COMPARISON OF THREE VISION SCREENING MEASURES FOR USE WITH PRIMARY SCHOOL STUDENTS

by

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Abstract

Literature regarding the vision care needs of school children indicates that a variety of visual anomalies occur in sufficient numbers among children to warrant recommendation of a comprehensive school vision screening programme.

A quasi-experimental study was conducted to investigate the referral efficacy (accuracy) of the Keystone Telebinocular (KTT), the Modified Telebinocular (MTT), and the Snellen against a standard optometric exam.

Sixty children, aged 6-0 to 9-11, who had scheduled appointments with one of five optometrists in Coquitlam, Surrey, and White Rock, British Columbia, were administered the three screening measures, a letter identification test, and a standard optometric examination.

Subjects' performance on each screening measure was compared to their performance on the standard optometric exam and categorized as a positive referral, a negative referral, an overreferral, or an underreferral.

Chi-square and phi coefficient analyses were used to make the following comparisions: 1) the referral efficacy of the MTT versus that of the KTT, 2) the referral efficacy of the MTT versus that of the Snellen, 3) the referral efficacy of the KTT versus that of the Snellen.

The MTT had greater efficacy than the Snellen for positive referrals ($\chi^2(1)=7.000$, $p<.01$) and underreferrals ($\chi^2(1)=8.909$, $p<.01$). The Snellen had greater efficacy than either the MTT ($\chi^2(1)=7.363$, $p<.01$) or the KTT ($\chi^2(1)=5.444$, $p<.05$) for overreferrals.

Overreferrals and underreferrals were both undesirable, with underreferrals being the more serious. In addition to statistical performance, the suitability of test requirements for the target population and ease of administration were also considered in evaluating the usefulness of a screening measure.

When all the factors of vision screening were considered, the MTT proved to be the superior procedure for identifying children requiring professional care.

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CHAPTER I - INTRODUCTION

Within disciplines concerned with the well-being and learning potential of students, current emphasis is on the early detection of difficulties and the implementation of early interventions to reduce and/or relieve these difficulties. This viewpoint is supported within the literature on visual screening of school students (Eisner & Oglesby, 1971; Shaw, 1964; Taubenhaus & Jackson, 1965).

The issue is not whether children should undergo visual screening, but what type of screening would be adequate for school children. This study compared the relative efficacy (accuracy of referrals) of the Keystone Telebinocular, the Modified Telebinocular, and the Snellen as valid school vision screening measures.

A glossary of selected visual terms is presented in Appendix A.

Incidence of Vision Disorders in Children

Although the literature supports the position that there is a need for all children to have an early visual evaluation, there seems to be limited data regarding the national incidence of vision problems requiring professional care among children in Canada or the United States. A

report by the Vision Care Task Force, B.C. Ministry of Health (1977) noted that "The proportion of each age group in the population with vision care needs is not known" (p.112). However various estimates of the national need for vision care have been made in Canada and the United States. Table I shows the estimated percentage of school children with vision care needs.

The variability shown in Table I reflects a survey of the literature on overall incidence of vision needs in children. The references reported below discuss different age groups and visual anomalies thereby making comparisons difficult. Coleman (1970), reporting results from optometric evaluations given to over three thousand elementary students in West Warwick, Rhode Island, found an overall rate of 15% for refractive errors (hyeropia, myopia, and astigmatism). Hyperopia was the predominant refractive error in kindergarten, grade one, and grade two. Starting in grade three, cases of myopia began to outnumber hyperopia. In grades five and six approximately five times as many cases of myopia as hyperopia were found. However, refractive errors are not the only type of visual difficulty experienced by children. Rosen (1966) cites evidence that indicates more than far point acuity needs to be included in school vision screening programmes. Of the more than six hundred first grade students screened in Minneapolis, Minnesota 16.27% were reported to require a professional referral. Slightly more oculo-motor coordination problems

(6.48%) than refractive errors (4.27%) were found. Another 5.52% were found to have a combination of ocular-motor coordination and refractive problems. The Ontario Ministry of Health (1976) also identified two main groups of vision defects from school vision screening programmes - refractive errors and strabismus. While no rate is given for the former, the latter was reported to be present in 1-2% of children between five and seven years. A study of 73 kindergarten youngsters by the School of Optometry, University of Waterloo (Jervis,1978), found 14% of the youngsters had serious vision handicaps and another 12% had potential handicaps that required professional monitoring. Incidence of visual anomalies of 20%, or greater, have been cited by Cross (1975), Harley and Lawrence (1977), and Woo and Badger (1978). While the statistics of incidence vary they consistently indicate the need for comprehensive vision screening of school aged children, particularly at the primary level.

Table I

Percentage of School Children Needing Vision Care

age group	Boyd, 1965[1]	B.C. Optometric Association, 1973	Canadian Optometric Association, 1965	U.S. Public Health Survey, 1964, 1973 a&b	summary statistics
0-4	6.0		2.5		6.0
5-9	8.0	12.0	19.5	8.0	9.0
10-14	31.5	18.0		17.0	25.0

Note. Summarized from Province of British Columbia (1977)
[1]estimates of Canadians needing glasses

Vision and Reading

Although debated for years, the exact role vision plays in determining a student's success in reading has yet to be conclusively established. Several factors limit the comparison of vision screening studies: variation in the age of students studied, differences in sampling techniques, investigation of different vision tests, questionable validity and reliability of some vision screening tests, differences in the criteria used to determine if professional care was required and in defining reading disability, and differences in analyzing data (Dreby, 1979; Harris & Sipay, 1975; Rosen, 1965). Results are also influenced by whether the authors are writing from an optometric or ophthalmological point of view. Ophthalmologists often tend to concentrate on the physical mechanisms and diseases of the eye while optometrists tend to be concerned with a broader range of functional disorders (e.g. fusion difficulties).

Harris and Sipay (1975) suggest that results favour there being a positive relation between poor near-point acuity and poor eye-muscle balance and reading difficulties. From a study involving 162 fifth grade students, Brod and Hamilton (1973) concluded that a disturbance in binocular vision is significantly related to decreased reading performance. Further evidence that visual disorders impair mastery of reading skills is presented by Allen (1977);

abnormal pursuit and saccidic movements (see Appendix A) and abnormal focus control were found to be greater in children with learning disorders (reading). He also maintains these disorders are responsive to treatment thereby placing "...the learning disordered child in a condition of visual readiness to learn to read" (p.415). Campian (1965, cited in Martin, 1971), claims that poor visual acuity and defects in muscle imbalance or convergence do not directly interfere with the reading process. Martin suggests that the source of a reading disorder may lie in the brain where visual stimuli are interpreted and associated with past memory and language rather than within the eye or the optic nerve. Cross (1975) considers reading difficulties, including dyslexia, to reside within the central processing areas of the brain.

Bond, Tinker, and Wasson (1979) present a concise summary of some consistent trends found in the literature:

> 1. There is a slightly greater percentage of visual defects among children with reading disability than among children without reading disability.
> 2. Children with visual defects, as a group, tend to read more poorly than children without visual defects.
> 3. On the other hand, many children with visual defects learn to read as well as or better than children without defects.
> 4. No matter what kind or type of visual deficiency is studied, some children can be found who have that specific kind or type of visual deficiency and who are making good progress in reading.(p.74)

In acccord with this last statement is the view that good vision aids reading, but "problems with vision do not necessarily result in reading problems" (Ritty, 1979, p.796). Dreby (1979), Eberly (1972), Efron (1965), Jobe (1976), and Rosen (1965) present similar views. The degree to which an individual is inconvenienced by a visual disorder varies; a minor disorder may be quite limiting to one person while another may be able to compensate neuromuscularly for a more serious disorder. It should be remembered that other physical conditions (illness, fatigue, malnutrition), emotional problems, or academic deficits may contribute, alone or in conjunction with visual disorders, to reading difficulty. Thus it may be concluded that visual disorders per se do not cause reading deficits, but may contribute to a student's difficulty in reading and for this reason school screening of children's eyes is advisable.

Purpose of the Study

The efficacy of the most commonly used school vision screening procedure, the Snellen letter chart, has been criticized by many (Harris & Sipay, 1975; Jobe, 1976; Marshall, 1969; Pennock & Shapiro, 1980; Rubin, 1972; Schubert, 1976; Spache, 1965). The purpose of this study was to investigate three vision screening measures for possible use by non-vision specialists in British Columbia schools. The Keystone Telebinocular Technique (KTT), the

Modified Telebinocular Technique (MTT), as developed by Walton, and the Snellen were studied with respect to efficacy (i.e., accuracy) of referral. Student performance on these measures was compared to results of a regular optometric examination.

Questions To Be Answered:

1. Does the MTT have a greater efficacy (fewer under- or overreferrals) than the KTT when the standard optometric examination is used as the criterion for referral?

2. Does the MTT have a greater efficacy (fewer under-or overreferrals) than the Snellen when the standard optometric examination is used as the criterion for referral?

3. Does the KTT have a greater efficacy (fewer under- or overreferrals) than the Snellen when the standard optometric examination is used as the criterion for referral?

Definition of Terms

A brief description of the three vision screening measures investigated and the standard optometric exam are given below. The four referral categories employed to differentiate performance on each screening measure are also defined.

Screening Measures

Keystone Telebinocular and Modified Telebinocular

The Keystone Telebinocular Technique (KTT) and the Modified Telebinocular Technique (MTT) are binocular, stereoscopic screening instruments which employ a separate series of cards for far and near point test items. The eyes are tested separately and/or together on specific subtests. These instruments screen for monocular and binocular acuity at far point and reading distances, muscle imbalance, fusion, amblyopia, stereopis, and colour perception. In addition, the MTT screens for hyperopia, astigmatism, and anisometropia.

Snellen Chart

The Snellen chart consists of rows of letters of decreasing size. While both eyes remain open

during testing each is occluded in turn; sometimes both eyes are tested together. The test is administered at a distance of twenty feet (six metres) and thus essentially measures far point acuity and myopia, although severe hyperopia and severe astigmatism may also be detected.

Standard Optometric Examination

Although the specifics of any clinical exam are determined by the needs of the examinee there exists a core of measures upon which the professional relies as a starting point for examination. For the purposes of this study a consensus was obtained from the participating optometrists regarding the measures which comprise a standard optometric examination. These include tests of objective refraction (retinoscopy), subjective refraction (myopia, hyperopia, astigmatism), tropias, phorias and fusion at near and far points, vergences and versions at far and near points, amplitude of accommodation, stereo acuity, colour vision, and internal and external ocular health.

Types of Referrals

Positive Referrals

Those subjects identified by a screening measure as needing professional evaluation and who upon examination were placed under professional care (prescribed corrective lenses, given therapy, or placed under continued observation).

Negative Referrals

Those subjects for whom professional evaluation was not indicated by a screening measure and who were not placed under professional care.

Overreferrals (false positives)

Those subjects identified by a screening measure as needing professional evaluation, but who upon examination were not placed under profesional care (referred unnecessarily).

Underreferrals (false negatives)

Those subjects who should have been referred for professional evaluation as they required professional care, but who were not.

CHAPTER II - LITERATURE REVIEW

A variety of procedures are available to screen visual acuity, refraction, muscle balance, stereopsis, colour discrimination, or a combination of these. Examples include: the Snellen letter chart, Illiterate E test, Allen cards, HOVT, Ortho-Rater, Keystone Telebinocular, Titmus Stereotest, Maddox rod test, and the Cover Test. In keeping with the objective to compare three screening instruments with the standard optometric examination this review is confined to studies concerning the Snellen chart, the Keystone Telebinocular Test, and the Modified Telebinocular Technique. No attempt is being made to provide a generalized or comprehensive account of vision screening techniques.

Problems in Vision Screening

Prior to discussing the three tests selected for investigation some considerations applicable to any vision screening programme are presented.

