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Analysis of the results of the Washington County District 15 elementary school vision screening program: The Abbo study (volume I)

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ANALYSIS OF THE RESULTS OF THE WASHINGTON COUNTY DISTRICT 15 ELEMENTARY SCHOOL VISION SCREENING PROGRAM

THE ABBO STUDY

(VOLUME I)

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INTRODUCTION

Vision screening programs have been the subject of conversations and controversies between members of the vision care professions for many years. Many significant research projects involving various aspects of vision screening have preceeded this analysis project. The screening program which provided the data analyzed in this study evolved from the concerned community service spirit of the Student Optometric Association (SOA) at Pacific University College of Optometry (PUCO). A brief review of the history behind the development of this analysis will provide some additional insights to the reader.

One of the principal investigators chaired the SOA Community Health Committee and as a result of that responsibility became quite involved in the planning of the 1974 Save Your Vision Week (SYVW) program at PUCO. He felt that some type of community service program during SYVW would be quite in the spirit of the week. The idea of a vision screening program for the local school system was presented and unanimously approved by the SOA in January 1974. After discussions with the PUCO administration, it was decided that the SOA program might conflict with the ongoing "for fee" screening program that is a part of the PUCO clinical services program. Thus, it was decided that the SYVW screening program would be sponsored independently by SOA and that it would be staffed by volunteer student clinicians and supervising optometrists.

The Superintendent of the District 15 Elementary School System in Washington County was approached with the screening program idea; his reception was enthusiastic and he referred the topic on to a principals meeting scheduled at a later date. A presentation was made at that meeting by SOA leaders. The discussion presented the need, purpose, administration and usefulness of the screening program. After a lengthy question period, the principal group accepted the offer of the screening program. Subsequently it was decided to screen the elementary school children (grades K through 6) in District 15, a sample size of approximately 2,000 children.

The next question that arose was which vision screening tests would be performed in the SYVW program. The accepted PUCO practice and a brief review of pertinent literature indicated that the tests of the Modified Clinical Technique should be included. The well know Orinda Study (discussed in detail later) has shown the MCT to be most efficient in having a minimum of over and under referrals. In addition, it was felt that the SYVW program should attempt to detect children who had visual inadequacies that hampered their ability to achieve up to their potential. After reviewing the often contradictory literature in this area, several tests were added to the battery that might relate to the achievement aspects. Literature from the physiological area of vision pointed to ocular pursuits and saccades, near point visual acuity, stereopsis, dynamic retinoscopy and near point of convergence tests as being appropriate to include in the battery. Color vision testing was included because it is not widely performed elsewhere and there is a need for the subject to know if color anomalies are present for educational and safety reasons. The distance rock (near-far-near response time) test was added at the request of 6th year students doing a research project on various aspects of that test. So the test battery was formed from accepted PUCO practice, literature suggestions and other associated needs.

The implementation and administration of the screening program is discussed later in the data gathering section of this report. The many students and optometrists who volunteered their time made the program the success it turned out to be. The broad exposure to a number clinically related activities certainly enhanced the student doctor's educational experiences. Reception by the school, the children and their parents, and the local eye care professionals was excellent with no major problems or incidents.

A few weeks after the screening project was completed, it was realized that an enormous amount of valuable data had been accumulated and the potential for an analysis projects was initially discussed by the investigators. It should be stressed at this time that the screening program was designed as a community service project and not as a scientific research effort into the various aspects of vision screening. A disadvantage of this circumstance is that many pieces of data necessary to probe various questions on vision screen were not accumulated. An advantage to this is that since there was no prior hypothesis proposed, the results should not be open to questions of examiner prejudice.

While information about the various tests used in the screening program was available, the writers felt it would be worthwhile to add to the current information on incidence, mean, standard deviation, etc. for the various samples screened in our project. Also, failure rates for the various tests were available in the data collected and the effectiveness in detecting additional problems with the added tests could be determined. A third area of analysis could be to determine if any inferences relating achievement and visual findings could be established.

In order to establish these inferences some measure of achievement needed to be added to the data base. After contacting school personnel, it was determined that standardized scores on the Metropolitan Achievement Tests were available for most of the third through sixth graders. The Reading and Math subtest scores were added to our data base. It should be emphasized that we were using whatever measure of achievement level was available and not necessarily what would be the best measure for use in a pre-planned research project. With this information the writers will draw inferences that relate the visual skill findings and achievement levels at a statistically significant level.

The availability of a 2,000 child elementary school population, an optometry school which voluntarily staffed a screening program, and computer resources has enabled an enormous amount of data to be gathered and processed in a timely fashion. We hope that the results and discussions presented will provide an impetus to the establishment of an active research effort connected with an active vision screening program at PUCO and will provide some answers to some of the many questions surrounding vision screening programs.

REVIEW OF PERTINENT LITERATURE

The review of literature is divided into a number of areas. We begin with a definition of vision screening; then state the reasons why a good vision screening is needed; try to summarize what the literature says about visual skills and how they relate to learning; and review previous vision screenings. What is a vision screening? Most would agree with the broad definition of Coleman, "a vision screening is a test or a battery of tests whose purpose is to identify and direct attention to the need of certain children for a professional examination".[1] We agree with this definition and would like to stress one of it's implications, which is that a vision screening does not replace a complete professional examination. Until our health delivery system evolves to providing a complete clinical examination comensurate with a given childs needs, we must do the next best thing, a vision screening that detects as many visual problems as possible without an abundance of over-referrals.

In most states of our country some sort of vision screening is required. It's surprising in light of all the research done on vision screening that most school systems use visual acuity tests at far as their screening device. This is done usually without previous training of the examiner and without properly controlled conditions. What is ironic about this method of screening is that the school systems may not only feel that it fulfills the requirements of the law but also that it provides a satisfactory service to the community. Research has shown that far VA screening usually misses over 50% of those needing professional care [2] and is in some ways a disservice by giving a false sense of visual well being. We hope to further stress the need for a more complete visual screenings and define what constitutes an adequate vision screening test battery.

Is there a need for a good vision screening program? There appears to be an overwhelming need. Coleman write "eight million children in our school system are having trouble reading. Comprehensive vision screenings detect between 20-30% of an entire school population for vision care. Most cursory studies only find 50% or less of those children needing care." [3] Templeton states "Twenty-five percent of the children in our schools have visual handicaps that prevent them from acquiring skills they need to read". [4] There are educational reasons for a good screening as well as social reasons. The Michigan Health Department found"two times as many vision problems in low socioeconomic areas". [5] Gates writesin a study in New York it was found that "75% of children with reading problems are emotionally disturbed" [6] and "75% of all juvenile defenders are two years behind grade level in reading". [7] These are just a few of the many reasons for good visual screening programs. Unfortunately the above figures appear to be getting progressively worse and not better. Our society must begin immediately to start to remedy some of the causes for these problems; one of the simplest would be to institute a good efficient vision screening program.

The Orinda Study states the following as to the purpose of a vision screening: "to detect children who have vision problems, that may affect the physiological or perceptive processes of vision and to find children who have vision problems that interfere with performance in school". [8] Most people would agree that is a reasonable purpose for a school vision screening program. This statement goes much further than just saying the purpose of a screening is to detect myopia, high hyperopia, high astigmatism and high anisometropia, the conditions uncovered by a traditional visual acuity test at far. The purpose stated above says any visual condition that interferes with performance in school should be detected. Therefore before any decisions are made as to what screening tests are to be performed we must look at what the research literature says on what are the visual conditions that interfere with a person achieving up to his or her potential.

Upon delving into the research literature on the relationship between vision and learning, it became apparent that there are no singular and clearcut relationships. Most of the studies are small, contradict each other and don't paint a very clear picture of any relationships. There is a vast amount of literature and research in this area and the writers were unable to study all that was available, a truly life long chore. What we will attempt to do in the following pages is to point out some of the contradictions as well as apparent relationships in this controversial area.

A useful way to study the inter-relationships in this area would be to divide vision into three areas; "the physical, psychological and physiological components." [9] An example of the physical components could be refractive error or amblyopia. The psychological area of vision includes ability to perceive likeness in form, visual memory and visual encoding and decoding to name a few. The physiological component includes phoria, ductions, focus facility, AC/A, eye movement skills, etc. Let us now look within these areas of vision and see how these visual skills relate to learning.

Most vision screening is devised to look for defects in the physical component of vision. A number of studies have shown that far visual acuity does not correlate with achievement as measured by a standard reading test. [10,11] The reason for this is that most children who fail a far V.A. test are myopic and studies have shown the incidence of myopia in poor reading groups is less than in a normal population. [12,13] As was just pointed out concerning refractive error, myopia does not appear to be related to poor achievement. There are a number of studies relative to hyperopia. Eames found the incidence of hyperopia greater than one diopter in a group of children with reading problems to be 43% compared to 12% of those in the control. [14]

However, Cole reports an incidence of only 16% in his reading problem group. [15]

A small study showed a relationship of anisometropia and astigmatism to reading achievement. [16] A number of other studies however do not support this finding. [17,18] Some research has been done by artificially inducing astigmatism, anisometropia and aniseikonia with a resultant decrease in the reading skills of normal people. [19] We feel the artificial nature of these studies does not make them applicable to how these problems affect children who normally acquire them.

It appears from reviewing the literature that the physical components of the eye do not have a very strong relationship with reading achievement. Of all the possible factors uncorrected hyperopia seems to be most related. Nevertheless it is still very important to screen in this area because of the relationships to comfort, safety, recreational activity and sustained visual activity.

The next component of vision we will look into is the perceptual or psychological aspects. This is a rather broad area and research has shown a number of factors in this area relate to learning. Silver and Hagin have found that 80% of children with reading disabilities have difficulty with the orientation of visual stimuli in space. [20] Eames found "the speed of perception of words is found to be low in 49% of reading failures and in 25% of an unselected group. The median was 3 times slower."[21] He noted that if speed of perception is faster for objects than words then it is probably an educational problem. Robinson, Edson, and Sabitina all found that copy forms are not indicative of achievement. [22] But Silver and Hagin found on the Bender-Gestalt forms that children with learning problems had difficulty with angularization, had a tendency to verticalize the diagonals, to rotate entire figures towards the vertical and to replace dots with primitive loops. They found 90% of children with learning problems having one or more of these problems. They also found these children having trouble drawing overlapping forms that have been seen for as long as 15 seconds. [23]

Shorr and Svagr in a study of second grade students; found that body image and directionality as measured by "Simon Sez" and pegboard progression significantly predict reading accuracy. [24] Coleman [25] in a very complete study of vision, by doing a factor analysis found four major components of vision. They are ocular movement and motility, reproduction of perceptual patterns, space perception, and accommodative and convergence relationships. He found by doing a step-wise linear regression analysis on first grade children that perceptual pattern reproduction and space perception were the only two areas that correlated with Stanford achievement test scores. Subtests in this group include: writing, stereognosis, body image, number sequence, visual memory, laterality and directionality, spatial orientation, hand-eye coordination and graphesthesia. In his screening, Coleman conducted the more traditional visual screening tests. We feel it is interesting to note that these skills do not relate to learning but to the perceptual skills listed above. Shearer found that 66% of the children one or more years behind in reading had what he called perceptual motor problems. [26]

The literature in the field of psychology, education and optometry in this area is vast and we have just skimmed the surface. There does appear to be emerging, even though many studies do contradict each other a strong relationship between visual perceptual skills and greeting. More research however is needed to better delineate the critical and significant factors that effect learning.

Physiological factors of vision are included in most of the more comprehensive screening studies. The first one to usually be included is some kind of test for a phoria. A number of methods have been employed to measure a phoria on a school screening: a maddox rod, cover test or a stereoscope. The order of validity relative to correct referral for an examination appears to be cover test, Maddox Rod and Stereoscope testing. Brod when discussing phorias and tropias concludes that "binocular instability is more of a problem than lack of binocularity."[27] It appears that the person who exhibits a tropia has adapted to his binocular vision problem in such a way that it doesn't interfere with his ability to read. There has been some research into the direction of a phoria and how it relates to achievement. Eames found that exo deviation has more of a correlation with reading problems than eso deviation [28]. However, Haines in a small study showed a relationship of eso and reading problems. [29]

It is evident that there exists much controversy on the significance of phoria measurements and learning. Many reading experts feel there is a relationship between binocular uncoordination and reading failures. Many studies however show no such relationship. [30,31] There are, however, many studies that do show a significant correlation between binocular coordination and reading achievement. "Parks when studying a group of children with reading problems found that 50% had weak ductions, phorias, convergence insufficiency or accommodative or convergence spasm. Westheimer found a high preponderance of binocular problems in the low 25% of reading ability. Park and Burr found a relationship of .647 between ductions and reading ability." [32] Haynes and Pratt in a study involving children from the same geographical area as our study found a higher incidence of eye movement and binocular vision problems in the retarded reading group. [33] Shorr found that the near point of convergence and the best distance to read is significantly related to reading accuracy. Ludlam agrees with the significance of reading distance and also feels that the ability to visually suppress the alpha rhythm is significant. [34]

A study at the Pediatric Study Center of the University of California showed that 42% of dyslexic children have foveal suppression on a 4Δ prism test at near compared to only 9% of the control.[35] Problems with ocular motility have demonstrated a relationship to achievement; 52% of dyslexic children showed gross jerkiness of the eye while attempting to follow a pencil tip on a diagonal line compared to 11% of the control.[36]

Accommodation has been felt by many to correlate strongly with visually related learning problems. Solan found the most frequent visual anomaly to be sluggishness of the accommodative response eith insufficiency or inability to change accommodation rapidly.[37] Nedrow found a difference between retarded readers and a normal group at the .05 level of significance for the accommodative score value. The accommodative score value is based on the accommodative tests in an analytical exam. However, when he looked at each test by itself these two groups could not be statistically differentiated. He did find a slight relationship in the MEM retinoscopy findings; the poor readers having a higher lag on the 20/200, 20/50 and 20/20 stimulus demands. However, this is not the case for the fused cross cylinder findings. Nedrow suggests this indicates that the poorer reader does not focus in as much in response to the accommodative stimulus.[38]

It is evident that the literature is contradictory. There are a number of studies that show no relationship between visual skills and ability to learn; and others that show a clearcut relationship. By studying our population of 2,000 children in grades K through 6 we hoped to find answers to some of the above questions, and to begin a more extensive research effort to get at the basis of the relationship between vision and learning. The previously related purposes of a good vision screening can not be fulfilled until we better determine what visual deficiencies do relate to academic problems. This does not infer that we should leave out tests which we are not sure relate to achievement but quite the contrary; to include and study all visual skills in an attempt to define what visual skills are significant to a visual screening program.

REVIEW OF PREVIOUS VISION SCREENING PROGRAMS

Many vision screenings have been done and we would like to review some of the major ones and review what was gained from each of them.

There are many types of vision screenings used for the detection of vision problems. Some of them are symptom inventories, observation by teacher or parent, school achievement, pencil and paper tests, perceptual tests, visual acuity, plus two diopter sphere test, cover test, Worth Four Dot, Maddox Rod test, California State recommended procedure (V.A. at far, plus sphere and Cover test), Massachusetts Vision Test (V.A. at far, plus sphere and Maddox Rod at distance and near), various stereoscope screening devices and the Modified Clinical Technique (Retinoscopy, Visual Acuity at far, Cover Test at far and near and opthalmoscopy). The following is a brief over view of the different types of screening tests which have been employed.

The St. Louis Study 1948-9 [39] was one of the first attempts at a study of vision screening. The screening results of 606 first graders and 609 sixth graders were compared with the results of an opthalmological examination. The clinical examination found that 31% of the 6th graders and 23% of the first graders needed some kind of visual care or observation. When comparing the results of the various screening tests and the results of the clinical exam, they found that stereoscope screening instruments over referred more than the number of correct referrals. The best method they found was the Mass. Vision Test which had a point correlation coefficient of .45. Teacher judgement, previously thought to be a valid and important screening method, had a correlation of .15. They found even the best screening method they used missed one third of those children needing attention. Another finding of the study was that a teacher, a nurse and a technician can administer the screening with very little difference in the results, although the technicians were slightly better. They also concluded that responses from first graders were valid and they are capable of being screened. The plus two diopter sphere test was found useful in detecting hyperopia and all but 5 of the 59 1st graders who failed that test had over one diopter hyperopia. This study also found that you can reduce the number of incorrect referrals by retesting those who fail, however, when you do this you also loose some correct referrals. Their conclusions were that there really is no good vision screening and the Snellen test is better than the stereoscope screening they used and slightly worse than the Mass. Vision Kit.

The Shewsbury study (1952) [40] used the Mass. Vision Kit to test 1,575 children grades 1-12. The children who failed the test were advised to have a complete clinical examination. After the child was examined a report was to be sent back to the school. Of the returning reports, one third of the cases referred were over referrals and no attempt was made to discover under referrals. The test which gave the poorest results was the Maddox Rod phoria test. An interesting innovation of this study was that if the child was wearing glasses; the practitioner who examined the child was called and consulted before any referral was made.

The Danbury Study (1955) [41] was notable in that it was the first time that optometrists and opthalmologists in an area consulted with each other about the screening. A total of 4,662 children in grades K thru 12 were screened by a Mass. Vision Kit and all of those who failed were retested and then referred. The children were divided between those wearing glasses and those not. The study made an inquiry to the last examiner of those wearing glasses to see if they should be reexamined. Reports were returned on 1/2 of those referred and they reported little over referral. No attempt was made to study under referral. The incidence of failure was 20% of the children not wearing a refractive correction and 50% of those wearing a correction. One of the factors that is believed to have led to the success of this screening was the pre-screening briefing of the doctors before the screening occurred.

The Columbus Study (1947) [42] tested 188 students from 1st thru 11th grades on the Mass. Vision Kit, Snellen Acuity, teacher observation and the Keystone Telebinocular. Each child was then given a clinical exam. The results of the screening can be expressed in phi coefficients. The Mass. Vision Kit had a phi coefficient of .72 with a high under referral rate, teacher observation was considered unreliable with a phi coefficient of .16, the telebinocular had a phi coefficient of .34 and was felt to have too high an over referral rate. The Snellen test with a phi of .58 was considered to be the single most reliable screening method. Although with a phi coefficient of .58 it could hardly be considered an adequate vision screening method.

The Orinda Study (1955-7) [43] is considered by many to be the "Bible" of vision screening. It was very well planned and was a milestone in intra-professional relations of the two eye care professions. The study was conducted by Blum,Peters, and Bettman with the cooperation of the University of California College of Optometry and the Stanford University School of Medicine. Besides the information on screening, much other useful information came out of this study. A comparison was done on 229 children between an optometric and ophthalmological exam with a remarkable agreement between them. The study was for three years 1955, 1956, and 1957 with a sample of 1,168, 1,554, and 1,475 respectively. In order to have a check on the under referral rate a control group of 20 percent of the population were randomly selected to have a complete vision exam regardless of passing or failing the screening.

The 1954 Method included a Parent Questionnaire, Teacher Observation, Nurse Observation, Calif. State Recommended Procedure (V.A. at far, +1.50 D sphere test, Cover Test administered by teachers and if the child failed or gave a questionable response, he was referred to a school nurse who decided if he should be referred out.), and Mass. Vision Kit (V.A. at far, plus sphere, lateral and vertical phoria in the distance). Referral criteria for V.A. was 20/40 or less for grades 1-3 and reading the 20/20 line with a plus 2.25, for grades 4-6, 20/30 or less was used and a plus 1.75. Criteria for referral of heterophoria was 6Δ of eso or exo deviation, or 2Δ of vertical. This test was administered by a nurse. The Modified Clinical Technique was also used to screen the children it includes V.A., retinoscopy, cover test far and near and internal and external examination of the eye for pathology. This was conducted by an eye care professional.

In 1955 the method was essentially the same except on the California State recommended procedure the Cover Test was replaced by the Worth Four Dot and also the Worth Four Dot was added to the Modified Clinical Technique. The only other change was the addition of a telebinocular screening instrument.

In 1956 the Worth Four Dot was dropped from the California State recommended procedure. The criteria for referral was changed for the Mass. Vision Kit and if one failed this test once they were retested. Another change was the telebinocular was given two times, and the Modified Clinical Technique was the same as 1954.

Each student referred was examined by an optometrist or an ophthalmologist or both. In the clinical exam four major areas were screened: visual acuity, refractive error, ocular coordination and organic problems. The criteria for referral was set by a group of optometrists and ophthalmologists and was in very close agreement with a questionnaire filled out by 279 optometrists and 261 ophthalmologists. The criteria decided upon are listed in Table I on next page.

TABLE I [44]

Orinda - Referral Criteria Developed from Eye Care Professionals Questionnaire

Visual Acuity -	20/40 or less either eye
Refractive Error	
Hyperopia	+1.50 or more
Myopia	-.50 or more
Astigmatism	$\pm$1.00 or more
Anisometropia	$\pm$1.00 or more
Coordination at Distance	
Tropia	Any
Esophoria	5Δ or more
Exophoria	5Δ or more
Hyperphoria	2Δ or more
Coordination at Near	
Tropia	Any
Esophoria	6Δ or more
Exophoria	10Δ or more
Hyperphoria	2Δ or more
Organic Problem	Any

Whether a referral was correct was determined by the need for care rather than the need for treatment. The following table will summarize the efficiency of the various screening methods studied in the Orinda. It is given in the form of a phi coefficient using as the basis for correct referral a clinical examination.

TABLE II [45]

Orinda - Efficiency of Various Screening Methods as Compared to Clinical Exams-Phi Coefficients

	1954	1955	1956
Modified Clinical Technique	.85	.93	.95
California Recommended	.37	.40	.41
Mass. Vision Kit	.24	--	.59*
Parent Questionnaire	.14	.33	---
Nurse Observation	.12	.36	.40
Teacher Observation	.10	.33	.24
Telebinocular	--	.20	--

*Combined with telebinocular

It is obvious from looking at this table that the Modified Clinical Technique was far and away the most efficient method of screening. For example in 1954 this method detected 90% of the correct referrals and 4% over referrals and this was the poorest year; it was very evident that the MCT is a very adequate vision screening method. Looking at the other methods the California State Procedure missed 2/3 of the correct referrals. These over referrals can be partially eliminated by discontinuing the cover test which is unreliable in the hands of a teacher or a nurse. The Mass. Vision Kit, shown by previous studies to be one of the more useful screening methods, resulted in 3/4 of the children referred being over referrals in 1954. When combined with a telebinocular the phi coefficient increased to .59.

An often used method of screening is far visual acuity conducted by a teacher combined with teacher observation. Although VA at far was not taken as a single test it was calculated to have a Phi coefficient of +.48 with a few over referrals but missing many children who needed visual care. If you combine this with teacher referral it decreases to +.28. It is apparent that the other techniques tried are inadequate and very much inferior to the Modified Clinical Technique.

Let us now take a closer look at the results of the screening. The question arises how important in detecting failures are each of the tests included in the M.C.T. Table III will help answer this question by listing the numbers failing one, two, three, or all four tests. As you can see from this table 50 % of the children who were correct referrals failed just one test. Therefore it is very important to perform all four tests because they test in different areas. It is interesting to note that if we were to leave out any test it could be visual acuity at far because only 2% of those needing referral would be missed.

TABLE III [46]

Orinda - Number of Students Failing One or More Tests

	1954					1955					1956				
	T	1	2	3	4	T	1	2	3	4	T	1	2	3	4
Visual Acuity	95	9	59	24	3	115	5	69	38	3	99	3	70	25	1
Refractive Error	129	43	59	24	3	168	37	65	38	3	139	37	76	25	1
Coordination	94	44	29	18	3	122	47	42	31	3	94	51	22	20	1
Organic	36	18	9	6	3	36	11	15	7	3	28	18	4	5	1
Total test fail	354	114	156	72	12	441	100	216	114	12	350	109	172	75	4
Children who failed	219	114	78	24	3	249	100	108	38	3	221	109	86	25	1

The incidence of vision problems is 18% for 5, 6, and 7 year olds and increases 1.6% per year to 31%. The failure rate on each test of the MCT will be examined next.

TABLE IV [47]

Orinda - Failure Rate on Tests of the MCT Battery

	1954	1955	1956
Visual Acuity # failed	131	156	96
Refractive Error # failed	145	160	81
Cover Test # failed	69	151	114
Inspection for Organic Problems	19	11	18
# who failed one or more tests	246	271	229
Approximate % of test group	21%	17.4%	15.5%

This table also shows the inadequacy of far visual acuity testing as 50% of all needed referrals are missed.

The report on the Orinda study ended with a series of recommendations which we are including in this report as very worthwhile to review.[48]

Summary and Conclusions

The most significant over-all cost in a vision-screening program will be the expense to the individual families, or to the community resources, for clinical examinations of the children screened out as needing professional attention. If there is significant over-referral, the cost will be increased needlessly. In addition to wasting community resources, over-referrals may well destroy confidence in the program. If there is significant under-referral, many children needing professional attention will not be detected, although screening costs will be minimized. In terms of visual health and welfare, the hidden costs of under-referrals are inestimable. Only the MCT avoided significant over-referral as well as under-referral.

A steering committee should decide whether one of the color-discrimination tests should be used, and its results made a part of the record for counseling purposes.

The investigators unanimously agreed that a successful vision-screening program could be set up in the following manner.

1. A steering committee, with representatives from education, ophthalmology, optometry, public health, and parent groups, should develop the program. Through its professional members, the committee should obtain acceptance of the program and screening criteria by the professional people in the community who are concerned.

2. A qualified professional examiner should be employed to screen, with the MCT, all children in the first grade and all new entrants to the elementary school at that grade or above (see chap. IX). Children who have had the MCT once and were found to be non-referrals should be tested annually thereafter with the Snellen test. Teacher Observation should be done continuously. If feasible, the Snellen testing and the reports of Teacher Observation should be completed before the annual visit of the professional examiner. In this way children failing the Snellen or referred by Teacher Observation could be screened by the MCT at the same time as the first graders, and before being referred for private professional attention.

3. The Snellen test (described in chap. IX) could be given by a qualified tester hired by the school to do the work once each year. This would avoid the significant cost of teacher training as well as teacher screening.

4. Those children failing the MCT should be referred for professional vision attention.

5. The parents of those children with known visual problems should receive a reminder that their children need regular professional attention at least once each year without screening.

6. The professional examiner should act as an employee of the agency responsible for the school health program and, even if he is a part-time employee, should not be in private practice in the area so that the economic interest of the examiner cannot become an issue.

7. The school health-education program should include material on visual health that influences parents to get regular professional attention for those children with vision problems.

8. The administrator responsible for the vision-screening program in the schools

should receive from the professional examiner an analysis of the cases referred. These results should be compared with the estimates cited in this study (see p. 110), for a check on the effectiveness of the program. Significant departures should be studied carefully.

Modified Clinical Technique. If a large number of first-grade children are given the MCT, approximately 18 per cent will fail the screening, up to 30 per cent of whom may have had previous professional attention, and approximately 2 per cent will be unnecessary-referrals.

Most of the children who are referred by the MCT will fail more than one of the criteria. The amount of previous professional attention will influence the number failed. The referrals may be as high as 20 per cent. If the MCT is used for children in grades above the first grade, the number failing will be increased by approximately 1 per cent per grade, owing largely to increased failures in visual acuity and refractive errors.

Visual Acuity. In successive years the visual acuity (Snellen) testing of those children previously screened by MCT and without identified vision problems, should result in the failure of up to 4 or 5 per 100, 2 or 3 of whom may be unnecessary-referrals when rescreened by the MCT.

Teacher Observation. In successive years Teacher Observation of those children previously screened by MCT and without identified visual problems, may fail as many as 15 per 100, most of whom will be unnecessary-referrals when rescreened by the MCT. This, however, will help to detect the borderline new-referrals.

The steering committee should have the obligation of verifying the adequacy of the screening program, the absence of excessive under-referrals and over-referrals, and the modification of the referral criteria to meet local requirements, and should also assist in the development of the school visual-health education program.

Vision is the primary avenue to education and the identification and removal of visual handicaps most certainly will increase the educability of children with vision problems, improve their visual health, and be of ultimate benefit to the community. The study staff believes that the vision program recommended here will contribute significantly to the general educational program. "

The plan that was outlined lead to approximately 16% of the first graders being referred. The amount of previous attention and socioeconomic status will effect this percentage. Visual acuity would be done on all children which should result in a 4 to 5% failure rate and teacher observation would probably add another 15%, most of which will be shown to be over referral when rescreened with the M.C.T. This will, however, help detect the borderline new referrals.

The Orinda study has provided much information on the subject of vision screening. Previous to this, no study approached it's efficiency. It answered many questions on referral criteria, incidence of problems, as well as what battery of tests correlate best with a clinical examination. It did not however, try to ascertain what in fact are the visual skills that relate to achievement.

The author of the West Warick Study (1972) [49] is Howard Coleman. Prior to this study he did an analysis of an entire school population of 3,623 children in grades K thru 6 [50]. In this screening he used the Orinda study but added near V.A., rotations,versions, and fixations, as well as Keystone skills. His findings on visual problems are illustrated in Table V. Refractive error in the table was classified by it's major component.

TABLE V [51]

Coleman - Analysis of a School Population of 3,623 Children in Grades K through 6

Grade		VA	Myopia	Hyperopia	Astig	Binoc	Amb.	Strab	Total%
K	M	1	1	10	1	2	0	3	15.8
	F	3	0	10	2	4	2	5	25
1	M	15	5	25	12	2	1	6	21
	F	13	2	36	12	1	0	2	22
2	M	15	12	15	11	3	0	9	21
	F	14	10	12	5	4	5	4	20
3	M	15	15	7	5	2	3	5	19
	F	12	21	4	3	5	1	2	17
4	M	3	28	8	6	9	0	4	10
	F	10	39	10	2	4	1	7	25
5	M	5	31	3	3	7	0	3	19
	F	4	49	13	6	5	0	5	35
6	M	4	36	5	1	11	4	5	26
	F	11	57	57	4	15	6	7	39
Incidence			8.4%	4.7%	2%	2%	.6%	1.8%	

15% of his sample failed as a result of manifest refractive error. The incidence of refractive error increases at a rate of 4% a year in his sample compared to 1.6% per year in the Orinda. It is interesting to note that in kindergarten the ratio of myopes to hyperopes is 1:20 and by the third grade the ratio is 36:11. The rate of referral was 17.9% to 30.9% of the population screened depending on the grade. It is also interesting to note that in kindergarten, 4th, 5th, and 6th grades referrals were greater for females than males. The inadequacy of the far Snellen test is again evident because even when combined with a plus two Diopter sphere test it still only yielded a referral rate in the same population of 8%. Coleman also made an attempt to evaluate the follow-up care. He found 60% of those referred received professional care. Evaluation by the doctors in the area of the correctness of referral was 80-100% for optometrists and

51-88% for ophthalmologists. One of the major areas of discrepancy he found to be for the correction of hyperopia on young children. He did look into the relationship of visual skills and grade repetition. He found a significantly higher incidence of hyperopia and astigmation amongst children who repeated a grade.

The West Warick study by Coleman was a broad investigation into various aspects of vision. He included visual and visual-perceptual tests in his screening. By doing a factor analysis he found the following tests related at significant levels to achievement. Factor 1 was called Ocular Movement and Coordination and it included versions, rotations, fixations, and form concepts. Factor 2 Reproduction of Perceptual Patterns, consisted of writing ability, body image, number sequence and number concepts, and visual memory. Spatial Discrimination was Factor 3 and it included tests of laterality, directionality, spatial orientation, hand-eye coordination, graphethesia and Titmus Stereofly. Factor 4 included accommodation and convergence, VA at near, cover test and color vision tests. These factors are listed in the order of predictability of achievement as measured by the Metropolitan Readiness Tests and the Stanford Achievement Scores.

Tests of ocular motility were found to be most predictive of achievement. It is also interesting to note that near VA had a higher relationship to achievement than for VA. His battery of tests showed that 26.2% of the grade repeaters exhibited visual perceptual problems.

Another interesting aspect of Coleman's study was his attempts at remediation of the visual problems he discovered. The description of this successful remediation program is beyond the scope of this paper.

The Ohio Comprehensive Vision Project (1973) [52] was comprehensive in the number of children involved (44,885) but not in the scope of the screening. The screening consisted of Visual Acuity at far and a +2.00 D sphere test was done on first graders to test its validity. The criteria for referral was 3/4 of 20/40 for those under fourth grade and 20/30 in those children in the fourth grade or higher. If a child failed the test once he was retested and if he failed again he was referred.

The reliability of this method of screening is pointed out by the fact that 20.4% of the children who failed and then were rescreened passed. The children who wore glasses were separated from the rest of the group and the table below shows the much higher incidence of failure for those wearing glasses as compared to the entire population.

TABLE VI [53]

Ohio Project - Percent Referral vs Grade

Grade	% of total population	% of those wearing glasses
1	9.7	35.3
2	7.5	27.6
3	9.0	26.9
4	12.0	23.2
5	14.0	26.9
6	11.4	20.0
7	13.0	19.3
8	11.8	14.1
9	12.0	13.2
10	9.1	11.5
11	9.2	9.5
12	8.5	8.7
Special Ed.	24.2	27.5

The higher incidence of failure in the special education group would tend to infer a relationship between far visual acuity and the need for special education. The plus two diopter sphere test failed 2.7% of the first graders and 58.9% of those referred received a correction.

Special arrangements were made by the state to provide vision exams for those who could not afford them and this resulted in 90% of those who failed the screening received an examination. A report was requested back from the examining doctor on the results of the eye examination. Of the 4,880 referred, 2,008 (41.4%) reports were returned. Of those reports returned, 4% of the children referred were normal and 15.2% had problems not severe enough for correction. Unfortunately, no attempt was made to determine how many children who needed care were not referred.

A study was conducted by Dr. Harold Haynes on a segment of our present screening population [54]. He analyzed the results of a full clinical examination on 91 children right before they entered the first grade. His findings were that 30 of the children were satisfactory visual performers, 16 were satisfactory, but should be carefully watched, 36 exhibited inadequate performance and 9 should be reexamined. He found a 20% incidence of refractive problems using -.25 to +.75 and less than .50 of astigmatism or anisometropia as his definition of normal. It will be interesting to see what percentage of this same group need some type of care as defined by our screening.

PROCEDURE FOR THE 1974 DISTRICT 15 SCREENING PROGRAM

All screening was done by the first, second, and third year student clinicians from Pacific University College of Optometry. Clinicians volunteered their time and signed up for the days they desired to participate. Also accompanying each screening group was a licensed O.D. to oversee any questionable findings.

Twelve to fourteen clincians were needed each day to man 9 stations. A chairman was selected each day from the third year to oversee locations of each station, setting up of equipment, assigning personnel to stations and checking completed forms before the student left the area. Occasionally, the chairman would assist if the students started accumulating at any one station.

Second and third year clinicians were rotated every hour to enable all to experience each station. This ruled out subjective findings being biased by having only one clinician on a station all day.

It was most convenient for the school to release one classroom of students at a time for the screening program. The teacher was asked to accompany the class to the screening area. Each class averaged 25 to 35 students making it necessary to provide a place for the students to wait. Chairs were assembled near the entrance area where the students received their screening forms. The teacher could then provide some help in controlling the students while they waited.

The first station was registration. Two or more first year clinicians placed the student's name, the date, and teacher's name on the screening form. Some teachers were helpful by having this information on the forms before arriving at the screening area. This was very helpful in reducing the amount of time needed for registration and fewer spelling errors resulted. The students carried their forms from station to station.

Station 2 was visual acuity. Two second year clinicians conducted this testing at far and near OU, OD. OS using Snellen charts. For far, 2 A-O projectors mounted on floor stands projected a chart onto a movie screen at 20 feet. The near acuity was tested using a reduced Snellen card at 16 inches. The acuity was recorded as a Snellen fraction. The clinicians were usually seated by a stand or flat top desk perpendicular to the screen. Attempts were made to control the illumination in the acuity testing area by locating the station appropriately, covering windows, turning out lights, and providing goose-neck lamps for near testing.

Station 3 was stereopsis. One or two second year clinicians used rows A, B, & C on the Titmus Stereofly for this test.

Station 4 was color testing. Only one second year clinician did this test because for the most part only boys were tested. The screening portion of the Ishihara color test was used as prescribed by the manufacturer. A corrected color fluorescent bulb was used for illumination.

Station 5 was distant rock. This test was performed on only 676 of the 1949 total sample and was not manned by our volunteers as explained in introduction. An 8 letter horizontal row of 20/80 and 20/25 Sloan letters was placed at 20 feet and at 16 inches. The student was asked to read one letter from the 20' line and then one from 16" and then back to 20' until each row had been read twice. The elapsed time was recorded in seconds. More details are available in a paper by Mann, et. al. [55]

Station 6 was a combination of near point of convergence, cover test at far and near, pursuits, saccades, and near-far fixations. Three third-year clinicians performed these tests. The near point of convergence was tested using a fixation bead of approximately 5 mm diameter and asking the student to watch it as it was moved toward their nose. It was usually done twice, once without the patient reporting doubling and the clinician observing the eye movements, the second time asking patient to report any doubling. If doubling was present, the distance at which it occurred was recorded as the break and the report of "one" as the bead moved away from the student was recorded as recovery. If no doubling was present, the clinician's observation of one eye no longer tracking was recorded as the break and recovery was recorded as the distance at which the non-fixing eye was observed to resume tracking the bead. If the patient followed the bead up to their nose, one eye was occluded for approximately 2 seconds and then the bead was moved back out until binocular fixation was again obtained. The break was then recorded as 1 and recovery as the distance at which the binocular fixation was obtained.

The cover test was performed using a 20/30 target or the best acuity attainable by the patient. All tropias and any lateral phorias greater than approximately 5 prism diopters were neutralized. Any vertical movement reported by the patient was also neutralized.

Pursuits in horizontal, vertical, oblique, and circular patterns were tested using the same bead as mentioned earlier.

The near-far fixations were tested using 2 beads and having the students fixate one, at approximately the Harmon distance or at the NPC break which ever was greater, and then the other at approximately 30 inches from his nose. The student alternated fixation between the two beads on command by the clinician who then observed any over-shooting, under-shooting or abnormal movement during the changes in fixation. The clinician was usually seated with a stand or flat topped desk near by on which to place his loose prisms, beads, cover paddle, and recording form.

Station number 7 was static retinoscopy. Two or three third-year clinicians were stationed here. A flat top desk or table was needed to hold lens bars, working distance lenses, retinoscope, and recording form. The clinician was usually seated with his back to the movie screen. A super 8 projector with a film loop of a cartoon was used to keep far fixation at

20 feet. The illumination was kept just bright enough to enable the clinician to record his results on the recording form. It worked best if the students waiting were not in a position to watch the movie until they were being tested.

Plus 2 diopter working lenses were placed on the student (over his prescription if wearing one) and the refractive status of the 2 principal meridians was determined. This refractive error was then written on the recording form.

Station 8 was dynamic retinoscopy using the monocular estimate method (MEM). One third-year clinician was usually sufficient for this test. The 180th meridian was tested using 1 cm numbers on a card at a distance of 16 inches. A with motion was usually observed and the estimated amount of plus lens needed to neutralize it was noted. This was usually verified by momentarily holding a plus lens in front of the eye as the retinoscope streak was swept across. A table was used here also to hold equipment.

Station 9 was ocular helath. Two or three third year clincians did the examinations. Students were checked for pupillary light response (direct and consensual), the near reflex, and any external or internal pathology. Students were often asked to stand on a chair or table to enable more ease in observation by the clinician.

The students soon spread out into the various stations as the screening progressed. This enabled the teacher to return to the classroom to keep control as the students returned.

At the conclusion of the screening, all students who were screened were sent a letter from SOA through their elementary school (see Appendix for sample letter) which listed the student's performance on the screening. If he failed, the letter attempted to explain the area of failure and what kind of follow-up care was needed.

After the screening project was completed, standardized math and reading achievement scores were obtained for as many of the subjects as possible with the assistance of school district personnel. At the time of the screening project, the examiners did not know that a study was planned and in no way were they aware of which subjects were high or low achieving students. Thus no influencing of the findings for high or low achievers was possible.

The special education class was composed of students from grades 1 to 6. The criteria for placement in special education are numerous, such as poor reading ability, referral from the Oregon Medical School, or the Washington County Child Development Clinic, or numerous other agencies. The special education class was mixed in with the other classes during the screening program. The examining clinicians were not aware of which students were special education and which were not, thus not prejudicing the data with examiner bias.

SCREENING REFERRAL CRITERIA

The following criteria were developed to serve as the basis for making referrals during the screening program. The screening results for each child were summarized in a letter that was sent to the parents through the schools. The referral criteria were used in indicating to the parent what follow-up care was needed for their child.

The pass-fail criteria indicated on the vision screening form were derived from two sources. Those marked with * are taken from the results of the Orinda Study and the others are from Pacific University College of Optometry with the assistance of Professor Haynes.

