

Pattern Visual Evoked Potentials in Dyslexic versus Normal Children

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Abstract

Purpose: Presence of neurophysiological abnormalities in dyslexia has been a conflicting issue. This study was performed to evaluate the role of sensory visual deficits in the pathogenesis of dyslexia.

Methods: Pattern visual evoked potentials (PVEP) were recorded in 72 children including 36 children with dyslexia and 36 children without dyslexia (controls) who were matched for age, sex and intelligence. Two check sizes of 15 and 60 min of arc were used with temporal frequencies of 1.5 Hz for transient and 6 Hz for steady-state methods.

Results: Mean latency and amplitude values for 15 min arc and 60 min arc check sizes using steady state and transient methods showed no significant difference between the two study groups (*P* values: 0.139/0.481/0.356/0.062). Furthermore, no significant difference was observed between two methods of PVEPs in dyslexic and normal children using 60 min arc with high contrast (*P* values: 0.116, 0.402, 0.343 and 0.106).

Conclusion: The sensitivity of PVEP has high validity to detect visual deficits in children with dyslexic problem. However, no significant difference was found between dyslexia and normal children using high contrast stimuli.

Keywords: Dyslexia; Pattern Visual Evoked Potential; Visual Impairment

J Ophthalmic Vis Res 2015; 10 (3): 274-278.

INTRODUCTION

Dyslexia is defined as an abnormality in which children have specific difficulties in learning to read and spell

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Received: 28-05-2014

Accepted: 04-09-2014

despite normal intelligence and sensory acuity.^[1,2] It is a hereditary disorder that affects about 5% of school age children, classifying it in the category of childhood learning disabilities.^[3,4] Although the role of visual factors in dyslexia has been a controversial subject, it has been suggested that dyslexia correlates with sensory and motor visual deficits. Two principal channels of transient and sustained visual system have been described in visual pathways.^[5] Dyslexia is classified into two subgroups:

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How to cite this article: Heravian J, Sobhani-Rad D, Lari S, Khoshshima M, Azimi A, Ostadimoghaddam H, *et al.* Pattern visual evoked potentials in dyslexic versus normal children. *J Ophthalmic Vis Res* 2015;10:274-8.

Access this article online

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DOI:
10.4103/2008-322X.170361

One with a deficit of the transient visual system and the other with a deficit of the sustained visual system.^[5] It has been suggested that deficits of the transient visual system are best evaluated in experiments involving low levels of luminance. This may be due to the reason that transient visual system adapts quickly and has larger summation fields.^[6] Furthermore, visual abnormalities in dyslexia have been well described by subjective and electrophysiological tests indicating a specific abnormality in temporal processing of visual information.^[7-13]

To determine the etiological factors involved in dyslexia, a number of studies have been carried out using functional magnetic resonance imaging (MRI) and psychophysical and electrophysiological techniques.^[13-15] Moreover, it has been found that some aspects of pattern visual evoked potential (PVEP) against grating stimuli were different in dyslexia, although findings were inconclusive.^[14] Some authors reported diminished amplitude of PVEP at high temporal frequencies with low-contrast stimuli in children with dyslexia.^[16]

Beside inconsistencies about the role of visual factors in dyslexia, several studies emphasized deficiencies in the transient or sustained visual systems in dyslexia.^[17-19] The current study aimed to investigate visual function in children with dyslexia using transient and steady-state PVEPs. Since the majority of the research in this area has been conducted on small groups of subjects, we aimed to investigate sensory visual stimulation in a larger group of children with dyslexia in comparison with matched controls.

METHODS

Our protocol was approved by the Ethical Committee at Mashhad University of Medical Sciences. The procedure involved in this study was explained to all the subjects and their parents, and informed consent was obtained before examination.

We enrolled 72 children including 36 children with dyslexia and 36 normal children. The dyslexic group included 16 girls and 20 boys with mean age of 9.3 ± 0.88 (range, 8–12) years and the control group consisted of 20 girls and 16 boys with mean age of 9.29 ± 0.83 (range, 8–12) years. None of the participants had ophthalmic disorders. Other exclusion criteria were neurological, emotional, or behavioral disorders, or any unusual educational circumstance, which could account for poor performance in reading, spelling^[20,21] and IQ test.^[22,23] All participants were diagnosed by a psychiatrist and a speech therapist using Nama, a reading and dyslexia test. All participants had the best corrected visual acuity of 6/6 or better in each eye when examined by a standard Snellen distance chart (Clement Clark International, UK). Biomicroscopic and ophthalmoscopic

examinations showed clear media with no abnormalities in all study subjects.

