5-1976

The correlation of various techniques of near phoria measurement

John W. Crotty
Pacific University

Douglas A. Safley
Pacific University

The correlation of various techniques of near phoria measurement

Abstract

The correlation of various techniques of near phoria measurement

Degree Type

Thesis

Degree Name

Master of Science in Vision Science

Committee Chair

Niles Roth

Subject Categories

Optometry

THE CORRELATION OF VARIOUS TECHNIQUES OF NEAR PHORIA MEASUREMENT

Clinical Research

presented to the faculty of the

College of Optometry

Pacific University

in partial fulfillment

of the requirements for the degree

Doctor of Optometry

by

John W. Crotty

and

Douglas A. Safley

May, 1976

Approved - Niles Roth
Advisor 5-7-76

ACKNOWLEDGEMENT

The authors of this treatise would like to thank Dr. Niles Roth for his invaluable assistance in organizing the experimental data into a form that is presentable to the optometric profession..

INTRODUCTION

Fluctuations from day to day and even from one moment to the next have made reliable phoria measurements elusive and even impossible. The necessity for standardized, regulated testing procedures has for this reason been underscored. However, heterophoria cannot be ignored. It is a measurement which reveals the extent of the motor task which has to be accomplished in order to maintain simple fusion.

The clinical measurement of phorias has always been an approximate science and has never afforded the eye care specialist a uniform method of communicating with his associates. Not only methods but also various techniques employed have presented the practitioner with confusion. The optometric profession has reached a stage of development at which it can no longer afford to utilize an approximate science. Therefore, the methods and techniques of measurement of phorias must be refined and standardized throughout the profession.

The authors will not attempt to judge the validity of any particular phoria measurement technique since an absolute position of rest, the true phoria, is unobtainable due to the presence of subconscious nervous influences in the living subject.[1]

[1]Scobee, Richard G., Green, Earl L. "Tests for Heterophoria-Reliability of Tests, Comparisons Between Tests, and Effect of Changing Testing Conditions". Transactions Am. Acad. of Ophth. and Otol. Jan.-Feb. 1947 p. 179-197

In a brief survey of related articles and optometric theses, it was determined that the various techniques used in performing different methods of testing had never been compared in a systematic study. The theses had all dealt with correlation of one method of testing with another and they all arrived at basically the same conclusions that there are essentially no differences in the method of phoria measurement employed as long as they all used the continuous technique. It is with this in mind that the authors attempt to quantify any differences arising from the utilization of various techniques within a single method of phoria measurement and also any differences arising from the utilization of a single technique in the performance of various methods.

PROCEDURE

Fifty subjects were drawn from a population of optometry students at the clinic of the College of Optometry in Forest Grove, Oregon. The students ranged in age from twenty to forty-six years of age, with the mean being twenty-five, and represented all four professional years. Binocular vision at far and near distances and a near visual acuity of 20/20 were the only criteria. Phoria measurements were taken on each subject through their near correction at a sixteen inch standardized distance. An American Optical phoropter was used on each subject to minimize variation in phoropter readings and for measuring prism consistency.

Three methods of phoria measurement were done.- the Von Graefe, the Maddox Rod, and the Modified Thorington. The Von Graefe began with 6$^{\Delta}$ BUOS and 12$^{\Delta}$ BIOD. If necessary, the prisms were increased to 9$^{\Delta}$ BUOS and any amount of BIOD greater than 12$^{\Delta}$ that would put the top line of letters to the right of the bottom line. Four values were then taken for both the continuous and alternate techniques and one for the bracketing technique. The Maddox Rod began with 12$^{\Delta}$ or greater BIOD to assure the red line being to the right of the light. Four values were then taken for both the continuous and alternate techniques and one for the bracketing technique. No prisms were used in the Modified Thorington and only one value was taken for both the continuous and flash techniques. The near point light was removed in both the Maddox Rod and Modified Thorington methods to facilitate the

subject's awareness of the red line. Room illumination was sufficient in the Modified Thorington to allow the subject to perceive the letters on the card.

Three techniques of testing were used for both the Von Graefe and the Maddox Rod:

1) continuous presentation - both eyes viewing a target at all times
2) alternate presentation - the eyes rapidly alternately occluded so that each eye gets a very brief view of the target
3) bracketing or flash presentation - the eye with the measuring prism in front of it only gets a brief view of the target. The subject then reports it as being to the left or right of the other, the prism is adjusted accordingly and the eye is then uncovered briefly again and it is repeated until the targets are subjectively aligned vertically.

