A study of vision of young children (particularly 3-to-4-years-old) was conducted in day care centers sponsored by the Office of Economic Opportunity. Investigation of vision test methods showed the British Stycar Test to be best for preschoolers. Vision of three-year-olds can be screened, and their acuity is higher than generally assumed.

VISION SCREENING OF YOUNG CHILDREN

Otto Lippmann, M.D., F.A.P.H.A.

Development of Vision

GESELL, et al.,[1] described the total and visual developments of the child. Sensory impressions gradually develop from a level of discrimination through a perceptual level (gradually sharpening) to a final conceptual level (Werner).[2] Although the eye is anatomically nearly complete at birth, vision develops only gradually (Zubek and Solberg).[3]

Experimental rearing of animals in complete darkness arrests visual development. One wonders whether more subtle differences in a child's environment influence vision and learning? Does cultural deprivation impair visual development as does experimental light deprivation? Oberman[4] cites that "blindness and visual impairment accounted for 12.4 per cent of chronic conditions in the under $2,000-a-year-income group and only 6.4 per cent in those with $7,000 or more." In Michigan, more than twice as many vision defects were found in preschool children from low socioeconomic areas[5] than in children from affluent families. North[6] showed that children in slum areas have a lower educational potential measured by intelligence tests (commonly including many visual tasks). Savitz et al.[7,8] found children of low economic income families to be about 6 months behind according to Gesell's norms of certain activities.

Statistics listing a high incidence of visual defects in the lower socioeconomic population don't tell the whole story. Some defects are correctible, preventable, or curable. Michigan statistics[5] show poor follow-up care among the low socioeconomic population. Follow-up reports were obtained in 50 per cent of the "poor" children, but in 80 per cent of the children from higher socioeconomic levels. Obviously, children with remediable or preventable eye defects get better medical care and finally better results in educated and financially "comfortable" families than in poor families. Mere higher incidence of visual defects among the poor, therefore, does not prove that cultural deprivation leads to real visual impairment.

Vision Test Methods

This paper will discuss central, distance, form vision. The visual acuity of the better eye is usually almost the same as that of the two eyes used to-

gether (Parks).[9] "Binocular visual acuity testing as a screening procedure is not necessary" (Lippmann).[10] Best corrected distance vision acuity and near vision acuity nearly always run closely parallel. A screening program of children need not test near vision acuity. (Parks[9] and Snell).[11]

Vision tests on children "must be within the comprehension" as to age or development. In very young babies, we usually test only light sense, e.g., pupil reflex, and obtain only a qualitative (vision or no vision) answer. Quantitative tests depend on observation of behavioral and movement responses to to visual stimuli[12] (Schwarting's metronome test)[13] or testing of optokinetic nystagmus responses by Gorman et al.[14] When the child is mature enough to tell responses, adult-type quantitative testing begins based on the Snellen principle of presenting graded symbols (optotypes).[15]

A set of test symbols for younger children is the Stycar test, published in Great Britain.[16] S-T-Y-C-A-R is an acronym standing for *S*creening *T*est for *Y*oung *C*hildren *A*nd *R*etardates. The test symbols are based on knowledge which has been universally used in psychologic research. An average child copies a vertical line at age 2 years, a horizontal line at age 2½ years, a circle at age 3 years, a cross at age 4, square and triangle at age 5. Modern child development standards[17] agree with those measures. Pugmire and Sheridan[18] devised a block letter chart containing certain letters which would be recognized easily by children from the age of 2 and above. Children do not read the letter on the chart as a certain letter of the alphabet, but either copy it or match the shape of the letter on the chart with one within their reach. More complicated selections of letters were later replaced by simpler ones; the chart for 2-year-old children contains 4 letters, T H O V.[19] Modifications of the Stycar test have been devised by Ffooks,[20] by Holt,[21] and others.

Other test charts use pictures as Snellen optotypes. These picture charts have the disadvantage of introducing other factors besides visual acuity measurement (familiarity of the child with the particular object; good verbalization).

Snellen's letter symbols were successfully modified for children by using one symbol, the letter "E" presented in different positions. Children at age 6 and below are able to perform this test before they acquire knowledge of the alphabet (National Society for Prevention of Blindness).[22] The "Illiterate E" has become the most commonly used test for children's vision in the United States. Various modifications using the principle of testing with directional symbols have been described. Examples are: The Michigan Preschool Test (also used in Titmus Optical Company's Vision Tester (Petersburg, Va.), and in the Junior Vision Screener by Good-Lite Company of Forest Park, Ill.), and Sjogren's hand chart.[23]

Some studies cover testing personnel and test environment. Vision testing of shy and timid children is often less successful in the privacy of an office of an ophthalmologist or research worker than in mass-testing. Thus, Taubenhaus[24,25,26] found disagreement of two testers in 4 to 10 per cent of all tests. "Young college-educated housewives and mothers whose youngest child had recently entered school or nursery school" were found to be the best vision screeners. In contrast, ophthalmologists in Taubenhaus' study disagreed twice as much (in about 20%) in their screening results. Many attempts have been made to conduct the tests in an environment causing less apprehension in those timid children.

