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The use of VER in establishing a prognosis for the treatment of amblyopia

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by
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and
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Abstract

VERs were run on four amblyopes, both before and after visual training. After training, all the amblyopes showed single letter acuities as good or better than the smallest target size from which an initial VER had been obtained. Among those subjects whose attention permitted VERs to be obtained during both sessions, the initial ratios between the normal and amblyopic eyes' VER amplitudes did not change significantly after training.

Introduction

In recent years much interest has been generated by the use of visual evoked responses (VERs) in the diagnosis of amblyopia. Arden[1] describes a patient who showed no response to pattern reversal and who, after occlusion, showed no improvement in acuity. Levi[2] states that he was unable to improve the acuity of an amblyope who has shown a 54% reduction in his amplitude response to a checkerboard pattern. Thus despite observations by Dawson[3] that "all humans with normal acuity may not display strongly pattern-sensitive evoked responses" (p. 789), VERs promise to be a useful objective test for determining if a patient's amblyopia is of functional or organic nature.

A number of researchers, using patterned stimuli, have compared the VER amplitudes for normal and amblyopic eyes. Using 60' checks, Lombroso, Duffy, and Robb[4] found reduced amplitudes in 50% of the amblyopic eyes. Dawson, Perry, and Childers[5] using 5-10' checks, obtained VERs on three amblyopes. Two of the amblyopes showed no response peak in their amblyopic eyes. The third amblyope, who had eccentric fixation, showed a reduced response peak in his amblyopic eye. Sokol and Bloom[6], using 15' checks, found reduced amplitudes of response in all of the amblyopic eyes in their study as did Yinon, Jakobovitz, and Auerbach[7] using .69° to 5.52° checks. Arden[8] using 9' to 1° checks, found that 61% of the amblyopes in his sample showed VER amplitudes reduced by 40%

in their amblyopic eyes as compared to their normal eyes. Levi[9] using 11' checks found that all subjects showed amplitude reductions ranging from 13 to 81% in their amblyopic eyes as compared with their normal eyes.

More recently, researchers have begun to explore the possibility of varying target check sizes when evaluating amblyopia with the VER. Levi[10] suggests that varying check size may be important. Sokol and Shaterian[11] measured the magnitude of normal and amblyopic eyes' response amplitudes as a function of 30', 15', and 7.5' check sizes. They found the normal eyes' amplitude responses were most consistently larger than the amblyopic eyes' amplitude responses for the 15' check size. Similarly, Sokol[12] stresses: "the necessity for a systematic use of different check sizes when attempting to clinically evaluate amblyopia using the VER" (p.37).

With the two exceptions of Levi and Arden, none of the above-mentioned authors attempted to use visual training to improve the acuities of the amblyopic eyes of any of their patients. Thus the majority of the studies tell us little about how VER findings may differ for organic and functional amblyopes. Of greatest interest, therefore, to the present clinically oriented study is an observation by Ludlam[13] that the check size to which the VER A-B waveform first becomes indistinguishable from the noise indicates the approximate acuity obtainable after treatment. Indeed, it was Ludlam's observation which suggested the present study.

The purpose of our thesis was threefold: 1) We wanted to

determine if our own observations agreed with Ludlam's. 2) We wanted to determine if the VER A-B waveform would change after a patient had received training. 3) We wanted to see for ourselves just how useful a VER might be in a vision training practice.

Instrumentation

The apparatus for measuring VERs which was used in this study has been previously described by Ludlam and Meyers[14]. That paper (page 170) gave the following list of factors which the authors believed were most responsible for the clinical success of their apparatus:

> A. Tailoring bandwidth to the frequency spectrum of the VER.
> B. Utilization of a slow repetition rate of flashes to avoid interaction of responses to successive flashes.
> C. Previewing occipital activity preceeding the onset of the flash.
> D. Use of a 20-foot refraction distance to avoid proximal effects and a 12° field of view to ensure foveal stimulation despite wandering fixation.
> E. The proper type, placement, attachment, and termination of electrodes to enhance signal-to-noise ratio.
> F. A reduced number of visual presentations to establish the response for a given dioptric value, thus reducing contamination by subject fatigue and habitation factors.
> G. Utilization of a type of response-averaging electronics that minimizes artifactual machine contributions to the response.

