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Effects of task complexity on dynamic retinoscopy observations

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Abstract

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Effects of Task Complexity on Dynamic Retinoscopy Observations

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Introduction

We became interested in whether task complexity and problem solving tasks influences accommodative response as studied by dynamic retinoscopy from the lecture of Skeffington[1] and Haynes[2]. Dr. Skeffington discribed changes in retinoscopy when translating English words to Greek, and when doing complex problems solving tasks. He appeared convinced that "book retinoscopy" procedures were very important in studying complex intellectual activities. Haynes' lectures reviewing the literature as well as his own work with dynamic retinoscopy stated that the problem was still very much open to serious question. The clinical observation of less with movement or more against motion during various problem solving tasks has been widely reported in clinical discussion in the past ten years. These clinical reports pose a number of problems. 1. Can we establish concomitant changes in retinoscopy observations while the subject changes from a simple to a complex task? 2. What operational definition can be used to differentiate between a simple or complex visually directed task? 3. If changes in motion or color are concomitant with task complexity, what mechanisms are responsible for the retinoscopic observations? 4. Does the movement from "with" to "against" motion represent a valid appraisal of the changes in the accommodative posture during the specific task in question? 5. Are the changes in motion made as adaptive movements, thus improving the optical definition of the proximal stimulus? Therefore are the movements of accommodation used to facilitate visual discrimination? 6. Are changes in motion concomitant with increased central nervous system activity mediated by changing from a simple inspection task to a complex problem, but not directly related to discrimination of form and size?

The frequent observation of 'against motion' reported by previous investigators has been investigated by Haynes.[3] "In my opinion, the frequent reporting of 'against motion' may be explained as errors in measurement resulting from inadequate control of a number of physical variables. The major physical and optical variables which influence the observations by the examiner may be summarized as follows: "1. Task to retinoscope aperature distance. 2. Task to subject distance. 3. Retinoscope to subject eye distance. 4. Obliqueness of central ray of retinoscope beam with line of sight. 5. Physical characteristics of retinoscope emergent light. 6. Optical characteristics of corneal surface. 7. Pupil size. 8. Surface and index characteristics of the crystalline lens. 9. Physical characteristics of reflectiveness of posterior of eye. 10. Aberrations of the eyes, and 11. Distance and orientation of neutralizing lens."[4]

Studies have been made of the pupil diameter in relation to task complexity. It was found that the pupil dilates when difficult material is presented via the auditory mechanism. "Two distinct phases are apparent in the pupillary response to this immediate memory task: a loading phase during which the pupil dilates with every digit heard, and an unloading phase during which the pupil constricts with every digit reported. ....Hess and Polt had concluded that changes of accommodation do not account for the effects of mental activity on the pupil. However, we were impressed by the subjective feeling reported by many subjects that the visual field apparently becomes blurred during those stages of memory tasks where pupillary diameter is at its maximum."[5]

Problem

To observe if there is a change in motion in dynamic retinoscopy with a change in the complexity of a nearpoint task that is independent of other variables.

In attempting to design an experiment to study if retinoscopic changes were concomitant with task complexity we set up the following conditions: 1. Optical variables must be controlled. 2. Fixation must be kept within 4-5 degrees of the task during all retinoscopic observations. 3. The complex task must be clearly recognizable as more difficult than the simple task. 4. The simple and complex task must take sufficient time to allow adequate retinoscopic observations. 5. The discrimination requirements relative to visual acuity must be the same in both the simple and complex task.

The use of words in the target design failed to produce a definite criteria between a simple task and a complex task--what may be considered a difficult word for one subject may be simple for another, therefore, not representing universal complexity.

The use of mathematical problems failed to keep the subjects fixation on the plane of regard.

The target which met the above requirements was designed as follows: As shown in sketch II, the design consists of a continuous circle of circles. It is used for both the simple task and the complex task--the difference being the instructions given by the examiner which eliminates changing cards. The simple task consists of counting the number of circles and the complex task is solving the rotation of various circles if the adjacent circles are rotated in a specific direction. Acuity discrimination is liminal and constant; the two tasks require fixation at the plane of regard continually; and the task complexity is great enough to allow sufficient time for retinoscopic observations.

