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Normative analysis: A method for determining a need for and verifying success in accommodative and convergence visual training cases

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Abstract
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Grade Sheet

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NORMATIVE ANALYSIS: A METHOD FOR DETERMINING A NEED FOR AND VERIFYING SUCCESS IN ACCOMMODATIVE AND CONVERGENCE VISUAL TRAINING CASES

INTRODUCTION:

In the area of visual training, there exists a need for an exact and quantified method for predicting the need for and success of accommodative and convergence visual training (A&C V.T.). Up until now, the prevalent quantified method for prescribing A&C V.T. was based on the Optometric Extension Program Analysis (O.E.P.A.) method, where visual training was prescribed on the basis of case typing and deteriorations as shown in Table "A".[1] Using clinical "expecteds", as shown in Table "B",[2] for the 21 point exam and their analysis method of checking, chaining, and case typing, a therapy framework which may include A&C V.T. can be determined.

Another method of case analysis which we feel may be used as a criterion for prescribing A&C V.T. is that of Normative Case Analysis (N.C.A.), a method compiled by H.M. Haynes. These norms are shown in Table "C".[3] Hayne's normative analysis defines normalcy on a test finding as the mean, plus or minus one probable error (P.E.), where a P.E. is equal to .6745 times the standard deviation (S.D.). Using this definition of clinical normalcy on all the possible analytical tests and combinations as shown in Table "C", one can calculate a composite index score for both A&C tests. Haynes suggests the possible clinical use of index scores for convergence and accommodation as follows: (1) quantitatively to describe in a single numerical score, a larger number of individual standard scores from each individual finding. (2) it can be used to quantify the intensity of deviation. (3) it can be used to evaluate the before and after training effects of relevant forms of V.T. (4) it allows the clinician, by using a point scoring system, to give equal weight to each test score.

Although composite index scores can give an indication of deviancy in total accommodative or convergence behavior, it is imperative that one analyze the deviant sets to determine the areas of need for V.T. Likewise, if one is comparing the quantitative value of composite index scores of successive examinations, one must analyze the changes in the deviant sets to see if it is those values which have undergone change and not the normal values becoming superior, giving the appearance of overall improvement while the deviant scores remain deviant.

Other research has been done in the area of case analysis to define norms and expecteds of the analytical visual exam. In 1941, Dr. Carl F. Shepard published a paper, The Most Probable Expecteds.[4] On a population of 2000 complete examinations, Shepard presented a table of statistical expecteds with probable errors and standard errors of a normal population including all age levels. He states that "r", the coefficient of reliability, should be .8 or higher to be considered as a basis for predicting or prescribing a therapy. See Table "D" for his statistical expecteds.

Also in 1941, Dr. Howard F. Haines published a paper, Normal Values of Visual Function and Their Application in Case Analysis. The Analysis of Findings and Determination of Normals.[5] He agreed that certain normal values or expecteds should be found for each test. His "normal values" however, were set up as minimum requirements. His findings were based on statistical analysis of clinical data. In general his analysis advocates a less rigid analysis than that of O.E.P.A. See Table "E" for his normal values.[6]

In 1944 Dr. Meridith W. Morgan, Jr., published a paper, Analysis of Clinical Data.[7] He set up his standards for analysis with normal defined arbitrarily as plus or minus .5 S.D. as shown in Table "F". His analysis was a statistical study of clinical data on a nonselected group of 800 prepresbyopic subjects, 50 trained observes, and a reliability study on 500 prepresbyopic subjects.[8] It can be seen that the norms or expecteds of Haynes, Morgan, Haines, and Shepard are all within one S.D. of each other.

In this study we will attempt to correlate the methods used to prescribe A&C V.T. used by a successful V.T. practitioner, Dr. Tole Greenstein, of Oregon City, Oregon, with that of a quantified system of analysis; Normative Case Analysis.

Our hypothesis is that the criteria used for prescribing V.T. and the methods of training A&C dysfunctions have validity and that the method of N.C.A. will positively correlate with these criteria. If such a positive correlation can be shown, then we have as a tool a mathematical model for prescribing V.T. and for gauging its success.

A sample population of 30 A&C V.T. cases which have gone through a V.T. program by Dr. Greenstein were analyzed using N.C.A. An age and sex matched control population of patients, who have been determined not to need V.T., was also analyzed using the same N.C.A. From the data gathered from the analysis of the two populations, we will test the following hypotheses: (1) using the norms established by Campagne and Mjelde[9] on a clinical population of 60 for A&C composite index scores, (see Table "G"), and defining deviant scores as those equal to or less than the mean minus one P.E., we predict that N.C.A. does positively correlate with Dr. Greenstein's clinical criteria for prescribing A&C V.T. (2) N.C.A. will show a statistically significant improvement in composite A&C index scores in post V.T. exams, thereby showing positive correlation with clinician criteria for success. (3) standard scores of deviant sets of N.C.A. will show a statistically significant change when comparing pre and post V.T. exams.

METHODS:

N.C.A. considers an individual finding as normal if its magnitude is within one P.E. from the mean. A P.E. is equal to about 2/3 of the S.D. of the distribution (.6745), so that 50% of the population is plus or minus one P.E. around the mean.

