International Journal of Research in Medical Sciences
Gupta S et al. Int J Res Med Sci. 2015 Jul;3(7):1745-1750
www.msjonline.org
pISSN 2320-6071 | eISSN 2320-6012
DOI: http://dx.doi.org/10.18203/2320-6012.ijrms20150263

Research Article

Study of voluntary alteration of visual evoked potentials: Evaluating role in functional visual loss

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Received: 20 May 2015
Accepted: 21 May 2015

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ABSTRACT

Background: Pattern reversal visual evoked potentials (PRVEP) are one of the recommended tests for detection of functional visual loss. However, voluntary alterations producing abnormal records have been reported in the normal subjects limiting the role of the test. Hence, this study aimed to record voluntarily altered PRVEP responses and to study the role of various modifications in the technique for detection of the condition.
Methods: 20 normal subjects in the age-group of 18-25 years were studied. PRVEP records were obtained in the normal perceiving states and then with voluntary alterations in different stimulus conditions and the changes in the mean P100 latency and N75-P100 amplitude were compared and analysed using paired t-test.
Results: 15 out of 20 subjects could voluntarily alter their PRVEP records with 26 out of 30 eyes demonstrating statistically significant abnormal records in terms of latency delay or amplitude reduction or both. Modifications in the technique with increased check size, field size and binocular stimulation reduced the number of abnormal records. But, mean P100 latency and N75-P100 amplitude recorded from the above stimulus conditions in voluntarily altered states were still statistically significantly altered from those in the normal perceiving conditions ($p<0.05$).
Conclusion: Normal subjects can voluntarily produce abnormal PRVEP responses. Various modifications in the technique like increase in the check-size, field size and binocular stimulation should be employed if voluntary alteration is suspected, but interpretation should be made carefully in the context of clinical findings of the subject.

Keywords: Visual evoked potentials, Voluntary alteration

INTRODUCTION

Visual evoked potentials (VEPs) constitute valuable electrophysiological tests for objective and non-invasive evaluation of the functional integrity of visual pathways. Visual evoked potentials record the electrical potentials from the scalp in response to the visual stimuli. For most clinical purposes, pattern reversal is the preferred stimulus. Pattern-reversal visual evoked potentials (PRVEPs) are less variable in waveform and timing than those elicited by other stimuli. VEPs are useful in many important clinical conditions to complement the diagnosis. They may be of great value in distinguishing between functional and organic visual loss. Functional Visual Loss is a decrease in visual acuity and/or visual field, not caused by any organic lesion. Functional visual loss runs the spectrum from the malingerer to subconscious visual loss caused by underlying psychological disorders in the patient. The three major categories of functional disorders described are somatoform disorders (also commonly referred to as "hysteria"), factitious disorders and malingering.[1] In general, malingering implies purposeful feigning or exaggeration of symptoms usually for secondary gain, while somatoform disorders (hysteria) are thought to occur outside the patient's conscious awareness.[2] In Factitious disorders, patients present with intentionally produced symptoms for the purpose of assuming the sick role.[1]

Visual evoked potential being an objective test prove to be a vital tool in the assessment of the organic integrity of the visual system.[3,4] They constitute one of the recommended tests by the International Society for Clinical Electrophysiology of Vision for the detection of non-organic visual loss.[5] A well formed VEP of normal amplitude in a patient complaining of visual loss with decrease in visual acuity and/or visual field strongly suggests the presence of Functional visual loss. Halliday and Mc Donald suggested that a well formed VEP is incompatible with a visual acuity of 6/36 or less.[6] However, in deliberate malingerers, it has been reported that the VEP responses can voluntarily be altered by various manoeuvres despite careful monitoring during the procedure.[7-9] The abnormal responses thus obtained, mimic those due to demyelinating and compressive optic nerve lesions.[9] This can affect the sensitivity of the test. In such suspected abnormal responses, in addition to emphasizing on the direct observation of the patient, some modifications in the recording techniques like increase in check size, increase in field size and binocular stimulation which are known to be less affected by defocusing have been suggested to evoke a genuine response. [9,10,11] In the present study, we aimed to record voluntarily altered PRVEP responses in the normal subjects and to evaluate the role of those suggested modifications in the technique to detect deliberate alterations by the subjects so that the patients with suspicion of malingering and hysteria can be diagnosed by the test.