The starting point of the observations was set at low neutral minus .25D leaving a slight with motion. If the subject was left in a great deal of with motion we would anticipate a decrease in with motion but no quantitative data could be obtained other than just a decrease in motion. The same applies if the subject was left in against motion. If the subject was left in a neutral motion it would be possible for the change to be .25D to .50D before any change would be noted as shown by the differences obtained in successive low neutral findings. Low neutral minus .25D allows the observation of relative small changes in either direction--positive if moved to neutral, and negative if increased with motion. Also, it precludes changes made on the basis of response of accommodation to produce a better optical definition of the proximal stimulus with a target of 20/100 or better.

Experimental Conditions

1. Subjects---Twenty-one non-presbyopic subjects from the student body of Pacific University. Each subject was unaware of the purpose or technique involved before hand. This was done to control any pre-experimental bias preceeding the experiment. Each subject was capable of standard acuity at twenty feet and sixteen inches through his habitual glasses or plano if an emmetrope.

2. Illumination--During the Static Retinoscopy illumination in the room approximated 2 foot-candles. The near-point task was conducted under an illumination of 5 foot-candles at the target plane. This illumination was constant for all near tasks.

3. Neutralizing lenses--Those of a Bausch and Lomb Green's phoropter.

4. Target Distance--Measured from the standard scale of a Bausch and Lomb near-point rod. It was maintained at a constant twenty inches.

5. Interpupillary Distance--The pd was set according to the distance of the visual task. The far pd for the static retinoscopy, and the near pd for the near tasks.

6. Scope---A.O. retinoscope with a plano lens system was used throughout the experiment.

Procedure

The procedure followed with each subject was:

1. Subject was brought into refracting room B-8 in the Pacific University Clinic and seated in the chair. After customary procedures of pd and phoropter adjustments a routine #4 (static retinoscopy) was performed with the patient fixating an 20/300 E chart. This was done for axis and cylinder and sphere power.

2. The phoropter light was turned on and projected behind the patient. This gave approximately 5 foot-candles of illumination at the target plane of twenty inches.

3. A low neutral finding was taken at twenty inches with the patient fixating the card displayed on illustration No 1. This low neutral was first performed by the subject looking at the X on top of the card and then performed with the subject reading the paragraph below the X. If a difference was observed the finding was recorded as the average of the two.

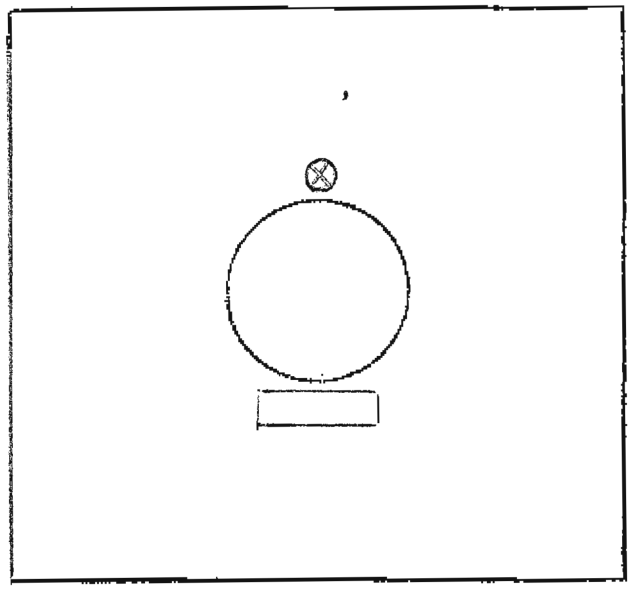
4. After the low neutral was determined we presented the task nearpoint card and the subject was given the simple counting task instructions. The task was started with the low neutral finding from the paragraph and X card. During the simple task the observer noted any change in motion.

5. After determining any change with the simple task, the complex task was given and any change in motion was noted. The time interval from the beginning of the counting task to the end of the complex task was timed and recorded.