See Table "H".[10] An O.E.P. 21 points analytical exam with certain additional findings is divided into two distinct performance groups. One set of findings, Type I, is scaled as a continium from inferior, to normal, to superior motor performance. A second set of findings, Type II, is a continium from hypo activity, to normal, to hyper activity. Both hyper and hypo activity constitute abnormal behaviors for performance. See Table "I".[11]

Our composite index scores for A&C behaviors are compiled from a larger number of individual standard score findings. In a routine Pacific University College of Optometry (P.U.C.O.) clinical exam, there are approximately 40 items for evaluation which are considered for the composite A&C index scores. Two studies by Campagne and Mjelde of patient and interclinician reliability support the use of a point system index score.[12] See Table "J". The final composite index score can range from zero to 40 with mean (Ci)=29.93, S.D.=4.25 and mean (Ai)=28.80, S.D.=3.93. (Table "G"). Differences of greater than four index score points would be expected about 5% of the time by chance on two successive duplicate exams by the same examiner. A composite index score is a sensor which detects a change from any number of findings without identifying which variables are responsible. In comparing the values of composite index scores on successive visual exams, changes in the deviant, normal, and superior sets should be analyzed to isolate specific reasons for change. More detailed information about the analysis for refractive and motor tests can be found in Chapter 2 of a soon to be released book by Dr. H.M. Haynes, F.U.C.O.

A population of 30 A&C V.T. cases were selected from Dr. Greenstein's files, chosen on the basis of having completed a V.T. program and undergone a post V.T. exam. Another group of 30, matched by age and sex, was selected from the same population, chosen on the basis of not having had V.T. prescribed to resolve their vision problems, but may have had Rx changes. All patients in both V.T. and non V.T. groups were binocular and non-amblyopic. This last group will be used for our control findings. Our non V.T. population will be referred to as either pre norms, those receiving their initial exam from Dr. Greenstein; or post norms, the same population seen at a later date for a follow up exam. It was not possible to exactly match the length of time between exams for our V.T. and non V.T. populations. See Table "K" for a listing of mean ages and average time between exams. When comparing the refractive errors of our V.T. and non V.T. populations, it can be seen in Table "L" that there is no significant difference in their distribution.

The data used for the 30 V.T. and non V.T. cases was that of an O.E.P. analytical 21 points exam. A N.C.A. computer program written by L. Czapla[13] was used to analyze the case findings on a Data General Nova 800 computer. The program results are in the form of composite accommodation (Ai) and convergence (Ci) index scores, based on the means and standard deviations of norms as stated previously.

After collating all the data, the following analyses were applied: (ALPHA) A comparison of the pre V.T. and non V.T. composite Ai and Ci scores to the established norms of Hayne's study to see if a statistical deviation exists. (BETA) An analysis of the pre vs. post of the V.T. and non V.T. composite Ai and Ci scores to see if a statistically significant improvement indeed did take place. (GAMMA) An interpopulation analysis of the composite Ai and Ci scores between a) our pre norms & pre V.T. groups b) our pre norms & post V.T. groups and c) our post norms & post V.T. groups. (DELTA) An analysis of each of the individual subscores in pre vs. post V.T. to see if a statistically significant change in these particular individual areas did take place. In our **actual data** analysis for analysis ALPHA, a T test for a difference between a sample mean and the population mean was used. The formula for this analysis is:

$$t = \frac{\bar{X} - u}{\sqrt{\dfrac{\Sigma X^2 - \dfrac{(\Sigma X)^2}{N}}{N(N-1)}}}$$

where $\bar{X}$= the mean of the sample
u= the mean of the population

ΣX^2= the sum of the squared score values

$(\Sigma X)^2$= the square of the sum of all the scores

N= the number of scores used in the analysis

For results see Table "M".

For analysis BETA, a T test calculating a "student's T value" was used. For results see Table "N". For analysis GAMMA- a,b, and c, a T test for a difference between two independent means was utilized. The formula for this test is:

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\left[\frac{\Sigma X_1^2 - \frac{(\Sigma X_1)^2}{N_1} + X_2^2 - \frac{(X_2)^2}{}}{(N_1 + N_2) - 2}\right] \cdot \left[\frac{1}{N_1} + \frac{1}{N_2}\right]}}$$

where $\bar{X}_1$= the mean of the first group of scores

$\bar{X}_2$= the mean of the second group of scores

ΣX_1^2= the sum of the squared score values of the first group

ΣX_2^2= the sum of the squared score values of the second group

$(X_1)^2$= the square of the sum of the scores in the first group

$(X_2)^2$= the square of the sum of the scores in the second group

N_1= the number of scores in the first group

N_2= the number of scores in the second group

For results see Table "O". For analysis DELTA , a "student's T value" was utilized. For results see Table "P".

Dr. H.M. Haynes N.C.A. looks at the interrelationships of performance between findings of a 21 points analytical exam and not just isolated findings. The thrust of this paper is to look at our sample population composite Ai and Ci scores and see if certain changes have taken place in the analytical findings due to V.T. Individual patient symptoms were not taken into consideration by our analysis, but were considered by Dr. Greenstein in deciding whether V.T. was necessary for his patients.