The Modified Thorington uses no prism so therefore it was done only with continuous presentation and a flash technique in which the occluder was placed over the Maddox Rod and removed just briefly.

The instructions given to each subject were as follows:

Von Graefe - continuous and alternate, (the target consisted of a vertical row of 20/20 letters)

"Do you see two lines of letters? Is the top line to the right? Keep the letters in the top line as clear as possible and say now when the top line is directly over the bottom line of letters."

Von Graefe - bracketing (flash)

"When the top line of letters is visible, tell me if it is to the left, right or directly above the bottom line of letters."

Maddox Rod - continuous and alternating

"Do you see the light? Do you see the red line ? Look at the light. Say now when the red line passes directly through the center of the light.

- bracketing (flash)

"When the red line is visible, tell me if it is to the left, right, or directly through the center of the light."

Modified Thorington - flash

"Look at the 'v' directly above the spot of light."

Uncover, then cover the eye with the Maddox Rod. "Did you see the red line? Did it pass to the right, left, or through the 'v'? Look at the letter you thought the line passed through." Uncover and cover the eye with the Maddox Rod. Repeat until the line is through the letter.

- continuous

"Look at the light. Do you see the red line? Look at the letter the line passes through. What letter is it? What is the number directly above it?"

ANALYSIS OF DATA

Eight individual findings were taken on each of the fifty subjects. The eight findings consisted of: Von Graefe continuous, alternate, and bracketing; MaddoxRod continuous, alternate, and bracketing; and Modified Thorington continuous and bracketing. Analysis of variance was the procedure employed to compare the independent variables. Two different groups of independent variables were analyzed. In the first group, the methods were the independent variables while the technique was held constant and in the second group the techniques became the independent variables within each method.

Name		JC	DJ	PS	MM	BV	BG	DG	TA
Age		24	24	25	25	25	30	23	25
Von Graefe	1)	9x	4x	1x	4x	7x	7s	2x	5x
	2)	8x	2x	1x	4x	7x	11s	1x	1x
	3)	9x	3x	1s	4x	8x	4s	1x	1s
Continuous	4)	8x	Ø	1x	3x	7x	11.5s	1x	1.5s
	$\bar{x}$)	8.5x	2.25x	.5x	3.75x	7.25x	8.375s	1.75x	.875x
	$\bar{x}^2$)	72.25	5.06	.25	14.06	52.56	70.22	3.06	.77
	1)	9x	4x	Ø	2x	8x	4s	1x	1x
	2)	7x	4x	Ø	3x	7x	4s	2x	1x
Alternate	3)	8x	3x	Ø	3x	8x	4s	1x	.5x
	4)	6x	4x	Ø	3x	7x	3s	2x	1x
	$\bar{x}$)	7.5x	3.75x	Ø	2.75x	7.5x	3.75s	1.5x	.875x
	$\bar{x}^2$)	56.25	14.06	Ø	7.56	56.25	14.06	2.25	.77
Bracketing	1)	7x	4x	.5x	3x	8.5x	1x	3x	1x
	x^2)	49	16	.25	9	72.25	1	9	1
Maddox Rod	1)	9x	1x	2s	5x	12x	3s	4x	3x
	2)	8x	1s	Ø	5x	13x	2.5s	4x	3s
	3)	9x	Ø	Ø	6x	12.5x	2.5s	3.5x	.5x
Continuous	4)	8x	2s	1.5xx	6x	13x	1s	4.5x	9s
	$\bar{x}$)	8.5x	.5s	.125s	5.5x	12.62x	2.25s	4x	2.13s
	$\bar{x}^2$)	72.25	.25	.02	30.25	159.26	5.06	16	4.54
	1)	9x	4x	Ø	6x	13.5x	2s	4.5x	1x
	2)	9x	5x	2x	8x	13x	.5x	5.5x	1x
Alternate	3)	9x	4x	1x	9x	13x	1x	6x	1.5x
	4)	9x	4x	3x	9x	13.5x	1.5x	6x	2x
	$\bar{x}$)	9x	4.75x	1.5x	8x	13.25x	1.25x	5.5x	1.38x
	$\bar{x}^2$)	81	22.56	2.25	64	175.56	1.56	30.25	1.9
Bracketing	1)	9x	1x	Ø	7.5x	11x	1.5x	6x	2s
	$\bar{x}^2$)	81	1	Ø	56.25	121	2.25	36	4
Modified Thorington									
Continuous	1)	6.5x	1.5x	1x	2.5x	9.5x	1.5x	4x	1s
	$\bar{x}^2$)	42.25	2.25	1	6.25	90.25	2.25	16	1
Bracketing	1)	6x	2x	1.5x	.5s	8.5x	2x	3.5x	.5s
	$\bar{x}^2$)	36	4	2.25	.25	72.25	4	12.25	.25