6. All lenses were removed from the phoropter and the habitual Rx in place, the complex task instructions were given and the motion of the reflex was was observed and recorded. These instructions were the same as the original complex instructions with the exception that animal moved in opposite direction.

Sketch I

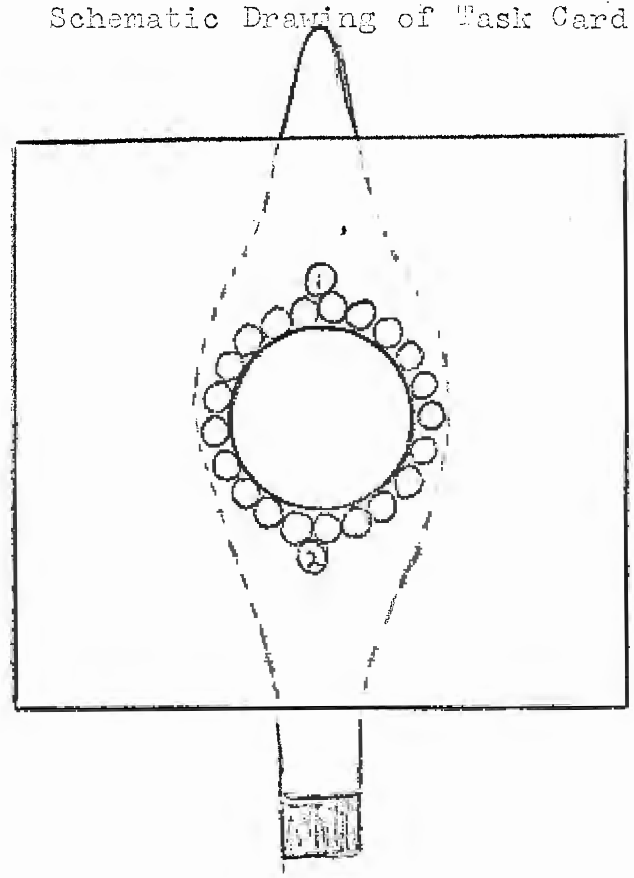
Schematic Drawing of low neutral target #1



Circle at top of card subtends approximately 20/200 and paragraph at bottom approximately 20/100. Circle at top of card is exactly the same size as our task card display. This circle has an X extending the full diameter, in order to maintain fixation while determining the low neutral.

Sketch II

Schematic Drawing of Task Card # 2



Card consists of 23 circles arranged in a circular pattern. Each circle subtends approximately 20/200 visual angle. Circles numbered 1 & 2 are the reference points used in outlining the complex task.

INSTRUCTIONS

1. Static Retinoscopy #4

   A. "Look at the big letter E on the Wall, do not pay any attention to the light I am going to shine in your eye."

2. Low Neutral

   A. "Look at the X in the top circle."

   B. "Now read the paragraph below."

   C. "Look at the X in the top circle again."

3. Simple Counting Task

   A. "Do you see a group of circles?"

   B. "Do you see a circle with a number 1 in it, and a circle with a number 2 in it?"

   C. "Count the number of circles on the card?"

4. Complex Task

   A. "Now if we were to assume that each of these circles represents an individual gear, and that gear No. 1 is being turned by an animal running from left to right within the gear, in what direction will gear No. 2 be turning.

R E S U L T S

Table I displays the data obtained on twenty-one subjects. Column #1 represents the static retinoscopy (#4). Column # 2 the low neutral with the LN target #1. Column #3 represents the simple task determined with the task card. Column #4 the complex task determined with the task card. Column #5 the low neutral also determined with the task card. Column #6 the measured time interval between the beginning of the simple task and completion of complex task. Column #7 the reported habitual motion under conditions of task complexity.

Representation of neutral points.

LN_1 = Low Neutral finding at 20" determined with low neutral card.

LN_2 = Neutral point of the simple task at 20" determined with task card.

LN_3 = Neutral point of complex task at 20" determined with task card.