Limitations of Screening Measures

Of paramount importance in the use of any test is recognition of both its advantages and limitations; techniques of vision screening are no exception. Results obtained from a vision screening programme, whether a single technique or a battery of tests, are not equivalent to those from a clinical examination. Screening results do not equal diagnosis. The latter can only be made by ophthalmologists or optometrists, not screening personnel (Bond et al., 1979; Harris & Sipay, 1975; Jobe, 1976; Ontario Ministry of Health, 1976; Spache, 1965). Therefore, the purpose of a school vision screening programme is to identify those students who require professional attention, be that examination only, examination plus treatment, or examination with continued observation, rather than to diagnose visual problems or their causes.

Variability in Referral Criteria

Acknowledgement of the fundamental differences between screening tests, clinical examination, and diagnosis partly accounts for the apparent discrepancies between screening referrals and incidence of vision problems based on clinical treatment. Given that the purpose of screening measures is to identify individuals in need of professional referral they should only be interpreted as pass or fail. Agreement

regarding the passing criteria does not exist either among tests or among vision care specialists. This lack of accord results in disagreement as to the number of children who are correctly referred, those who are referred unnecessarily (overreferrals), and those the screening techniques do not refer, but should (underreferrals). Another factor complicating the classification of referrals raised by Jobe (1976) is that vision problems needn't be synonymous with vision defects, but rather a student's vision "...may not be adequate for the tasks he is expected to perform" (p.3). The concern with function reflects not only the controversy surrounding passing criteria, but also the differring, and at times opposing, orientations of ophthalmologists and optometrists. Within the literature it is suggested that agreement regarding passing criteria between those responsible for conducting the vision screening and the local specialists who will receive the referrals is more important than following arbitrary criteria (Blum, Peters, & Bettman, 1959; Eisner & Oglesby, 1971; Ritty, 1979; Rosen, 1969)

While standardized criteria have yet to be adopted the following cut-offs have been suggested as indicative of the need for professional evaluation. They reflect the diversity of criteria between screening procedures and reported studies.

The Ontario Ministry of Health (1976) advised referral

if visual acuity of preschool or school aged children was poorer than 20/30 in either eye.

The National Society for Prevention of Blindness (1969, in Harley & Lawrence, 1977) recommended acuity levels allow for changes in vision with maturation: 20/50 or poorer for three year olds, 20/40 or poorer for ages four through eight, and 20/30 or poorer for students above the third grade. Muscle balance should be screened using the Maddox rod test with referrals for lateral deviations of four prism diopters (see Appendix A) at twenty feet, eight prism diopters at near point, inward deviations of six diopters at far or near point, and vertical imbalance of more than one diopter.

The clinical criteria employed in the Orinda study (Blum et al., 1959), (see Appendix C), and recommended by Jobe (1976) were: visual acuity of 20/40 or less, refractive errors - hyperopia +1.50 D.S. or more, myopia -0.50 D.S. or more, astigmatism ±1.00 D.S. or more, and amisometropia when there is a difference of 1 between eyes; coordination at far point - any tropia, inward or outward movement of five diopters or more, vertical imbalance of two or more diopters; coordination at near point - any tropia, inward movement of six plus diopters, outward turning of ten or more diopters, upward turning of two diopters or more; any known organic anomaly.

Another method of interpreting a child's performance on

either screening or clinical tests is to focus on what difference, if any, is displayed between the relative functioning of the eyes.

Screening Personnel

Screening personnel are a determining factor in the scope and accuracy of any school vision screening programme. Ideally, every child would have a full clinical evaluation prior to or soon after entering school, with periodic checks during his/her school years. At present this ideal is not feasible in terms of professional manpower or economics. Nor is it likely every parent would assume this responsibility. Results from the Orinda study (Blum et al., 1959) (see Appendix C) showed the Modified Clinic Technique (see Appendix B), which closely approximated a clinical evaluation, to be the most accurate school vision screening programme. Although desirable, this technique is impractical for many school districts because of the need for ophthalmologists or optometrists to conduct the screening.

To meet the desired goal of a district wide screening programme, many districts have adopted procedures which rely on public health nurses, school nurses, or teachers trained in the procedure employed and often assisted by trained volunteers. The emphasis is being put on trained personnel

rather than any particular screening test or combination of tests (Ontario Ministry of Health, 1976). Taubenhaus and Jackson (1969) support the view that accurate vision screening may be done by non-vision specialists. In their preschool vision screening study they found that community volunteers who were alert, intelligent, and possessed empathy for children could be trained as satisfactory screeners. Until such time as vision care is readily available throughout the province, one possible means of obtaining thorough vision screening for students in British Columbia would be for learning assistant teachers, school psychologists, and school nurses to be trained in a comprehensive screening procedure.

Besides training, the interest of the examiner towards both children and the screening programme affects the accuracy of referrals. This factor became evident in the use of the Keystone Telebinocular Test in the Orinda study (Blum et al., 1959). Investigation into the numerous overreferrals from the Telebinocular in 1955 revealed that the individual assigned to this procedure, while adequately trained, lacked interest in the programme and only reluctantly accepted the job. Among the changes instituted the following year was the employment of interested screeners; more efficient results (fewer unnecessary referrals) were then obtained.

Three Screening Measures

The three vision screening measures investigated in this study were the Snellen, the Keystone Telebinocular (KTT), and the Modified Telebinocular (MTT). A description is given for each test along with its advantages and limitations. Test interpretation is also discussed for each screening measure.

Snellen Letter Chart

Format

An often used instrument to screen children's vision is the Snellen letter chart developed, in 1862, by the Dutch ophthalmologist Hermann Snellen. The design of Snellen's chart was based on Frans Donders' work in geometric optics. For the initial chart Snellen chose the letter E because of the simplicity of its form. The size of each letter and the spacing between rows on the chart were calculated from the visual angle of five minutes of an arc at varying distances. Today this E chart is known as the Illiterate E or Tumbling E test and is used primarily with preschoolers and non-readers. The Snellen test used to screen older students is

a chart having a random assortment of letters, but designed in the same way as the original E chart.

Administration

The test is administered using either a wall chart and the available room lighting or by a chart stand with an internal light source. Students may sit or stand twenty feet (six metres) from the chart. The eyes are tested separately, an occluder being placed over each eye in turn. Students are instructed to keep both eyes open during screening. Although the standardized administration procedure of the National Society for the Prevention of Blindness (Harley and Lawrence, 1977) recommends both eyes first be tested together, the literature surveyed implies this recommendation is seldom followed.

Test Interpretation

An individual's visual acuity is noted by the Snellen fraction where the "...denominator indicates the smallest letters or symbols seen, and the numerator indicates the test distance. The larger the denominator the worse the acuity" (Brajkovich, 1980, p.473). For example a person whose visual acuity is 20/100 would read at 20 feet the letters a person with "normal" vision (20/20) would see at

100 feet.

Although 20/20 (6/6 using the metric scale) is commonly referred to as normal vision this term is a misnomer. Many individuals have better than 20/20 acuity (e.g. 20/15 or 20/10) and 20/30 or 20/40 acuity in young children reflects their developmental level rather than a vision disorder. Instead von Noorden (1980) advises the term standard vision be used. Harley and Lawrence (1977), Jobe (1976), Marshall (1969), and Vetterli (1959) support this position. The twenty foot measure is useful for diagnosis because at this distance light rays are so nearly parallel that the eyes are able to clearly focus the stimulus on the retina while remaining at rest (without accommodation). Therefore, errors on the 20/20 line suggest the eyes are having to accommodate to focus the stimulus clearly. No errors imply the person sees what s/he ought to see at twenty feet. Snellen fractions are a means of expressing visual acuity. They do not represent a percentage of vision; 20/40 acuity does not represent 50% poorer vision than 20/20 acuity. "In the AMA [American Medical Association] scale of visual efficiency, 20/40 would be 15% reduction from 'normality', hence 85%" (Rubin, 1972, p.31).

The Snellen chart is a measure of distant central field acuity. It was designed as a screening device of the visual pathways and refraction and hence results should not be interpreted diagnostically. Brajkovich (1980) presented the

following guidelines for interpreting the Snellen:

> When the test is normal, it should indicate the following; (1) that myopia is not present or, if present, is of a minor degree or has been compensated; (2) that hyperopia, if present, has been compensated by accommodation; (3) that the cornea and lens are clear and permit an image to be formed on the retina; (4) that the fovea centralis [an area of the retina] is intact as well as nervous connections to the brain; (5) that perception by the higher visual centers is intact.(p.473-4)

Advantages

The Snellen's low cost, ease of administration and short administration time per examinee have contributed to its worldwide usage. It is one of the most common visual screening instruments used in today's schools; 67% of the respondents in Pennock and Shapiro's (1980) survey indicated use of this chart. Proponents of the test maintain a large number of children with vision problems, particularly myopia, are detected. Rubin (1972) considers the Snellen to be the best available measure of all-around seeing ability.

Limitations

The Snellen is severely criticized in the literature on the basis of procedure, content, and design. (Harris & Sipay, 1975; Jobe, 1976; Marshall, 1969; Rubin, 1972;

Schubert, 1976; Spache,1965).

Standardized testing conditions and administration procedures are requirements of any test. The Snellen's format makes it vunerable on both these accounts. Use of a wall chart and the available room lighting does not ensure adequate or consistent illumination from one administration to the next. Nor will room lighting and the built in lighting of the chart stand necessarily be equivalent. Inconsistency may also occur in the distance between students and the chart. Variations among charts produced by different manufacturers also contribute to referral discrepancies among patients and for students tested at different times with different charts.

Often other students are waiting in the testing room while one is being screened and thus have the opportunity to memorize the chart before their turn. Some youngsters may close the eye covered by the occluder or they may squint thereby distorting test accuracy. von Noorden (1980) points out that although the reason is uncertain, binocular visual acuity is better than monocular visual acuity. The implication seems to be that tests like the Snellen are of limited value in determining a person's visual status.

Inter-screener differences in administration and interpretation are another limitation. Some screeners maintain it is necessary to begin with the largest letters and systematically progress through the rows until all

letters in one row are incorrectly identified. Jobe (1976) proposes it is sufficient to begin with the largest letter (20/200) to acquaint the student with the procedure, then to present the 20/50 line and if no errors are made to go to the 20/20 line, only if passing criterion is not met is the 20/30 line presented. Controversy exists as to the appropriate passing criterion. Some screeners consider a line passed if four of the six items are correctly identified, while others require all six to be correct. Whether the 20/20, 20/30, or 20/40 line serves as the referral criterion is also debated. Some consensus is present to recommend the 20/30 line as the referral standard, especially for students beyond the primary grades; that is, a student making errors on this line would be referred for clinical examination (Blackhurst & Radke, 1964; National Society for the Prevention of Blindness, 1969, in Harley & Lawrence, 1977; Ontario Ministry of Health, 1976). As noted earlier the selection of a criterion should be made jointly between screening personnel and local vision specialists.

One of the main limitations of the Snellen is its restricted content. It is a test of monocular distance visual acuity which detects myopia, amblyopia, and severe hyperopia and astigmatism. The following are not detected: near point or reading acuity (unless an alternate form is given at sixteen inches), moderate degrees of hyperopia which a student can overcome by accommodation during the

brief screening period, binocular coordination, fusion, most astigmatism, fixation, convergence, stereopsis, and colour vision.

Design characteristics have led to challenges against the Snellen's validity. Spache (1965) states that "...the letters of the alphabet or the E's used are not dependable, accurate measures of acuity" (p.43). He further claims "Some of the lines are easier to read than others, while some are especially difficult because of the similarity of the letters." Data are not cited to support these claims. More specific criticisms are offered by Rubin (1972): there is an irregular progression in letter sizes between lines, lack of consistency in the space separating letters in a given line, and non-standard spacing between lines. The spacing used in a particular chart may create a "crowding phenomenon" (p.32) which could influence the examinee's test performance. He also disputes that the letters comprising the Snellen chart constitute a measure of acuity, specifically resolution acuity and that resolution acuity is an index of general visual ability.