Name		MH	JG	EC	RM	BK	TR	SH	RR
Age		23	26	28	25	24	20	26	21
Von Graefe	1)	8s	2x	4x	4.5x	2x	7.5x	3x	9.5x
Continuous	2)	13s	5s	3x	∅	1x	6x	2x	9.5x
	3)	11s	∅	4x	5,5x	3x	7.5x	2x	10x
	4)	16s	6s	2x	2x	2x	6x	2x	10x
	$\bar{x}$)	12s	2.25s	3.25x	3x	2x	6.75x	2.75x	9.75x
	$\bar{x}^2$)	144	5.06	10.56	9	4	45.56	7.56	95.06
Alternate	1)	8s	9x	6x	6x	3.5x	10.5x	3.5x	9x
	2)	11s	8x	2x	2.5x	∅	7x	2.5x	10x
	3)	9s	6x	4x	4.5x	4x	7x	3.5x	9x
	4)	11s	6.5x	4x	4x	2s	7x	3x	10x
	$\bar{x}$)	9.75s	7.38x	4x	4.25x	1.38x	7.88x	3.13x	9.5x
	$\bar{x}^2$)	95.06	54.46	16	18.06	1.9	62.09	9.8	90.25
Bracketing	1)	8s	6x	3x	4.5x	3.5x	6.5x	4x	11.5x
	$\bar{x}^2$)	64	36	9	20.25	12.25	42.25	16	132.25
Maddox Rod	1)	4s	2x	7x	4.5x	3x	8x	3x	12.5x
Continuous	2)	5s	2s	4.5x	5x	3x	7.5x	3x	12x
	3)	4s	1xx	7x	5.5x	2x	8.5x	2.5x	11x
	4)	8s	1s	6x	5.5x	2.5x	8x	2x	12.5x
	$\bar{x}$)	5.25s	∅	6.13x	4.88x	2.63x	8x	2.63x	12x
	$\bar{x}^2$)	27.56	∅	37.58	23.81	6.92	64	6.92	144
Alternate	1)	3s	5x	7.5x	6x	3x	9x	3.5x	12.5x
	2)	3.5s	∅	6x	5.5x	3x	8.5x	3x	13x
	3)	4s	1x	6x	6.5x	3.5x	7.5x	3x	13.5x
	4)	5s	∅	6x	5.5x	3.5x	7.5x	3x	14x
	$\bar{x}$)	3.88s	1.5x	6.38x	5.88x	3.25x	8.13x	3.13x	13.25x
	$\bar{x}^2$)	15.05	2.25	40.70	34.57	10.56	66.1	9.8	175.56
Bracketing	1)	4s	2x	5x	4.5x	3.5x	8.5x	3x	12x
	$\bar{x}^2$)	16	4	25	20.25	12.25	72.25	9	144
Modified Thorington									
Continuous	1)	2s	9.5x	2x	3x	1.5x	6x	3x	11x
	$\bar{x}^2$)	4	90.25	4	9	2.25	36	9	121
Bracketing	1)	1.5s	8s	4.5x	4x	2x	6.5x	3x	9.5x
	$\bar{x}^2$)	2.25	64	20.25	16	4	42.25	9	90.25