Nurses (Nordlöw and Joachimson),[27] or specially trained testing technicians (Davens,[28] Barrett,[29] Hatfield et al.)[30]

performed the screening. Savitz[7,8] tested children in their own home. Parents test their own children in several projects (National Committee,[31] Austin et al.,[32] Press et al.,[33] Weisenheimer).[34]

Trotter compared vision test results done by parents with screening by an ophthalmologist and found good agreement.[35] About 70 pediatricians have accumulated a large statistic of vision testing for the Maryland Society for Prevention of Blindness (according to a written communication, January 18, 1966).

Reasons for New Investigation

We can learn how good a screening method is from the answers to these questions: 1. What is the best visual acuity found with the method? 2. How many children are untestable by it? 3. How long does it take to prepare and test one child? 4. How many cases of apparent visual impairment does the method find? 5. How many are referred for examination who didn't need it (overreferral) and how many are not referred who had needed it (underreferral)?

There is little agreement in the literature on any of these questions. We know much about the vision of older children, but very little of that of younger children. Workers even disagree about what is normal visual acuity in children aged 3 to 8. Different studies are hard to compare, because of different test methods or test standards. There are contradictory opinions on advantages and disadvantages of various test symbols. Other factors affecting vision testing in young children, e.g., the test distance, or ways to expose the test symbols, have only barely been mentioned in the literature. This lack of knowledge led to this study which attempted to find best methods to test vision in children 3- to 5-years-old.

I studied children enrolled in Day Care Centers under the administration of the Office of Economic Opportunity for several reasons: 1. They were readily available. 2. They were younger than in other preschool groups. 3. Vision of children in Day Care Centers, while being tested in some communities, has never been statistically reported (Dittman).[36] 4. Other factors affecting vision, such as cultural deprivation, could be studied in this group.

This paper deals mainly with the public health aspects of vision of young children. Details of the ophthalmological problems of their vision testing are reported in a separate paper (Lippmann).[37]

Phase I

The first phase of this project took place in June and July 1966. Three hundred and thirty-eight children were tested in 879 comparative tests in 9 Day Care Centers.

Results of Eye Screening

Among these 338 children, 280 were testable and 58 (17.1%) were not testable. Pass/fail criteria were: for 5- and 6-year-old children: visual acuity of 20/30 or better, passing; 20/40 or less, failing; 4-year-olds, 20/40 or better, passing; 20/50 or less, failing; 3-year-olds, 20/50 or better, passing; 20/60 or less, failing. Children with obvious detectable eye trouble were also referred. Among 280 testable children, 29 (16.79%) were referred for visual acuity or medical reasons. (This included some doubtfully testable children who had low acuity scores.) The incidence of untestability and failure in the screening was high in Phase I, because the test situation was more complicated.

On those 29 failing we got 27 (89%) follow-up reports by August 1967.

They showed:

14 correct referrals
10 false referrals

3 children moved away and could not be followed.

Research Goals

Phase I was a pilot study to determine the influence of these factors on the efficiency of the screening: 1. The kind of test symbol. 2. The test distance. 3. Exposure of a single test symbol vs. exposure of whole test line or whole test chart 4. The spacing of the test symbols.

Comparative studies were undertaken. Borg and Sundmark[38] have stressed that children progressively improve with retesting. Since repetition of testing in this age group influences the result of the test considerably, the total number of children was divided into small groups. Only one small group then took one particular test as first test.

Pilot Test Group No. I

Comparison of Various Test Symbols

According to Rubin[39] "there seem to be disadvantages in almost all vision tests for this group."

The following symbols were used in this series completed by 43 children:

American Optical Company Picture Chart (wall)
Good-Lite Illiterate E Chart
Allen Pictures (flash card)
Stycar Symbols (wall chart)
Stycar toys

All test symbols were observed at 20 feet distance.