A number one (1) beside the criteria denotes failure, number two (2) denotes borderline, and number three (3) denotes pass. Any child who failed a test had a letter sent home stating he needed a full visual examination. A child who was borderline had a letter sent home stating that he had borderline performance and if there were any visual symptoms, a full visual examination was indicated.

Some of the tests, such as dynamic retinoscopy are not routinely done by most practitioners, thus the criteria used were sufficiently broad that a child that failed would likely show visual problems in a standard visual examination. The screening referral criteria used in our program are given below.

*Far and near visual acuity either eye

Score

1. 20/40 or less
2. 20/30 or 20/25
3. 20/20 or more

Stereopsis (Depth Perception)

1. No response at all
2. Missed one or two stereo patterns
3. All stereo patterns correct

Color Vision

Score

1. Missed 5 or more symbols. List plate and symbol missed.
2. Missed 4
3. Missed less than 4 symbols

Distance Rock (far-near-far response time)

1. less than 10 cycles/min
2. 10 to 21 cycles/min
3. Greater than 21 cycles/min

Near Point of Convergence

	Break	Recovery
1.	Greater than 7	Greater than 8
2.	4 to 5	6 to 7
3.	Nose to 3	Nose to 6

*Cover test at Far

1. Any tropia or any phoria greater than 5 eso, 5 exo, or two vertical
2. 4 eso, 4 exo, or 1 vertical
3. less than 4 eso, 4 exo, or 1 vertical

*Cover test at Near

1. Any tropia, or any phoria greater than 5 eso, 9 exo, or two vertical
2. Phoria of 2 to 5 eso, 9 exo, or 1 vertical
3. less than 2 eso, 9 exo, or 1 vertical

Pursuits

1. Erratic tracking movement, frequent fixation loss
2. Intermittent fixation losses, effort more evident
3. Smooth, relatively effortless tracking movements

Near-far fixations

1. Unequal speed, movement erratic, great effort, loss of binocular focus
2. Unequal speed, greater effort
3. Smooth, equal speed of shift, relatively effortless

*Static Retinoscopy over habitual prescription

	Myopia	Hyperopia	Astigmatism	Anisometropia
1.	-.50 or more	+1.50 or more	1.00 or more	1.00 or more
2.	-.37	+1.25 or more	.75 or more	.75 or more
3.	-.25 or less	less than +1.25	less than .75	less than .75

Dynamic Retinoscopy--Monocular Estimate Method--MEM

1. 1.75 or more of with motion
2. 1.62 to 1.25 with motion
3. less than 1.25 with motion

*Ocular Health

1. Any pathological condition	Record observation if
2. Questionable	classified by 1 or 2.
3. Good	

DATA PREPARATION FOR COMPUTER PROCESSING

The material in this section covers some of the details of the data preparation before computer processing. Since we have about 24 pieces of data for each child in the screening (about 50,000 items), an efficient manner of inputing the data to the computer had to be established. We chose to punch the data into a Hollerith card with a keypunch. Each child's information was conveniently placed on one card and these cards could then be processed as often as needed. The material below discusses how the format for the punched card was determined and some sample data are presented. References should be made to the Multiple-Card Layout Form on the following page for additional explanations.

The far visual acuity recorded was the denominator of the Snellen fraction. An example would be 20/30 recorded as 030, 20/100 recorded as 100. The near visual acuity was also recorded as the denominator. An example would be 20/30 recorded as 30.

Stereopsis, color vision, pursuits and fixations, and ocular health were recorded as 1,2, or 3 according to pass-fail criteria listed previously.

Distance rock was recorded as the number of seconds needed to do 16 cycles.

Near point of convergence is recorded in inches as break over recovery. An example is 2/8 recorded as 0208 or 2/10 recorded as 0210.

The cover test was recorded using magnitude, direction, and phoria or tropia. For example, an 8 prism diopter exotrope would be recorded 0811. A 10 prism diopter esophore would be recorded as 1000.

MEM retinoscopy was done over the habitual prescription in the 180th meridian only. An example of 1.50 D "with" motion would be recorded as -150.

Static retinoscopy was done with +2.00 D working lenses over the habitual prescription and recorded as the refractive error. For example a

IBM

NOTE: DO NOT USE THIS FORM WHEN ORDERING NEW OR REVISED CARD FORM COMPOSITION

INTERNATIONAL BUSINESS MACHINES CORPORATION

MULTIPLE-CARD LAYOUT FORM

GX24-6599-1 U/M025*
Printed in U.S.A.

Company: College of Optometry
Application: Screening Thesis by D.L. Olson Date: Sept. 74 Job No. ______ Sheet No. ______

Sex		1
Grade		2
Far VA	OD	3–5
	OS	6–8
	OU	9–11
Near VA	OD	12–13
	OS	14–15
	OU	16–17
Stereo		18
Color		19
Accom Flex		20–22
NPC	Bk	23–24
	Re	25–26
Cover Test	Δ	27–28
	E X V	29
	P T	30
	Δ	31–32
	E X V	33
	P T	34
Pursuit		35
Fixation		36
MEM OD	±	37
	(value)	38–40
MEM OS	±	41
	(value)	42–44
Static Retinoscopy OD	±	45
	Sph	46–49
	-cyl	50–52
	axis	53–55
Static Retinoscopy OS	±	56
	Sph	57–60
	-cyl	61–63
	axis	64–66
Ocular Health	P	67
	E	68
	I	69
Reading		70–71
Math		72–73
		74–76
School		77
Student ID Number		78–80

Codes:

#1
F = 1
M = 2

#2
ϕ = Kindergarten
– = Special Ed
1 = First, etc.

#29 & #33
0 = E = ESO
1 = X = EXO
2 = V = vertical

#30 & #34
0 = P = Phoria
1 = T = Tropia

*Number of sheets in this pad may vary.

+2.00-1.00x90 refractive error would be recorded as +0200-100090.

The reading and math scores are standardized achievement scores obtained from District 15 counseling office. The mean is 50 and 10 points equal one standard deviation. Thus a score of 75 would be 2.5 standard deviations above the mean or about the 98th percentile.

The schools were numbered in alphabetical order. One-Central, two-Cornelius, three-Dilley, four-Gales Creek, five-Harvey Clark, and six-Joseph Gale. The student I.D. number was assigned at random as the screening form appeared for processing. It serves only as a means of referring back to a screening form and in no way was there any attempt made to use the achievement score in a discriminatory manner. An example of recording would be the 35th student processed from Dilley would be recorded 3035.

RESULTS OF THE SCREENING PROJECT

In summarizing the results of our project, three areas of investigation are presented. These areas include: what are the various characteristics of our sample, what relationships between general achievement scores and visual findings can be inferred, and what significance did our test battery have in uncovering failures beyond the Modified Clinical Technique. The results relating to each of these sections will be presented in the form of charts, graphs and frequency diagrams in an attempt to visually summarize as much of the calculated results as possible.

Summary of Various Characteristics of the Sample

The various findings from the screening program are summarized in the frequency diagrams included on the following pages. These diagrams present the range of findings encountered in the study and the number of individuals in various intervals for each of the primary vision screening tests.

Figure 1. indicates the number of students screened in each grade K through 6 and in the special education group. Each grade had well over 200 children in the sample, which should be sufficient to derive significant statistics. The relatively low number in the Special Education category would lead one to be cautious about statistical generalizations for this group. The total sample size for our project was 1949 individuals.

Habitual distance acuity at 20 feet for the right, left and both eyes is summarized in Figure 2. The number of individuals with various Snellen visual acuity values is given in the form of a frequency diagram. The large number in the 20/30 column is partially a function of the testing methods for kindergarten and elementary children who did not know their alphabet.

Figure 3. shows the frequency distribution for the habitual near-point visual acuity as measured in the right, left and both eyes together conditions. Again, the Snellen denominator is used as the basis for building the frequency diagram. As in the previous figure, the relatively large peak at 20/30 is a function of the symbol chart used to test children who did not know their letters.

The results for the distance rock screening test are summarized in 2 cycle/min intervals in Figure 4. With an N of 676, the number in each interval yields a rather smoothly shaped distribution about the double modes of 21 and 25.

Figure 5. shows the number of individuals having near-point of convergence findings between various one inch intervals from the nose to beyond 12 inches. Both the break and recovery findings are presented with the modal break from zero to one inch and the modal recovery from two to three inches. A total of 1,911 are included in this sample.

Figure 6. presents the frequency distribution for the phoria findings in the distance cover test. Two prism diopter intervals are used in the diagram and the modal point is centered about orthophoria. The total N in the sample was 1,894 and only one 2Δ vertical phoria was recorded. Similar to the above, Figure 7 provides a break down of the results for the near point cover test results. Again the mode is centered around orthophoria and the reader should note the expected shift toward exophoria when compared to the results in Figure 6.

Figure 8. gives the frequency summary for the accommodative lag findings as measured in dynamic retinoscopy with the Monocular Estimate Method (MEM) for each eye. The modal value for each eye was centered about the .5 to .75 diopters of lag. With a total N of 1,932, the distribution shows a smooth pattern over the range of findings.

Figures 9 and 10 show the number of individuals exhibiting various refractive errors over their habitual state as measured with static retinoscopy. The findings given have been converted to just use the results in the horizontal meridian as the basis for the distribution. The modal result for both eyes is .25 to .50 D hyperopia.

The standardized reading and math subset scores from the Metropolitan Achievement Test for our sample are distributed with 5 point intervals in Figure 11. These scores were provided by District personnel as a readily available measure of academic achievement. A total of 921 reading and 916 math scores were obtained.

Figure 1.

Frequency Distribution for the Number of Students Screened in Each Grade (N=1949)

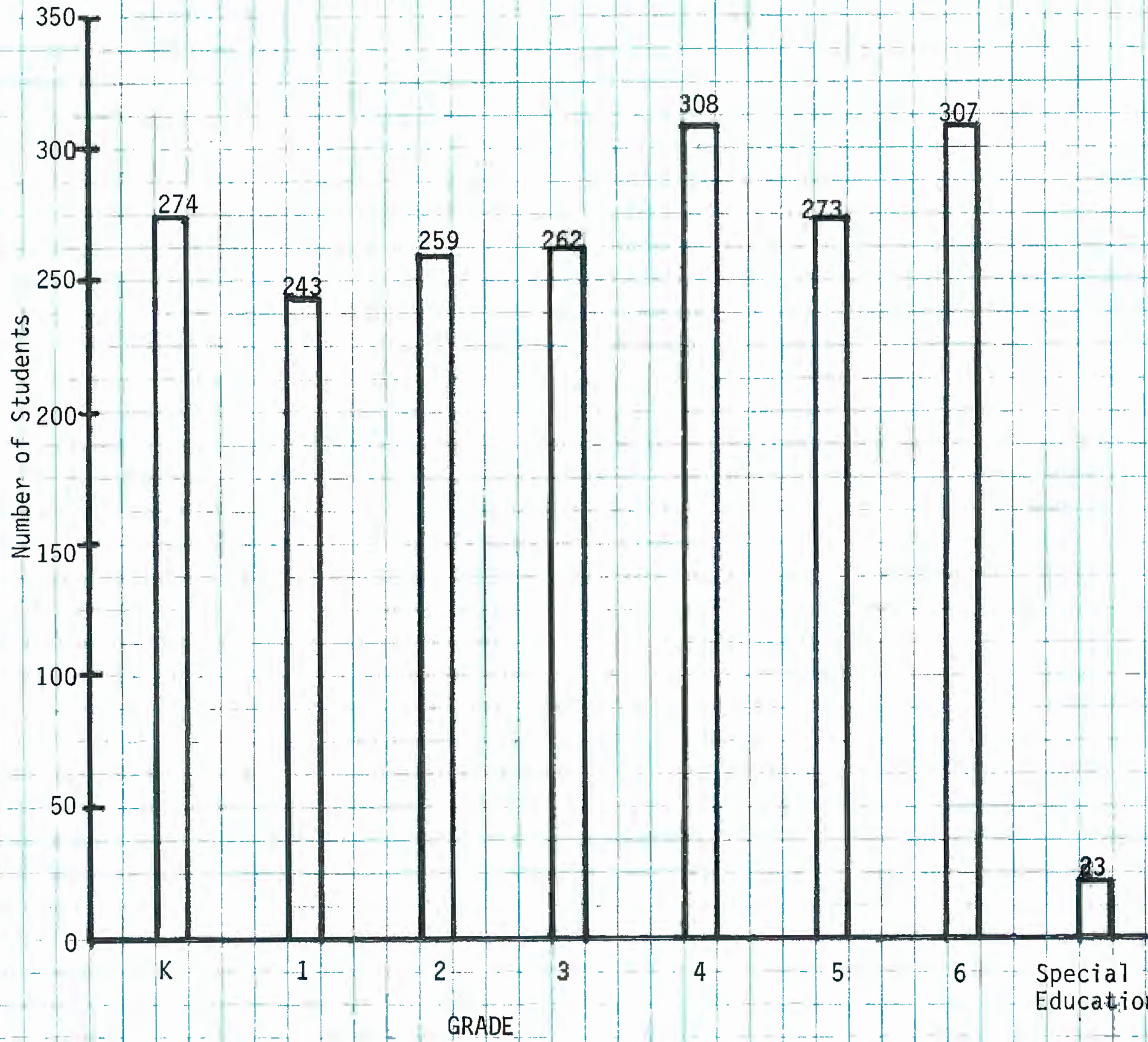


Figure 2.

Frequency Distribution for Habitual Distance Visual Acuity--O.D., O.S., O.U.

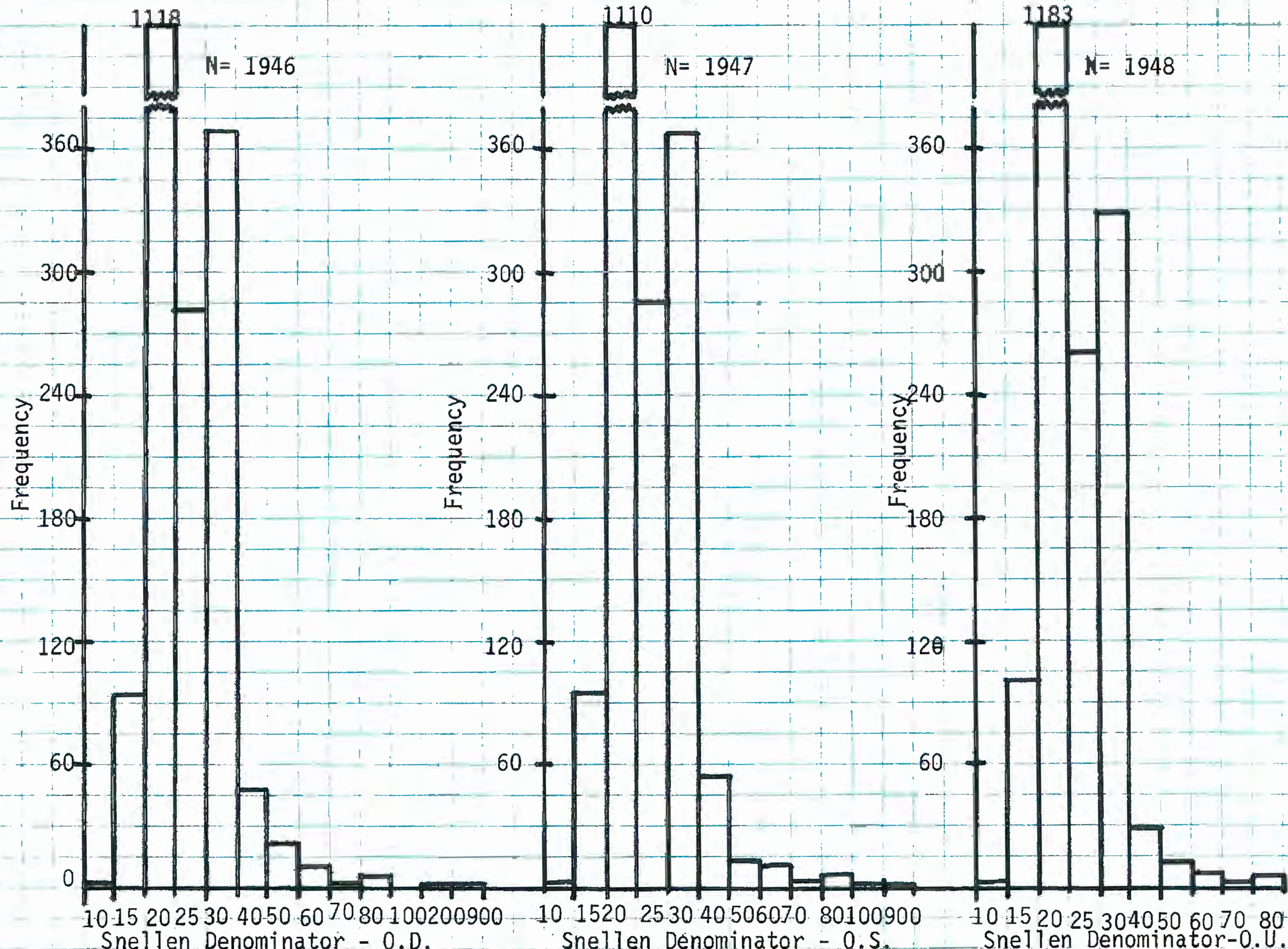


Figure 3.

Frequency Distribution for Habitual Near Visual Acuity--O.D., O.S., O.U.

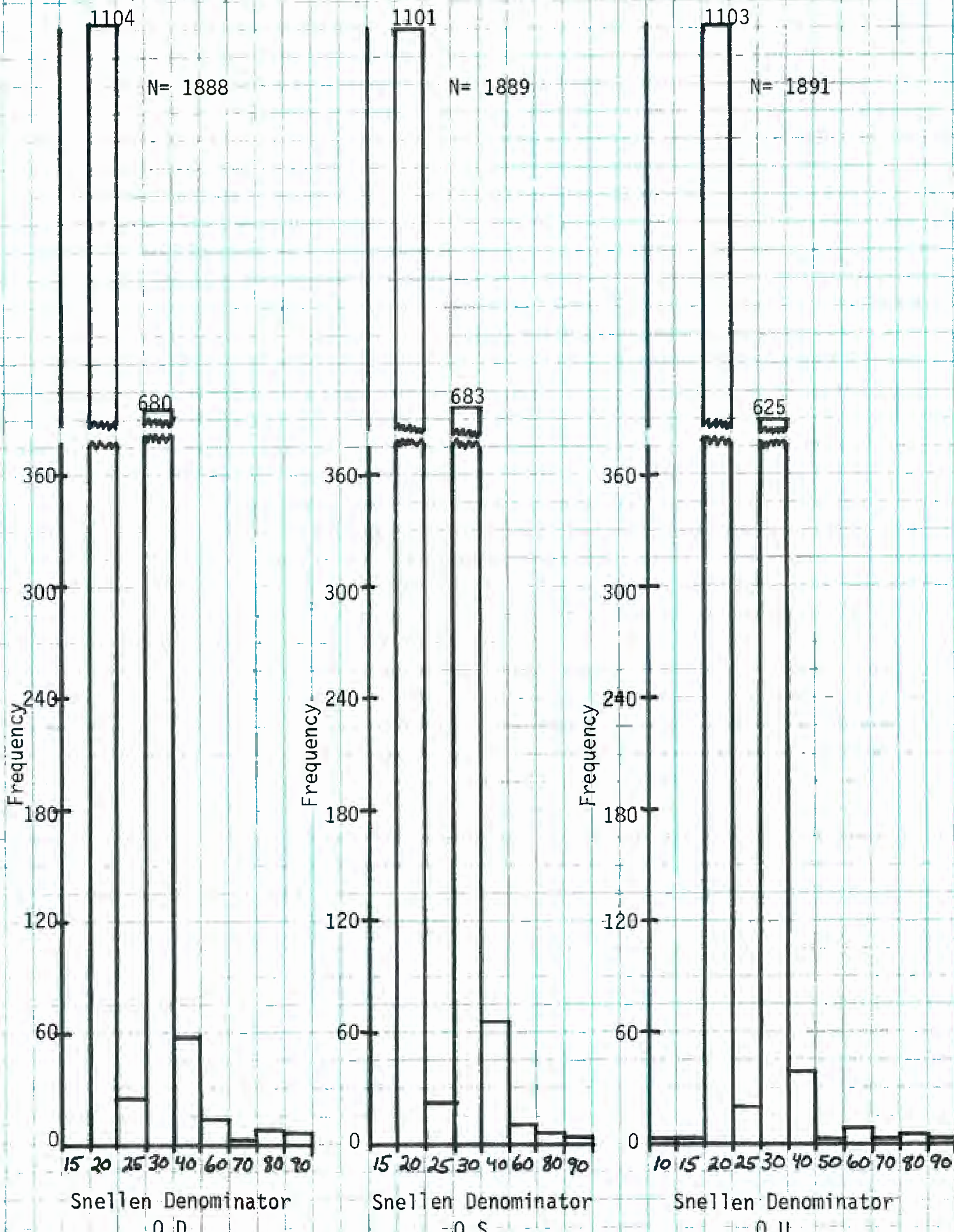


Figure 4.

Frequency Distribution for Distance Rock Results in Cycles/Min.

Combined Sample of Grades 1 through 6

(N=676)

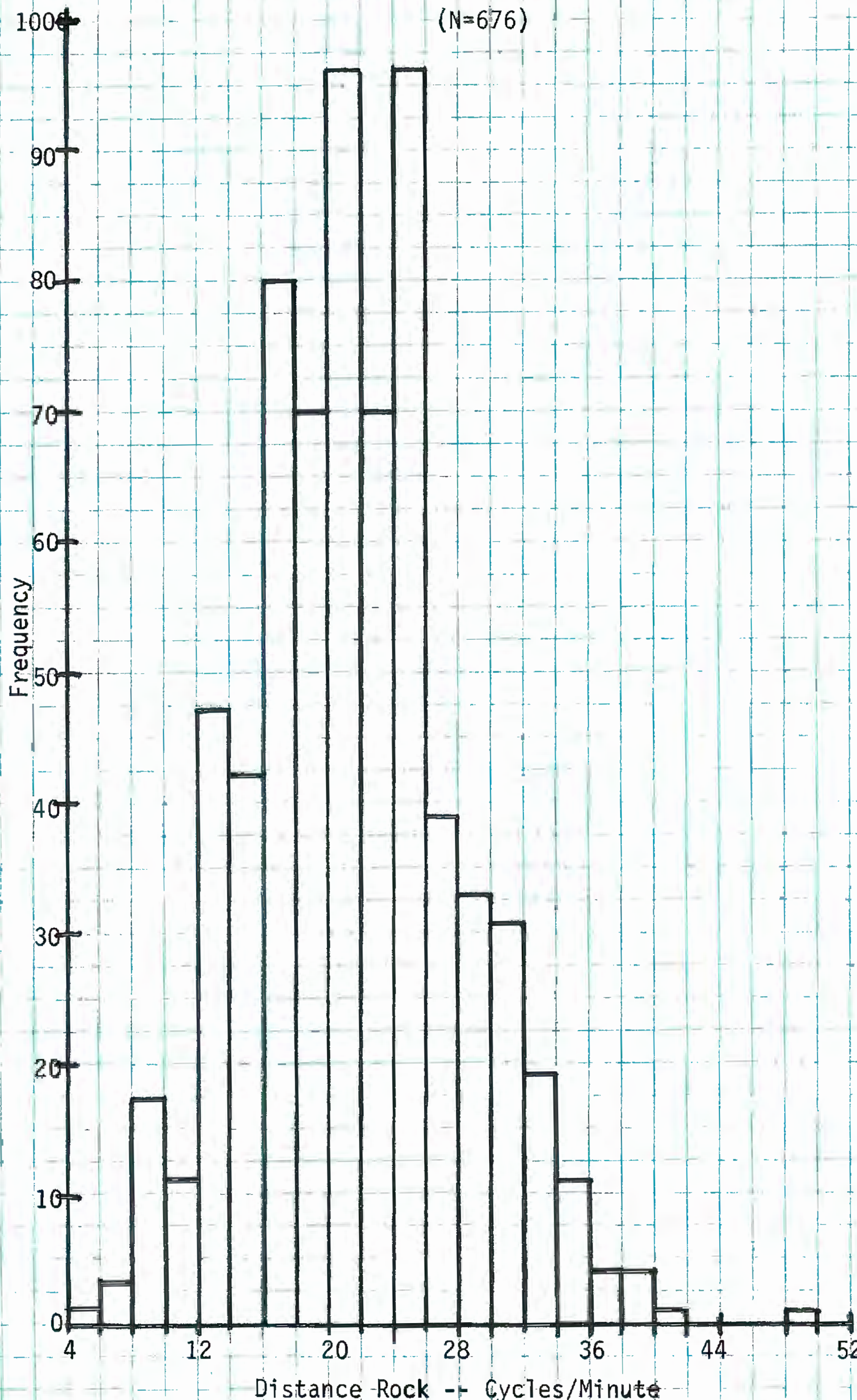


Figure 5.

Frequency Distribution for Near Point of Convergence

(N=1911)

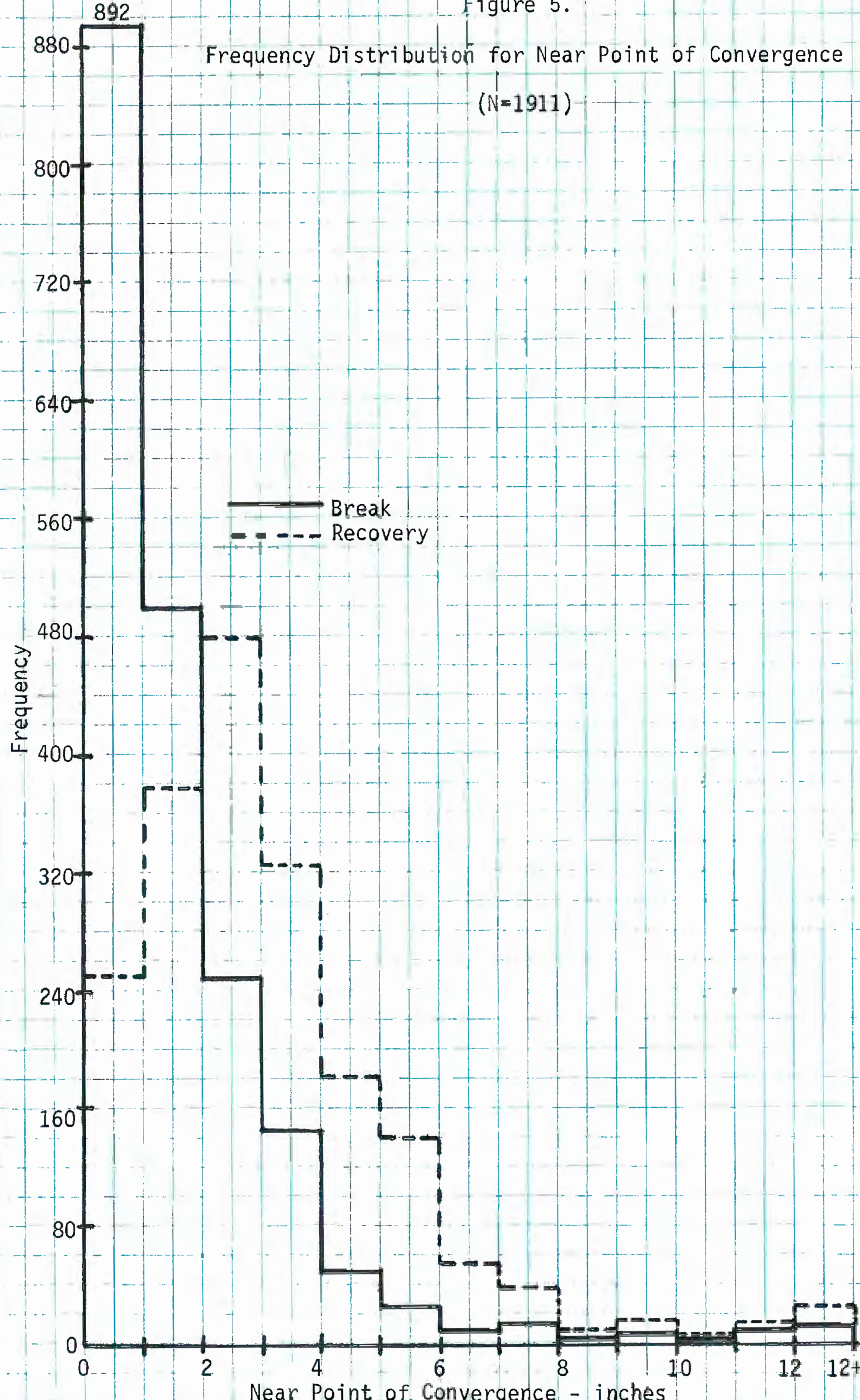


Figure 6.

Frequency Distribution for Far Cover Test Phorias

(N=1894)

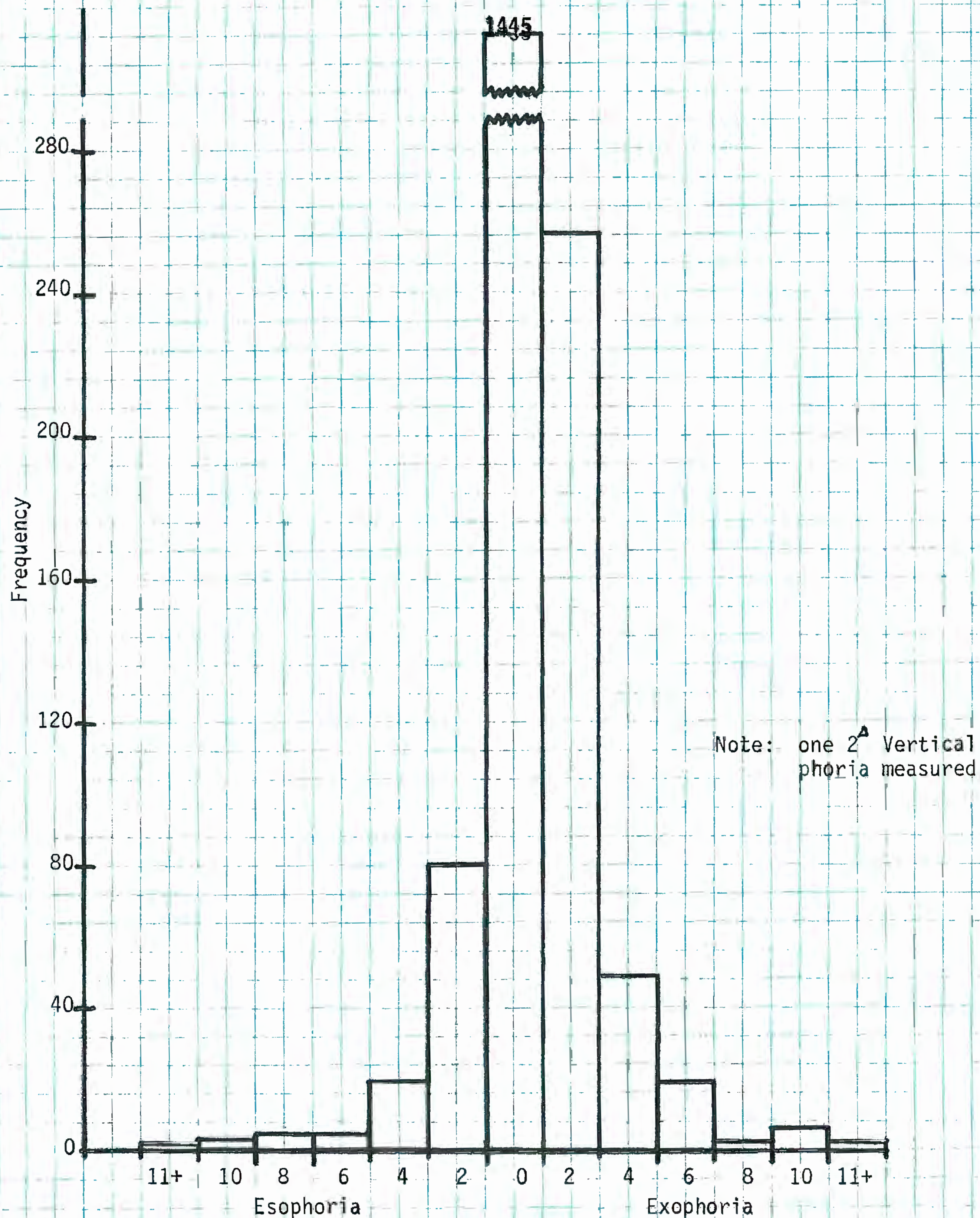


Figure 7.

Frequency Distribution for Near Cover Test Phorias

(N=1881)

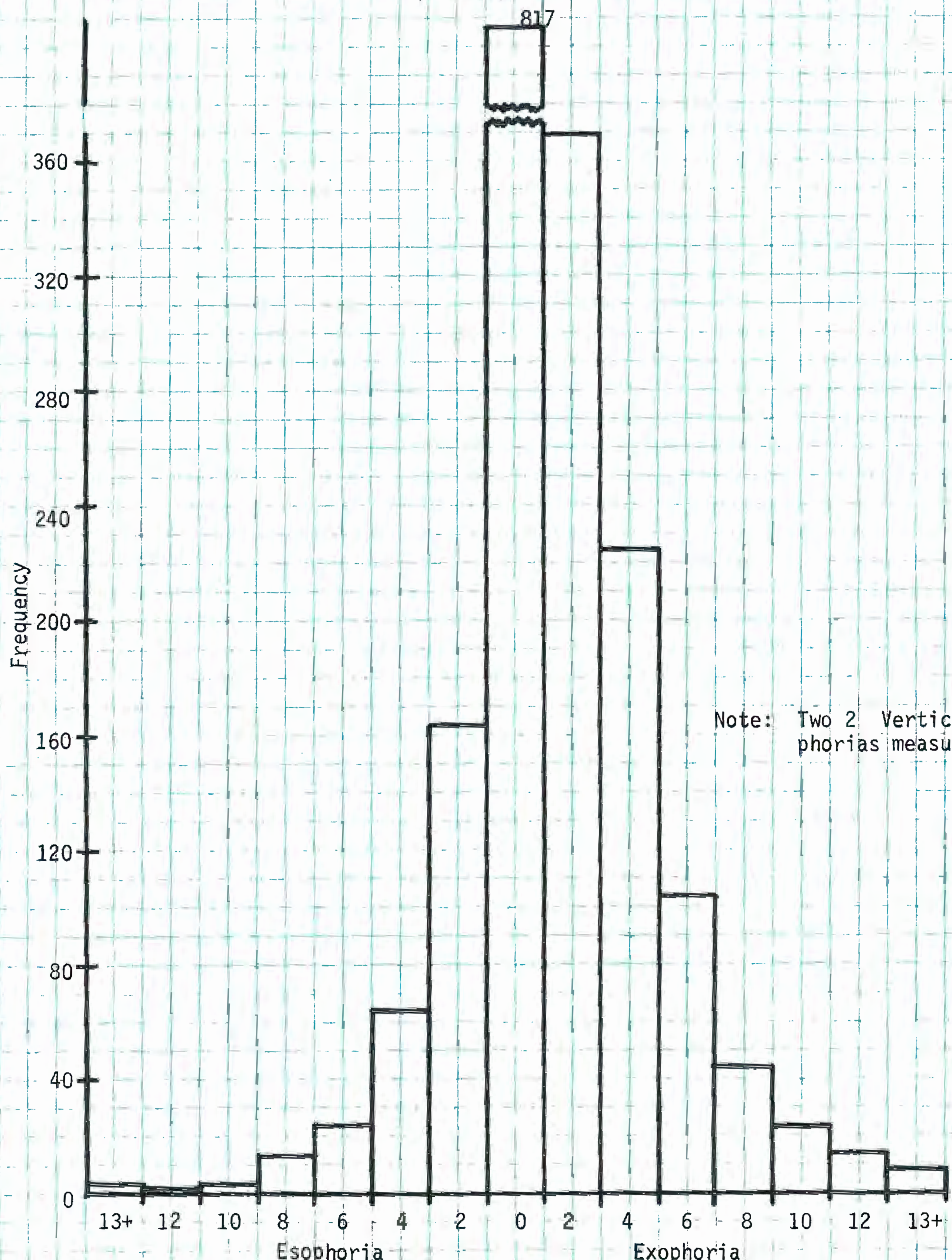


Figure 8.

Frequency Distribution for Results of Dynamic Retinoscopy, Monocular Estimate Method, Right and Left Eye

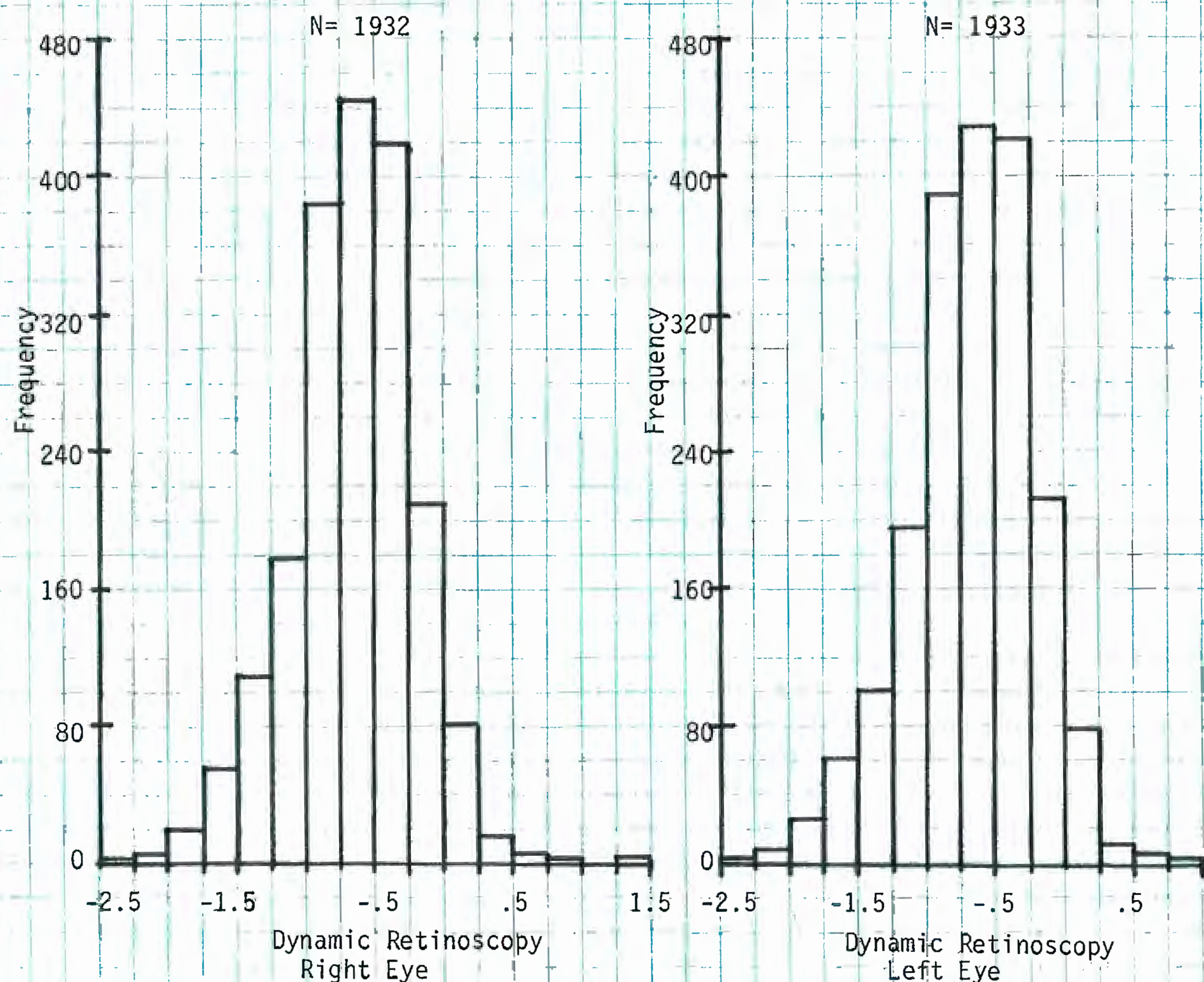


Figure 9.