The PVEP recording equipment consisted of a RETI-scan (model ISCEV60, Roland Consult, Brandenburg an der Havel, Germany) and an amplifier for storing and summing the waves.^[24,25] Amplifier band-pass filters were set at 1–50 Hz with sensitivity at 100 μV per volt. The mean screen luminance was 100 cd/m^2 with image contrast of 99% and a full field display. Mean luminance of the test room was 80 cd/m^2 and recording condition was in accordance with standards set by the International Society of Clinical Electrophysiology of Vision (ISCEV).^[25] The electrodes were positioned according to the ISCEV for PVEP recording. The active electrode was positioned 1 inch above the inion (Oz). Referencing was to the center of the forehead with a ground electrode on the vertex of the head (Cz). Two check sizes of 15 and 60 min arc were used at a viewing distance of 1 m. The small 15 min arc stimulus encourages a response mainly from the central part of the visual field (macular area).^[25] It has been reported that most of the responses recorded from the scalp at Oz are likely to be dominated by foveal responses, partly due to cortical magnification.^[24] In each recording, 100 sweeps were averaged and monocular PVEP was recorded. The pattern reversal alternation rates were 1.5 Hz (3 reversals/s) and 6 Hz (12 reversals/s) to elicit definite transient and steady-state PVEP responses.^[24] The inter-electrode impedance was maintained below 5 k Ω in all recordings.

SPSS software version 13 (SPSS Corporation, Chicago, IL, USA) was used for statistical analysis, and Pearson or Spearman correlation tests were applied based on normal or abnormal distribution of data, respectively.

RESULTS

Figures 1 and 2 illustrate a typical set of results from children with dyslexia and normal children for transient and steady-state responses. The visual evoked potential (VEP) waves generally consisted of a negative trough N1 around 80 ms, followed by a positive peak P1 around 160 ms, followed by a negative trough N2 160 ms.

In Figures 1 and 2, waveforms A and B are VEP recordings obtained at 1.5 Hz for evaluating the transient state response using 15 and 60 min arc check sizes in normal and dyslexic children. Waveforms C and D are VEP recordings obtained at 3 Hz for evaluating the steady state response in normal and dyslexic children using 15 and 60 min arc check sizes.

PVEP parameters revealed no significant difference between right and left eyes in terms of mean latency and amplitude values and mean age with both check sizes using both methods. Furthermore, the correlation between mean values of responses from the right and left eyes was high ($r = 0.94$). No significant difference

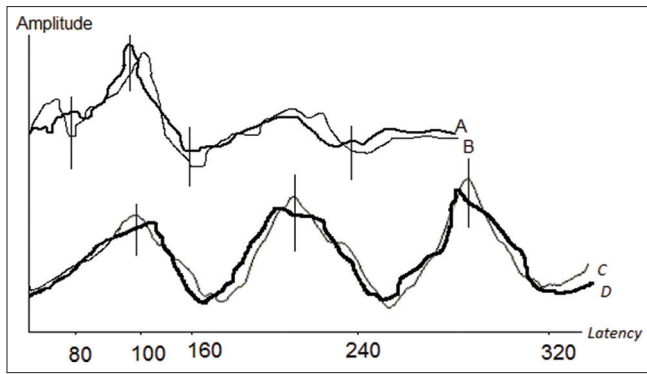


Figure 1. A typical set of four VEP recordings obtained from normal and dyslexic children using transient and steady state responses with 15 min arc stimuli. A is the 1.5 Hz tracing used for evaluating the transient response in a normal child, B is the a comparable tracing from a dyslexic child, C is the 3 Hz tracing used for evaluating steady response in a normal subject and D is a comparable tracing in a dyslexic subject.

was observed between the two groups in terms of PVEP latency or amplitude with both check sizes using the two methods of transient and steady-state response [Table 1].