The following tests were eliminated from further study: The use of Stycar toys disrupted the screening procedure too much; the Allen picture cards were easy to use, but would not allow testing of acuity to better than 20/30; the American Optical Picture Chart was too complicated. The Illiterate E chart and Stycar wall chart ranked equally in their ratio of untestability. The incidence of good visual acuity was approximately equal with both tests. However, the Illiterate E chart proved less reliable with younger children.

The Stycar test takes a little longer than the Illiterate E test because the children can point faster than match symbols, but the children appeared to enjoy the matching game more than the pointing E. To train children for the Stycar test is quick and easy. It appears well-suited to the developmental stage of the younger child: a class of eleven children learned to take the Stycar test in 5 minutes.

Pilot Test Group No. II

Influence of Test Distance

Testing distances smaller than 20 feet have ophthalmological disadvantages (Lippmann).[10] However, the literature contains a number of reports stating the advantages of using test distances of 15, 12, and 10 feet (Gesell,[1] Sheridan,[16] Savitz et al.,[7,8] Maryland Society for Prevention of Blindness [according to written communication, January 18, 1966], Press and Austin,[33] manufacturer's report by P. Good [oral communication, October 1967]).

We, therefore, compared the Good-Lite Illiterate E test at 20 feet and the Good-Lite Illiterate E at 10 feet, and because of "psychological nearness," the Titmus Vision Tester. We found the vision-testing machine more difficult and less useful than charts. The Illiterate E tests at 20 and at 10 feet test distance ranked almost equally as to the ratio of untestability with either test in all ages. The Illiterate E test at 10 feet showed slightly better visual acuity than the test at 20 feet.

Pilot Test Group III

Exposure of a Single Symbol on the Test Chart Versus Exposure of a Whole Line

Berens[40] in 1938 has stated "that a single letter for each distance is less con-

fusing when testing children." However, some investigators (Parks)[9] have suggested that a whole line of symbols should always be offered in visual testing.

How important is single symbol vs. line exposure in visual acuity testing of preschool children? Does normal child development influence this factor?

For comparison of single symbol vs. whole line exposure, the Good-Lite Illiterate E chart with suitable window cards was used at 20 feet. Forty-six children completed both tests.

There was slightly better testability when only one single test symbol was exposed. Even those children who could master the test had slightly more difficulty when a whole line was exposed.

There was slightly better visual acuity when a single symbol was exposed. The difference in visual acuity was usually one line on the test chart, only very rarely two lines.

Pilot Test Group No. IV

Comparison of Test Result Related to Various Spacing of the Test Symbols

Space between test symbols and between test lines greatly varies in different vision test equipment. We investigated the influence of crowding of test symbols and lines with specially prepared slides in the Titmus Vision Tester and specially prepared Stycar wall charts, in which intersymbol distance was decreased. Testability appeared to depend more on the whole line exposure (vs. single symbol exposure) than on intersymbol space. Testability rose with age. Visual acuity ratings differed with intersymbol spacing, but never more than one test line on the chart.

Phase II

In Phase I, each child took several tests. In Phase II, larger groups of children took only one test to study the factors found important in Phase I.

Phase II extended through April and May 1967, and involved 347 new children. Seventy-seven children took the Michigan Preschool test in the Titmus Vision Tester. Seventy-six children took the Illiterate E Test at 20 feet test distance. One hundred and six children took the Illiterate E test at 10 feet test distance. Eighty-eight children took the Stycar test.

Results of Eye Screening

Phase II yielded the following results: Five children from last year's roster were accidentally retested with the same pass-fail scores in both years. This result was considered a good spot check of the reliability of the program. The same referral criteria were used in Phase II as in Phase I. Among 347 children 31 (or 8.93%) were untestable. Three (or 0.86%) children failed visual acuity test. Three hundred-thirteen or (90.20%) children passed. Five children (1.44%) were referred for medical examinations: 2 children were referred because of their visual acuity score, only, 2 children because of observation of abnormalities only, and 1 child because of a combination of failing visual acuity standards and of observed abnormalities. Follow-up of these 5 children showed that one didn't have an eye examination; the others were correct referrals.

During the same period we had in Austin another study conducted by volunteers in private and church nurseries and kindergartens, under the auspices of the Texas Society for Prevention of Blindness.

The results of this latter study are: Total number of children tested: 1,080. Among these: 32 (2.96%) were untestable. Failing visual acuity: 13 (1.2%).

The two studies are not altogether comparable. One was mainly done for investigation, while the other aimed at case-findings. Also, we must consider

differences of the testing personnel. However, both projects used the same criteria for referral and were supervised by the same author.