The general methods for V.T. used by Dr. Greenstein will be listed since there is variance in training procedures used by different practitioners. For general binocular dysfunctions involving accommodation and convergence, Dr. Greenstein does not specifically train just accommodation or convergence alone, but integrates his training in both areas to maintain the balance that is necessary for efficient vision. The general schema is as follows:

1) rotation, fixation, and pursuit training
2) modified UpDegrave; Hart card with flashing light
3) rotations, fixations in a stereoscope
4) rotations, fixations in a saccadascope
5) accommodative rocks
6) Marsden ball rock; fused and unfused
7) tele-trainer rocks
8) Keystone rocks
9) visualization process training
10) binocular balance board
11) binocular & monocular pursuits-chalkboard
12) visualization with vectographs

DATA:

When we compared our V.T. and non V.T. populations for both the pre and post conditions with the Hayne's study population norms, we find that all but one of the conditions are significantly different at the .005 level of significance. The only condition which showed no significant difference from Hayne's norms was the post V.T. composite Ai scores. See Table "M". When we analyzed the pre vs. post V.T. and pre vs. post non V.T., we find that our non V.T. population over time showed no significant change in accommodation scores over the pre and post testing periods, but there is a statistically significant decrease at the .01 level in convergence scores. Thus convergence abilities degenerate over time without V.T. When we compare our pre vs. post V.T. groups we find a statistically significant increase in both Ai and Ci scores at a .005 level of significance. The decrease in our control non V.T. group of the Ci scores combined with the increase in the post V.T. group Ci scores, makes the significance even greater. See Table "N".

When we compared our pre norm population to our pre V.T. population there was no significant difference between these two populations for both the Ai and Ci scores. See Table "O". When we compared our pre norm population to our post V.T. population we find a significant difference at a .025 level for Ai scores and a .005 level for Ci scores. See Table "O".. The analysis of each of the individual subscores in the pre vs. post V.T. groups for significant changes are listed in Table "Q". The "T values" for all subscores for the pre vs. post V.T. population are listed in Table "P".

CONCLUSIONS:

1) Using Hayne's norms of total Ai and Ci scores, no difference between our non V.T. and our pre V.T. population could be found. We could therefore by N.C.A. not determine who would

need V.T. and who wouldn't, by looking only at the total composite Ai and Ci scores.

2) In our non V.T. population at this age group, there is a significant decrease in Ci scores at a .01 level while Ai scores showed no significant change.

3) In contrast, those patients receiving V.T. showed a significant increase in their Ai and Ci scores at a .005 level.

4) When comparing our post non V.T. population to our post V.T. population, we now find a significant difference in the two populations at a .025 level for Ai scores and a .005 level for Ci scores. The change in Ai scores for the two populations can be attributed almost exclusively to the V.T. as can be seen in the T scores in Table "O". However, the change in Ci scores for the two populations is not solely due to increased ability from V.T. but is also due to a decrease in convergence ability over time in our normal non V.T. population as is also shown in Table "O".

5) In analyzing the individual subscores in our pre vs. post V.T. population we found, as indicated by the T scores in Table "Q", certain areas of visual performance are more affected than others by V.T. We found that accommodation and convergence facility were most amenable to change. See Table "P". Positive and negative relative accommodation were able to be significantly changed by V.T. while accommodative posture

showed no change. Convergence facility showed a significant change only on the base out side at far and near while base in facility showed no significant change due to V.T. Convergence posture, as shown by phorias at far and near and slopes of various far and near phorias, showed no significant change. This indicates that the success of V.T. may be due to building ranges around the posture rather than the actual change of a posture position. This may explain why many V.T. practitioners find it more difficult to train eso postured problems as opposed to exo postured problems. Our data supports the work of Fry[14] (1943) and Hofstetter[15] (1945) and to a limited extent, Morgan[16] (1947). Fry and Hofstetter stated that the width of the zone of clear single binocular vision can be altered by training but the slope of the zone is not alterable. Our data indicates that the width of the zone is alterable by V.T. predominantly on the positive relative convergence side and not on the negative reletive convergence side.

6) We feel that it is imperative in the area of V.T. that a quantitative method of analysis be used to identify a need for and success of V.T. We feel that Hayne's N.C.A. is one such method capable of fulfilling such a need. We do question the equal weighting of all subscores as they relate to visual performance, thus affecting the validity of the composite Ai and Ci scores.

7) The data from the V.T. population in this study indicate that certain people may be better V.T. candidates than others.

visual performance brought about by vision training, will V.T. gain the widespread acceptance we feel it truly deserves.

TABLE A

From Visual Analysis Handbook II

B-1 - 1	(Simple)	7 + (5) 6	14A	16A-21	19	(lens application
		9-11-16B	15A	17A-20		
B-1 - 2		7 + (5) 6	14A-15A	16A-21	19	(lens application
		9-11-16B		17A-20		
B-1 - 3		7 + (5) 6	15A	16A-21	19	(lens application
		9-11-16B	14A	17A-20		visual training)
B-1 - 4		7 + (5) 6	15A	16A-20	19	(lenses and
		9-11-16B	14A	17A-21		visual training)
B-1 - 5		7 + (5) 6	15A	16A-20		(lenses and
		9-11-16B	14A	17A-21	19	visual training)
B-1 - 6		7 + (5) 6	15A	16A-20		(visual training)
		9-10-16B	14A	17A-21	19	
B-1 - 7		7 + ( ) 6	15A	16A-20		(visual training)
		9-5-10-16B	14A	17A-21		