Frequency Distribution for Static Retinoscopy Measured

Over Habitual Rx-Right Eye, Horizontal Meridian

(N=1942)

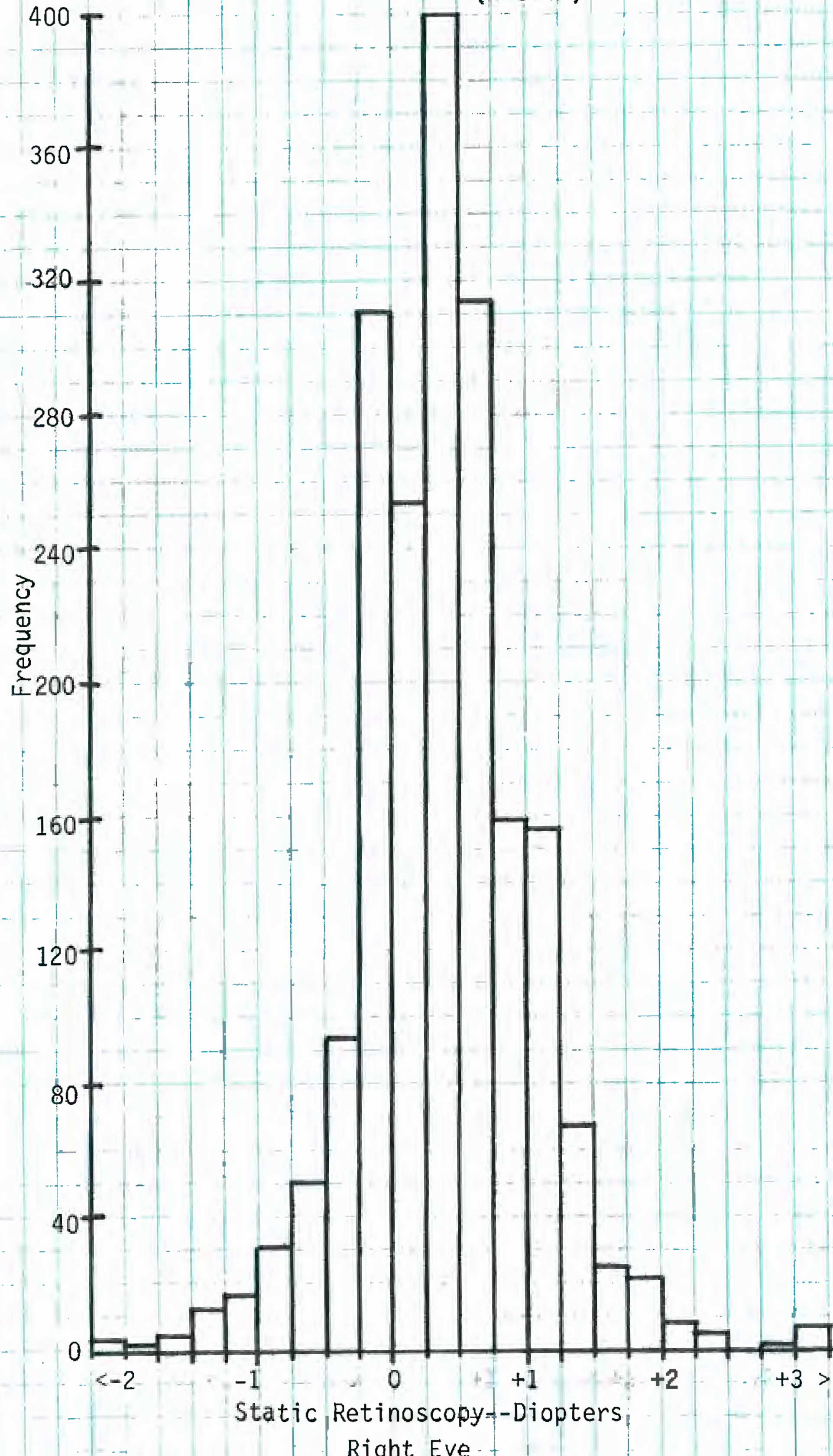


Figure 10.

Frequency Distribution for Static Retinoscopy Measured Over Habitual Rx-Left Eye, Horizontal Meridian (N=1942)

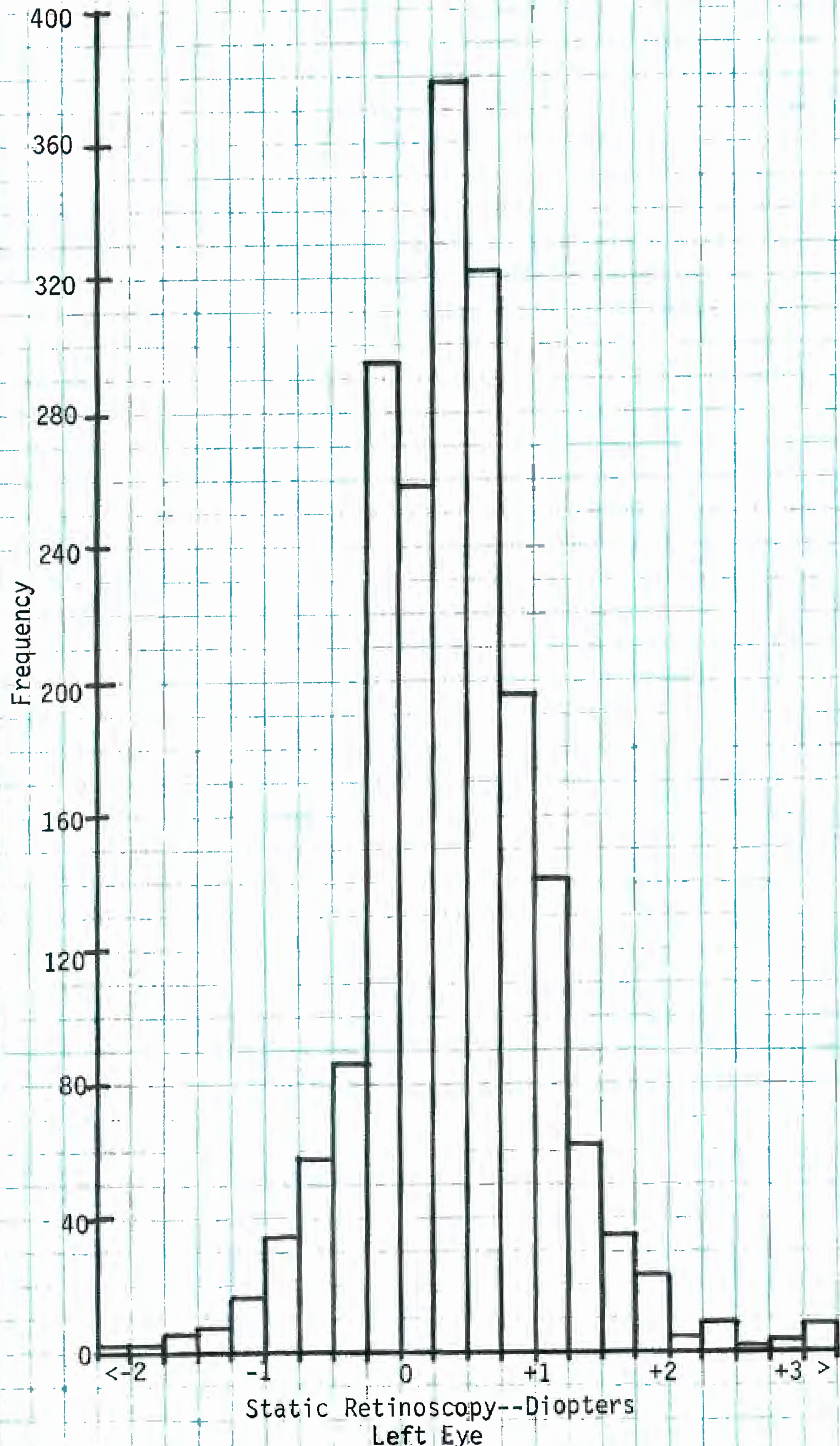


Figure 11.

Frequency Distribution for Standardized Reading and Mathematics Achievement Scores

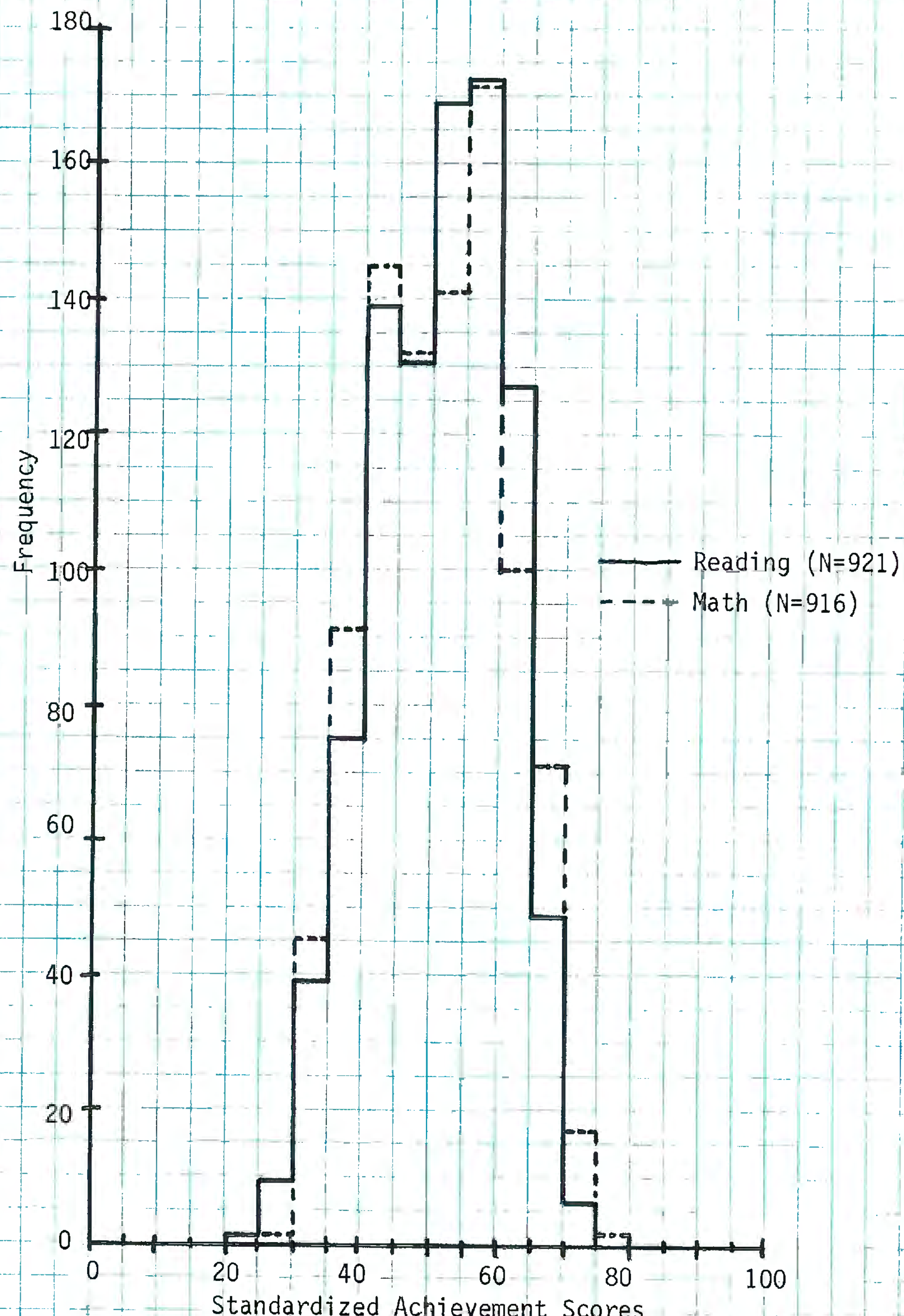


Table VII on the following pages presents a summary of the mean, standard deviation, and number in the sample for each grade, sex and total group for all of the different tests used in the screening set. This table summarizes most of the basic findings of the study; when combined with the pass-fail findings presented later, the results of the entire study can be reviewed.

Following the summary table, several graphs are presented which visually represent the changes in various test findings for the different grade levels in our study. It should be noted that the dips in VA values for the kindergarten group is probably an artifact of the testing method because for those children who did not know the alphabet, the smallest test target available was 20/30 at both far and near.

The group labeled SP (Special Education) is a mixed group of various ages, achievement potentials, etc. It should be noted that for most of the test results, their findings are significantly removed from the total mean of the sample. The graphs that follow show the data changes for the various grade and sex groups of the sample.

The relationship between grade level and decimal equivalent visual acuity at distance in the right eye, left eye, and both eyes is plotted in Figure 12. The horizontal line labeled x_t denotes the mean for the entire sample. The low visual acuity in kindergarten is partially an artifact of the testing materials used for those children who did not know the alphabet. The dip in the curve at grade 3 could possibly be related to the onset of myopia at age 9, that has been reported in other studies.

Figure 13 is a plot of decimal visual acuity at near for the right, left, and both eyes versus grade level. X_t is represented as previously stated and the low kindergarten VA is partially an artifact of the testing materials.

TABLE VII

Summary of Vision Screening Results by Grade, Sex and Total Sample

		K	1	2	3	4	5	6	SP	Girls	Boys	Total
1. Far VAOD	- x	.712	.899	.924	.905	.943	.952	.953	.813	.895	.902	.899
	σ	.136	.165	.191	.154	.171	.207	.194	.165	.192	.193	.192
	n	272	243	259	262	307	273	307	23	928	1018	1946
VAOS	- x	.711	.898	.928	.896	.938	.958	.955	.779	.895	.901	.898
	σ	.124	.164	.181	.168	.180	.206	.193	.187	.193	.193	.193
	n	272	243	259	262	308	273	307	23	928	1019	1947
VAOU	- x	.721	.915	.942	.918	.961	.978	.978	.824	.913	.917	.915
	σ	.128	.151	.172	.145	.165	.193	.170	.159	.182	.180	.182
	n	273	243	259	262	308	273	307	23	929	1019	1948
2. Near VAOD	- x	.682	.777	.869	.879	.916	.926	.901	.797	.850	.855	.853
	σ	.088	.195	.184	.166	.160	.155	.167	.194	.181	.181	.181
	n	271	216	252	240	306	273	307	23	905	983	1888
VAOS	- x	.685	.776	.869	.861	.923	.925	.906	.782	.852	.853	.853
	σ	.087	.191	.178	.178	.151	.160	.163	.184	.180	.180	.180
	n	272	216	252	240	307	273	306	23	906	983	1889
VAOU	- x	.684	.809	.889	.889	.934	.942	.919	.810	.865	.872	.869
	σ	.084	.187	.169	.158	.141	.141	.151	.176	.172	.171	.172
	n	273	216	252	240	307	273	307	23	907	984	1891
3. Dist. Rock	- x	-	14.157	17.337	19.477	21.343	24.071	26.011	-	21.752	21.177	21.445
	σ	0	4.333	4.629	4.089	4.58	5.028	5.73	0	6.154	6.362	6.268
	n	0	84	71	88	147	110	176	0	315	361	676
4. NPC-BK	- x	2.147	2.248	2.125	2.156	2.266	2.151	2.089	4.476	2.230	2.16	2.194
	σ	2.135	2.163	1.899	2.187	1.702	1.63	1.657	6.622	2.152	1.912	2.030
	n	272	237	255	255	300	270	301	21	914	997	1911
-Rec	- x	3.452	3.493	3.764	3.592	3.926	3.574	3.681	5.523	3.711	3.628	3.668
	σ	2.511	2.515	2.392	2.648	2.346	2.174	2.235	6.446	2.611	2.365	2.486
	n	272	237	255	255	300	270	301	21	914	997	1911
-"Ratio"	- x	1.516	1.648	1.417	1.492	1.473	1.491	1.382	3.780	1.533	1.488	1.510
	σ	1.966	2.065	1.778	1.984	1.529	1.475	1.504	6.774	2.016	1.777	1.895
	n	272	237	255	255	300	270	301	21	914	997	1911
5. Far CT-EsoP	- x	3.099	2.279	2.263	2.619	3.823	2.882	3.0	5.333	2.705	3.0	2.862
	σ	2.726	1.594	.991	1.283	3.264	2.147	2.586	4.163	2.266	2.224	2.241
	n	10	25	19	21	17	17	33	3	68	77	145
-ExoP	- x	3.227	2.824	2.935	2.358	2.779	3.103	2.634	3.0	2.969	2.698	2.832
	σ	2.111	1.659	1.782	.962	1.81	3.291	2.134	2.878	2.482	1.626	2.097
	n	44	57	62	53	50	58	63	8	196	199	395
-VertP	- x	-	2	-	-	-	-	-	-	-	2.0	2.0
	σ	0	0	0	0	0	0	0	0	0	0	0
	n	0	1	0	0	0	0	0	0	0	1	1
-EsoT	- x	8.333	20.0	12.25	11.5	10.	23.833	11.5	-	12.363	16.2	14.576
	σ	5.859	14.142	6.448	4.949	9.165	8.495	5.576	0	8.547	8.977	8.837
	n	3	2	4	2	3	6	6	0	11	15	26
-ExoT	- x	14.0	9.0	10.0	25.0	-	9.0	14.0	-	13.833	12.777	13.2
	σ	9.539	6.928	0	0	0	8.485	5.291	0	7.985	8.135	7.802
	n	3	4	1	2	0	2	3	0	6	9	15

TABLE VII (Continued)

Summary of Vision Screening Results by Grade, Sex and Total Sample

		0	1	2	3	4	5	6	SP	Girls	Boys	Total
5. Far CT-Vert T -	x	.5	-	-	-	-	-	-	-	5	-	5
	σ	0	0	0	0	0	0	0	0	0	0	0
	n	1	0	0	0	0	0	0	0	1	0	1
Ortho -	n	212	153	172	179	236	188	201	12	642	711	1353
6. Near CT-EsoP -	x	3.684	3.302	3.361	3.638	4.121	3.974	3.339	5.666	3.681	3.557	3.623
	σ	1.733	1.669	1.724	3.226	3.210	2.170	1.993	3.785	2.369	2.398	2.379
	n	19	43	47	47	41	39	56	3	157	138	295
-ExoP -	x	4.134	3.896	4.24	3.991	4.087	4.462	4.295	7.0	4.328	4.106	4.214
	σ	2.386	2.186	2.597	2.520	1.846	3.170	2.822	4.113	2.898	2.292	2.606
	n	119	97	104	123	114	121	132	14	402	422	824
-VertP -	x	-	2.0	-	-	2	-	-	-	-	2.0	2.0
	σ	0	0	0	0	0	0	0	0	0	0	0
	n	0	1	0	0	1	0	0	0	0	2	2
-EsoT -	x	11.666	20.0	13.00	19.5	8.799	23.166	16.5	-	15.076	17.5	16.545
	σ	3.511	8.66	7.023	6.14	6.379	11.513	3.728	0	9.056	7.83	8.284
	n	3	3	4	6	5	6	6	0	13	20	33
-ExoT -	x	13.0	9.0	7.5	25.0	7.5	8.666	10.5	-	9.9	12.454	11.238
	σ	8.286	6.928	3.535	0	3.535	1.154	1.0	0	5.989	7.16	6.594
	n	4	4	2	2	2	3	4	0	10	11	21
-VertT -	x	5	-	-	-	-	-	-	-	5.0	-	5
	σ	0	0	0	0	0	0	0	0	0	0	0
	n	1	0	0	0	0	0	0	0	1	0	1
-Ortho -	n	127	94	101	79	143	103	108	5	342	418	760
7. Near MEM-R -	x	-.879	-.831	-.817	-.757	-.724	-.692	-.712	-.792	-.765	-.774	-.770
	σ	.460	.429	.401	.447	.417	.493	.428	.329	0.439	.446	.443
	n	269	242	254	259	308	271	306	23	920	1012	1932
-L -	x	-.889	-.833	-.842	-.769	-.745	-.714	-.694	-.852	-.774	-.787	-.781
	σ	.456	.469	.414	.466	.431	.477	.404	.454	.448	.451	.449
	n	270	242	255	259	308	271	305	23	922	1011	1933
8. Static Ret-R -	x	.673	.641	.579	.465	.454	.418	.310	.535	.519	.482	.499
	σ	1.691	.617	.706	.581	.674	.645	.602	.430	1.092	.605	.872
	n	271	243	258	262	308	273	305	22	926	1016	1942
-L -	x	.812	.630	.535	.495	.469	.480	.278	.636	.562	.487	.523
	σ	.733	.597	.670	.582	.680	.607	.973	.521	.704	.740	.724
	n	271	243	258	262	308	273	305	22	926	1016	1942
9. Achievement -Rd -	x	-	-	-	51.25	51.305	49.702	50.205	-	51.170	50.037	50.572
	σ	0	0	0	8.963	9.739	9.496	9.597	0	8.836	10.049	9.508
	n	0	0	0	168	255	235	263	0	435	486	921
-Math -	x	-	-	-	50.226	51.333	50.634	50.868	-	50.277	51.310	50.822
	σ	0	0	0	9.854	9.504	10.849	9.576	0	9.66	10.167	9.939
	n	0	0	0	163	252	235	266	0	433	483	916

Distance rock cycles per minute versus grade are plotted in Figure 14. The horizontal line marked x_t denotes the mean cycles per minute for the entire sample. The number of cycles per minute shows a very linear increase with grade. The ramifications of this progression will be discussed later in the paper.

The change in the break and recovery of the near point of convergence as a function of grade is shown in Figure 15. The horizontal lines marked x_t are the means for the entire sample. The break and recovery plots show a definite horizontal line relationship with grade.

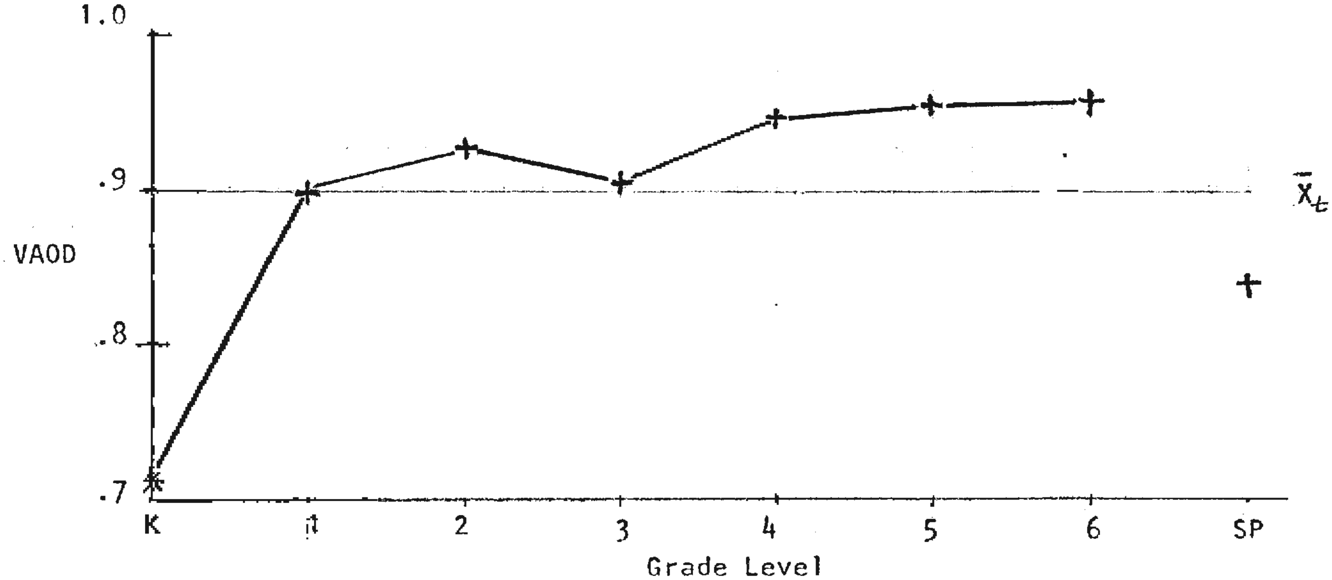
Accommodative lag as measured by dynamic retinoscopy - Monocular Estimate Method - for the right and left eyes is plotted versus grade in Figure 16. Again the total sample means are designated by x_R and x_L.

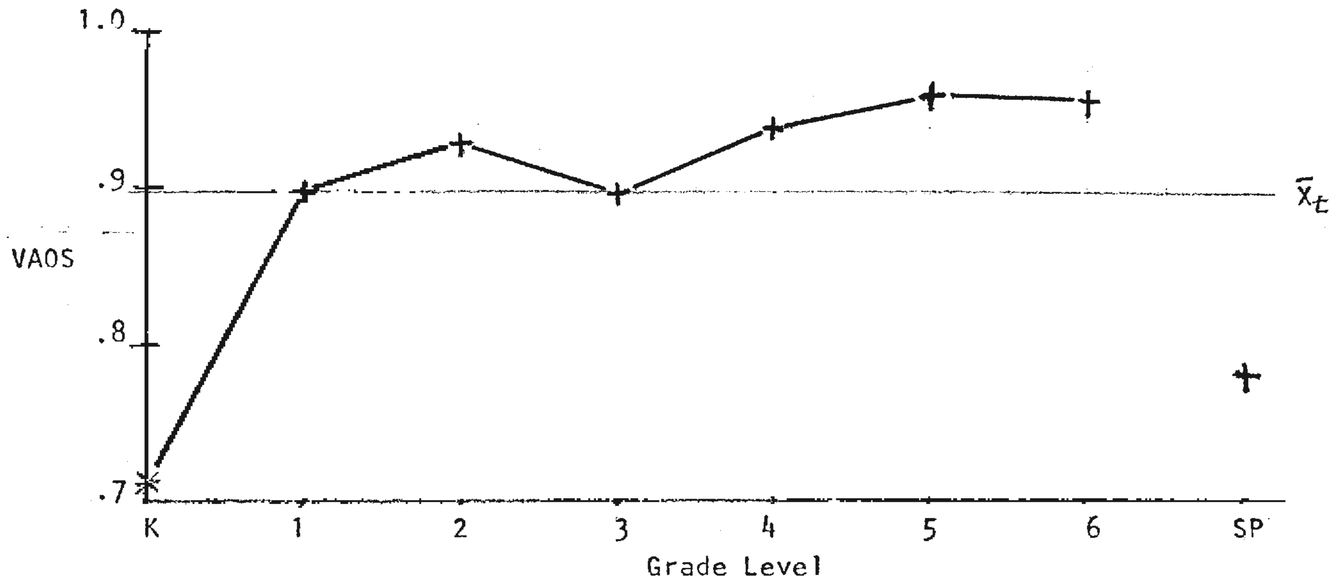
The plot of static retinoscopy over habitual Rx versus grade, for the right and left eye is shown in Figure 17. X_t, serves the same function as in previous figures. The difference between the mean refractive error in kindergarten and 6th grade is approximately .37 Diopters. This is the expected amount of change as indicated by previous investigations, but from our data there is no way to tell whether this change is due to change in refractive error or from more visual care being provided to the older students.

In reviewing the change in test values versus grade, it is apparent that MEM retinoscopy, distance rock, and static retinoscopy all show some rate of change as a function of grade. However, the near point of convergence, far cover test, and near cover test do not show this change. This lack of change with grade could be interpreted as evidence that the accommodative system is still changing through the 6th grade, whereas convergence is essentially stable by kindergarten age.

Figure 12

Habitual Decimal Equivalent Distance Visual Acuity vs Grade Level





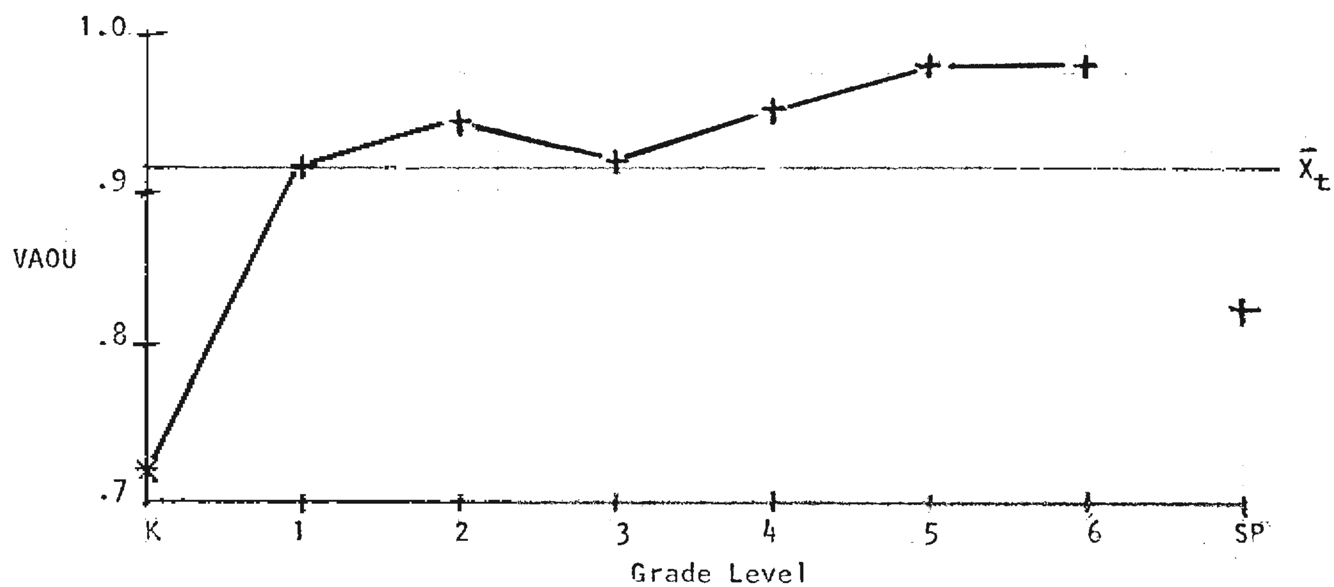
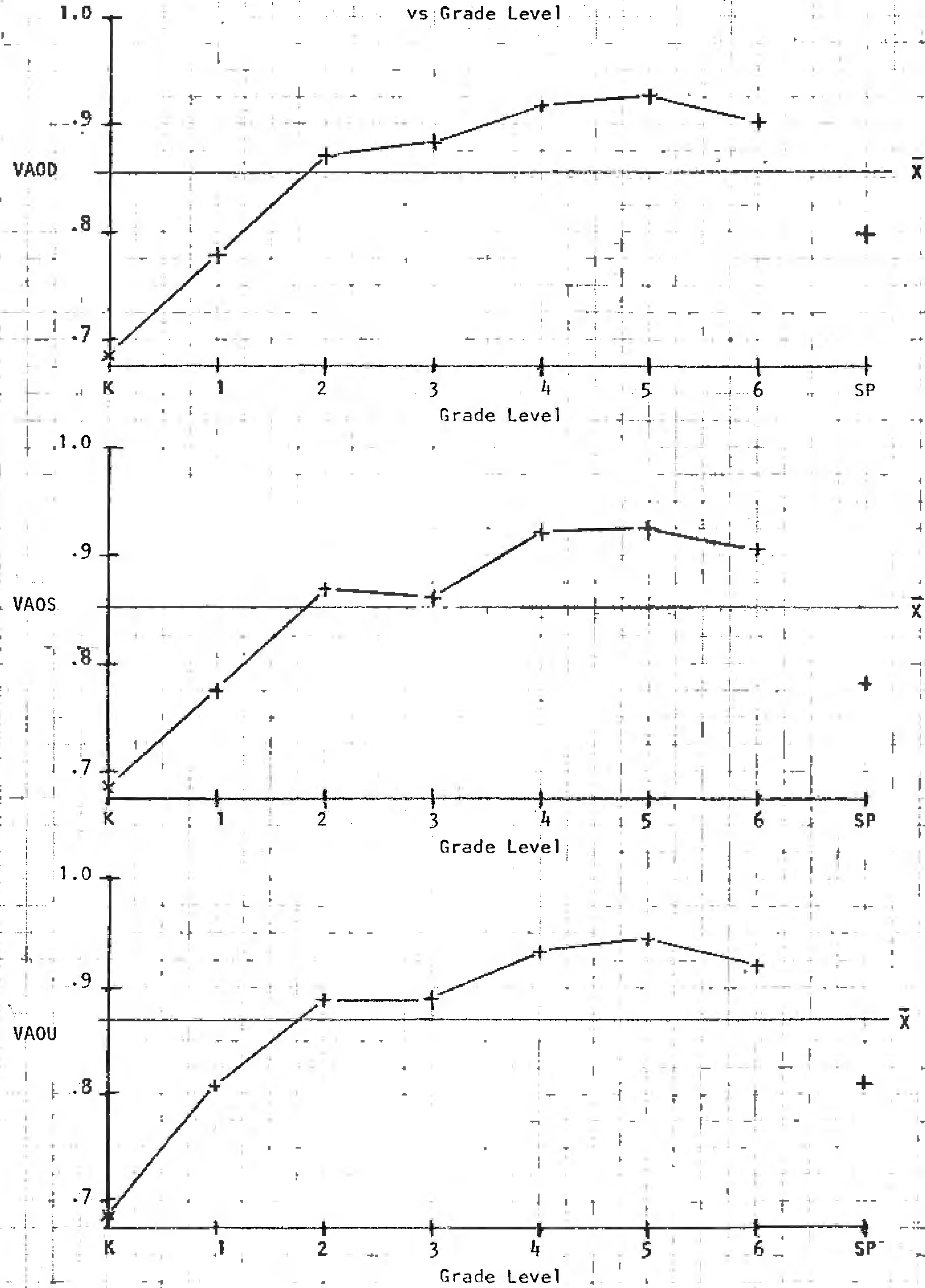


Figure 13

Habitual Decimal Equivalent Near Visual Acuity vs Grade Level



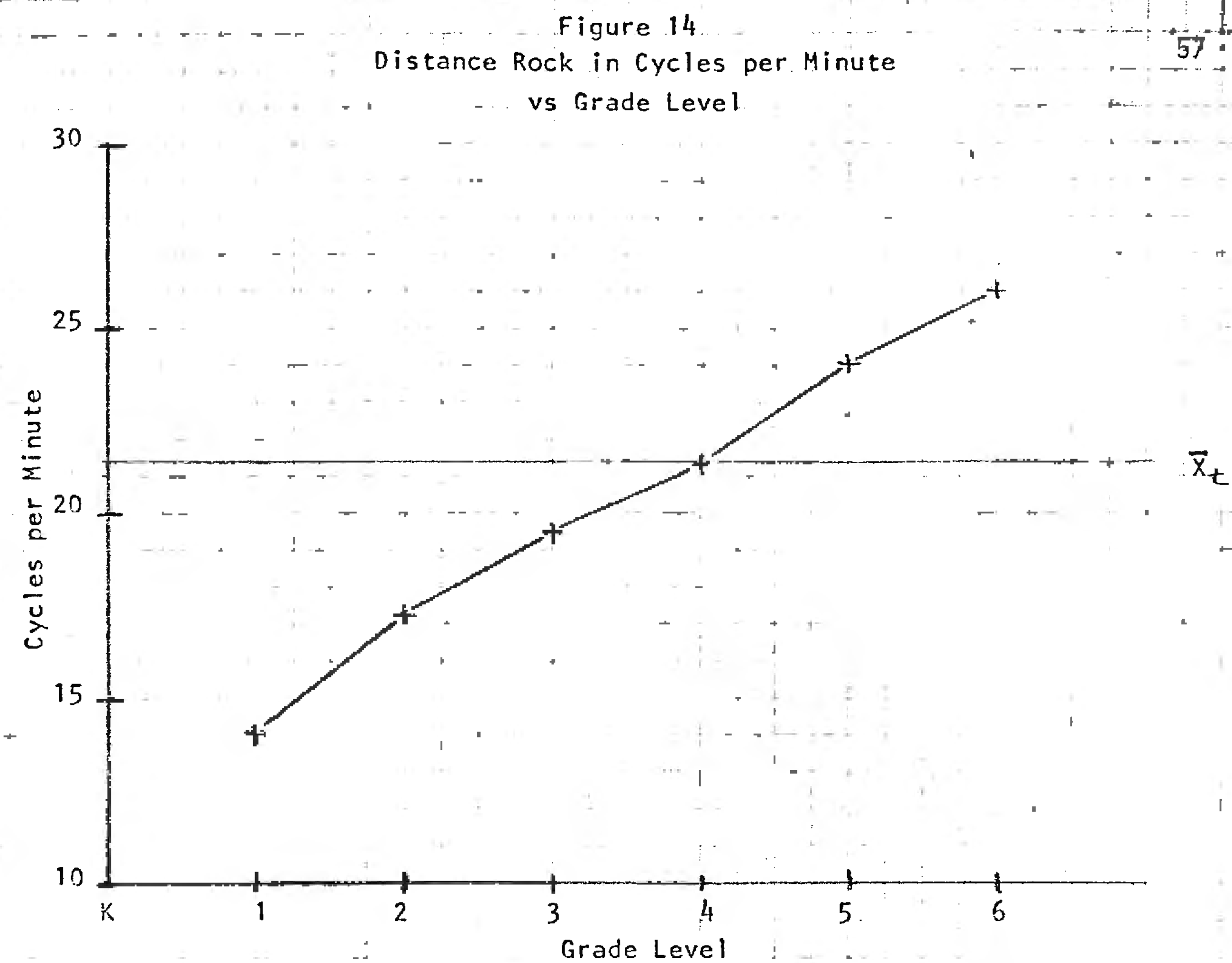


Figure 14
Distance Rock in Cycles per Minute
vs Grade Level
Cycles per Minute
30
25
20
15
10
K
1
2
3
4
5
6
Grade Level
$\bar{X}_t$

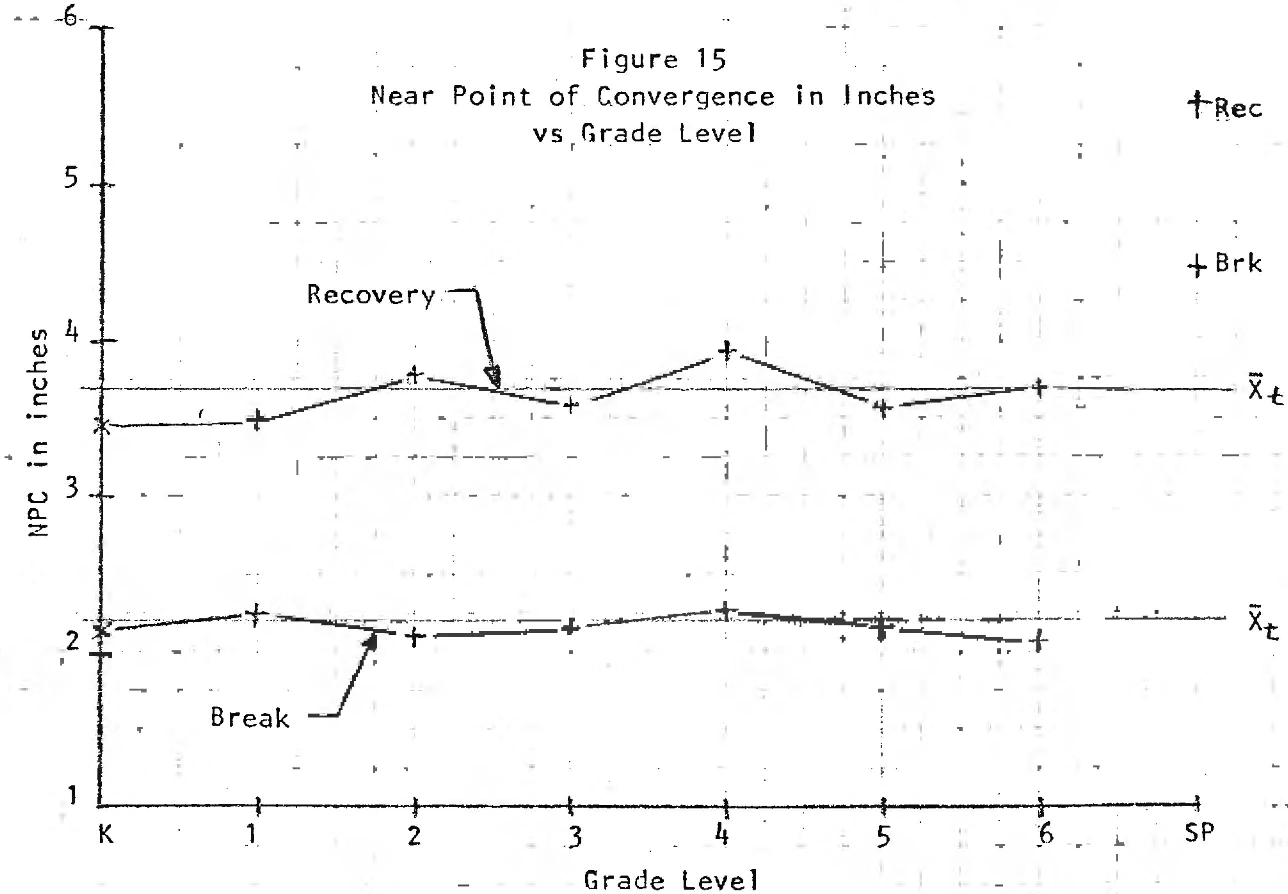


Figure 15
Near Point of Convergence in Inches
vs Grade Level
NPC in inches
6
5
4
3
2
1
Rec
Brk
Recovery
Break
$\bar{X}_t$
$\bar{X}_t$
K
1
2
3
4
5
6
SP
Grade Level

