EVALUATION OF THE REFLEX FUSION TEST AS A MEANS OF SCREENING BINOCULAR VERGENCE DISORDERS

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ABSTRACT

The time required to complete a step vergence eye movement was investigated. The stimulus for the vergence response was binocular retinal image disparity created by horizontal prism. The reflex fusion test was used to stimulate divergence and convergence responses. These responses were timed with fixation directed at both distance and near. Specifically, the stimuli were 6^ BI at distance, 10^ BO at distance, 10^ BI at near, and 15^ BO at near, each installment being performed once. It was suspected that those subjects who failed to complete the vergence eye movement or who required more time to complete the vergence movement would also show latent binocular misalignments such as those classified as Duane-White Syndromes. It was discovered that all subjects who failed to complete a vergence eye movement had binocular motor system disorders. Subjects who were able to complete each step vergence task, but required greater than 3.0 s on two or more of the four tasks also were found to have binocular motor disorder. When heterophoria existed, it took longer to complete step vergence movements in the direction which opposed the phoria seventy percent of the time. The effectiveness of this sequence of reflex fusion tests as a screening method was surveyed.

KEY WORDS : binocular disparity, vergence facility, oculomotor dysfunctions, reflex fusion test, step vergence completion time

INTRODUCTION

Over the last fifteen years investigators have begun to turn their attention to the reflex fusion test (RFT) as a means to evaluate vergence facility.[1] The reflex fusion test (akin to the more familiar four base out test) allows the examiner to assess the dynamic properties of the vergence system, which are response latency, velocity, accuracy and fatigue. Fusional vergence eye movements are controlled by a fast-acting mechanism that aligns the eyes in response to retinal image disparity and a slow-acting mechanism that acts on the output (leakage) from the fast vergence controller to sustain binocular alignment.[2]

If a prism is applied in front of one eye under binocular viewing conditions, a retinal disparity is created. The fast vergence controller responds to the disparity and stimulates the visual motor system to perform a vergence eye movement to restore fusion. The time required to complete this vergence movement will be referred to as the step vergence completion time (SVCT). The SVCT can be considered a combined measure of latency and velocity. An experienced observer can objectively make a qualitative assessment of vergence system dynamics and a quantitative assessment of the SVCT. On the other hand, the untrained examiner can subjectively determine the SVCT by measuring the time required for the patient to eliminate diplopia. When the prism is removed, retinal disparity is recreated, and the eyes must perform a vergence movement that is opposite that required after prism insertion.

With careful observation the examiner can assess the accuracy of the vergence response, and by repeating the test, the examiner can evaluate the subject's level of stamina or fatigue. Experience with the technique allows the clinician to make gross judgments of the velocity of the vergence response. Increased vergence latency is revealed if a version movement is detected prior to the vergence movement. This phenomena can best be explained by comparing the latency of the vergence system to the latency of the version system. The normal version latency (200 msec.) is about equal to the normal vergence latency (160 msec.). If a version movement precedes the vergence movement, then this probably indicates an increased vergence latency which is allowing the version movement to occur first. Nevertheless, some subjects with normal vergence latency may prefer to perform a version movement before completing the vergence eye movement. Version movements are best observed in the eye without prism.[3]

Grisham found step vergence velocity decreases as one samples further from the phoria position.[4] He also found vergence latency is not significantly influenced by the level of vergence in effect before stimulating a step vergence response. The time required to complete the vergence response is a function of the vergence latency and velocity. Schor and Ciuffreda report subjects who demonstrate slow reflex fusion responses often have restricted vergence ranges.[5]

Consider the effect of the heterophoria on the RFT. If the condition of orthophoria exists when the prism is introduced, then the vergence demand approximates the power of the prism. If a subject was exophoric and convergence was stimulated with BO prism then the total relative fusional vergence demand is greater than the prism value by the amount of the phoria. If this same exophore is presented with BI prism, the divergence demand is less than the prism value by the amount of the phoria. In contrast, the vergence demand on an esophore is greater than the prism when stimulating divergence with BI prism, and the demand is less than the prism when stimulating convergence with BO prism.

The step vergence velocity is a function of the starting vergence position of the eyes when within the limits of fusion. That is to say the vergence velocity decreases the further the test is performed from the phoria. Therefore we can predict that a subject with a large exophoria would show a slow response to prism base-out (convergence) and a quick response to prism base-in (divergence); a large esophore would respond slowly to base-in prism and rapidly to base-out prism. Thus the same prism can create different vergence demands depending on the phoric position of the subject.Therefore, the vergence demand can be considered a function of the amount and direction of the phoria, and the nature of the stimulus disparity.

