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A study of astigmatic lenses on digit recognition under tachistoscopic conditions.

Abstract
A study of astigmatic lenses on digit recognition under tachistoscopic conditions.

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Committee Chair
Harold M. Haynes

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A STUDY OF ASTIGMATIC LENSES ON DIGIT RECOGNITION UNDER TACHISTOSCOPIC CONDITIONS.

A FIFTH YEAR THESIS

PRESENTED TO THE FACULTY

OF

THE COLLEGE OF OPTOMETRY

PACIFIC UNIVERSITY

BY

DANIEL W. BERRY

RANDALL K. COREY

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IN PARTIAL FULFILLMENT

OF THE REQUIREMENT FOR THE

DEGREE DOCTOR OF OPTOMETRY

DECEMBER 1966

FACULTY SPONSOR

PROFESSOR HAROLD M. HAYNES

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We would like to express our sincere appreciation to Dr. Harold M. Haynes for his guidance and assistance in this thesis.

We also wish to thank the persons who patiently cooperated with us in this study.

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INTRODUCTION

During one of the lectures given by Professor Haynes,[1] the question of the influence of uncorrected astigmatic errors on digit recognition was raised. Professor Haynes stated that he had on occasion demonstrated the importance of prescribing cylinder in uncorrected astigmatism using a tachistoscope. The demonstration consisted of using plus cylinder lenses to induce astigmatism and then measuring their effect on digit recognition under tachistoscopic flash. From these demonstrations it appeared that even small amounts of induced astigmatism caused a reduction in digit recognition. He felt that there was a need for controlled research in this area. We became interested in determinig whether the incorporation of an astigmatic correction in a prescription would be of significance in digit recognition under controlled tachistoscopic conditions.

A review of the optometric literature in this area of study produced only one article which was related to the problem. Walton and Schubert, conducted a study to determine the effect of induced myopia on far point perception.[2] The two most important conclusions which were drawn from their study were: 1.) a half diopter of induced myopia results in a decrement of visual performance with every letter size used in the study.

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1. Harold M. Haynes, Unpublished lecture notes from his Optometry V course.

2. Walton, Howard N., and Schubert, Delwyn N., "Induced Myopia and Far Point Perception", American Journal of Optometry and Archives, May 1965, p. 311.

2.) Maximum visual acuity is essential for far point tachistoscopic training as well as other environmental distance seeing.

PROBLEM

This experiment was designed to study the effect of optically induced astigmatism on digit recognition under tachistoscopic viewing conditions. This approach constitutes an initial attack on the more general hypothesis of Professor Haynes[3] that induced or uncorrected astigmatism degrades digit, letter, and word recognition by either increasing the frequency of errors or necessitating the increase of exposure time.

3. *op. cit.*, Haynes

EXPERIMENTAL DESIGN

Each subject was pretested to determine their digit span. The subject was shown ten exposures each of 6, 5, and 4 digit slides at an exposure of 1/25th second. The group in which the subject achieved 70% correct was the level at which he was tested. If the subject could not achieve 70% of the 4 digit slide group he was excluded from the study.

The lenses used were plano, +.50, +1.00, +1.50, axis 180 degrees combined with their negative spherical equivalent. The lenses were placed in a trial frame. Two lenses were placed in each lens well, so there were no clues as to the power of the lenses used during the experimental sequence.

The test was presented twice to each subject. The order of presentation on sequence A was plano, +.50, +1.00, +1.50 and plano. For sequence B the order was plano, +1.50, +1.00, +.50 and plano, The plano lenses were used twice in each sitting to determine if a practice effect was present. The two sequences were used to determine if the sequence itself was a variable. There were two sittings with each subject. Every other subject was started with sequence B, while the remainder were started with sequence A.

Twelve subjects were selected on the basis of cover test, case history, refractive and performance criteria.

In the case history we determined name, age, health history (both medical and dental), and visual history. Subjects with any indication of pathological disorders or who were under the influence of any medication wer excluded from the study. Specific questions asked in the visual history were:

1. Have you ever worn glasses, and for how long?
2. What were they prescribed for?
3. Have you had surgery and/or visual training, and if so, for what?
4. How would you describe your visual health?

A cover test was performed at far and near. Any tropic responses were grounds for rejectioh. The phoria limitations were:

1. 3 p.d. esophoria or 3 p.d. exophoria at the far point.
2. 1 esophoria or 9 exophoria at the near point.
3. Vertical imbalance greater than 1 prism diopter.

Refractive conditions considered as basis for rejection were:

1. Uncorrected astigmatism greater than .50D.
2. Corrected astigmatism more than 1.50D.
3. Astigmatic axis other than 90 or 180 ± 30.
4. Hyperopia greater than three diopters or myopia greater than five diopters.
5. Uncorrected anisometropia of .50D or more.
6. Corrected anisometropia of 1.50D or more.