Figure 16

Dynamic Retinoscopy by the MEM Method vs Grade Level

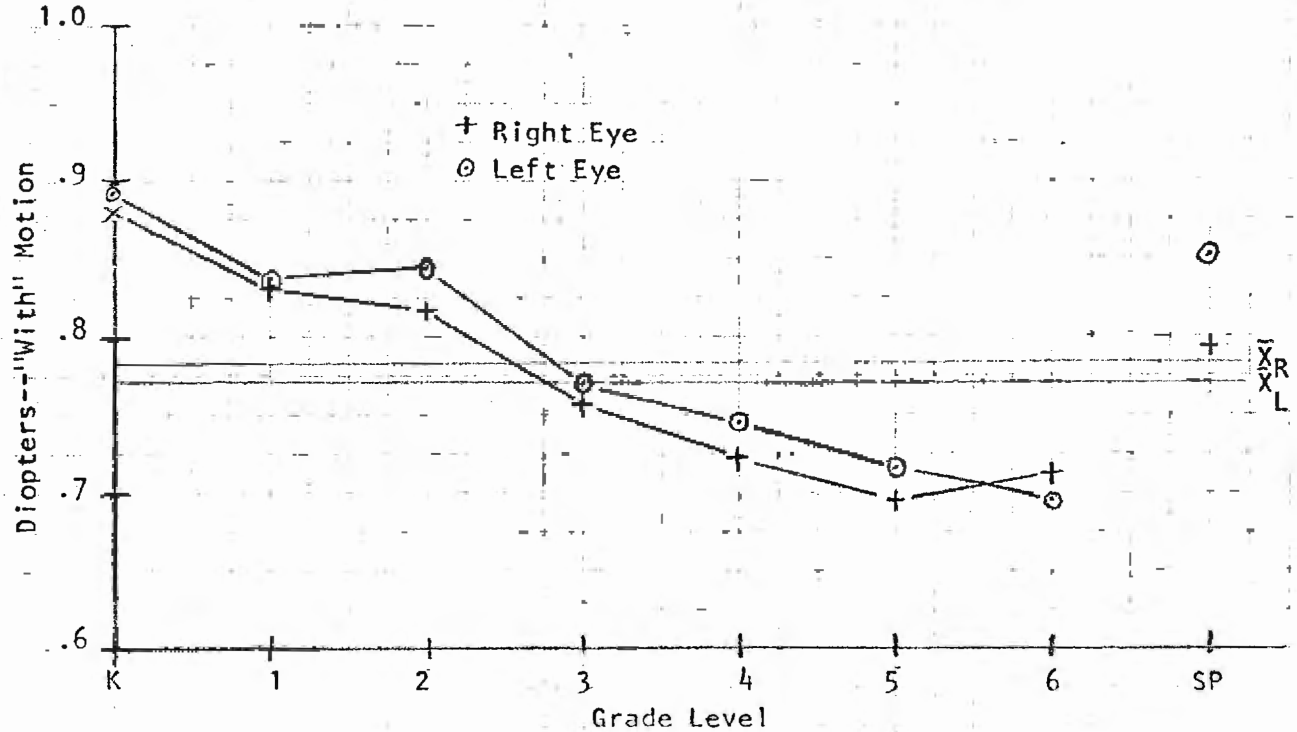
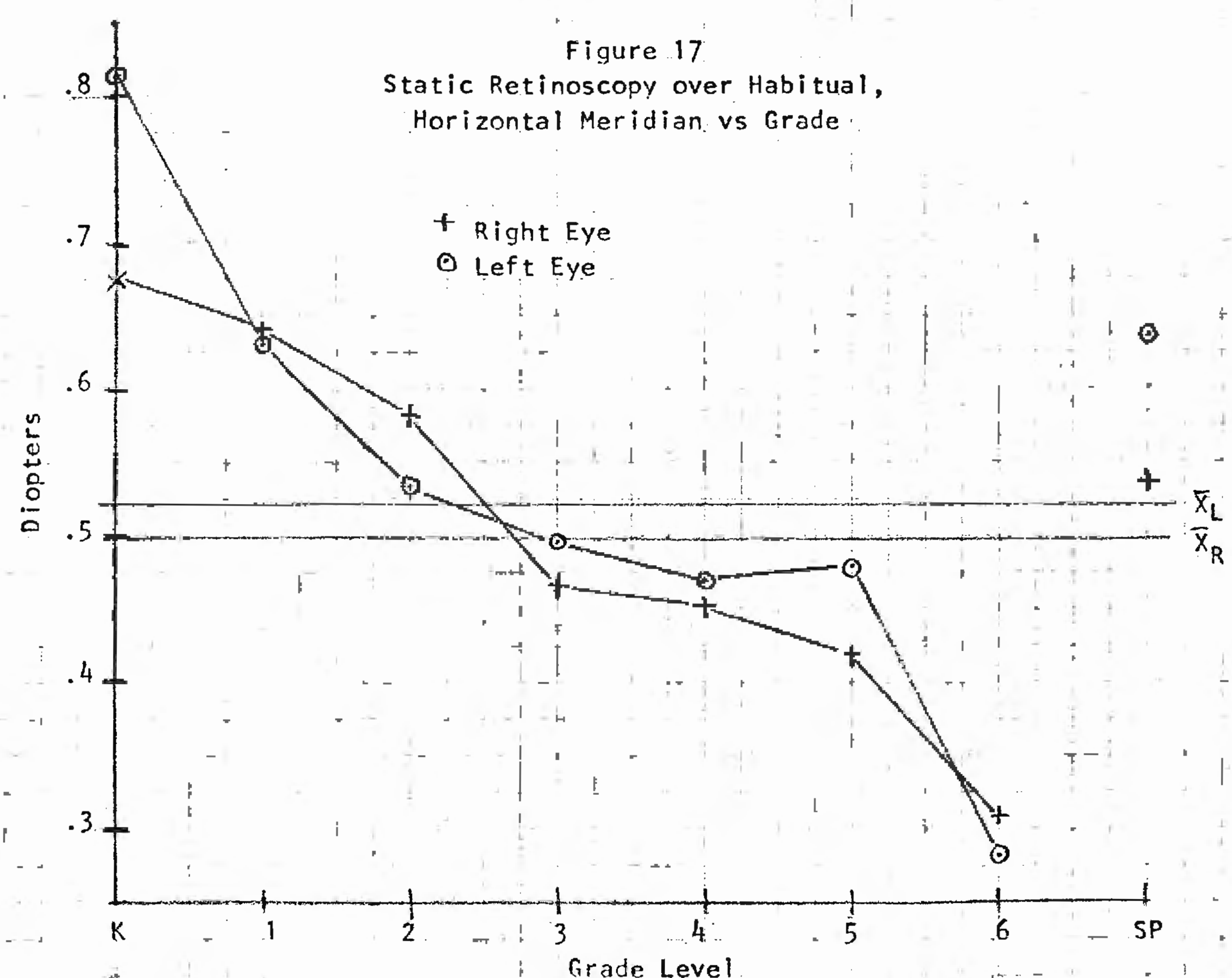


Figure 17

Static Retinoscopy over Habitual, Horizontal Meridian vs Grade



The distribution of pass, fail and borderline results for each of the tests in the screening are presented in the following section. The pass/fail decision was based on the referral criteria presented previously in this study. The data for each grade, sex and the total sample are presented in tabular and chart form.

Table VIII on the following pages presents the number of individuals in each group that failed, were borderline or passed each of the tests in the screening set. Following that table, various pie-charts are presented which give a percentage break-down for each group and test in the study. With these charts relative comparisons between grades and the total sample can be made conveniently.

The actual computer printout from which the previous summaries were tabulated are included in Volume II. Result sheets for each grade, sex, achievement test group, and the total sample are included.

TABLE VIII

Summary by Grade, Sex and Total Sample of the Number of Passes (P), Fails (F), or Borderline (B) on Each Test

		K	1	2	3	4	5	6	SP	G	B	Total
1. Far VA	F	18	14	11	17	12	18	22	3	60	55	115
	B	223	89	82	82	79	50	58	13	314	362	676
	P	32	140	166	163	217	205	227	7	555	602	1157
2. Near VA	F	9	28	12	11	14	13	19	2	55	53	108
	B	247	108	87	87	64	51	70	12	348	378	726
	P	17	80	153	142	229	209	218	9	504	553	1057
3. Stereo	F	12	4	7	3	8	13	14	1	21	41	62
	B	8	20	6	9	10	16	9	2	35	45	80
	P	252	215	244	247	290	242	284	20	864	930	1794
4. Color	F	8	16	8	10	8	9	6	2	6	61	67
	B	4	7	11	5	2	3	4	1	6	31	37
	P	155	138	168	149	190	166	191	18	286	889	1175
5. Dist RK	F	-	16	9	5	0	0	0	-	13	17	30
	B	-	63	48	50	68	31	37	-	136	161	297
	P	-	5	17	35	79	79	139	-	169	185	354
6. NPC	F	14	10	21	13	20	13	14	1	50	56	106
	B	25	28	12	24	37	29	42	7	101	103	204
	P	233	199	222	218	243	228	245	13	763	838	1601
7. Far CT	F	17	12	12	7	12	13	19	2	42	52	94
	B	6	10	11	8	5	12	8	1	32	29	61
	P	250	220	235	242	289	246	279	20	850	931	1781
8. Near CT	F	19	19	22	20	20	25	31	6	85	77	162
	B	15	34	38	34	29	31	37	2	114	606	220
	P	239	189	198	203	257	216	238	14	726	828	1554
9. Pursuit	F	11	11	6	5	4	3	6	2	20	28	48
	B	45	51	28	17	25	23	33	4	102	124	226
	P	218	179	225	240	279	246	268	17	804	867	1671
10. N-F Fix	F	7	7	11	7	8	4	4	1	21	28	49
	B	46	41	23	19	26	20	21	6	86	116	202
	P	221	192	225	236	274	248	282	16	819	875	1694
11. MEM-R	F	22	11	11	10	7	7	11	0	37	42	79
	B	48	40	35	41	34	35	29	3	118	147	265
	P	199	191	208	208	267	229	266	20	765	823	1588
-L	F	23	15	13	14	9	7	10	1	42	50	92
	B	47	38	42	39	38	38	28	3	119	154	273
	P	200	189	200	206	261	226	267	19	761	807	1568

TABLE VIII (Continued)
Summary by Grade, Sex and Total Sample of the Number of Passes Fails, or Borderlines on Each Test

		K	1	2	3	4	5	6	SP	G	B	Total
Static Retinoscopy												
12. Sph-R	F	50	29	37	30	41	26	38	2	135	118	253
	B	49	19	20	18	23	15	22	1	87	80	167
	P	172	195	201	214	244	232	245	19	704	818	1522
13. Cyl-R	F	16	2	6	3	6	1	6	0	24	16	40
	B	8	1	5	2	9	5	7	1	19	19	38
	P	247	240	247	257	293	267	292	21	883	981	1864
14. Sph-L	F	53	32	33	27	42	28	43	3	153	108	261
	B	40	21	17	21	23	25	14	2	72	91	163
	P	178	190	208	214	243	220	248	17	701	817	1518
15. Cyl-L	F	11	2	8	3	7	2	5	1	19	20	39
	B	7	5	6	4	10	8	4	0	19	25	44
	P	253	236	244	255	291	263	296	21	888	971	1859
16. Aniso	F	10	2	8	2	7	7	6	0	24	18	42
	B	12	9	13	5	7	5	12	1	36	28	64
	P	249	232	237	255	294	261	287	21	866	970	1836
Ocular Health												
17. Pupil Rlx	F	0	0	0	0	1	0	1	1	2	1	3
	B	2	2	2	5	2	3	2	0	8	10	18
	P	269	241	256	257	305	270	304	22	917	1007	1924
18. External	F	9	7	7	1	10	5	9	1	27	22	49
	B	8	7	3	5	4	3	6	1	16	21	37
	P	254	229	249	256	294	265	292	21	885	975	1860
19. Internal	F	2	2	0	1	2	0	1	0	4	4	8
	B	6	17	9	7	12	8	13	3	33	42	75
	P	263	224	250	254	294	265	293	20	891	972	1863

Figure 18 shows the failure rate on the habitual distance acuity test. It shows a large number of borderline cases in kindergarten. This resulted primarily from the use of the A.O. symbol recognition chart when the child did not know the alphabet. This chart has a minimum angle of resolution of 20/30 which was a borderline reading. The failure rate seems to be consistant throughout the samples except for the special education group which had a fail rate about twice that of the rest of the study. The failures include either monocular or binocular failure thus counting individual failures only once.

Figure 19 shows the failure rates for habitual near point visual acuity. Special education is slightly higher than the other groups but the first grade has an even higher failure rate.

Figure 20 shows the stereopsis pass-fail distribution.

Figure 21 presents the color vision results. Again the special education and first grade groups have a larger percentage of failure than the other grades. This test was done primarily with the boys in our sample.

Figure 22 summarizes the distance rock findings. The failure rate for the first three grades probably represents the fact that the failure criteria was not adjusted for grade level. The graph presented earlier shows that the cycles/min. increases with age. Therefore, the failure criteria needs to be established for grade level being tested.

Figure 23 shows the pass-fail distribution for the near point of convergence test. Failure ratios are consistant for the various samples except for the second grade which had a higher rate than the rest. Failure was recorded based on either the break or the recovery criteria.

Results for the far cover test are presented in Figure 24. The sixth grade exhibited a somewhat higher failure rate than the rest of the sample and special education an even larger rate.

Figure 25 shows the results for the near cover test. The failure rate is consistant except for sixth grade which was somewhat greater and special education is three times greater than the other samples.

The pass-fail distribution for pursuit eye movements is presented in Figure 26. The evaluations in this test were very subjective and varied greatly from clinician to clinician. These results should be considered with that subjectiveness in mind.

Figure 27 shows the results of the near-far fixation combined with saccades tests. These were very subjective tests to evaluate also and again varied with clinician.

Figures 28 and 29 show the results of the dynamic retinoscopy - monocular estimate method - findings for the right and left eye respectively. The kindergarten sample shows a failure rate twice that of the rest of the population.

Figures 30-34 summarize the pass-fail data for the various criteria associated with static retinoscopy of the right and left eyes. This retinoscopy was performed over whatever habitual Rx the child was wearing. Some refractive error problems may have existed but were masked by whatever habitual Rx the child was wearing.

Figures 35-37 show the pass-fail distributions for the ocular health evaluations of pupillary responses, external and internal ocular views. Very few failures were noted.

Figure 18.

Percent Pass-Fail Distribution for Habitual Distance Visual Acuity

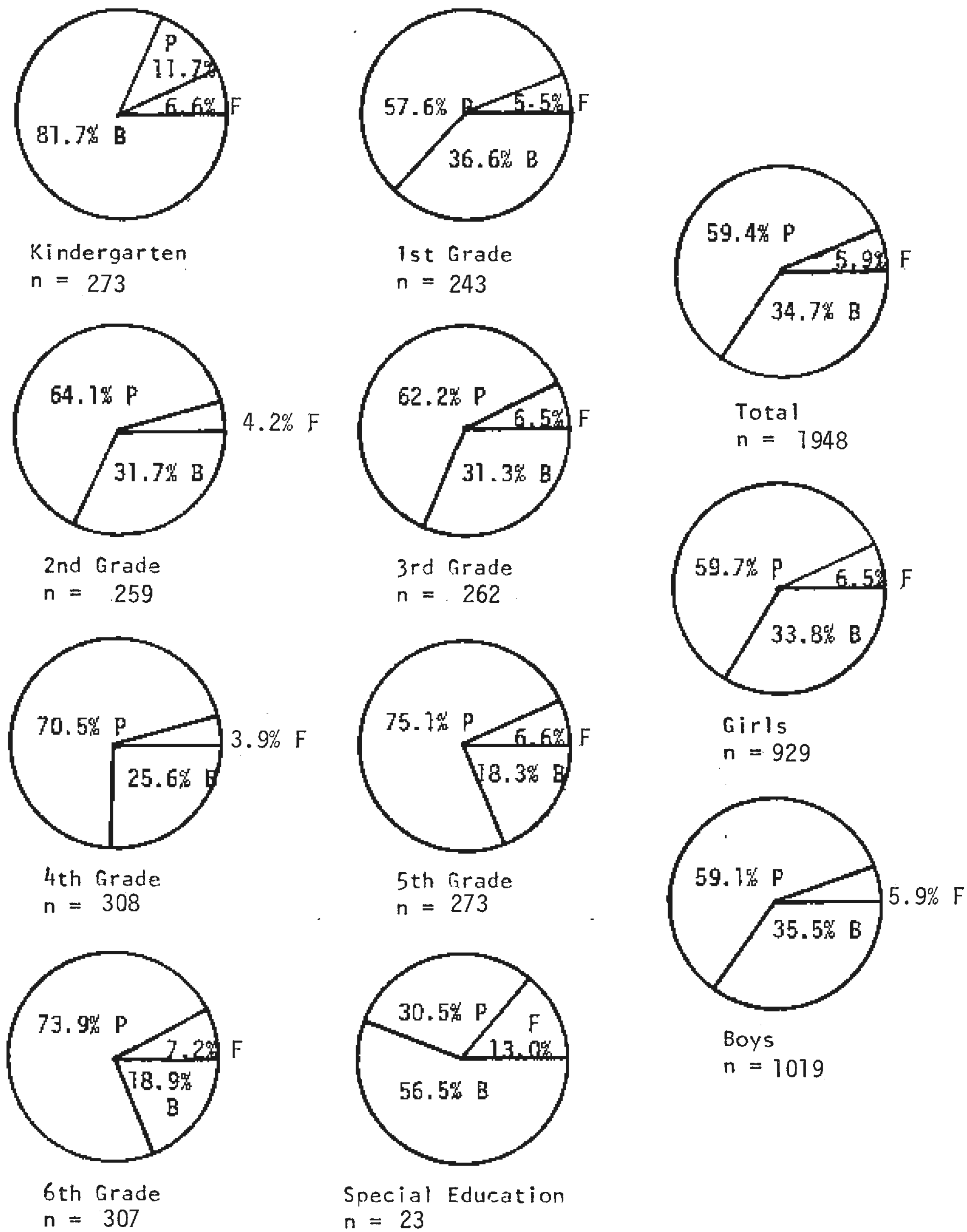


Figure 19.

Percent Pass-Fail Distribution for Habitual Near Visual Acuity

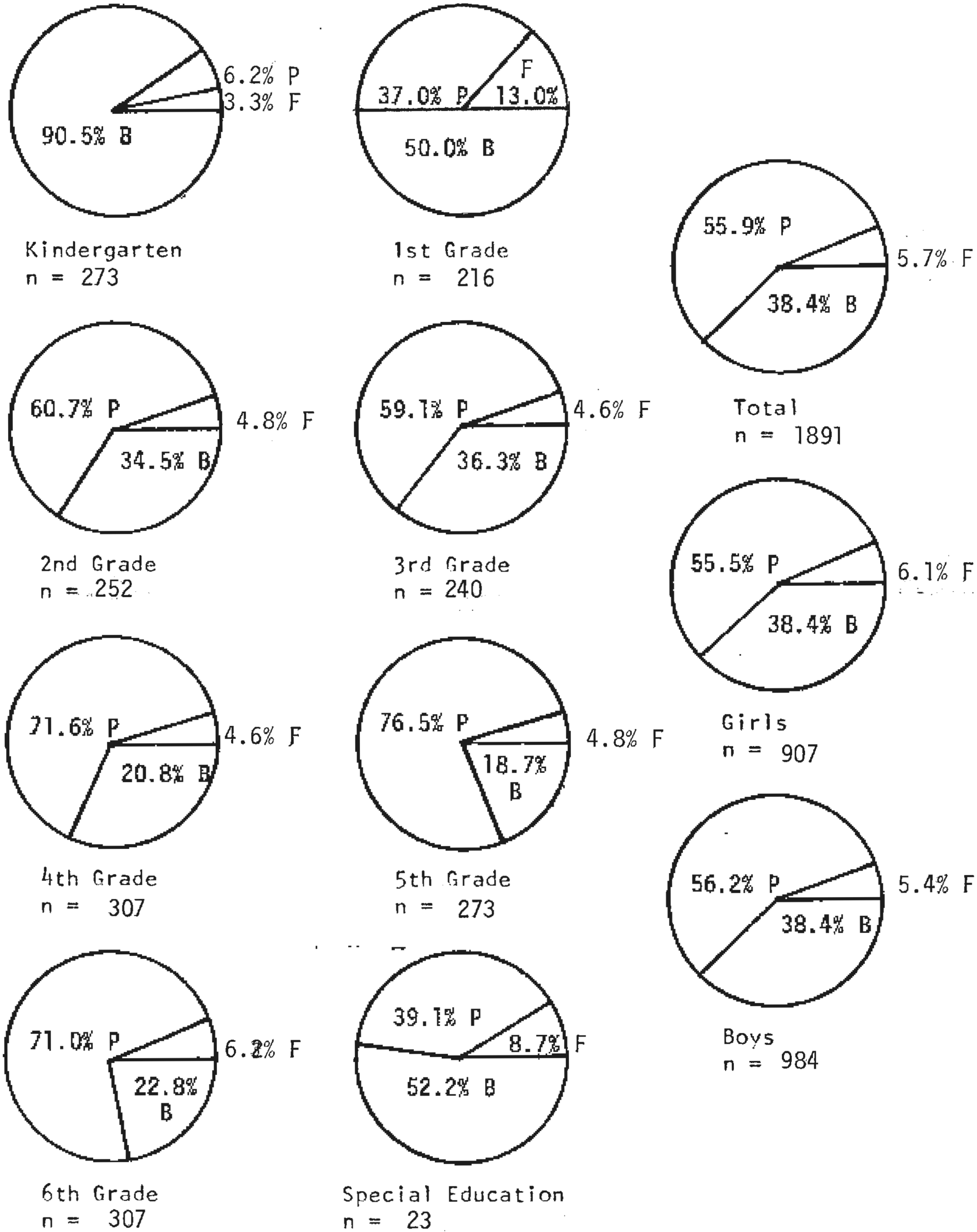


Figure 20.

Percent Pass-Fail Distribution for Stereopsis

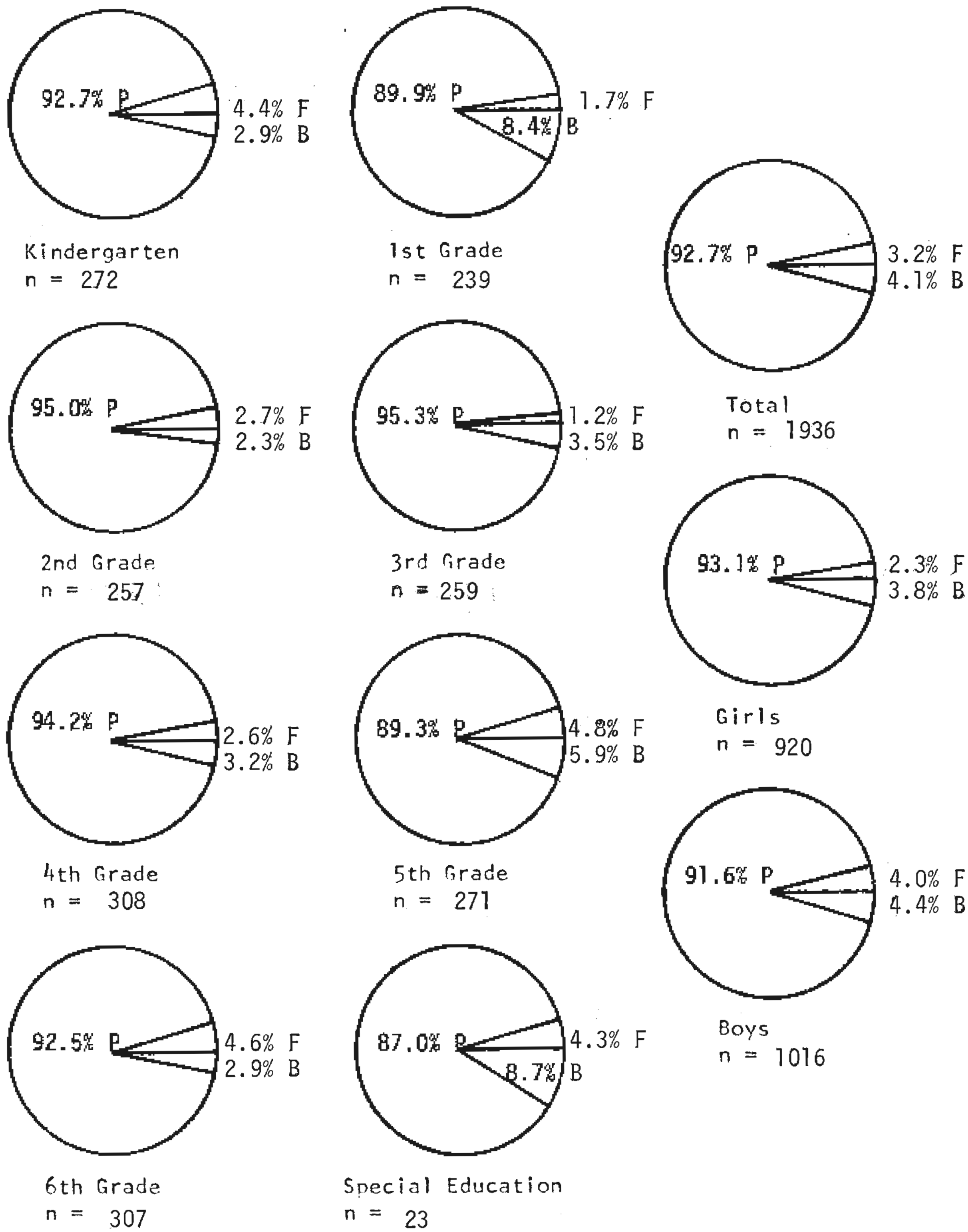


Figure 21.
Percent Pass-Fail Distribution for Color Vision

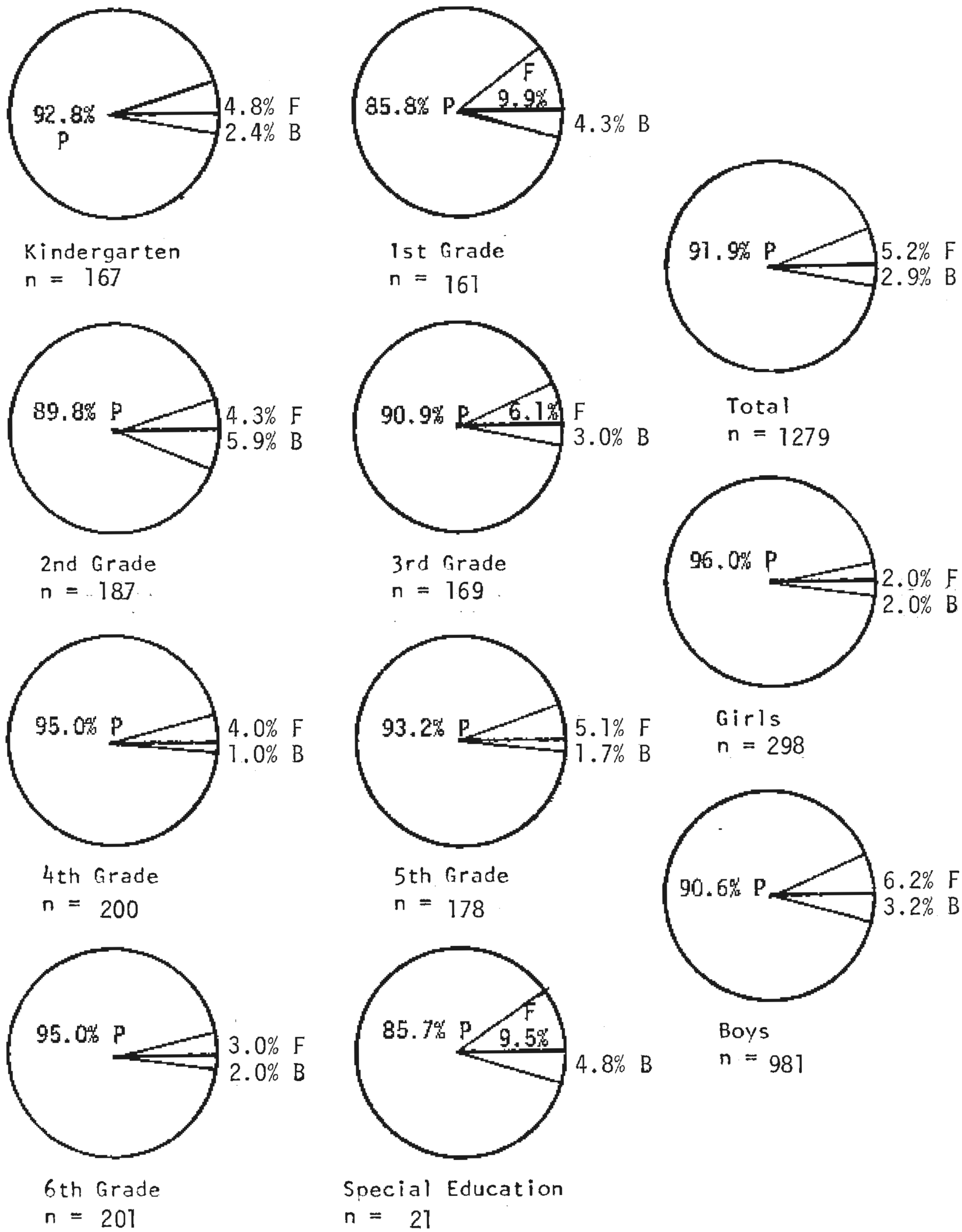


Figure 22.

Percent Pass-Fail Distribution for Distance Rock

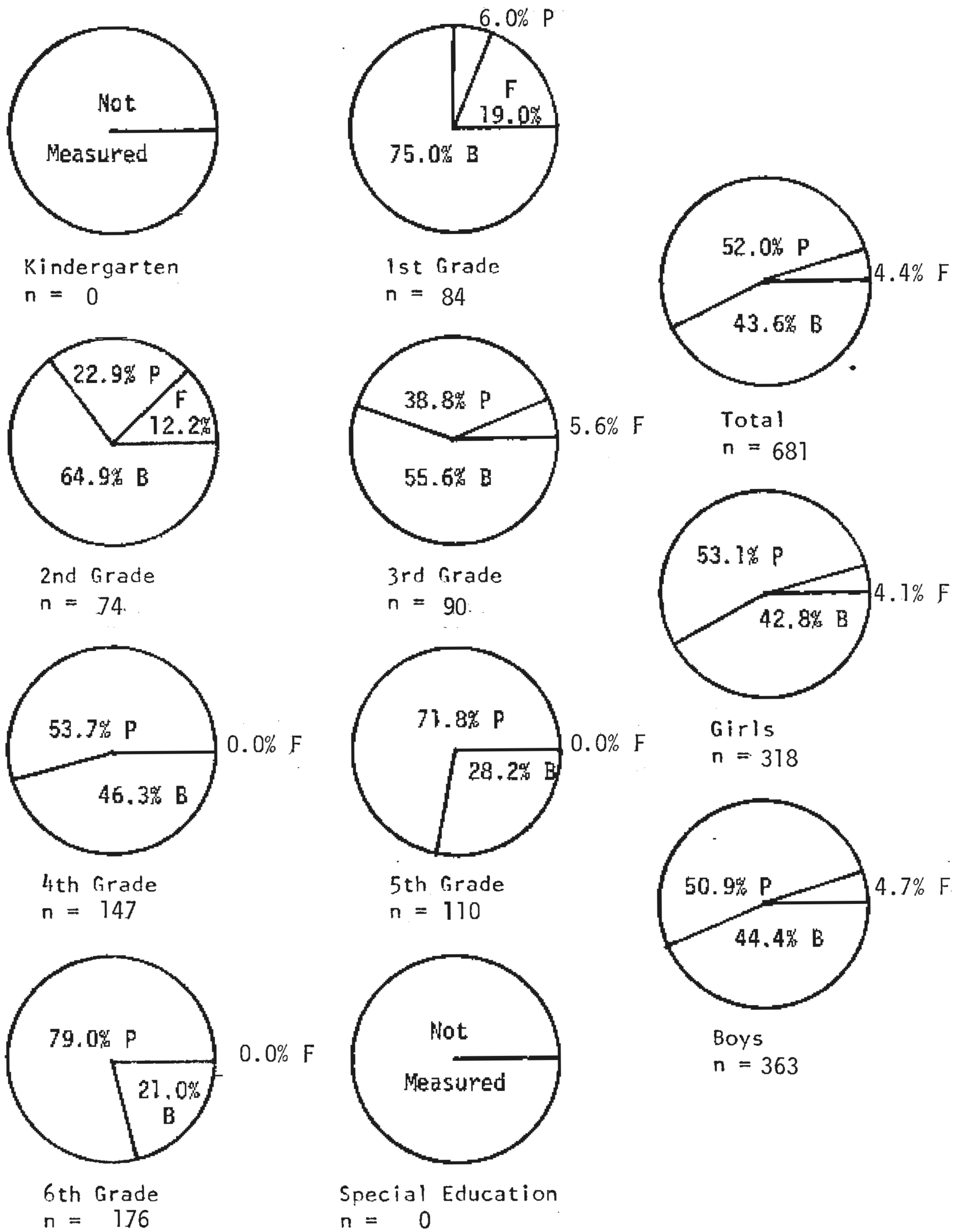


Figure 23.

Percent Pass-Fail Distribution for Near Point of Convergence

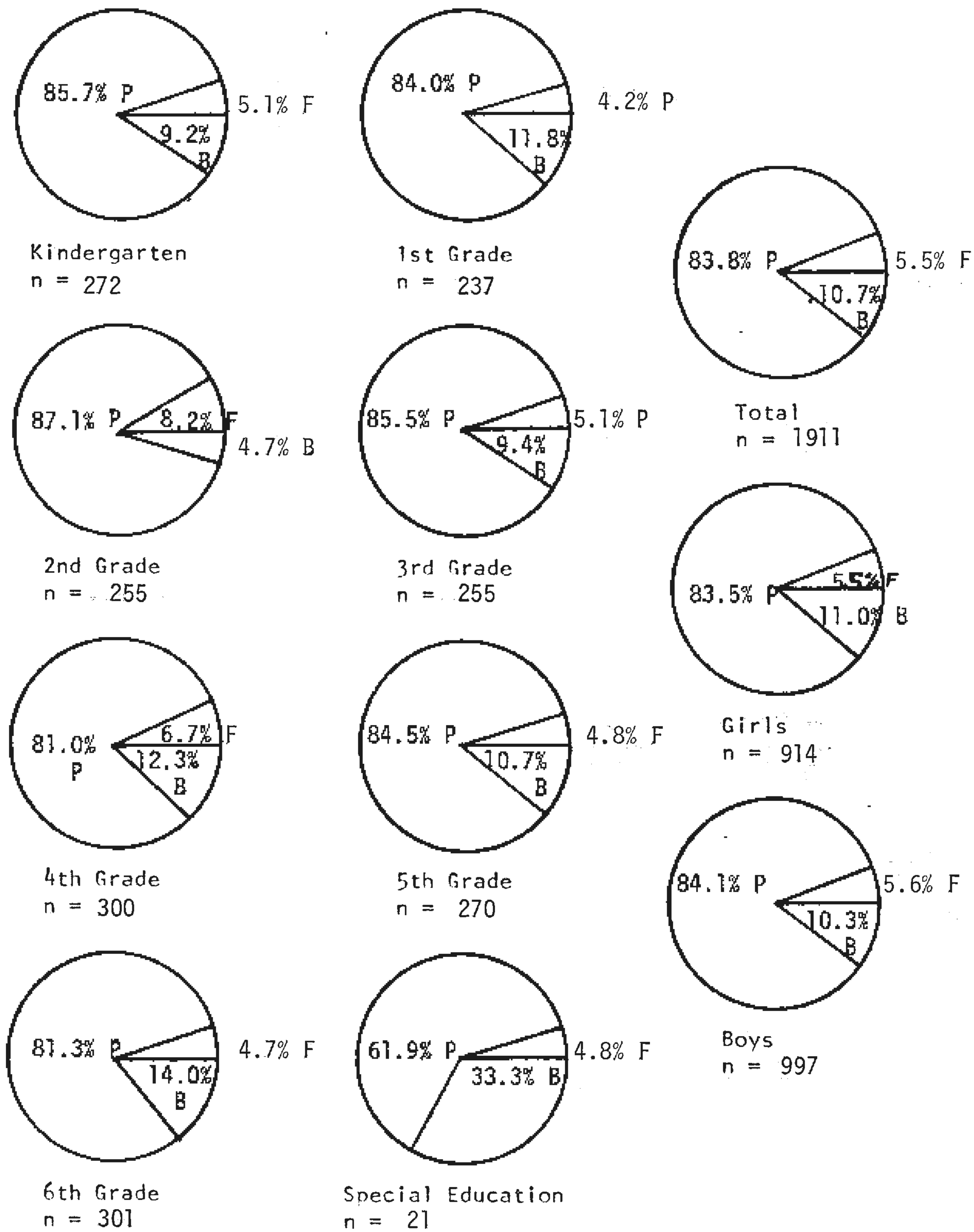


Figure 24.
Percent Pass-Fail Distribution for Far Cover Test

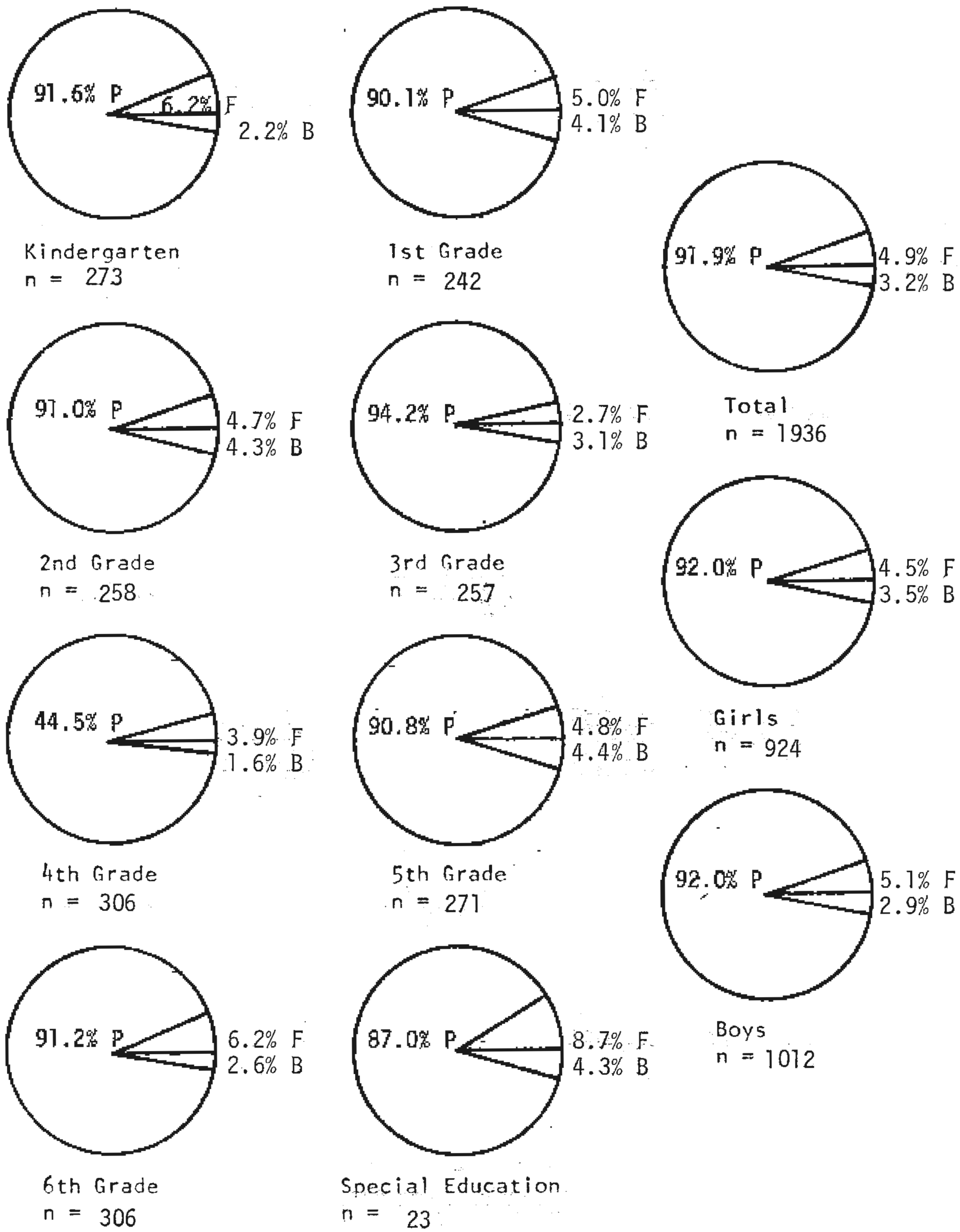


Figure 25.