We find one remarkable difference. The rate of untestability in Day Care Centers is much higher than in private nurseries (8.93% vs. 2.96%). Part of the reasons for the difference are the younger average age of the children in the Day Care Centers (49 months vs. 60⅓ months in the private nurseries). Developmental differences of the children in these 2 groups caused by environmental factors (poorer economic status of the parents) also explain some of the difference in the results.

As far as poor vision is concerned, the rate of failing was reversed: less (0.86%) in the Day Care Centers, and more (1.2%) in the private nurseries. The smaller ratio of failures in the Day Care Centers may be due to more thorough testing methods in these centers.

Evaluation of Four Different Test Methods Used in Phase II

A. *Testing Time*

1. Michigan Preschool Test in the Titmus Vision Tester. This test proved less useful than the other tests used in this group for several reasons: preparation time, attention of children, positioning of child, and verbalization. An advantage of this test is the small space requirement of the equipment.

2. Illiterate E Test Administered with 20 Feet Test Distance. Training time of the children was shorter than with the Michigan Preschool slides usually taking about 5 minutes per group. However, the consistency of responses of 3- and 4-year-old children was worse than that of 5- and 6-year-old children.

3. Illiterate E at 10 Feet Test Distance. Application of this test appeared somewhat easier since there was greater rapport with the children and less distraction over the short test distance.

4. Stycar Symbols at 20 Feet Test Distance. This test was the easiest in training, administering, and taking the test. The children frequently learned to take this test so fast that it appears superior to any other test. Many children, who were unable to learn other tests in 2 previous attempts, learned to take the Stycar test in about 5 minutes, without ever having been exposed to it, and completed this test successfully.

Table 1 shows a summary of the testing time as obtained in these 4 tests.

B. *Untestability*

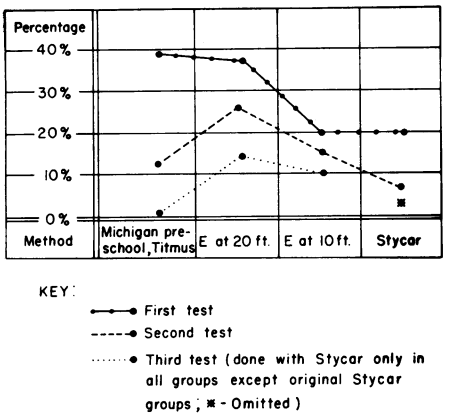
Untestability means inability to learn the test and to give reliable responses. This term comprises both "inability to train" and "inability to screen" as used by statistics of the National Society of Prevention of Blindness.

The ratio of untestability decreases from 28.2 per cent of 347 children in the first test to 15.8 per cent after the second test of the same children (using the same method as in the first test). When found untestable twice with other tests, the children took the Stycar test, and

Table 1—Testing time

	3- and 4-years-old	5- and 6-years-old
Michigan preschool	4.5 minutes	2.5 minutes
Illiterate E at 20 ft.	4.3 minutes	2.0 minutes
Illiterate E at 10 ft.	1.9 minutes	1.5 minutes
Stycar at 20 ft.	2.0 minutes	1.4 minutes

Figure 1—Untestability with various test methods



the untestability rate finally fell to 9 per cent.

The four used methods ranked unequally the Stycar being the best. Figure 1 shows a comparison of untestability ratios as found by different methods in testing and retesting.

C. *Comparison of Visual Acuity Rating Obtained with the Four Methods Used in Phase II*

The children in the Michigan Preschool test group show the smallest number of high acuity scores and the largest number of low acuity scores.

The children in the Illiterate E at 20 Feet and the Illiterate E at 10 Feet took the mid-position; these 2 methods also showed similar distributions of each acuity rating.

The children of the Stycar group show the largest number of high acuity scores.

Figure 2 illustrates the distribution of the visual acuity scores with each test.

All test methods showed a steady increase of the visual acuity rating with advancing age. The most typical and most consistent increase of the visual acuity related to increase of age is shown in the Stycar statistic.

D. *Visual Acuity of Young Children*

All test methods were finally combined to compute the composite distribution of visual acuity scores in various ages. These visual acuity scores included all obtained scores, regardless of the kind of test and the number of tests employed to obtain such scores. Some children were untestable in their first test, others became testable in a second test, or finally could be tested with the Stycar test as third test. The 31 children remaining untestable after 3 tests are not included in this statistic.

The visual acuity scores were plotted for each one-half year of age. The plotting showed that children consistently gain visual acuity with each one-half year their age increases.

Simpler plotting of the visual acuity related to 12 months' increment of age increase is shown here by Figure 3.