TABLE B

OEP EXPECTED

	Finding	Expected	CHECK	COMPARE (*
#3	Habitual phoria	.5$^{\Delta}$ XO	H-N-L	EXPECTED
#13a	Habitual phoria	6$^{\Delta}$ XO		EXPECTED
#4	Static retinoscope	#7 or more plus	H-N-L	#7
#5	Dynamic retinoscope	net = #4 or more plus	H-N-L	#4
#6	Dynamic retinoscope	net = #4 or more plus	H-N-L	#4
#8	Phoria through #7	.5$^{\Delta}$ XO	H-N-L	EXPECTED
#9	Base out to blur	7 - 9$^{\Delta}$	H-N-L	EXPECTED
#10	Base out to B/R	19/10 R=1/2 B	H-L-LL	EXP & #11
#11	Base in to B/R	9/5 R = 1/2 B	H-L-LL	EXP & #10
#13b	Phoria through #7	6$^{\Delta}$ XO	H-N-L	EXPECTED
#14a	Unfused Cross Cyl.	net = #7 or more plus	H-N-L	NET TO #7
#15a	Phoria through #14a		H-N-L	#14a NET
#14b	Fused Cross Cyl.	Net = #7 or more plus	NO	#7
#15b	Phoria through #14b		NO	
#16a	Base out to blur out	about 15$^{\Delta}$, not less than 10$^{\Delta}$	NO	#17a
#16b	Base out to B/R	21/15 R=2/3 of B	H-L-LL	EXP & #17b
#17a	Base in to blur out	about 15$^{\Delta}$, not less than 10$^{\Delta}$	NO	#16a
#17b	Base in to B/R	22/18 R=3/4 B	H-L-LL	EXP & #16b
#19	Amplitude of Accom.	Net = 5.00 or more	H-N-L	EXPECTED
#20	Minus to Blur Out (PRA)	about -2.25 net; not lower than -1.50	NO	#21 NET
#21	Plus to Blur Out (NRA)	about +2.25 net; not lower than +1.50	NO	#20 NET

* HYPEROPES AND EMMETROPES ONLY. FOR MYOPES, COMPARE TO (1) HABITUALLY WORN MINUS OR (2) PLANO, IF MYOPE WAS PREVIOUSLY UNCORRECTED (3) NO. 7, IF MORE PLUS THAN (1)

TABLE C

NORMATIVE ANALYSIS RATING SCALE

Convergence Sets

Amplitude (Rc)

	Mean	P.E.	Dev.	Score
NPC (K)	2.5"	.7"		
NPC (R)	4"	1.7"		
Convergence Posture (Pc)				
8	.5 xo	1.7		
13B	4 xo	3.5		
$13B^{10}$	6.5 xo	4		
S (8,13B)	.75	.23		
S (8,15A)	.55	.2		
S (8,15B)	.6	.2		
Fxd				
Fxd				
S(Fxd)				
Convergence Facility (Fc)				
9 (B&O)	8 (12)	3		
10K	19	4.6		
10R	9	3		
11K	8	2.2		
11R	3.5	1.8		
10R-8	9	3		
11R-8	3	1.8		
11R-10R	12	2.8		
11K-10K	28	4		
16A (B&O)	13 (16)	4		
16K	19	4.7		
16R	9	4		
17A (B&O)	11 (14)	3		
17K	20	2.8		
17R	12	2.9		
16R-13B	11	4		
17R-13B	8	3.3		
17R-16R	22	4		
17K-16K	38	5		
17A-16A	23 (30)	5 (6)		
Convergence Response Time (C/M)				
BO (8)	23	5		
BI (8)	18	5		
Asymetric Convergence (B.M.F.) @ 33cm.				
R+L÷2,BK	42°	5°		
R+L÷2,R	37°	5°		
BK-R	5°	1.7°		
Other				
Other				

C-Sc.	0	1	2	3	4	Σ(f)
freq.						
Sc. x f.						Σ

$$C_i = \frac{\Sigma(Sc \times f)}{\Sigma(f)} \times 10 = \_\_\_\_\_\_$$

Patient ______________________

Exam Date ______________________

Accommodative Sets

Amplitude (Ra)

	Mean	P.E.	Dev.	Score
NPA-P (OU)				
Accommodative Posture (Pa)				
14A-P	+1.25	.37		
$14A^{10}$-P	+2.00	.50		
14B-P	+1.00	.37		
$14B^{10}$-P	+1.62	.50		
S(⁻14B)	.80	.15		
S(⁺14B)	.60	.15		
Dynamic Retinoscopy				
MEM·4(#Card)	.62	.18		
MEM·4(20/100)	.62	.18		
LN·4-P	.87	.37		
S(MEM)(20/100)	.80	.08		
S(Hdy)	.75	.15		
Accommodative Facility (Fa)				
20B-P	2.50	.87		
20BO-P	3.50	1.00		
20R-P	2.62	1.00		
20BO-20R	.87	.62		
20BO-21BO	6.00	1.12		
20R-14B	4.50	1.12		
21B-P	1.87	.37		
21BO-P	2.37	.50		
21R-P	1.87	.37		
21BO-21R	.50	.37		
21R-20R	5.25	1.12		
21R-14B	1.00	.37		
19-P	4.25	1.25		
5-4	1.12	.37		
$S(HN_r)$	.35	.15		
Accommodative Response Time (C/M)				
Plus (bin.)	21	5		
Minus (bin.)	21	5		
Other				
"				