Name		MG	CB	JS	RH	TM	LN	BB	CS
Age		24	25	23	32	28	25	23	23
Von Graefe	1)	5x	7x	10.5x	5x	10.5x	6.5x	.5s	3x
	2)	4x	5.5x	10x	4x	11.5x	6x	1.5x	2x
Continuous	3)	5x	4.5x	12x	6x	11.5x	5x	4x	3.5x
	4)	4x	4x	12.5x	2x	12.5x	5x	2x	∅
	$\bar{x}$)	4.5x	5.25x	11.25x	4.25x	11.5x	5.63x	1.75x	2.13x
	$\bar{x}^2$)	20.25	27.56	126.56	18.25	132.25	31.7	3.06	4.54
Alternate	1)	7x	4x	12x	8x	14x	5x	5.5x	1.5x
	2)	6x	3x	11x	7x	14x	4x	5.5x	.5x
	3)	6x	4x	10.5x	7x	14.5x	5.5x	6x	1.5x
	4)	5.5x	3x	10x	7x	15.5x	5x	6x	.5x
	$\bar{x}$)	6.13x	3.5x	10.88x	7.25x	14.5x	4.88x	5.75x	1x
	$\bar{x}^2$)	37.58	12.25	118.37	52.56	210.25	23.81	33.06	1
Bracketing	1)	7x	4x	9.5x	8.5x	15x	5x	4.5x	2.5x
	$\bar{x}^2$)	49	16	90.25	72.25	225	25	20.25	6.25
Maddox Rod	1)	6x	5x	12.5x	7.5x	17x	8x	3x	4.5x
	2)	5x	5x	10x	7.5x	17.5x	8.5x	∅	2x
Continuous	3)	6x	5.5x	12.5x	6.5x	17x	9x	2x	4x
	4)	6x	6x	11x	7x	17x	9.5x	1x	1.5x
	$\bar{x}$)	5.75x	5.38x	11.5x	7.13x	17.13x	8.75x	1.5x	3x
	$\bar{x}^2$)	33.06	28.94	132.25	50.84	293.44	76.56	2.25	9
Alternate	1)	6.5x	6x	11.5x	8x	18.5x	9x	4.5x	4x
	2)	7x	6x	12x	8.5x	17.5x	10.5x	4x	3x
	3)	8x	7.5x	11.5x	8x	18.5x	10.5x	5x	3x
	4)	8x	8x	12.5x	8.5x	17.5x	11x	4.5x	2x
	$\bar{x}$)	7.38x	6.88x	11.88x	8.25x	18x	10.25x	4.5x	3x
	$\bar{x}^2$)	54.46	47.33	141.13	68.06	324	105.06	20.25	9
Bracketing	1)	7.5x	6.5x	12x	7x	17.5x	8.5x	4.5x	5x
	$\bar{x}^2$)	56.25	42.25	144	49	306.25	72.25	20.25	25
Modified Thorington									
Continuous	1)	4.5x	6x	8.5x	7.5x	13x	5.5x	.5x	.5x
	$\bar{x}^2$)	20.25	36	72.25	56.25	169	30.25	.25	.25
Bracketing	1)	4.5x	6x	12.5x	8.5x	13x	6x	1.5x	1.5x
	$\bar{x}^2$)	20.25	36	156.25	72.25	169	36	2.25	2.25

Name		JS	JD	GB	BF	LS	LA	GB	PC
Age		22	25	24	24	24	22	24	23
Von Graefe	1)	1x	7s	10x	3x	8.5x	7x	.5x	1.5x
Continuous	2)	.5x	6s	8x	2x	9x	4.5x	1s	5s
	3)	1.5x	3s	9x	4x	10x	5.5x	1x	2.5s
	4)	1.5x	6s	8.5x	3x	10x	3x	1.5x	8s
	$\bar{x}$)	1.13x	5.5s	8.88x	3x	9.38x	5x	.25x	3.5s
	$\bar{x}^2$)	1.28	30.25	78.85	9	87.98	25	.06	12.25
Alternate	1)	1.5x	1s	9.5x	3.5x	12.5x	10x	2x	5.5s
	2)	2x	5s	9.5x	3x	12x	6x	2.5x	8s
	3)	1.5x	3s	9x	3x	13x	7.5x	2.5x	6s
	4)	1.5x	4s	9.5x	3x	13x	4.5x	2.5x	5s
	$\bar{x}$)	1.63x	3.25s	9.38x	3.13x	12.63x	7x	2.38x	6.13s
	$\bar{x}^2$)	2.66	10.56	87.98	9.8	159.52	49	5.66	37.58
Bracketing	1)	1.5x	1.5s	9.5x	3x	13x	6.5x	2x	4.5s
	$\bar{x}^2$)	2.25	2.25	90.25	9	169	42.25	4	20.25
Maddox Rod	1)	Ø	5s	10x	3x	14.5x	5.5x	6x	10s
Continuous	2)	1s	5s	10.5x	2x	10.5x	4.5x	5x	11s
	3)	1x	3s	10x	2.5x	16.5x	5x	6x	11s
	4)	.5s	5s	10.5x	2x	13.5x	4x	3x	10s
	$\bar{x}$)	.13s	4.5s	10.25x	2.38x	13.5x	4.75x	5x	10.5s
	$\bar{x}^2$)	.02	20.25	105.06	5.66	182.25	22.56	25	110.25
Alternate	1)	2x	1.5s	11.5x	3x	18x	6.5x	5.5x	4s
	2)	2.5x	2.5s	11x	3x	17x	7x	4.5x	5s
	3)	2.5x	2s	11.5x	4x	17x	9x	5.5x	2.5s
	4)	3.5x	4s	11x	4x	17x	10.5x	4x	4s
	$\bar{x}$)	2.63x	2.5s	11.25x	3.5x	17.25x	8.25x	4.88x	4.38s
	$\bar{x}^2$)	6.92	6.25	126.56	12.25	297.56	68.06	23.81	19.81
Bracketing	1)	1.5x	3s	11x	4x	4x	10x	4.5x	2s
	$\bar{x}^2$)	2.25	9	121	16	16	100	20.25	4
Modified Thorington									
Continuous	1)	3x	3s	8x	1x	10x	3x	3x	2s
	$\bar{x}^2$)	9	9	64	1	100	9	9	4
Bracketing	1)	3.5x	1.5s	8x	1.5x	10x	3x	2x	1.5s
	$\bar{x}^2$)	12.25	2.25	64	2.25	100	9	4	2.25