> Very few, indeed, of the letters on a Snellen chart constitute resolution targets at all. The L does not, nor does the T, D, A, O (unless it is compared with the C), P (unless it is compared directly with the F), ... A chart comprising only B's and E's, or one bearing only F's and P's or only O's and C's, could be a very fine primary acuity chart, but one might then just as well use Landolt rings [see Appendix A] with various orientations and be done with it. (p.30)

Perception more than resolution is involved in identifying letters on the Snellen, the test therefore being a measure of a student's letter shape recognition. But he contends "The various letters ... are not equal as tests of visibility or shape recognition. A few measure resolution or resolution and one or more additional functions. The chart as a whole, then, measures an inextricable complex of visual functions - not 'visual acuity'" (Rubin,1972, p.30). Therefore, in contrast to many researchers and vision personnel, Rubin advocates the Snellen chart be used to screen general seeing ability, but not acuity.

Efficacy of referral is an important factor when selecting a vision screening programme. The debate over what constitutes a correct referral has been previously discussed. Some researchers have been concerned with the overreferral rates of techniques while others have pressed for consideration of both over- and underreferrals. Conflicting reports exist regarding the Snellen's referral efficacy. Brajkovich (1980) suggests 97% of the children

with significant vision problems will be identified. In contrast, Spache (1965) claims only 20% to 40% of students requiring professional attention will be discovered. He reports the Snellen's underreferral rate, based on the 1949 St. Louis study, to be 25%. The difficulty involved in interpreting research findings and choosing a screening technique is evident in the referral rates presented by Eisner and Oglesby (1971): overreferrals for the Snellen ranged from 32.7% to 35.4% with underreferrals of 16.4% to 51.3%.

Despite the test's advantages in terms of low cost and ease of administration, its numerous limitations have prompted development of more comprehensive standardized vision screening batteries. Two such batteries, the Keystone Telebinocular Test and the Modified Telebinocular Technique, were employed in the present study.

Keystone Telebinocular Test

Format and Administration

The Keystone Telebinocular Test (KTT), also known as the Keystone School Survey, was developed in 1934 by E.A. Betts as a visual reading readiness test (Harley & Lawrence, 1977). It is a binocular, stereoscopic screening instrument consisting of two side-by-side achromatic prism lenses separated by an interlens occluder which restricts the vision field of each eye, thereby controlling the stimulus to each eye. Test plates are placed in a card holder situated at specific distances from the lenses. Far point (20 feet or 6 metres) and near point (reading distance of 16 inches or 41 cm) are produced optically and therefore are standardized between administrations. Test plate images differ slightly for each eye, thus simulating actual scenes viewed by the examinee's eyes.

The test measures monocular and binocular distance and near point acuity, horizontal and vertical eye-muscle balance, far and near point fusion, stereopsis (depth perception), and colour vision. Available supplementary materials include a primary skills test set (recommended for students below grade three), a plus lens test to check for hyperopia, and a periometer test of side vision. The literature surveyed did not indicate that any of these

supplementary tests are routinely included in vision screening programmes employing the KTT.

The Keystone Telebinocular is similar to the Ortho-Rater and the Titmus School Vision Tester.

Test Interpretation

Designed solely as a vision screening procedure, the KTT must be interpreted as a whole. Subtest performance does not yield diagnostic data, therefore results should not be compared to findings from clinical tests of the same name. The purpose of the KTT, as with any vision screening programme, is to identify students in need of professional evaluation.

Referral criteria are presented in the test manual to guide the examiner in evaluating examinee performance. In addition, typical examinee responses, for each subtest, fall into one of three categories indicated on the record form: expected response, re-test area, or unsatisfactory.

Advantages

Several advantages recommend the KTT over the Snellen chart. Besides screening a variety of skills, the KTT has both a standardized sequence of tests and administrative

procedure. Administrative consistency is also aided by the test plates which control the stimulus presented to each eye and the viewing distance. An internal light source provides standardized, constant illumination. Occluders attached to the instrument permit standardized monocular acuity testing. The instrument is portable, requires little table space, and can be adjusted for varying heights. Another attractive feature of this technique is that it can be administered by non-vision professionals after brief training.

Record forms are easily completed and include student identification data, space for recording rapid screening and comprehensive test battery results, plus the standardized questions for the comprehensive battery. Typical examinee responses are recorded under three performance categories which reduces subjective response evaluation by the examiner. Thus passing criteria are more standardized than on the Snellen where examiner preference sets passing at four of six or six of six correct responses.

The concisely written manual details instrument components, test administration, and the individual subtests of the rapid screening test, the comprehensive battery, the primary skills test (which may be given to primary students rather than the comprehensive battery),the plus lens test, and the periometer test. Passing criteria for most subtests are suggested, along with the possible implication of incorrect responses.

Limitations

Fewer disadvantages have been reported for the KTT than for the Snellen. Jobe (1976) raises the concern that the occluder between the lenses might be too wide for some primary students. In the attempt to see through both lenses a youngster would shift his/her head from side to side distorting test accuracy. A potential deterrent to a school district's adopting use of the KTT is its cost; approximately six hundred and sixty-five dollars, U.S. funds, in February 1981. The test's advantages could be considered to offset the high initial outlay.

The referral efficacy of the KTT is controversial. Harley and Lawrence (1977, citing Foote & Crane, 1954) and Williams (1974) maintain the test has a high overreferral rate which limits its suitability as a school vision screening programme. Harris and Sipay (1975) and Mangrum (1970), on the other hand, support school use of the KTT. Mangrum feels the technique checks the major vision problems common in children with reading difficulties. Results from the 1956 testing conducted as part of the Orinda study (Blum et al., 1959) indicated the KTT to be a useful school vision screening technique: 9% correct referrals, 6% overreferrals, 8% underreferrals, and 77% non-referrals. Thus the visual status of 86% of the subjects (correct referrals plus non-referrals) was correctly identified, while that of 14% (overreferrals and underreferrals) was erroneously

classified.

Technical data are lacking for the KTT. Apart from Snellen equivalents for monocular distance and near acuity, available in the manual, no technical standards are provided. No reference is provided for the Snellen equivalents, therefore it could not be ascertained whether these criteria are in accord with those set by Canadian or American Medical Associations. Data on which passing criteria were based is not presented preventing comparision of KTT referral criteria with those of other techniques. Nor are data provided on the reliability or validity of the KTT. The manual states the procedure to be "...accurate and dependable....Overall results show very high validity. In fact, the tests are so reliable that thousands of eye specialists use them to assist in their diagnoses. And the tests are accepted and approved by leading professional organizations." Data supporting these claims are lacking. None of the literature supplied by the manufacturer indicated the availability of a technical manual. Justification for the substitution of the primary skills tests, for the comprehensive battery, until the end of the second grade rather than the first grade, is not given. The equivalency of the primary and comprehensive forms can only be assumed, as supporting data are missing from the manual.

Modified Telebinocular Technique

Format and Administration

The continued search for an efficient vision screening technique, suitable for school use, led to development in the late 1970's of the Modified Telebinocular Technique (MTT) by Dr.Howard Walton, of the Southern California School of Optometry. The MTT employs the standard Keystone telebinocular and twelve of the comprehensive battery test plates. Test slides for near point acuity have been eliminated. A new card was designed to screen myopia, amblyopia, and astigmatism. Hyperopia is checked using the standard distance acuity cards and a +2.00 lens. All visual problems screened by the Modified Clinical Technique (MCT) are detected by the MTT: myopia, hyperopia, astigmatism, fusion, suppression, anisometropia, amblyopia, muscle imbalances, and colour perception. Stereopsis is also checked by the MTT. School nurse and/or teacher observations plus eye pathology are not included in the procedure.

Test Interpretation

Like the KTT, the MTT was not designed to yield diagnosis, but an indication of whether or not a student

should be referred for professional evaluation. In addition to referral criteria being included in the test directions, the record form lists and categorizes examinee responses as being within the expected range, the borderline area, or as unsatisfactory.

Advantages

Advantages of the KTT are applicable to the MTT. A primary advantage is that the technique can be administered by school personnel, psychologists, and other non-vision specialists. Therefore the MTT overcomes the major limitation of the MCT.

Limitations

To date, results from only one study employing the MTT have been reported. In a 1976 study, Walton and his associates administered the MTT and the MCT to 102 elementary students in Los Angeles. Based on the obtained 89.2% referral agreement between the two procedures, it was concluded that the MTT and MCT are comparable. More research is needed before a conclusive decision can be reached on the merits of the MTT.

CHAPTER III - METHOD

A quasi-experimental study was conducted to investigate the referral efficacy of the Snellen, Keystone Telebinocular Technique (KTT), and Modified Telebinocular Technique (MTT) against a standard optometric examination.

Subjects

Subjects were children having scheduled appointments with one of five optometrists practising in Coquitlam, Surrey, and White Rock, British Columbia. These communities are predominantly suburban, middle-class in character. Although the sample was not randomly selected, informal discussion with subjects and their parents indicated that optometric appointments were made for a variety of reasons: parents considered a professional visual exam a necessary part of a good health programme, parents had concerns regarding their child's vision, or the child's teacher, the school nurse, or the family doctor had recommended a professional evaluation. Thus the sample was likely representative of the referred population.

The screening tests were administered from early April until early July, 1983, with students being registered in Kindergarten through fourth grade. The age limits were six years, zero months (6-0) to nine years, eleven months (9-

11).

Parents/guardians of children within the age limits who had scheduled appointments with the participating optometrists were informed of the study during a routine office appointment reminder call. Those who expressed interest in the research were given a written description of the study by office staff at the time of their child's appointment. Parents/guardians wishing to have their youngster participate indicated their permission by completing a written consent form.

Screening measures were administered to sixty-six subjects. However six subjects were excluded from the study - one child did not meet letter recognition criteria, two children were younger than six years, two youngsters did not complete optometric evaluations, and non-compliance during screening invalidated one subject's responses. Thus sixty children aged six years, zero months (6-0) to nine years, eleven months (9-11) participated in the study. (Tables XVI and XVII in Appendix E show subjects classified by chronological age and sex respectively.)

Measures

A brief description of the content of each of the three screening measures and the letter identification test is presented along with criteria for scoring and interpretation.

Letter Identification

Prior to administration of the KTT and MTT each subject was asked to identify upper case letters printed individually on 7.5 X 12.5 cm (3 X 5 inch) blank white cards. The same random order of letters was presented to each subject. A letter was considered known if the subject correctly gave the name or sound of the letter. Self-corrections were counted as known. The purpose of this task was to help determine whether errors made on the MTT far and near point acuity subtests, the MTT astigmatism subtest, and on the Snellen were due to vision difficulties or limited letter identification skills.

Snellen

The Snellen chart consists of rows of letters, of decreasing size presented at a distance of twenty feet (six metres). School screening programmes conducted by public health staff employ either a wall chart or a chart stand.

In the present study the optometrists presented the Snellen by means of a projected technique, which gives the effective distance of twenty feet (six metres). Each eye is tested separately while the other is occluded. This test primarily measures far point acuity and myopia, although severe hyperopia and astigmatism may be detected. The passing criterion (usually 20/30 or 20/40) is at the examiner's discretion. In this study a set passing criterion of 20/40 was employed.

Keystone Telebinocular and Modified Telebinocular

The Keystone Telebinocular Technique (KTT) and the Modified Telebinocular Technique (MTT) are binocular, stereoscopic screening instruments which measure the following visual skills at far and near points: monocular and binocular acuity, muscle imbalance, fusion, and amblyopia. Stereopsis and colour perception are also tested at far point. In addition, the MTT screens for hyperopia, astigmatism, and anisometropia. A standardized sequence of cards is employed. The recording forms indicate whether an examinee's visual skills are satisfactory, should be re-screened, or evaluated by a professional.

Standard Optometric Exam

Among the optometrists participating in the study a consensus was obtained regarding the visual skills assessed in a standard optometric examination. These include tests of objective refraction (retinoscopy), subjective refraction (myopia, hyperopia, astigmatism), tropias, phorias and fusion at near and far points, vergences and versions at far and near points, amplitude of accommodation, stereo acuity, colour vision, and internal and external ocular health.

Table II shows the vision subtests included in each screening measure and a standard optometric evaluation. (Copies of the summary data sheet and test record forms are included in Appendix D).