It has been established that during reflex fusion testing the vergence demand and the vergence response velocity are dependent on the phoria. It occurred to me that a short battery of reflex fusion tests could be devised to exploit this relationship for the sake of identifying latent position errors and anomalies of vergence. The reflex fusion test battery was designed to include the following prism presentations :

- 6^{Δ} BI with distance fixation, to reveal farpoint eso problems (divergence insufficiency, basic eso)
- 10^{Δ} BO with distance fixation, to reveal farpoint exo problems (divergence excess, basic exo)
- 10^{Δ} BI with near fixation, to reveal nearpoint eso problems (convergence excess, basic eso)
- 15^{Δ} BO with near fixation, to reveal nearpoint exo problems (convergence insufficiency, basic exo).

These prism disparities were chosen in an effort to balance various criteria. The attempt was to reconcile studies of vergence facility with Morgan's norms for vergence recovery. To increase clinical acceptance and convenience of the RFT screening method, the prisms chosen had to be commonly available in standard loose prism sets (4,6,8,10,15 and 20 pd). Table 1 compares prism disparity vergence data of previous investigators (Rosner, Jacobson et al., Griffin, and Morgan), presents reasonable choices of prisms to stimulate disparity vergence, and lists the prism selected for this study. Since our design imposes single applications of prism for each task and since the goal of a screening test is to maximize sensitivity and specificity, the largest reasonable disparity stimulus was elected. This guideline was violated when selecting the disparity for the distance convergence and the near divergence tasks. In these instances it was judged that an absolute 15 pd. demand would excessively reduce the specificity of these tasks while the 10 pd. disparity appeared significant enough to maintain adequate sensitivity.

The purpose of this investigation was to examine the fast vergence adaptation mechanism's response to disparity and determine how well the timing of this response identifies binocular vergence dysfunctions compared to traditional testing methods such as vergence range and phoria measurements. The drawback suffered by these traditional tests is that they are influenced to considerable extent by nonphysiological variation.

> Test results are markedly influenced by such procedural factors as speed and smoothness of prism power introduction, amount of contour in the fixation target, and phrasing of patient instructions (for example, "Tell me when the target doubles" as opposed to "Try to keep the target single"). Several psychological factors as well introduce variation into vergence range measurements. As with most subjective techniques, a subject's attentional or arousal level can influence the test endpoints, as can other intangible factors, such as toleration of discomfort and precision of observation.[6]

Although the proposed RFT sequence gives cursory insight into vergence facility, the primary goal is to identify or screen binocular alignment disorders albeit somewhat indirectly. If this study proves to be effective at detecting binocular vergence disorders, then this RFT sequence would provide clinicians with a quick, objective and somewhat diagnostic test of the vergence system to augment his more traditional tests.

TABLE 1

COMPARISON OF DISPARITY INDUCED VERGENCE DATA FROM VARIOUS INVESTIGATORS FOR RFT DISPARITY DETERMINATION

ROSNER (a)	JACOBSON (b)	GRIFFIN (c)	MORGAN (d)	REASONABLE PRISM CANDIDATES	PRISM DISPARITY CHOSEN
06 BI(D)		5 BI(D)	4 BI(D)	4 , 6	6 BI(D)
12 BO(D)		15 BO(D)	10 BO(D)	10 , 15	10 BO(D)
12 BI(n)	5 BI(n)	5 BI(n)	13 BI(n)	10 , 15	10 BI(n)
14 BO(n)	15 BO(n)	15 BO(n)	15 BO(n)	10 , 15	15 BO(n)

where (D) - at distance
(n) - at near

comments :

(a) - VF data : screening criteria 3c/30s
training goal 18c/90s

(b) - fixation alternated between two pair Quoits rings at 40cm with demand set at 5 BI and 15 BO relative to the phoric position, testing young adults without binocular problems

(c) - goals for VF, 20c/60s, values are absolute prism demands to be met at distance and near, applies to esophores and exophores

(d) - Morgan's normative values for vergence recovery

(a), (b), (c), and (d) from Griffin [7]

abbreviations : VF - vergence facility
c - cycles
s - seconds

METHODS

Data was collected at the Optometric Institute and Clinic of Detroit (OIC). Twelve subjects were investigated, and were selected from the OIC clinic population and from volunteer senior optometry interns staffing OIC. Constant strabismic subjects were rejected from the study. Subjects ranged in age from 15 to 42 years with a mean age of 26.6 years. Five subjects were male and seven were female. Nine subjects were Caucasian and three were Black.