METHODS

We studied 20 adults (11 males and 9 females) in the age group of 18-25 years with normal visual acuity. Approval from the institutional ethical committee was taken to carry out the research work. A complete neuro-ophthalmologic examination of each subject was done after obtaining a written informed consent and a detailed clinical history.

Inclusion criteria

Adult subjects with normal visual acuity, normal fundus and visual field examinations.

Exclusion criteria

Subjects with metabolic , endocrine or demyelinating pathologies; glaucoma, strabismus, amblyopia, optic neuropathies, inherited or acquired neurological disorders, compressive lesions of anterior visual pathways, HIV infections, history of drug- abuse and history of cerebro-vascular accidents.

Pre-test evaluation

For the best results of VEP testing, subjects were advised to come without applying oil or any hair chemical to the scalp, asked to put on their usual glasses. Subjects were instructed to have an adequate sleep the previous night to prevent the effect of drowsiness on the responses. Subjects were explained about the test to ensure full cooperation. Subjects were also instructed to avoid any mydriatic or miotic drug 12 hours before the test. Preparation of scalp skin was done before electrode application.

VEP recording

VEP was recorded with Allengers Scorpio EMG, EP, NCS system in a specially equipped electro-diagnostic procedure room, made dark and sound attenuated for the test. Subjects were seated comfortably about 95 cm away from a video-monitor with a 30 cm screen. The video-monitor presented a black and white checker-board pattern with a fixation spot in the center of the screen (mean luminance 50 candela/m^2 and contrast 70%). The checks/pattern elements reversed alternately at the rate of 2 Hz. The visual angle subtended by the checks was 54.6 min and the screen subtended a visual angle of 19 degrees for the first set of recording. The signals were amplified (gain 20,000), filtered with a system band pass filter of 2-100 Hz and 100 responses were averaged. Standard disc surface electrodes were placed according to the International 10/20 system of electrode placement, with active electrode at Oz, reference electrode at Fz and ground electrode at Fpz.[12] Volunteers were instructed to fix the gaze on a small red square at the center of the screen of video-monitor. Monocular stimulation was done with an eye-patch covering the other eye. To verify the reproducibility of the waveform, two responses were recorded and superimposed. The replicated response measurements with P100 latency within 2.5 ms difference and N75-P100 (peak-peak) amplitude within a 15% difference was accepted.[12]

To record the voluntarily altered responses, with same preset stimulus conditions, subjects were instructed to avoid perceiving the stimulus, while still maintaining the gaze on the stimulus. In subjects who were able to alter the VEP, further experiments were performed during non-perceiving conditions with decreasing the check sizes as 34 min and increasing as 71.6 min (by varying the display settings of the monitor) then in next setting field size was increased to 23 degrees (with the check size unchanged as 54.6 min) and further in the next setting, a binocular VEP record was obtained in which the subject was instructed to avoid the stimulus while fixating at the target with both the eyes open; rest of the stimulus setting were same as in the first recording (54.6 min checks and 19 degrees field). P100 latency and N75-P100 amplitude were recorded and analysed in all the settings. All the data was expressed as mean ± S.D.

RESULTS

Out of 20 subjects, 15 (30 eyes) could voluntarily alter their VEP record with delayed P100 latency or reduced N75-P100 amplitude or both. Out of those 15, one subject could produce unrecordable or absent waveform from one eye in non-perceiving conditions.