Name		JD	TC	MS	DC	DL	RP	BO	CT
Age		32	26	21	20	24	25	29	28
Von Graefe	1)	9.5x	10x	16x	7x	9.5x	7x	8x	7x
	2)	8x	8x	14x	7x	8x	4x	6.5x	7x
	3)	9x	12x	15x	7x	9.5x	7.5x	8x	7x
Continuous	4)	6x	9.5x	14x	6.5x	8x	2x	5.5x	7x
	$\bar{x}$)	8.13x	9.88x	14.75x	6.88x	8.75x	5.13x	7x	7x
	$\bar{x}^2$)	66.1	97.61	217.56	47.33	76.56	26.32	49	49
Alternate	1)	10.5x	7.5x	16.5x	9x	9x	8x	8.5x	7x
	2)	9.5x	6.5x	16.5x	6.5x	9x	9x	8.5x	4x
	3)	9.5x	6.5x	16.5x	7.5x	9x	8x	8x	6x
	4)	9.5x	6x	16x	6x	9x	7x	8x	5x
	$\bar{x}$)	9.75x	6.88x	16.38x	7.25x	9x	8x	8.25x	5.5x
	$\bar{x}^2$)	95.06	47.33	268.3	52.56	81	64	68.06	30.25
Bracketing	1)	14.5x	7.5x	16.5x	6x	8x	7.5x	6.5x	7x
	$\bar{x}^2$)	210.25	56.25	272.75	36	64	56.25	40.25	49
Maddox Rod	1)	11.5x	7.5x	19x	7.5x	9.5x	9x	11.5x	12x
	2)	9.5x	6.5x	18.5x	7x	9.5x	9x	9.5x	12x
	3)	11.5x	7.5x	19.5x	7.5x	9.5x	8x	9.5x	13x
Continuous	4)	11.5x	6x	19x	7x	9x	9.5x	7.5x	13x
	$\bar{x}$)	11x	6.88x	19x	7.25x	9.38x	8.88x	9.5x	12.5x
	$\bar{x}^2$)	121	47.33	361	52.56	87.98	78.85	90.25	156.25
Alternate	1)	15.5x	8x	19x	7.5x	9.5x	9x	9.5x	12x
	2)	15.5x	6.5x	19x	7.5x	9x	10x	8x	13x
	3)	15.5x	8x	19x	7.5x	9x	9x	8.5x	13x
	4)	15x	7x	19x	7.5x	9.5x	9x	8.5x	13x
	$\bar{x}$)	15.38x	7.38x	19x	7.5x	9.25x	9.25x	8.75x	12.75x
	$\bar{x}^2$)	236.54	54.46	361	56.25	85.56	85.56	76.56	162.56
Bracketing	1)	16x	6x	19x	7.5x	7x	8x	6x	14x
	$\bar{x}^2$)	256	36	361	56.25	49	64	36	196
Modified Tharington									
Continuous	1)	9.5x	4x	--	6x	1x	8x	7x	11x
	$\bar{x}^2$)	90.25	16	--	36	1	64	49	121
Bracketing	1)	10x	4x	--	6x	.5x	6x	6.5x	12x
	$\bar{x}^2$)	100	16	--	36	.25	36	40.25	144