The distribution of all visual acuity scores among the entire group of 315 children ranging from 2½ to 6½ years of age is shown in Table 2.

Figure 2—Distribution of visual acuity in all tested ages as found with four test methods

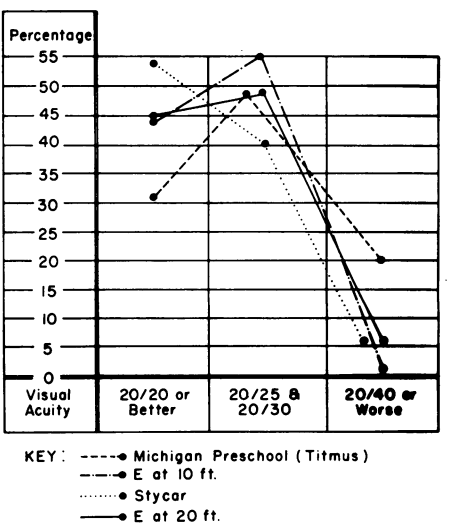
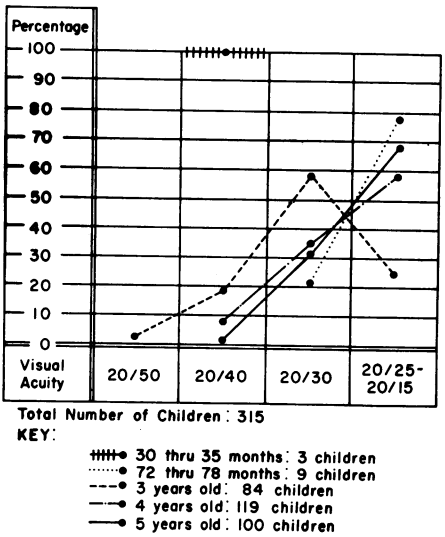


Figure 3—Increase of visual acuity related to one year's increment of age increase



Discussion

1. *Visual Acuity*

Best visual acuity scores were obtained with the Stycar wall chart administered at 20 feet distance. About 53 of all children showed a visual acuity of 20/20 or better with the Stycar method. The second best scores were obtained with the Illiterate E chart administered at 10 feet distance.

Perfect vision is more common the older a preschool population is. In our study only about 25 per cent of the 3-year-old children had an acuity of 20/25 or better while 78 per cent of the six-year-old children had an acuity of 20/25 or better.

Accurate comparison of visual acuity scores of different surveys must consider the age of the children (not only age in years, but better, the age in months).

The literature contains many opinions about the distribution of various acuity scores according to age and other factors of the population[41,42,43] and also on the school-age population.[10] Statistics on the preschool child are smaller. Examples are as follows: Keeney's tabulation[44] on the development of vision. Allen:[45] 3-years-old should have 15/30 and 4-years-old should have 20/30. Sheridan:[19] 5-years-old should have 20/20. Trotter[35] reported about 217 children: only 7.8 per cent had less than 20/30 vision in either eye. Trotter also found that 86 per cent of his 4-year-old children had an acuity of 20/30 or better in both eyes and 47.3 per cent had 20/20 in each eye. The Maryland Society for Prevention of Blindness (according to written communication, January 18, 1966) showed that among their three-year-old children 53.2 per cent had a visual acuity of 20/20. Visual acuity among all (7,349) preschool Maryland children was: about 66 per cent had 20/20; about 26 per cent had 20/30; about 8 per cent had 20/40 or less. Many pub-

Table 2—Visual acuity

Visual acuity	No. of children*	Percentage of children
20/15 or 20/20 or 20/25	164 children	52.06%
20/30	121 children	38.41%
20/40	29 children	9.20%
20/50 or less	1 child	0.31%

* The average age of these children was 4.08 years of age.

lished studies cannot be readily compared because they differ in research goal, test equipment or set-up, and criteria. Therefore, a recent survey (1966 Oberman)[4] stated: "A major gap in planning effective programs for the preschool child is our lack of knowledge of normal visual development." Most authors agree, however, that most recent programs, including our own, found better vision in younger children than one used to think; only about 10 per cent of children have an acuity of 20/40 or less.

2. *Untestability*

Previous studies and our own work have shown that the rate of untestability of children decreases with advancing age. Test methods influence the rate of untestability. The Stycar test has the lowest rate of untestability. Sheridan[16] reported that 3.2 per cent among 1,552 children were untestable.

Nordlöw et al.[27] reported 2.4 per cent among 3,473 four-year-old children. Trotter[35] mentioned 5.5 per cent untestable children. Savitz[7,8] reported a rate of untestability varying with the test used for their 94 children; variation of untestability ranged from 15 per cent to 75 per cent (Illiterate E tests showing 42% untestability). Our own study shows an untestability ratio after retesting of about 9 per cent.