Subjects were given a complete clinical binocular vision evaluation. Subjects were tested with distance optical correction in place. Clinical data included (but was not limited to) the following procedures. History was taken. Subjects were asked if symptoms of blur, diplopia, asthenopia, or headaches existed. Any health conditions or medications were noted. Cover test was done at distance and near, and was prism neutralized. Von Graefe measurement of phoric posture was taken at distance and 40cm. A + 1.00 D phoria was also taken at 40cm and used to compute the gradient AC/A. Risley prism vergence ranges were measured in both horizontal directions with distant and near fixation. Stereopsis was measured with the AO Titmus Fly (actually taken after timing the vergence response at distance and before timing the vergence response at near). A binocular diagnosis was made based on these findings. Additional clinical data were permitted when needed to confirm a diagnosis.

Once the clinical data were gathered, the reflex fusion test sequence was administered as follows. A full chart of 20/60 to 20/20 letters was projected and fixated at distance in a fully lit examining room. The subject was told, "When I place this lens before your right eye, the chart will double. Tell me when it's single." A

6^{Δ} base-in loose prism was placed in the line of sight of the right eye and a stopwatch was activated simultaneously. When the examiner observed the completion of the vergence eye movement (or the patient reported "single") the timer was stopped, the SVCT noted, and the watch reset. The prism was removed and the timer again was simultaneously reactivated, while the time was measured for the eyes to regain bifixation. This procedure was repeated with a 10^{Δ} base-out disparity at distance.

Stereo acuity was taken next, the crossed polarized glasses were left in place, and the patient told to fold back the stereofly booklet so only the fly was exposed. This served as the target for the near RFT. Full room illumination was maintained. The step vergence completion time was measured as a 10^{Δ} base-in prism was inserted then removed from the line of sight of the right eye. Finally, the step vergence completion times for insertion and then removal of the 15^{Δ} base-out prism were measured.

RESULTS

The twelve subjects were categorized according to visual motor skills as normal, abnormal, or presbyopic. Table 2-A compares phoric posture, vergence ranges, and step vergence completion times (SVCT) for twelve subjects. Also given in table 2-A are diagnoses and comments for each subject. Of the twelve subjects, four were esophores and seven were exophores. Subject SC had a small and variable phoria. SC was being treated for nerves with Mellaril and for sinus with Benadryl. Table 2-B shows only SVCT for twelve subjects (insertion/removal).

Comparison of the twelve subjects' vergence range findings to Morgan's norms revealed that 30% failed to come within 1 pd of meeting or exceeding Morgan's expected norms for the various measurable vergence range parameters. Vergence range failure rate is broken down and compared to Morgan's norms in Table 3, below. It is interesting to note all subjects met the distance BI vergence range criterion. Also of interest is the fact that all but one subject (ST) failed the BO recovery norm at distance. Subject SC had the second worst vergence ranges overall, failing to meet two-thirds of the expected values of Morgan, in spite of having only a small phoric misalignment.

TABLE 3
NUMBER OF FAILURES TO MEET MORGAN'S VERGENCE RANGE NORMS

	BI-dist BL/BR/ R	BO-dist BL/BR/ R	BI-near BL/BR/ R	BO-near BL/BR/ R
NORMS :	X/ 7/ 4	9/19/10	13/21/13	17/21/11
FAILURES :	0 0 0	3 4 11	4 7 3	2 4 6

