (Fpz)

The input impedance was kept below 5 kohms. Using shielded headphones alternating tone bursts, with a starting condensation phase of 10 msec rise/fall time, 100 msec duration (plateau time), intensity 70 dB NHL and rate one every 2 sec were used as target stimuli. 80% of total 160 tones were 1 KHz (frequent) and 20% were 2 KHz (rare). Stimulus sequence was random. The signals were in phase at two ears. The MEB-5200 settings were properly selected and evoked responses to frequent and rare stimuli were filtered with a band pass 5–30 Hz and averaged simultaneously for 32 responses. Data obtained was stored, analyzed and averaged by the computer. The latency of N1, N2, P1, P2, P3 and amplitude of P300 for target stimulus was calculated. During the recording session the subject was asked to fix his eyes on a particular spot on the ceiling in order to avoid electro-oculographic artifacts due to eye movements and improve his concentration and attention to the stimuli presented. The method used for recording P300 was similar to the ones reported earlier in our laboratory (18).

The event related potentials were recorded twice in quick succession, separated only by a period of 10 minutes during which a mental task was administered.

The *auditory mental task* comprised of hearing and repeating strings of digits. The digits were spoken out clearly at a constant rate with a help of a metronome. The string length was varied according to the performance of the subject : for 3 successive correct responses, the string length was increased while for each incorrect response, the string length was reduced by one. Most subjects could correctly respond to string lengths of 5–6 digits and could be administered about 65 to 70 strings in a period of 10 minutes. The *visual task* comprised of reading laterally inverted typewritten text for 10 minutes. Most of the subjects could read upto 11–12 lines.

Test Protocol

	Task	
Pre-task Auditory ERP (baseline)	Auditory	Post-Task Auditory ERP
	Visual	

RESULTS

The latencies of all the prominent ERP values viz., P1, N1, P2, N2 and P3 were compared individually for any task related changes (Table I), using Students' unpaired t-test. Post task latencies of P300 were significantly increased, both in case of auditory and visual task as compared to pre task latencies. The mean P300 latency before auditory task was 330 ± 24.43 msec where as post task was 342.9 ± 27.66 msec, a difference of 12.9 msec which is significant. The mean P300 latency before visual task was 333.2 ± 26.66 msec and post task was 345.65 ± 26.56 msec, again a significant difference of 12.45 msec ($P<0.05$). However, for all other ERP waves the latency changes were insignificant.

Table II shows that amplitude of P300 component of ERP does not change significantly after a period of task, whether it is visual or auditory.

TABLE I : Comparison of ERP latiencies before and after auditory and visual task (n=20).

Wave	*Task*	*Pre task (msec)*		*Post task (msec)*		*P-value*	*Sign.*
		Mean	*S.D*	*Mean*	*S.D*		
N1	Auditory	111.50	13.79	109.70	13.75	0.66	NS
N2	Auditory	226.30	35.86	225.50	19.15	0.91	NS
P1	Auditory	63.50	18.85	63.10	19.20	0.89	NS
P2	Auditory	186.30	24.91	176.90	17.92	0.08	NS
P3	Auditory	330.00	24.43	342.90	27.66	0.00	S
N1	Visual	120.90	33.51	121.30	32.30	0.95	NS
N2	Visual	235.70	32.69	244.10	43.53	0.36	NS
P1	Visual	82.10	30.79	81.10	31.88	0.82	NS
P2	Visual	193.80	33.40	190.80	35.42	0.73	NS
P3	Visual	333.20	26.66	345.65	26.56	0.01	S

TABLE II : Comparison of P300 amplitude before and after auditory and visual task (n=20).

Wave	*Task*	*Pre task (μv)*		*Post task (μv)*		*P-value*	*Sign.*
		Mean	*S.D*	*Mean*	*S.D*		
P3	Auditory	13.55	5.22	13.18	4.90	0.717	NS
P3	Visual	10.92	4.12	11.56	5.32	0.519	NS

NS : non-significant; S : significant; ($P<0.05$)

DISCUSSION

P300 latency reflects an individual's capacity to retain encoded information for comparison with new incoming information. If an individual's capacity to maintain a mental representation were diminished, the accessibility of previously stored information would be retarded, causing slower internal changes and prolonged P300 latencies (8, 9, 19–21). According to our results delay in P3 latency following auditory and visual task was comparable and statistically significant, but the type of mental task did not affect the change in latency. It goes well with the speculations of Sokolov (22), that if a specific stimulus is repeated several times and then test stimuli are presented the test responses are depressed. In hippocampal pyramidal neurons which show covergence of signals from all sensory channels (mental task processed) instead of cells habituating to characteristics of the stimulus, there is habituation of cells to the orienting response to the stimulus.

