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TASK RELATED CHANGES IN CONTINGENT NEGATIVE VARIATION (CNV) RESPONSE OF ENDOGENOUS EVOKED POTENTIALS

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Abstract : Contingent negative variation (CNV) is a slow negative cortical potential shift, which occurs during a warned foreperiod reaction time paradigm. Most studies of evoked potentials have concentrated on components occurring during the first 300 msec, although there are important and recordable aspects of signal processing occurring well beyond 300 msec e.g. late negative slow wave. CNV has proven sensitive to a number of psychological variables, none of which can yet be singled out as a definitive or exclusive correlate. Changes are expected if measured after a rigorous mental exercise. CNV was measured in 20 normal male subjects aged between 18 and 20 years. CNV was recorded twice in each subject before and after the administration of a mental task. The auditory mental task comprised repeating in reverse order string of random digits read out to the subject at a uniform speed of 1 per second. The visual mental task comprised reading laterally inverted type written text. Each subject had to undergo 2 sessions in separate sittings. The latency and amplitude of waves N1, P3, orientation (O), expectancy (E), CNV, reaction time (RT) were recorded. These values recorded before and after the task were compared statistically using student's unpaired t-test.

The significant latencies recorded before and after the auditory task were, N1: 88.00 ± 11.96 and 100.00 ± 21.52 msec, P3: 289.00 ± 54.85 and 299.00 ± 52.91 msec, reaction time (RT): 102 ± 17.05 msec and 123 ± 17.5 msec, and in case of visual task, N1: 88 ± 13.16 msec and 99.00 ± 16.51 msec, reaction time (RT): 107 ± 11.74 msec and 127 ± 13.42 msec respectively. All other CNV wave latencies and amplitude changes were insignificant. Hence task effects sensory perception as reflected by increased latency of the long latency response N1 and the cortical integrative processes resulting in increased reaction time.

Key words : contingent negative variation (CNV) mental task

INTRODUCTION

The Contingent Negative Variation (CNV) is a slow negative potential shift that was first described by Walter et al (1). The experimental paradigm that most reliably elicits the CNV consists of a warning stimulus (S1) followed one to several seconds

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later by an imperative stimulus (S2) to which the subject must make a response. The response need not be motor and, CNV could occur during purely mental tasks such as recognizing a picture or deciding when a specified time interval had elapsed (2). The CNV corresponds to the interval between the two stimuli, S1 and S2.

Investigations of the CNV in clinical cases have been concentrated largely on patients with psychiatric disorders, but a number of factors have been shown to alter the CNV. The duration of the interval between the warning and imperative stimulus affects the CNV (3). Sleep deprivation may diminish its amplitude or may abolish it (4). There is a higher amplitude CNV during trials in which the subject has a shorter reaction time (5). There may be enlargement of CNV with stimulant drugs like caffeine, it may become smaller after nitrazepam ingestion (6). The CNV amplitude reflects, among other things, the anticipatory state of the subject (7) and if the subject is too retarded to develop adequate anticipation, his CNV will also be defective.

Attention, intention, expectancy and conation favor the appearance of the CNV. Distraction, anxiety, a sense of constraint, surveillance or uncertainty may attenuate it.

Clinical application of studies of the CNV have been limited by the difficulties of estimating or controlling the above mentioned factors. We wanted to establish how a given mental stressor in the form of a mental task would alter CNV like other factors and whether visual and auditory mental tasks have different effect on CNV.

METHODS

A total of 20 male subjects in the age group of 18 to 22 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 was included in the study after a detailed physical, ENT and opthalmoscopic examination. Cases having history of acute and chronic systemic disease, psychiatric illness and recent intake of drugs were also excluded. The test procedure was done after college hours (i.e. 4 p.m) so that there was sufficient time for testing and it could proceed in an easy and unhurried manner. The subjects were given half an hour rest before the procedure. He was made to sit on a chair comfortably in a soundproof air-conditioned room and briefed about the procedure. SMP4100 auditory/visual stimulator and MEB5200 NeuropackII evoked potential recorder was used for CNV recording. The electrode recording sites on the scalp were cleaned with skin-pure and spirit. Electrolyte paste (Elefix) was applied on the recording surface of the disc electrodes. Ag/AgCl disc electrodes were placed as per 10–20 International System of electrode placement.