TABLE 2-A

MEASURES OF PHORIC POSTURE, VERGENCE RANGES, STEP VERGENCE COMPLETION TIMES AND DIAGNOSES FOR TWELVE SUBJECTS

--Hx--		-------DISTANCE--------			----------NEAR----------			
		P	VR	SVCT	P	VR	SVCT	
S	+Sx	CT	BIV	6^BI i/r	CT	BIV'	10^BI i/r	DIAGNOSES
A	RS	vG	BOV	10^BO i/r	vG	BOV'	15^BO i/r	COMMENTS
				abnormals				
MW	+Sx	0	XX/14/ 4	F	4E	16/20/10	F	CE
15	BF	0-3E	XX/24/ 3	3.0/1.3	0-2E	XX/26/16	2.5/1.2	BASIC ESO
AS	+Sx	4X	6/ 8/ 5	1.2/1.2	8X	XX/15/14	1.5/0.8	CI
26	WF	2X	4/12/ 4	F /1.1	7X	XX/16/ 5	10.6/0.8	60"STEREO
TG	+Sx	4X	XX/ 9/ 7	10.3/0.8	10X	10/16/12	4.2/2.0	CI
20	BF	2X	SUPP. OD	2.5/1.5	11X	0/ 8/-2	F /1.2	
DP	+Sx	1E	XX/07/05	2.5/1.1	2E	12/14/ 5	4.6/0.8	BASIC ESO
23	WM	3E	XX/20/07	1.9/1.4	4E	XX/23/14	5.5/1.2	CE ?
SC	-Sx	0	XX/ 8/ 4	7.1/1.2	2X	8/16/10	F /1.3	MEDS
25	BF	2E	XX/16/ 1	16.0/1.1	2E	XX/16/ 3	12.0/1.3	dec. VR
				presbyopes				
DC	+Sx	1X	XX/ 8/ 4	1.2/0.8	4X	XX/16/14	1.2/0.9	LO XP'
42	WM	1X	4/10/ 8	4.1/1.2	6X	XX/24/16	1.4/1.0	pre-presby
VZ		0	XX/ 9/ 5	1.1/0.6	0	XX/18/12	1.5/0.9	LO XP'
41	WF	0	XX/18/ 3	8.2/1.4	5X	XX/18/ 6	2.2/0.9	pre-presby
				normals				
RW		2E	XX/13/ 5	1.1/0.9	2E	XX/23/13	0.8/0.8	BASIC ESO
24	WM	4E	XX/29/ 5	3.4/0.8	2E	XX/36/24	0.9/0.8	adeq. VR
TR		0	5/ 9/ 4	0.8/0.7	0	12/16/13	3.2/0.9	LO XP'
27	WM	1X	20/26/ 0	1.0/0.6	3X	22/32/ 6	1.8/1.3	adeq. VR
ST		0	XX/19/ 9	0.9/1.1	4X	23/28/16	0.8/0.8	XP'
21	WM	0	14/22/10	1.1/1.0	9X	XX/31/ 8	2.0/0.8	adeq. VR
JK		0	XX/ 7/ 5	1.1/0.7	0-3E	10/20/15	1.8/1.3	EP'
33	WF	0	XX/39/ 8	1.3/0.9	8E	XX/42/28	1.3/1.2	adeq. VR
TH		2X	XX/ 8/ 6	0.9/0.8	8X	XX/24/17	0.9/0.7	XP'
23	WF	1X	18/28/ 2	1.1/0.9	3X	XX/42/12	1.0/0.9	adeq. VR

abbreviations : S-subject, Sx-symptoms, A-age, RS-race+sex (W-white, B-black, M-male, F-female), P-phoria, CT-cover test, vG-von Graefe, VR-vergence ranges (BIV-base-in vergences, BOV-base-out vergences), SVCT-step vergence completion time, i/r-insertion/removal, XP-exophoria, EP-esophoria, (')-nearpoint, dec.-decreased, adeq.-adequate, SUPP.-suppressed, MEDS-patient taking medication

TABLE 2-B
STEP VERGENCE COMPLETION TIMES - INSERTION / REMOVAL
FOR TWELEVE SUBJECTS

	6^BI	10^BO	10^BI	15^BO
TH	0.9/0.8	1.1/0.9	0.9/0.7	1.0/0.9
JK	1.1/0.7	1.3/0.9	1.8/1.3	1.3/1.2
ST	0.9/1.1	1.1/1.0	1.8/0.8	2.0/0.8
TR	0.8/0.7	1.0/0.6	3.2/0.9	1.8/1.3
RW	1.1/0.9	3.4/0.8	0.8/0.8	0.9/0.8
VZ	1.1/0.6	8.2/1.4	1.5/0.9	2.2/0.9
DC	1.2/0.8	4.1/1.2	1.2/0.9	1.4/1.0
SC	7.1/1.2	16.0/1.1	F /1.3	12.0/1.3
DP	2.5/1.1	1.9/1.4	4.6/0.8	5.5/1.2
TG	10.3/0.8	2.5/1.5	4.2/2.0	F /1.2
AS	1.2/1.2	F /1.1	1.5/0.8	10.6/0.8
MW	F / x	3.0/1.3	F / x	2.5/1.2

x - the prism removal SVCT was not measured on subject MW after failure to fuse the prism insertion stimulus

	6^BI	10^BO	10^BI	15^BO
MEAN ($\bar{x}$)	2.6/0.9	3.9/1.1	2.1/1.0	3.8/1.0
St.D.(σ)	3.2/0.2	4.5/0.3	1.4/0.4	4.0/0.2

Note: A paired T-test was preformed comparing the insertion time to the removal time for each stimulus disparity. The paired T-test values and one tailed significance levels are given below for each prism disparity.