LN_4 = Low Neutral finding obtained after completion of the complex task with task card.

Inspection of Table I and the respective Graphs yield the following information.

1. 21 of 21 observations of the change in motion from the static retinoscopy finding to the LN_1 were in the positive direction, changing from a slight with to a neutral or against motion. No observations were in the negative direction or showed no change.

a) Graph I displaying the frequency distribution of these results show a change in the magnitude of the motion extending through a range of +.25D to +2.25D. The most frequently occurring magnitude being +.75D.

2. 7 of 21 observations of the change in motion from LN_1 to LN_2 were in the positive direction. 13 of 21 showed no change, and 1 of 21 were in the negative direction.

a) Graph II displaying the frequency distribution of these results show a change of the magnitude of the motion extending through a range of no change to +.25D. The most frequent occurring magnitude was plano.

3. 18 of 21 observations of the change in motion from LN_2 to LN_3 were in the positive direction. 3 of 21 showed no change, and in no instance was there a change in the negative direction.

a) Graph IV displaying the frequency distribution of these results show a change in the magnitude of motion extending through no change to +.50D. The most frequently occurring magnitude was +.25D.

4. 18 of 21 observations of the change in motion fromm LN_1 to LN_3 were in the positive direction. 3 of 21 showed no change and in no instance was there a change in the negative direction.

a) Graph III displaying the frequency distribution of these results show a change in the magnitude of motion extending from no change to +.75D. The most frequent occurring magnitude was +.25.

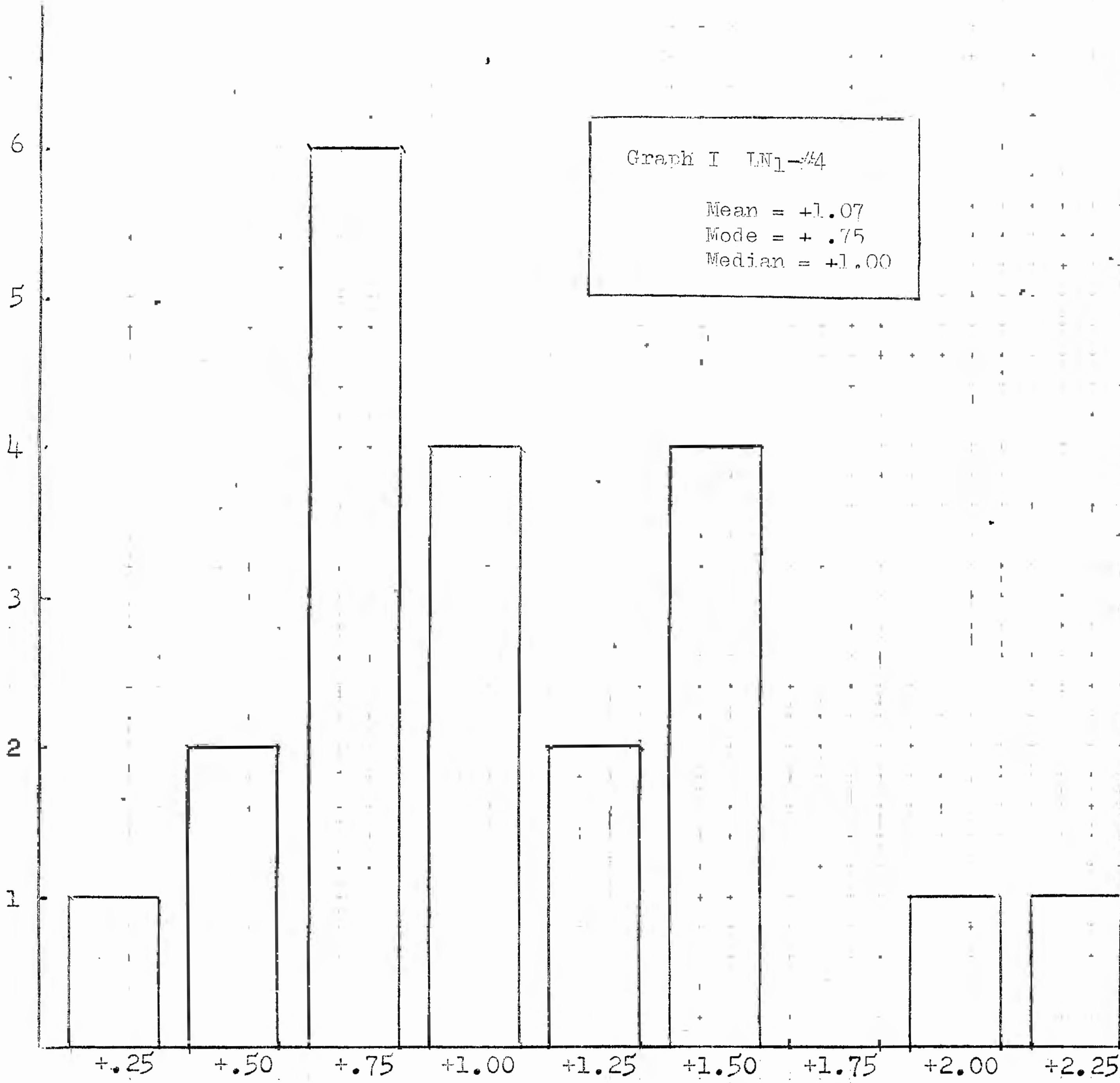
5. 21 of 21 observations of the LN_1 and the LN_4 showed no change in the magnitude of the neutral point.