Mean P100 latency and N75-P100 amplitude in normal perceiving conditions from 15 subjects (30 eyes) were 104.13±5.189 ms and 6.42±1.58 µv respectively. Mean P100 latency and N75-P100 amplitude after voluntary alteration with same stimulus conditions, calculated from 29 eyes (absent waveform from one eye out of 30 eyes) were 113.89±7.73 ms and 1.99±1.053 µv respectively (Table 1).

Table 1: Mean P100 latency and N75-P100 amplitude in subjects with normal perceiving and non-perceiving conditions (Monocular stimulation, check size: 54.6 mins, and field-size: 19 degrees).

	Normal perceiving conditions	Non-perceiving conditions (Voluntary alterations)
Mean P100 latency ± SD (ms)	104.13±5.19	113.89±7.73
Mean N75-P100 amplitude ± SD (µv)	6.42±1.58	1.99±1.05

P value <0.0001, when mean P100 latency and mean N75-P100 amplitude were compared in normal perceiving and non-perceiving conditions (paired t-test).

P100 latency was delayed beyond 2.5 standard deviations from the normal in 13 out of 29 eyes with 54.6 min check size. The delay in the latency with or without the reduction in the amplitude is a feature of optic nerve demyelination. N75-P100 amplitude reduction below 50% was a commoner finding than latency delay, which was demonstrated by 24 out of 30 eyes in voluntarily altered records with 54.6 min check size. Distorted VEP waveform was another feature in most of the voluntarily altered responses (Figure 1). Waveform distortion and amplitude attenuation have been found to be the prominent features of compressive lesions of the anterior visual pathways.

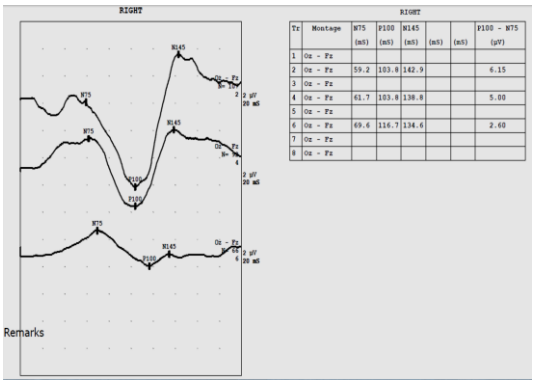

Figure 1: PRVEP record of a normal subject showing responses from perceiving as well as non-perceiving/voluntarily altered conditions (monocular stimulation, check size: 54.6 min and field size: 19 degrees): Responses from normal perceiving conditions are shown in the first two traces while the last trace depicts a voluntarily altered response showing delayed P100 latency (116.7 ms), reduced N75-P100 amplitude (2.6 µv) as well as a distorted waveform.

On increasing the check size to 71.6 min, 12 eyes out of 30 eyes demonstrated latency delay while abnormal reduction in the amplitude was found in 21 eyes. Increased field size of 23 degrees produced latency delay in 8 out of 30 eyes and abnormal amplitude reduction in 16 eyes. When binocular VEP were recorded in similar non-perceiving conditions, the latency delay was found in only 5 out of 30 eyes and also provided the least number of abnormal reductions in the amplitude as 7 out of 30 eyes with least distorted waveforms. On decreasing the check size to 34 min, similar significant delayed responses increased in number as 16 eyes out of 29 eyes (with absent P100 recorded in one eye out of 30 eyes) while 27 out of 30 eyes showed amplitude reduction. The latency delay in all the above voluntarily altered records were calculated as >2.5 SD from the mean values recorded with similar stimulus conditions in normal perceiving states and abnormal amplitude reduction as > 50 % reduction from the value in normal perceiving states (Table 2).

The manoeuvres employed by the 15 subjects for deliberately altering the responses or not perceiving the pattern varied among the subjects with 6 subjects reported to perform near point focussing i.e. focussing on an imaginary point in front of the screen while 7 subjects reported to perform eccentric fixation at the corner of the screen and 2 subjects fixated beyond the screen. The manoeuvres were undetected by the observer, but while recording binocular VEP, near point focussing by sharp adduction was evident. Also, it provided the least number of abnormal responses. Increasing the field size by reducing the distance between eye and the screen also made near point focussing difficult.