Percent Pass-Fail Distribution for Near Cover Test

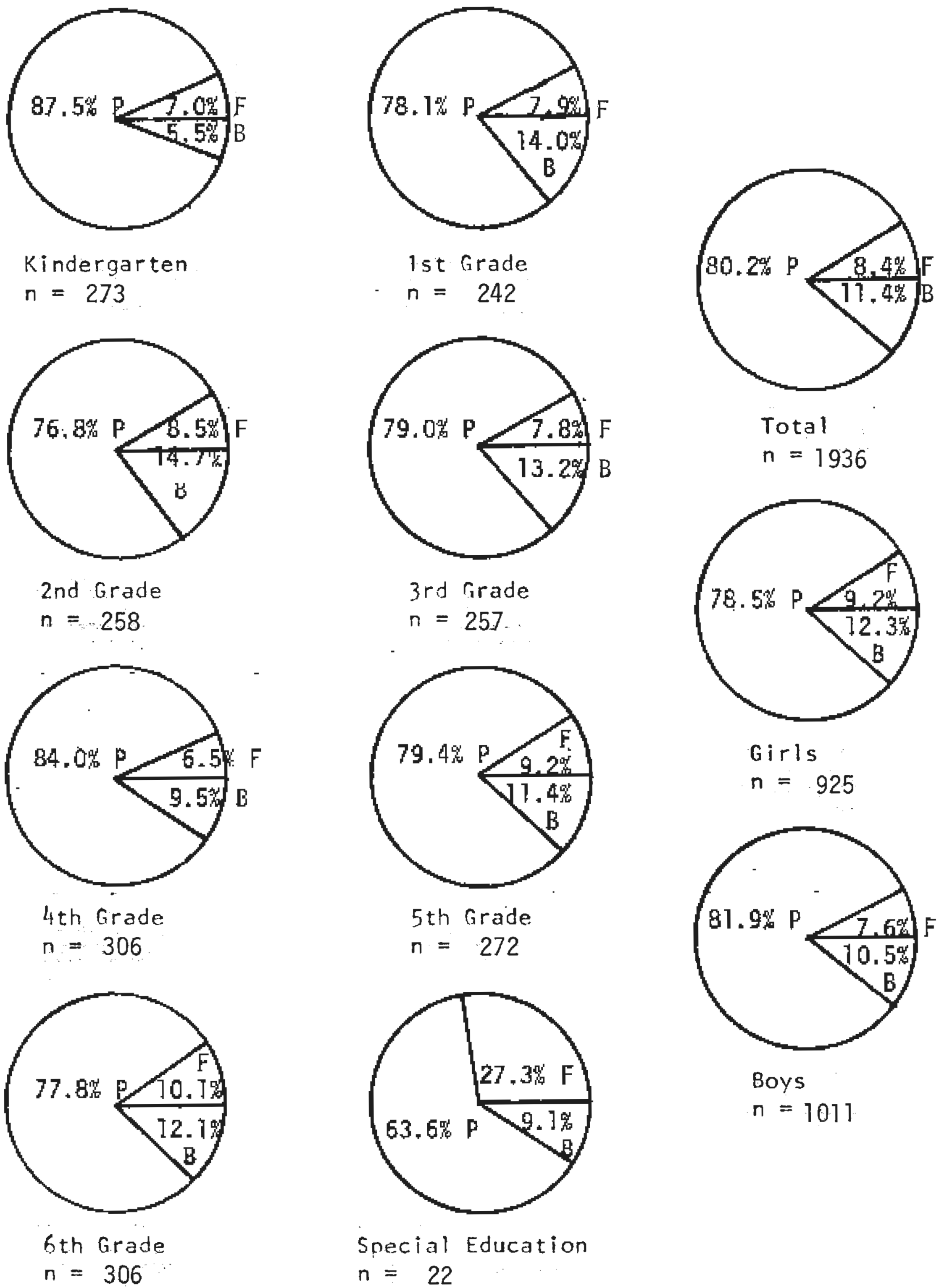


Figure 26.

Percent Pass-Fail Distribution for Pursuit Eye Movements

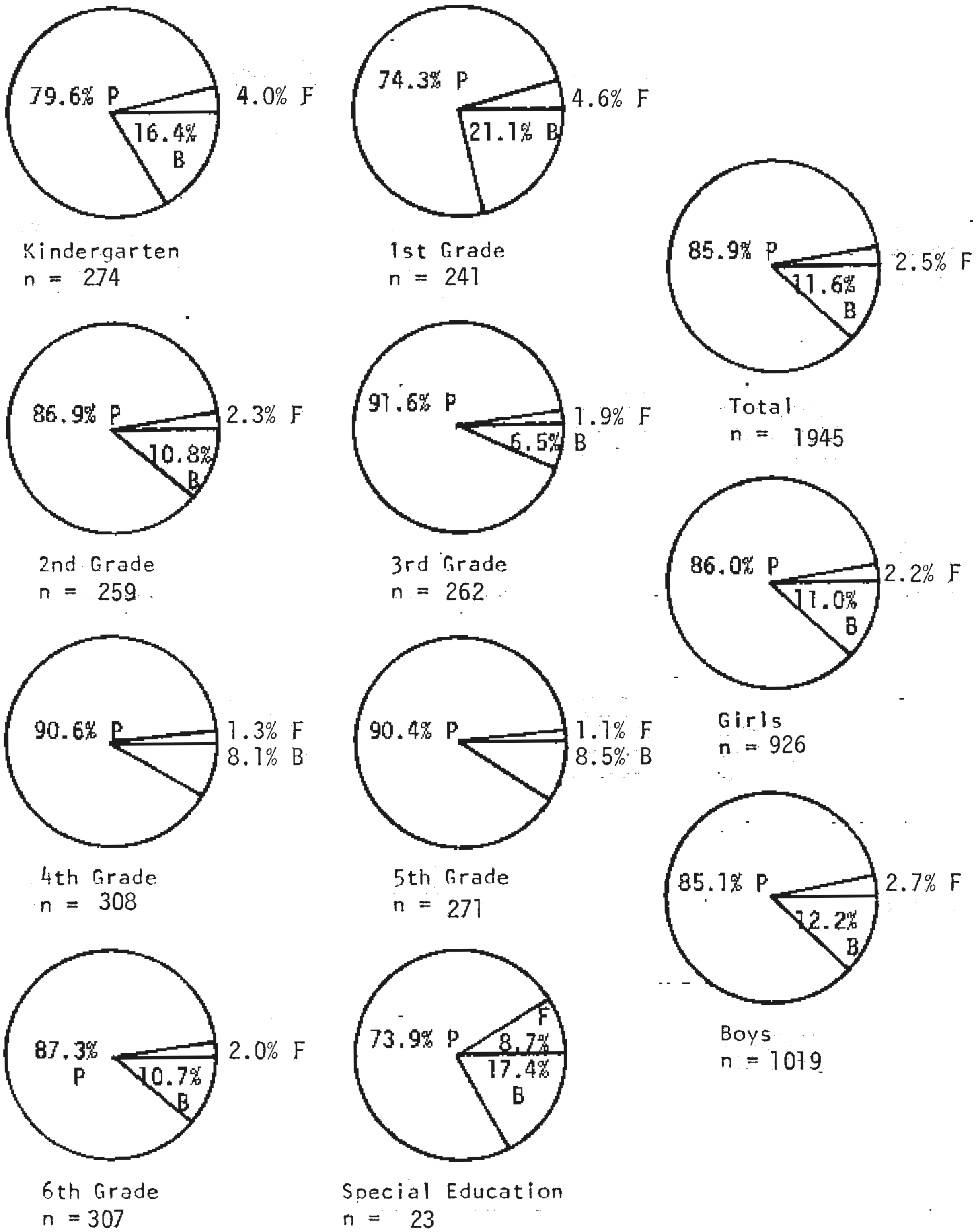


Figure 27.

Percent Pass-Fail Distribution for Near -- Far Fixations Combined with Saccades

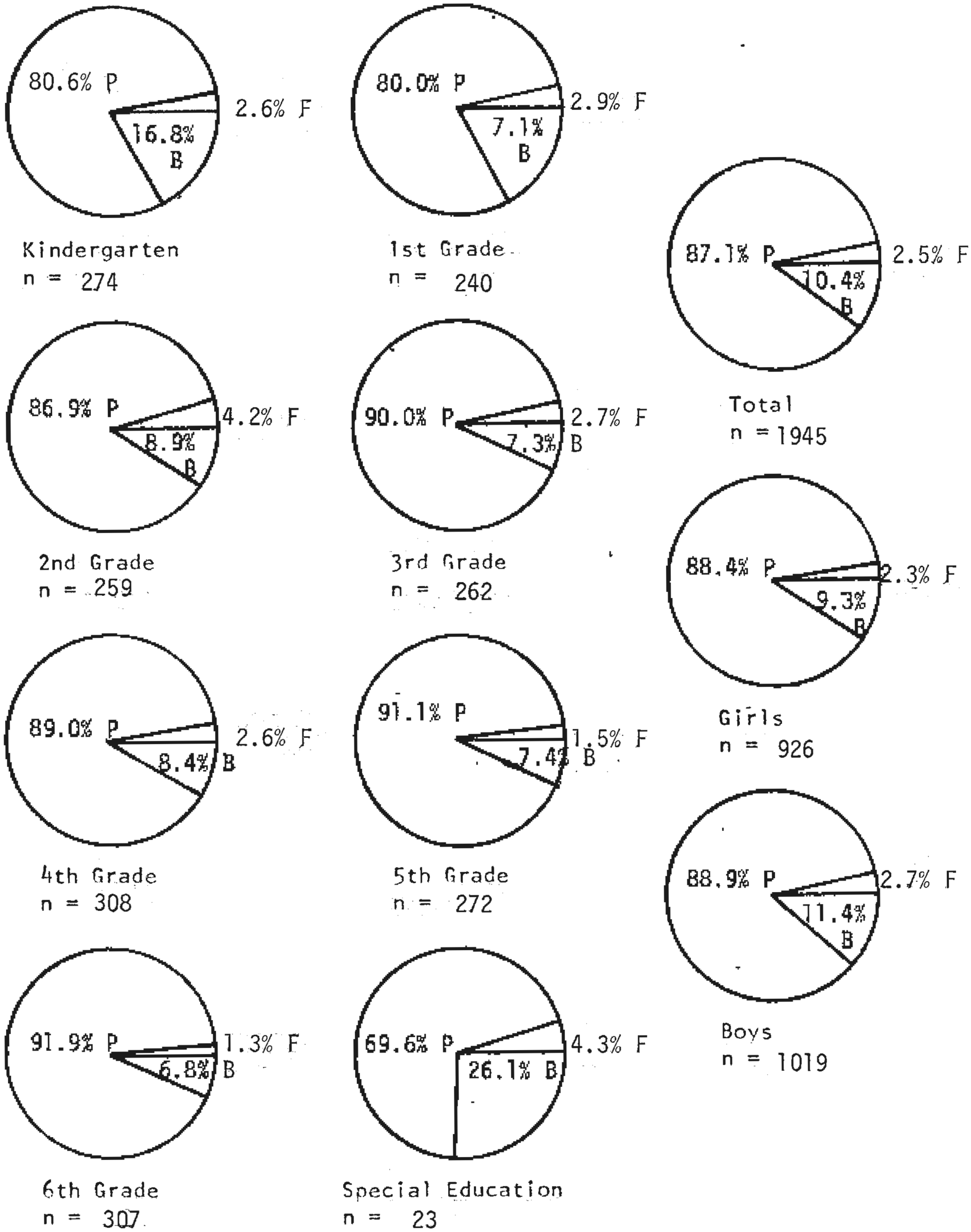


Figure 28.

Percent Pass-Fail Distribution for MEM Retinoscopy of Right Eye

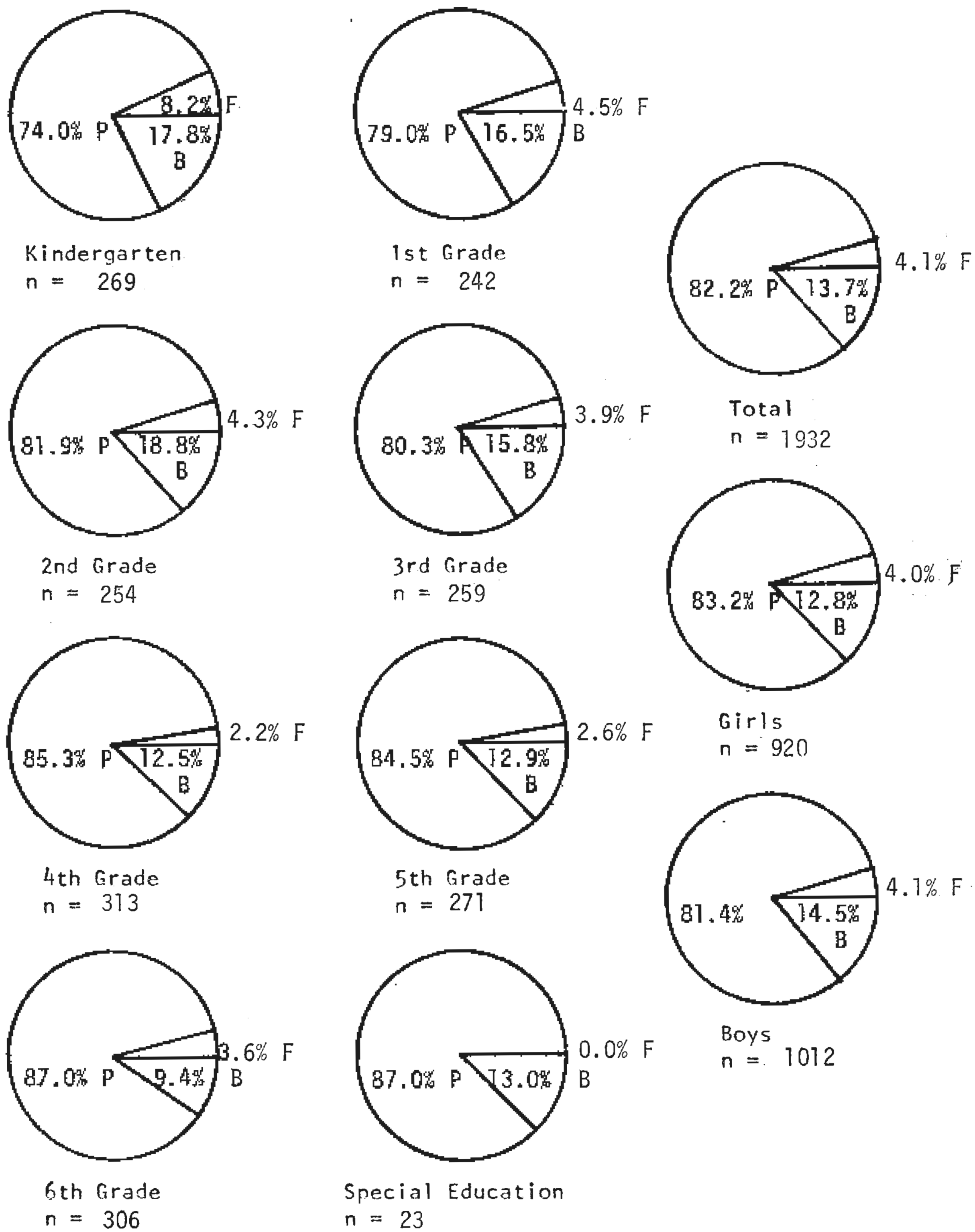


Figure 29.

Percent Pass-Fail Distribution for MEM Retinoscopy of Left Eye

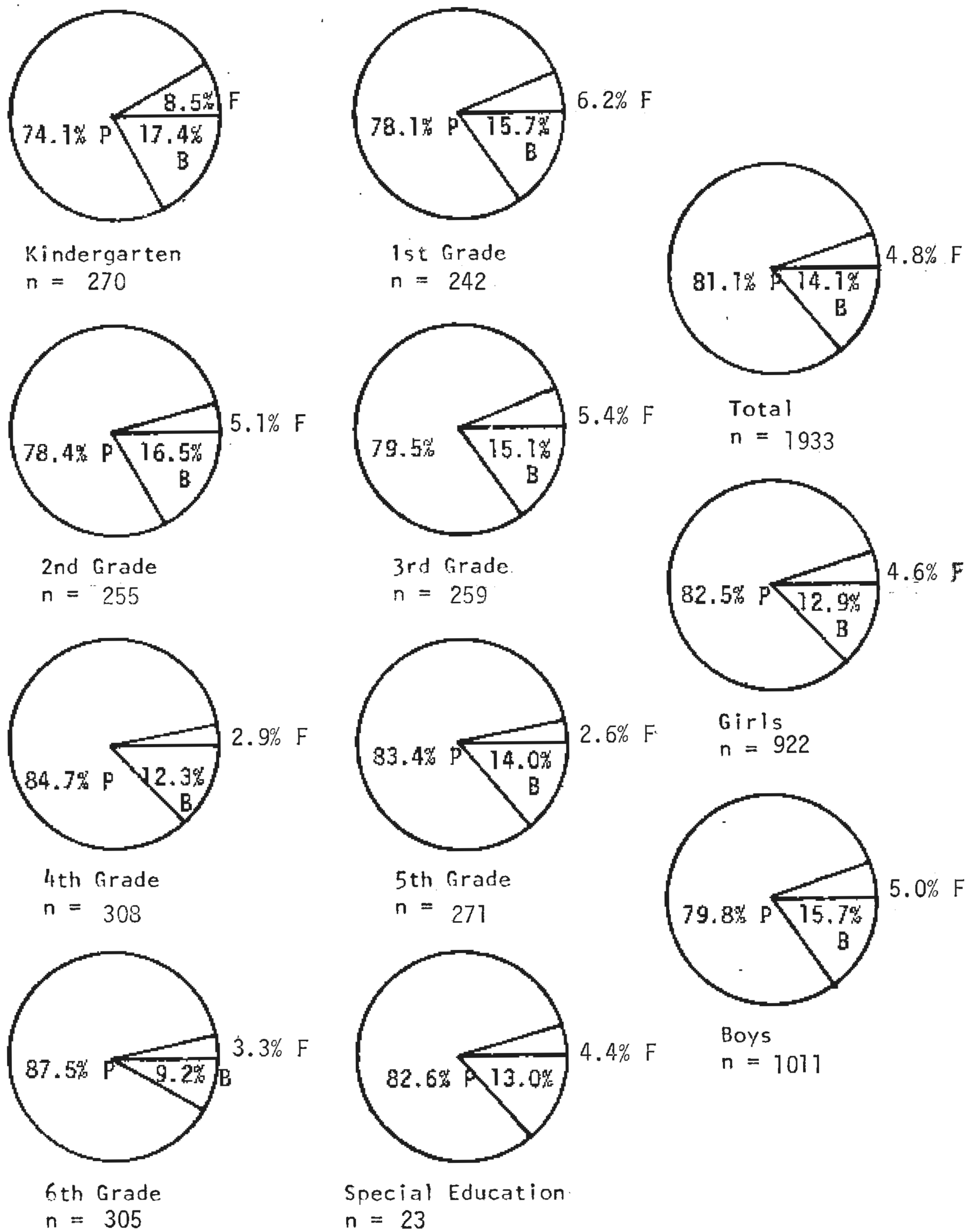


Figure 30.

Percent Pass-Fail Distribution for Static Retinoscopy of Right Eye-Sphere

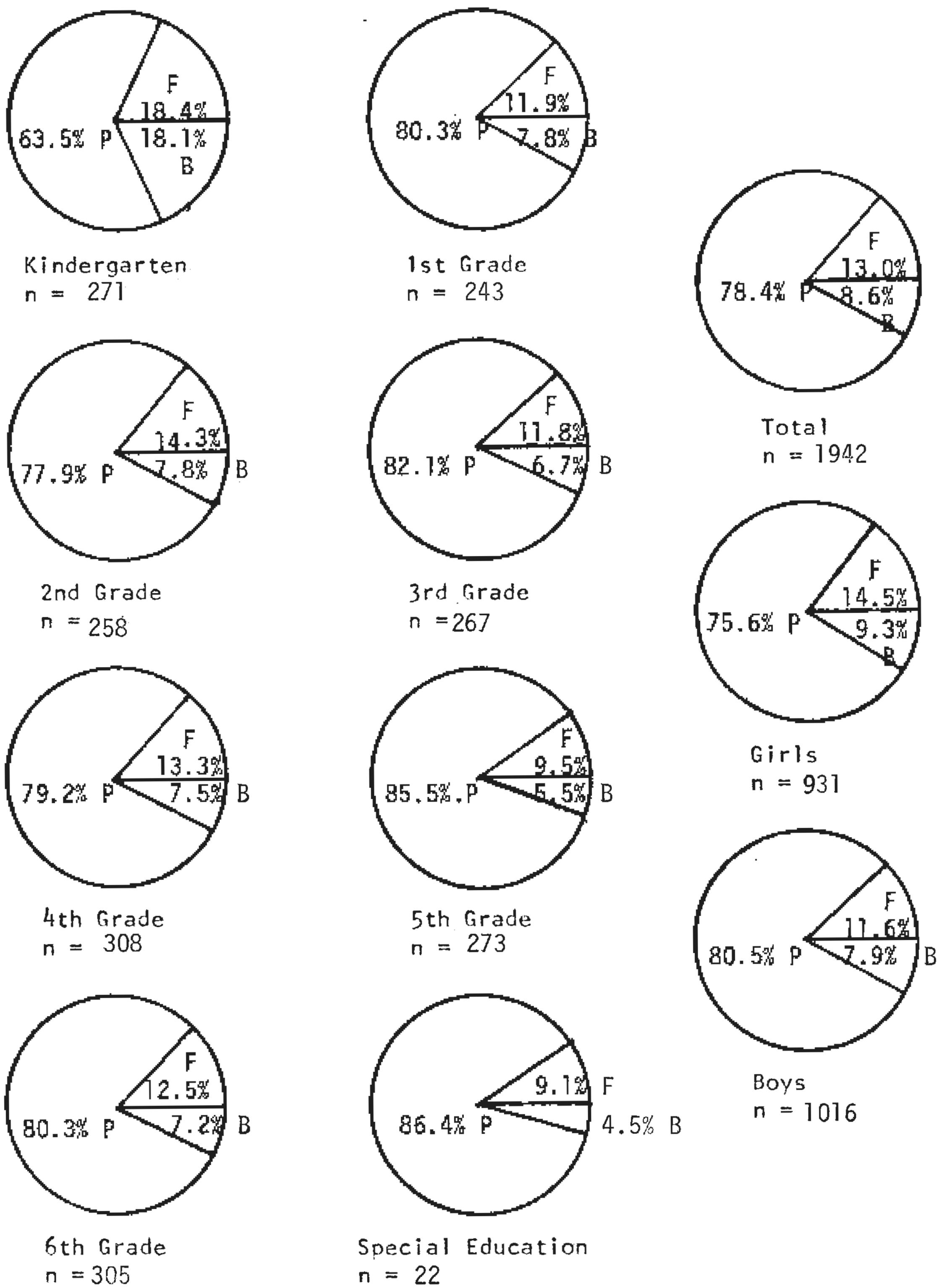


Figure 31.

Percent Pass-Fail Distribution for Static Retinoscopy of Left Eye-Sphere

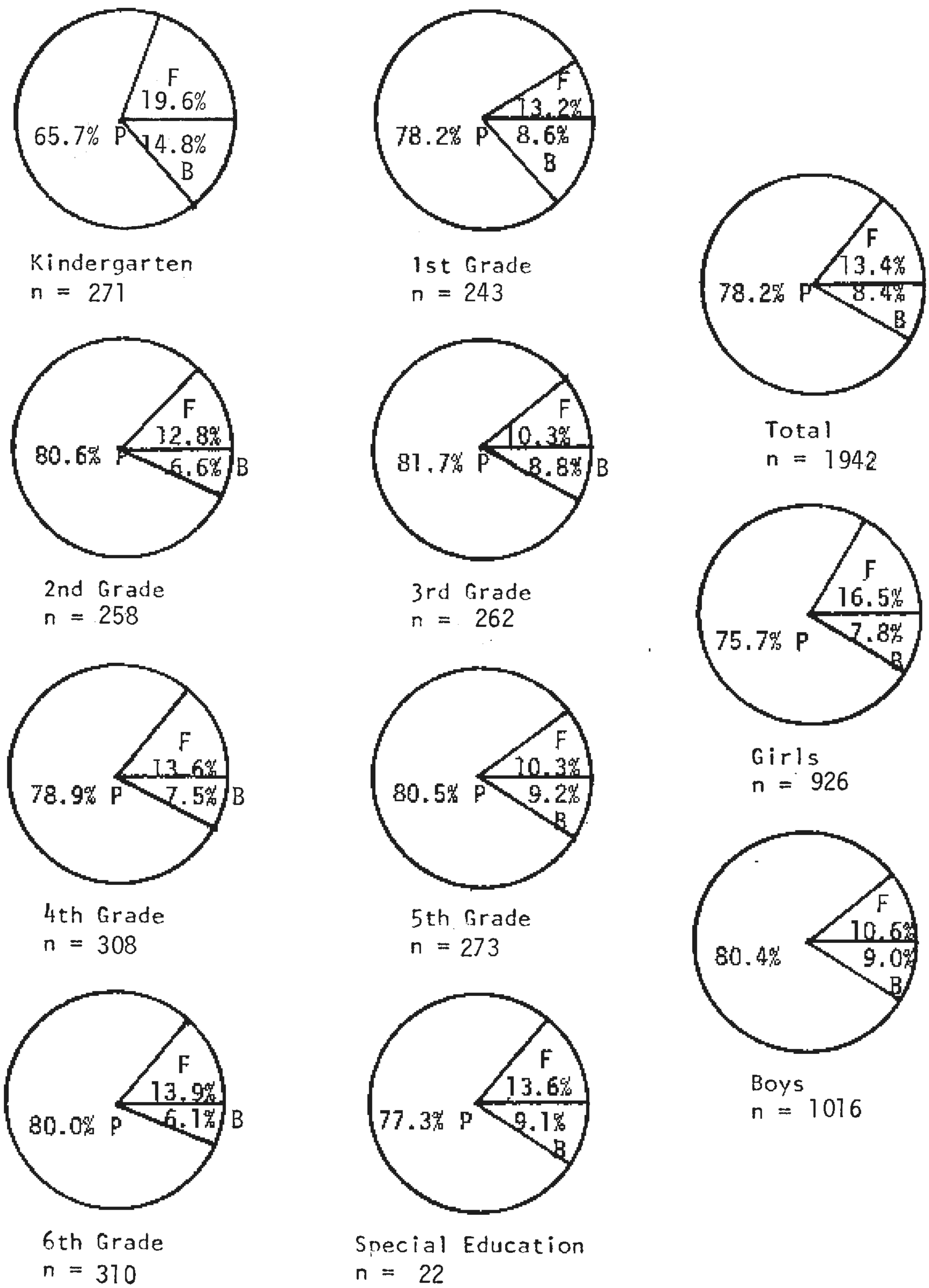


Figure 32.

Percent Pass-Fail Distribution for Static Retinoscopy of Right Eye-Cylinder

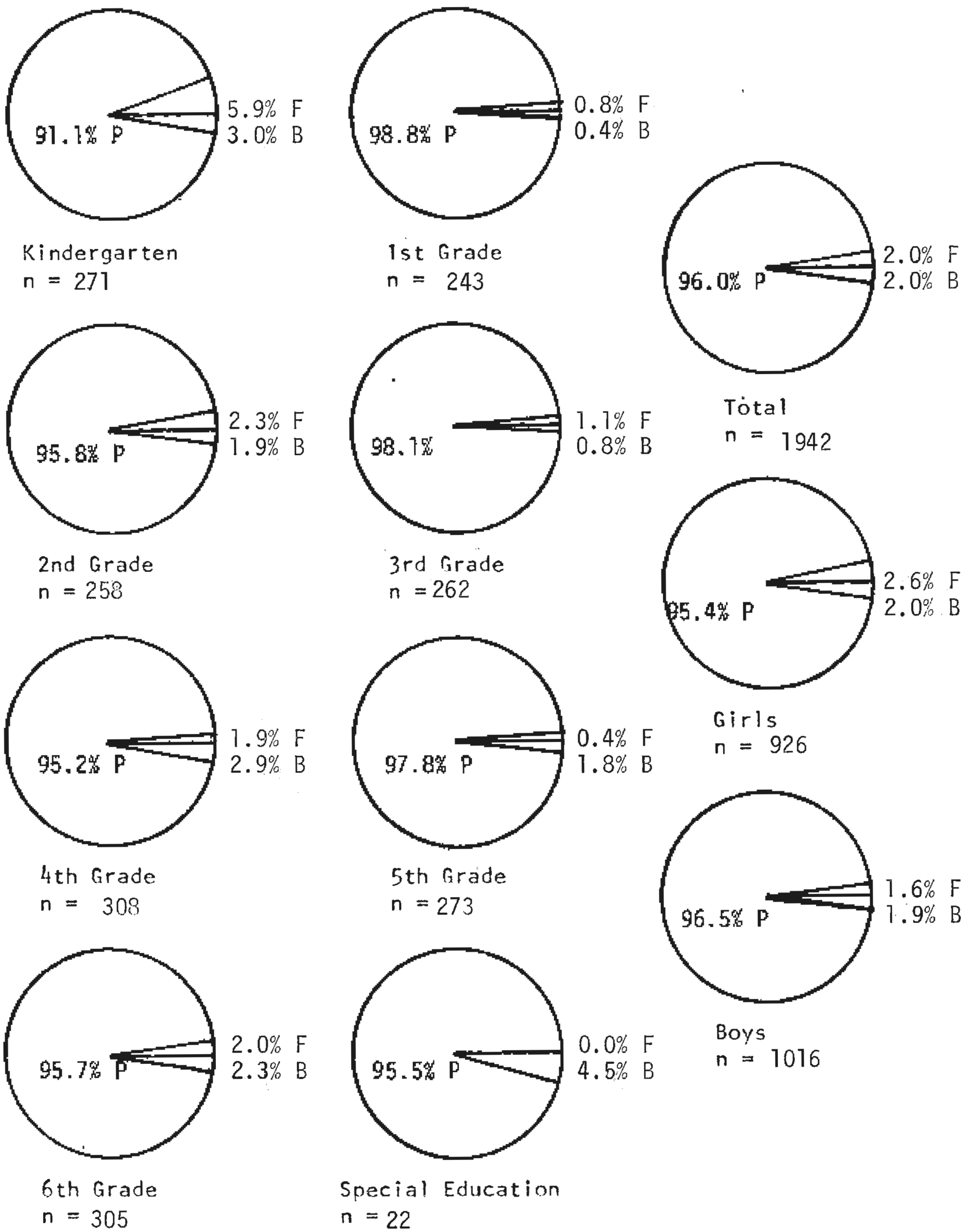


Figure 33.

Percent Pass-Fail Distribution for Static Retinoscopy of Left Eye—Cylinder

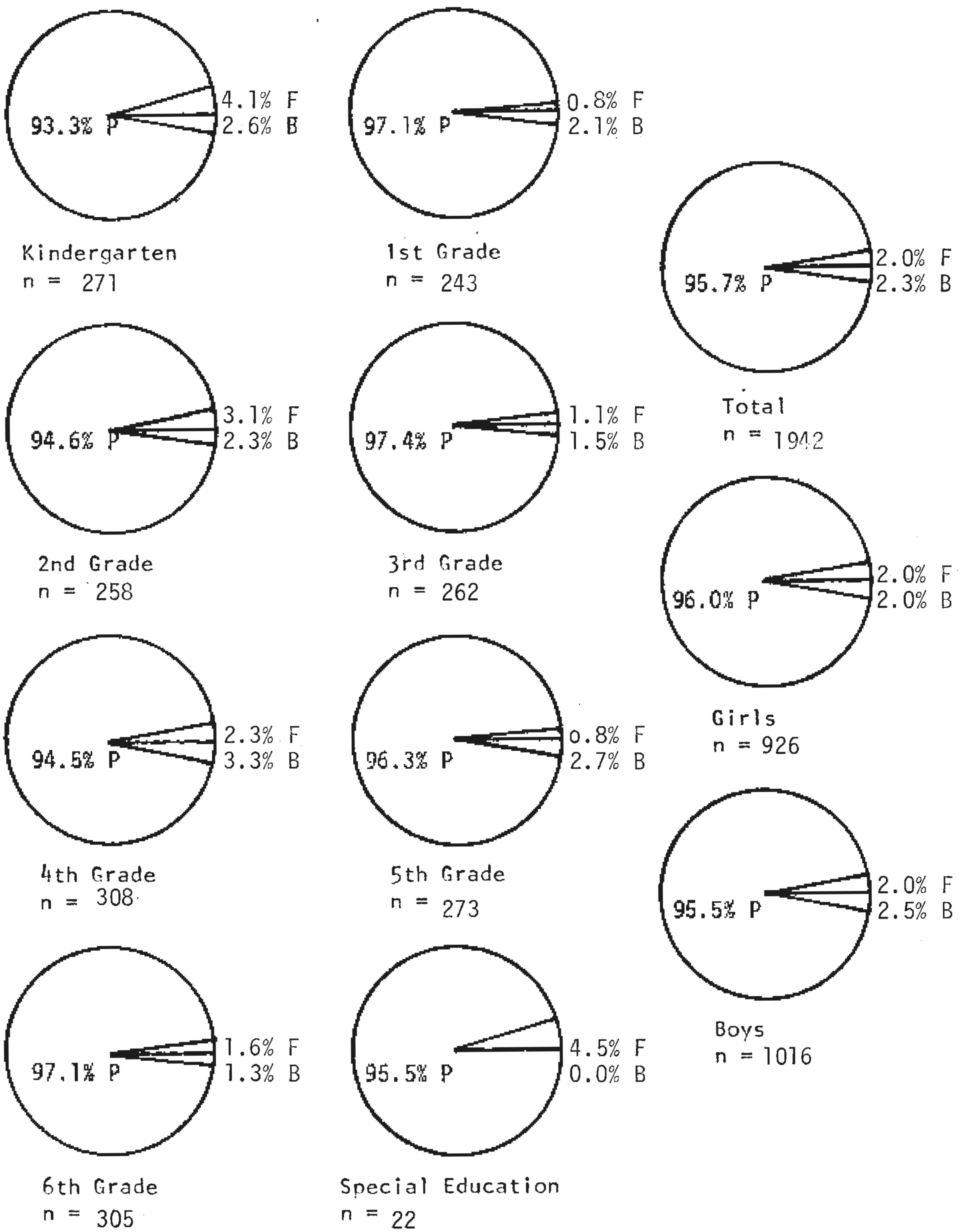


Figure 34.

Percent Pass-Fail Distribution for Anisometropia
Over Habitual Prescription

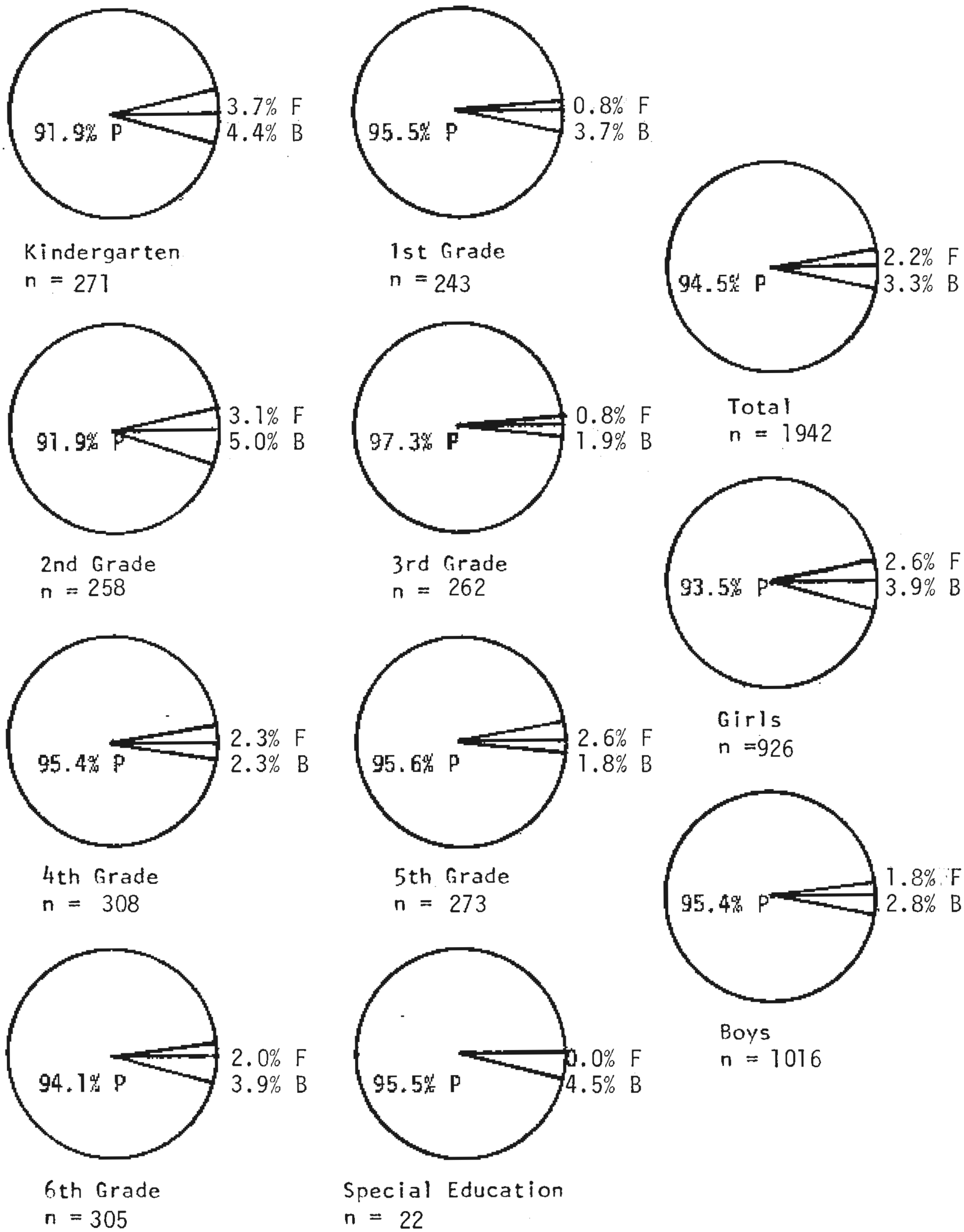


Figure 35.

Percent Pass-Fail Distribution for Ocular Health - Pupillary Reflex

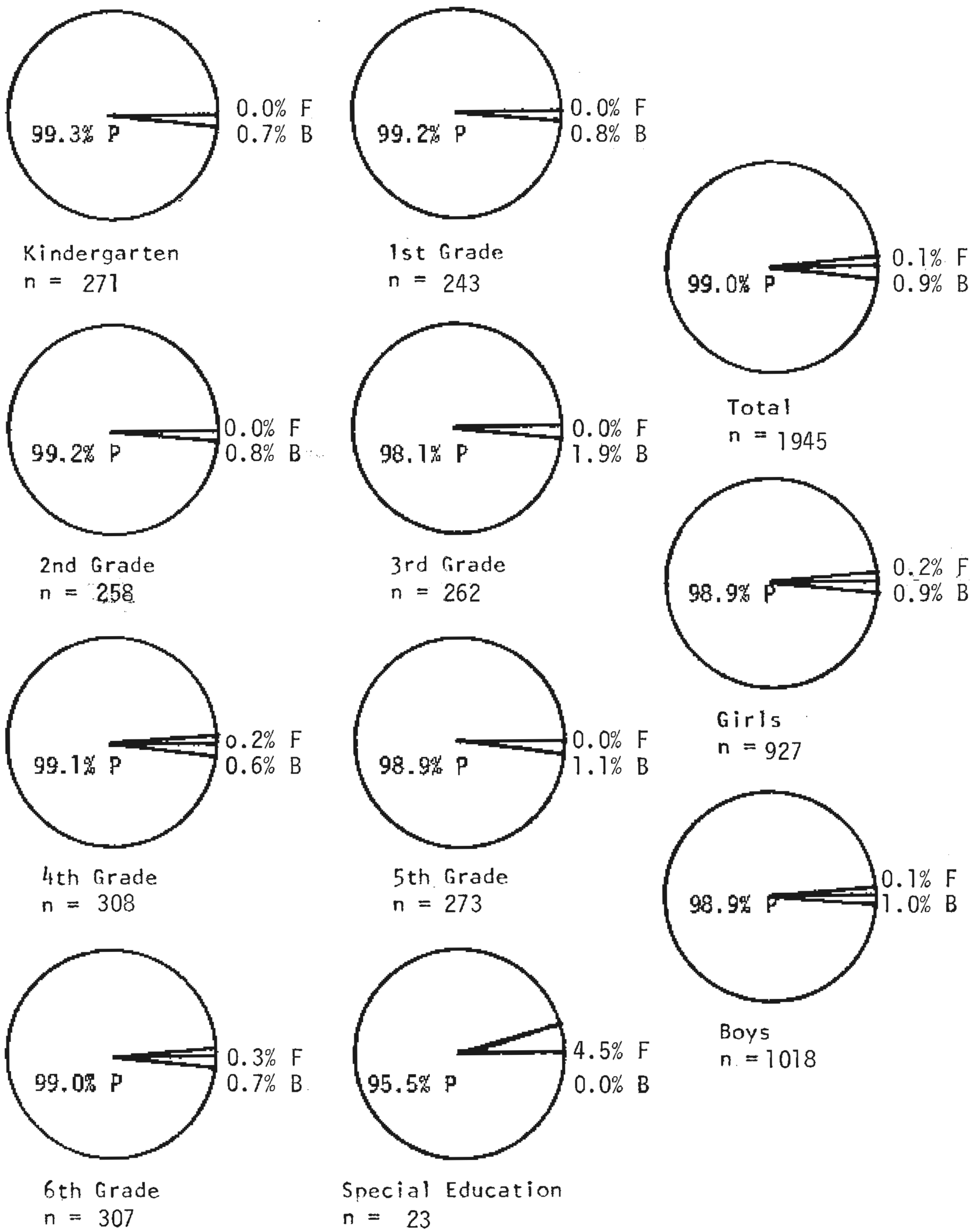


Figure 36.