	6 BI	10 BO	10 BI	15 BO
T-value	1.76	2.13	3.00	2.29
Significance	0.53	0.02	0.007	0.05

Table 4 lists the prism insertion SVCT's in order, and shows the means and medians for each prism insertion stimulus disparity. Table 5 lists the prism removal SVCT's in order, and shows the means and medians for each prism removal stimulus disparity. These tables are graphically represented in Histogram 1. Comparison of the SVCT's for prism insertion (Table 4) to SVCT's for prism removal (Table 5) reveals some significant differences. The step vergence response times for prism insertion had a considerably wider range of responses than the SVCT's for prism removal (0.8 s to 16.0 s v. 0.6 s to 2.0 s, respectively). The distribution of SVCT responses for prism insertion for the entire group tended to be leptokurtotic, while the removal SVCT responses reflected a more gaussian distribution. The prism insertion SVCT mean for all subjects and all disparities was 3.9 s compared to a mean of 1.0 s for all prism removal SVCT's. The prism insertion SVCT median for all subjects and all disparities was 1.9 s compared to the prism removal SVCT median of 0.9 s to 1.0 s. Comparison of each prism removal SVCT to its complement insertion SVCT shows that except for three instances, the removal vergence was always faster than the insertion vergence (93%). This agrees with Grisham's finding [8] that " When the vergence direction changes - convergence to divergence or vise versa - a considerable increase in step velocity consistently occurred." He aptly coined this phenomena the "rebound" effect.

Table 6 lists in order the prism insertion SVCT's for the normal group, and shows the means and medians for each prism insertion stimulus disparity. Table 7 lists in order the prism removal SVCT's for the normal group, and shows the means and medians

TABLE 4
STEP VERGENCE COMPLETION TIMES - PRISM INSERTION
(ORDERED WITH REGARD TO SPEED)

	6^BI	10^BO	10^BI	15^BO
	0.8 TR	1.0 TR	0.8 ST	0.9 RW
	0.9 TH	1.1 TH	0.8 RW	1.0 TH
	0.9 ST	1.1 ST	0.9 TH	1.3 JK
	1.1 JK	1.3 JK	1.2 DC	1.4 DC
	1.1 RW	1.9 DP	1.5 VZ	1.8 TR
	1.1 VZ	2.5 GT	1.5 AS	2.0 ST
	1.2 AS	3.0 MW	1.8 JK	2.2 VZ
	1.2 DC	3.4 RW	3.2 TR	2.5 MW
	2.5 DP	4.1 DC	4.2 GT	5.5 DP
	7.1 SC	8.2 VZ	4.6 DP	10.6 AS
	10.3 GT	16.0 SC	F SC	12.0 SC
	F MW	F AS	F MW	F GT
MEAN (S.D.)	2.6 s (3.2)	3.9 s (4.5)	2.1 s (1.4)	3.8 s (4.0)
MEDIAN	1.1-1.2 s	2.5-3.0 s	1.5-1.8 s	2.0-2.2 s