A-Sc.	0	1	2	3	4	Σ(f)
f						
Sc. x f.						Σ

$$A_i = \frac{\Sigma(Sc \times f)}{\Sigma(f)} \times 10 = \_\_\_\_\_\_$$

Statistical Expecteds

Test	r	M	PE	2 S. D.
P. D. Far	.90	63.5 mm.	7.	21.
P. D. Near	.92	60. mm.	2.5	7.5
Monocular Vision Far	.84	20/25	/5	/15
Binocular Vision Far	.89	20/21	/6	/13
Binocular Vision Near	...	20/20	/+—	/1
K. V. Co. DB2, 3	...	61.5%	6%	20%
P. P. of Conv.	.47	3.5 inches	1.	2.5
K. V. Co. Stereometric Set	...	28%	12%	28%
#3	.64	1 Exo.	1.	3.
#13A	.56	5 Exo.	3.5	10.
#2 Cyl.	.34	.62 D. with Rule	.37	1.
#4 Gross Sph	.98	+.50	1.	3.50
#4-#7 to 20/20	...	0.00 D.	.37	1.00
#4-#7 to Best Vision	...	+.37 D.	.50	1.25
#4 Cyl.	.93	.12 D. with Rule	.50	1.50
#5 Gross Sph.	.96	1.50 D.	1.	3.50
#5-#4	...	2-(19 OU./4)	.37 D.	1.00
#5-#4	...	2-(Push Up Amp./8)	.50 D.	1.50
#5-#4 (After Age 40)	...	+1.00 D.	.50	1.50
#6 Gross Sph.	.84	+.75 D.	.75	2.00
#6-#4	...	+.25 D.	.50	1.25
2#6-(#5 + #4)	.94	—.12 D.	.37	1.26
#7 Sph. to 20/20	.98	+.87 D.	.75	1.75
#7 Sph. to Best Vision	.98	+.50 D.	1.12	3.25
Duochrome	.98	+.50 D.	1.12	3.25
#7 Cyl.	.91	.12 D. with Rule	.50	1.50
#8	.66	1. Exo.	2.	5.
#9	.22	9.	3.	7.
#10 Break	.62	21.	6.	17.
#10 Recovery	.62	9.	3.	9.
#11 Break	.80	9.	2.	6.
#11 Recovery	.60	4.	2.	4.
#12 Phoria	.36	0.	.5	1.
#12 Breaks	.38	4.	1.	3.
#12 Recovery	.67	1.5	.5	2.5
#13B	.79	5 Exo.	4.	10.
#14A Sph. Gross	...	+1.75 D.	.75	2.00
#14A-#7 to 20/20	...	+.37 D.	.37	1.25
#14A-#7 to B. V.	.70	+.75 D.	.37	1.25
#15A/(#14A-#7)	...	8.	10.	30.
#15A	.80	6. Exo.	3.	9.
#14B Sph. Gress	...	+1.25 D.	.75	2.50
#14B Sph.-#7 to 20/20	...	0.	.37	1.25
#14B Sph.-#7 to B. V.	.47	+.25 D.	.37	1.25
#15B/(#14B-#7)	...	3.	18.	53.
#15B	.66	5. Exo.	3.	8.
#13B/(#14B-#7)	...	2.	17.	52.
#16A	.35	13.	4.	11.
#16 Break	.85	25.	7.	22.
#16 Recovery	.66	13.	5.	15.
#17A	.55	10.	3.	7.
#17 Break	.30	20.	4.	11.
#17 Recovery	.38	11.	3.	8.
#18 Phoria	.46	0.	1.	2.
#18 Breaks	.46	5.	1.	3.
#18 Recovery	.53	2.	1.	2.
#19 O. U.	.94	9-(Age/8)	.50 D.	+1.25
Push Up Amp. ACC.	.59	13-(Age/4)	4.50 D.	12.00
#20	.74	—2.37 D.	.87	2.0?
#21	.40	+1.75 D.	.37	1.12
Anisometropia	...	.25	.50	1.50

TABLE E

Haines' Table (1941)

Tests	N	Mean	Mean Dev
Lateral Phoria, 6M	*1000*	*0*	*±1.00*
Negative Convergence 6M	*443*	*9.24*	*±1.46*
Negative Reversion to Fusion, 6M	*443*	*4.63*	*±1.42*
Positive Relative Convergence, 6M	*443*	*8.71*	*±2.13*
Positive Total Convergence, 6M	*443*	*22.26*	*±6.11*
Positive Reversion to Fusion, 6M	*443*	*6.31*	*±2.86*
Dynamic Retinoscopy, 40 cm.	*900*	*+1.02 above static*	*±0.41*
Lateral phoria, 40 cm.	*1000*	*4.85 Exo*	*±3.25*
Fused Crossed Cylinder, 40 cm.	*1000*	*+.44 above Subj. at 6M.*	*±0.43*
Negative Relative Convergence, 40 cm.	*500*	*14.91*	*±3.22*
Negative Total Convergence, 40 cm.	*500*	*22.44*	*±2.84*
Positive Relative Convergence, 40 cm.	*500*	*16.30*	*±2.94*
Positive Total Convergence, 40 cm.	*500*	*22.86*	*±5.41*

TABLE F

Morgan's Table (1944b; 1946)

Test	Mean	S.D.
Phoria	*1 Δ Exo*	±2 Δ
Adduction		
Blur	*9 Δ*	±4 Δ
Break	*19 Δ*	±8 Δ
Recovery	*10 Δ*	±4 Δ
Abduction		
Break	*7 Δ*	±3 Δ
Recovery	*4 Δ*	±2 Δ
Dynamic Lag	*+1.37 D.*	±0.37 D.
Mon. X Cyl. Lag	*+1.00 D.*	±0.50 D.
Bin. X Cyl. Lag	*+0.50 D.*	±0.50 D.
F.S.C.	*−3 Δ*	±5 Δ
P.R.C.	*17 Δ*	±5 Δ
P.F.R.		
Break	*21 Δ*	±6 Δ
Recovery	*11 Δ*	±7 Δ
N.R.C.	*13 Δ*	±4 Δ
N.F.R.		
Break	*21 Δ*	±4 Δ
Recovery	*13 Δ*	±5 Δ
P.R.A.	*−2.37 Δ*	±1.12 D.
N.R.A.	*+2.00 D.*	±0.50 D.
Gradient	*- 4 Δ/+1.00 D.*	±2 Δ
Amplitude	*Age**	±2.00 D.