The subjects had to meet all of the above criteria to be accepted as a subject. We also considered physical variables in establishing the design of our experiment. The physical variables controlled and the method withwhich they were controlled is as follows:

1. Spacing of the digits was constant.

2. Black letters on a white background.

3. The digits were flashed in a horizontal line and at the egocentric position for each subject.

4. Letter size of 20/100 was chosen so that the letter size would be above the threshold of acuity through the various astigmatic lenses.

5. The viewing distance was held constant at four meters.

6. The control lens was determined by first performing the far cross cylinder accommodative finding from the plus side. The subject was then given a near reading task and the far cross cylinder was again performed, this time from the minus side. The dioptric midpoint of the plus and minus side of the far cross cylinder accommodative finding was used as our control lens. This was done to simulate the accommodative posture during the testing, as the subject looked from the screen to the paper and back to the screen again.

7. A set of four diagonal lines was used as a fixation and gross accommodative control.

8. Illumination was held constant for all subjects. This was room illumination and foot candles from the projector. The illumination from the testing screen was

9. Exposure time was constant at 1/25th second.

10. Written response was used to facilitate error analysis.

11. Ten exposures per lens were used. Therefore, fifty exposures per sitting were flashed.

12. Instructions given were always given in the following manner:

    a. The subject was given a pencil and paper. He was then shown the fixation control on the screen at his egocentric position.

    b. "I am going to show you some digits. Write them on your paper. If you are not sure what you say I want you to guess."

    c. Verbal instructions of "Ready, set, now!" were given, followed by the exposure. The interval between "ready, set, now" and exposure was one second.

EQUIPMENT

We used the Kaystone Overhead Projector with a tachistoscopic attachment. Our slides were the standard Keystone digit slides. A rectangular white screen with four diagonal lines was used as a fixation and accommodative control. A trial frame was used to hold the various lenses. The lenses used were standard trial case lenses.

RESULTS

In analyzing our findings we calculated the group mean and median of the percent correct with each lens (Graph I and II). A correct response was the identification of all the digits in the proper sequence. The median was considered to be a more representative form of analysis due to the small number of subjects tested. We then considered the total number of errors made with each lens. (Graph III). Graph IV represents the total number of individual error types with each lens. Graph V represents the percent of total errors, by the individual error types, for the various astigmatic lenses.

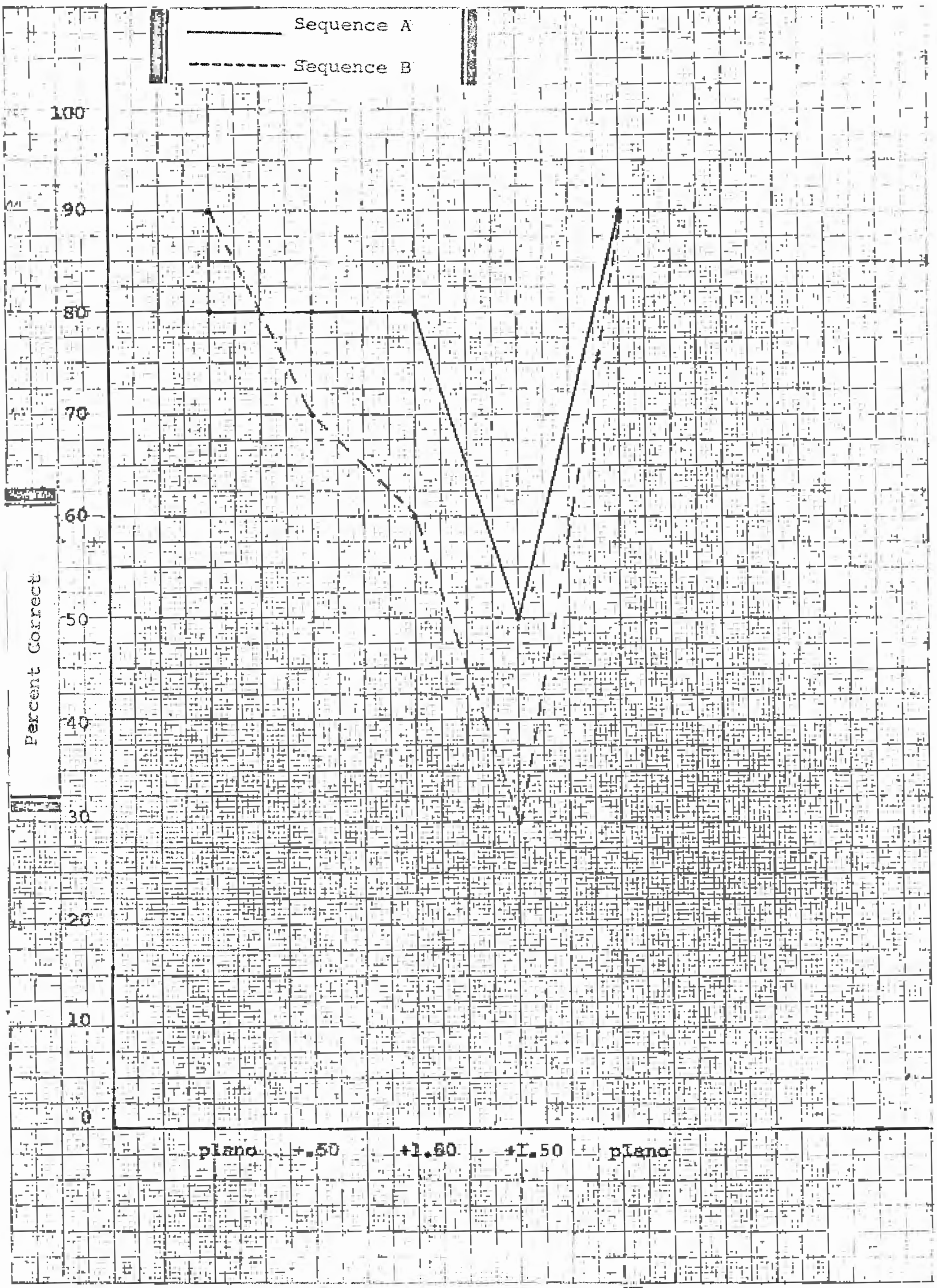
Our date is represented in Tables I, II, III, and IV. Table I shows the distribution of the various error types per lens. In Table II the percent correct per lens for each individual subject tested is presented. Table III shows the control lenses for each subject, and that subject's visual acuity through each of the various astigmatic lenses. Table IV represents the total number of errors made through each lens for each subject.