Assumptions

The following assumptions were made in the study:

1. Since the study was investigating the efficacy of the three screening measures against a standard optometric exam, it was assumed a self-selected sample would be adequate.

Table II

Visual Skills Tested by Three Screening Measures and a Standard Optometric Exam

	VISION TEST			
VISUAL SKILL	Snellen	KTT	MTT	Standard Optometric Exam
suppression		X	X	X
objective refraction (retinoscopy)				X
subjective refraction				
myopia	X	X	X	X
hyperopia	*		X	X
astigmatism	*	*	X	X
fusion (far & near)		X	X	X
phorias (far & near)		X	X	X
tropias (far & near)		X	X	X
vergences & versions				X
amplitude of accommodation				X
stereopsis (lack of)		X	X	X
colour vision		X	X	X
external & internal ocular health (tissue exam)				X
case history				X

* severe only

2. Subject fatigue is often a factor when testing young children. It was assumed that the fatigue displayed by some children was not sufficient to distort test results.

3. It was assumed that inter-optometrist differences in testing techniques and evaluation were representative of those differences found among all optometrists and were randomized throughout the sample.

4. Since no measure of inter-optometrist reliability could be obtained it was assumed that as all the participating optometrists had trained at the same school of optometry, all are currently licensed by the British Columbia Optometric Association, and all follow conventional optometric procedures the optometric findings would be similar.

5. An arbitrary decision was made to eliminate subjects who made more than two errors on the Letter Identification test. It was assumed that this error criterion would ensure reliable results on the Snellen and on the MTT subtests for acuity and astigmatism while allowing for initial test anxiety; Letter Identification was the first test

administered.

6. Although discrete referral categories are given for the KTT and MTT, the visual skills assessed are assumed to exist along a performance continuum.

Procedures

Test Administration

Each subject, identified by number, was administered all screening measures and a letter identification test in addition to a standard optometric examination. Subjects wearing glassses were screened without their glasses.

Several test items are common to the Keystone Telebinocular Technique (KTT) and the Modified Telebinocular Technique (MTT). These items were administered only once. Odd numbered subjects were administered the complete KTT followed by the remaining items from the MTT. Even numbered subjects were given all items from the MTT followed by the remaining items from the KTT. Table III summarizes the order of test administration.

Table III

Administration Order of Visual Tests

Odd Numbered Subjects	Even Numbered Subjects
1. Standard Optometric Exam & Snellen	1. Standard Optometric Exam & Snellen
2. Letter Identification	2. Letter Identification
3. KTT subtests (1-14 inclusive)	3. MTT subtests (1-12 inclusive)
4. MTT subtests (4W,4 1/2,5,6,12)	4. KTT subtests (4 1/2,5,6,12,13,14)
5. Retesting of KTT subtests scored as retest	5. Retesting of MTT subtests scored as retest
6. Retesting of MTT subtests scored as retest	6. Retesting of KTT subtests scored as retest

Note. See samples of protocols in Appendix D for KTT and MTT subtest headings.

The letter identification test, the KTT, and the MTT were administered by the researcher. The Snellen was administered by the optometrists as part of the standard optometric exam. Fifty-six subjects were seen by the optometrist and then administered the screening measures. Four subjects underwent vision screening prior to clinical examination. Whether a subject was screened before or after optometric evaluation depended upon which best facilitated optometric bookings.

Performance on the KTT and the MTT was not compared to results from the Snellen or the optometric exam until after a subject had completed all testing.

Recording Data

Consistency in recording subjects' performance was facilitated by use of standard recording forms which accompany the KTT and MTT. Data sheets were used for recording letter identification responses and overall performance on each screening measure and the standard optometric exam. (See Appendix D for copies of all recording forms.)

Inconsistency in recording and interpreting subjects' responses on letter identification, the KTT, and the MTT was reduced by these measures being administered by one examiner.

Optometric Exam

The validity of the three screening measures investigated was increased by including patients from five optometrists. The benefits gained were considered to out weigh limitations due to inter-optometrist differences. Such differences could have stemmed from variation in administration techniques or evaluation criteria employed during the standard optometric exam. Differences in technique may also have occurred during Snellen administration. For this study the same Snellen passing criterion (20/40) was used by all optometrists. Reliability of inter-optometrist findings would have required subjects to be seen by more than one optometrist which was not feasible given time and economic restraints.

Other Testing Factors

Other factors which may have biased screening results were parent observation and subject fatigue. Although the written description of the study suggested subjects be

screened alone, in nine cases either the child or parent requested the parent be present. As in any testing situation with young children fatigue was exhibited by some youngsters, but a brief pause to discuss school or their outside interests was sufficient to restore interest in the screening tasks. Therefore the subjective judgement was made that fatigue did not bias test results.

Scoring and Interpretation

Letter Identification.

A 92% (24/26) identification criterion was considered necessary for reliable performance to be obtained on the MTT and Snellen. Subjects not meeting this criteria were not included in the study.

Snellen.

A passing criterion of 20/40, for each eye, was employed for evaluating Snellen performance. This criterion was recommended by the participating optometrists.

Keystone and Modified Telebinocular Techniques.

In order to examine the efficacy of the KTT and the MTT the established scoring procedures and performance criteria, as indicated on the test record forms and in the test directions, were followed. Unsatisfactory performance on a subtest was interpreted as suggesting the need for professional evaluation, rather than as being diagnostic of a deficit in the visual skill covered.

Use of commercially available record forms for the KTT and MTT ensured that recording of subjects' responses was consistent and objective.

Responses falling in the Expected Response range or in the Retest (Borderline) category were classified as passes (no referral indicated). Responses in the Unsatisfactory range were classified as a referral for subtests measuring simultaneous vision (test 1 - KTT & MTT), vertical posture (test 2 - KTT & MTT), far point acuity (tests 4 1/2, 5, & 6 - KTT; test 4W - MTT), and near point acuity (test 12 - MTT). Unsatisfactory performance on colour vision (tests 8 & 9 - KTT & MTT) was noted, but was not sufficient by itself to constitute a referral. Age was considered in interpreting performance on lateral posture (tests 3 & 10 - KTT & MTT), fusion (tests 4 & 11 - KTT & MTT), stereopsis (test 7 - KTT & MTT), and near point acuity (tests 12, 13, & 14 - KTT). The interpretation suggestions given in the test directions for these subtests were followed when evaluating

responses for six and seven year olds.

Standard Optometric Exam.

Performance of subjects on the standard optometric exam was evaluated by the optometrists' professional judgement. Those children who were judged to require corrective lenses (glasses), contact lenses, therapy, or continued observation were classified as needing professional care (positive referral).

Referral Categories

Based on a comparison of screening and optometric findings, subjects were categorized on each screening measure as a(n):

positive referral -

referral indicated by both screening measure and optometric exam

negative referral -

referral not indicated by screening measure nor by optmetric exam

overreferral (false positive) -

referred by screening measure, but not requiring professional care

underreferral (false negative) - referral not indicated by screening measure, but requiring professional care

Table IV summarizes referral categories.

Table IV

Types of Referrals

	SCREENING TEST	
	referral indicated	no referral indicated
OPTOMETRIC EXAM		
professional care required	positive referral	underreferral (false negative)
professional care not required	overreferral (false positive)	negative referral

Scoring Reliability

As a check on the accuracy of the researcher's scoring and interpreting of the KTT and the MTT 30 protocols from each measure were re-evaluated by an independent scorer. Optometrist Howard Walton, of the Southern California College of Optometry, developer of the Modified Telebinocular Technique, did the independent scoring. The 60 protocols scored by Dr. Walton included all those in which there might be controversy over whether or not the child should be referred for professional evaluation (26 each of KTT and MTT), plus others selected at random (4 each of KTT and MTT).

Agreement between the researcher and the independent scorer with respect to the referral status of subjects is shown in Table V. Consensus on referral was present for 29 MTT protocols. Different interpretations of the inconsistent responses given on the hyperopia subtest resulted in conflicting referrals being made for one subject. Phi coefficient (Guilford, 1965) and chi-square analyses comparing scoring agreement on the MTT found significant agreement between the researcher and the independent scorer regarding referral status, $\phi=.93$, $\chi^2(1)=26.17$, $p < .001$. Referral agreement existed for 26 KTT protocols. Disagreement on the remaining four protocols stemmed from different interpretations of performance on the muscle balance, stereopsis, and near point acuity subtests

where age may influence responses. On these subtests the errors made by young children may reflect visual immaturity rather than a visual anomaly. The KTT manual is not specific in whether the error responses of young children should be interpreted as passes or referrals. Statistical analyses yielded lower, but still significant scoring agreement for the KTT, ϕ=.75, $\chi^2(1)=16.83$, $p < .001$. These results indicated that the researcher's scoring and interpreting of the KTT and the MTT were sufficiently accurate to yield reliable screening data.

Table V

Agreement of Referral Status on KTT and MTT protocols by the researcher and the independent scorer

	Agreed no. (%)	Disagreed no. (%)
Keystone Telebinocular	26 (87)	4 (13)
Modified Telebinocular	29 (97)	1 (3)

Note. Scoring on 30 protocols of each measure was compared.

Data Analysis

The intent of the study was to compare the frequency of referral categories for each screening measure against referrals from a standard optometric exam. Results were subjected to chi-square and phi coefficient analyses.

Delimitations

The delimitations of the study concerned the sample. Children aged 6-0 to 9-11 were selected for the study. There were few children in each age category (see Table XVII, Appendix E). Subjects were only those children who had scheduled appointments with the participating optometrists and whose parents consented to their participating in the study.

CHAPTER IV - RESULTS

Data, obtained from a sample of 60 primary students, on the referral efficacy of the MTT, the KTT, and the Snellen are presented. Each screening measure is compared to the standard optometric exam for visual skills tested and efficacy of referrals. The significance of the different referral rates among the three screening measures is discussed.

Visual Skills Tested

Chi-square analyses were performed to determine whether the visual skills measured by each screening measure and the standard optometric exam were independent or related. Following the recommendation of Hopkins and Glass (1978) the Yates correction for continuity was not applied. Phi coefficients were computed to measure the strength of the relationship between each screening measure and the standard optometric exam. These results are shown in Table VI. Standard scores (Hopkins & Glass, 1978) were computed from the phi coefficients to determine whether the screening measures differed significantly in their agreement with the standard optometric exam. These results are presented in Table VII.

The significant results obtained from the chi-square

analyses (Table VI) indicate that each of the screening measures tested visual skills covered by the optometric exam. The differences between the phi coefficients, as shown by the Z scores in Table VII, are not significant. These results indicate that each of the three measures studied does test essential visual skills, but they do not show the efficacy of the measures.

Table VI

Comparison[1] and Strength of Agreement[2] of the Visual Skills tested by Three Screening Measures and a Standard Optometric Exam

	χ^2	ϕ
MTT and Standard Optometric Exam	17.94*	.55
KTT and Standard Optometric Exam	6.70*	.33
Snellen and Standard Optometric Exam	7.98*	.36

[1]Chi-square analysis
[2]Phi coefficient analysis
*$p<.01$

Table VII

Standard Score Comparisons of the Strength of Agreememt (Ø) between Three Screening Measures and a Standard Optometric Exam (SOE)

	Z
MTT and SOE vs KTT and SOE	1.47, ns
MTT and SOE vs Snellen and SOE	1.29, ns
KTT and SOE vs Snellen and SOE	.181, ns

$p > .05$

Referral Efficacy

Answers were sought to the following questions for the sample of 60 primary aged optometric patients.

Question 1 -

Does the MTT have a greater efficacy (fewer under- or overreferrals) than the KTT when the standard optometric examination is used as the criterion for referral?

Question 2 -

Does the MTT have a greater efficacy (fewer under- or overreferrals) than the Snellen when the standard optometric examination is used as the criterion for referral?

Question 3 -

Does the KTT have a greater efficacy (fewer under- or overreferrals) than the Snellen when the standard optometric examination is used as the criterion for referral?