** Amplitude from Donders' or Duane's tables.*

TABLE 2.6- Frequency Distribution of Accommodative and Convergence Index Scores (Reliability Study)

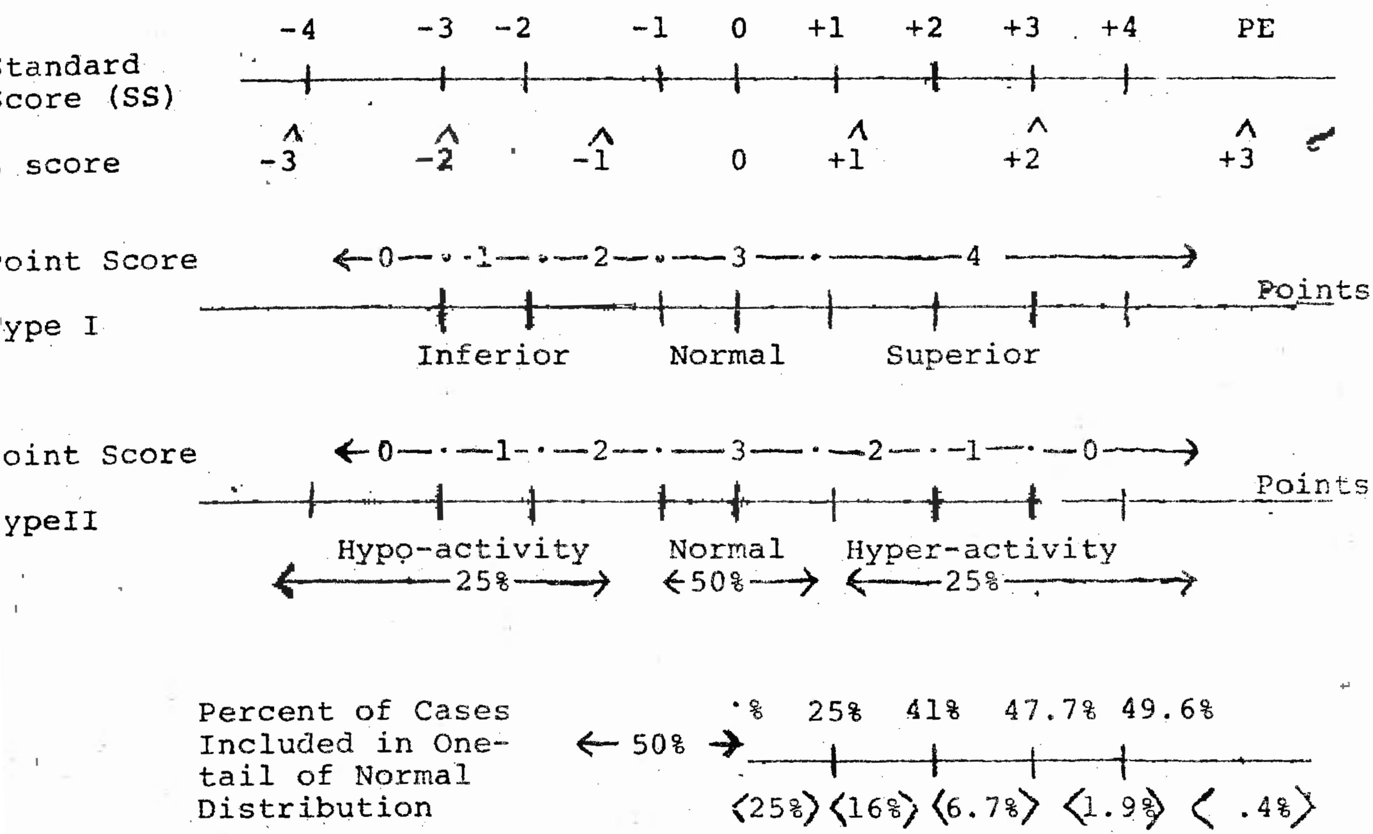
TABLE G

	A_i (N = 60)			C_i (N = 60)		
Score	f	%	Σ%	f	%	Σ%
14-15	0			0		
16-17	1	1.67	1.67	1	1.67	1.67
18-19	1	1.67	3.33	1	1.67	3.33
20-21	2	3.33	6.67	1	1.67	5.00
22-23	2	3.33	10.00	2	3.33	8.33
24-25	4	6.67	16.67	1	1.67	10.00
26-27	9	15.00	31.67	11	18.33	28.33
28-29	11	18.33	50.00	8	13.33	41.67
30.31	15	25.00	75.00	11	18.33	60.00
32-33	9	15.00	90.00	12	20.00	80.00
34-35	6	10.00	100.00	8	13.33	93.33
36-37	0			3	5.00	98.33
38-39	0			1	1.67	100.00

	A_i	C_i
N	= 60	= 60
Median (A_i) / (C_i)	= 30	= 30.5
Mean (A_i) / (C_i)	= 28.8	= 29.93
Standard Deviation	= 3.93	= 4.25
Correlation (r)	= .92	= .92
Correlation between A_i and C_i	= .72	

Table 2.6: Contains the frequency distribution of the accomodative and convergence index scores for the 60 subjects used in the test-retest reliability study. This distribution of index scores was derived by averaging each subject's scores for the two examinations administered from 7 to 12 days apart. Index score intervals are listed under column marked "score". The frequency of each score value is displayed under "f". Percentages and cumulative percentages are shown under columns marked % and Σ% respectively. Test-retest correlations between the first and second examinations, are listed separately under A_i and C_i respectively.