When mean value of P100 in voluntarily altered responses (113.89±7.73 ms) with 54.6 min check size was compared with those obtained with increased check size of 71.6 mins (112.46±9.34 ms), increased field size of 23 degrees (111.03 ±10.08 ms) and binocular VEP (106.7±7.53 ms), the statistically significant decrease in the mean P100 latency was only found with that from binocular VEP records ($p<0.05$). Decreasing the check size to 34 min prolonged the mean P100 latency significantly (116.99±7.24 ms) while decreased the amplitude with no statistical significance. On the other hand, mean N75-P100 amplitude increased with statistically significant difference in all the above voluntarily altered trials ($p<0.05$) when compared with the mean value in voluntary alteration with original stimulus settings (Table 3).

When the mean values of P100 latency and N75-P100 amplitude obtained with increased check size, increased field size and binocular VEP recording, during voluntary alterations were compared with those with similar stimulus conditions in normal perceiving states, the difference is statistically significant with p-value less than 0.05 (Table 4).

pISSN 2320-6071 | eISSN 2320-6012

Table 2: Voluntary alteration of VEP in 15 subjects (30 eyes) showing the number of abnormal records.

Stimulus conditions	54.6 min checks 19˚field, monocular	34 min checks 19˚field, monocular	71.6 min checks, 19˚field, monocular	54.6 min checks, 23˚field, monocular	54.6 min checks, 19˚field, binocular
Absent P100 Eyes	1	1			
Delayed P100 latency (>Mean + 2.5 SD) Eyes	13	16	12	8	5
N75-P100 amplitude reduction > 50% Eyes	24	27	21	16	7
Total abnormal eyes (Delayed P100 latency >Mean + 2.5 SD) or N75-P100 amplitude reduction > 50% or both)	26	29	23	18	9

Table 3: Voluntary alteration in different stimulus conditions.

Trials	Stimulus conditions			Mean P100 Latency(ms)	Mean N75-P100 amplitude(µv)
	Check-size (mins)	Field size (degrees)	Monocular/ Binocular		
1.	54.6	19	Monocular	113.89±7.73	1.99±1.05
2	34	19	Monocular	116.39±7.15	1.92±0.91
3.	71.6	19	Monocular	112.5±9.35	2.58±1.02
4.	54.6	23	Monocular	111.03±10.08	3.19±1.3
5	54.6	19	Binocular	106.7±7.53	4.24±1.11

P value >0.05, when mean P100 latency was compared in the first set of trial with those with increased check size and increased field size, while P <0.05, when compared with the binocular values (paired t-test). Decreased check size in the second set increased the mean P100 latency with p<0.05. Mean N75-P100 amplitude increased with P<0.05 in all the set of trials when compared with those in the first trial.

Table 4: Mean P100 latency and N75-P100 amplitude in normal perceiving conditions and voluntary alterations with modifications in the stimulus conditions.

Stimulus conditions	Mean P100 latency (ms)		Mean N75-P100 amplitude (µv)	
	Perceiving	Voluntary alteration	Perceiving	Voluntary alteration
Decreased check-size (34 mins checks, 19 degrees field, monocular)	106.14±5.09	115.96±7.15	6.51±1.48	1.92±0.91
Increased check-size (71.6 mins checks, 19 degrees field, monocular)	103.04±5.2	112.46±9.34	6.04±1.5	2.58±1.02
Increased field size (54.6 mins checks, 23 degrees field, monocular)	103.23±5.1	111.03±10.08	5.9±1.56	3.19±1.3
Binocular stimulation (54.6 mins checks and 19 degrees field)	101.41±6.03	106.7±7.53	7.5±1.5	4.24±1.11

P<0.0001, when mean P100 latency and mean N75-P100 amplitude from voluntary altered records were compared with those in normal perceiving conditions (under all the stimulus conditions employed) (paired t-test).

pISSN 2320-6071 | eISSN 2320-6012

DISCUSSION

In the present study majority of the subjects (15 out of 20) could voluntarily alter their VEP responses. This supports the observation that normal subjects can deliberately alter their VEP records by various manoeuvres despite careful monitoring.