Percent Pass-Fail Distribution for Ocular Health - External

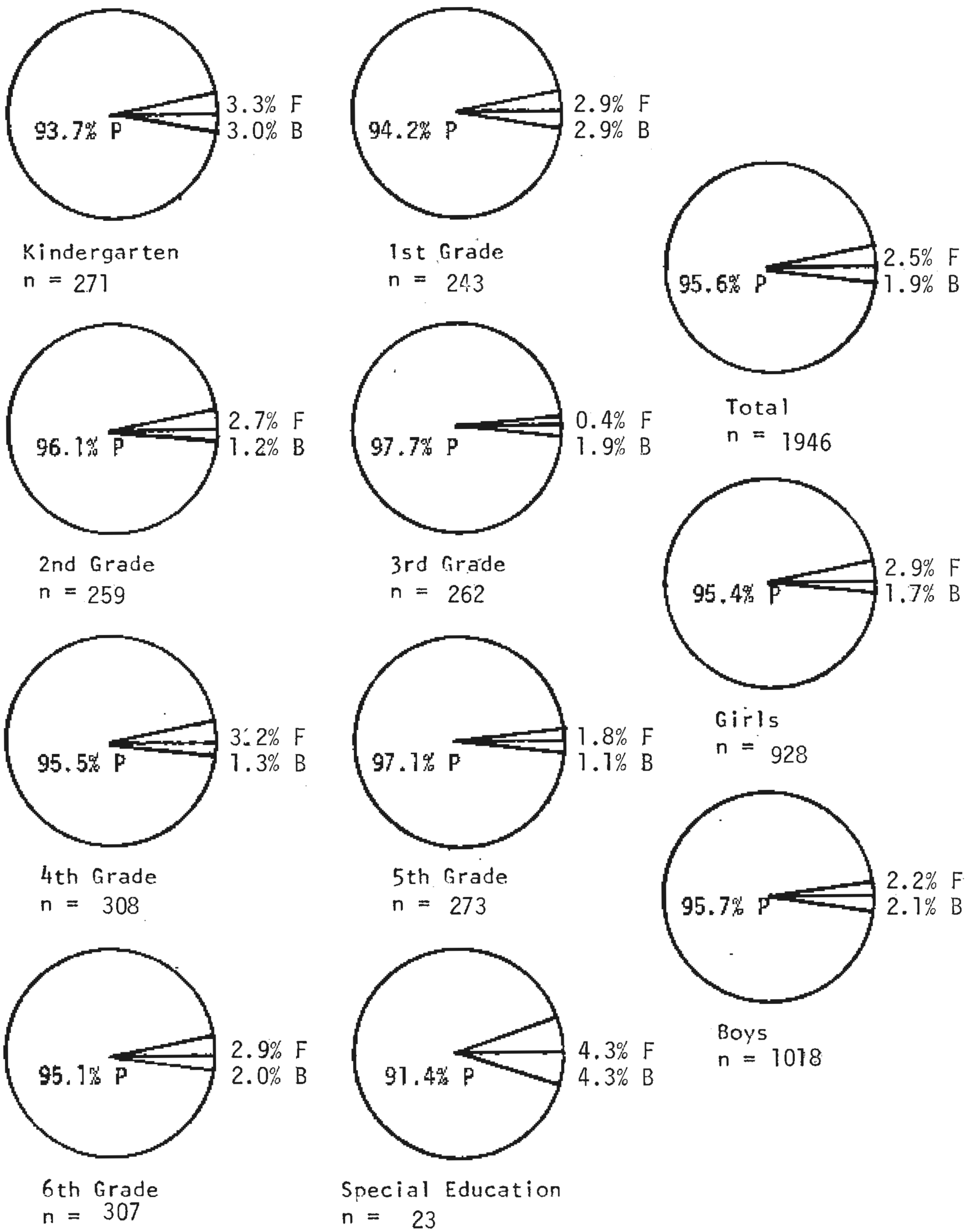
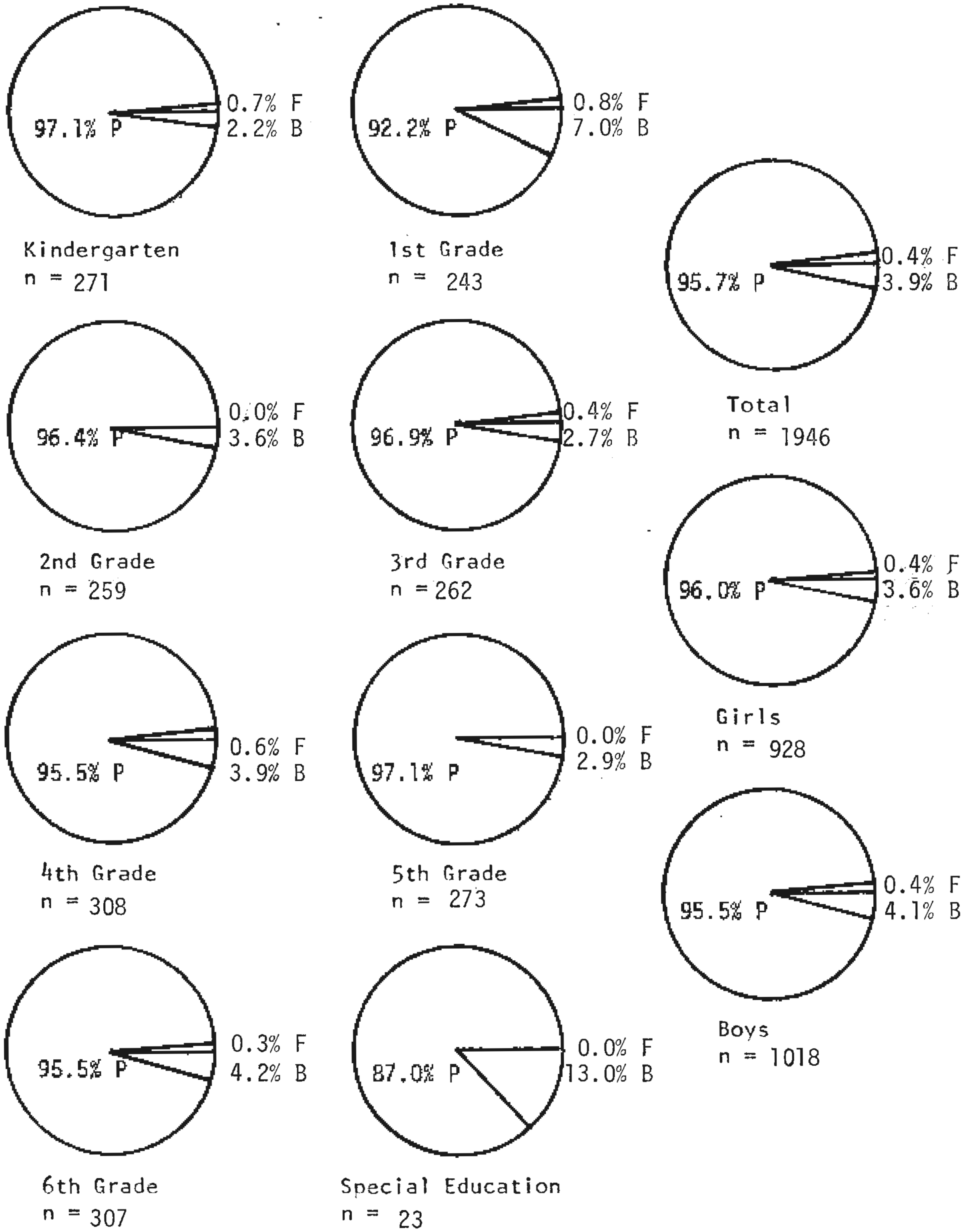


Figure 37.

Percent Pass-Fail Distribution for Ocular Health - Internal



INTERRELATIONSHIPS BETWEEN ACHIEVEMENT SCORES AND SCREENING RESULTS

One of the purposes of the ABBO Study was to investigate any relationships that might exist between achievement scores and the findings of a vision screening set. In this section the relationships that are apparent from our results are reviewed and summarized.

Tables IX and X on the following pages present the results for both the high and low achievement groups for both the reading and problem solving (Math) tests. These results are for those individuals whose scores were more than one standard deviation above or below the mean. The second set of summary tables, XI and XII, present the numbers and percentages in the pass/fail categories for each test in each achievement grouping.

Following the above tables, several graphs are included which present the by-grade mean findings for the various tests which show significant relationships to achievement.

Figure 38 presents the habitual decimal equivalent near visual acuity versus grade level for the total sample with points added indicating the findings for the high and low reading achievement groups. Similar findings are presented for the Math group in Figure 43.

Distance rock results in cycles per minute versus grade level are presented for the total sample in Figure 39, along with points for the high and low reading group. Figure 44 shows a similar pattern for the high and low math groups. Again the basically linear increase in cycles with grade is noted and the high and low groups are distributed on the high and low sides of the line for the total sample.

Figure 40 shows the results for the near point of convergence test with the high and low reading group added to the plot. The two groups tended to follow the trends of the total sample results with the low achievement groups showing a receeded NPC relative the high achieving group. Figure 45 shows a similar pattern for the data as separated into high and low math groups.

Results for the right and left eye dynamic retinoscopy - MEM versus grade are presented in Figure 41 for the high and low reading achievement groups. It is interesting to note the relatively large lag for the third graders when compared to the other grades and also that both points are higher than the mean point for the total sample from that grade whereas the high and low groups are on opposite sides for the other grades. Figure 46 shows similar results for the math groups.

Figure 42 presents the Static retinoscopy over habitual Rx results versus grade level with the high and low achievement groups also plotted. The variability of the points indicates little significance between the high and low reading groups on the static retinoscopy finding. However, in Figure 47 the math groups show a pattern much closer to the total sample with little difference between the high and low math achievement groups.

TABLE IX
Summary of Vision Screening Results by Grade, Sex and Total Sample
for the High and Low Reading Achievement Groups

		high σ 3	low σ 3	high σ 4	low σ 4	high σ 5	low σ 5	high σ 6	low σ 6	high σ Girls	high σ Boys	low σ Girls	low σ Boys	high σ Total	low σ Total
1. Far VAOD -	x	.944	.864	.909	.955	.958	.935	.949	.949	.966	.914	.910	.958	.937	.940
	σ	.136	.152	.175	.163	.256	.195	.192	.201	.163	.209	.178	.187	.191	.185
	n	38	15	58	44	37	40	48	54	81	100	58	95	181	153
VAOS	x	.938	.839	.912	.927	.971	.940	.946	.949	.945	.933	.902	.947	.939	.930
	σ	.134	.168	.171	.215	.235	.137	.201	.196	.191	.185	.175	.209	.187	.197
	n	38	15	59	44	37	40	48	54	81	101	58	95	.182	153
VAOU	x	.951	.873	.911	.967	.983	.968	.964	.960	.966	.934	.929	.971	.948	.955
	σ	.113	.143	.169	.167	.251	.174	.178	.193	.163	.180	.171	.179	.173	.177
	n	38	15	59	44	37	40	48	54	81	101	58	95	182	153
2. Near VAOD -	x	.945	.875	.954	.882	.963	.897	.933	.899	.945	.951	.852	.915	.948	.891
	σ	.118	.204	.115	.195	.104	.183	.132	.164	.121	.117	.197	.166	.118	.181
	n	38	15	58	44	37	40	48	54	81	100	58	95	181	153
VAOS	x	.925	.853	.949	.390	.981	.874	.926	.899	.942	.946	.852	.906	.944	.886
	σ	.163	.198	.120	.193	.076	.191	.150	.173	.142	.124	.202	.171	.132	.185
	n	38	15	59	44	37	40	48	54	81	101	58	95	182	153
VAOU	x	.959	.866	.960	.901	.981	.895	.937	.917	.956	.960	.864	.928	.958	.904
	σ	.106	.175	.108	.184	.076	.179	.131	.149	.111	.108	.193	.148	.109	.169
	n	38	15	59	44	37	40	48	54	81	101	58	95	182	153
3. Dist. Rock -	x	20.22	18.257	21.282	19.301	25.973	22.170	26.705	24.977	24.413	23.089	20.871	22.517	23.627	21.867
	σ	3.319	4.401	4.539	3.585	5.323	4.286	7.249	5.469	6.762	5.751	5.689	4.863	6.181	5.227
	n	14	8	36	22	13	15	33	26	39	57	28	43	96	71
4. NPC Break -	x	2.135	2.33	2.509	2.651	1.972	2.102	1.808	1.851	2.402	1.919	2.241	2.161	2.13	2.192
	σ	1.397	2.819	1.923	2.318	1.258	1.483	1.035	1.234	1.544	1.112	1.922	1.825	1.492	1.857
	n	37	15	55	43	37	39	47	54	77	99	58	93	176	151
Recovery	x	3.675	1.589	3.836	4.604	3.106	3.641	3.50	3.50	3.909	3.292	4.155	3.720	3.562	3.887
	σ	1.915	2.519	2.315	2.854	1.744	2.443	1.863	2.08	2.368	1.630	2.827	2.323	2.004	2.528
	n	37	15	55	43	37	39	47	54	77	99	58	93	176	151
"Ratio"	x	1.420	1.589	1.777	1.741	1.414	1.444	1.130	1.140	1.683	1.274	1.454	1.422	1.453	1.434
	σ	1.224	2.519	1.780	2.054	1.165	1.212	0.905	1.008	1.713	0.970	1.651	1.579	1.357	1.602
	n	37	15	55	43	37	39	47	54	77	99	58	93	176	151
5. Far CT Esop -	x	1	3	5.250	1.50	5.00	2.666	2.00	2.428	3.500	4.250	2.571	2.166	4.09	2.384
	σ	-	-	5.315	.707	4.582	0.577	1.414	2.149	.707	4.682	2.070	0.983	4.14	1.609
	n	1	1	4	2	3	3	2	7	2	8	7	6	10	13
ExoP	x	2.285	2.33	3.11	4.70	7.33	2.40	1.909	2.076	2.285	2.473	3.142	1.909	2.393	2.599
	σ	0.487	1.527	1.763	4.349	1.211	1.140	0.700	0.640	.913	1.389	2.444		1.197	1.979
	n	7	3	9	4	6	5	11	13	14	19	14	11	33	25
VertP	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	σ	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	n	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EsoT	x	-	-	20.00	-	-	15.00	-	12.00	25.00	20.00	-	13.50	22.5	13.5
	σ	-	-	-	-	-	-	-	-	-	-	-	2.121	3.53	2.121
	n	0	0	1	0	1	1	0	1	1	1	0	2	2	2
ExoT	x	25.00	-	-	-	-	-	-	-	-	25.00	-	-	25.00	-
	σ	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	n	1	0	0	0	0	0	0	0	0	1	0	0	1	0

TABLE IX (Continued)

Summary of Vision Screening Results by Grade, Sex and Total Sample
for the High and Low Reading Achievement Groups

		Highσ 3	Lowσ 3	Highσ 4	Lowσ 4	Highσ 5	Lowσ 5	Highσ 6	Lowσ 6	Lowσ Girls	Highσ Girls	Highσ Boys	Lowσ Boys	Highσ Total	Lowσ Total
5. Far CT - Vert T	x	-	-	-	-	-		-	-	-	-	-	-		-
	σ	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	n	0	0	0	0	0	0	0	0	0	0	0	0	0	0
- Ortho	n	29	11	44	37	27	31	35	33	36	63	72	76	135	112
6. Near CT- Eso P	x	2.750	4.0	4.500	2.200	4.750	4.220	3.125	3.700	3.770	2.923	4.294	3.500	3.700	3.599
	σ	.866	-	4.836	1.095	2.127	2.905	2.167	1.490	2.108	1.977	3.737	2.160	3.131	2.101
	n	8	1	10	5	4	9	8	10	9	13	17	16	30	25
- Exo P	x	4.460	3.625	3.611	4.588	3.678	3.500	3.473	4.700	5.068	3.606	3.909	3.738	3.757	4.281
	σ	1.853	1.060	1.419	1.938	1.778	1.505	1.925	3.292	3.283	1.456	2.005	1.593	1.745	2.496
	n	13	8	18	17	16	16	19	30	29	33	33	42	66	71
- Vert P	x	-	-	-	2	-	-	-	-	-	-	-	2.0	-	2.00
	σ	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	n	0	0	0	1	0	0	0	0	0	0	0	1	0	1
- Eso T	x	-	-	20.0	5.500	35.0	-	-	17.0	5.0	35.0	20.0	11.50	27.5	9.333
	σ	-	-	-	.707	-	-	-	-	-	-	-	7.778	10.61	6.658
	n	0	0	1	2	1	0	0	1	1	1	1	2	2	3
- Exo T	x	25.0	-	-	-	-	-	-	-	-	-	25.0	-	25.0	-
	σ	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-
	n	1	0	0	0	0	0	0	0	0	0	1	0	1	0
- Vert T	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	σ	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	n	0	0	0	0	0	0	0	0	0	0	0	0	0	0
- Ortho	n	16	6	29	18	16	15	21	13	18	33	49	34	82	52
7. Near MEM - R	x	-.862	-.899	-.679	-.720	-.590	-.764	-.629	-.751	-.736	-.686	-.684	-.775	-.685	-.760
	σ	.508	.500	.404	.457	.329	.577	.285	.481	.534	.373	.415	.482	.396	.501
	n	37	15	59	44	37	40	47	54	58	80	100	95	180	153
- L	x	-.881	-.991	-.688	-.768	-.577	-.761	-.645	-.735	-.715	-.705	-.684	-.814	-.694	-.777
	σ	.515	.575	.408	.467	.395	.564	.279	.441	.477	.373	.442	.508	.412	.497
	n	37	15	59	44	37	40	47	54	58	80	100	95	180	153
8. Static Retinos-R	x	.427	.299	.355	.346	.317	.527	.199	.251	.314	.331	.314	.381	.321	.356
	σ	.541	.599	.608	.593	.906	.555	.656	.579	.678	.605	.735	.520	.678	.583
	n	38	15	59	44	37	40	48	53	57	81	101	95	182	152
-L	x	.470	.399	.343	.394	.486	.615	.237	.323	.349	.359	.379	.476	.370	.428
	σ	.658	.632	.636	.569	.633	.646	.687	.563	.621	.682	.638	.585	.656	.600
	n	38	15	59	44	37	40	48	53	57	81	101	95	182	152

TABLE X

Summary of Vision Screening Results by Grade, Sex, and Total Sample for the High and Low Mathematics Achievement Groups

Measure		High σ 3	Low σ 3	High σ 4	Low σ 4	High σ 5	Low σ 5	High σ 6	Low σ 6	High σ Girls	Low σ Girls	High σ Boys	Low σ Boys	High σ Total	Low σ Total
1. Far VA - O.D. -	x	.929	.927	.938	.908	.942	.958	.979	.913	.944	.920	.952	.937	.949	.929
	σ	.160	.126	.164	.193	.219	.206	.201	.227	.166	.183	.205	.211	.189	.197
	n	34	31	52	39	50	53	53	47	80	83	109	87	189	170
- O.S. -	x	.924	.916	.935	.899	.947	.958	.983	.937	.944	.926	.954	.936	.950	.931
	σ	.155	.141	.163	.189	.209	.201	.199	.215	.169	.173	.197	.211	.185	.193
	n	34	31	53	39	50	53	53	47	80	83	110	87	190	170
- O.U. -	x	.942	.932	.935	.917	.963	.979	1.002	.947	.957	.944	.967	.950	.962	.947
	σ	.125	.119	.163	.177	.189	.191	.174	.216	.149	.171	.182	.197	.169	.184
	n	34	31	53	39	50	53	53	47	80	83	110	87	190	170
2. Near VA- O.D. -	x	.974	.892	.951	.863	.953	.916	.914	.874	.939	.870	.950	.904	.945	.888
	σ	.085	.180	.124	.208	.116	.168	.145	.185	.128	.193	.121	.175	.123	.184
	n	34	31	52	39	50	53	53	47	80	83	109	87	189	170
- O.S. -	x	.954	.870	.946	.876	.959	.905	.908	.882	.932	.880	.946	.890	.940	.885
	σ	.112	.181	.129	.201	.109	.180	.159	.183	.137	.190	.127	.181	.131	.185
	n	34	31	53	39	50	53	53	47	80	83	110	87	190	170
- O.U. -	x	.984	.908	.962	.888	.973	.927	.924	.895	.947	.891	.966	.921	.958	.906
	σ	.065	.160	.106	.192	.091	.158	.140	.169	.120	.181	.100	.156	.109	.169
	n	34	31	53	39	50	53	53	47	80	83	110	87	190	170
3. Dist. Rock -	x	21.216	19.795	22.703	20.813	26.897	22.856	27.943	25.881	25.620	22.031	25.353	22.749	25.456	22.403
	σ	3.349	4.343	4.895	4.067	5.166	4.475	5.817	6.337	5.991	5.587	5.656	5.155	5.758	5.346
	n	12	16	27	27	23	18	37	22	38	40	61	43	99	83
4. NPC Break -	x	1.878	2.419	2.419	2.324	2.000	2.500	1.884	1.956	2.250	2.536	1.926	2.059	2.059	2.295
	σ	1.082	3.836	2.051	2.211	1.228	2.014	1.231	1.210	1.848	2.634	1.152	1.983	1.482	2.333
	n	33	31	50	37	50	52	52	46	76	82	109	84	185	166
Recovery -	x	3.424	3.838	3.799	4.027	3.280	3.807	3.384	3.914	3.685	4.048	3.385	3.738	3.475	3.891
	σ	1.785	3.847	2.515	2.466	1.629	2.679	1.971	2.116	2.366	2.926	1.736	2.537	2.016	2.732
	n	33	31	50	37	50	52	52	46	76	82	109	84	185	166
"Ratio" -	x	1.185	1.793	1.694	1,564	1.381	1.799	1.201	1.144	1.583	1.828	1.239	1.306	1.380	1.546
	σ	.986	3.834	1.875	2.074	1.129	1.669	.943	.993	1.699	2.594	.949	1.695	1.317	2.195
	n	33	31	50	37	50	52	52	46	76	82	109	84	185	166
5. Far CT - Eso P -	x	2.000	-	6.500	4.333	4.500	2.000	1.666	2.250	3.333	3.000	4.299	2.333	4.076	2.799
	σ	1.414	-	4.509	4.932	3.872	1.000	1.154	1.500	.577	3.265	4.191	1.154	3.662	2.740
	n	2	0	4	3	4	3	3	4	3	7	10	3	13	10
- Exo P -	x	2.000	2.166	3.142	3.000	2.699	2.111	2.125	3.000	2.636	3.176	2.473	2.200	2.533	2.648
	σ	.707	.983	1.951	1.632	1.337	.781	.991	3.380	1.126	3.147	1.504	1.151	1.357	2.311
	n	5	6	7	7	10	9	8	15	11	17	19	20	30	37
- Vert P-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	σ	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	n	0	0	0	0	0	0	0	0	0	0	0	0	0	0
- Eso T -	x	-	15.0	20.0	-	25.0	14.0	-	7.000	25.0	10.67	22.50	12.5	23.33	11.40
	σ	-	-	-	-	-	1.414	-	4.242	-	5.859	3.535	3.535	2.886	4.615
	n	0	1	1	0	2	2	0	2	1	3	2	2	3	5
- Exo T -	x	25.00	-	-	-	-	-	-	12.0	-	12.0	25.00	-	25.00	12.00
	σ	-	-		-	-	-	-	-	-	-	-	-	-	-
	n	1	0	0	0	0	0	0	1	0	1	1	0	1	1
- Vert T-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	σ	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	n	0	0	0	0	0	0	0	0	0	0	0	0	0	0
- Ortho -	n	26	24	40	28	34	39	42	25	64	54	78	62	142	116

TABLE X (Continued)

Summary of Vision Screening Results by Grade, Sex, and Total Sample
for the High and Low Mathematics Achievement Groups

		High σ 3	Low σ 3	High σ 4	Low σ 4	High σ 5	Low σ 5	High σ 6	Low σ 6	High σ Girls	Low σ Girls	High σ Boys	Low σ Boys	High σ Total	Low σ Total
6. Near CT - Eso P -	x	2.250	2.500	5.777	3.888	5.000	4.444	3.571	2.666	4.200	3.769	4.599	3.615	4.440	3.692
	σ	.957	2.121	5.238	3.951	2.828	2.743	2.370	.816	2.973	3.539	4.222	2.180	3.708	2.881
	n	4	2	9	9	5	9	7	6	10	13	15	13	25	26
- Exo P -	x	3.250	4.314	3.421	3.785	4.565	3.608	4.318	4.500	3.848	4.238	4.116	3.924	4.000	4.085
	σ	2.301	3.180	1.387	1.251	3.341	1.827	2.514	3.062	2.873	3.066	2.332	1.858	2.560	2.539
	n	12	19	19	14	23	23	22	26	33	42	43	40	76	82
- Vert P -	x	-	-	-	2.00	-	-	-	-	-	-	-	2.000	-	2.00
	σ	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	n	0	0	0	1	0	0	0	0	0	0	0	1	0	1
- Eso T -	x	-	20.00	20.00	5.00	23.50	17.0	-	13.50	35.00	13.00	16.00	17.00	23.33	13.80
	σ	-	-	-	-	16.21	-	-	4.949	-	6.782	5.656	-	11.67	6.140
	n	0	1	1	1	2	1	0	2	1	4	2	1	3	5
- Exo T -	x	25.00	-	5.00	-	-	10.00	-	11.00	-	11.00	15.00	10.00	15.00	10.77
	σ	-	-	-	-	-	-	-	1.414	-	1.414	14.14	-	14.14	1.154
	n	1	0	1	0	0	1	0	2	0	2	2	1	2	3
- Vert T -	x	-	-	-	-	-	-	-		-	-	-	-	-	-
	σ	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	n	0	0	0	0	0	0	0	0	0	0	0	0	0	0
- Ortho -	n	16	9	22	13	20	19	24	11	35	21	47	31	82	52
7. Near MEM Ret. - R-	x	-.795	-.911	-.678	-.768	-.621	-.744	-.663	-.855	-.676	-.797	-.681	-.824	-.679	-.811
	σ	.519	.402	.429	.383	.472	.579	.337	.478	.413	.486	.454	.479	.436	.481
	n	33	30	53	39	50	52	52	47	79	81	109	87	188	168
- L-	x	-.810	-.966	-.716	-.842	-.606	-.816	-.662	-.797	-.708	-.780	-.674	-.903	-.688	-.843
	σ	.521	.447	.434	.424	.503	.475	.334	.408	.413	.457	.472	.418	.447	.440
	n	33	30	53	39	50	52	52	47	79	81	109	87	188	168
8. Static Retinos- R-	x	.426	.459	.450	.435	.367	.417	.317	.355	.388	.455	.386	.370	.387	.412
	σ	.454	.563	.640	.584	.775	.520	.708	.716	.585	.653	.724	.540	.667	.597
	n	34	31	53	39	50	53	53	47	80	83	100	87	190	170
- L-	x	.470	.532	.459	.496	.510	.476	.301	.349	.414	.485	.443	.428	.431	.455
	σ	.487	.523	.677	.849	.563	.647	.722	.716	.612	.761	.650	.613	.633	.688
	n	34	31	53	39	50	53	53	47	80	83	110	87	190	170

TABLE XI

Numbers of Pass, or Fail, or Borderline on Various Tests for the High-Low Achievement Groups

	High Math	Low Math	High Reading	Low Reading	Total Sample
Stereopsis					
Failed	5	11	4	9	62
Borderline	4	3	4	4	80
Passed	180	155	173	140	1794
Color					
Failed	7	10	5	5	67
Borderline	1	3	1	3	37
Passed	122	96	111	99	1175
Pursuits					
Failed	1	4	2	4	48
Borderline	15	14	14	14	226
Passed	173	152	166	135	1671
Fixations					
Failed	2	5	3	5	49
Borderline	12	16	13	17	202
Passed	176	149	166	131	1694
Retinoscopy					
Right Eye					
Sphere					
Failed	20	18	24	18	253
Borderline	14	11	10	9	167
Passed	156	141	148	125	1522
Cylinder					
Failed	4	5	2	3	40
Borderline	2	2	1	3	38
Passed	184	163	179	146	1864
Left Eye					
Sphere					
Failed	22	19	28	17	261
Borderline	18	7	11	9	163
Passed	150	144	143	126	1518
Cylinder					
Failed	0	8	0	5	39
Borderline	7	5	5	3	44
Passed	183	157	177	144	1859
Anisometropia					
Failed	2	5	3	3	42
Borderline	4	5	4	5	64
Passed	184	160	175	144	1836

TABLE XII

Percent Pass-Fail on Various Tests for the High-Low Achievement Groups

	High Math	Low Math	High Reading	Low Reading	Total Sample
Stereopsis					
Failed	2.6%	6.5%	2.2%	5.9%	3.2%
Borderline	2.1%	1.8%	2.2%	2.6%	4.1%
Passed	95.3%	91.7%	95.6%	91.5%	92.7%
Color					
Failed	5.4	9.2	4.3	4.7	5.2
Borderline	.8	2.7	.8	2.8	2.9
Passed	93.8	88.1	94.9	92.5	91.9
Pursuits					
Failed	.5	2.3	1.1	2.6	2.5
Borderline	7.9	8.2	7.6	9.1	11.6
Passed	91.5	89.5	91.3	88.3	85.9
Fixations					
Failed	1.0	2.9	1.6	3.3	2.5
Borderline	6.3	9.4	7.1	11.1	10.3
Passed	92.7	87.7	91.3	85.6	87.2
Retinoscopy					
Right Eye					
Sphere					
Failed	10.5	10.6	13.2	11.8	13.0
Borderline	7.4	6.5	5.5	5.9	8.6
Passed	82.1	82.9	81.3	82.3	78.4
Cylinder					
Failed	2.1	2.9	1.1	2.0	2.0
Borderline	1.0	1.2	0.5	2.0	1.9
Passed	96.8	95.9	98.4	96.0	96.1
Left Eye					
Sphere					
Failed	11.5	11.2	15.4	11.1	13.4
Borderline	9.5	4.1	6.0	5.9	8.4
Passed	79.0	84.7	78.6	83.0	78.2
Cylinder					
Failed	0.	4.7	0.	3.3	2.0
Borderline	3.7	2.9	2.7	2.0	2.3
Passed	96.3	92.4	97.3	94.7	95.7
Anisometropia					
Failed	1.0	2.9	1.6	2.0	2.2
Borderline	2.1	2.9	2.2	3.3	3.3
Passed	96.9	94.2	96.2	94.7	94.5

Figure 38

Habitual Decimal Equivalent Near Visual Acuity
vs Grade Level
With High and Low Reading Achievement Groups Added

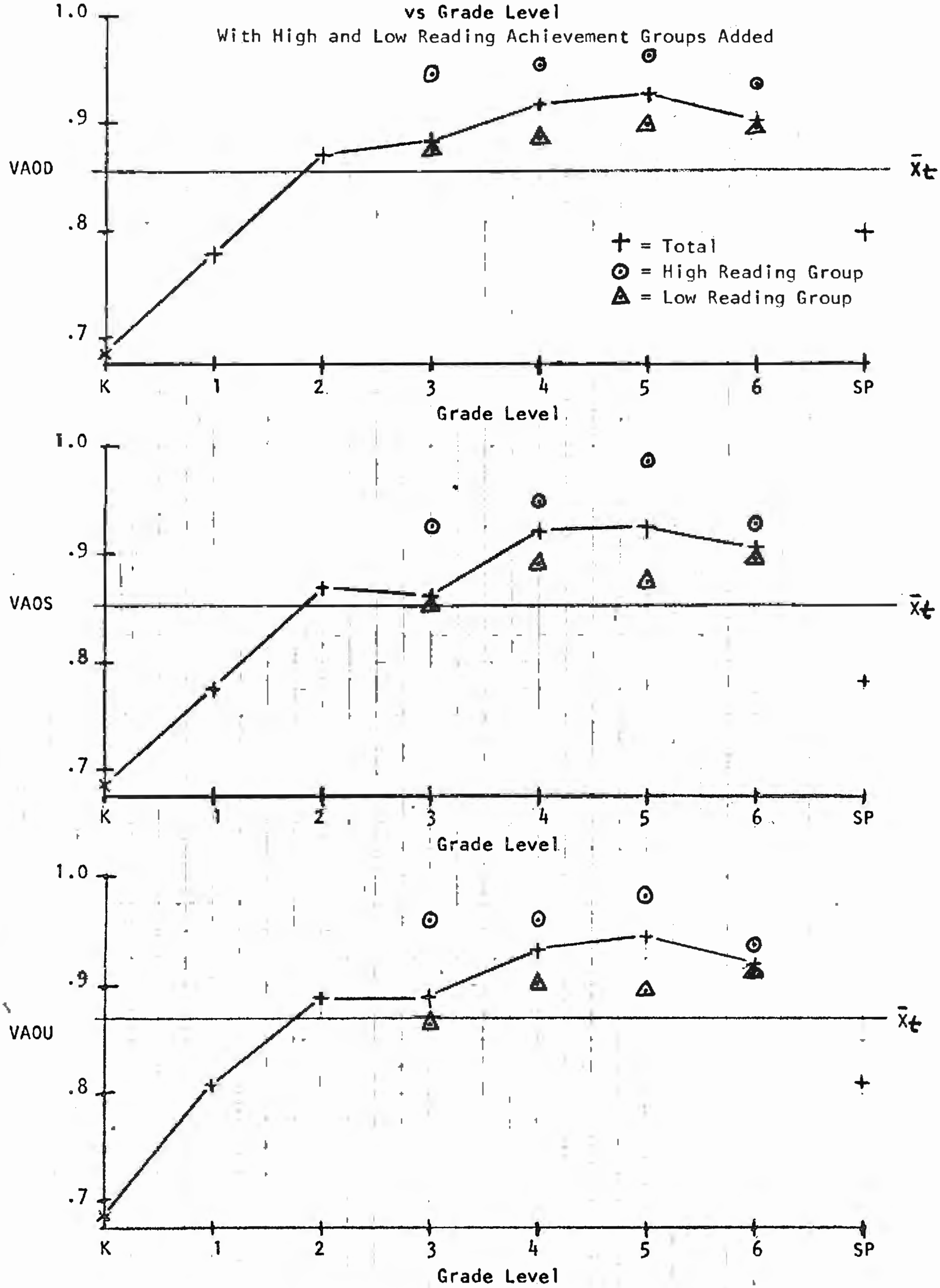


Figure 39
Distance Rock in Cycles per Minute
vs Grade Level
With High and Low Reading Achievement Groups Added

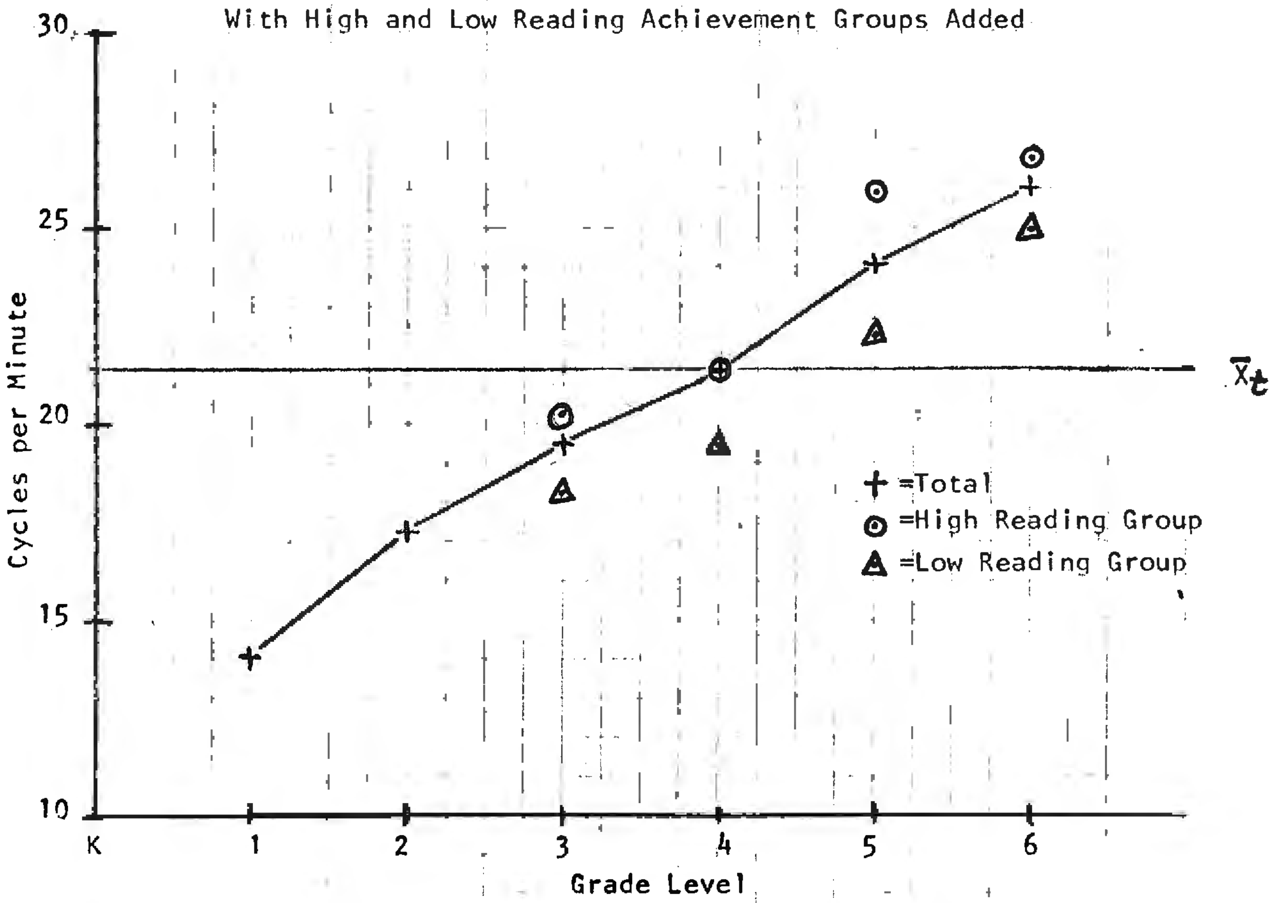


Figure 40
Near Point of Convergence in Inches
vs Grade Level
With High and Low Reading Achievement Groups Added