TABLE I

NAME	STATIC RETINOSCOPY	LOW NEUTRAL	SIMPLE TASK	COMPLEX TASK	LOW NEUTRAL	TIME	HABITUAL MOTION
B.K.	O.D. pl -50x90	+50	+ 50'	pl	+50		CHANGED
	O.S. +25 -75x90	+75	+ 75	+50	+75	2'35"	LESS WITH
C.S.	O.D. -25	+50	+25	pl	+50		
	O.S. pl	+75	+50	+25	+75	2'	LESS WITH
S.G.	O.D. -75	pl	pl	pl	pl		LIGHTER
	O.S. -50	+25	+25	+25	+25	2'20"	NO CHANGE
J.J.	O.D. +25	+1.75	+1.75	+1.25	+1.75		
	O.S. +25	+1.75	+1.75	+1.25	+1.75	2'10"	LESS WITH
S.R.	O.D. -50	+1.25	+1.00	+.75	+1.25		
	O.S. -50	+1.25	+1.00	+.75	+1.25	2'25"	LESS WITH
L.R.	O.D. +50	+2.00	+1.75	+1.50	+2.00		
	O.S. +75	+2.25	+2.00	+1.75	+2.25	2'30"	NO CHANGE
A.L.	O.D. -25	+1.00	+75	+25	+1.00	2'45"	
	O.S. pl	+1.25	+1.00	+50	+1.25		LESS WITH
A.J.	O.D. +50 -50x180	+1.75	+1.75	+1.50	+1.75		
	O.S. +75	+2.00	+2.00	+1.75	+2.00	2'10"	NO CHANGE
A.H.	O.D. -50 -50x165	+50	+.75	+.25	+.50		FASTER MOTION
	O.S. pl - 25x90	+75	+1.00	+.25	+.75	2'	LESS WITH
D.W.	O.D. +25 -1.oox120	+1.00	+1.00	+1.00	+1.00		
	O.S. pl -50x90	+75	+75	+75	+75	2'50"	NO CHANGE
M.R.	O.D. pl	+1.00	+1.00	+75	+1.00		
	O.S. pl	+1.00	+1.00	+75	+1.00	2'40"	NO CHANGE
C.P.	O.D. -4.25	-2.75	-2.75	-3.25	-2.75		
	O.S. -3.75	-2.25	-2.25	-2.75	-2.25	2'25"	NO CHANGE
L.C.	O.D. -25 -25x90	+50	+50	+25	+50		
	O.S. -50 -50x90	+75	+75	+50	+75	2'40"	LESS WITH
C.M.	O.D. +75 -50x180	+1.25	+1.25	+1.00	+1.25	2'30"	
	O.S. +1.00 -50x180	+1.50	+1.50	+1.25	+1.50		NO CHANGE
N.B.	O.D. -2.00	-1.25	-1.25	-1.25	-1.25		
	O.S. -3.00 -75x90	-2.25	-2.25	-2.25	-2.25	2'50"	NO CHANGE
D.W.	O.D. Plano	+1.00	+1.00	+.75	+1.00		
	O.S. +25-50x90	+1.25	+1.25	+1.00	+1.00	2'	No CHANGE