The ability of the subjects to focus and resolve the pattern is critical in pattern reversal VEP testing. Defocusing of the pattern affects the latency, amplitude as well as the waveform. Near point focussing alters the responses due to reduction in the pupillary diameter as well as due to near accommodation response. Near accommodation response in near point focussing produces blurring of the image and is the principle mechanism suggested to be involved in producing abnormal VEP.[9] Reduction in the pupillary diameter is known to reduce the retinal illumination, which can also prolong P100 latency.[13,14] However, observation of the pupillary size during the procedure was not easy in the darkened recording room and in subjects wearing spectacles. Also, adduction in near point focusing was not evident with only the tested eye open, hence remained undetectable. Eccentric fixation either along the edge of the screen or beyond the screen was another mode of altering the normal VEP records. In a full-field stimulation, the pattern extends equally to both the sides of fixation point and majority of the P100 response arises in the neural elements of eye for central 8-10 degrees of the visual field. This emphasizes the importance of fixating the target in the center of the pattern for a well formed normal record in the pattern reversal visual evoked potentials.

The recommended modifications in the technique like reduction in the distance between eye and the screen (increasing the field size) made the alteration in the VEP by near point focussing difficult with reduced number of abnormal records and significant increase in the amplitudes (Table 2 and 3). It was also found that the voluntary suppression was more with small check sizes than that with the large check sizes. Small checks, however, are needed to be used in some patients with subclinical optic neuritis for detecting the condition. Hence, improvement of VEP by the use of large checks alone does not confirm the presence of non-organic visual loss. Similarly, using small field size also improves the detection of optic neuritis, but it also renders the eccentric fixation undetectable. However, the conditions like subclinical optic neuritis that require smaller check sizes to be detected, are characterised by the absence of visual complaints while in non-organic visual loss as in malingering and hysteria, visual complaints with incompatible clinical findings is the prominent feature.

Binocular VEP records helped to detect deliberate alterations as they make the convergence obvious and also provided considerably shorter latency and larger amplitudes than those with monocular recordings. Hence, though normal clinical testing requires monocular stimulation, a well-formed binocular VEP waveform with P100 latency and amplitude within normal laboratory range for binocular values in a subject with absent, unidentifiable or abnormally delayed P100 response with monocular stimulation indicates deliberate alterations.

The modifications employed in the technique in our study reduced the number of abnormal responses in terms of both delayed latency and reduced amplitudes, also mean amplitude increased significantly. But, when mean values (from voluntary alteration with technical modifications) were compared with those in the normal perceiving states, the differences were still statistically significant ($p<0.05$).

CONCLUSION

VEP responses can be deliberately altered by the normal subjects using different manoeuvres despite being carefully observed. The records, thus obtained, simulate demyelinating as well as compressive lesions of the optic nerve. Thus, although visual evoked potentials are objective electrophysiological tests for the visual functions, they are susceptible to the subjective factors necessitating subject's cooperation during the procedure. Technical modifications in the stimulus conditions like use of the large checks, large field and binocular stimulation reduce the number of abnormal records and should be employed when suspecting the presence of non-organic visual loss like malingering and hysteria, but like all other electrophysiological investigations, interpretations should be done cautiously with careful correlation with the neuro-ophthalmological findings of the subjects.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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Cite this article as: Gupta S, Gupta G, Singh S. Study of voluntary alteration of visual evoked potentials: Evaluating role in functional visual loss. Int J Res Med Sci 2015;3:1745-50.