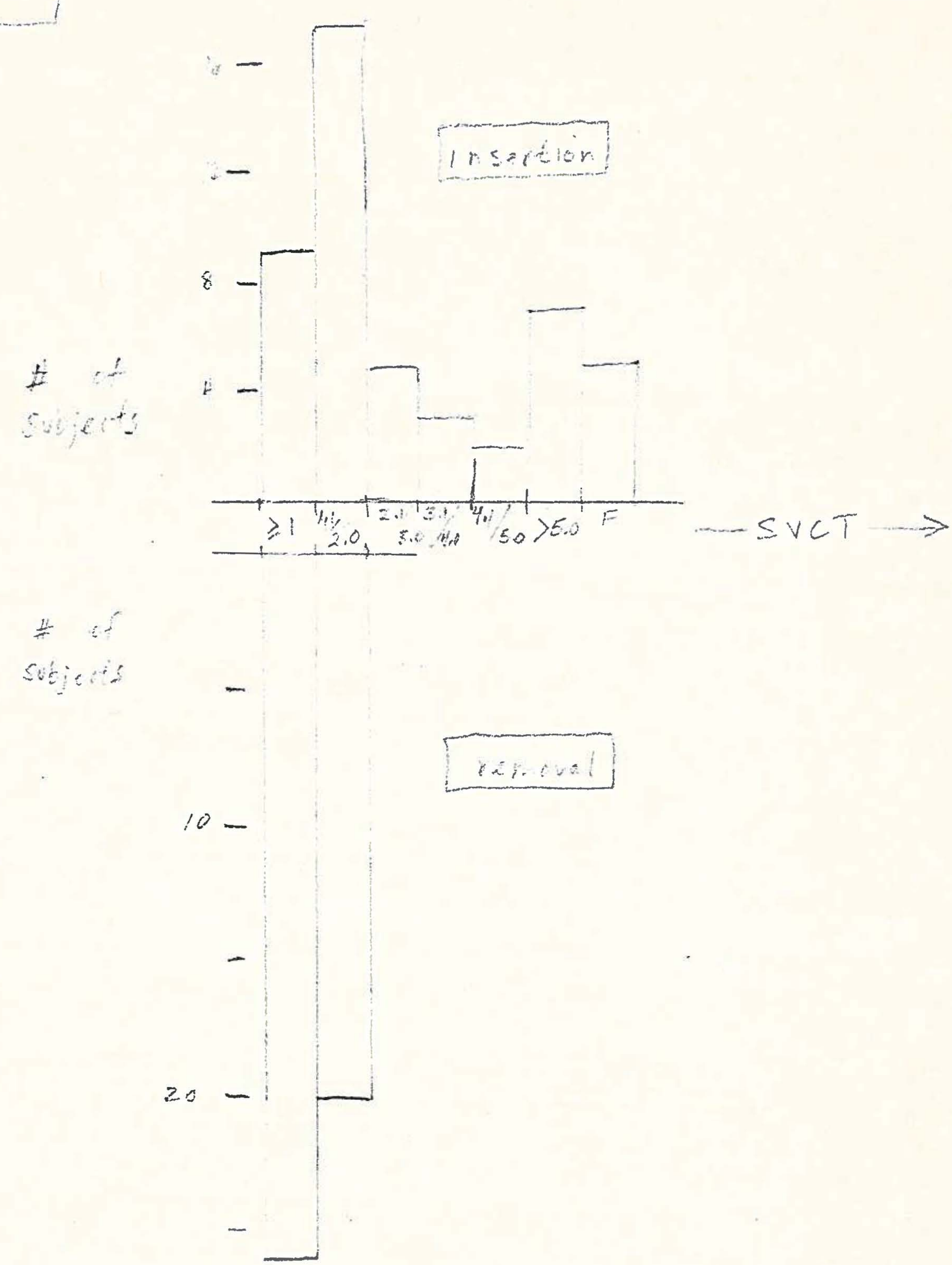
OVERALL MEAN = 3.9 s OVERALL MEDIAN = 1.9 s

TABLE 5
STEP VERGENCE COMPLETION TIMES - PRISM REMOVAL
(ORDERED WITH REGARD TO SPEED)

	6^BI	10^BO	10^BI	15^BO
	0.6 VZ	0.6 TR	0.7 TH	0.8 ST
	0.7 JK	0.8 RW	0.8 AS	0.8 AS
	0.7 TR	0.9 JK	0.8 DP	0.8 RW
	0.8 GT	0.9 TH	0.8 RW	0.9 VZ
	0.8 DC	1.0 ST	0.8 ST	0.9 TH
	0.8 TH	1.1 SC	0.9 TR	1.0 DC
	0.9 RW	1.1 AS	0.9 VZ	1.2 MW
	1.1 DP	1.2 DC	0.9 DC	1.2 GT
	1.1 ST	1.3 MW	1.3 JK	1.2 DP
	1.2 SC	1.4 DP	1.3 SC	1.2 JK
	1.2 AS	1.4 VZ	2.0 TG	1.3 SC
	- MW	1.5 TG	- MW	1.3 TR
MEAN (S.D.)	0.9 s (0.2)	1.1 s (0.3)	1.0 s (0.4)	1.0 s (0.2)
MEDIAN	0.8 s	1.1 s	0.9 s	1.0-1.2 s