Scoring was based on percent correct with each lens. To have been correct the subject must have correctly identified all digits in a single exposure of his particular pre-test level. If all the digits were not correct, that exposure was counted as an error. The errors were analyzed as to reversal, configurational, ommissions, rotational, or complete misses. Examples of each error type will be demonstrated in the discussion of Graph IV.

Graph I

In graph I the median of the percent correct is plotted against the five astigmatic lenses used in the testing. Sequences A and B are superimposed in order that the effect of the sequencing may be studied. Sequence A presented the astigmatic lenses in the following order: (1) plano, (2) +.50, (3) +1.00, (4) +1.50, (5) plano. Sequence B was: (1) plano (2) +1.50, (3) +1.00, (4) +.50, (5) plano. The final measurement of plano was to determine the effect of practice.

Sequence A shows no difference from plano to +1.00. In sequence B there is considerable difference between +1.00 and plano. This discrepancy between the two orders of presentation demonstrates that there is a definite sequencing effect. From these observations one could postulate that the system is given an opportunity to organize and thereby minimize the effect of the lenses. With sequence B the system could be disorganized by the +1.50 cylinder lens and therefore, is more susceptible to the effects of the smaller lenses. In all cases regardless of sequencing, there was a marked reduction in the percent correct with the application of the +1.50 cylinder lens.