Name		JA	JA	GC	BW	DS	MR	DD	JM
Age		29	24	22	31	26	25	36	24
Von Graefe	1)	10.5x	5s	4.5x	1.5x	2x	3x	12.5x	1x
	2)	10.5x	5s	4.5x	.5x	3s	2x	13.5x	2s
Continuous	3)	10x	4s	4.5x	2x	2x	3x	11.5x	1x
	4)	10x	4s	4.5x	Ø	3s	2.5x	12x	4.5s
	$\bar{x}$)	10.25x	4.5s	4.5x	1x	.5s	2.63x	12.38x	1.13s
	$\bar{x}^2$)	105.06	20.25	20.25	1	.25	6.92	153.26	1.28
Alternate	1)	10.5x	2x	6.5x	3x	4x	5x	8.5x	2x
	2)	9.5x	3s	5.5x	Ø	4x	3.5x	8x	2s
	3)	10x	2s	6x	3x	4x	4x	8x	1s
	4)	10x	3s	6.5x	Ø	4x	3x	8x	1s
	$\bar{x}$)	10x	1.5s	6.13x	1.5x	4x	3.88x	8.13x	.5s
	$\bar{x}^2$)	100	2.25	37.58	2.25	16	15.05	66.1	.25
Bracketing	1)	11.5x	Ø	5x	1x	6.5x	5x	8x	4.5x
	$\bar{x}^2$)	132.25	Ø	25	1	40.25	25	64	20.25
Maddox Rod	1)	10.5x	4s	7x	1.5s	6.5x	5x	11.5x	6x
	2)	10.5x	4s	8x	Ø	2x	5x	11x	5x
Continuous	3)	10.5x	4s	8.5x	.5s	4x	5.5x	10.5x	5x
	4)	11x	4s	8x	2s	4s	6x	10.5x	7x
	$\bar{x}$)	10.83x	4s	7.88x	1s	2.13x	5.38x	10.88x	5.75x
	$\bar{x}^2$)	117.29	16	62.09	1	4.54	28.94	118.37	33.06
Alternate	1)	12x	2s	9x	Ø	6.5x	8x	8.5x	7.5x
	2)	11.5x	2s	8.5x	.5s	5.5x	10x	8.5x	7x
	3)	12.5x	1s	9x	.5s	6x	10x	8.5x	8x
	4)	12x	Ø	9x	2s	5.5x	9x	8.5x	8x
	$\bar{x}$)	12x	1.25s	8.87x	.75s	5.88x	9.25x	8.5x	7.63x
	$\bar{x}^2$)	144	1.56	78.68	.56	34.57	85.56	72.25	58.22
Bracketing	1)	12x	1s	7x	3s	8.5x	7.5x	8.5x	12x
	$\bar{x}^2$)	144	1	49	9	72.25	56.25	72.25	144
Modified Thorington									
Continuous	1)	9x	3.5s	4x	1s	Ø	5.5x	8x	3x
	$\bar{x}^2$)	81	12.25	16	1	Ø	30.25	64	9
Bracketing	1)	9x	2s	4x	1s	2x	5.5x	6.5x	1x
	$\bar{x}^2$)	81	4	16	1	4	30.25	42.25	1

Name		BB	DP
Age		22	46
Von Graefe	1)	2x	2s
	2)	1s	2s
Continuous	3)	1.5x	3s
	4)	2.5s	3s
	$\bar{x}$)	Ø	2.5s
	$\bar{x}^2$)	Ø	6.25
Alternate	1)	1x	3s
	2)	1s	3s
	3)	.5x	3.5s
	4)	1s	4s
	$\bar{x}$)	.13s	3.38s
	$\bar{x}^2$)	.02	11.42
Bracketing	1)	1.5x	1s
	$\bar{x}^2$)	2.25	1
Maddox Rod	1)	Ø	3s
	2)	1.5s	3.5s
	3)	1x	3s
Continuous	4)	.5s	4s
	$\bar{x}$)	.25s	3.38s
	$\bar{x}^2$)	.06	11.42
Alternate	1)	3x	3s
	2)	2.5x	3s
	3)	2.5x	4s
	4)	2x	4s
	$\bar{x}$)	2.5x	3.5s
	$\bar{x}^2$)	6.25	12.25
Bracketing	1)	.5x	3s
	$\bar{x}^2$)	.25	9
Modified Thorington			
Continuous	1)	.5x	.5s
	$\bar{x}^2$)	.25	.25
Bracketing	1)	.5x	Ø
	$\bar{x}^2$)	.25	Ø