Table 2.3: STANDARD SCORE TO POINT SCORE CONVERSION SCALES



ıble 2.3: The relationship among scales for conversion from SS
andard score to point scores for Type I and Type II findings is
ıown. The Z score (^) distribution is seen immediately below the
standard score. Percentages shown are based on a normal dis-
ibution. Empirical distributions may vary. To change the stan-
rd score deviation (SS) into a point score use the appropriate
ale shown for Type I and Type II respectively. Conversion bet-
en Z and SS standard scores may be estimated from scales shown.

TABLE I

Table 2:1 GENERIC LISTING OF TYPE I and TYPE II FINDINGS

Type I Accommodative Tests

- Amplitude of Accommodation (NPA)
- Relative Accommodative Tests
- Reaction Time
- Relative Response Time (Accommodative Rock)
- Distance Rock (Monocular)
- High Neutral Dynamic Retinoscopy
- Accommodative Tracking
- Relative Accommodative Tracking

Type II Accommodative Tests

- Crosscylinder Tests for Accommodation
- Red-Green and Red-Blue Bichrome Tests
- Low Neutral Dynamic Retinoscopy
- Heterodynamic-Bell Retinoscopy
- Monocular Estimate Method, Book and Loose Lens Retinoscopy
- Accommodative-Convergence Ratios

Type I Convergence Tests

- Nearpoint of Convergence (NPC)
- Positive and Negative Relative Convergence
- Convergence Response Time
- Relative Response Time - Prism Rock
- Distance Rock (Binocular)
- Convergence Tracking
- Relative Convergence Tracking

Type II Convergence Tests

- Phorias
- Fixation Disparity
- Convergent-Accommodation Ratios

Table 2.1: Generic classes of Type I and Type II accommodative and convergence tests are listed. Type I tests include those where scaling of the population distribution is a continuum from inferior to superior performance. Type II tests are those whe both ends of the population distribution curve show clinical malfunction by either hypo-activity or hyper-activity.

Table 2.5: ACCOMMODATION AND CONVERGENCE INDEX SCORE RELIABILITY (Campagna-Mjelde Data)

Set I: Test on Test Reliability
(One subject and one examiner)

Subject	Consecutive Weekly Scores n = 12 examinations						Mean
	1	2	3	4	5	6	
RM A-score	32.6	33.8	32.0	31.5	33.0	31.4	32.[illegible]
C-score	31.7	31.3	31.2	33.4	32.5	26.8	31.1[illegible]
SH A-score	31.8	30.0	31.3	32.9	30.6	32.2	31.47
C-score	33.6	35.6	34.0	34.8	36.5	34.4	34.32

Subject	Mean Differences		S.D. of Difference (S_d)		Range	
	A_i	C_i	A_i	C_i	A_i	C_i
RM	1.30	1.27	.76	.86	0-3	0-3
SH	1.23	1.71	.73	2.11	0-2	0-6

Set II: Interclinician Reliability - Student Clinicians

Subject	Consecutive Weekly Scores by 18 Examiners						Mean
	1	2	3	4	5	6	
GK A-score	35.4	30.6	32.3	33.1	30.6	32.3	32.38
C-score	36.7	35.6	35.7	35.2	37.6	37.0	36.30
RE A-score	36.0	33.0	33.0	36.1	32.3	33.3	33.9[illegible]
C-score	28.0	31.3	32.0	35.0	30.8	32.6	31.62
DC A-score	26.9	22.0	28.4	29.2	27.6	29.2	27.20
C-score	32.7	30.4	33.9	32.2	29.0	33.6	31.96

Subject	Mean Difference		S.D. of Difference (S_d)		Range	
	A_i	C_i	A_i	C_i	A_i	C_i
GK	2.3	1.23	1.54	.73	0-5	0-3
RE	2.23	2.97	1.6	2.05	0-6	0-7
DC	2.43	2.17	2.1	1.65	0-7	0-4

Table 2.5 continued

Set III: Interclinician Reliability - Practicing Optometrists

Subject	Consecutive Weekly Scores n = 5					Mean
	1	2	3	4	5	
BP A-score	20.9	30.8	25.0	36.0	33.0	29.14
C-score	32.3	29.6	24.0	30.0	26.0	28.38

Subject	Mean Difference		S.D. of Difference (S_d)		Range	
	A_i	C_i	A_i	C_i	A_i	C_i
BP*	8.5	3.4	3.9	1.75	0-15	0-8

* Practicing optometrists took fewer tests than student clinicians.