Findings

Referral efficacy was determined by comparison of the number of referrals, in each category, made by each screening measure against findings from the standard optometric exam. Table VIII presents the referral rates of the three screening measures, while Table IX summarizes the number and percentage of correct and incorrect referrals for each measure. The MTT made the most correct referrals (77%), with fewer than a quarter of the subjects being

incorrectly referred. Most of the errors (10/14) made by the MTT were overreferrals. In comparison, the KTT and the Snellen both erroneously referred almost one third of the sample. The KTT made 18 overreferrals and 11 underreferrals. The Snellen's error rate was composed predominately of underreferrals. It did not refer 30% (18/60) of the subjects who required professional care. These referral rates pertain to the efficacy of the three screening measures studied. They should not be interpreted as representing the proportion of B.C. primary children within each referral category.

The chi-square analyses computed to determine whether the obtained referral rates were significantly different are shown in Table X. These findings are discussed below in relation to the research questions posed.

Table VIII

Number and Percentage[1] of Sixty Subjects in Each Referral Category, per Screening Measure as Compared to a Standard Optometric Exam

	REFERRAL CATEGORIES			
	Correctly Referred		Incorrectly Referred	
SCREENING MEASURE	positive referrals no.(%)	negative referrals no.(%)	over referrals no.(%)	under referrals no.(%)
MTT	21 (35)	25 (42)	10 (17)	4 (7)
KTT	14 (23)	27 (45)	8 (13)	11 (18)
Snellen	7 (12)	34 (57)	1 (2)	18 (30)

[1] Percentage values have been rounded.

Table IX

Summary of Correct and Incorrect Referrals[1] for Each Screening Measure as Compared to a Standard Optometric Exam

	REFERRALS			
	Correct Referrals[2]		Incorrect Referrals[3]	
	no.	(%)[4]	no.	(%)
SCREENING MEASURE				
MTT	46	(77)	14	(23)
KTT	41	(68)	19	(32)
Snellen	41	(68)	19	(32)

[1]N=60 for each screening measure
[2]Correct Referrals - positive plus negative referrals
[3]Incorrect Referrals - overreferrals plus underreferrals
[4]Percentage values have been rounded.

Table X

Chi-square Comparisons of the Number of Referrals per Category between Screening Measures

	REFERRAL CATEGORIES			
	positive referrals	negative referrals	over referrals	under referrals
SCREENING MEASURE				
MTT vs KTT	1.4000	.0769	.2223	3.2667
MTT vs Snellen	7.0000**	1.3729	7.3636**	8.9091**
KTT vs Snellen	2.3334	.8033	5.4445*	1.6896

*$p<.05$
**$p<.01$

Question 1

Chi-square analysis indicated there was no significant difference between the MTT and the KTT for either overreferrals or underreferrals.

Question 2

A significant difference was found between the MTT and the Snellen with respect to overreferrals, $\chi^2(1)=7.3636$, $p < .01$. The fewer overreferrals made by the Snellen indicate it was the more accurate test for this referral category.

The difference between the MTT and the Snellen for underreferrals was also significant, $\chi^2(1)=8.9091$, $p < .01$. The MTT made fewer underreferrals and therefore had greater efficacy than the Snellen for this referral category.

Question 3

Chi-square analysis was significant for the difference between the KTT and the Snellen for overreferrals, $\chi^2(1)=5.4445$, $p < .05$. The Snellen, with its fewer overreferrals, had greater efficacy than the KTT for the sample studied.

No significant difference was found between the KTT and the Snellen with respect to underreferrals.

Comparisons for Positive and Negative Referrals

Comparisons between all screening measures with respect to identifying negative referrals (subjects not requiring professional care) were non significant. For positive referrals (subjects identified as requiring professional care) the comparison between the MTT and the Snellen was significant, $\chi^2(1)=7.000$, $p<.01$. The greater number of positive referrals identified by the MTT indicates it had greater efficacy than the Snellen for this referral category.

Discussion

The study was concerned with the efficacy of three vision screening measures rather than establishing referral rates for visual anomalies among primary students. Therefore the findings of the study should not be interpreted as referral rates for the general population of British Columbia primary students. What the data do indicate is how the Snellen, the Keystone Telebinocular (KTT), and the Modified Telebinocular Technique (MTT) compare with each other and to the standard optometric exam with respect to the frequency of positive referrals, negative referrals, overreferrals, and underreferrals.

The number of overreferrals and underreferrals are of the most concern in any vision screening programme.

Overreferrals, which unnecessarily utilize professional services, were judged to be less serious than underreferrals. The latter are those examinees who do require professional attention, but are not identified by the vision screening programme. The undetected visual difficulties of these children may develop into more serious visual anomalies and/or hinder their school performance.

Analysis indicated that the MTT and the KTT did not differ significantly in their referral efficacy for any referral category (see Table X). The fact that a number of MTT and KTT subtests utilize the same test plates would partly account for these results. However, some differentiation might be expected given the MTT's more specific referral criteria, particularly with respect to developmental factors. Although statistically significant differences were not found for the sample tested, the obtained chi-square comparison of the number of underreferrals made by the two measures approached significance at the .05 level. Therefore it could be hypothesized that a larger sample size would have yielded a significant difference for this referral category.

Statistically, the MTT had greater efficacy than the Snellen for positive referrals and underreferrals. The Snellen made fewer overreferrals. No significant difference was found for negative referrals. If a choice were to be made between using the MTT or the Snellen in a school vision

screening programme the obtained data would support the MTT. This choice would be largely determined by the MTT's greater efficacy with respect to underreferrals.

The KTT and Snellen did not differ significantly in their referral efficacy except for overreferrals. The Snellen made fewer overreferrals and thus had the greater efficacy. A similar relationship was found between the MTT and the Snellen. Factors which may have influenced these findings are the number and type of visual skills screened by a measure or the sample tested. The Snellen primarily measures far point acuity. An important advantage of the KTT and MTT is their comprehensiveness. However, because these measures screen a number of far and near point skills there exists a greater possibility of referral error than on the Snellen. That is, the more tests that are administered during a vision screening, the greater the opportunity for errors to occur. The results shown in Table VIII show the errors made by the KTT and MTT tended to be overreferrals, rather than the more serious underreferrals made by the Snellen. Several subtests on the KTT and MTT are influenced by developmental factors (e.g., muscle balance, stereopsis) again increasing the potential for errors. Different results might have been obtained had the sample been randomly selected, been larger, and/or had included students from a wider grade range.

Although it is difficult to make direct comparisons

between studies regarding a test's efficacy, because of differences in samples, procedures, and referral criteria, such comparisons can sometimes give an indication of whether a particular test tends to consistently overrefer or underrefer. With this in mind, the present results are compared to earlier studies involving the Snellen, the KTT, and the MTT.

Snellen

In the present study the Snellen had an underreferral rate of 30% (see Table VIII) which is consistent with the 25% rate reported by Spache (1965) for the 1949 St.Louis study. Eisner and Oglesby (1971) reported Snellen underreferrals that ranged from 16.4% to 51.3%.

The 2% (see Table VIII) overreferral rate obtained in the present study is significantly lower than the 32.7% to 35.4% reported by Eisner and Oglesby (1971). This is probably due to the size and nature of the sample tested in this study. Had a large number of children, randomly selected from the general primary student population, been tested different results may have been obtained.

Keystone Telebinocular Technique

Table XI compares the percentages of different referrals obtained for the KTT in the present study to those found in the 1956 testing of the Orinda study (Blum et al., 1959). In the present study referrals were higher in all categories, except negative referrals. Differences in the sample may have influenced the findings of the two studies. The Orinda sample was randomly selected from a large school population, while the present sample was drawn from five optometric practices.

Table XI

Comparison of KTT Referral Rates for Primary Students in the Present Study and in the 1956 testing of the Orinda Study

	REFERRAL CATEGORIES			
	positive referrals	negative referrals	over referrals	under referrals
Orinda Study, 1956[1]	9%	76%	6%	9%
Present Study	23%	45%	13%	18%

[1]Summarized from Blum et al. (1959)

Modified Telebinocular Technique

In a 1976 study Walton compared the MTT to the MCT and obtained a referral agreement of 89.2%. The present study found that, of the three screening measures tested, the MTT had the highest percentage (77%) of correct referrals (see Table IX). These results suggest the MTT would be a useful vision screening measure that could be given by non-vision specialists, particularly where professional vision services are limited.

CHAPTER V - SUMMARY AND RECOMMENDATIONS

Although the actual incidence of children requiring professional vision care does not yet seem to have been established, the reported rates indicate that a variety of visual anomalies occur in sufficient numbers among children to warrant recommendation of a comprehensive vision screening programme within the school system (Coleman, 1970; Cross, 1975; Harley & Lawrence, 1977; Jervis, 1978; Ontario Ministry of Health, 1976; Province of British Columbia, Ministry of Health, 1977; Rosen, 1966; and Woo & Badger, 1978). The purpose of the present study was to investigate which of three vision screening measures would be the most accurate in identifying students in need of professional attention and could be administered by non-vision specialists (e.g., educational psychologists, school nurses) in British Columbia schools. A quasi-experimental study was conducted to investigate the referral efficacy of the Keystone Telebinocular Technique (KTT), the Modified Telebinocular Technique (MTT), and the Snellen against a standard optometric exam.

Screening Measures

No screening measure, regardless of its comprehensiveness, is equivalent to, or replaces, a clinical examination. Screening results do not equal diagnosis. This limitation must be considered when evaluating either an individual's screening performance or a measure's overall efficacy.

Snellen

The Snellen consists of rows of letters, of decreasing size, presented on either a wall chart or a light stand at a distance of twenty feet (six metres). Both eyes remain open during testing. Each eye is tested separately while the other is occluded. The standardized administration procedure of the National Society for the Prevention of Blindness (Harley & Lawrence, 1977) recommends both eyes first be tested together. However, the literature surveyed did not indicate this procedure to be commonly followed. The Snellen primarily measures far point acuity and myopia, although severe hyperopia and astigmatism may be detected. Visual acuity is expressed as a fraction; the numerator referring to the subject's distance from the chart, the denominator to the smallest letters seen. Standard vision is reported as 20/20. Passing criterion is usually 20/30 or 20/40 and is set at the examiner's discretion.

As the Snellen can be quickly and easily administered

and is inexpensive it is a widely used test. However it is not without limitations. Standardized testing conditions can be easily violated. Inconsistencies can occur in lighting and distance from the chart. Students can close or squint the occluded eye. Several students may be present in the testing room and thus have the opportunity to study or memorize the chart prior to being tested. A standardized administration procedure is lacking and there is no set referral criterion. Perhaps the greatest limitation is the test's restricted content. For example, near point acuity is not checked unless an alternate form is given. The literature did not report this to be a common procedure in most school vision screening programmes employing the Snellen, yet a significant amount of near point work is required of students.

Keystone Telebinocular and Modified Telebinocular

The Keystone Telebinocular Technique (KTT) and the Modified Telebinocular Technique (MTT) are binocular, stereoscopic screening instruments which measure the following visual skills at far and near points: monocular and binocular acuity, muscle imbalance, fusion, and amblyopia. Stereopsis and colour vision are also tested at far point. The MTT also screens for hyperopia, astigmatism, and anisometropia. A standardized sequence of cards is presented following a standardized administration procedure. The eyes are tested separately and/or together on specific

subtests. Recording forms indicate whether the examinee's visual skills are satisfactory, should be re-screened, or evaluated by a professional. Overall performance on both the KTT and the MTT is evaluated in determining whether a referral should be made. The subtests have not been designed to yield diagnostic data, therefore results should not be compared to findings from clinical tests of the same name.

The main advantages of the KTT and the MTT include standardized procedures for testing, recording, and interpreting a variety of visual skills at far and near point distances. Also important is that these measures can be administered by non-vision professionals after brief training. Other advantages include an internal light source which provides constant illumination between administrations, a compact size which makes it portable, and a height adjustment mechanism.