Active electrode (–): Vertex (Cz), Midline frontal (Fz)

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

Grounding Electrode : Forehead (Fpz)

The warning stimulus (S1) was click sound and visual stimulus or imperative stimulus (S2) obtained by light emission of red LED goggles was delivered through SMP 4100 Auditory/Visual stimulator. The subject had to press a switch to terminate the imperative stimulus S2. Each trial consisted of a warning stimulus (S1) of 70 dB intensity, frequency 0.4 Hz and duration of 0.1 msec and S1–S2 interval was 2 sec. The latencies of all the CNV waves, viz., N1, P3, O, E, CNV, RT and amplitudes of CNV were recorded as per standardized methods (8). 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 mental task comprised reading laterally inverted typewritten text (i.e. mirror image of the text) for 10 minutes. If they could not identify the word they were asked to identify the alphabets. The incorrect responses were skipped as the task was not to assess his comprehension but to tax his mind. The subject was encouraged to read correctly as much he could in 10 minutes. Most of the subjects could read upto 11–12 lines. The subject had to undergo two sessions, only one session was done in a day. In each session CNV was recorded twice in quick succession, separated only by a period of 10 minutes during which a mental task was administered. The mental task was auditory in one and visual in other.

RESULTS

CNV was recorded from two channels (I & II) corresponding to Cz and Fz electrode placement sites on scalp (Fig. 1). The observations were noted as per the programmed CNV settings in the SMP4100 auditory/visual stimulator and MEB5200 NeuropackII evoked potential recorder. The

TABLE I : Comparison of CNV latencies (msec) and reaction time (msec) before and after mental task (N = 20).

Variable	*Task type*	*Before task*		*After task*		*P-value*	*Sign. (at 5%)*
		Mean	*S.D*	*Mean*	*S.D*		
N1	Auditory	88.00	11.965	100.00	21.521	0.014	S
P3	Auditory	289.00	54.85	299.00	52.90	0.029	S
O	Auditory	1.422s	0.291	1.454s	0.237	0.436	NS
E	Auditory	1.316s	0.182	1.333s	0.178	0.555	NS
CNV	Auditory	2.569s	0.187	2.593s	0.202	0.438	NS
RT	Auditory	102.00	17.04	123.00	17.50	0.000	S
N1	Visual	88.00	13.611	99.00	16.512	0.004	S
P3	Visual	272.00	37.50	277.00	45.54	0.287	NS
O	Visual	1.350s	0.144	1.356s	0.134	0.776	NS
E	Visual	1.252s	0.187	1.241s	0.146	0.693	NS
CNV	Visual	2.569s	0.147	2.591s	0.183	0.586	NS
RT	Visual	107.00	11.743	127.00	13.416	0.000	S

S : Significant; NS = Non-significant.

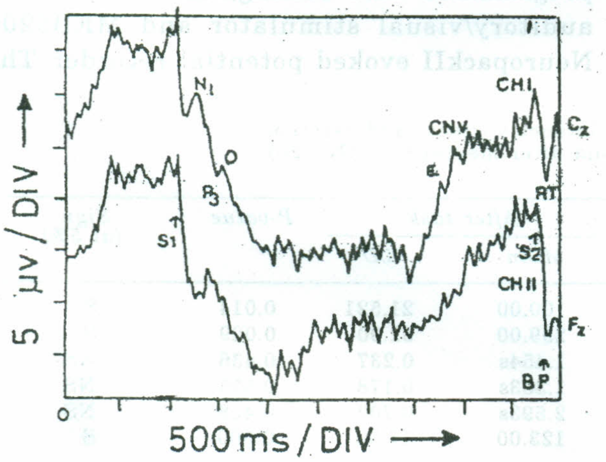
TABLE II : Comparison of P300 and CNV amplitude (µV) before and after mental task (N = 20).