TABLE K

	V.T.	Non V.T.
Mean age	13.1 yrs.	13.1 yrs.
Average time between pre & post exams	14.8 months	26 months

TABLE 1

Distribution of Refracrive Errors

	>-2	-2→-1	-1→-.5	-.5→0	P1	0→+.5	+.5→1	1→2	>2
V.T.		2			3	20	5		
Non V.T.		1	1	2	3	13	6	2	2

TABLE M

POPULATIONS	T SCORES ACCOMMODATION	T SCORES CONVERGENCE
1) Pre V.T. vs. Haynes' norms	6.235	7.034
2) Post V.T. vs. Haynes' norms	-.379	5.628
3) Pre non V.T. vs. Haynes' norms	5.780	15.025
4) Post non V.T. vs. Haynes' norms	5.963	14.935

TABLE N

	ACCOMMODATION				CONVERGENCE			
	Mean	S.D.	VAR	S.S.	Mean	S.D.	VAR	S.S
Pre V.T.	23.33	4.81	23.09	669.56	21.44	3.06	9.36	271.36
Post V.T.	27.72	3.89	15.16	439.67	24.55	3.22	10.37	300.62
Pre non V.T.	24.12	4.43	19.67	570.40	22.98	2.49	6.22	180.43
Post non V.T.	23.94	4.46	19.87	576.30	21.27	3.15	9.95	288.57

T SCORES

	ACCOMMODATION	CONVERGENCE
Non V.T.(pre vs. post)	.23	2.72
V.T. (pre vs. post)	-4.56	-6.41

TABLE O

T Scores

Pre non V.T. vs. pre V.T.	.664	1.19
Pre non V.T. vs. post V.T.	2.15	1.476
Post non V.T. vs. post V.T.	2.26	2.929

TABLE P

T Scores; Pre vs. Post V.T. for Individual Subscore Tests

Patient ______________________

Exam Date ______________________

NORMATIVE ANALYSIS RATING SCALE

Convergence Sets

Amplitude (Rc)

	Mean	P.E.	Dev.	T Score
NPC (K)	2.5"	.7"		
NPC (R)	4"	1.7"		
Convergence Posture (Pc)				
8	.5 xo	1.7		.82
13B$_{10}$	4 xo	3.5		-.07
13B^{10}	6.5 xo	4		
S (8,13B)	.75	.23		-.48
S (8,15A)	.55	.2		-.60
S (8,15B)	.6	.2		.27
Fxd				
Fxd				
S(Fxd)				

Convergence Facility (Fc)

	Mean	P.E.	Dev.	T Score
9 (B&O)	8 (12)	3		
10K	19	4.6		-2.74
10R	9	3		-3.62
11K	8	2.2		.91
11R	3.5	1.8		.38
10R-8	9	3		-4.02
11R-8	3	1.8		-.08
11R-10R	12	2.8		-4.62
11K-10K	28	4		-2.51
16A (B&O)	13 (16)	4		
16K	19	4.7		-1.75
16R	9	4		-3.12
17A (B&O)	11 (14)	3		
17K	20	2.8		-1.20
17R	12	2.9		.55
16R-13B	11	4		-2.96
17R-13B	8	3.3		-1.04
17R-16R	22	4		-3.95
17K-16K	38	5		.83
17A-16A	23 (30)	5 (6)		

Convergence Response Time (C/M)

	Mean	P.E.	Dev.	T Score
BO (8)	23	5		
BI (8)	18	5		
Asymetric Convergence (B.M.F.) @ 33cm.				
R+L÷2,BK	42°	5°		
R+L÷2,R	37°	5°		
BK-R	5°	1.7°		
Other				
Other				

C-Sc.	0	1	2	3	4	Σ(f)
freq.						
Sc. x f.						Σ

$$C_i = \frac{\Sigma(Sc \times f)}{\Sigma(f)} \times 10 = \_\_\_\_\_\_$$

Accommodative Sets

Amplitude (Ra)

	Mean	P.E.	Dev.	T Score
NPA-P (OU)				
Accommodative Posture (Pa)				
14A-P	+1.25	.37		-.75
14A^{10}-P	+2.00	.50		
14B-P	+1.00	.37		-.81
14B^{10}-P	+1.62	.50		
S(⁻14B)	.80	.15		
S(⁺14B)	.60	.15		
Dynamic Retinoscopy				
MEM·4(#Card)	.62	.18		
MEM·4(20/100)	.62	.18		
LN·4-P	.87	.37		
S(MEM)(20/100)	.80	.08		
S(Hdy)	.75	.15		

Accommodative Facility (Fa)

	Mean	P.E.	Dev.	T Score
20B-P	2.50	.87		
20BO-P	3.50	1.00		-2.99
20R-P	2.62	1.00		-1.92
20BO-20R	.87	.62		-2.31
20BO-21BO	6.00	1.12		-2.84
20R-14B	4.50	1.12		-3.01
21B-P	1.87	.37		
21BO-P	2.37	.50		-4.00
21R-P	1.87	.37		-2.28
21BO-21R	.50	.37		-1.98
21R-20R	5.25	1.12		-2.61
21R-14B	1.00	.37		-2.21
19-P	4.25	1.25		-4.93
5-4	1.12	.37		-.68
S(HN$_r$)	.35	.15		

Accommodative Response Time (C/M)

	Mean	P.E.	Dev.	T Score
Plus (bin.)	21	5		
Minus (bin.)	21	5		
Other				
"				

A-Sc.	0	1	2	3	4	Σ(f)
f						
Sc. x f.						Σ

$$A_i = \frac{\Sigma(Sc \times f)}{\Sigma(f)} \times 10 = \_\_\_\_\_\_$$

TABLE Q

Pre vs. Post V.T. Scores

I Which showed a significant change at the .05 level

Convergence	Accommodation
16 brk	20R-P
	21BO-21R

II Which showed a significant change at the .025 level

Accommodation
20BO-20R
21R-P
21R-14b

III Which showed a significant change at the .01 level

Accommodation
21R-20R

IV Which showed a significant change at the .005 level

Convergence	Accommodation
10 brk	20BO-P
10 rec	20BO-21BO
10R-8	20R-14b
11R-10R	21BO-P
16 rec	19-P
16R-13b	
17R-16R	

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