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Detection of Learning Disabilities Using the Visually Evoked Cortical Potential

James P. Lux
San Diego, California

More than one-fourth of all school-age children have a learning disability of some type.[1] The majority of these learning disabled children have dyslexia (an inability to read), or dyscalculia (an inability to perform arithmetic computation).

It would be a great help if dyslexia or dyscalculia could be detected before a student encounters difficulties in school. Early detection would allow appropriate preventive measured to be taken.

Present methods of detection not only require too much time to administer but also are applicable only in certain age ranges. Past research indicates that the Visually Evoked Cortical Potential (VECP) can be used as a clinical tool to diagnose vision dysfunctions.[2-4] The author hypothesized that the VECP technique could be extended to provide a lower cost, more accurate method of detecting a learning disability.

Some researchers have stated that learning disabilities are due in part to mixed cerebral dominance.[5-7] Cerebral dominance can be established by measuring the differences between the VECPs recorded from the two cerebral hemispheres.[8] The author hypothesized that the presence of a learning disability would manifest itself as an asymmetry of the VECPs recorded from the left and right hemispheres because of the connection possibly existing between dominance and learning disabilities. Research was carried out to test this hypothesis.

Requests for reprints should be addressed to J.P. Lux, 11320 Florindo Rd., San Diego, California 92127.

METHODOLOGY

Subjects

The subjects used were all high school students ranging in ages from 14 to 17 years. Nine students, six males and three females, participated as subjects. All of the subjects were students in the regular course of study, *i.e.,* none were in classes for the learning disabled. This may seem to indicate that the subjects did not have any disability; however, one of the largest problems in schools today is that many learning disabled children go unidentified. One of the subjects (E) was identified and subsequently remediated.

Experimental Design

Two types of tests were administered to the nine subjects. The first was a conventional achievement test. The second was the measurement of the subjects VECPs. The results from the two were then correlated.

The conventional achievement test was used to determine the presence and type of any learning disabilities. The test used provided a set of scores from which the disabilities of the student could be determined. A learning disability score was then computed that ranged from $^{-}50$ to $+50$, on a scale from dyscalculia to normal to dyslexia.

The VECP was measured from the two hemispheres and the latency differences between the various peaks were measured. The latency of the right side minus the latency of the left side was used. These latency differences were then plotted against the learning disability scores and the correlation was computed.

Equipment

Conventional Tests: The Wide Range Achievement Test was used to quantify each subject's ability in three areas: reading, spelling, and arithmetic. The authors of the test suggested that the reading and spelling scores, when compared with the arithmetic score, would provide an indicator of learning disabilities.[5] In order to provide a numerical score for comparison with the latency differences the following Learning Disability Score (LDS) was computed for each subject:

$$\text{LDS} = \text{Arithmetic score} - \frac{\text{Reading score} + \text{Spelling score}}{2}$$

All of the scores had been normalized to: mean, 100, and standard deviation, 15, before computation.

VECP: A Nicolet model 1072 signal averager was used to average the electrical responses of the brain to a given stimulus. The potentials picked up from the scalp were amplified by a factor of 10^4 before being processed by the signal averager. Grass P15b amplifiers were used for this purpose. A montage of seven electrodes was used. The two ears were grounded to reduce 60 and 120 Hertz artifact. The vertex was used as a reference for the four active electrodes. These four electrodes were placed over the occipital and parietal lobes approximately 2.5 centimeters either side of the sagittal plane. This corresponds to locations 01,02,P3, and P4 in the International 10-20 System. The vertex was used as a reference to cancel the large vertex response picked up at the parietal electrodes.

The input voltages were sampled every two milliseconds for the 512 millisecond epoch following the presentation of the stimulus. This sampling interval gives a Nyquist frequency of 250 Hertz. This is sufficiently high to eliminate problems of frequency aliasing or folding.

To reduce noise even further the input signals were filtered during the amplification process. A two-stage RC filter, having a rolloff of 12 dB per octave and a -6dB voltage point at 30 Hz, was inserted to reduce noise above 40 Hertz. In addition, the amplifier coupling provided the equivalent of a RC high-pass filter at .3 Hertz.

The stimulus consisted of a checkerboard pattern back illuminated by a Grass PS2 photostimulator viewed at a distance of one meter. The stimuli were presented at one Hertz rate. The check size varied from four to 32 millimeters. The characteristics of the stimuli are summarized in Table I.

The average of the responses to 32 stimulus presentations was computed. The stimuli were presented in a counterbalanced sequence to counteract accommodative effects.

A diagram of the equipment setup is shown in Fig. 1.

RESULTS

The WRAT scores from each subject and the Learning Disability Scores derived from them are given in Table II.

Sample Visually Evoked Cortical Responses from the nine subjects are shown in Fig. 2. They are, in all cases, the responses to 32 stimulations of a checkerboard with 16 millimeter checks.

The latency differences of the various

TABLE I

STIMULUS CHARACTERISTICS

Stimulus	Check Size	Minutes of Arc	Visual Acuity
A	4 mm	13.75	20/130
B	8 mm	27.50	20/220
C	16 mm	55.00	20/500
D	32 mm	110.0	20/1000

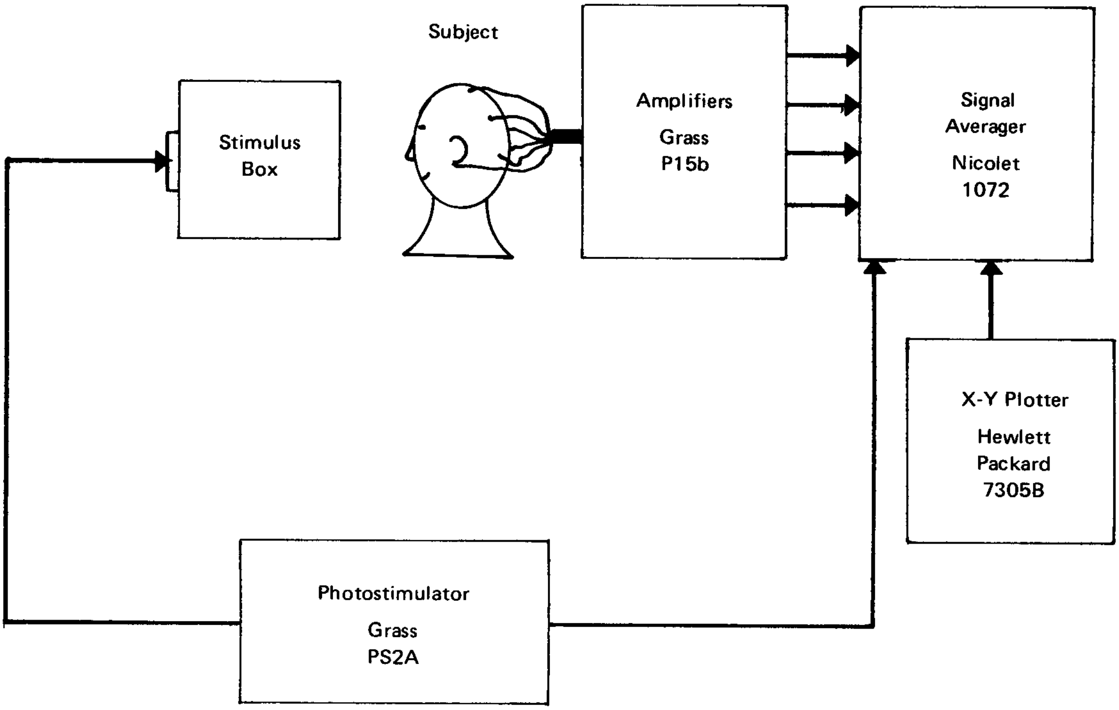


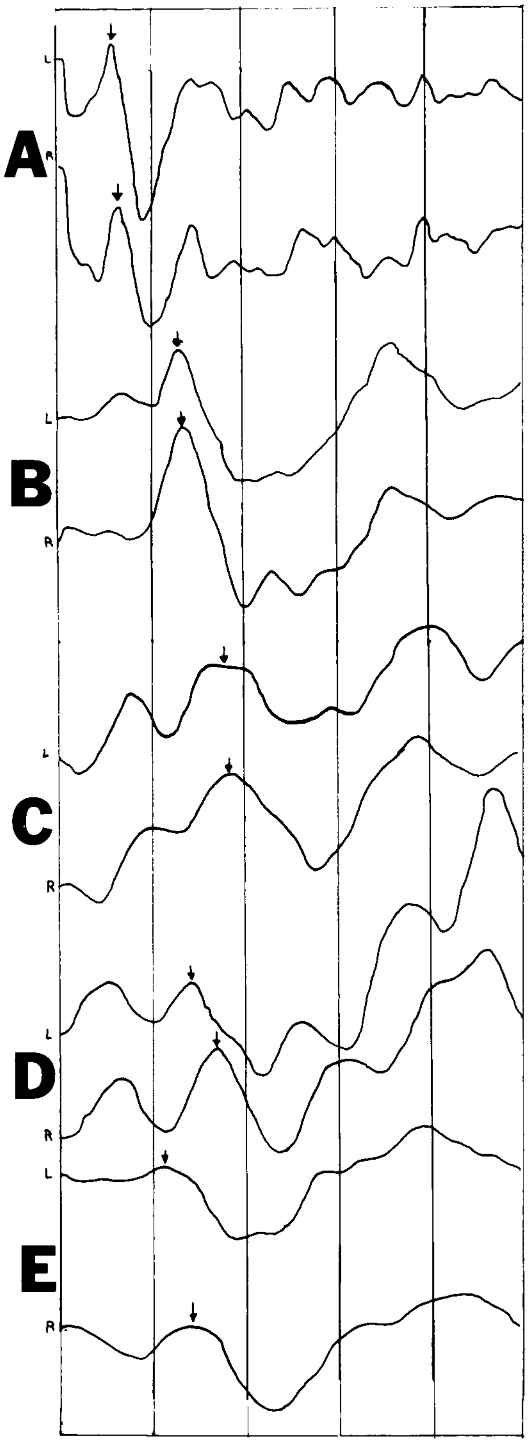
Fig. 1. Experimental Equipment Configuration.

TABLE II

TEST SCORES FROM THE WIDE RANGE ACHIEVEMENT TEST (WRAT)

Subject	Reading	Spelling	Arithmetic	Mean of Reading and Spelling	Learning Disability
A	106	96	126	101	+25
B	110	94	93	102	− 9
C	136	133	101	134	−33
D	96	92	105	94	+11
E	101	106	118	103	+15
F	119	99	88	109	−21
G	124	127	132	125	+6
H	114	96	102	105	−3
I	114	112	90	113	−23

NOTE: The Learning Disability Score is the arithmetic score minus the mean of the reading and spelling scores. All three scores have mean of 100 and a standard deviation 15 taken from the standardization population.



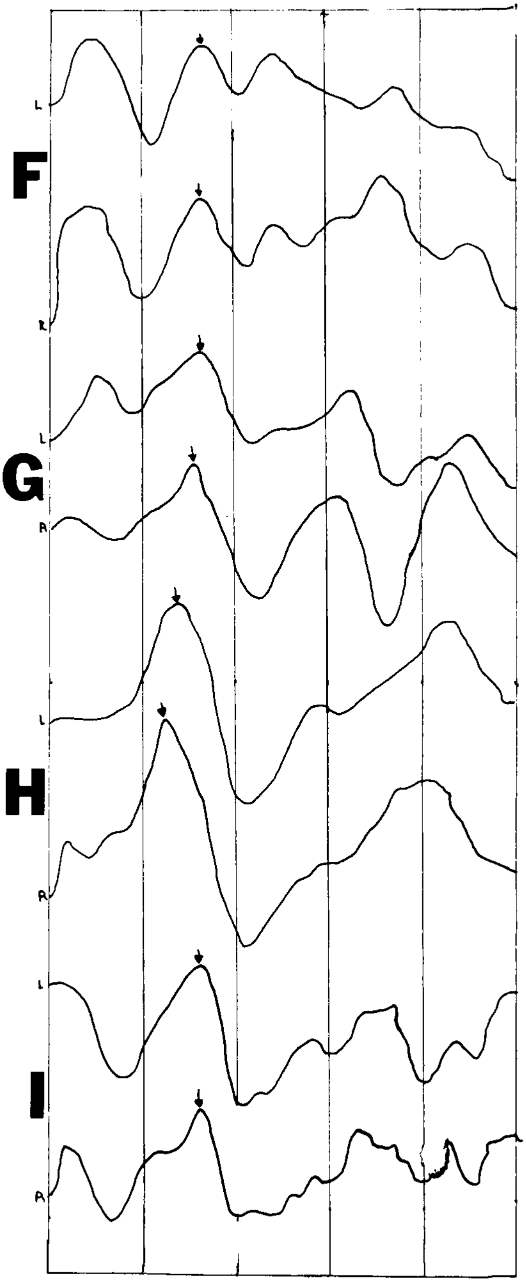


Fig. 2. Sample VECPs from the nine subjects. The arrows indicate the peaks used for latency computation. Horizontal scale is 100 milliseconds per large division for all graphs except A which has a horizontal scale of 200 milliseconds per large division. Since only the position of the peak is important the amplitude calibration is irrelevant.

peaks (right-left) were tabulated for the various stimuli. The peak showing the widest amount of variance was at approximately 160 milliseconds after the stimulus, recorded from the parietal lobes. The inter-hemispheric latency differences for this peak are tabulated in Table III. A notation of A indicates that photic driving of the ongoing alpha activity was occurring as indicated by the appearance of a peak at about 50 milliseconds.

The Learning Disability scores were plotted against the latency differences in Fig. 3. The vertical lines indicate the .01 confidence interval; that is, the probability is .01 that the actual value of the measurement lies outside the specified interval. The horizontal axis is the LDS and the vertical axis is the latency difference in milliseconds. A regression line is also plotted.

ANALYSIS AND CONCLUSIONS

As shown in Fig. 3 there is a strong correlation between latency and learning disability. The computed correlation coefficient is approximately .79 which corresponds to a significance of about .01. As a further step in the analysis the fitting of a least squares line was attempted. The resultant equation relating the LDS and the Latency difference is:

$$\text{LDS} = -3.23 + 1.41\ \text{L}$$

Where:

$$\text{L} = (\text{Latency of peak from R Parietal}) - (\text{Latency of peak from L Parietal})$$

and

$$\text{LDS} = \text{Arith} - \frac{\text{Read} + \text{Spell}}{2}$$

The definite correlation found between the latency differences between the two parietal lobe responses and the presence of a learning disability tends to support the theory that the process of reading is a transcoding between the spatially encoded symbols (words) on the paper and the temporally encoded symbols internal to the brain, and that this transcoding is performed by the right hemisphere. On the other hand, arithmetic computation is handled by the left hemisphere as is shown by the longer latency in the left hemisphere in those subjects with dyscalculia. Although this would seem to be the opposite

TABLE III

LATENCY DIFFERENCES BETWEEN HEMISPHERES
FOR PEAK AT 150 MILLISECONDS

	Check Size (mm)				Combined Differences	
Subject	32	16	8	4	Average	SD
A	10	20*	20	22		
	10	11	15	27	16.88	6.33
B	5	0	0	0		
	7	5*	0	0	2.13	3.0
C	−5	0	−16	−15		
	−45	−16*	−36	−20	−19.13	14.91
D	23	25	−5	15		
	0	30*	10	20	14.75	12.33
E	40	22	35	22		
	23	35*	25	30	29.0	7.01
F	−12	0	0	−12		
	−5	−5*	−7	−25	− 8.25	8.17
G	0	A	5	−12		
	−5	−10*	10	A	− 2.0	8.6
H	0	0	−10	0		
	0	−10*	0	−4	− 3.0	4.54
I	−10	−11*	−20	−15	−14.0	4.55

NOTES: (1) All times are in milliseconds; (2) Values marked with an "A" indicate excessive photic driving.
**Indicates data shown in Fig. 2.*

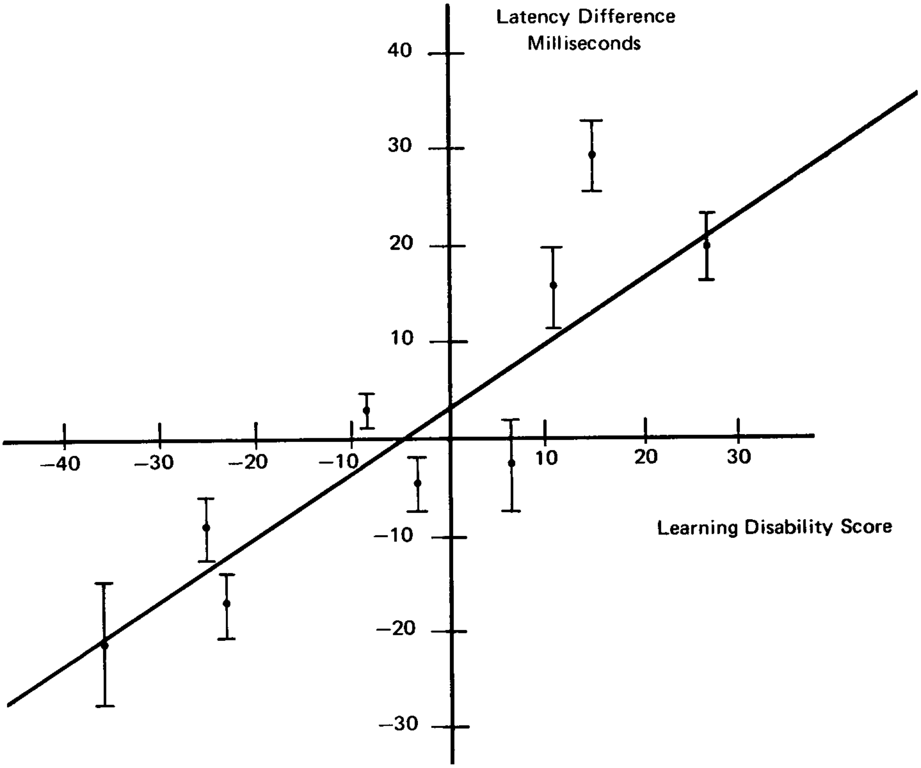


Fig. 3. Learning Disability Score vs. Latency Difference.

of the expected, other studies relegating various processing functions to each hemisphere would tend to confirm this theory.

It was found that the VECP method does indeed provide a viable alternative to conventional testing methods, at least for the limited scope of this study.

SUMMARY

It was proposed that the Visually Evoked Cortical Potential (VECP) could be used to detect learning disabilities. It was found that a comparison of the responses from the two parietal lobes to a checkerboard pattern could provide such a detector. The latency differences had a correlation of .79 with scores on a test of learning disabilities for high school aged children.

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