Since the transient and steady-state PVEPs were the area of interest in this experiment, the two methods compared with both check sizes in children with dyslexia versus normal children. No significant difference was observed between two methods of steady state and transient PVEPs in right and left eyes of children with dyslexia and normal children using 15 and 60 min arc check sizes [Tables 2 and 3]. Table 3 shows only significant levels for different between two methods.

DISCUSSION

In this study, we assessed a possible deficiency in transient and sustained visual systems in children with dyslexia. The mean age of both groups was 9.3 ± 0.83 and our results indicated no significant difference between PVEP components in children with dyslexia or normal children with respect to age-dependent changes in the PVEPs responses. Some investigators reported that systematic prolongation of PVEP latencies which begins in late adulthood could be a good indicator of biological aging.^[26,27] Accordingly, no differences in PVEP component may be completely attributed to the participation of young individuals in this study.

Our findings regarding the P100 component of PVEP in terms of latency and amplitude revealed no significant difference between dyslexic and normal children with both check sizes using both the steady-state and transient methods. These findings are in agreement with previous reports. Victor et al used steady-state and transient PVEPs in 5 participants with dyslexia and 11 normal participants with a stimulus of 8×8 array of checks over a range of contrast and luminance^[28] and failed to reveal any

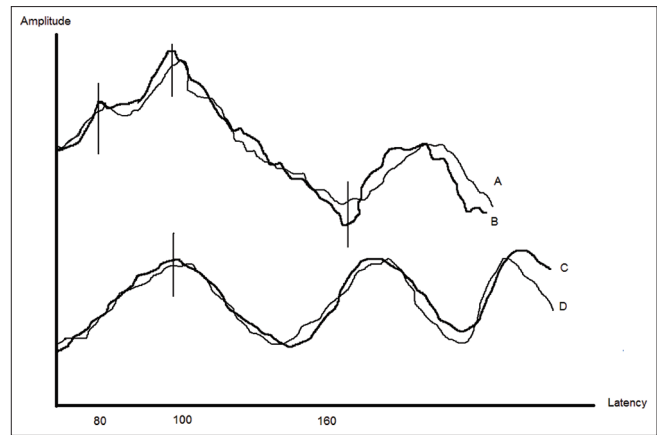


Figure 2. A typical set of four VEP recordings obtained from normal and dyslexic children using transient and steady state responses with 60 min arc stimuli. A is the 1.5 Hz tracing used for evaluating the transient response in a normal child, B is the a comparable tracing from a dyslexic child, C is the 3 Hz tracing used for evaluating steady response in a normal subject and D is a comparable tracing in a dyslexic subject.

differences between children with dyslexia and normal children. The temporal frequency used by Victor et al ranged from 3 to 10 Hz, which was close to that used in our study. Lovegrove et al found evidence of a transient systematic deficit in terms of decreased sensitivity at low-spatial frequencies in dyslexia. However, they demonstrated that spatial tuning which is thought to be mediated by the sustained visual system, was similar in children with dyslexia and normal children.^[29]

The visual pathway is comprised of two separate and interactive subsystems with different characteristics: First, the magnocellular system, which brings the responses from widely across the retina and projects to the lateral geniculate nucleus (LGN) and visual cortex. This system is believed to be related to fast temporal resolution, low-spatial frequencies and eye movements. Second is the parvocellular system which comes from the fovea and projects to the visual cortex via the LGN and is related to high-spatial frequencies, high-contrast, color and form.^[30]

Our results are not in line with reports demonstrating delayed P100 latency in children with dyslexia. For instance, Breclj et al used PVEPs with three different check sizes of 24, 49, and 180 min arc and three levels of contrasts, i.e., 5, 42, and 100%. They found significant prolongation of P100 wave in children with dyslexia at low contrast of 5% and smallest checks of 24 min arc.^[31] Moreover, Livingstone et al showed latency of PVEPs along with low-contrast and high-temporal frequencies as physiologic signs of magnocellular deficit.^[32] Our PVEP components in terms of latency and amplitude were confined to the highest contrast of 100% but not to the lower contrast as assumed with magnocellular deficits. The discrepancy between our

Table 1. Correlation between PVEP parameters and age using steady state and transient responses with 15 and 60 min arc check sizes