Testability varies most among all previous findings. Testability is influenced by cultural deprivation and economic status of the family. The highest untestability rate was found by Savitz et al.,[7,8] in a low-cost housing project. In our study the rate of untestability was 3 times greater in the children coming from poorer homes. Simpler experimental studies with light deprivation of animals showed diverse effects, but all authors agree that light deprivation, at least, causes behavioral changes.[47]

The relation of cultural deprivation to earlier visual perceptual development and learning ability needs further study; controlled studies are very difficult because of the many variables (Am. Acad. Pediatrics).[48]

3. *Referral Standards for Medical Examination*

The uncertainty as to the normal visual acuity among preschool children is reflected by the wide variety of criteria for referral. While criteria for referral of children failing a screening test must necessarily vary according to available local resources, the majority of programs still use such low visual acuity standards as to be unrealistic (Lippmann).[10] Project Headstart recommends acuity of 20/40 as passing[49] for older preschool children.

According to the above results, one should strive to set higher visual acuity scores as pass-fail scores in the screening program. At least for children 4-years-old or older, one should expect and set as passing grade 20/30 or better (failing 20/40 or less).

4. *Referral Rate*

Ratios of children referred for definitive medical examination failing a screening test vary a great deal with the chosen criteria and the quality of the project. Examples of the literature are:

Moran:[50] 7.5 per cent

Oberman:[4] about 5–8 per cent

Kittredge:[51] 4 per cent

N.S.P.B.:[52] 4.4 per cent out of 98,197 children

N.S.P.B.:[53] 4.4 per cent out of 28,665 children

Michigan:[5] about 4–5 per cent

American Academy of Pediatrics (Press & Austin):[33] 7.5 per cent

Kaivomen in Finland:[54] 3.6 per cent

Nordlöw et al., Scandinavia:[27] 10.4 per cent

Weisenheimer,[34] San Francisco area: 5.8 to 10.2 per cent

Taubenhaus:[24,26] 14.7 per cent

Headstart:[6] about 5–10 per cent

Day Care Center findings have not yet been tabulated, although vision tests are usually given (Eisenstein,[71] Dittman).[36]

Some projects refer children whose visual acuity in one eye is 2 or more lines better than that of the other eye because of the implication of amblyopia. Such referral criteria are useful only in those programs who choose 20/40 or less as passing grade. High pass-fail criteria for each eye are sufficient for case-findings since they would detect poorer visual acuity of one eye anyway. Taubenhaus[24,25] found a rate of 11.5 per cent failing the screening because of 2 lines difference.

Our own referral rate in this study was 1.44 per cent. Several reasons explain this particularly low rate of referral: 1. Referral criteria were lenient (i.e., so as to allow more children to pass). 2. Testing was more elaborate. 3. Retesting was employed more than once in order to investigate the influence of retesting on the final score. 4. Untestable children were separated from children failing the test.

Overreferral of children who needed no eye care often discredits a program. Too many overreferrals mean a poor program. However, overreferrals are seldom reported. Kittredge et al.[51] mention 0.2 per cent overreferrals, Nordlöw et al.,[27] 14 per cent overreferrals. Hatfield[55] found about 16 per cent of all referred children proved to be normal. However, many children with a normal definitive medical examination may well be correct referrals. Some of these children needed the medical evaluation, even though they were finally found normal or didn't need eye care. Underreferrals are hardly ever reported. Trotter[35] reported that only 4 per cent failed a certain screening test; however, screening by an ophthalmologist found 8 per cent failing. He considered 4 per cent as cases of "false security" because the screening program did not detect them.

5. *Length of Time Required for Each Test*

How long a test takes is important. Easy-to-do tests take little time and are the most useful ones. Easy tests also help us budget the cost of a screening program. Taubenhaus[25] stated that the preschool screening of a single child should take 5 to 15 minutes. Savitz *et al.*,[7,8] spent 10 minutes for an explaining visit and up to 2 hours for each child performing multiple testing. The national statistic of all National Society for Prevention of Blindness sponsored programs reported 52,409 children who were tested in one year (1963–64) in 86 projects spending 18,500 volunteer hours; this amounts to a rate of 2.8 children in one hour per volunteer or 8.4 children in one hour per team of three volunteers.