Of special interest to the present study are the 12° field size and the 25 msec. stimulus presentation which reduce loss of acuity due to eccentric or unsteady fixation. Thus the apparatus is ideal for estimating what acuity will be obtained after training improves fixation.

Procedure

Four amblyopes were obtained from the Pacific University optometry Clinic population. Each of the four was examined to determine the following:

1) Acuities--whole line, single letter
2) Refractive error
3) Eye health--opthalmoscopic exam
4) Ability to see Haidinger brush
5) Visuoscopy to determine fixation pattern
6) Cover test to determine presense of strabismus
7) Transfered afterimage compared to Haidinger brush; subjective and objective angles on the major amblyoscope to determine correspondence.

After this examination, VERs were run on each subject. Target check sizes presented ranged between 34 minutes of arc (20/700) and 2.0 minutes of arc (20/40).

The VER measurements recorded, each subject was trained using those passive and active techniques outlined in Borish's Clinical Refraction (3rd edition, pp. 1295-1299). Perceptual, sensory, and motor training were stressed.

At the end of training each subject was again given a general examination and a VER evaluation. Having completed these steps, we compared the initial VERs to both the results of the treatment and the second VERs.

Results

Initial Strabismus Work-up:

Table # 1 shows the results of the initial strabismus work-up on the four subjects. All four were unilateral amblyopes. All four were strabismic. All had eccentric fixation. Three of the four showed ARC responses. At the initial exam the two older subjects definitely saw the Haidinger brush. Because of communication problems, we were uncertain if the younger two subjects were seeing the brush. Subsequent work with the younger two subjects, however, assured us that they were indeed perceiving the phenomenon.

Initial VER Evaluation:

Table # 2 shows the results of the initial VER evaluations. Three of the four subjects showed amblyopic-eye VERs to the 20/40 equivalent check size. One subject did not show VERs with either eye. This subject, H.M., demonstrated a high alpha wave response.

Strabismus Work-up at the Time of the Second VER Evaluation:

Table # 3 shows the results of the second strabismus work-up. At this time three of the four subjects had unsteady central fixation and 20/40 or better acuity in their amblyopic eyes. The fourth subject, J.S., still showed 20/80 acuity in her amblyopic eye. At the time of this writing, however, J.S. is still being trained and now shows 20/60 whole line and 20/40 single letter acuity.

Second VER Evaluation:

Table # 4 shows the results of the second VER evaluations. Subjects J.D. and J.S. continue to show VERs with either eye to the 20/700 and 20/40 equivalent target sizes. H.M., who previously showed an alpha wave response with either eye, now shows VERs with either eye to both the 20/700 and 20/40 equivalent targets. Subject K.R. shows a high noise level response for either eye which built faster than the VERs to small test targets.

Initial Compared to Second VER Evaluation:

Table # 5 shows the ratios of the VER amplitudes between each subject's amblyopic and normal-seeing eye. When such a ratio was obtained to a particular check size both before and after training, the two ratios were compared. If to a particular check size we obtained a VER for both eyes at one session but not the other session, the ratio for the successful session was not included in the average ratios calculated at the bottom of Table # 5. Thus H.M.'s ratios on the VER session after training were not included in the average ratios because we obtained no initial ratio with which to compare his after-training ratios.

Initial VER Results Compared to the Training Results:

Table # 6 compares the initial VER results with the acuity obtained at both the time of the initial VER and at the time of the conclusion of training. For subjects J.D. and K.R. the initial VER acuity responses compare well with the acuities obtained

after training. Subject J.S. is still being trained and as of this writing has obtained a single letter acuity equal to that estimated by both her first and second VERs. For none of the four amblyopes does the equivalent target size to which an initial VER was obtained compare with the amblyopic eye's acuity before training.

