

Impact of eye-dominance on pattern reversal visual evoked potentials

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Abstract

Background and Objectives: Ocular dominance refers to the tendency to prefer visual input from one eye to the other and is found in majority of the individuals. The role of eye dominance as one of the confounding physiologic variables affecting the PRVEP (pattern reversal visual evoked potential) responses needs to be evaluated. Hence, the present study was planned to assess the influence of eye dominance on the PRVEP records in the healthy subjects.

Methods: The study was conducted on 52 healthy subjects in the age group of 18-65 years. Eye dominance was measured by Miles test and Porta test. PRVEP parameters were compared and analysed between the two eyes among the right eye and left eye dominant subjects by paired t-test.

Results: 69% of the subjects were right eye dominants while 29% were left eye dominants. PRVEP mean P100 latency decreased and mean N75-P100 amplitude increased statistically significantly in the dominant eyes in both right and left eye dominant subjects.

Conclusion: PRVEP records are influenced by eye dominance. One should take into account the effect of eye dominance while comparing the VEPs of two eyes of the same subject. Clinical interpretation should be done on the basis of the eye-dominance matched normal subjects.

Keywords: Pattern reversal visual evoked potentials, eye dominance

1. Introduction

Ocular dominance or eyedness is the tendency to prefer visual input from one eye to the other. [1,2] Physiological predominance is found in many other bilateral paired structures in the body too. Vision has almost certainly been the most popular modality for laterality research. Around two-thirds of the population is right eye dominant, however neither eye is dominant in a small portion of the population.[3,4] Dominance does appear to change depending upon direction of gaze due to change in the image sizes on the retinas.[5] Furthermore, the eye preferred for sighting does not indicate handedness. There is no direct analogy between handedness and eyedness as lateral phenomenon since each eye projects to both cerebral hemispheres whereas each hand is represented mainly in the opposite hemisphere. In exploration of visual significance of sighting dominance, it has been found that sighting eye is more efficient in gathering information from eye movements, has faster processing time, longer persistence of its visual image than the non-sighting eye.[6-9] Hence, it has been shown to be related to a large number of perceptual performances and clinical phenomena.[10]

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Visual evoked potential test has been utilized as an electrophysiologic tool to investigate the processes like fusion, suppression and stereopsis. PRVEPs (pattern reversal visual evoked potentials) are very useful and sensitive in testing optic nerve function and anterior chiasmatic lesions of the optic pathways but the records have been known to be affected by various physiological variables like age, gender, visual acuity and also by eye dominance which necessitates the acquisition of a data adjusted to these confounding variables. Influence of age, sex and visual acuity have been the most frequently studied variables while the data for the effect of eyedness or eye dominance on PRVEP responses still remains sparse. Moreover, the influence of ocular dominance on PRVEPs in terms of latency and amplitude changes can provide an electrophysiological evidence of the eyedness in the individuals and hence the laterality in human brain. The present study attempts to analyse PRVEP records to evaluate the influence of sighting dominance on VEP changes and to compare the data with the previous studies.

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2. Materials and methods

The study was conducted on 52 healthy subjects (31 males and 21 females) in the age group of 18-65 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. Eye dominance was determined by Miles test and confirmed by Porta test before recording VEP.

Miles test: In this test the observer extends both arms, brings both hands together to create a small opening, then with both eyes open views a distant object through the opening. The observer then closes the eyes alternately or slowly draws opening back to the head to determine which eye is viewing the object that is the dominant eye. [11, 12]

Porta test: The observer extends one arm and then with both eyes open aligns the thumb or index finger with a distant object. The observer then closes the eyes alternately or slowly draws the thumb/finger back to the head to determine which eye is viewing the object that is the dominant eye. [11, 13]

2.1 Inclusion criteria

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

2.2 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 cerebrovascular accidents.

2.3 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.

2.4 VEP recording

VEP was recorded on RMS Polyrite-Ad 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/m² and contrast 70%). The checks/pattern elements reversed alternately at the rate of 1.71 Hz. The visual angle subtended by the checks was 54.6 min and the screen subtended a visual angle of 19 degrees. The signals were amplified (gain 20,000), filtered with a system band pass filter of 2-200 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.[14] 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.[14]

3. Results

Right eye dominant subjects were 69%, left eye dominant were 29% and one subject had bilateral dominance in both Porta & Miles test (table 1). A gender comparison revealed that 74 % males were right eye dominant while among females, 60% were right eye dominant (table 2 and figure 1). Mean P100 latency decreased with statistical significance in right eye for right eye dominant subjects while it was found to be reduced in left eye in left eye dominants (table 3 and 4, figure 2). Mean N75-P100 amplitude increased statistically significantly in right eye when compared to left eye in right eye dominants and increased in the left eye for left eye dominant subjects (table 3 and 4, figure 3).