We found testing time to depend on the equipment used. The Stycar test could be administered faster than any other test for 3- and 4-year-old children. Administration of the Illiterate E symbol at 10 feet distance follows as close second. The Illiterate E at 20 feet distance takes almost twice that long. To plan the program time needs, we must also consider pretest training time. The Stycar test ranks well there.

6. *Test Symbols*

This study proved the influence of the test symbol on vision testing. The British Stycar is the best vision test for this age.

The superiority of the Stycar test rests also on another fact. Consistency of responses of 3-year-old children tested with directional symbols was inferior in both phases of the study. The younger the child, the less concept of direction he has. Vertical direction sense develops before horizontal direction sense as the child grows older. Thus, frequently younger children reliably report vertically pointing Illiterate E sym-

bols, but make frequent mistakes in reporting horizontally pointing E symbols. Development of direction sense is confirmed by newer research in the field of dyslexia.

Bettman[56] reported in 1967 that "15 per cent of more than 2 million school beginners each year will be retarded readers." "Although some retarded reading is caused by low IQ, by hearing disorders, and other disabilities, the majority of retarded readers have one of several specific learning disorders and are often called dyslexic." It is a well-known fact that some specific dyslexia is merely a problem of late maturing, i.e., some children outgrow their dyslexia. One of the typical symptoms of specific dyslexia is poor spatial orientation. Such children are easily confused in their directional sense and mix up right and left even after having learned to distinguish between up and down. When testing preschool children we must expect children with delayed development anyhow. Test methods using directional symbols, therefore, must work less well in young children. With prevalence of about 10 per cent specific dyslexia even after the age of 6, one must prefer preschool test methods which avoid directional test symbols. The Stycar test also overcomes this difficulty.

7. *Spacing of Test Symbols*

The average adult vision test methods expose a whole test chart or at least an entire test line. Most vision tests of younger children expose only one test symbol at a time. Untestability or unreliability of whole-line test methods becomes much more frequent with decreasing age. Therefore, in 3-year-olds single-exposure testing is the method of choice. Programs of older preschool children may use whole-line exposure in testing. For better standardization and comparison, one must specify which test method has been used.

Using standard (non-crowded) test charts, variations of the inter-symbol distances is not important under screening conditions.

8. *Follow-Up Care After Screening*

The best screening program is that which has the highest rate of children who, through it, receive final eye evaluation or treatment. The National Society for Prevention of Blindness omitted from its tabulation all programs which resulted in less than 40 per cent follow-up care of the referred children. In the Vision Screening Program conducted in Detroit,[29,30] 84 per cent of all referred children obtained an eye examination (out of a total of 14,100 children). The Senior Pediatrician of Project Headstart[6] reports that 90 per cent of all enrolled children had an eye screening; about 5 to 10 per cent were referred and about ⅔ of the referred children finally received a professional examination.

In our 1967 program, 80 per cent of all referred children received an eye examination with results reported to the project director.

9. *Incidence of Defects Found in Screening*

The value of a screening program increases with its case-finding rate. Statistics often are misleading because some programs exclude cases which previously had eye care for any defect. Some programs show an unusually high incidence of defects because they had attracted a population with higher risk to their screening. An example of such programs is a study in the San Francisco area.[34] In an effort to reach more children, the program investigated groups of children who were screened by their parents. Such procedure naturally triggers participation in the test of those children who had been suspected for any reason to have some abnormality. Referral rate in national statistics of 4.4 per cent closely approached the San Francisco re-

ferral rate of 5.8 per cent. Home-screening in the same region, however, resulted in 10.2 per cent referrals. Positive yields of defects, (as confirmed by ophthalmologists), in the same study were: national 2.1 per cent vs. regional 2.6 per cent; however, regional home screening produced 3.6 per cent yield.

Generally, vision defects rank high among all abnormalities found in preschool children.[57,58,59] With a preponderance of refractive errors among those, the incidence of refractive errors increases with age; the over-all ratio is about 50 per cent among referred children.[50,53] The next common defect is abnormalities of the external ocular muscles; the national statistic of the National Society for Prevention of Blindness (Hatfield)[53] lists 9.4 per cent eye muscle imbalance among the referred children (or 0.28% among the total number of screened children). Moran[50] lists 20 per cent ocular abnormalities. Other statistics[54] show a higher incidence.

The value of a screening program is particularly enhanced if it can detect early remediable defects which would later become unremediable, e.g. amblyopia exanopsia. Unfortunately, careless use of statistics on amblyopia has recently confused lay as well as expert opinion.