Three way analysis of variance

Assumption: all populations used possess equal variances

number of samples (i) = 3

number in each sample (n_i) = 50

number analyzed (n) = 150

y_{ij} = measured response on the j^{th} experiment unit in the i^{th} sample

T_i = total and $\bar{T}_i$ = mean of observations in the i^{th} sample

Equations used:

correction for the mean (CM) = $\dfrac{\left[\sum_{i=1}^{p} \sum_{j=1}^{n_i} y_{ij}\right]^2}{n}$

Total sum of squares (Tot SS) = $\sum_{i=1}^{p} \sum_{j=1}^{n_i} y_{ij}^2 - CM$

SS for treatments (SST) = $\sum_{i=j}^{p} \dfrac{T_i^2}{n_i} - CM$

SS for errors (SSE) = Tot SS - SST

Mean square for treatment (MST) = $\dfrac{SST}{i-1}$

Mean square for error (MSE) = $\dfrac{SSE}{n-i}$

F test $F = \dfrac{MST}{MSE} > F_{\alpha}$

where F_{α} is the critical value of F for probability of a type I error, α.

Group I

1) Continuous presentation (VGC/MRC/MTC)

$CM = \frac{679,140.61}{150} = 4527.61$

Tot SS= 7064.42-4527.61= 2536.82

SST= 4610.6-4527.61= 82.99

SSE= 2536.82-82.99= 2453.82

$MST = \frac{82.99}{2} = 41.50$

$MSE = \frac{2453.82}{147} = 16.69$

$F = \frac{MST}{MSE} = 2.49$; the critical value of $F_{.05} = 3.00$

therefore the null hypothesis is accepted

and VGC=MRC=MTC

2) Alternate presentation (VGA/MRA)

A two way analysis of variance

$CM = \frac{420,811.69}{100} = 4208.12$

Tot SS= 5983.93-4208.12= 1775.81

SST= 4271.64-4208.12= 63.52

SSE= 1775.81-63.52=1712.29

$MST = \frac{63.52}{1} = 63.52$

$MSE = \frac{1712.29}{98} = 17.47$

$F = \frac{63.52}{17.47} = 3.64$; the critical value of $F_{.05} = 3.84$

therefore the null hypothesis is accepted

and VGA=MRA

3) Bracketing (Flash) presentation (VGB/MRB/MTB)

A) 3 way analysis of variance

$CM = \frac{870,489}{150} = 5803.26$

Tot SS= 7629- 5803.26= 1825.74

SST= 5996.13- 5802.26= 192.87

SSE= 1825.74-192.87= 1632.87

$MST = \frac{192.87}{2} = 96.44$

$MSE = \frac{1632.87}{147} = 11.11$

$F = \frac{96.44}{11.11} = 8.69$; the critical value of $F_{.05} = 3.0$

therefore the null hypothesis is rejected

and VGB≠MRB≠MTB

B1) (VGB/MRB) 2 way analysis of variance

$CM = \frac{483,720.25}{100} = 4837.2$

Tot SS= 5831.25-4837.2= 994.05

SST= 4868.01-4837.2= 30.81

SSE= 994.05- 30.81= 963.24

$MST = \frac{30.81}{1} = 30.81$

$MSE = \frac{963.24}{98} = 9.83$

$F = \frac{30.81}{9.83} = 3.13$; the critical value of $F_{.05} = 3.84$

therefore the null hypothesis is accepted

and VGB=MRB

B2) (VGB/MTB) 2 way anlysis of variance

$CM = \frac{310,806.25}{100} = 3108.06$

Tot SS= 4229.75 3108.06= 1121.69

SST= 3176.13-3108.13= 68.07

SSE= 1121.69-68.07= 1053.62

$MST = \frac{68.07}{1} = 68.07$

$MSE = \frac{1053.62}{98} = 10.75$

$F = \frac{68.07}{10.75} = 6.33$; the critical value of $F_{.05} = 3.84$

therefore the null hypothesis is rejected

and VGB≠MTB

B3) (MRB/MTB) 2 way analysis of variance

$Cm = \frac{375,769}{100} = 3757.69$

Tot SS= 5197-3757.69= 1439.31

SST= 3948.13-3757.69= 190.44

SSE= 1439.31-190.44=1248.87

$MST = \frac{190.44}{1} = 190.44$

$MSE = \frac{1248.87}{98} = 12.74$

$F = \frac{190.44}{12.74} = 14.95$; the critical value of $F_{.05} = 3.84$

therefore the null hypothesis is rejected

and MRB≠MTB

Group II

1) Von Graefe with various techniques (VGC/VGA/VGB)