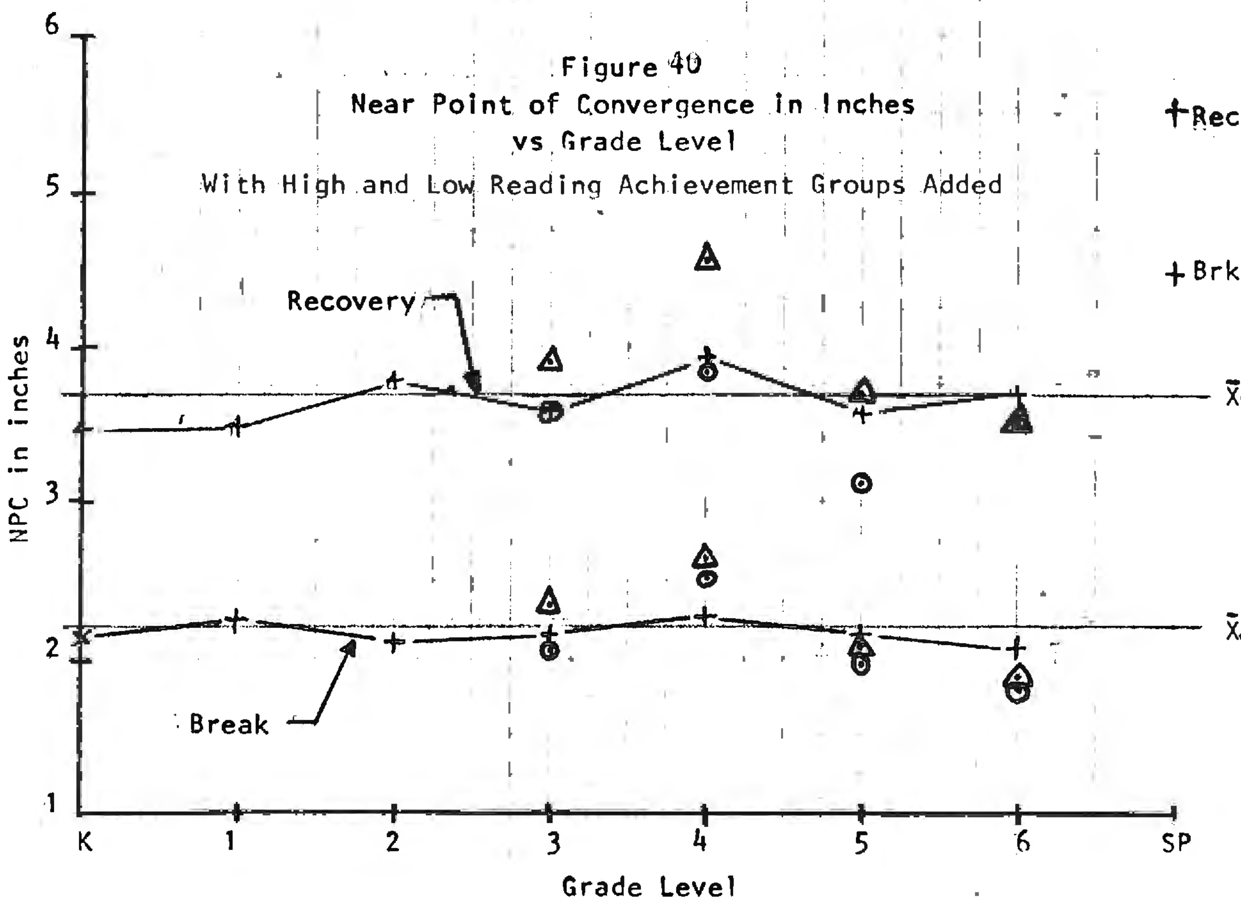


Figure 41a

Dynamic Retinoscopy by the MEM Method
vs Grade Level, Right Eye
With High and Low Reading Achievement Groups Added

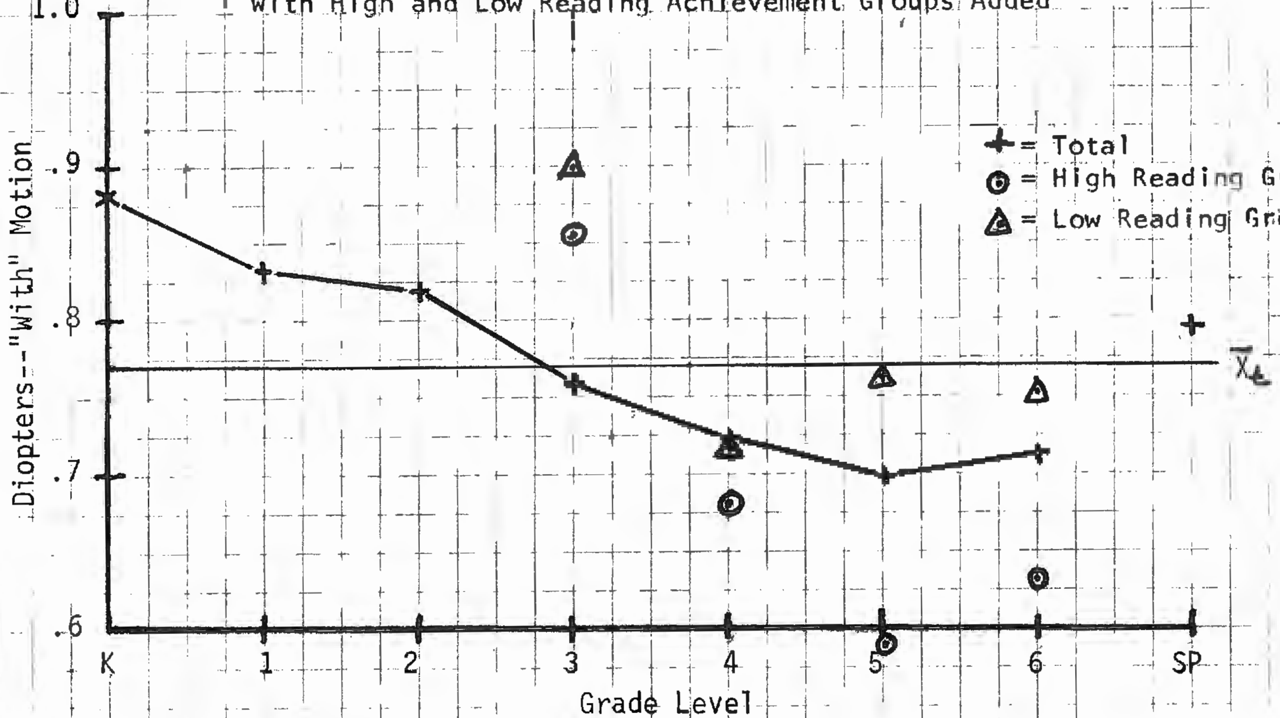


Figure 41b

Dynamic Retinoscopy by the MEM Method
vs Grade Level, Left Eye
With High and Low Reading Achievement Groups Added

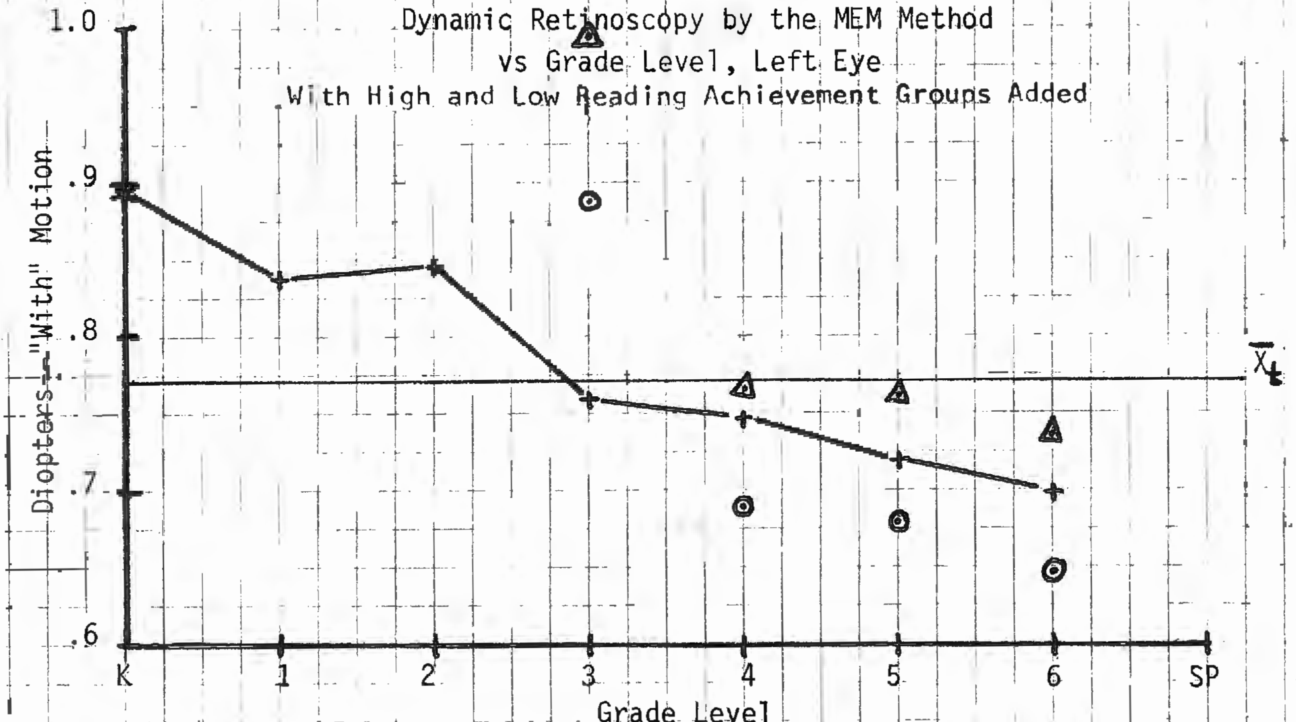


Figure 42a

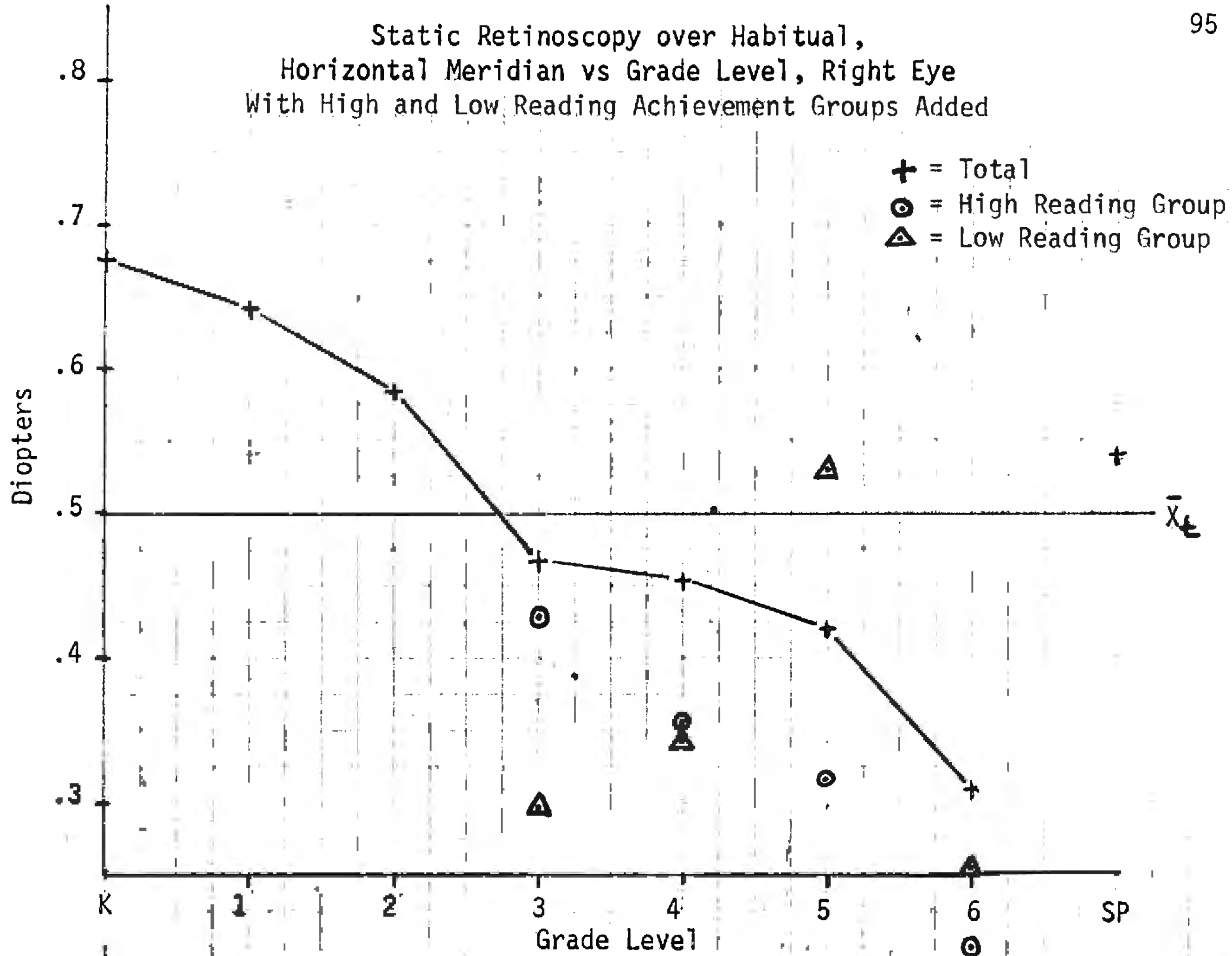


Figure 42b

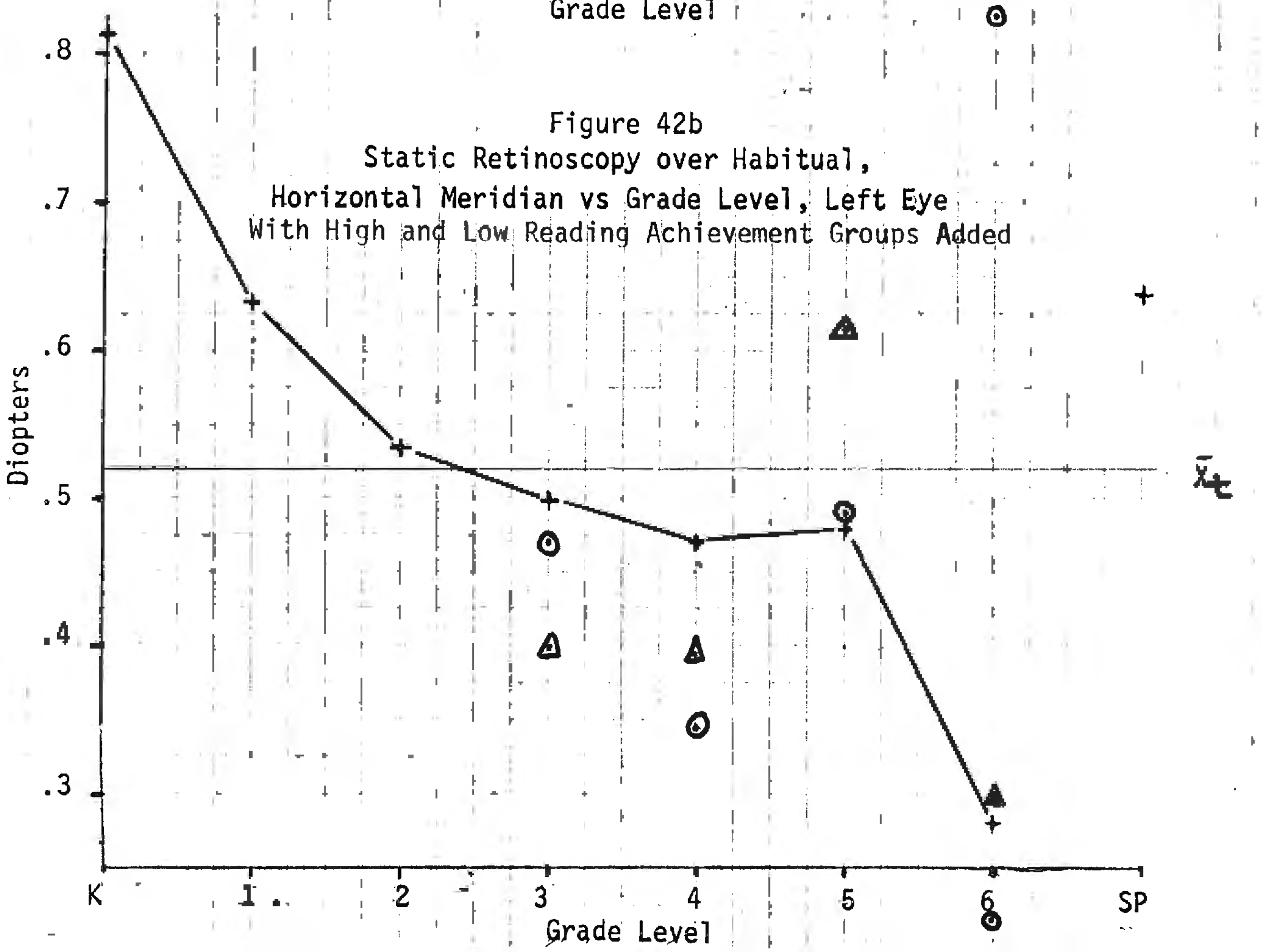


Figure 43

Habitual Decimal Equivalent Near Visual Acuity vs Grade Level With High and Low Math Achievement Groups Added

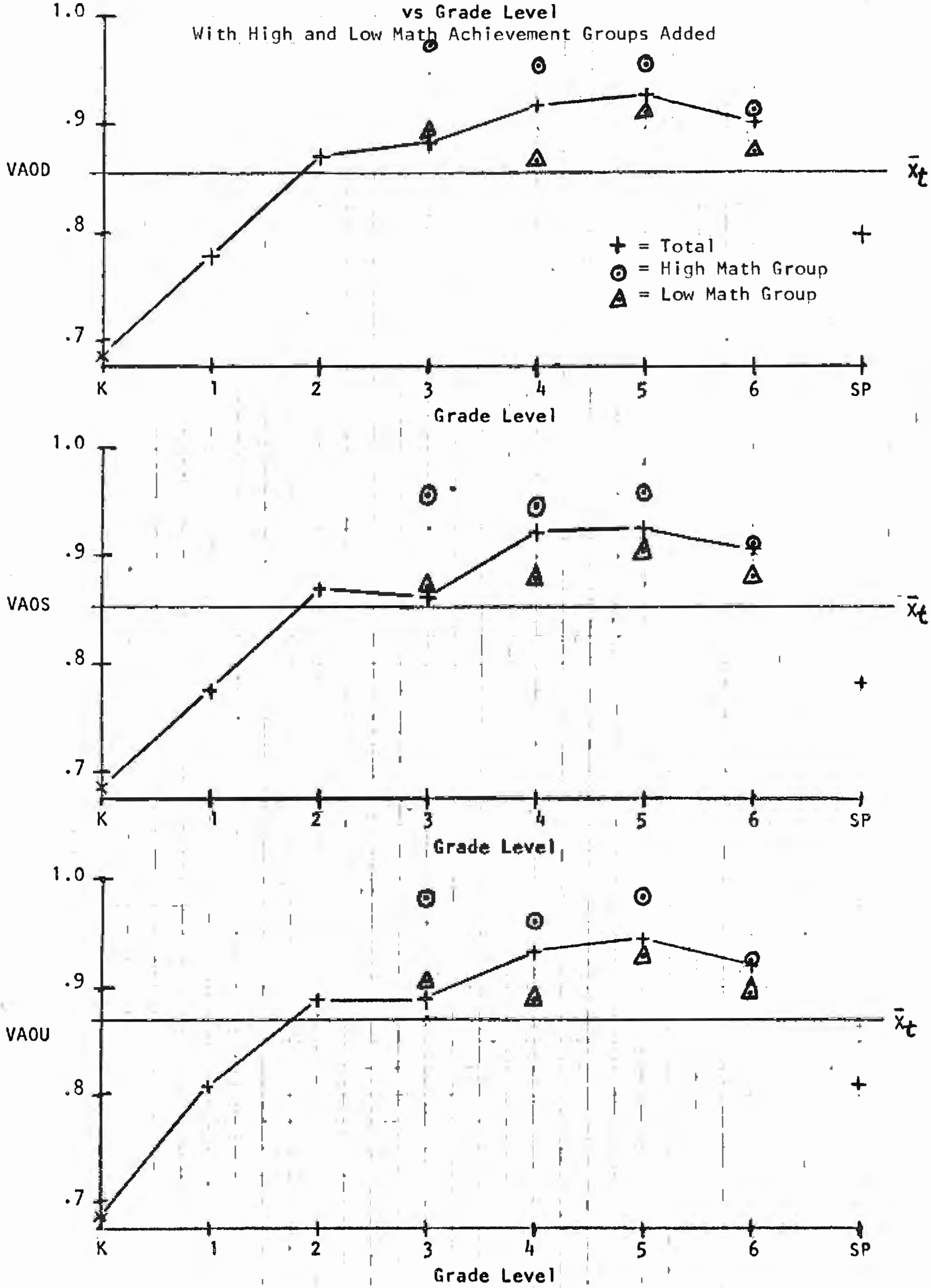


Figure 44

Distance Rock in Cycles per Minute vs Grade Level

With High and Low Math Achievement Groups Added

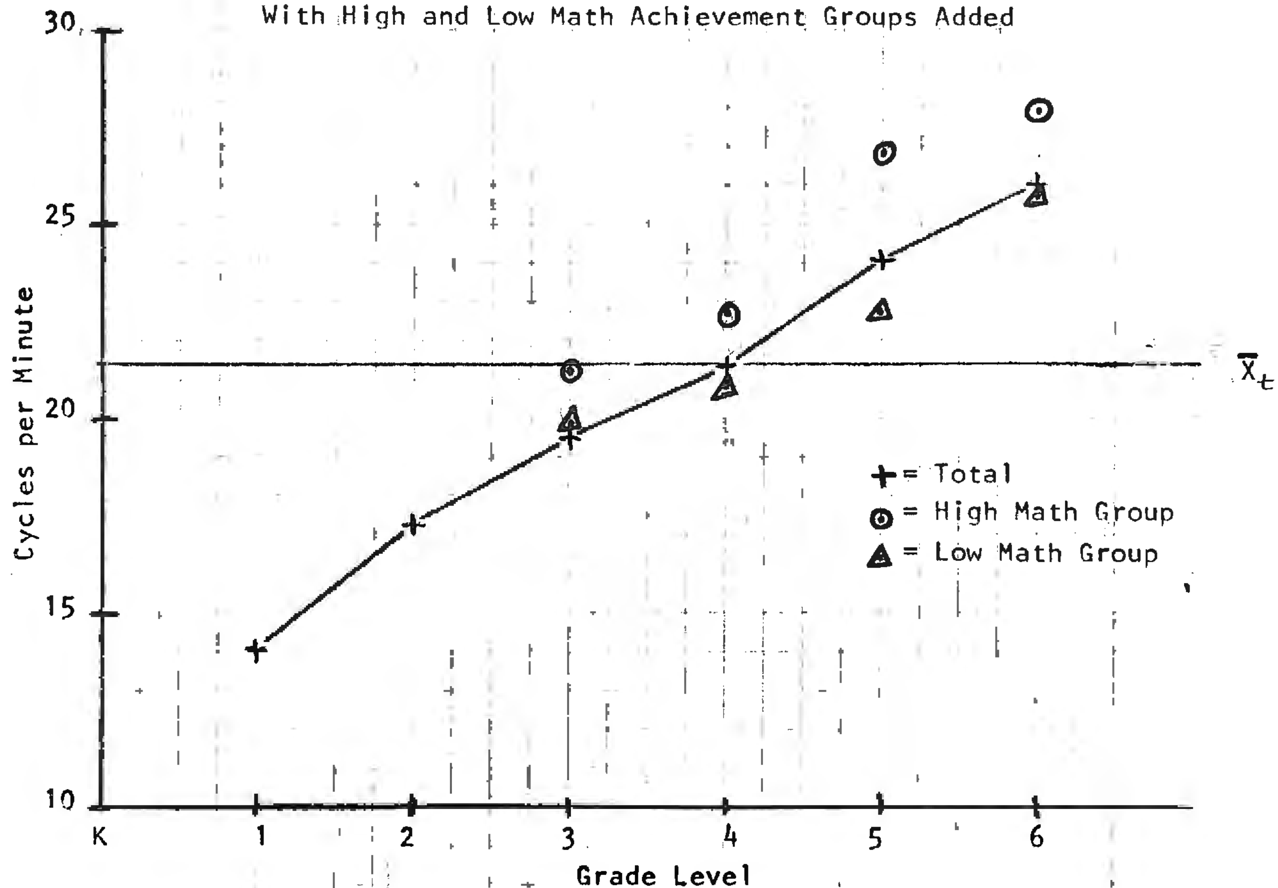


Figure 45

Near Point of Convergence in Inches vs Grade Level

With High and Low Math Achievement Groups Added

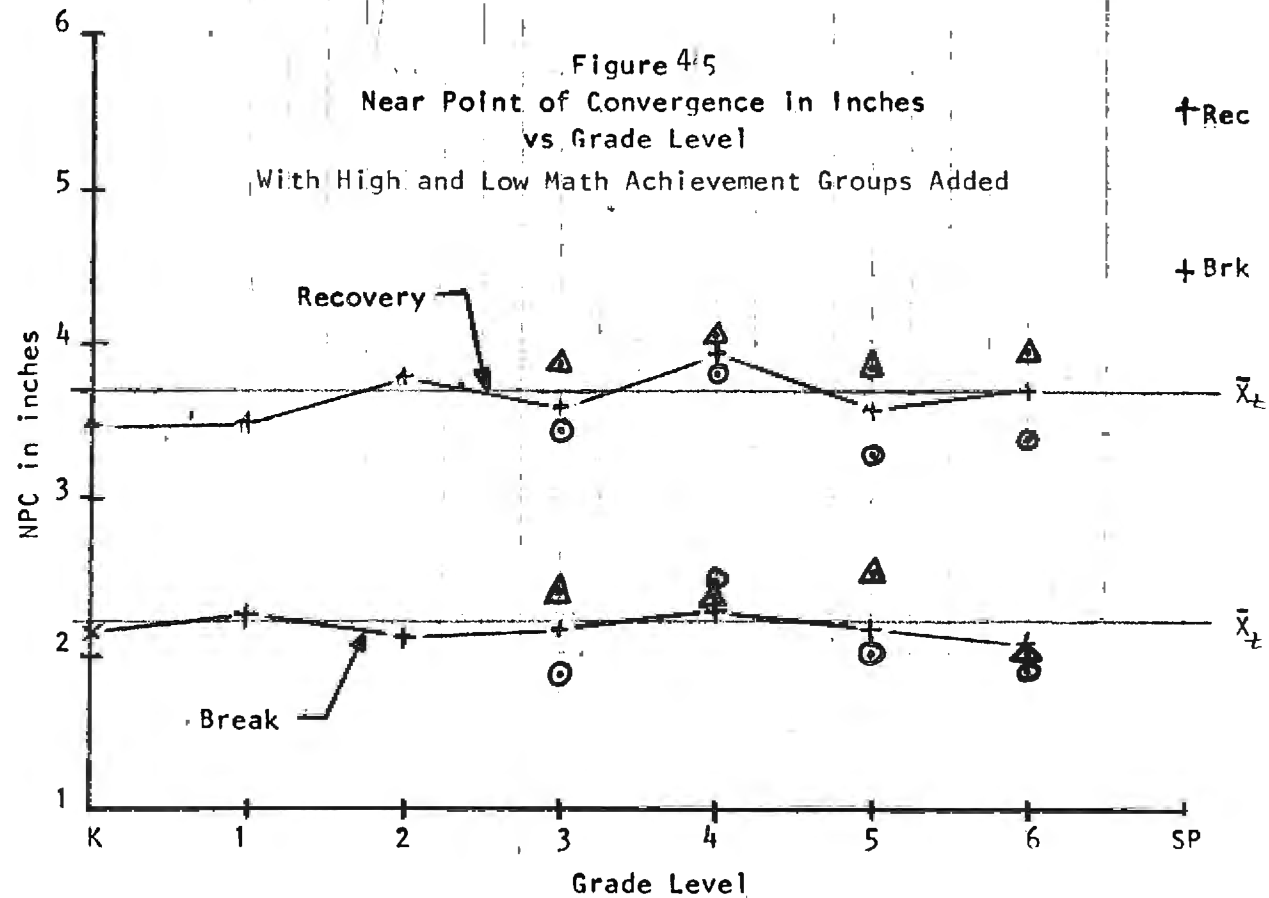


Figure 46a

Dynamic Retinoscopy by the MEM Method
vs Grade Level, Right Eye
With High and Low Math Achievement Groups Added

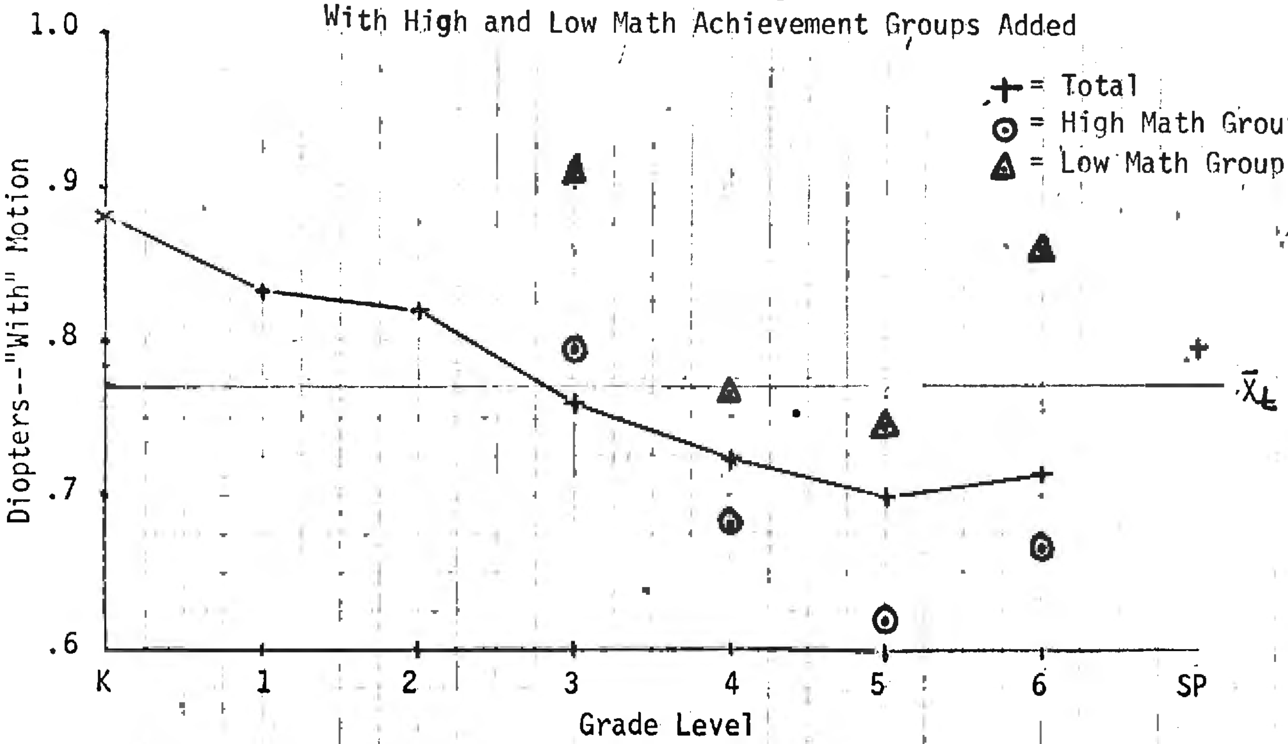


Figure 46b

Dynamic Retinoscopy by the MEM Method
vs Grade Level, Left Eye
With High and Low Math Achievement Groups Added

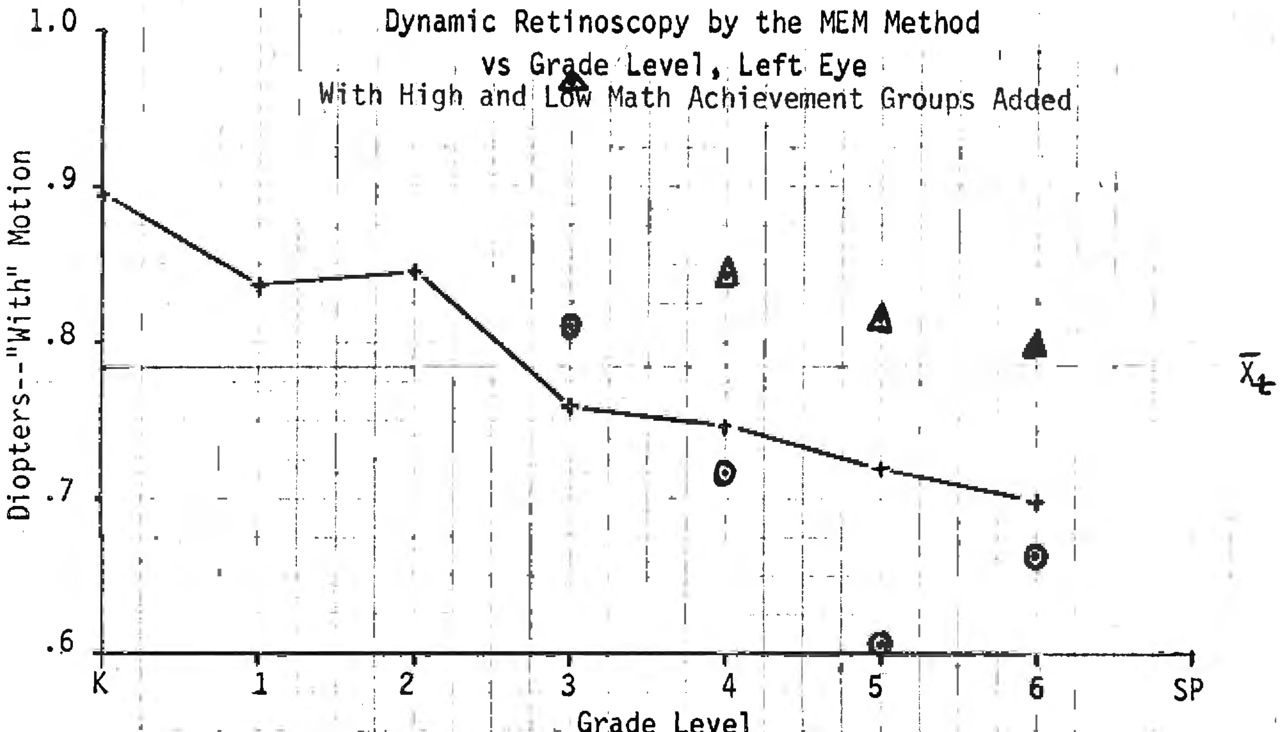


Figure 47a

Static Retinoscopy over Habitual, Horizontal Meridian vs Grade Level, Right Eye With High and Low Math Achievement Groups Added

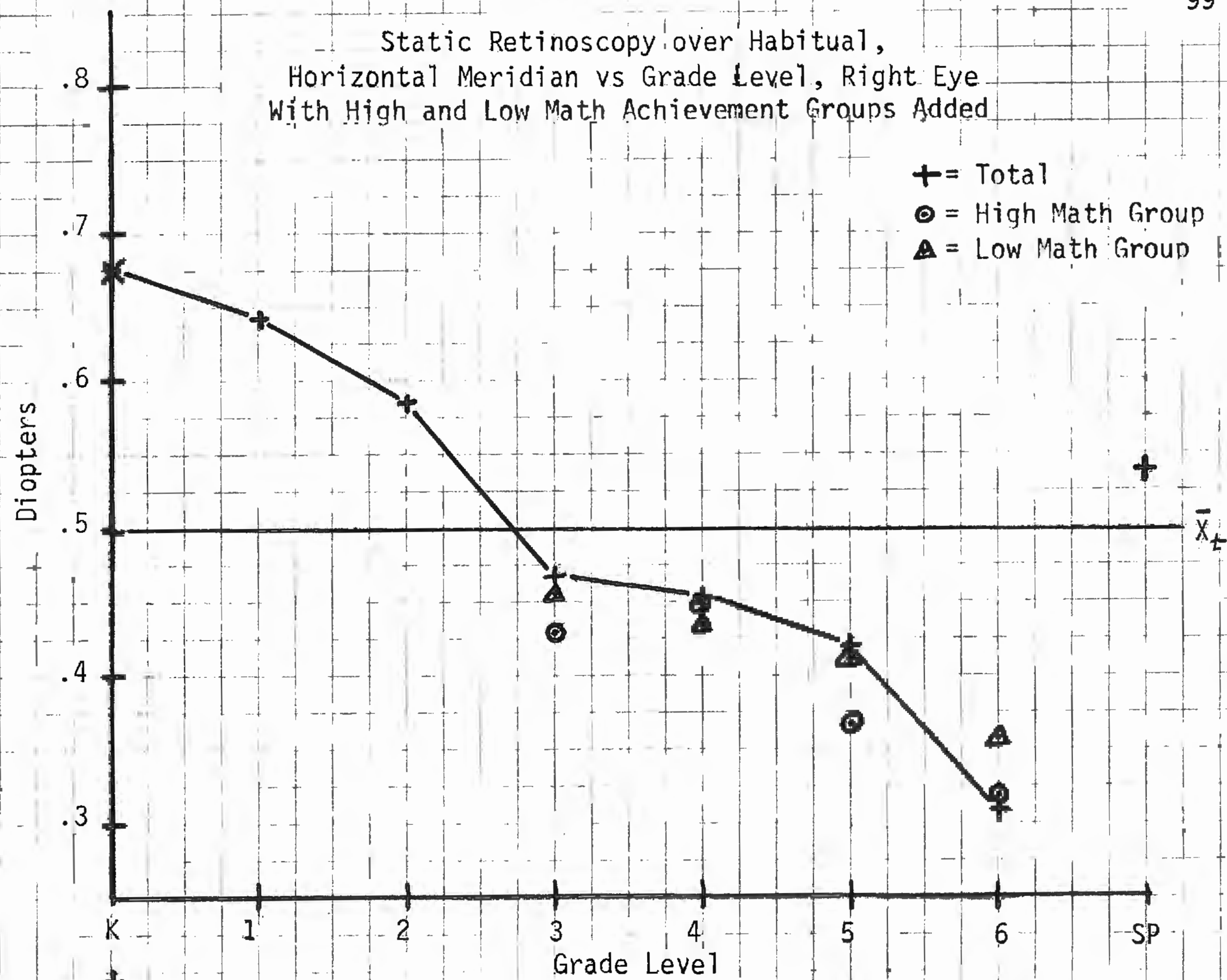
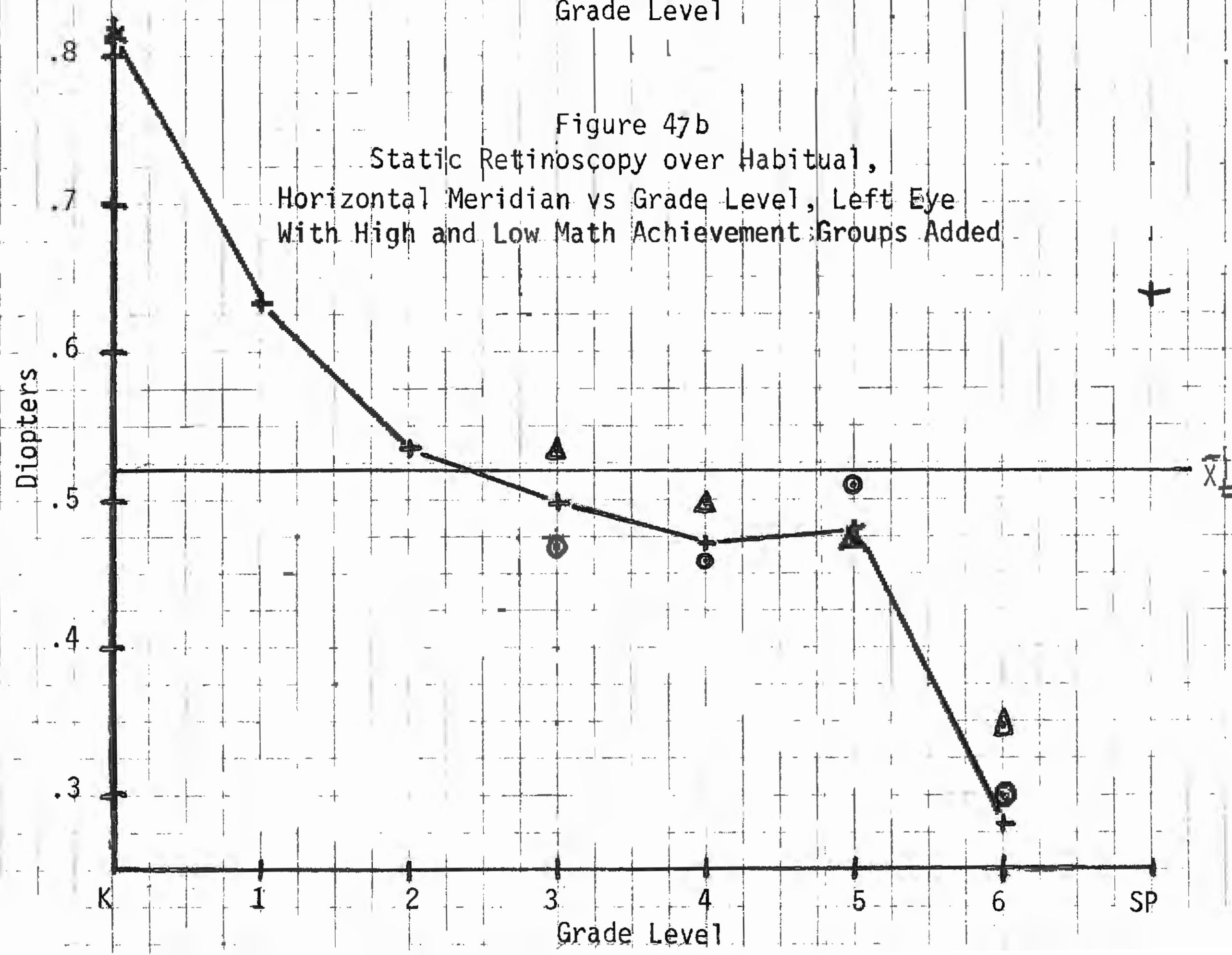


Figure 47b

Static Retinoscopy over Habitual, Horizontal Meridian vs Grade Level, Left Eye With High and Low Math Achievement Groups Added



An analysis of the various statistical summaries yielded the results given in Table XIII on the following page. The table presents calculated F and t values for the various screening findings when comparing the high and low achievement groups as measured by the math and reading tests. Also included are the two-tail levels at which any differences are significant. Those findings with a "--" in the level (p) column did not yield a statistically significant difference. Those with a "*" in the p column after the t value are ones inwhich the F values yielded non-homogeniety of variance, so the t values were not valid but the samples are still considered to be significantly different. By reviewing the following table, the reader will see which tests yielded significant differences between the high and low achievement groups.