Hence a given mental task does affect P3 latency significantly, based on which we can go a step ahead in the field of electrophysiology, for example, it could be a better index of intelligence than the ones recorded during mental relaxation. According to a study (23), there is marked increase in post task latency in subjects of high IQ group and latency changes may vary accordingly, probably due to large 'cognitive pool' comprising of multi-synaptic parallel neural circuits in the transhippocampal region as compared to low IQ group. It will be interesting to find out if similar task related changes occur in other ERP's (like visual/somatosensory) on presentation of different modality mental tasks besides auditory and visual. The application of this type of work will be immense in the world of computers and advancement in information technologies. It will assess how taxing these signals are on the human brain particularly on its higher functions.

REFERENCES

1. Callaway E, Halliday R. Evoked potential variability: Effects of age, amplitude and methods of measurement. *Electroencephalogr Clin Neurophysiol* 1973; 34 : 125–133.
2. Goodin DS, Squires KC, Henderson BH, Starr A. Age related variations in evoked potentials to auditory stimuli in normal human subjects. *Electroencephalogr Clin Neurophysiol* 1978; 44 : 447–458.
3. Brown WS, Marsh JT, LaRue A. Exponential electophysiological aging: P3 latency. *Electroencephalogr Clin Neurophysiol* 1983; 55 : 277–285.
4. Picton WT, Stuss DT, Champagne SC, Nelson RF. The effects of age on human event related potentials. *Psychophysiology* 1984; 21 : 312–325.
5. Hillyard SA, Hink RF, Schwent VL, Picton TW. Electrical signs of selective attention in human brain. *Science* 1973; 182 : 177–180.
6. Geisler MW, Polich J. P300 and time of day: circadian rhythms, food intake and body temperature. *Biol Psychol* 1990; 31 : 117–136.
7. Fleck KM, Polich J. P300 and the menstrual cycle. *Electroencephalogr Clin Neurophysiol* 1988; 71 : 157–160.
8. Ford JM, Hillyard SA. Event-related potentials (ERPs) to interruptions of a steady rhythm. *Physiology* 1981; 18 : 322–330.
9. Ford JM, Pfefferebaum A, Kopell BS. Event-related potentials to a change of pace in a visual sequence. *Physiology* 1982; 19 : 173–177.

10. Goodin DS, Squires KC, Starr A. Variation in early and late event related components of the auditory evoked potential with task difficulty. *Electroencephalogr Clin Neurophysiol* 1983; 55 : 680–686.

11. Kramer A, Schneider W, Fisk A, Donchin F. The effect of practice and task structure on the components of event related potential. *Psychophysiology* 1986; 23 : 33–47.

12. Pfefferebaum A, Horvath TB, Rith WT, Kopell BS. Event related changes in chronic alcoholics. *Electroencephalogr Clin Neurophysiol* 1979; 47 : 637–647.

13. Callaway E. Human information processing. Some effects of methyl phenidate, age and scopalamine. *Biol Psychiat* 1984; 19 : 649–662.

14. Meador KJ, Loring DW, King DW et al. Cholinergic modulation of human limbic evoked potentials. *Int J Neurosci* 1988; 38 : 407–414.

15. Meador KJ, Loring DW, Davis H et al. Cholinergic and serotonergic effects on the P3 potential and recent memory. *J Clin Exp Neuropsychol* 1989; 11 : 252–260.

16. Meador KJ, loring DW, Huh K et al. Comparative cognitive effects of anticonvulsants. *Neurology* 1990; 40 : 391–394.

17. Dustman RE, Emmerson RY, Ruhling RO et al. Age and fitness effects on EEG, ERPs, visual sensitivity and cognition. *Neurobiol Aging* 1990; 11 : 193–200.

18. Tandon OP. P3 event related evoked potentials in young adults. *Indian J Physiol Pharmacol* 1990; 34 : 191–194.

19. Squires NK, Squires KC, Hillyard SA. Two varieties of long latency positive waves evoked by unpredictable auditory stimuli in man. *Electroenphalogr Clin Neurophysiol* 1975; 38 : 387–401.

20. Squires K, Petuchowski S, Wickens C, Donchin E. The effects of stimulus sequence on event related potentials : A comparison of visual and auditory sequences. *Perception and Psychophysics* 1977; 22 : 31–40.

21. Ford JM, Roth WF, Mohs RC, Hopkins WF, Kopell BS. Event-related potentials recorded from young and old adults during a memory retrieval task. *Electroencephalogr Clin Neurophysiol* 1979; 47 : 450–459.

22. Sokolov EN. Learning and memory : Habituation as negative learning In : Neural Mechanisms of Learning, edited by M.R. Rosenzweig and E.L Bennet. Cambridge, MA : The MIT Press, 1976; p. 475–479.

23. Sircar SS, Tandon OP, Chaturvedi A. Post-task event related potential (ERP) correlates of psychometric intelligence. *Indian J Physiol Pharmacol* 1999; 43(1) : 89–93.