Variable	*Task type*	*Before task*		*After task*		*P-value*	*Sign. (at 5%)*
		Mean	*S.D*	*Mean*	*S.D*		
P3	Auditory	18.425	5.893	18.675	6.063	0.816	NS
CNV	Auditory	18.420	5.837	17.070	4.793	0.278	NS
P3	Visual	20.905	5.932	21.465	5.950	0.531	NS
CNV	Visual	20.500	4.757	20.640	5.230	0.885	NS

NS : Non-significant

latency and amplitude of waves N1, P3, orientation (O), expectancy (E), CNV, reaction time (RT) were measured from channel I as they were more prominent.

On studying the task-related changes in CNV latency and reaction time in 20 subjects, it was seen that N1 and RT were significantly altered following both auditory and visual task, and P3 latency was significantly altered after an auditory task. The significant latencies recorded before and after the auditory task were, N1: 88.00 ± 11.96 and 100.00 ± 21.52 msec, P3: 289.00 ± 54.85 and 299.00 ± 52.91 msec, reaction time (RT): 102 ± 17.05 msec and 123 ± 17.5 msec, and in case of visual task, N1: 88 ± 13.16 msec and 99.00 ± 16.51 msec, reaction time (RT): 107 ± 11.74 msec and 127 ± 13.42 msec respectively). All other CNV wave latencies (Table I) and amplitude (Table II) changes were insignificant.



S1 : Warning stimulus
S2 : Imperative stimulus
CNV: Contingent Negative Variation
O : Orientation wave
E : Expectancy wave
RT : Reaction Time
CH I : Channel I (Cz)
CH II : Channel II (Fz)
BP : Buttons Press

Fig. 1 : Showing CNV potentials and Reaction time elicited in two stimuli paradigm.

DISCUSSION

The CNV appears to represent the summation of at least two, and probably more, component waveforms. There is a stimulus-related frontally predominant negativity, perhaps related to the orienting response, and a centrally predominant negativity thought to be related to the premotor potential associated with the motor response (9, 10, 11). The first portion and perhaps part of the second portion of the CNV are independent of the motor response (9, 12). Additionally, the CNV is present despite an absent bereitschaft potential following a cerebellar outflow lesion (13).

The first component of CNV is the O wave (Orientation wave) which seems to be associated with a process of orienting to S1, whereas the second component labelled as the E-wave (Expectancy wave) seems to be related to motor preparations prior to S2

(2). O-wave is related to the information delivered by S1 (14). CNV activity is generated in frontal or parietal cortical areas, encompassing the premotor cortex, the supplementary motor area (SMA) for motor CNV and the parietal association cortex for sensory CNV. In motor CNV paradigms, the E-wave reflects activity in neuronal circuits involving not only premotor cortex but also basal ganglia (15). Nevertheless it is still appropriate to conclude that at least part of the E-wave encompasses a readiness potential in preparation for a motor response to S2.

In scalp recordings, the CNV is widely distributed over the head with its highest amplitude at the frontal and central electrodes. Studies with intracranial recordings using invasive electrodes in animals and humans have stressed the role of the frontal lobe as a possible generator of CNV (16). CNV has two component processes on the basis of latency, topography and functional properties. An early component is maximal over the frontal cortex and appears in response to the warning stimulus. A second later component appears before the imperative stimulus first described by Kornhuber and Deecke (17).