OVERALL MEAN = 1.0 s OVERALL MEDIAN = 0.9-1.0

Histogram 1

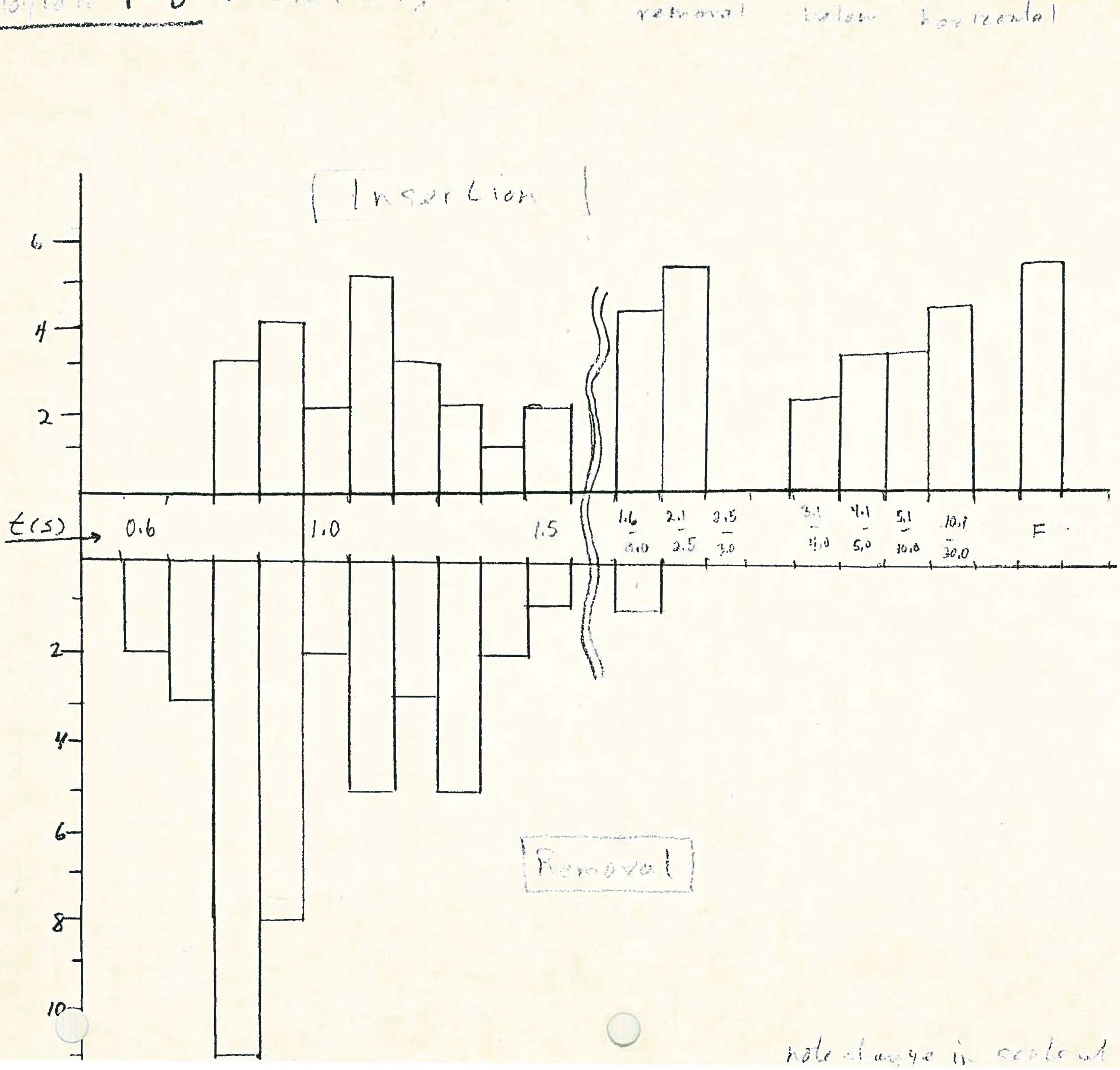


Histogram 1-A

comparison of the occurrence of SVCT for prism insertion (above) and removal (below)

part B is the same graph set to a diffent x-axis (SVCT) scale.

Histogram 1-B



for each prism removal stimulus disparity. The SVCT's for the normal group were considerably less than those for the entire group. Both the insertion and removal SVCT's for the normal group followed gaussian distributions.

When a subject demonstrated a heterophoria at some distance, the BI SVCT finding was compared to the BO SVCT finding from the same distance. For seventy percent of these comparisons it was found that the SVCT was greater when the RFT vergence demand was in the direction opposite the phoria than when the vergence demand was in the same direction as the phoria. That is to say an exophore usually required more time to complete the convergence movement (BO) than the divergence movement (BI). Likewise, an esophore's SVCT for divergence (BI) was usually greater than the SVCT for convergence (BO).

TABLE 6
STEP VERGENCE COMPLETION TIMES - PRISM INSERTION
FOR THE NORMAL GROUP
(ORDERED WITH REGARD TO SPEED)

	6^BI	10^BO	10^BI	15^BO
	0.8 TR	1.0 TR	0.8 ST	0.9 RW
	0.9 TH	1.1 TH	0.8 RW	1.0 TH
	0.9 ST	1.1 ST	0.9 TH	1.3 JK
	1.1 JK	1.3 JK	1.8 JK	1.8 TR
	1.1 RW	3.4 RW	3.2 TR	2.0 ST
MEAN (S.D.)	1.0 s (0.1)	1.6 s (1.0)	1.7 s (1.0)	1.4 s (0.5)
MEDIAN	0.9 s	1.1 s	0.9 s	1.3 s