Variables	Groups of study							
	Steady state				Transient			
	15 min arc		60 min arc		15 min arc		60 min arc	
	Correlation coefficient	P	Correlation coefficient	P	Correlation coefficient	P	Correlation coefficient	P
Latency versus age	0.607	0.062	0.342	0.114	0.086	0.470	0.211	0.075
Amplitude versus age	0.562	0.070	0.170	0.163	0.182	0.127	0.028	0.816

Min, minute; P, probability; PVEP, pattern visual evoked potentials

Table 2. P100 latency and amplitude values of steady state and transient PVEP responses using two check sizes in left eye of dyslexic and normal children

	Steady state				Transient			
	15 min arc		60 min arc		15 min arc		60 min arc	
	Latency (ms)	Amplitude (µv)	Latency (ms)	Amplitude (µv)	Latency (ms)	Amplitude (µv)	Latency (ms)	Amplitude (µv)
Dyslexic	113.9±6.1	13.9±3.1	106.9±3.3	16.9±4.5	112.4±5.1	16.1±4.2	106.1±3.9	19.6±3.7
Normal	110.7±7.2	12.5±2.6	105±6.3	18.3±3.5	110.9±6.8	19.6±4.4	107.2±5.3	22.8±4.9
P	0.139	0.481	0.116	0.402	0.356	0.062	0.343	0.106

ms, millisecond; µv, microvolt; min, minute; P, probability; PVEP, pattern visual evoked potentials

Table 3. Significance levels for differences between transient and steady state responses in right eye PVEP components using two check sizes of 15 and 60 min arc

Transient versus steady state	15 min arc		60 min arc	
	Normal	Dyslexic	Normal	Dyslexic
RE latency	P=0.892	P=0.518	P=0.115	P=0.385
RE amplitude	P=0.319	P=0.259	P=0.030	P=0.088

RE, right eye; min, minute; P, probability; PVEP, pattern visual evoked potentials

results and aforementioned reports can be attributed to the differences in the characteristics of stimulus, variation in luminance, sensitivity and specificity of PVEP for detecting sustained or transient visual deficit, and likely various other technical approaches used for PVEP recording. For example, the spatial characteristics of visual stimuli used by Brecej et al^[31] were 24, 49, and 180 min arc, and only large check sizes (180 min arc) were used by Livingstone et al^[32] while two check sizes of 15 and 60 min arc were used in this study.

Differences in temporal frequency could also partly explain this discrepancy, as Livingstone et al found delayed PVEPs over a frequency of 5–15 Hz with the greatest effect at rapid temporal frequency of 15 cycle degree. The level of contrast should be considered as another reason for different results; in our study, it was confined to the highest contrast of 100%, while in the study of Livingstone et al and Brecej et al it was low.^[31,32] In this regard, the high contrast stimulus is thought to be involved in parvocellular system, and this could explain why no difference was found in PVEP components between the children with dyslexia and normal children in our study.

We demonstrated no significant difference in children with dyslexia and normal children with high contrast stimuli, which implies that the visual deficit is either not solely confined to the magnocellular system or that our stimuli were not selective enough for the magnocellular system. Indeed, some authors claimed that sensitivity and specificity of PVEP paradigm are still disputable for detection of magnocellular deficit. For example, Kuba et al found that the motion-onset PVEP is better for studying the magnocellular system in dyslexia.^[33] Their results confirmed the findings of functional MRI, which also revealed abnormal activation of V5/MT area to motion stimuli in subjects with dyslexia.^[33]

In summary, this study evaluated transient and sustained visual systems in children with dyslexia versus normal age matched controls. We found no difference in PVEP components in terms of latency and amplitude between these two groups of children. Our findings do not support an isolated deficit of magnocellular function in dyslexia due to age and high contrast. The high contrast and different age used in this study is thought to be processed by the parvocellular system, which should be explored in future studies.

Acknowledgments

This article was extracted from the thesis prepared by Samaneh Lari for earning her MSc degree. The authors wish to express their appreciation for the assistance and financial support provided by the Vice Chancellor for Research at Mashhad University of Medical Sciences.

Financial Support and Sponsorship

Nil.

Conflicts of Interest

There are no conflicts of interest.

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