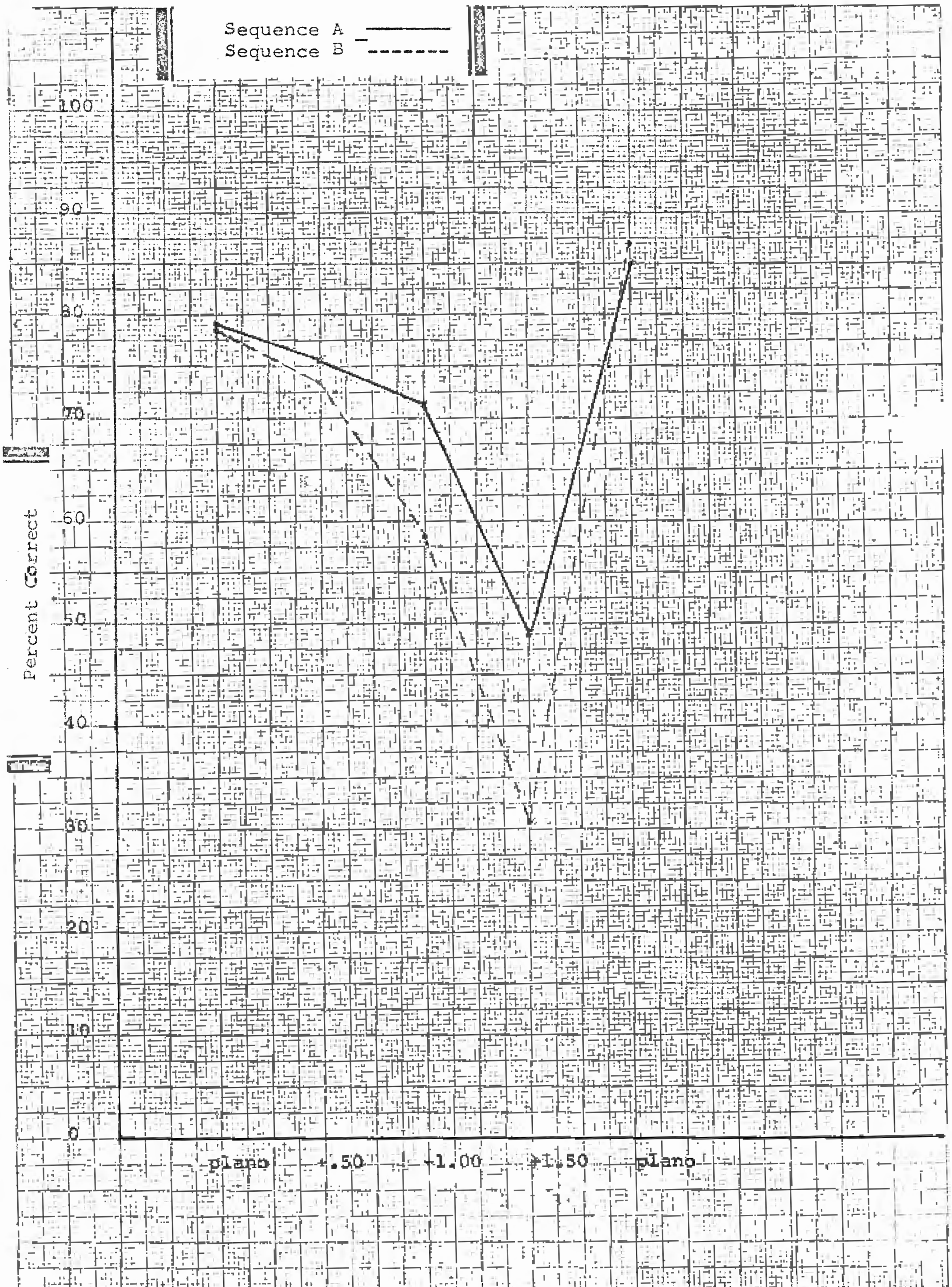


Graph I: Median of the Percent Correct Per Lens

Millimeters to the Centimeter

Graph II

Graph II represents the mean of the percent correct against the various astigmatic lenses. The effect of the sequencing is not as pronounced when the two sequences are compared on the basis of their means as they are when compared on the basis of their medians. The mean graph shows more of a gradual transition from plano to +1.50 cyl. and from +1.50 cyl. to plano than the median graph. This graph also shows a definite practice effect in both sequences. Basically, however, the two graphs illustrate the same relationships.