There are limitations for both the KTT and the MTT. The occluder between the lenses may be too wide for some young children causing them to move their head from side to side distorting test accuracy. Both measures are considerably more expensive than the Snellen. Controversial referral rates have been reported for the KTT (Harley & Lawrence, 1977; Williams, 1974; Harris & Sipay, 1975; and Mangrum, 1970). Blum et al.(1959) reported 14% of subjects tested in 1956 were erroneously referred. Technical data

are lacking in the KTT manual. The MTT is a relatively new vision screening measure. Little published data is available to recommend its use in a school vision screening programme. Walton (1976) reported the MTT to be comparable to the MCT as a screening measure (89.2% referral agreement).

Standard Optometric Exam

A consensus was obtained from the participating optometrists regarding the visual skills assessed during a standard optometric exam. These include tests of objective refraction (retinoscopy), subjective refraction (myopia, hyperopia, astigmatism), tropias, phorias and fusion at near and far points, vergences and versions at far and near points, amplitude of accommodation, stereo acuity, colour vision, and internal and external ocular health.

Subjects and Method

Sixty children, aged 6-0 to 9-11, who had scheduled appointments with one of five optometrists in Coquitlam, Surrey, and White Rock, British Columbia participated in the study.

All subjects were given the three screening measures, a letter identification test, and a standard optometric examination. Subjects wearing glasses were screened without

their glasses.

A letter identification test was given to each child prior to administration of the KTT and the MTT in order to determine whether limited letter identification skills or vision difficulties were responsible for errors on MTT subtests and the Snellen. Subjects making more than two errors were excluded from the study.

Each child was administered the KTT and the MTT by the researcher. Subtests common to both measures were given only once; the complete KTT and remaining MTT subtests were alternated with the complete MTT and KTT specific subtests. The Snellen was given by the optometrists during the standard optometric exam.

Commercial recording forms were utilized to record KTT and MTT performance. Summary data for each subject were noted on individual record sheets.

The referral criteria given in the directions and on the record forms were followed for the KTT and the MTT. For this study all optometrists used a passing criterion of 20/40, for each eye, on the Snellen. Performance on the standard optometric exam was evaluated by the optometrist's professional judgement.

Subjects' performance on each screening measure was compared to their performance on the standard optometric exam and categorized as a positive referral, a negative

referral, an overreferral (false positive), or an underreferral (false negative).

Referral rates for each screening measure were compared to referrals from a standard optometric exam by chi-square and phi coefficient analyses.

Delimitations

Delimitations centered on the sample. Subjects were children aged 6-0 to 9-11 and registered in Kindergarten through fourth grade. There were few children in each age category. Only children who had scheduled appointments with one of the participating optometrists and whose parents agreed to their taking part in the study were screened. Other delimitations included restricting the number of optometrists involved and not obtaining inter-optometrist reliability because of the economic restrictions of a non-funded study and the number of visual exams allowed under health plans.

Limitations Within Measures

As in any test, limitations exist within the three screening measures which are inherent within the measures. These involve the complexity and completeness of directions to the examinee, the response mode required, the nature of

the subtest stimuli, and the explicitness of instructions to the examiner regarding administrative procedures and/or test interpretation.

Keystone Telebinocular and Modified Telebinocular

Difficulties were encountered on the following KTT and MTT subtests:

1. KTT far point acuity (cards 4 1/2, 5, & 6)

For this subtest the examinee must indicate in which cardinal position dots are located on receding signboards. Some children, particularly six and seven year olds, confused left and right. Therefore hand gestures tended to be more reliable than verbal responses. Because the examinee must locate dots on a total of 30 signboards, on the three cards, boredom or the adoption of a response set (tendency to locate the dot in one position, e.g., on the left) may have decreased validity of some answers on later signboards.

2. MTT hyperopia (cards 4 1/2, 5, & 6)

The KTT distance acuity cards are viewed through a +2.00 lens to screen for hyperopia. Therefore difficulties noted for the KTT apply to the MTT: the left-right confusion displayed in the verbal responses of young children, boredom with the task, and adoption of a response set. Because the

stimulus cards are viewed through a plus lens, dots are not always visible. Some children had difficulty with the requirement that they were to look for something which might or might not be present. This task is contrary to most school tasks which require students to locate the one correct answer.

3. KTT near point acuity (cards 12, 13, & 14)

This subtest requires the examinee to identify diminishing patterns as being black lines, black dots, or solid gray presented on a yellow background. Some children had difficulty remembering the names for the patterns. For example, some large patterns of black lines were called squares. Upon questioning it was learned that the children were referring to the yellow squares formed by the black lines. A possible total of 66 patterns could be identified on the three cards, which sometimes led to boredom, guessing, or a response set.

4. MTT far and near point acuity (cards 4W & 12)

On both cards the examinee was required to identify rows of capital letters of decreasing size. Some children, particularly the younger ones, became confused about which line(s) they had read and which one followed.

5. colour vision (KTT & MTT cards 8 & 9)

The examinee is required to read two digit numbers. Some children displayed reversals (e.g., reading 23 for 32), but correctly identified numerals pointed out independently.

6. KTT interpretation

Directions for interpreting KTT subtest performance tend to be vague. Developmental factors are noted for some subtests (e.g., stereopsis, lateral posture, fusion, and near point acuity), but specific guidelines with respect to making referrals are not given.

Snellen

The Snellen, as frequently administered in a school vision screening programme, is not without limitations. It has a non- standardized administration procedure and referral criterion is at the examiner's discretion. Other limitations include inconsistent light conditions, variability in the distance between the examinee and the chart, and, in school settings, the frequent presence of several children in the testing room which affords the opportunity for studying and/or memorizing the chart prior to screening.

Results and Conclusions

Chi-square and phi coefficient analyses were used to make the following comparisons:

1) the referral efficacy of the MTT versus that of the KTT
2) the referral efficacy of the MTT versus that of the Snellen
3) the referral efficacy of the KTT versus that of the Snellen

Results indicated that there were no significant differences in the referral efficacy of the MTT and the KTT, for any type of referral. The MTT was found to have greater efficacy than the Snellen for positive referrals and underreferrals, $\chi^2(1)=7.000$, $p < .01$ and $\chi^2(1)=8.909$, $p < .01$ respectively. No significant difference was found between these measures for negative referrals. The Snellen had greater efficacy than either the MTT or the KTT for overreferrals, $\chi^2(1)=7.364$, $p < .01$ and $\chi^2(1)=5.444$, $p < .05$ respectively. No other significant referral diferences were found between the KTT and the Snellen.

Not only is it important to know whether there are significant differences in the referral efficacy of screening measures, but also for which type(s) of referrals these differences apply. Overreferrals and underreferrals are both undesirable. The former make unnecessary and therefore inefficient use of professional services.

Underreferrals are more serious as required professional attention is not obtained. Therefore, in selecting a vision screening measure emphasis should be placed on the measure which makes the fewest underreferrals. The obtained results indicate a significant difference between only the MTT and the Snellen for underreferrals; the MTT had the greater efficacy. Although the Snellen had greater efficacy than either the MTT or the KTT for overreferrals, its higher underreferral rate decreases its usefulness as a screening test. Also of note is that the MTT was more accurate than the Snellen in identifying positive referrals.

The appropriateness of a test depends upon more than its statistical merits. While statistical analyses did not show significant differences between the MTT and the KTT there are administrative factors which differentiate between them. The MTT employs letter identification subtests to screen far and near point acuity. Thus the subtests' requirements are familiar to students. The KTT far point acuity subtest requires examinees to locate the position of dots on receding signboards. This task was found to be confusing. Some children were not sure what was required. Others displayed confusion between the left and right sides of the signboards and therefore gestures had to be used to ensure reliability of responses. The near point acuity subtest on the KTT requires pattern identification. Some children had difficulty remembering the correct pattern names and whether they were to identify the black or yellow

part of the pattern. Others frequently lost their place. Several children found the novelty of this subtest frustrating and its length and repetition boring. In fairness, not all MTT subtests are free of confusion or administrative difficulties. For example, the MTT subtest for hyperopia employes the KTT far point acuity cards and a plus lens, hence dots are not always visible. The length, repetition, and novelty of this task posed difficulties for some children. However, the overall impression was that administration of the MTT went more smoothly, for most children, than did the KTT. It could be hypothesized that the less frustration experienced by the examinee during screening, the more reliable his or her responses.

Taking into consideration both statistical findings and administrative differences when selecting among the Snellen, the KTT, and the MTT for use in a school vision screening programme, the MTT appears to be the more useful measure for identifying students requiring professional care.

Recommendations

Test Modifications

Modification to either administrative procedures or to test stimuli for parts of the KTT, the MTT, and the Snellen would improve screening efficacy. The following changes are

suggested:

1. KTT far point acuity and MTT hyperopia (cards 4 1/2, 5, & 6)

These cards be replaced with a test that would eliminate left-right differentiation and would be either shorter or more varied and therefore less boring to young children.

In order to avoid confusion with the terms left and right children be required to use a pointing response for the existing cards.

2. KTT near point acuity (cards 12, 13, & 14)

This subtest be replaced with one that is shorter and less confusing to children.

3. MTT acuity subtests (cards 4W & 12)

The rows of letters be preceded by a numeral or geometric shape to aid children in keeping their place.

4. KTT and MTT colour vision (cards 8 & 9)

Administration include retesting of failures due to reversals by having the examinee identify numerals individually rather than reading two digit numbers.

5. KTT manual

The manual be made more specific regarding interpretation and types of referrals, especially for primary students for whom developmental factors influence test performance.

6. Snellen

Clarification and standardization of administration procedures are needed.

a) Whether the examiner should begin with the first row and work systematically through the chart or whether certain rows should be skipped if the previous row was passed should be established.

b) The number of letters that must be correctly identified for the row to be scored as passed (e.g., 4/6 or 6/6) should be established.

c) The referral criterion should be set for specific ages.

d) Only the examinee should be able to see the chart. Other children should not be waiting where they can view it.

Further Research

Given that the differences in referral efficacy obtained for the Snellen, the KTT, and the MTT are applicable only to the sample studied, it is recommended that a more extensive study of the efficacy of vision screening measures, suitable for use by non-vision specialists in a school screening programme, be undertaken. Ideally such a study would be a joint venture by optometrists, ophthalmologists, public health nurses, and school personnel. The following parameters are suggested:

a) a randomized sample from throughout British Columbia

b) students aged 6-0 to 18-6 be represented

c) establishment of standard screening referral criteria

d) assignment of examinees to a participating optometrist and/or oththalmologist for professional evaluation

e) inter-rater reliability be established among the vision professionals (i.e., between optometrists, between ophthalmologists, and between optometrists and ophthalmologists).

f) all screeners receive formal training in the administration of each screening measure investigated.

Besides investigating referral efficacy of screening measures, such a study would provide guidelines for a standardized provincial school screening programme (e.g., all school districts use specified tests to screen far and near point acuity in set grades) and also guidelines for provincial referral criteria.

While the present study recognized the need for such guidelines, its intent was to identify a reliable screening measure which could be used by non-specialists until such time as a comprehensive provincial vision screening programme could be established. Of the three screening measures studied the MTT had the lowest rate of underreferrals. This finding recommends the MTT as a valid school vision screening measure.