Discussion

Our Observations Compared with Ludlam's:

For two out of three of the amblyopes on which an initial VER response was obtained our findings agree with Ludlam's observations; that is, the acuities obtained after training were as good or better than the smallest check size to which a VER was obtained. As we have not yet completed training the third amblyope, we cannot say at this time whether or not she will obtain the 20/40 whole line acuity which agrees with the check size that elicited a VER. That she still has eccentric fixation, and that she already has obtained 20/40 single letter acuity suggest that as fixation is trained, acuity will improve.

Our fourth subject, H.M., initially did not show a definite VER in either his normal-seeing or amblyopic eye. His alpha wave response was large and continuous. These findings agree with our clinical observations. H.M. was unable to maintain attention. He could not sustain a visual task for more than several minutes. Eye movements in both eyes were uncertain and inaccurate. H.M.'s performance in school was similarly poor.

After a year of visual training, however, his attention span has improved greatly. His eye movements have become more stable. His VER response is now stronger than his alpha wave response. From our experience with H.M., we feel that with hyper-active, alpha-persistent, learning-disabled children, the VER may be attenuated in both eyes and thus the VER may be limited as a tool for gaining exact information about amblyopia prognosis. For a VER to be obtained with these children, the sessions will have to be very brief; the examiner will have to be adept at keeping the child's attention focused at the end of the room; and multiple sessions may be needed.

Because we had no subjects who showed a good VER response in one eye but not the other, and because all of our subjects see the Haidinger brush, it appears that we had no organic amblyopes with which to work. Thus we did not have an opportunity to observe any organic amblyopes' VERs and we cannot add to Ludlam's observations in this area. Further studies are needed.

Comparison of VERs Before and After Training:

Among those subjects whose attention permitted VERs to be obtained during both sessions, the initial ratios between the normal and amblyopic eyes' amplitudes did not change significantly after training, at least for our small experimental population. If this finding can be duplicated with a larger expermental population, the finding would suggest that if a VER is reduced

before training, it will not change after training and that the initial prognosis obtained from the VER will not improve. It will, however, remain the clinician's task to determine if a reduced VER is the result of organic damage, or merely inattention, before a definitive prognosis can be made. Again, multiple sessions may be needed, especially when the VER is attenuated in both eyes.

Usefulness of the VER in a Visual Training Practice:

1) The VER required little communication between ourselves and our patients. Thus, the instrument would be ideal for work with a non-verbal patient.

2) The VER required no perceptual skills on the part of the patients. Thus the instrument would be ideal for work with a young patient.

Other Considerations:

1) Those subjects who could not maintain attention on the flashing target did not show good VER responses. We found that it was necessary to run the VERs rapidly, before attention waned.

2) Neck movements produced pseudo-VERs which built all on one flash. Thus both the oscilloscope and the patient had to be constantly monitored.

3) Occasionally a VER would build for a number of flashes, only to fade by the end of the sequence. It would have been useful if we had had a means to record other than the final oscilloscope summation.

In conclusion, we feel that the VER has a definite place in a pediatric or visual training practice. Like any clinical tool, it is no better than the clinicians who use it. In dealing with young patients, however, who do not have the necessary perceptual and verbal skills to describe entopic phenomena, the VER could provide valuable information not otherwise obtainable in the diagnosis of amblyopia.

Table # 1
Subjects' Data Before Training

	Acuities		Refractive Error	Opthalmoscopy	Sees Haidinger Brush:	Fixation	Strabismus	Correspondence
	Whole line:	Single letter:						
J.D.								
OD	20/20	20/20	plano -2.25 x 180	neg.	yes	central, steady	left xot	NRC
OS	20/60	20/50	+1.25 -250 x 180	neg.	yes	1-4 Δ nasal EF		
H.M.								
OD	20/20	20/20	+2.00	neg.	yes	Centrally steady	left esot	ARC
OS	20/100	20/80	+2.00	neg.	?	2-4 Δ temp EF		
J.S.								
OD	20/150	20/150	+1.25 -25 x180	neg.	?	> 5 Δ sup. EF	Right esot	ARC
OS	20/20	20/20	+.75	neg.	?	Central, steady		
K.R.								
OD	20/20	20/20	+6.00 -1.50 x 143	neg.	yes	Central, steady	left esot	ARC
OS	20/100	20/80	+5.50-1.55 x 48	Neg.	yes	4-5 Δ nasal EF		

Table # 2
VERs Before Training

Target Size:		20/700	20/90	20/40
J.D.	OU	16/100**	X	X
	OD	10/100	4.8/108	3.6/108
	OS	10/92	5.6/88	5.0/100
H.M.	OU	9.6/104	x	6.0/92
	OD	x	x	x
	OS	4.0/112	x	x
J.S.	OU	13.6/104	x	x
	OD	12.2/103	19.2/104	14.4/112
	OS	12.0/86	16.8/100	x
K.R.	OU	9.4/96	x	x
	OD	6.4/112	9.2/84	4.0/104
	OS	9.8/98	5.2/80	6.0/112

** mean amplitude in μvolts/ mean latency in msec.

Table # 3
Subjects' Data After Training

Subject Age	Acuities Whole line	Acuities Single letter	Refractive Error	Opthalmoscopy	Sees Haidinger Brush	Fixation	Strabismus	Correspondence
J.D.								
OD 22	20/20	20/20	-25 -2.25 x 180	neg.	yes	steady, central	left xot	NRC
OS	20/40	20/30	+50 -2.25 x 180	neg	yes	unsteady, central		
H.M.								
OD 9	20/20	20/20	+2.75	neg.	yes	steady central	left est	ARC
OS	20/30	20/25	+2.75	neg.	yes	unsteady, central		
J.S. ***								
OD 7	20/80	20/70	+1.25 -50 x 180	neg.	yes	3-6 sup. EF	right esot	ARC
OS	20/20	20/20	+75	neg.	yes	steady, central		
KR								
OD 16	20/20	20/20	+6.00 - 1.50 x 143	neg.	yes	steady, central	left esot	ARC
OS	20/30	20/25	+5.50 - 1.50 x 48	neg.	yes	unsteady, central		

***Still being trained, still showing improvement

Present OD acuity: 20/60 whole line
20/40 single letter

Table # 4
VERs After Training

Target Size:		20/700	20/90	20/40
J.D.	OU	13.4/94**	8.4/112	6.0/108
	OD	6.0/88	7.6/112	6.4/104
	OS	7.2/96	7.6/104	8.0/92
H.M.	OU	13.2/102	10.0/96	6.8/96
	OD	8.6/110	x	6.8/116
	OS	4.4/104	x	4.0/100
J.S.	OU	11.0/96	5.6/100	11.2/88
	OD	14.0/92	8.8/116	4.4/102
	OS	10.0/116	9.2/104	4.0/100
K.R.	OU	13.7/110	x	x
	OD	18.8/96	x	x
	OS	17.6/104	x	x

**mean amplitude in μvolts/ mean latency in msec.

Table # 5

Ratio: Amplitude of Amblyopic Eye/Non-amblyopic Eye

Check Size:	20/700		20/90		20/40	
	Before Training	After Training	Before Training	After Training	Before Training	After Training
J.D.	1.0	1.2	1.16	1.0	1.4	1.25
H.M.	x	.51	x	x	x	.58
J.S.	1.01	1.4	1.14	.96	x	1.1
K.R.	1.53	.93	.56	x	1.5	x
Aver.	1.18	1.17	1.15	.98	1.4	1.25

Average Ratios of Subjects Showing Ratios both Sessions:	Before Training	After Training
	1.16	1.12

Table # 6

	Smallest check size to which amblyopic eye responded during the initial VER	Single letter Acuity at time of initial VER	Single letter acuity obtained after training
J.D.	20/40	20/50	20/30
H.M.	No response either eye	20/80	20/25
J.S.	20/40	20/150	20/40***
K.R.	20/40	20/80	20/25

***Still being trained, Still improving.

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