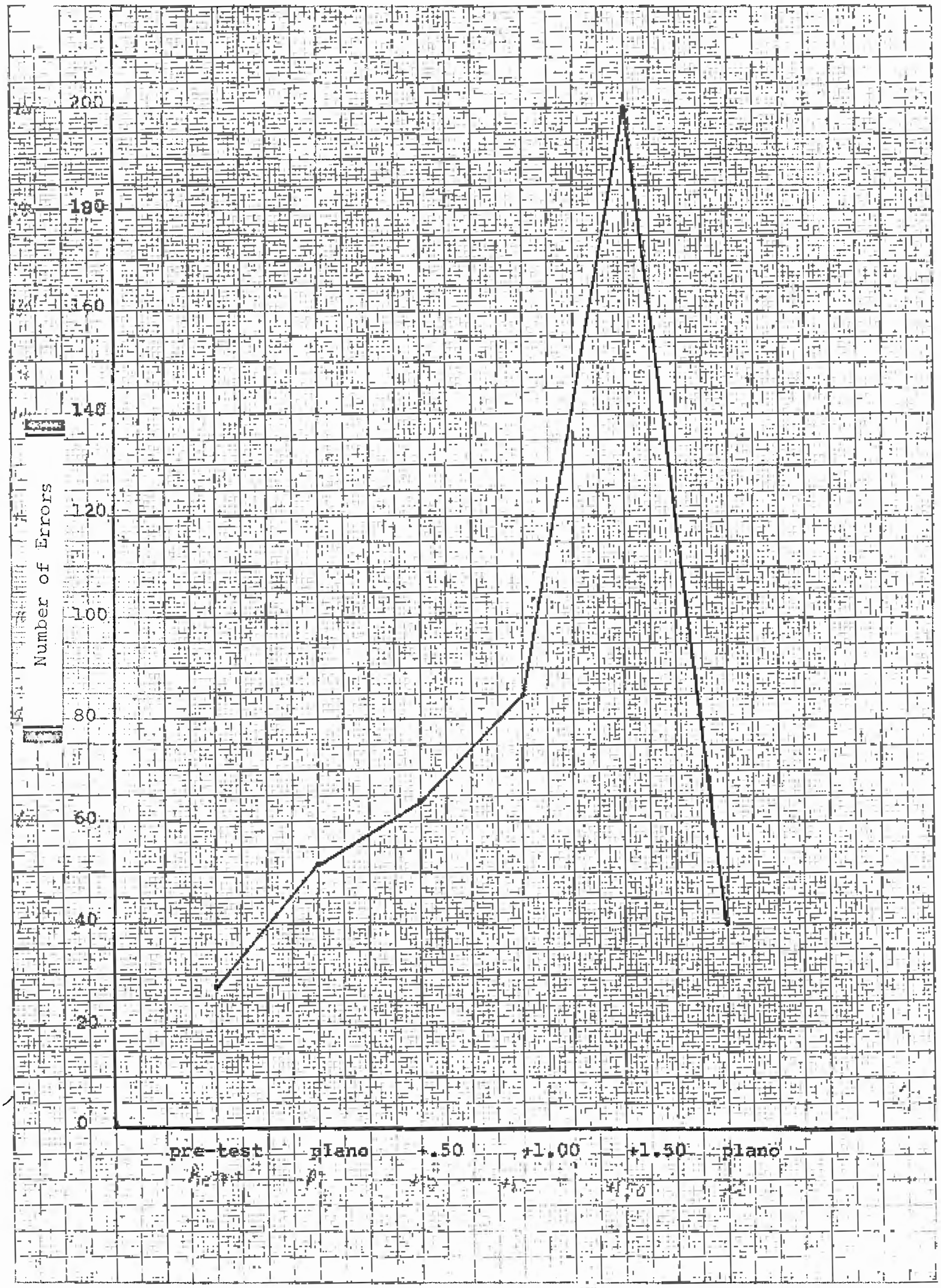


Graph II: Mean of the Percent Correct Per Lens

10 Millimeters to the Centimeter

Graph III

In graph III the sum of the reversal, configural, rotational, and complete miss errors are plotted against the various astigmatic lenses. This indicates there is a definite increase in the total number of errors corresponding to an increase in the cylindrical power. There is a nea r linear increase from plano to +1.00 followed by a marked increase with +1.50. This graph demonstrates that any amount of induced astigmatism results in an increase in the total number of errors under the testing conditions presented.