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APPENDIX A

Glossary of Vision Terms

GLOSSARY OF VISION TERMS

Anatomical Components of Vision

crystalline lens - a biconvex, transparent structure which, as a result of changes in its curvature, alters the accommodative state of the eye

extraocular muscles - the external eye muscles which control eye movements

fovea - a 1.5 mm diameter area of the central retina having the highest resolving power and therefore maximum visual acuity

intraocular muscles - the muscles inside the eyes which control pupil diameter and accommodation

visual cortex - that part of the brain located in the occipital area which is involved with visual perception

Visual Terms

accommodation - the neuro-muscular process responsible for changes in the shape of the lens which causes changes in the eye's focussing distance, therefore objects at varying distances can be viewed clearly; is important in near point tasks (e.g., reading)

amblyopia (lazy eye) - reduced acuity not attributable to structural or pathological anomalies and not responsive to refractive correction

aniseikonia - a relative difference in the size and/or shape of an image is perceived

colour blindness - the inability to perceive some or all wave lengths of light

convergence - the neuro-muscular process responsible for turning the eyes inwards, when changing fixation from far to near; associated with increased accommodation

corresponding retinal points - two retinal points, one in each eye, which when stimulated give rise to a single visual percept

diplopia - the condition in which a lack of fusion results in a single object being perceived as two objects; may not be detected unless the eyes are tested together

divergence - the neuro-muscular process responsible for turning the eyes outwards when changing fixation from near to far; associated with decreased accommodation

fusion - the slightly different images seen simultaneously by each eye are fused into one image in the brain; slow fusion may hinder reading

motor fusion - the extraocular muscular process resulting in the simultaneous stimulation of corresponding retinal points

sensory fusion - the neural process which combines and integrates into a single percept the perceptual images which are seen separately by the two eyes

fixation - looking at and briefly focusing on an object so that its image falls on the fovea of the eye

pursuits - following eye movements which maintain foveal fixation on a moving object

saccades - abrupt, voluntary shifts in fixation from one point to another, as occurs in reading; may not be fully developed until age six or seven

phoria - a latent ocular deviation (not detected unless specific testing done, e.g., a cover test) in which the primary lines of sight fail to intersect at the object being viewed

esophoria (overconvergence) - the inward turning of the eyes relative to each other therefore, the primary lines of sight over-converge

exophoria (underconvergence) - the outward turning of the eyes relative to each other therefore, the primary lines of sight under-converge

primary line of sight - the line joining the fovea with the object being viewed

stereopsis (depth perception) the binocular visual process which permits the judgement of relative distances of visual objects; binocular fusion is necessary for stereopsis

tropia (strabismus, squint) - a manifest ocular deviation in which the primary lines of sight fail to intersect at the object being viewed due to a lack of binocular fixation, which results from abnormal alignment (lack of muscle balance) between the eyes

esotropia (cross-eyed) - convergent strabismus; lack of fusion because one eye turns in too far

exotropia (walleyed) - divergent strabismus; lack of fusion because one eye turns out too far

visual acuity - the clearness of vision which is a function of the sharpness of retinal focus, the sensitivity of the nervous system, and perception (interpretation) which occurs in the brain

ametropia - a clear image is not formed due to refractive errors

anisometropia - the refractive condition in which the degree of refractive error differs between the two eyes

astigmatism - the refractive condition in which light rays from a single source are not focused at a single point, but rather as two images at different distances, often at right angles, therefore a distorted (e.g., blurred or slanted) image is seen at both far and near distances

emmetropia - the refractive condition in which parallel light rays enter the eye and focus exactly on the retina resulting in a clear retinal image

hyperopia - the refractive condition in which parallel light rays are focused behind the retina when accommodation is relaxed; if there is sufficient accommodation to compensate distance objects may be seen clearly

myopia - the refractive condition in which parallel light rays are focused in front of the retina, resulting in a blurred retinal image for objects further than the near point

Vision Personnel

ophthalmologist - a medical practioner specializing in the medical and surgical care of the eyes who diagnoses and treats structures and functions of the eye, diseases of the eye, prescribes corrective lenses (glasses), contact lenses, medications, and performs surgery; provides specialized (secondary) vision care

optician - a person who fills prescriptions, from an ophthalmologist or an optometrist, for corrective or contact lenses

optometrist - a nonmedical practioner trained to diagnose structures and functions of the eyes (refractive errors, binocular anomalies, diseases of the eyes), and to prescribe corrective lenses (glasses), contact lenses, optical aids, and vision therapy; usually provides an individual with primary vision care

orthoptist - an individual who administers visual perceptual and coordination (eye muscle) training to enhance binocular vision, under the direction of an optometrist or ophthalmologist

Other Vision Terms

Landolt ring or Landolt broken circle test - a chart of circles with openings in different positions; dimensions of ring and opening are rigidly prescribed and therefore this test overcomes the letter size variations found among manufacturers of Snellen charts

prism diopter - a metric unit describing the amount of deviation in coordination or binocular vision

resolution acuity - involves the relationship of the stimulus and its background; part of the background shows through openings in the stimulus, hence the stimulus is viewed as a separate object from the background

Note. Recognition and appreciation are due the participating optometrists for their assistance in preparing this glossary, especially Drs. Jackson, Jantzi, and Smith for providing the more technical definitions.

APPENDIX B

The Modified Clinic Technique

THE MODIFIED CLINIC TECHNIQUE

The Modified Clinic Technique (MCT) employs a series of tests to screen for the presence and extent of visual anomalies. Tests screen for objective refraction (retinoscopy), subjective refractive status (myopia, hyperopia, astigmatism) at far point and reading distances, muscle imbalance (cover test), amblyopia, and anisometropia. Colour vision and stereo acuity tests may be administered. Internal and external ocular health is also noted. The inclusion of the cover test and retinoscopy necessitates the MCT be administered by professional vision care personnel.

APPENDIX C

The Orinda Study

THE ORINDA STUDY

(Vision Screening for Elementary Schools)

H.L.Blum, H.B.Peters, J.W.Bettman, 1959

The Orinda study investigated the referral efficacy of several vision screening procedures among school students in Orinda, California, a residential suburban community. The study began in 1954 with students in grades one through six being tested. Students were rescreened in 1955 and 1956. The number of participants varied over the three years of the study and reflects changes within the school population.

The following tables describe the sample, list the visual skills screened, and show the obtained results. Only information pertinent to the present study is presented.

Table XII

Subjects Tested and Vision Screening Tests Administered Each Year during the Orinda Study

							California State Recommended Procedure							
				parent	observations									clinical
year	N	ages	grades	questionnaire	teacher	nurse	Snellen	plus lens	cover test	MVT[1]	KTT[2]	MCT[3]	exam
1954	1163	5-13	1-6	X	X	X	X	X	X	X		X	X
1955	1475	6-14	1-7		X	X	X	X			X[4]	X	X
1956	1274	7-15	3-8	X	X	X	X	X		X	X[5]	X	X

Note. Summarized from Blum et al. (1959)
[1]Massachusetts Vision Test
[2]Keystone Telebinocular Technique
[3]Modified Clinic Technique
[4]no retesting of failures as recommended by manufacturer
[5]retesting of failures conducted

Table XIII

Keystone Telebinocular Subtests Administered during the Orinda Study in 1955 and 1956

visual skill	year 1955	1956
simultaneous vision	X	X
lateral phoria (far & near)	X	X
fusion (far & near)	X	X
left visual acuity (far & near)	X	X
right visual acuity (far & near)	X	X
stereopsis	-	X
visual acuity, both eyes (far & near)	-	-
colour perception	-	-

Note. Summarized from Blum et al. (1959)

Table XIV

Percentage of Referrals, by Referral Category, in the Orinda Study during 1955 and 1956

	REFERRAL CATEGORIES			
	correct referrals	non referrals	over referrals	under referrals
SCREENING MEASURES				
Clinical Exam				
1955	17%	83%	-	-
1956	17%	83%	-	-
KTT[1]				
1955	16%	27%	56%[3]	1%
1956	9%	77%	6%	8%
MCT[2]				
1955	17%	81%	2%	<.5%
1956	17%	82%	1%	<.5%

Note. Summarized from Blum et al. (1959)
[1]Keystone Telebinocular Technique
[2]Modified Clinic Technique
[3]due to examiner error

Table XV

Percentage of Primary Student Referrals, by Referral Category, in the Orinda Study during 1955[1] and 1956[2]

	REFERRAL CATEGORIES			
	correct referrals	non referrals	over referrals	under referrals
SCREENING MEASURE				
Clinical Exam				
1955	16%	84%	-	-
1956	18%	82%	-	-
KTT[3]				
1955	15%	23%	61%[5]	1%
1956	9%	76%	6%	9%
MCT[4]				
1955	15%	83%	1%	1%
1956	18%	79%	3%	<.5%

Note. Summarized from Blum et al. (1959)
[1]students aged 6-8 years
[2]students aged 7-9 years
[3]Keystone Telebinocular Technique
[4]Modified Clinic Technique
[5]due to examiner error

APPENDIX D

Recording Forms and Protocols

COMPARISON OF THREE VISION SCREENING MEASURES WITH A STANDARD OPTOMETRIC EXAM

SUBJECT: _____ DATE: _____

SEX: M ____ F ____ D.O.B. _____

GRADE: _____ C.A. _____

TIME: started _____ stopped _____ total _____

TEST PERFORMANCE:

LETTER IDENTIFICATION:
_____/26 criteria met _____
(criteria - 24/26, 92%) criteria not met _____

KEYSTONE TELEBINOCULAR TECHNIQUE:

	1st administration	retest
no referral indicated	_____	
referral indicated	_____	_____
retest	_____	_____

MODIFIED TELEBINOCULAR TECHNIQUE:

	1st administration	retest
no referral indicated	_____	
referral indicated	_____	_____
retest	_____	_____

SNELLEN:
no referral indicated _____
referral indicated _____

OPTOMETRIC EXAMINATION:
unnecessary referral _____
necessary referral _____
(corrective lenses, therapy, continued observation)

COMMENTS:

LETTER IDENTIFICATION TEST

T	_____
P	_____
G	_____
A	_____
F	_____
S	_____
D	_____
E	_____
L	_____
W	_____
K	_____
V	_____
C	_____
Z	_____
R	_____
O	_____
H	_____
J	_____
B	_____
I	_____
N	_____
Y	_____
U	_____
M	_____
X	_____
Q	_____

KEYSTONE
School Vision Screening

FOR USE WITH THE KEYSTONE TELEBINOCULAR SCHOOL SURVEY CUMULATIVE RECORD FORM NO. 5-A CATALOG ORDER NO. 5521

Name _____ Sex _____

School _____ City _____

Grade _____ Room _____ Teacher _____

Date of birth _____ Date of test _____

Wearing glasses? Yes: For reading only ____; for distance only ____; both ____. No ____.

Snellen Standard (if desired)

With glasses: RE _____ LE _____

Without glasses: RE _____ LE _____

RAPID VISION SCREENING TESTS

DISTANT VISION TESTS		Pass	Fail
1A.	Dog should be seen jumping over pig	___	___
	The 4 blocks should be seen merged into 3	___	___
2A.	Balloon No. 2 is farthest away / Balloon No. 5 is closest	___	___
	Balloon 2 is red; balloon 5 is green	___	___
	Letters in Block A: D C Z P T	(Training only)	
	Letters in Block B: Z P D T C *	___	___
	Letters in Block C: L D T C Z *	___	___
NEAR VISION TESTS (16 INCHES)			
3A.	Yellow line should pass through white square	___	___
	The 4 balls should be seen merged into 3	___	___
4A.	Letters in Block A: L O Z P C	(Training only)	
	Letters in Block B: T Z O D L *	___	___
	Letters in Block C: O P T D C *	___	___

** Passing score: at least 4 letters*

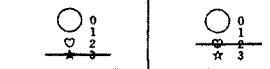
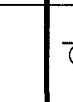
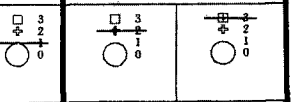
Failure on any test above indicates need for full test at right.

COMPREHENSIVE TEST BATTERY: QUESTIONS

1. What do you see?
2. Does the yellow line go through, above, or below the red ball?
3. To what number, or between what numbers, does the arrow point?
4. How many balls do you see?

4½. In each signboard there are five diamonds (point). In one diamond is a dot. (point to first signboard, show dot in the left diamond.) *Ask:* Where is the dot in Nos. 2, 3, 4, 5, etc.? *Tests 5 and 6 are the same as No. 4½. Ask:* Where is the dot?

7. (Point to the top line of symbols and name each one. Show by pointing that the cross stands out in 3-D.) *Ask:* Which symbol stands out in each of the next lines?
8. What number is in the upper circle? The lower left? The lower right? *(Test 9 is the same as Test 8.)*
10. To what number, or between what numbers, does the arrow point?
11. How many balls do you see?
12. In the three circles in the center (point) you see black crossed lines, black dots, and solid gray. Starting with No. 1 of the outer circles, you see black dots. No. 2 has black lines. What do you see in No. 3? Go as far as you can. *Tests 13 and 14 are the same as 12:* Name what you see in each of the circles.