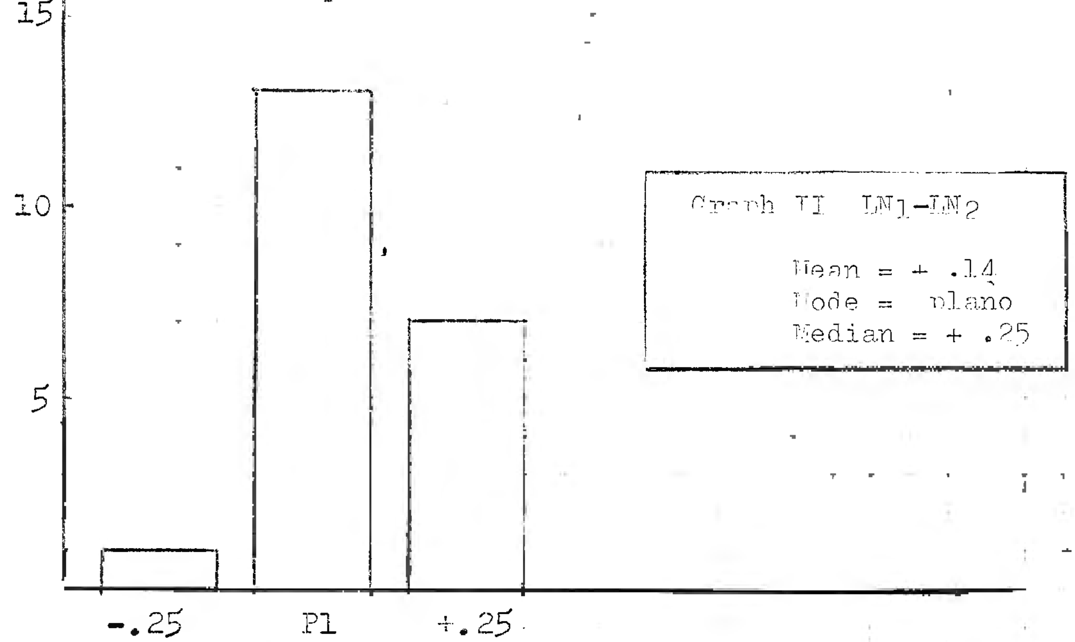
NAME	STATIC RETINOSCOPY	LOW NEUTRAL	SIMPLE TASK	COMPLEX TASK	LOW NEUTRAL	TIME	HABITUAL MOTION
	O.D. -3.50	-1.50	-1.75	-2.25	-1.50		NO
S.P.	O.S. -3.50	-1.50	-1.75	-2.25	-1.50	2'30"	CHANGE
	O.D.+1.00 -1.50x90	+3.25	+3.00	+2.50	+3.25		No
E.S.	O.S.+1.00 -1.00x90	+3.25	+3.00	+2.50	+3.25	2'30"	CHANGE
	O.D. -25	+1.25	+1.00	+.75	+1.25		CHANGE
D.B.	O.S. -25	+1.25	+1.00	+.75	+1.25	2'40"	LESS WITH
	O.D. +50	+1.25	+1.25	+1.00	+1.25		SLIGHTLY
S.N.	O.S. +50	+1.25	+1.25	+1.00	+1.25	2'10"	LESS MOTION
	O.D. pl	+1.00	+1.00	+.75	+1.00		
S.G.	O.S. -25	+.75	+.75	+.50	+.75	2'20"	LESS WITH