In literature such type of study has not been reported. Most of the studies have been done in a relaxed state of mind and factors altering CNV studied. It is here we have made a modification by studying CNV immediately after a mental stressor and compared it with CNV in relaxed state of mind. Present study has shown significant increase in N1, P3 and reaction time when CNV paradigm was employed. The vigorous mental exercise causes blunting of sensory perception as reflected by increase in latency of the long latency response (N1). P3 latency, which reflects the cognitive processing, is delayed because the "cognitive attention" is compromised due to mental exercise. Since RT reflects the level of arousal of central nervous system and is a good measure of vigilance, strenuous mental exercise provoked blunting of superior integrative capacities which severely compromises all parameters closely correlated to the genesis of bioelectric phenomenon (attention, concentration, capacity to complete task, etc). The same goes true for increased latency trend seen in O, E and CNV waves. Type of mental task did not affect much the changes in latency and amplitude of CNV waves. Application of this type of work will be immense in this present age of information technology and the upcoming high tech new millenium. It shows how mental stressors can affect the neurophysiological parameters of the human brain, which are reflection of its higher function.

REFERENCES

1. Walter WG, Cooper R, Aldridge VJ, McCallum WC, Winter AL. Contingent negative variation: An electric sign of sensorimotor association and expectancy in the human brain. *Nature* 1964; 203: 380–384.
2. Walter WG. Slow potential changes in the human brain associated with expectancy, decision and intention. *Electroenceph Clin Neurophysiol* 1967; 26 (Suppl): 123–125.
3. Klorman R, Bentsen E. Effect of warning signal duration on the early and late components of the contingent negative variation. *Biol Psychol* 1975; 3: 263–275.

4. Naitoh P, Johnson LC, Lubin A. Modification of surface negative slow potentials (CNV) in the human brain after total sleep loss. *Electroenceph Clin Neurophysiol* 1971; 30 (1): 17–22.

5. Loveless NE, Sanford AJ. The impact of warning signal intensity on reaction time and components of the contingent negative variation. *Biol Psychol* 1975; 2: 217–226.

6. Ashton H, Millman JE, Telford R, Thompson JW. The effect of caffeine, nitrazepam and cigarette smoking on contingent negative variation in man. *Electroenceph Clin Neurophysiol* 1974; 37: 59–71.

7. Teece JJ. Contingent negative variation and individual differences. *Arch Gen Psychiatry* 1971; 24: 1–16.

8. Tandon OP, Kumar S. Contingent negative variation response in chronic pain patients. *Indian J Physiol Pharmacol* 1996; 40 (3): 257–261.

9. Loveless NC and Sanford AJ. Slow potential correlates of preparatory set. *Biol Psychol* 1974: 303–314.

10. Rohrbaugh JW, Syndulko K, Lindsley DB. Brain wave components of the contingent negative variation in humans. *Science* 1976; 191: 1055–1057.

11. Gaillard AWK. Effects of warning signal modality on the contingent negative variation (CNV). *Biol Psychol* 1976; 4: 139–154.

12. Ruchkin DS, Sutton S, Mahaffey D, Glaser J. Terminal CNV in the absence of motor response. *Electroenceph Clin Neurophysiol* 1986; 63: 445–463.

13. Ikeda A, Shibasaki H, Nagamine T, Terada K, Kaji J, Fukuyama H, Kimura J. Dissociation between contingent negative variation and bereitschaftspotential in a patient with cerebeller lesion. *Electroenceph Clin Neurophysiol* 1994; 90: 359–389.

14. Rohrbaugh JW, Gaillard AWK. Sensory and motor aspects of the contingent negative variation. In: A.W.K. Gaillard and W. Ritter (Eds.) Tutorials in Event Related Potential Research: Endogenous components. *North Holland Amsterdam* 1983; 61: 269–310.

15. Mauritz KH, Wise SP. Premotor cortex of monkey: Neuronal activity in anticipation of predictable environmental events. *Experimental Brain Research* 1986; 61: 229–244.

16. Hammo T, Luders HO, Ikeda A, Collura TF, Comair YG, Shibasaki H. The cortical generators of the contingent negative variation in humans: a study with subdural electrodes. *Electroencephal Clin Neurophysiol* 1997; 104: 257–268.

17. Kornhuber HH, Deecke L. Hirnpotentialanderungen bei Willkurbewe gungen and passiven Bewegungen des Menschen: Beritschaftspotential and reafferente Potentiale. *Pflugers Arch* 1965; 284: 1–17.