Table 1: Eye dominance in 52 subjects

	Right eye dominant	Left eye dominant	Bilateral dominant	Total
No. of subjects	36	15	1	52
% of subjects	69	29	2	100

Table 2: Gender comparison of eye dominance

	Males			Females		
	Right eye dominant	Left eye dominant	Total subjects	Right eye dominant	Left eye dominant	Total subjects
No. of subjects	23	8	31	12	8	20
% of subjects	74	26	100	60	40	100

Table 3: PRVEP in right eye dominant subjects

	Right eye	Left eye	P value
Mean P100 latency (ms±SD)	97.91±1.089	98.37±1.22	0.0019
Mean N75-P100 amplitude (µv±SD)	7.29±2.23	6.54±2.22	<0.0001

Mean P100 latency decreased in the right eye ($p=0.0019$) and mean N75-P100 amplitude increased ($p<0.0001$) by paired t test.

Table 4: PRVEP in left eye dominant subjects

	Right eye	Left eye	P value
Mean P100 latency (ms±SD)	98.73±0.65	97.89±0.82	<0.0001
Mean N75-P100 amplitude (µv±SD)	6.02±1.72	6.8±1.58	0.0014

Mean P100 latency decreased in the left eye ($p<0.0001$) and mean N75-P100 amplitude increased ($p=0.0014$) by paired t test.