Graph III: Total Number of Errors Per Lens

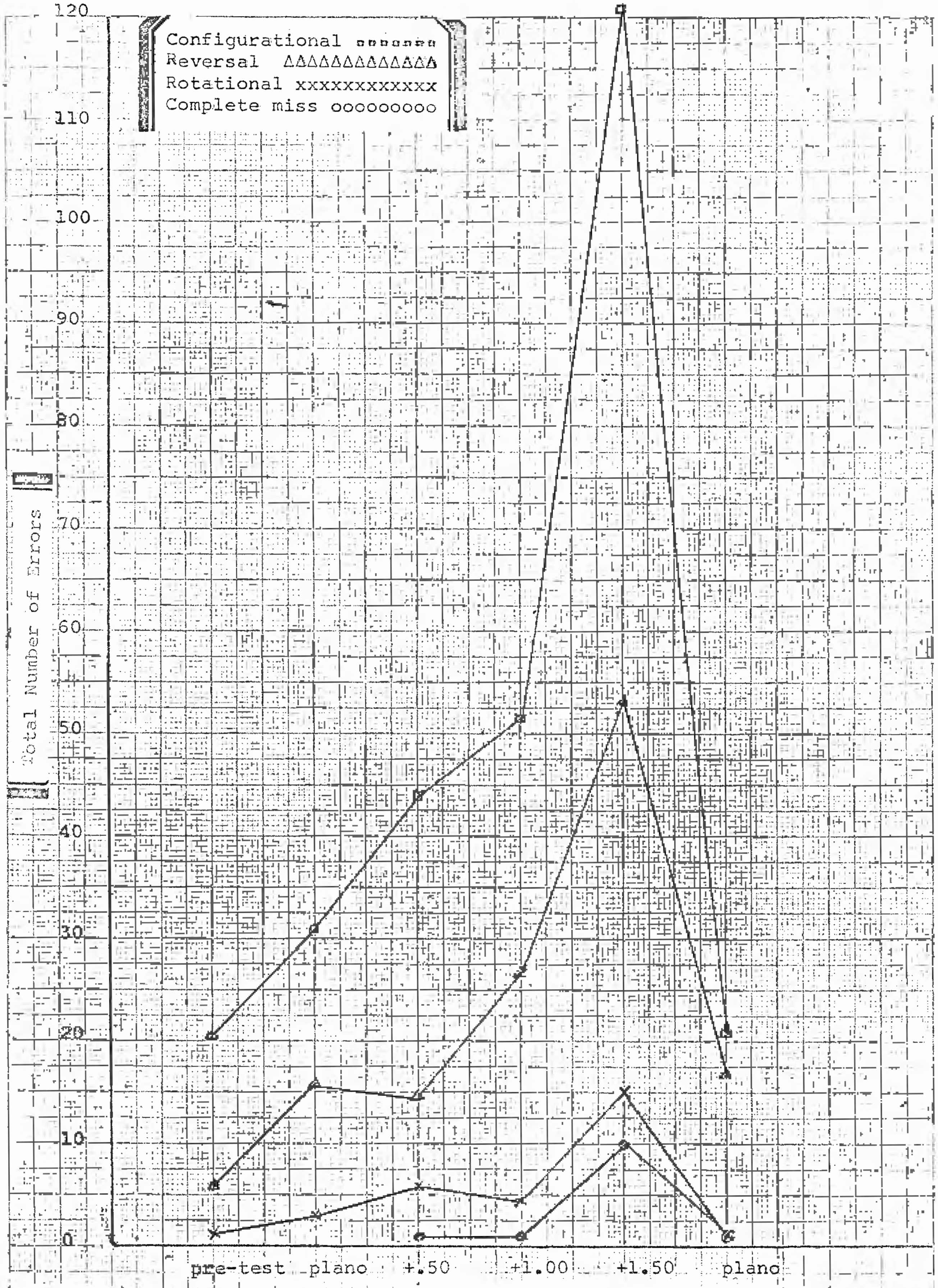
10 Millimeters to the Centimeter

Graph IV

The total number of errors are plotted against the individual lenses in graph IV. In the initial consideration configurational, rotational, reversal, complete miss, omission, and closure errors were to be analyzed.

Our subjects were primarily college students. This could account for the lack of closures and omissions that were expedted, and for the low number of complete misses. The errors made were more discriminatory in nature. The most common error was configurational. Typical of these were substitutions of a 7 for a 1, a 3 for an 8, a 2 for a 5, a 9 for a 4, a 9 for an 8, etc. Reversal errors were the second most frequent. Mostly these consisted of reversing the sequence of two digits, although occasional reversals of three were found. The rotational errors were a 6 for a 9, or a 9 for a 6. An error was considered a complete miss if all, or all but one of the digits presented were incorrectly identified.

All types of errors show a definite peaking around the +1.50 cyl. Once again there was a difference between the pretest and initial plano test. This was found on 3 of the 4 error types analyzed. When comparing the pretest to the final plano only the reversal showed any difference. The reason for this can be found in the analysis of graph V. All error-types showed an increase in number concomittant with the increase in cylindrical lens power. This graph illustrates again that there is a definite effect on digit recognition with any amount of astigmatic lenses.



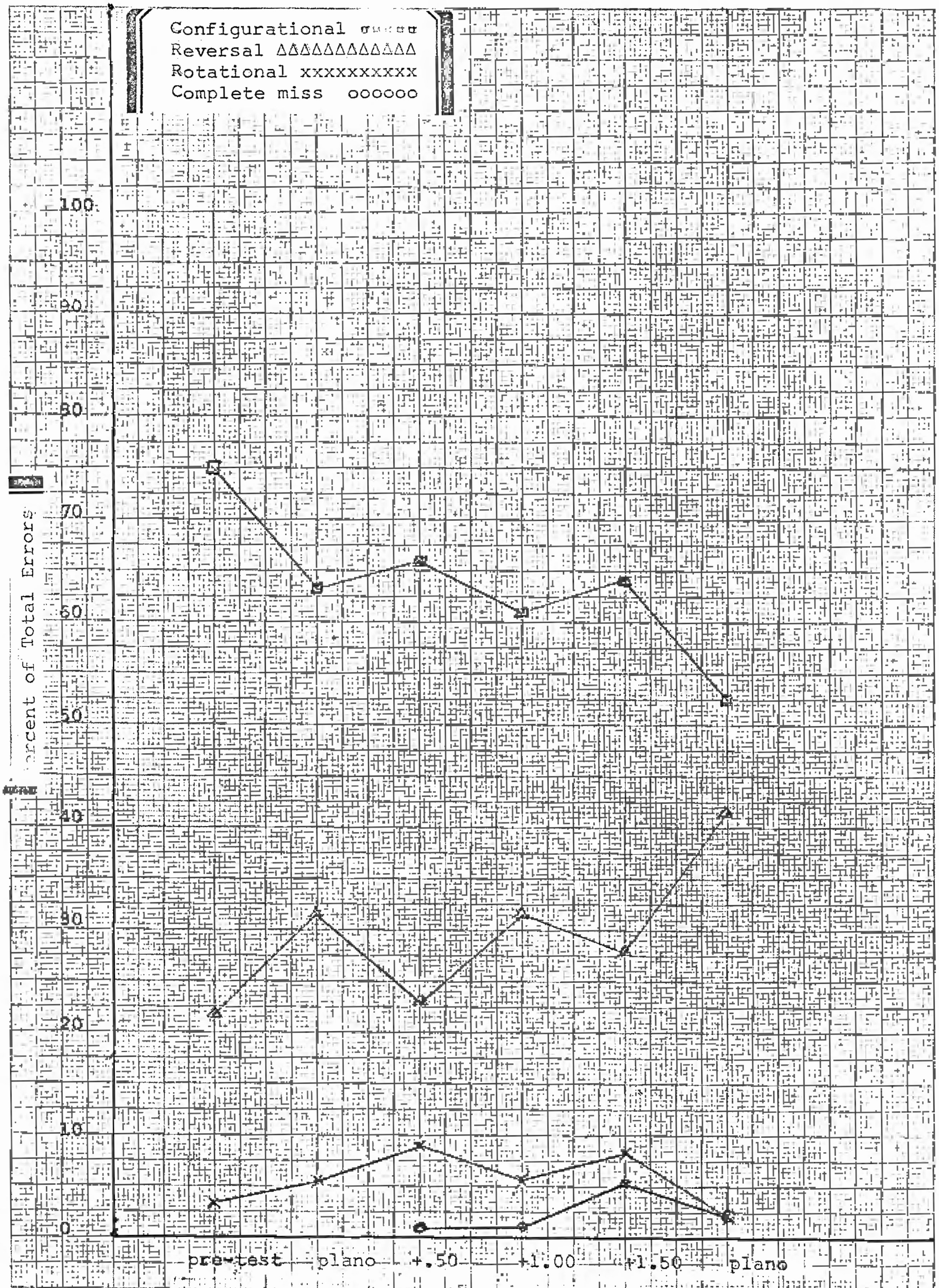
Graph IV: Total Number of Individual Error Type Per Lens