Graph No. I



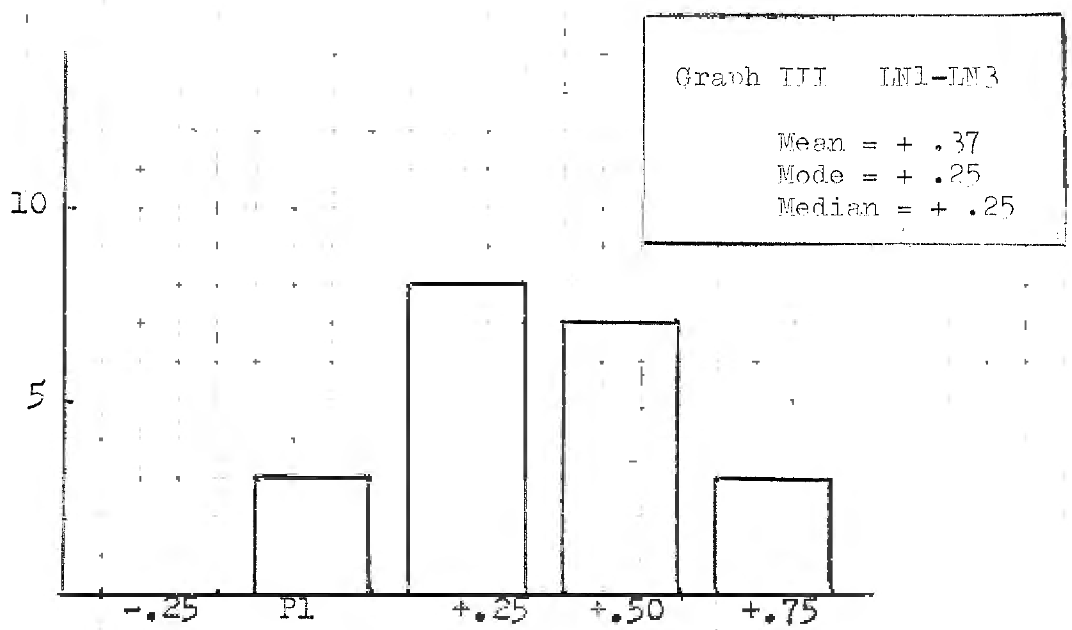
FREQUENCY DISTRIBUTION OF THE DIFFERENCE BETWEEN LOW NEUTRAL(LN_1) AND STATIC RETINOSCOPY