Military statistics[60,61] showing 1 to 3.2 per cent amblyopia are often quoted in emphasizing the importance of amblyopia in preschool children. These statistics are misleading since they include many other conditions which started after childhood. Other statistics confuse by their reporting the incidence among the follow-up examinations (*not* among the screened population group). Flom[62] tabulated statistics in the literature; his own finding has an incidence of 0.4 per cent of newly discovered amblyopia among children.

Other statistics agree that the incidence of remediable amblyopia among preschool children is much lower. Its incidence has been reported as follows: Moran,[50] Louisville 1958: 0.33 per cent of all screened; Kittredge and Cunningham,[51] New York State 1965: 0.2 per cent among 970 screened children. The statistics of the National Society for the Prevention of Blindness (Hatfield)[53] show: 28,665 preschool children screened: 1,259 (4.4%) among those were referred. 863 (68.5% of the referred) had professional examinations. 3 per cent of the examined children or 0.1 per cent of all screened preschool children had amblyopia. Hatfield's tabulation of 1967[55] reported an incidence of 2.5 amblyopia among 1,000 screened children (.25%).

Comparison with incidence of other health menaces, e.g., poliomyelitis shows: before the use of polio vaccine in 1952, 37 cases per 100,000 population were reported, i.e., 0.037 per cent (Morris et al.).[63] Paralytic cases were reported in about ⅔ of all poliomyelitis cases. Thus, paralytic poliomyelitis occurred in about 0.025 per cent of the population. Thus, amblyopia still represents a considerable health menace.

Should Preschool Eye Screening Determine Only Visual Acuity?

The relatively high incidence of ocular muscle disorders among preschool children has stimulated attempts to include eye muscle tests in preschool eye-screening procedures. Previous studies[10,24] have found that such tests are impractical for screening programs because of training and personnel demands.

Other tests useful in school screening programs are not suitable for this age group.

Special Application of Preschool Vision Screening Tests

The visual system is adversely affected in all conditions damaging the central nervous system. Eye defects are particu-

larly frequent among mentally retarded children, among children with cerebral palsy, and other children with multiple handicaps[59,4,64,65]: 70 to 90 per cent.

Vision tests are more important for the total assessment of such handicapped children than for normal children. They are also more difficult to administer. Several investigations have been made among such handicapped persons.[64,65,66,18,19] Blackhurst and Radke[65] concluded that for moderately retarded (trainable) children, regular screening procedures could not be used.

Since some older mentally retarded persons function in the level of chronological preschool age, one must conclude that tests particularly effective in 3-year-old children will also be more effective in the mentally retarded. The Stycar test was developed partly in working with such patients and is particularly suitable for handicapped children.

Need for Preschool Vision Screening

Ideally all children should get regular periodic complete ophthalmological examinations beginning with birth (Holt).[67] Since this ideal will not be reached in the near future, we have to look for other ways to bring eye care to the child. Vision screening programs attempt to bridge the gap between those who get eye care and those who don't, but may need it. Previous studies (Colassunno)[68] have shown how important such preschool screening tests are; 98 per cent of all preschool children had never had any eye examination before their preschool vision screening.

In spite of increase in numbers there were only 49 programs acceptable to the National Society for the Prevention of Blindness which only reached .2 per cent of the U.S. population aged 3 to 6 years. Discovery and correction of ocular defects early in life will often prevent amblyopia for the rest of one's life, and is as important a part of medical care as immunizations (Lippmann).[10] H. F. Allen in editorials in 1967[69,70] stated likewise: "Such considerations suggest that continued efforts should be made to lower the age of detection of defects in vision" and ". . . the community has a responsibility for the detection of a potentially disabling condition."

Summary

Development of vision in young children and appropriate methods of vision testing were discussed.

A study of vision in young children with particular attention to those aged 3- and 4-years-old was conducted in Day Care Centers (sponsored by the Office of Economic Opportunity). A pilot study compared various factors important for preschool vision screening: test symbols, test distance and test symbol spacing. A subsequent study determined the best vision test methods. The British Stycar test emerged as the best test for preschool children; it has the highest visual acuity scores, lowest untestability rates, shortest testing time, and best reliability. Vision of young children (3-years-old) can be screened. Their acuity is higher than commonly assumed.

Follow-up care, prevalence of eye defects, other aspects of preschool eye screening and special applications for the handicapped were reviewed. Need for earlier and better preschool eye screening programs was stressed.

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10. Julie (Mrs. Peter) Schaar, R.N., Public Health Nurse: tester.

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Vision test equipment based on the simplified Stycar test will be commercially available upon request from the following firms: Good-Lite Co., 7426 W. Madison St., Forest Park, Ill. 60130, and Titmus Optical Co., Petersburg, Va. 23803.

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