12-188
10 Millimeters to the Centimeter

Graph V

Graph V illustrates that there is a definite trend demonstrated by the configurational and reversal error-type. There is a 55% difference in the frequency of the two error-types with the pre-test sequence. This reduces to 10% with the final plano sequence. The configurational show a definite declining per cent while the reversals show a definite increasing per cent. One might postulate from these results that the system first attempts to identify the individual components of a figure; secondly, it attempts to organize the digits as an ordered sequence. The per cent of rotational errors is fairly constant. Rotational errors show a slight increase with a corresponding increase in lens power. It is significant that less than 10% of all errors were rotational for any lens power; and less than 5% were complete misses. The few rotational errors found were expected since digits do not lend themselves to rotational errors as do letters, particularly b, d, c, p, etc.

Referring back to graph IV it can be seen that a plausible explanation for the similarity and difference between the pre-test and final plano with the configurational and reversal errors could be the result of this trend shown in graph V.



10 Millimeters to the Centimeter

The data for individual subjects is presented in tables I through IV. Table I represents the percent correct each subject obtained through each lens. Table IV represents the total number of errors made through each lens. The control lens for each subject is listed in Table III along with the visual acuity of each subject through the different lenses. Table II represents the total number of each error type through each lens.

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	Pre-Test	Plano	+ .50	+ 1.00	+ 1.50	Plano
Reversals	6	16	15	27	53	17
Configural	21	32	44	52	122	21
Rotation	1	3	6	5	15	1
Complete Miss			1	1	10	1
Sum of Errors	28	51	66	85	200	40

Table I: Distribution of Error Types Per Lens

10 Millimeters to the Centimeter

Subject		Plano	+ .50	+ 1,00	+ 1.50	Plano	Pre-Test
# 1	A	80	80	70	50	90	100
	B	90	70	60	30	100	
# 2	A	70	90	70	20	90	90
	B	100	90	70	0	90	
# 3	A	80	70	80	40	90	90
	B	70	60	60	20	80	
# 4	A	90	100	80	70	80	100
	B	90	70	60	10	90	
# 5	A	100	80	90	20	100	80
	B	80	70	80	30	80	
# 6	A	70	70	40	40	80	80
	B	80	60	50	20	90	
# 7	A	100	100	100	60	100	100
	B	100	90	60	70	100	
# 8	A	70	50	70	70	80	90
	B	90	60	20	10	90	
# 9	A	70	70	20	10	50	80
	B	50	50	20	20	50	
#10	A	80	100	100	70	100	80
	B	90	100	90	50	100	
#11	A	80	60	100	60	70	80
	B	80	60	70	60	100	
#12	A	90	100	90	60	100	100
	B	100	100	80	50	90	

Table II: Distribution of Percent Correct Per Individual

10 Millimeters to the Centimeter

Subject	Far C.C. lens	Plano	+ .50 x 180	+ 1.00 x 180	+ 1.50 x 180
# 1	OD plano OS -25	20/15	20/20^{-1}	20/30	20/40^{+2}
# 2	OD -75-25x165 OS -75-25x15	20/15^{-1}	20/20^{-1}	20/30	20/40
# 3	OD -50 OS -50	20/15	20/20	20/30^{+2}	20/40^{+3}
# 4	OD pl-25x180 OS pl-25x180	20/15	20/15^{-2}	20/25	20/30
# 5	OD -75-75x95 OS -75-50x80	20/15	20/20^{+2}	20/25	20/30^{-2}
# 6	OD +50-25x180 OS +50	20/15	20/15^{-1}	20/20^{-2}	20/30^{-2}
# 7	OD -2.25 OS -3.50-50x160	20/15	20/20^{+4}	20/25	20/40
# 8	OD +25-25x175 OS pl-25x180	20/15	20/20^{+3}	20/25^{+1}	20/40^{+3}
# 9	OD -2.00-50x10 OS -2.00	20/15	20/25	20/40	20/60
# 10	OD -3.25 OS -3.25	20/15	20/15	20/25	20/30
# 11	OD -3.00 OS -3.00	20/15	20/15	20/20	20/30
# 12	OD -25-50x15 OS -25-25x180	20/15	20/15^{-1}	20/30	20/40