Graph No. II



FREQUENCY DISTRIBUTION OF THE DIFFERENCE BETWEEN LOW NEUTRAL (LN1) AND LOW NEUTRAL SIMPLE TASK

Graph No. III

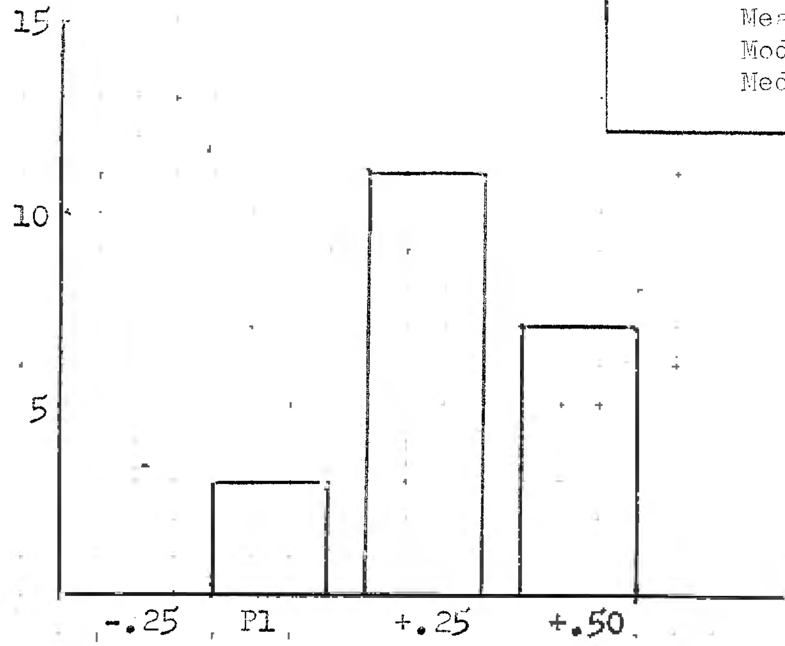


FREQUENCY DISTRIBUTION OF THE DIFFERENCE BETWEEN LOW NEUTRAL LN1) AND LOW NEUTRAL COMPLEX TASK

Graph No. IV

Graph IV LN2-LN3

Mean = + .30
Mode = + .25
Median = + .25



FREQUENCY DISTRIBUTION OF THE DIFFERENCES BETWEEN LOW NEUTRAL SIMPLE TASK AND LOW NEUTRAL COMPLEX

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TABLE II

TABLE OF DIFFERENCES

	LN1 - #4	LN1 - LN4	LN1 - LN2	LN1 - LN3	LN2 - LN3
-.25			1		
.pl		21	13	3	3
+.25	1		7	8	11
+.50	2			7	7
+.75	6			3	
+1.00	4				
+1.25	2				
+1.50	4				
+1.75					
+2.00	1				
+2.50	1				

Difference(diopters)/ frequency

LN1-#4 ....Difference between initial low neutral and the static retinoscopy
LN1.......Initial low neutral finding
LN2.......low neutral of the simple counting task
LN3 ......Low neutral of the complex task
LN4.......Low neutral determined after complex task

D I S C U S S I O N   O F   R E S U L T S

There was little change or variation in the retinoscopic observations for each individual during the approximate two minutes that was involved in the simple and complex task. This was checked by estimating the amount of change in the motion without lense additions; determining the magnitude of change(in diopters) required to neutralize the motion under conditions of the complex task; and then determining the magnitude of change needed to obtain a neutral motion under conditions of Low $Neutral_4$.

Further observations, involved observing the change in motion with the habitual lens in place. The conditions under which these observations where made was identical with those previously discussed except the complex task involved a rotation of circle#2 and a corresponding rotation of circle #1 rather than a rotation of circle #1 and a corresponding rotation of #2. Under these circumstances we could not differentiate changes as a function of task complexity from an adaptive movement to produce better imagery on the retina. This change in motion was never found to increase in to an against motion.

In concluding this discussion we would like to state that under these testing conditions we feel very confident that with a change in task complexity there was a definite change in the observed motion, being from a slight 'with' or neutral to a small against motion.(.50 maximum). We would further add that the magnitude of this change was found never to vary more than +.75D or less than the low neutral already obtained. This magnitude of change is much less than the limits imposed by the depth of focus of the eyes when viewing a target subtending an angle equal to or greater than 20/100, which approximates a depth of focus of $\pm$ 1.50.

Consideration of the pupil changes during the presentation of difficult material via the auditory mechanism may be given as a possible explaination of the observed change in motion. As discussed earlier, during the loading phase of pupillary response there is a dilation of the pupil. If there was a similiar dilation during visual loading this enlargement of the pupil may give an apparent decrease in the amount of 'with' motion. The magnitude of change which would be expected to occur under these conditions would seem to approximate that found in our observations, and therefore has to be considered as a possible explanation of the observed change in motion.

The magnitude of change observed under these testing conditions was found to be considerably less than that reported by previous clinicial observations. This poses considerable doubt that the magnitude of the change of motion reported previously can be solely attributed to a change in task complexity, intellectual activity or a search for meaning.

Summary

This study demonstrated a change in motion from a slight with or neutral motion to a slight against motion when the complexity of the nearpoint task is increased.

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1. Skeffington Lectures--Northwest Congress--December 1966.

2. Clinical Observations With Dynamic Retinoscopy by Harold M. Haynes, O.D. Pacific University, October 27, 1960.

3. Ibid

4. Ibid

5. Pupil Diameter and Load on Memory--by Daniel Kahneman and Jackson Beatty, Science Vol. 154, December 23, 1966.