OVERALL MEAN = 1.4 s   OVERALL MEDIAN = 1.1 s

TABLE 7
STEP VERGENCE COMPLETION TIMES - PRISM REMOVAL
FOR THE NORMAL GROUP
(ORDERED WITH REGARD TO SPEED)

	6^BI	10^BO	10^BI	15^BO
	0.7 TR	0.6 TR	0.7 TH	0.8 RW
	0.7 JK	0.8 RW	0.8 ST	0.8 ST
	0.8 TH	0.9 JK	0.8 RW	0.9 TH
	0.9 RW	0.9 TH	0.9 TR	1.2 JK
	1.1 ST	1.0 ST	1.3 JK	1.3 TR
MEAN (S.D.)	0.8 s (0.2)	0.8 s (0.2)	0.9 s (0.2)	1.0 s (0.2)
MEDIAN	0.8 s	0.9 s	0.8 s	0.9 s

OVERALL MEAN = 0.9 s   OVERALL MEDIAN = 0.9 s

DISCUSSION

The goal of this investigation was to find a step vergence completion cutoff criterion time that would identify those subjects with binocular disfunctions. Five subjects were found to have binocular vergence dysfunctions based upon analysis of clinical findings. It was found that several criteria could be adequately employed to separate this group from the remaining population. The problem then becomes deciding which criterion demonstrates the highest screening efficiency. It appeared the greatest possibility for clinical differentiation of the abnormal group lay with the prism insertion SVCT finding. This was because the insertion SVCT's fell over a wider range, which allows the examiner to make a better clinical assessment of increased SVCT (refer to figure 1A).

The simplest criterion employable is the failure to fuse any one of four stimulus disparity presentations. This minimum criterion alone identifies four of the five abnormal subjects (MW, AS, GT, and SC). The fifth member of the abnormal group, DP , was able to complete each vergence task thereby becoming a false negative using this cutoff. To improve the test's sensitivity a stricter cutoff criterion is required.

If the SVCT cutoff criterion time is reduced and positives are identifitied for failing to meet this time criterion on any one stimulus presentation, the sensitivity increases as expected but specificity drops unacceptably. If for example, the SVCT cutoff was 3.0 s and a subject was failed for needing longer than three seconds during any one stimulus presentation, it can be seen that although the test approaches complete sensitivity, the specificity drops dramatically as four false positives would be identified using this criterion.

To increase the specificity without raising the SVCT cutoff time too high above the means for the entire sample (3.9 s) or for the normal group (1.4 s), the criterion was modified so that subjects who failed to complete any two vergence eye movements within the SVCT criterion (3.0 s) would be positively identified. The ability of this criterion, (failure to complete any two vergence tasks within 3.0 s), to correctly separate abnormal subjects was high. No false positives or false negatives were identified using this criterion, so that sensitivity and specificity are both equal to one.

In addition to being effective, a worthwhile screening should satisfy a need and have appropriate design. For a screening to be considered needed, the condition to be identified should be prevalent, treatable, and asymptomatic. Binocular dysfunctions are found in a significant portion of the population.[9,10] Some estimates of the prevalence of convergence insufficiency alone are as high as 32% . These dysfunctions can be effectively treated by combinations of orthoptics, lenses and prisms. Symptoms of convergence insufficiency usually present during the second or third decade. Allen, studying children between kindergarten and sixth grade, found 5% with reduced near point of convergence and 6% failed the near cover test. Children may simply not be reporting symptoms due to reduced near point activity, avoidance of near point activity, or difficulty conveying symptoms. Children with binocular dysfunctions are usually asymptomatic. Screening test designs should involve innocuous, quick, easy, and inexpensive procedures. The reflex fusion test also meets these criteria.

CONCLUSION

To summarize, this investigation found that subjects who were unable to complete one or more of the RFT presentations also had binocular motor system disorders. In addition, subjects needing greater than 3.0 s to complete two or more of the four vergence movements had binocular vergence disorders. The prism removal SVCT was consistently less than the SVCT during insertion. This is supporting evidence for the rebound effect found by Griffin. When heterophoria existed the step vergence movement in the direction opposite the phoria was slower than the step vergence movement in the same direction as the phoria.

It is my opinion that the best potential application of this sequence of RFTs with measurement of the prism insertion SVCT is as a screening test for binocular motor dysfunctions that could be preformed either in or out of office. It would also be desirable to preform a similar study on a larger sample to see if the step vergence completion time cutoff criterion can be further refined.

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