Table III: Control Lens and Visual Acuities Per Individual

10 Millimeters to the Centimeter

	Pre-test	Plano	+.50	+1.00	+1.50	Plano
Sum Total	28	52	66	85	200	40
#1	0	5	5	6	12	1
#2	1	3	2	6	20	2
#3	2	4	7	7	29	2
#4	0	2	3	6	21	3
#5	2	2	7	4	17	2
#6	0	7	6	11	16	3
#7	4	0	1	4	4	0
#8	2	1	10	10	12	5
#9	5	16	14	17	31	16
#10	8	4	0	2	9	0
#11	4	6	11	4	8	4
#12	0	1	0	4	20	2

Table IV: Distribution of Total Errors Per Individual

10 Millimeters to the Centimeter

DISCUSSION AND CONCLUSIONS

Our results indicate that astigmatic lenses do have an effect on digit recognition under tachistoscopic exposure. We also studied the effect of these lenses on visual acuity, presentation sequence, and types of errors committed.

It was found that as the lens power was increased the percent of correct responses on the digit flashing was decreased. From this it can be concluded that the induced astigmatism had a detrimental effect on digit recognition. It was demonstrated that the various error types increased with the increasing power of the lenses used. The major error type was configurational. This would suggest that induced astigmatism causes a reduction in the ability to discriminate form under the flash conditions. As the subject was tested further the configurational errors decreased in prominence and reversal errors increased.

When given smaller lenses first, the subjects showed far less errors than when the larger lenses (sequence B) were exposed first. There was a practice effect in both sequences, though it was greater in the sequence A, where the small lenses were presented first.

The visual acuity through all lenses was above the threshold of acuity of the digits flashed. It was evident that each lens had a detrimental effect on the digit recognition. This is especially significant when the practice effect is considered.

In our study we attempted to control as many variables as possible. The same room was not always available for testing, but we do not think this is a significant variable. The screen illumination was at all times less than 2 foot candles, even though there were small variations. There were periodic interruptions during the testing from external environmental conditions. These were unavoidable, but they tended to interfere with the subject's concentration. It would have been ideal to have had a sound proof testing room. The major variables, such as distance, acuity size, and exposure speed were always maintained and controlled.

What our study did, in effect, was to artificially induce various amounts of uncorrected astigmatism and then determine the effect of the astigmatism on a subject's recognition accuracy. In a broad aspect our results could be applied to conditions where the effect of uncorrected astigmatism might be questioned. Such instances might be driving an automobile at high speed where rapid recognition of oncoming traffic would be vital; in a program of reading enhancement or reading in general, where rapid summation of information is important; in public school instruction utilizing tachistoscopic instrumentation; in an industry where a worker's job is the rapid inspection of parts for possible defects. This would also raise the question as to the effect uncorrected cylinder would have on a visual training patient's learning rate. These are just possible practical applications of our findings.

SUGGESTIONS FOR FURTHER STUDY

There has been very limited research in this area. Other than Walton and Schubert's study,[4] the literature in this area is virtually absent. From our study several other avenues of research in this area have been revealed. One such avenue is the question of the effect of wearing the cylinder for a prolonged period of time. Would this produce the same type and magnitude of effect as the results of our study? Another approach would be to test subjects manifesting various amounts of astigmatic errors and compare them to a control group of subjects without astigmatism. Research could be done utilizing the same basic procedures that we employed, to study the effects of other optical variables; such variables as anisometropia, vertical imbalances, extreme motor dysfunction (accommodative and convergent), extreme refractive errors, etc. One could also repeat our work utilizing a different variable. For example, one could vary the axis of the cylinder, distance, acuity size, duration of flash, etc.

It is evident that these are pioneer studies and that further research is needed in these areas.

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4. *op. cit.*, Schubert.

SUMMARY

Twelve subjects were tested. It was determined that the influence of the various astigmatic lenses on digit recognition under tachistoscopic exposure was:

1) The effect the induced lenses had on digit recognition was to decrease the performance at all levels of testing.

2) The types of errors made were primarily configurational and reversal, with a small number of rotational and complete misses.

3) The effect of the sequence of presentation, sequence A (+.50 to +1.50), sequence B (+1.50 to +.50) was very noticeable and indicated a practice effect and possible adaptation to the lenses.

The results and subsequent analysis show that astigmatic lenses have an effect on digit recognition.