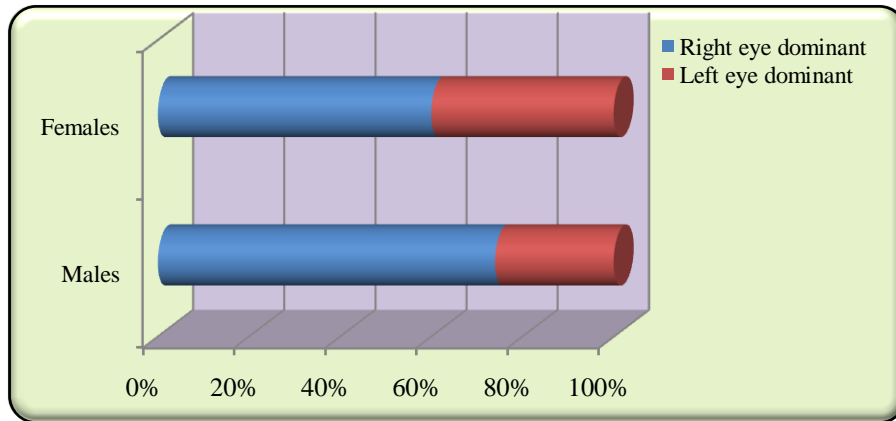


Figure 1: Gender comparison of eye dominance

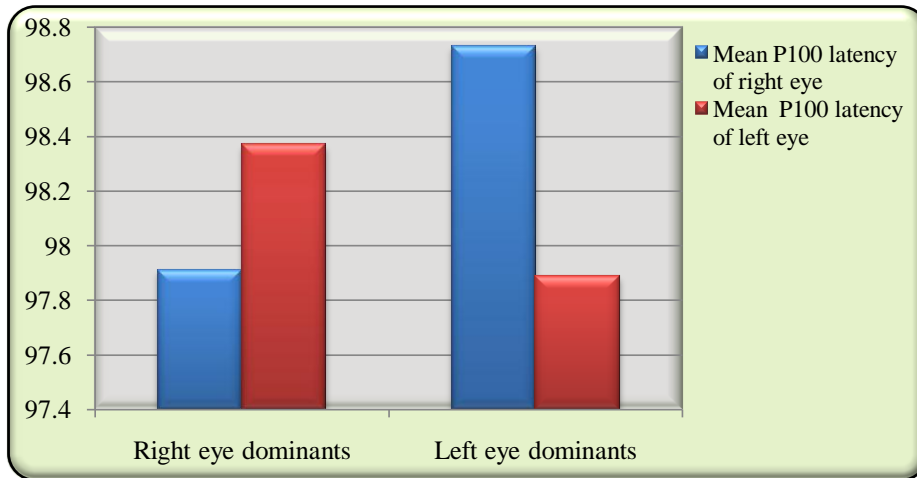


Figure 2: Mean P100 latency in right and left eye dominants

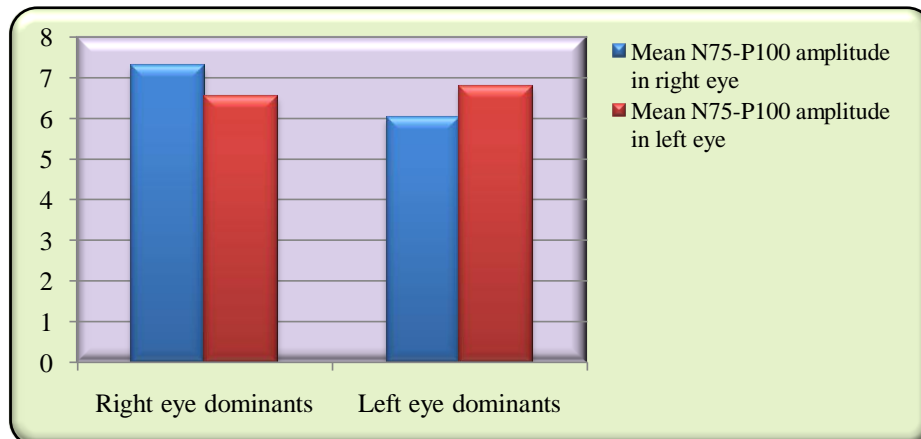


Figure 3: Mean N75-P100 amplitudes in right and left eye dominants

4. Discussion

Eye dominance has been argued as a more appropriate measure of an underlying lateralisation than the handedness and is subjected to minimal environmental pressure as well. It is thought to be developed as a result of binocular vision. Binocular vision makes visual perceptions more meaningful. The visual images in the two eyes normally fuse with each other on the corresponding points of the two retinas and the corresponding inputs from two eyes must converge onto the cells in the visual cortex to provide a single image of the fixated object. This binocular vision forms the basis for stereoscopic vision and depth perception and confers many other advantages too. But, the choice of one eye as the sighting eye is evident in the individuals and is thought to suppress the physiological diplopia which is attributed to binocular rivalry when monocular stimuli are too dissimilar. Hence, the eye which is able to hold its image for longer periods of time during this visual competition is chosen as the sighting eye while the view of the non-sighting eye is ignored or suppressed and the diplopia is not apparent. In effect, one sights or aligns with the dominant eye alone.

Pattern reversal visual evoked potentials have been utilised to study binocular vision providing electrophysiological evidence of summation of visual signals binocularly. [17-19] Researches in the past also have confirmed the better performance of the dominant eye in various eye performance measures providing morphological, physiological and psychological evidences.[20] Pattern reversal visual evoked potential can provide an electrophysiological data in this context. Also, the results of performance measures necessitate the assessment of the role of eye dominance as one of the confounding physiologic variables affecting the normative data of PRVEP test.

The present study revealed 69% of the total subjects studied, as right eye dominants and left eye dominant were 29% by subjective tests for eye dominance. In previous studies by Jagdamba *et al*, 75% were found to be right eye dominants and 25% as left eye dominant candidates, while Thakur *et al* suggested 2/3rd of subjects as right eye dominants [21,22]. Among male subjects, 74% revealed right eye dominance while 60% females demonstrated the same in the present study which conforms to the prevalence of preponderance of right eyedness in males as compared to females in the previous studies. [23] The study demonstrates decreased mean P100 latency and increased mean N75-P100 amplitude in the dominant eyes in both the right eye as well as the left eye dominants with statistical significance. The findings conform to the similar studies in the past.[21-25]

In the present study, the latency of P100 wave was shorter in dominant eye, reflecting the faster conduction and activity in the visual cortex. Data of a study showed that the mean latency of P100 peak was significantly shorter with stimulation of the dominant eye and amplitude was higher in the dominant eye, which provides objective

electrophysiological evidence of lateralization in the central nervous system. [25]

Another similar study employed white-black, green-black, red-black and blue-black pattern visual evoked potentials with normal visual acuity. The P100 latency of the white black PVEPS (pattern visual evoked potentials), for both sexes were significantly shorter in the PVEPs of the dominant eye. The results provided electrophysiological evidence for eye dominance as a lateralized CNS phenomenon that is not influenced by colour. [26] The present study demonstrates disparities in amplitude and latency too providing further electrophysiological evidence of lateralization in the nervous system.

Unlike limb lateral preference, lateralisation of visual functions is the form of sense organ lateral preference that is difficult to be explained by asymmetrical hemispheric processing as the afference from one eye is projected to both the hemispheres. Imaging studies in this field have conflicting results and the question of cortical asymmetries in processing between dominant and non-dominant eye remains an unresolved issue. [27, 28]

PRVEPs are non-invasive tools to study the normal ocular dominance and in future with the evolution of the technology, they are likely to provide more qualitative and quantitative information which could contribute to fully understand the functional significance of the visual lateralisation.

5. Conclusion

Eye dominance influenced PRVEP records in the normal subjects in terms of both amplitude and latency changes which provide an objective electrophysiological evidence of eye dominance and lateralization in the central nervous system. Eye dominance should be taken into account while comparing VEPs of two eyes of the same subject. Also, the normative data of VEP should have the records for both dominant and non-dominant eyes so that clinical interpretation could be done on the basis of eye-dominance matched normal subjects. The study can further be extended to evaluate the reliability of the VEPs as objective methods to measure the eye dominance.

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