TABLE XIII

Relationships Between Achievement and Screening Tests

	High-Low Reading				High-Low Mathematics			
	F	p	t	p	F	p	t	p
Far VA-O.D.	1.065	--	.145	--	1.087	--	.978	--
-O.S.	1.111	--	.427	--	1.089	--	.950	--
-O.U.	1.048	--	.364	--	1.186	--	.804	--
Near VA-O.D.	2.355	.001	3.446	*	2.239	.001	3.471	*
-O.S.	1.966	.001	3.328	*	2.000	.001	3.272	*
-O.U.	2.406	.001	3.515	*	2.405	.001	3.495	*
Dist. Rock	1.393	--	1.928	.05	1.159	--	3.753	.01
NPC-Break	1.551	.01	.334	*	2.480	.001	1.185	*
-Recovery	1.593	.01	1.292	*	1.828	.001	1.644	*
-"Ratio"	1.395	.05	.116	--	2.754	.001	.941	*
Far CT-Esophoria	6.790	.001	1.302	*	1.740	--	.880	--
-Exophoria	2.761	.005	.483	*	2.909	.01	.227	*
Near CT-Esophoria	2.206	.05	.135	--	1.662	--	.792	--
-Exophoria	2.044	.01	1.404	*	1.025	--	.196	--
Dyn. Retinoscopy-R	1.602	.01	1.520	*	1.218	--	2.708	.01
-L	1.457	.05	1.661	.05	1.031	--	3.281	.01
Static Retinos. -R	1.351	--	.499	--	1.247	--	.372	--
-L	1.194	--	.834	--	1.182	--	.344	--

-- = Not Significant Difference

* = Non-homogeniety of Variance

Significance of Screening Tests Included in the Project

Figure 48 shows the frequency of the number of tests failed by each student in the sample. It is interesting to note that the mode is just one test failed; 59.9% having failed only one test. This would seem to indicate that most of the tests measure unique and discrete functions.

Figure 49 presents the percentage of those tested who failed a particular test. The horizontal line in each column shows the percentage that failed only that single test. More than two times the number of children fail static retinoscopy than any other single test. Another interesting observation is that no other single test detects as many children as would be missed if the test battery excluded static retinoscopy.

The near cover test is shown to have the second highest failure rate. If it were eliminated from the test battery 3% of the sample would be missed.

The rate of failure on visual acuity is very close for far and near visual acuity, 5.9% and 5.7% respectively. What is interesting to note is that if each of these was eliminated from the battery, more children would go undetected if near VA rather than far VA was eliminated. Far VA is second only to stereopsis in having the least number of misses if dropped out of the screening test battery.

The near point of convergence test failed 5.5% of the sample with 2.3% failing only the NPC test. The ease of administration, failure rate and the percentage failing only this test should lead to serious thoughts on including it as a valuable screening tool. Its clinical importance in identifying orthoptics cases is also significant.

Far cover test, a procedure in the MCT, if eliminated from our battery would only lead to missing .75% of those screened; thus exhibiting questionable usefulness for this test in a screening battery.

Figure 48.

Frequency Dristribution for Number of Tests

Failed by Each Student In the Sample

(N=805)

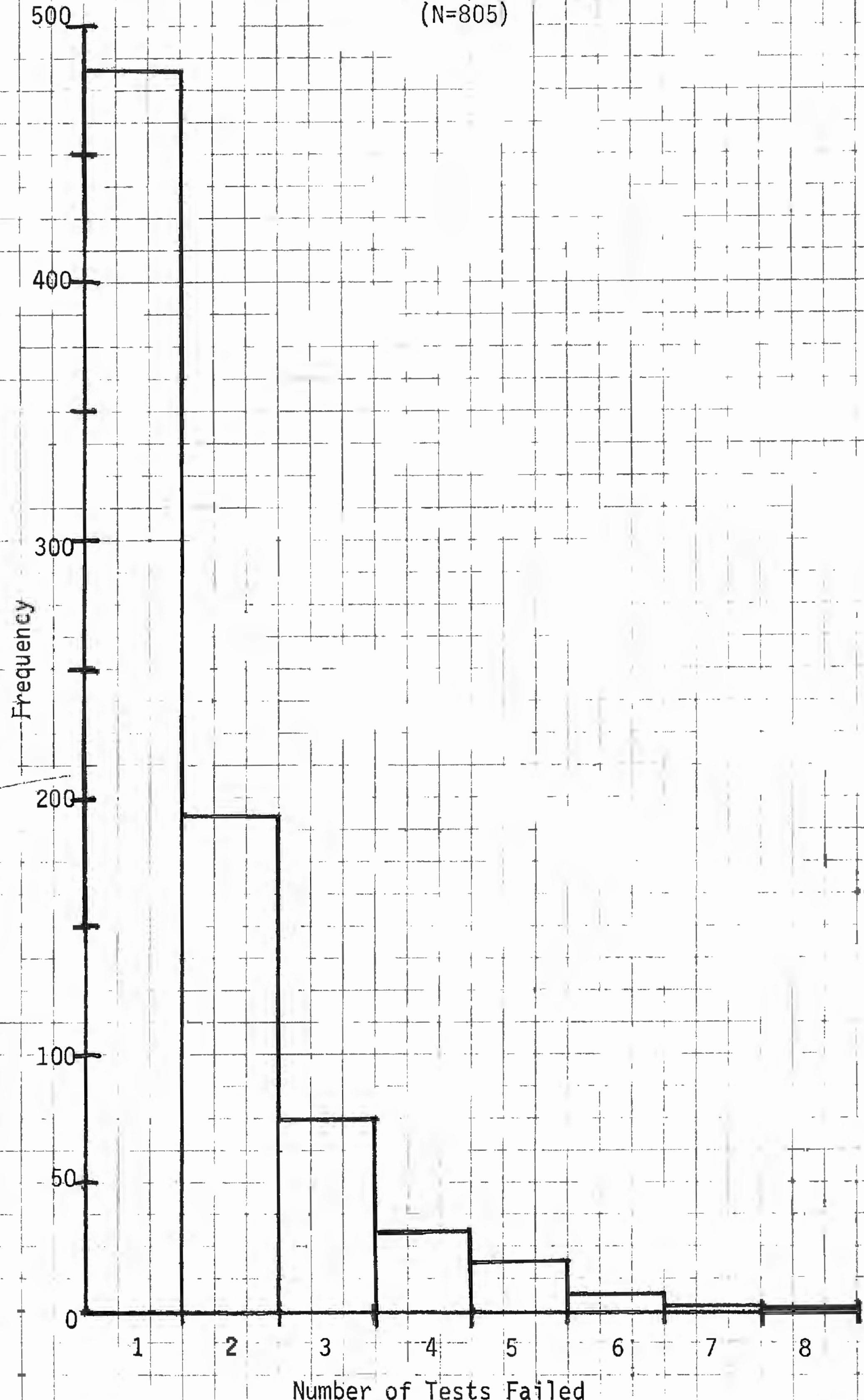
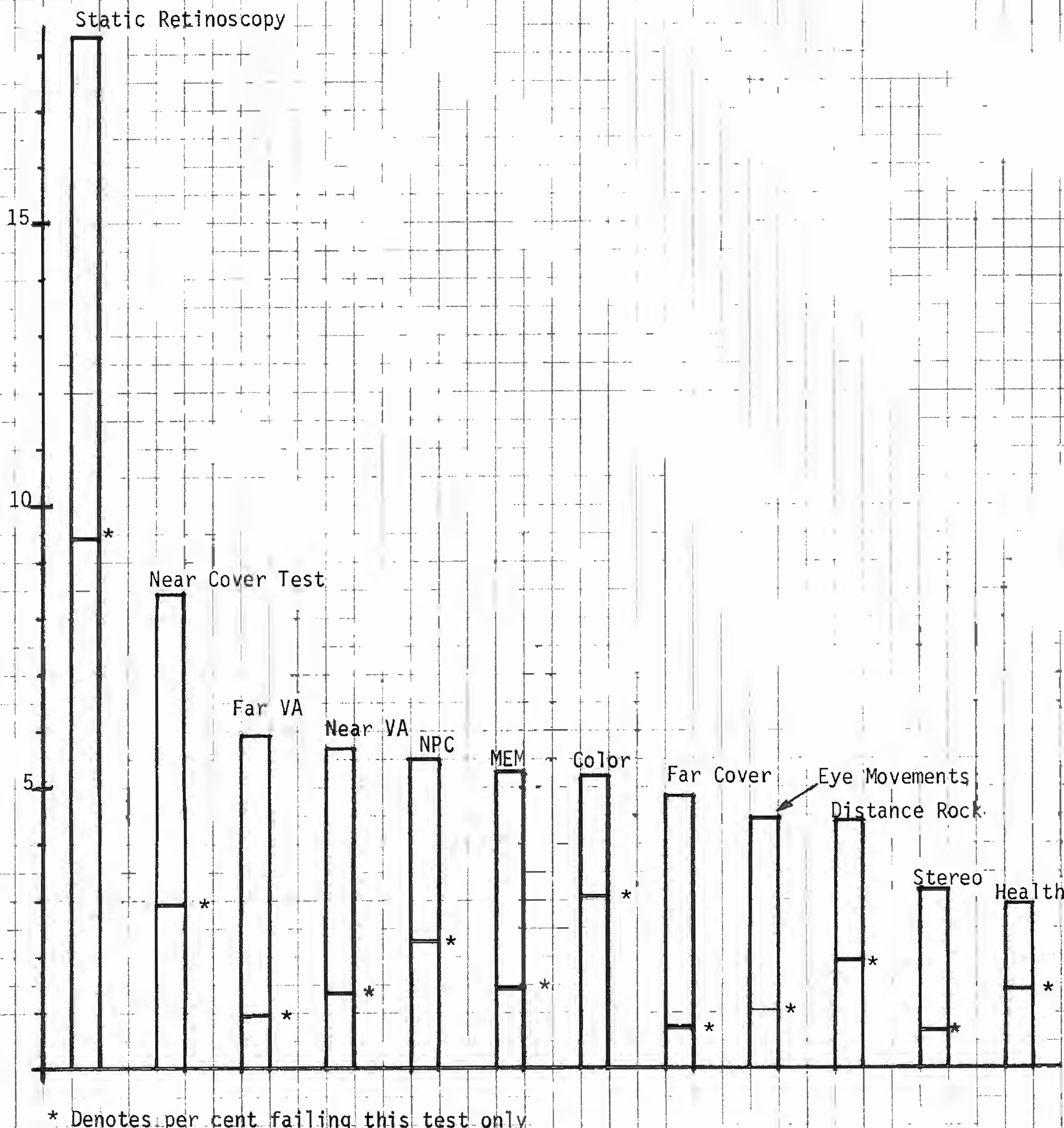


Figure 49.
Failure Rate on the Various Tests of the
Screening as a Per Cent of Those Tested



Distance rock was performed only on those able to read the chart at far and near binocularly. The referral criteria for this test was set for the entire population; analysis of the data shows it is a function that varies with grade level, so norms should be established for each grade. However, the referral criteria for failure was set low enough so that those who failed our screening would fail a revised criteria also. It is interesting to note that if 20/30 letters were used at near and far, all those failing VA O.U. at far and near and also those failing distance rock would be detected. The failure rate would then jump to about 10% of the sample; dramatically increasing its effectiveness as a screening tool.

Stereopsis as measured in our screening program did not have a very high overall failure rate nor did it have a large only-test-failed rate. It does not appear that this test adds much to our screening battery.

Ocular health had the lowest rate of failure of all the tests performed; it is a part of the Modified Clinical Technique. Of the 1950 children screened, only one case of a previously undetected serious ocular health problem was uncovered. Most of the ocular health problems encountered were blepharitus, a usually transient and apparant anomaly. The professional time, expense and low referral rate would lead to questioning the neccessity to include this test in a screening program.

Table XIV provides a rather detailed look at the number of individuals failing various combinations of screening tests. The various columns represent those failing 1, or 2, or 3, etc. tests. The letter abbreviations represent the following tests:

A= Far Visual Acuity
B= Near Visual Acuity
C= Stereopsis
D= Color Vision
E= Distance Rock
F= Near Point of Convergence
G= Far Cover Test
H= Near Cover Test
I= Pursuit Eye Movements
J= Near-Far Fixations and Saccades

K= Dynamic Retinoscopy-MEM
L= Static Retinoscopy
M= Ocular Health

The great scatter of tests failed as well as the large number who failed only one test points to the fact that each test is measuring a different function. Careful review of the findings yields certain relationships of interest.

As one would expect there is a relationship between far and near acuity and static retinoscopy. The results can be summarized in the following manner:

	Far	Near
Failed Retinoscopy and not acuity	40	64
Failed Retinoscopy and failed acuity	75	44

This shows that far VA is more related to static retinoscopy, thus it is more important to test near acuity rather than far acuity when static retinoscopy is a part of the screening program.

Far and near cover test may be related as the following suggests:

	Far	Near
Failed one or the other cover tests	31	97
Failed both cover tests	65	65

It can be concluded from the above that 67% of those who fail the far cover test would be detected by the near cover test but only 40% of those who fail the near cover test would be detected by the far cover test. This data suggests the importance of the near cover test on which more children failed and which detected a large proportion of those failing the far cover test.

Some might think that the near cover test would detect most of those people who fail the near point of convergence (NPC). This is far from the case in our data as only 12 out 106 people failing the NPC also failed the near cover test.

Another interesting relationship is that between static and dynamic retinoscopy. 48 of the 102 people failing dynamic retinoscopy also failed static retinoscopy; showing that although some relationship is

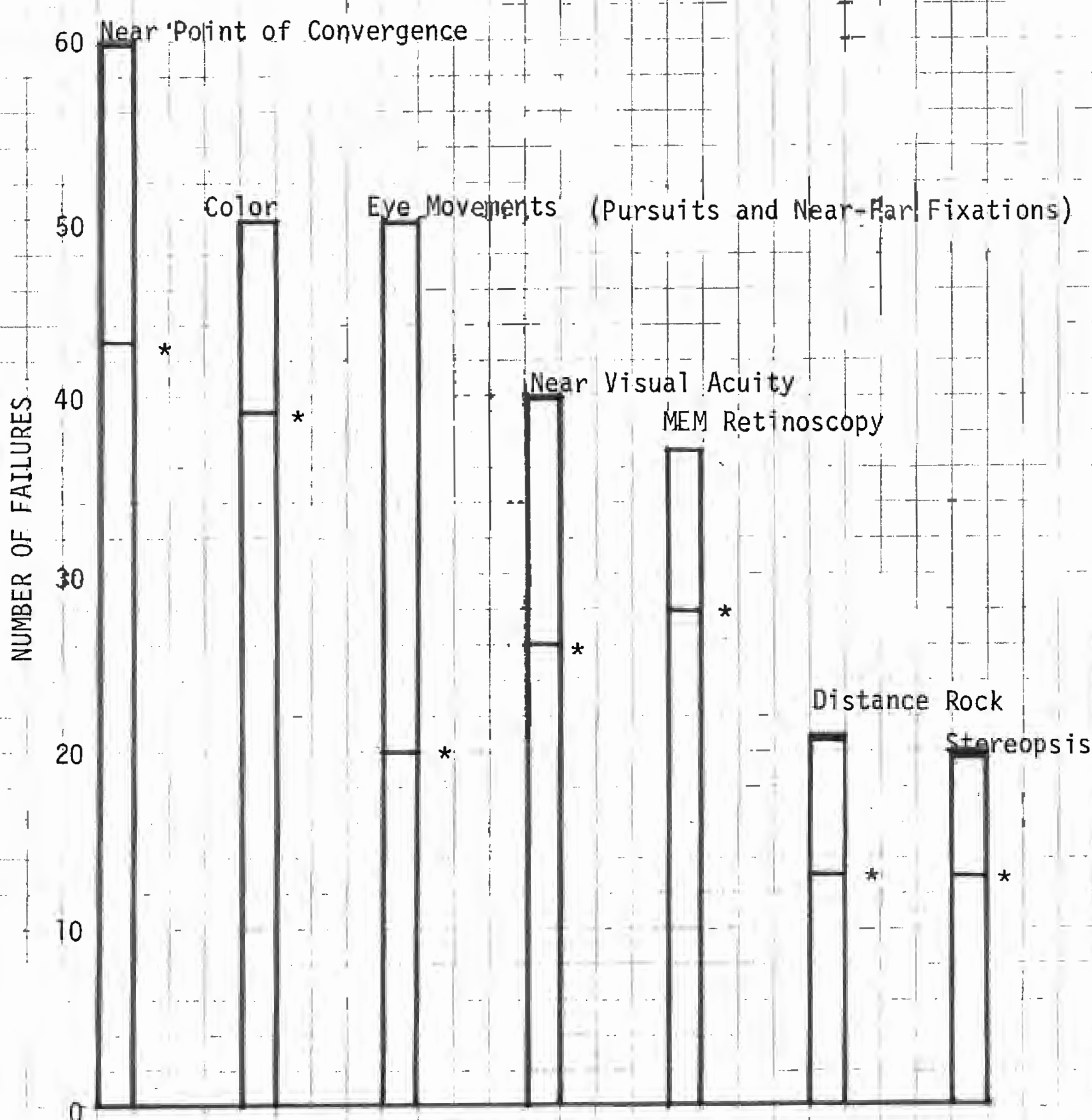
TABLE XIV
Number Failing Various Test Combinations
Arranged by Number of Tests Failed

1-Tests	2-Tests	3-Tests	4-Tests	5-Tests	6-Tests	7-Tests	8-Tests
A = 18	AB = 5	ABC = 1	ABCI = 1	ABCDL = 1	ABCHKL = 1	ABCGHIJ = 1	ABFGHIJKL = 1
B = 26	AG = 1	ABF = 1	ABCL = 1	ABCEL = 1	ABEGHL = 1	CGHIJKL = 1	
C = 13	AH = 2	ABL = 5	ABHJ = 1	ABCFL = 1	ABFGHK = 1		
D = 39	AI = 2	ACL = 1	ABIL = 1	ABCGH = 1	ABGHKL = 1		
E = 13	AL = 33	ACM = 1	ABKL = 5	ABCKL = 1	ACGHKL = 1		
F = 43	BC = 3	ADL = 1	AFJK = 1	ABDEK = 1	ACGHLM = 1.		
G = 14	BD = 1	AEL = 2	BCGH = 1	ABFGJ = 1			
H = 56	BE = 2	AFI = 1	BDHI = 1	ABJKL = 1			
I = 12	BF = 3	AFL = 2	BFGK = 1	ABKLM = 1			
J = 8	BH = 3	AFM = 1	BGHL = 1	ACDIL = 1			
K = 28	BI = 1	AGH = 1	CDKL = 1	ACFGH = 1			
L = 184	BK = 1	AGL = 1	CFGH = 2	BGHKL = 2			
M = 28	BL = 9	AHL = 3	CGHJ = 1	CFGHJ = 1			
	BM = 1	AJK = 1	CGHK = 2	CGHIJ = 1			
	CD = 2	AKL = 3	CGHL = 1	CGHKL = 2			
	CF = 1	BCL = 1	DFJL = 1	DGHLM = 1			
	CG = 1	BDL = 1	FHIJ = 1				
	CH = 1	BFK = 2	FIJL = 1				
	CL = 2	BFM = 1	GHIJ = 2				
	CM = 1	BGH = 2	GHKL = 3				
	DE = 3	BGK = 1					
	DF = 2	BIJ = 1					
	DG = 1	BIL = 1					
	DH = 2	BKL = 5					
	DK = 2	CDI = 1					
	DL = 3	CFL = 1					
	DM = 1	CGH = 6					
	EJ = 1	EGH = 1					
	EK = 1	EIJ = 1					
	EL = 3	FGH = 3					
	FG = 3	FIJ = 2					
	FH = 3	FIL = 1					
	FI = 2	FKM = 1					
	FJ = 3	FLM = 2					
	FK = 2	GHJ = 1					
	FL = 9	GHK = 2					
	FM = 2	GHL = 5					
	GH = 15	HIJ = 1					
	GK = 3	HKL = 1					
	GL = 3	IJK = 1					
	GM = 2	IJL = 3					
	HJ = 3	IJM = 1					
	HL = 8						
	HM = 4						
	IJ = 6						
	IL = 1						
	JL = 1						
	KL = 18						
	KM = 2						
	LM = 9						

Figure 50.

Failures on Tests Not Included in Modified Clinical Technique

These make up 28.1% of the total 805 students who failed one or more tests



* Denotes number failing this test only

present, 54 new people are detected if MEM is included in the screening tests in addition to static retinoscopy. Given additional evaluation of targets and referral criteria, even more significant relationships may become apparent. Screening in both principal meridians could enhance the effectiveness of this test.

The preceeding represents only a few of the many possible combinations of tests and evaluations that can be extracted from Table XIV. The present study has highlighted only the more obvious questions or interrelationships; thus much more could be obtained from the data.

When compared to the Orinda Study's overall failure rate of 15.5--21%, our study showed a higher rate of failure (29.7%) using the same tests and referral criteria. Possible reasons for this difference are dissimilar socioeconomic status between the areas and general population changes during the 20 years between the studies indicating an increase in the incidence of visual problems.

The screening tests added by the ABBO study increased the failure rate to 41.3%, an increase of 11.6% over the MCT battery. An analysis was performed to determine how many and in what areas our added tests identified failures. This analysis indicated that 28.1% of all the failures were the result of the added screening tests. Figure 50 on the following page shows the incidence of failures for the various tests added to the battery. Various relationships can be conceived through evaluation of this and the previous figures in this section.

CONCLUSIONS AND SUMMARY OF RESULTS

1. The characteristics of our sample as exhibited in the results section indicate that our sample is quite similar to others detailed in the literature--an essentially comparable sample.
2. The inadequacy of using only the distance Snellen chart as a screening device was demonstrated by its 19.9% proportion of those failing the MCT battery in our program and by its 14.3% proportion of those detected by the entire battery of this study.
3. The distance rock (near-far-near response time) function shows an almost linearly increasing relationship with age, thus pointing to the need to establish failure criteria for each grade.
4. Screening tests that measure the accommodative system appear to change in their results during the elementary school years while those measuring the convergence system appear to remain stabile during the same period.
5. Using the Orinda failure criteria and the MCT routine , the failure rate in our study was 29.7%. This compares with the 15.5--21% failure rate reported in the Orinda Study (1954-56). This could indicate that there has been an increase in the number of children with visual anomalies or some other population characteristic is different between the two groups.
6. The special education group, although small in number, appears to have visual characteristics that are quite different from the rest of the sample.
7. Near point of convergence, near cover test, near visual acuity, dynamic retinoscopy--MEM, and far cover test all show significantly different findings between the high and low achievement groups as measured by the Metropolitan Achievement test standarized scores for the reading subtest. Near visual acuity, near point of convergence, and dynamic retinoscopy--MEM, show significant differences for

achievement groups as measured by the math scores. Thus all but one of the tests that show significant differences with achievement are measured at the near point; this strongly points out the need for complete evalution of near point visual skills in school vision screenings and clinical examinations of children.

8. About 60% of those failing one or more tests only failed one test; thus indicating that the tests are measuring unique and discrete functions.
9. More than twice as many students failed static retinoscopy as failed any other test. The number that failed only static retinoscopy is greater than the total number that failed any other test; a strong indicator for inclusion of static retinoscopy in a screening battery.
10. If visual acuity is going to be measured at only one distance, then the near point distance is the preferred one.
11. If accommodative/convergence response time was screened in a distance rock procedure using 20/30 letters at far and near, the failure rate would significantly increase over that found in our study simply because those failing near or far visual acuity would be added to the failure rate of those lacking the accommodative, convergence, and fixation skills necessary to perform the test. These factors, plus the relationship to classroom activities (chalkboard copying), strongly suggest inclusion of this routine in a screening program.
12. The low incidence of serious internal ocular health problems raises the question as to whether it is worth the professional time and expense required for inclusion in a screening program. General health levels in the local area would need to be considered.
13. Since very few people failed the far cover test alone and since most of those failing the far cover test also failed the near cover test and since the reverse is not the case, the relative importance in a screening program of the near cover test is apparent.

14. Of those tests added over and above the MCT, the near point of convergence (NPC) was the most significant. A very low percentage of those failing NPC also failed the near cover test and the NPC finding shows a significant difference between the high and low achievement groups.

15. Visual screening programs as a part of a college of optometry's clinical and didactic programs can provide a significant educational experience for the student doctors and a prime community relations tool for the college.

16. The broad based screening program for Save Your Vision Week described in this study received wide acceptance by school district personnel, teachers and eye care practitioners in the community.

17. The incidence of failure and the relationships with achievement point out the strong need for a comprehensive ongoing vision screening program. According to Coleman, the cost of a year of standard education is about $1000 per student while that for special education is about twice that amount. The value of school screenings is evident if only one student in 500 is kept in a standard educational setting through correct referral, thus paying for any costs of the screening program.

RECOMMENDATIONS

Recommendations for a Vision Screening Test Battery

After reviewing the data from this study, the following test sequence would seem to be optimum in that it would pick out the largest number of low achievers and/or visual problems, for the least cost. The tests included are distance rock, near visual acuity, far retinoscopy, near point of convergence, far cover test, and near cover test. Color vision tests should be done on all first grade students and new students.

Dynamic retinoscopy - MEM showed a significant relationship to low academic achievement, but it did not pick up enough failures over other tests to merit inclusion in the test battery. MEM retinoscopy as a screening device has not been studied extensively. Future investigations are needed to see if, among other things, different targets and criteria are needed in a screening situation. It should be tested to see if anisometropia and cylindrical problems can be detected as easily as in static retinoscopy.

Distance rock was included in the test battery because it did separate the high and low achievers. When used with 20/30 letters at far and near, it would automatically fail any child with 20/40 visual acuity or poorer, with both eyes, at either far or near, in addition to students who fail due to poor accommodative and/or vergence skills. Our sample did not indicate failure on distance rock due to poor visual acuity, because if poor visual acuity was noted, the distance rock test was not done in the screening program.

Near visual acuity right eye, left eye, and both eyes was included as part of the test battery because it demonstrated a highly significant separation of the high and low achiever groups. Near visual acuity is also important because it is a source of detection of amblyopes that would be missed if the distance rock test was done without a monocular acuity check.

Near point of convergence is recommended to be included in the test battery because it shows a highly significant separation of high and low achievers, and because it adds more failures over the modified clinical technique than any other single test.

Far and near cover test are included to detect tropias and high heterophorias, a usual objective of most screenings. It should be noted that the magnitude of heterophoria as measured by the cover test, was significantly related to achievement when the upper and lower 1/3 of the sample are compared.

The last test in the battery is static retinoscopy at far. This test did not show a significant relationship to achievement. It was included as a means of detecting errors of refraction such as hyperopia, myopia, astigmatism, and anisometropia that would not be found any other way in the recommended battery.

Ocular health was not included in the test battery because in this screening and in others only 1.5% of the population failed and in our sample of those failures about 90% were due to blepharitis. Thus the time spent on internal ocular health did not contribute enough to the number of failures to warrant its inclusion. The decision to include ocular health in a screening would depend greatly on the general health of the population being screened and in some areas it definitely should be included.

In planning a screening using the previously mentioned tests, several factors would speed up the sequence as well as reduce the cost of the screening.

A device which includes a chin rest, a built in occluder, a brace to hold the near point card at a standard 16 inch distance, and provides a constant standard illumination, would facilitate and standardize near point visual acuity testing. The device should also include a rotating card holder, that has cards with the same letters, but arranged in a different order, to allow the examiner to randomize the letter presentation, yet still not produce variability due to the difference in visability of various letters.

The test sequence should begin with distance rock. By starting in this manner, the child's visual acuity at far and near would be determined to be better or equal to 20/40 at the outset. This would speed up testing of near visual acuity and retinoscopy. Near visual acuity would be done next with the device already mentioned, and in the standard manner. Near point of convergence would preceed cover test, and by using a bead with a 20/30 letter on it as a target, there would not need to be any delay between near point of convergence and near cover test. Far cover test follows near cover test, and retinoscopy at far is the last test in the sequence. Retinoscopy should be done with a cartoon or some similar method to keep the child's attention on the far point task.

When a child fails one test he is done with the screening and goes back to his classroom. This will speed up the screening process, as well as minimize the costs.

In the screening program outlined here, the first two tests (distance rock and near visual acuity) could be done by paraprofessionals. The last three tests (near point of convergence, cover test, and retinoscopy) should be done by professionals. An adequate screening program would include two paraprofessionals and two professionals to staff an appropriate number of stations.

RECOMMENDATIONS FOR FURTHER ANALYSIS OF THE DATA FROM THE ABBO STUDY

The mass of data accumulated in the ABBO Study has not been segmented and analyzed to yield all of the available information or interrelationships. What follows below are some avenues of possible further research using the available data.

Although we determined a mean refractive error over the habitual Rx for the high and low achievement groups, no attempt was made to break these groups into type and magnitude of habitual refractive error. To determine if incidence of astigmatism or hyperopia was significantly different for the high and low groups would be a worthwhile project. There is much controversy in the literature in this area and a study like the above might help answer some of the questions.

The investigators did a detailed analysis of the total sample to develop significant inferences between the visual skills screened and achievement based on standardized test scores. Since the data for grades 3-6 and both sexes is availabe, detailed analysis of the interrelationships within these samples could be done and such analysis might expose certain tests as being most useful when screening certain grades, etc.

Incidence of pass, borderline and fail for each of the tests was presented previously in the form of pie-charts. This data was inspected for any apparent relationships but a detailed statistical analysis was not performed. Some form of multiple correlation or multiple factor analysis on this data might yield some significant relationships.

The number and combination of screening tests failed were presented previously. All of the possible combinations of tests and how efficient they would be in a screening program have not been examined. Additional information about what is added by various tests could be derived from an analysis of the test combinations.

The above represents a few of the many ways that the data accumulated in this project could be analyzed. Detailed reading of the literature and careful review of this study should allow the interested inquirer to propose and perhaps answer many additional questions in the area of vision screening programs.

RECOMMENDATIONS TO THE COLLEGE OF OPTOMETRY

The 1974 Save Your Vision Week screening program of District 15 elementary school children was considered to be quite successful by all those involved. The following recommendations are an outgrowth of the experiences of that SYVW program and the preparation of this report and they may serve as an impetus for re-evaluation and improvement of the College's vision screening program.

The College's present vision screening program has expanded over the past several years and should be commended. However, much valuable data is wasted by only using the computer to prepare referral lists and letters. Fortunately, much of the previous year's results are still available in a computer readable form and could be analyzed in the future; such an analysis of that data is the first recommendation proposed.

The Modified Clinical Technique is currently the standard battery used in PUCO screenings. Although the efficiency of the MCT has been demonstrated in this study and others, does it represent the ultimate screening tool? Such questions need to be asked and with the pool of student clinicians and computer facilites available to it, the College is well equipped to answer some of these types of questions. Using tests not previously evaluated in a screening setting could pose several problems in the area of referral and the criteria used. There are many possible ways to answer these problems.

One possible avenue would be to just use these tests in a screening program as a data gathering method to help establish valid referral criteria, or the referral criteria could be set so high that those referred would show obvious clinical abnormalcy. Analysis of the data gathered could provide a significant basis for stating valid referral criteria. The systematic addition of screening tests with follow-up analysis could greatly enhance the current state of knowledge on vision screening.

A potential teaching tool could be the establishment of a seminar on vision screening in the third professional year program. This seminar could deal with the questions of what is the purpose of screening and what consitutes a valid screening battery. A term project might be to design and perhaps implement a screening program in one of the area schools. Concentration of learning in the aspects of vision screening when coupled with practical experience in the field would be a worthwhile learning program and may lead to discovery of some answers to many questions about vision screening.

The next aspect to consider is that of the usefulness of vision screening programs as an instructional aide. The Save Your Vision Week screening program used first through third year students in various phases of the activity. The exposure to working with many people and the practice at refining clinical skills was quite valuable to the student examiners. Some sample comments offered by the students are of interest: "After doing 80 kids on the cover test, I really became good at estimating movement", or "MEM Retinoscopy really isn't that hard after all, I didn't even need a lens bar after the first 20 kids". These comments are presented to illustrate the value that participation in screening projects can have for the student doctor.

Fourth year students at the Pennsylvania College of Optometry are currently being used as vision consultants in various schools throughout Philadelphia. This program has been very successful and acquaints the student with the responsibilities of a school vision consultant. One of the main areas of involvement for these students is that of providing vision screenings for the school. Implementation of a similar program in this area would be a worthwhile culmination of the students training and experience in vision screening.

The SYVW screening program was well received as a community service project. One of the primary questions asked by teachers at various meetings after the screening program was "when will it be done again?". Only an uncertain answer could be given at the time but the writers enthusiastically encourage the establishment of a regular vision screening program in this area. Community relations, research, and educational benefits will surely result from the establishment of an on going program.

RECOMMENDATIONS FOR FUTURE RESEARCH

There are so many unanswered questions on vision screening that any attempt to make a list of needed future research would be an endless task. However, we include the following list of possible research projects as a stimulant to future researchers.

1. There is a definite need for comprehensive studies into the relationships of vision skills and perception as they relate to achievement.
2. Complete clinical examinations of high and low achievers are needed to check against screening results and to determine if any inferences can be derived from the clinical findings.
3. In an effort to reduce over referrals and to refine the screening referral criteria, there is a need to establish what criteria the eye care professionals use before instituting treatment of various visual anomalies.
4. There is a need to evaluate the effectiveness of various new or different tests (4Δ suppression test, Worth 4-dot, Groffman visual tracing to name a few) as vision screening tools.
5. Norms for various tests like the distance rock test need to be determined along with their usefulness as screening devices.
6. The entire area of dynamic retinoscopy, Monocular Estimate Method and others, needs to be evaluated for targets, procedures, and referral criteria to be used in vision screening programs.
7. Research into and development of a useful eye movement monitoring device for vision screening programs would be a worthwhile project.
8. The validity and reliability of the vision screening test battery recommended in this study needs to be evaluated.
9. The amount of over and under referrals encountered through various testing batteries is always useful information to acquire.

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APPENDIX

VISION SCREENING PARENT REPORT FORM

Child's Name ______________________________ Age __________

Parent's Name ______________________________________

School ______________________________ Grade __________

Tests Performed With Glasses ______________ Without Glasses __________

Dear Parent:

On ______________ (date) your child participated in a vision screening program conducted by students of Pacific University College of Optometry. The screening tests were designed to evaluate your child's ability to see clearly the health of your child's eyes, and the ability of your child to control and use the eyes for tasks which must be performed in the classroom. The vision screening was NOT a complete vision exam, and should NOT replace the regular visits to your eye care practitioner.

Results of your child's screening tests:

_____ 1. Performance in all areas tested was satisfactory.

_____ 2. Overall performance was satisfactory, but several areas showed borderline results. Your child should be observed for any signs of visual difficulty, at which time a visit to your eye care practitioner is recommended.

_____ 3. Performance in areas tested was unsatisfactory. Observations indicated possible visual difficulty in the area(s) checked below:

_____ Visual Acuity _____ Refractive Status

_____ Eye Coordination _____ Focusing Ability

We emphasize that unsatisfactory performance in the areas checked above does not necessarily mean your child needs glasses. It does mean that your child should have a complete examination by an eye care practitioner. Please give this matter your immediate attention. Visual problems can only be corrected, or arrested, if given proper care and therapy.

_____ 4. Observation of eye health indicated child should be seen by your family physician.

NOTE: Please take this information with you when you visit your eye care practitioner (or family physician), and request that a report of the examination be sent to the school. In this way, your school can help you in effectively guiding your child's educational program.

Pacific University College of Optometry
Forest Grove, Oregon

FOR BETTER UNDERSTANDING

VISUAL ACUITY: The measurement of sharpness of sight, of clarity of vision. Restrictions in sight may hinder your child's achievement.

REFRACTIVE STATUS: The measurement of farsightedness, nearsightedness, and/or astigmatism as part of a vision examination or screening. This may be influenced by overall growth patterns, your child's adaptation to environmental stress, and hereditary factors.

EYE COORDINATION: The ability of the two eyes to work together as a team. This skill allows easy shifting of the eyes along the lines of print in a book and a rapid and accurate return to the next line, easy visual inspection of three dimensional materials, and visual efficiency in sports activities.

FOCUSING ABILITY: This skill allows for rapid and accurate changes of focus from near to far and far to near with immediate clarity at each distance involved; for example, from desk to chalkboard to teacher. It also relates to your child's ability to do sustained near work comfortably.

EYE HEALTH: External and internal observation of the eyes to detect evidence of possible ocular (eye) or systemic (body) diseases.

EYE EXAMINERS REPORT TO THE SCHOOL

Child's Name ______________________ Birth Date ______________

Parents's Name ______________________

Address ______________________ Phone Number ______________

City ______________________ State ______________

1. Does this child have an eye health problem? Yes No
2. Does this child have a sight (acuity) problem? Yes No
3. Does this child have a vision problem? Yes No
   a. Would this interfere with following along a line of print? Yes No
   b. Would this interfere with efficient use of the two eyes as a team? Yes No
   c. Would this interfere with concentration or achievement on near vision tasks such as reading? Yes No
   d. Would this interfere with the ability to shift attention adequately from book to chalkboard and back? Yes No
   e. Would this interfere with "depth" judgement? Yes No
   f. What other areas of school performance might this affect? ______________

      ____

      ____

   g. Additional remarks ______________________________

      ____

4. If a problem exists what therapy is recommended?

   a. Glasses __________ Unbreakable __________ To be worn __________
   b. Vision training ______________________
   c. Other ______________________

5. Uncorrected visual acuity: R _____ L _____ B _____. (If glasses are to be used for distance seeing what is corrected acuity? R _____ L _____ B _____

6. When should child return for re-examination ______________

7. Are there any further instructions or recommendations (including any need for special class, special seating, larger type books, limitation of activities, etc.)

Date of Examination __________ Signed ______________________

Address ______________________

Telephone ______________________

Pacific University Optometric Screening

Name ______________________ Date ______________ Teacher ______________

Visual Acuity: (with/without Rx)

far: R: near: R: 1 2 3
L: L:
OU: OU:

Stereopsis: Fly_____ Row_____ Box_____ 1 2 3

Color: ______________________ 1 2 3

Distance Rock: ______________________ 1 2 3

Near Point of Convergence: ________/________ 1 2 3

Cover: Far__________ Near__________ 1 2 3

Pursuits: Significantly Poorer R. L.
3-Smooth, relatively effortless tracking movement
2-Intermittent fixation losses, effort more evident
1-Erratic tracking movement, frequent fixation losses 1 2 3

Near-far fixations:
3-smooth, equal speed of shift, relatively effortless
2-Unequal speed, greater effort
1-Unequal speed, movement erratic, great effort,
loss of binocular focus 1 2 3

Retinoscopy: (with/without Rx)
MEM: R______________________
L______________________ 1 2 3

Static: R______________________
L______________________ 1 2 3

Ocular Health:
pupil reflexes: Dir_____ Con_____ Conver_____ Speed_____ 1 2 3
External: ______________________ 1 2 3
Internal: ______________________ 1 2 3
3-good 2-questionable 1-pathology

Recommendations: