Indian J Physiol Pharmacol 1999; 43(1) : 89–93

POST-TASK EVENT-RELATED-POTENTIAL (ERP) CORRELATES OF PSYCHOMETRIC INTELLIGENCE

SABYASACHI S. SIRCAR*, OM P. TANDON AND ANSHUMAN CHATURVEDI

Department of Physiology,
University College of Medical Sciences &
G.T.B Hospital, Shahdara,
Delhi, – 110 095

(Received on February 12, 1998)

Abstract : The standard psychometric scores show a fair degree of correlation with event-related evoked potential (ERP) latencies and amplitude. Since, both latency and amplitude are known to change during mental activity, it becomes important to consider both pre- and post-task ERP parameters is such correlative studies. In the present study, we have compared the psychometric scores obtained through WAIS-PR with evoked potential latencies and amplitude recorded at 2 sessions, one before, and the other immediately after a brief period of rigorous mental task. A negative corrrelation (–0.4) was found between the IQ of a subject and his P300 latency. Moreover, there was a positive correlation (+0.4) between the IQ of a subject and the latency changes of his P_{300} following mental exercise (post-task P300 latency minus pre-task P300 latency). Hence, there appears to be a reserve in 'latency increase' proportional to the IQ, which is manifest only following a mental task.

Key words : event-related potentials intelligence tests mental tasks P_{300}

INTRODUCTION

Event-related potentials (ERP) reflect the time course of information processing by the brain. Considerable literature has accumulated over the past few years on the ERP correlates of performance of intelligence tests (1). Much of the work has been stimulated by the interest in alternatives to conventional IQ testing which place members of certain groups at an unfair advantage. Several paradigms of evoked response testing as well as different analyses of the responses have been suggested to obtain better correlations with intelligence quotient (IQ) scores. For example, Schafer (2) reported a high correlation between the scores of IQ test and ERP amplitude changes with stimulus expectancy. Polich et. at. (3) found that the latency of a positive wave (P_{300}) evoked by a two tone 'oddball' task was negatively correlated with digit span. Blackwood et. al (4) reported a correlation between this wave and the scores for expressive speech and verbal memory in Luria's neuropsychological

*Corresponding Author

battery. Hendrickson and Hendrickson (5) have proposed 'string' measure of evoked responses, claiming remarkably high correlations with IQ, of the order of 0.7-0.8. Pelosi et. at. (6) explored the correlation between amplitude and latency of the ERPs evoked by a memory scanning task test and tests of memory function and intelligence. Their results demonstrated that those with higher scores on psychological tests as measured by the WAIS) have more negative ERPs. We propose a novel P300 measure - the 'post-cogitation increase in P300 latency' as a possible electro-physiological correlate of intelligence as we hypothesise that event-related potentials (ERP) recorded after a session of rigorous mental task could be a better index of intelligence than the ones recorded during mental relaxation.

METHODS

A total of 10 healthy subjects aged 18 years (18.4 ± 0.26) years) drawn from the medical students of our college were randomly selected for the study. Prior to selection, subjects had thorough ENT check up to rule out any hearing disorder. Subjects who had past history of conditions predisposing to hearing disorders like otitis media, meningitis, enteric fever, severe jaundice, congenital abnormalities, diabetes mellitus etc., were also excluded from the study. The IQ of the 10 subjects were evaluated using WAPIS-PR, a modified version of the WAIS which has been standardized on Indian population and was constructed to allow for the multilinguality of Indians.

The subjects were briefed about the test procedure. They were asked to lie down and relax on a bed in standard audiometric, sound-proof and air-conditioned room. SMP-4100, Auditory/Visual stimulator and MEB-5200 Evoked Potential Recorder (NIHON KOHDEN, Japan) were used for this study. P3 was measured from vertex (Cz & Pz) in response to random application of two type of sound stimuli, presented binaurally through head phones applied to subject ears. Standard auditory 'odd-ball' paradigm was used. In this paradigm design the subject was presented with a sequence of two distinguishable sound click stimuli, one of which occurs frequently (the frequent stimulus - non-target) and the other infrequently (the rare stimulus - target stimulus). The subject in asked to respond by pressing a button using his preferred hand, whenever a a target stimulus was presented. The evoked responses so obtained were recorded on the screen of the evoked potential recorder.

Ag/AgCl disc electrode, anchored with colloidion were used for recording P300. Active electrodes (-ve) were placed at Cz and Pz with reference electrodes at ear lobules (A1 + A2). The ground electrode was placed at Fpz. The input impedance was kept below 5K ohms. 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 of every 2 sec were used as target stimuli. 80% of total (160) stimuli tones were 1 kHz (frequent, 128 in number) and 20% were 2 kHz (rare, 32 in number). The stimulus sequence was random. The signals were in phase at 2 ears. The MEB-5200 settings were properly selected and evoked responses to the rare stimuli were filtered with a band pass of 5-30 Hz (Filter slope 12 dB/octave) and averaged simultaneously for 32 responses. Data for 2 trials were obtained consequently and stored, analyzed and averaged by the computer. The latency and amplitude of waves N2 and P3 for target stimulus (rare) were calculated. The methods used for recording P300 were similar to the ones reported earlier from our laboratory (7).

During P300 recording session, subject was instructed 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 equipment had provision for automatic rejection of any line defect or power spectra. In case any trial contained artifacts the entire trial was rejected. In this manner, only artifact free data were used in the final analysis.

The event-related potentials were recored twice in quick succession, separated only by a period of 10 minutes during which a mental task was administerded. The mental task comprised hearing and repeating strings of digits. The digits were spoken out clearly at a constant cadence with the help of a metronome. The string length was varied according to the performance of the subject: for 3 successive correct response, the string length was increased by one, while for each incorrect response, the string length was reduced by one. Most subjects could correctly respond to string lengths of 5 to 6 digits, and could be administered about 65 to 70 strings in a period of 10 minutes. The records of 2 subjects which showed unacceptable degrees of artifacts were rejected, and the records of the remaining 8 subjects which were artifact free were used for further analysis.

RESULTS

The results indicate that the latencies of most of the evoked waveforms, viz., P1, N1, P2, N2, P3, and N3 increase following the administration of mental task, although none of them are statistically significant

TABLE I : Comparison of auditory ERP latencies before and after auditory task.

Variable	*Before task*	*After task*	*P value*	*Significance**
P1	109.50 ± 35.58	103.00 ± 30.89	0.357	not significant
N1	154.50 ± 38.06	153.30 ± 46.19	0.909	not significant
P2	198.50 ± 33.46	217.40 ± 55.36	0.362	not significant
N2	221.00 ± 35.7	243.40 ± 45.97	0.126	not significant
P3	323.50 ± 21.53	334.50 ± 12.46	0.218	not significant
N3	394.00 ± 49.22	410.50 ± 24.74	0.364	not significant

*at 5% level

TABLE II : Comparison of auditory ERP amplitudes before and after auditory task.

Variable	*Before task*	*After task*	*P value*	*Significance**
P1	14.36 ± 6.28	12.60 ± 6.37	0.617	not significant
N1	17.77 ± 10.12	15.65 ± 5.77	0.525	not significant
P2	15.29 ± 9.48	20.84 ± 8.57	0.243	not significant
N2	9.95 ± 4.45	10.01 ± 4.37	0.973	not significant
P3	38.69 ± 7.90	31.39 ± 13.19	0.055	not significant
N3	23.03 ± 12.21	23.10 ± 10.65	0.983	not significant

*at 5% level

(Table I). The amplitude of these peaks tend to show a decrease following the task, with the exception of P2 (Table II). However, the changes are not significant except in case of P300, which showed a significant decrease (at nearly 5% confidence level) in amplitude following the task. The latency and amplitude changes in P_{300} were compared with the IQ scores of the subjects (Table III). It was found that there was a negative correlation (-0.510) between the IQ of a subject and his P_{300} latency (Table IV). Also, there was a strong positive correlation (+0.789) between the IQ of a subject and the latency changes of his P300 following mental exercise (post-task P300 latency minus pre-task P300 latency). The pre- and post-task amplitudes or their difference correlated relatively poorly with the IQ.

TABLE III : IQ and the pre- and post-task P300 latencies and amplitudes.

IQ	*P_{300} latencies*		*P_{300} amplitudes*	
	Before task	*After task*	*Before task*	*After task*
137	300	332	25.70	10.90
103	340	332	35.90	43.70
117	368	348	32.00	14.80
135	308	352	37.50	31.20
121	312	340	41.40	40.60
118	320	320	40.40	36.70
123	316	336	51.50	46.70
96	324	316	44.90	26.50

TABLE IV : Correlation coefficients of IQ with difference P_{300} parameters.

(a)	Pre-task P_{300} latency	– 0.510
(b)	Pre-task P_{300} amplitude	+ 0.574
(c)	Post-post P_{300} latency	– 0.363
(d)	Post-post P_{300} amplitude	– 0.268
(e)	(c) – (a)	+ 0.789
(f)	(d) – (b)	– 0.074

DISCUSSION

The correlations obtained in this study are obviously not remarkable. However, several observations can be made about these preliminary findings. The negative correlation between IQ and P_{300} latency is consonant with Hendrickson's theory that proposes that higher intelligence is a function of low error rates in the central nervous system and as a result of the way in which information is coded and transmitted in the brain, the effect of error is to reduce both the number and amplitude of excursions of the trace (5). Several others who have reported similar findings include Barry and Ertl (8), Chalke and Ertl (9) and Ertl and Schafer (10). Part of the increased post-task latency that is more marked in high iQ groups could be due to the shorter pre-task P300 latency that leaves a greater 'reserve' for increase. It is also possible that information processing in more intelligent individuals is associated with activation of a wider neural circuitry, probably regardless of the difficulty level of the task. It is tempting to envisage a parallel processing system for problem-solving where some of the parallel circuits have longer latencies. Individuals with higher IQ are could be endowed with more number of these slower, multi-synaptic parallel neural circuits, presumably trans-hippocampal, that enable them to process mental tasks more effectively though not necessarily, more speedily. The whole machinery of information processing is apparently activated steeply when the challenge exceeds a threshold.

ACKNOWLEDGEMENTS

This study was financially supported by a grant of the Department of Science and Technology, Government of India.

REFERENCES

1. Duffy et at. Brain correlates of psychological measures strategies and problem. *Brain Topography* 1993; 5: 399–412.
2. Schafer PWP Neural adaptability a biological determinant of behavioral intelligence. *Int J Neurosci* 1982; 17: 183–191.
3. Polich I, Howard LA, Starr A. P300 correlates with digit span. *Psychophysiology* 1983; 20: 665–669.
4. Blackwood DHR., St. Clair DM, Blackburn JM, Tyrer GMB. Cognitive brain potentials and psychological deficits in Alzheimer's dementia and Korsakoff's amnesic syndrome, *Psychol Med* 1987; 17: 349–358.
5. Hendrickson DE, Hendrickson AE. *J Personality Individual differences* 1980; 1: 3–33.
6. Pelosi L, Holly M, Slade T, Hayward M, Barrett G, Blumhardt, DL. Event-related potential (ERP) correlates of performance of intelligence tests. *Electroenceph Clin Neurophysiol* 1992; 84: 515–520.
7. Tandon OP, Kumar S. Event-related evoked potential in chronic pain patients. *Indian J Physiol Pharmacol* 1993; 37: 51–55.
8. Barry W, Ertl JP. Brain waves and human intelligence. In B. Davis (Ed.), Modern educational developments: Another look. New York: Educational records Bureau, 1965.
9. Chalke FRC, Ertl JP. Evoked potentials and intelligence, *Life Sciences* 1965; 4: 1319–1322.
10. Ertl J, Schafer EWP. Brain Response Correlates of Psychometric Intelligence, *Nature* 1969; 223: 421–422.