$Cm = \frac{745,804.96}{150} = 4972.03$

Tot SS= 6827.03-4972.03= 1855

SST= 5009.46-4972.03= 37.43

SSE= 1855-37.43= 1817.57

$MST = \frac{37.43}{2} = 18.72$

$MSE = \frac{1817.57}{147} = 12.36$

$F = \frac{18.72}{12.36} = 1.5$; the critical value of $F_{.05} = 3.00$

therefore the null hypothesis is accepted

and VGC=VGA=VGB

2) Maddox Rod with various techniques (MRC/MRA/MRB)

$CM = \frac{1,135,716}{150} = 7571.44$

Tot SS= 10266.08- 7571.44= 2694.64

SST= 7598.36-7571.44= 26.92

SSE= 2694.64-26.92= 2667.72

$MST = \frac{26.92}{2} = 13.46$

$MSE = \frac{2667.72}{150} = 18.45$

$F = \frac{13.46}{18.45} = .73$; the critical value of $F_{.05} = 3.00$

therefore the null hypothesis is accepted

and MRC=MRA=MRB

3) Modified Thorington with various techniques (MTC/MTB)

2 way analysis of variance

$CM = \frac{227,052}{100} = 2270.52$

Tot SS= 4584.25-2270.52= 1313.73

SST= 2270.55-2270.52= .03

SSE= 1313.73-.03= 1313.7

$MST = \frac{.03}{1} = .03$

$MSE = \frac{1313.7}{98} = 13.41$

$F = \frac{.03}{13.41} = .00$; the critical value of $F_{.05} = 3.84$

therefore the null hypothesis is accepted

and MTC=MTB

CONCLUSION

Often practitioners are strapped into a particular routine, unable or unwilling to change techniques for fear of contaminating their analysis. The authors hope that this paper will enable the practitioner to enlarge his battery of tests so that he may enjoy a flexibility to choose from various techniques available with confidence in their reliability.

The authors have found that a practitioner may use any technique on a specific method without obtaining a significant change in phoria at the .05 level. Furthermore, it was found that if a practitioner enjoys either a continuous , or alternating technique, he may use that technique with either the Von Graefe, Maddox Rod, or Modified Thorington with assurance that the findings, obtained will be reliable. However, it was found that if one uses the bracketing or flash technique, then he must be careful of the method employed. Von Graefe and Maddox Rod methods with the bracketing technique present no significant differences but they both differ significantly at the .05 level with the bracketing or flash technique on the Modified Thorington test.

BIBLIOGRAPHY

1. Barnett, John P., Sedway, Marvin M. "A Comparison of the Reliabilities of the Maddox Rod and Von Graefe Phoria Techniques" Optometric Doctoral Thesis, Pacific University College of Optometry 1954
2. Harrier, Donald; Kautz, AlVerne S. "A Comparison Study Between the Von Graefe and Maddox Rod Techniques at Far and Near" Optometric Doctoral Thesis, Pacific University College of Optometry 1960
3. Hirsch, Monroe J. "Clinical Investigation of a Method of Testing Phoria at 40 Centimeters" Am. J. Opt. Oct. 1948 25:492-495
4. Hirsch, MonroeJ., Bing, Lois B. "The Effect of Testing Method on Values Obtained for Phoria at 40 Centimeters" Am. J. Opt. Sept. 1948 25;407-416
5. Jacobs, Merci A., Landry, Earl J. "Phoria Measurements at Near with Three Different Target Designs" Optometric Doctoral Thesis, Pacific University College of Optometry 1969
6. Litts, Harry J., Rabbi, Ronnie "Phoria Measurements at Near With Varying Orientation of Line Segments in the Target" Optometric Doctoral Thesis, Pacific University College of Optometry 1966
7. Mendenhall, William. Introduction to Probability and Statistics, Third Edition Copyright 1971 pps. 336-339, 422-424
8. Morris, Floyd M. "The Influence of Kinesthesis upon Near Phoria Measurement" Am. J. Opt. July 1970 37:327-351

9. Scobee, Richard G., Green, Earl L. "Tests for Heterophoria- Reliability of Tests, Comparisons Between Tests, and Effect of Changing Testing Conditions" Transactions Am. Acad. of Ophth. and Otol. Jan.-Feb. 1947 p. 179-197