TEST	LEFT EYE ONLY	RIGHT EYE ONLY	UNSATISFACTORY Underconvergence and/or low usable vision	RE-TEST AREA	EXPECTED RESPONSE	RE-TEST AREA	UNSATISFACTORY Overconvergence
FAR POINT TESTS							
1 (DB-10A) Simultaneous Vision							
2 (DB-8C) Vertical Posture	— only	○ only					
3 (DB-9) Lateral Posture	Arrow only	Numbers only	15 14 13 12	11	10 9 8	7	6 5 4 3 2 1
4 (DB-4K) Fusion	only ◐ ●	● ◐ only	● Far apart ◐ ● ● Close ◐ ◐ ●		● ◐ ●		Close ● ◐ ◐ ● Far apart ● ◐ ◐ ●
4½ (DB-1D) Usable Vision, Both Eyes			1 L 49% 2 B 70% 3 T 84% 4 L 88% 5 R 92%	6 T 96%	7 L 98% 8 B 100% 9 B 103% 10 R 105%		
5 (DB-3D) Usable Vision, Right Eye		No Dots Seen Unless Left Eye Is Occluded	1 T 49% 2 R 70% 3 L 84% 4 T 88% 5 B 92%	6 B 96%	7 L 98% 8 R 100% 9 T 103% 10 R 105%		
6 (DB-2D) Usable Vision, Left Eye	No Dots Seen Unless Right Eye Is Occluded		1 B 49% 2 L 70% 3 R 84% 4 R 88% 5 T 92%	6 L 96%	7 B 98% 8 L 100% 9 R 103% 10 T 105%		
7 (DB-6D) Stereopsis	⊔ + only	⊔ only ●	+ ○ ✳ ○ □ □ ♡ +	✳	+ ♡ ○		
8 (DB-13A) Color Perception	Top 32 Left 79 Right 23		NONE CORRECT 1 Out of 3	2 Out of 3	ALL CORRECT		
9 (DB-14A) Color Perception	Top 63 Left 92 Right 56		NONE CORRECT 1 Out of 3	2 Out of 3	ALL CORRECT		
NEAR POINT TESTS							
10 (DB-9B) Lateral Posture	Arrow only	Numbers only	10 9 8	7	6 5 4	3	2
11 (DB-5K) Fusion	only ◐ ●	● ◐ only	● Far apart ◐ ● ● Close ◐ ◐ ●		● ◐ ●		Close ● ◐ ◐ ● Far apart ● ◐ ◐ ●
12 (DB-15) Usable Vision, Both Eyes	1 D 10% 2 L 20% 3 D 30% 4 D 40%		5 L 50% 6 D 50% 7 D 60% 8 L 60% 9 D 70% 10 D 70% 11 G 80% 12 L 80%	13 L 90% 14 D 90%	15 L 100% 16 D 100% 17 L 102% 18 D 102% 19 G 103% 20 D 103% 21 D 105% 22 L 105%		
13 (DB-16) Usable Vision, Right Eye	1 D 10% 2 D 20% 3 L 30% 4 D 40%		5 L 50% 6 D 50% 7 D 60% 8 L 60% 9 D 70% 10 L 70% 11 D 80% 12 G 80%	13 L 90% 14 L 90%	15 D 100% 16 D 100% 17 G 102% 18 D 102% 19 L 103% 20 D 103% 21 D 105% 22 L 105%		
14 (DB-17) Usable Vision, Left Eye	1 L 10% 2 D 20% 3 D 30% 4 D 40%		5 L 50% 6 D 50% 7 D 60% 8 L 60% 9 D 70% 10 D 70% 11 L 80% 12 L 80%	13 G 90% 14 D 90%	15 L 100% 16 D 100% 17 L 102% 18 D 102% 19 L 103% 20 G 103% 21 D 105% 22 L 105%		

Examined by: _____

Revised 1974 by Keystone View 73-6561

Test Record Form WT

Walton Modified Telebinocular Technique of Vision Screening

KEYSTONE VIEW

Name _____

School _____ District _____

Grade _____ Room _____ Teacher _____

Age _____ Date this test _____

Complaints _____

Glasses worn? ☐ Reading only ☐ Distance only ☐ All times ☐ No

TEST	LEFT EYE ONLY	RIGHT EYE ONLY	UNSATISFACTORY Underconvergence, left eye turns upward, myopia, and/or astigmatism	BORDER-LINE	EXPECTED RESPONSE	BORDER-LINE	UNSATISFACTORY Overconvergence, right eye turns upward, and/or hyperopia
Place Card Holder at Far Point Position							
FAR POINT TESTS							
1 *Simultaneous vision*							
2 *Vertical phoria*	Line only	Symbols only					
3 *Lateral phoria*	Arrow only	Numbers only	15 14 13 12	11	10 9 8	7	6 5 4 3 2 1
4 *Fusion*	Only ● ◐	● ◐ Only	● ◐ Far apart ◐ ● ● ◐ Close ◐ ●	Four becoming three	● ◐ ●	Three becoming four	Close ● ◐ ◐ ● Far apart ● ◐ ◐ ●
4W *Acuity, astigmatism, myopia and amblyopia*	Upper group: Right eye		NWM UZV 20/70 · DGO CFPE 20/50 · PGB OECF 20/40	BOF CPDE 20/30	CBDEGPO 20/25 · FBDPGEC 20/20		
	Lower group: Left eye		ZWN VMU 20/70 · EDP GFOC 20/50 · FCE OBGP 20/40	EDP CFOB 20/30	OPGEDBC 20/25 · CEGPDBF 20/20		
Insert plus lens							
4½ *Hyperopia, both eyes*	*Use 2.00 D plus lens*				1 L · 2 B · 3 T · 4 L · 5 R	6 T	7 L · 8 B · 9 B · 10 R
5 *Hyperopia, right eye*	*Use 2.00 D plus lens*				1 T · 2 R · 3 L · 4 T · 5 B	6 B	7 L · 8 R · 9 T · 10 R
6 *Hyperopia, left eye*	*Use 2.00 D plus lens*				1 B · 2 L · 3 R · 4 R · 5 T	6 L	7 B · 8 L · 9 R · 10 T
Remove plus lens							
7 *Stereopsis*	✣	○	✣ 1 ○ 2 ☆ 3 ○ 4 □ 5 □ 6 ♡ 7 ✣ 8	☆ 9	✣ 10 ♡ 11 ○ 12		
8 *Color vision*	Top 32	Left 79	Right 23	None correct	1 out of 3	2 of 3	All correct
9 *Color vision*	Top 63	Left 92	Right 56	None correct	1 out of 3	2 of 3	All correct
Place Card Holder at Near Point Position							
NEAR POINT TESTS							
10 *Lateral phoria*	Arrow only	Numbers only	10 9 8	7	6 5 4	3	2
11 *Fusion*	Only ● ◐	● ◐ Only	● ◐ Far apart ◐ ● ● ◐ Close ◐ ●	Four becoming three	● ◐ ●	Three becoming four	Close ● ◐ ◐ ● Far apart ● ◐ ◐ ●
12 *Acuity, presbyopia, reduced accommodation, and high ACA*	Column A: Left eye		R 20/200 · DCV 20/100 · VC ZRS 20/70 · VZ NOS 20/50 · DS CHV 20/40	ZO NSH 20/30	DVCNZOR 20/20		
	Column B: Right eye		D 20/200 · SHR 20/100 · HO NCZ 20/70 · DC RHV 20/50 · ZN ORD 20/40	CN ZOR 20/30	VNSCHOD 20/20		
	Column C: Both eyes		S 20/200 · NOZ 20/100 · ZD SVR 20/70 · SZ OND 20/50 · VZ ONS 20/40	RS DCV 20/30	SDCVNOZ 20/20		

Printed in U.S.A. (73-7161)
Ordering Number 5546

Examined by _____

☐ Passed ☐ Recommend professional examination

THE MODIFIED VISUAL SKILLS TEST
FOR USE WITH THE TELEBINOCULAR

GENERAL INSTRUCTIONS

The Modified Telebinocular test procedure is based on the standard fifteen card skills set with two cards added and three temporarily deleted.

> Insert the new 4-W (Walton) card between the #4 and #4½ test cards. Remove test cards #12, #13 and #14, and insert the Sloan Near Point Acuity Card to replace them.

Administer all tests per standard procedures except for cards #4W, #4 1/2, #5 and #6. See following special instructions.

INSTRUCTIONS FOR #4-W CARD

This test screens for the following conditions: Amblyopia, anisometropia, near-sightedness and astigmatism (also far-sightedness combined with astigmatism and near-sightedness combined with astigmatism.)

Present the test card binocularly, initially. Ask, "What do you see?" Answer should be: "two groups of letters." Ask, "Are they equally clear?" If not anisometropia, amblyopia or suppression is indicated.

Begin with the lower group of letters (right eye) and direct the subject to start at the top line and read down. Follow them on the record form testing each error. Stop them when they make four errors on one line. Repeat with the lower group of letters (left eye).

If the subject is confused by the presence of both groups of letters, the test may be performed by occluding the left eye and then the right eye.

Optional

After the initial binocular test, you may simply repeat under monocular conditions (left eye then right eye occluded) for additional information. Different results from the binocular test should be recorded.

> Note: The 20-70 line is non-astigmatic and is included to allow the average person to achieve some success before proceeding to the actual test material.

SPECIAL INSTRUCTIONS FOR ADMINISTERING THE #4 1/2, #5, and #6 TEST CARDS

Explanation:

This test is for far-sightedness. It is a Binocular Plus Lens Test. The targets provide enough stereoscopic clues to assure a relaxed test environment. TEST card #4 1/2 serves the dual purpose of allowing a moment of relaxation in the instrument prior to actually administering the tests on cards #5 and #6, and at the same time allows the instructions to be given for taking the test with the test clues available to both eyes, thus circumventing any problems created by a monocular (one-eyed) visual condition.

Administration:

Insert the Plus Lens into the instrument or place appropriate spectacles on person being tested and expose the #4 1/2 test card.

Ask the question, "Do you see the railroad tracks going under the bridge into the distance?" Continue, "Under the number one is a signboard with five diamonds in it. A black dot might be in one of them. "Do you see a black dot in either the top, bottom, left, right or middle diamond?" If no dot is reported proceed to test #5. If the dot is correctly identified have them locate dots successively in each signboard as far as possible. Record last correct response with a vertical divider line to its right. Proceed to test #5.

Test #5: Start at #1 signboard and record last correct response as above.
Test #6: Identical to test #5, except for the eye tested.
Remove Plus Lens.
Proceed to Tests #7, #8, #9, #10, and #11, and administer per standard procedures. Test #12: Ask the patient, "How many columns do you see?" If 3 are reported, have patient read columns A, B and C. If 4 or more columns are reported, occlude the right eye and have patient read column A. Then occlude the left eye and have patient read column B. (Disregard column C.) This completes the test. Referral is based upon failure to correctly identify 3 or more 20/40 letters in columns A, B or C. (Column C is only used if 3 columns are observed.)

INTERPRETATION AND REFERRAL CRITERIA

Test #1 - Failure to see both targets indicates either enucleated eye, blindness in one eye, a gross suppression or a markedly deviating eye. --Refer--
Proceed with following tests where feasible.

Test #2 - Failure indicates an incorrect vertical posture of one eye relative to the other. -- Refer --

Test #3 and #4 - Evaluate together -- failure on #3 and #4 -- Refer -- Failure on 3 or 4 only -- Refer to teacher for close classroom observation. Refer on classroom symptoms if found.

Tests 4-W - Primary grades -- Refer when they fail to read four or more letters on the 20/40 line. (Refer upper elementary grades if they fail four or more on the 20/30 line.)

Test #4 1/2 - No referral - See manual for evaluation.

Tests #5 and #6 - Refer unsatisfactory responses (7 thru 10.)

Test #7 - (Stereopsis) - Administer to all age groups. Failure below 3rd grade refer to teacher for classroom observation and evaluation. 3rd grade and up refer only if associated with a failure on one or more of the other tests (3 & 4; 10 & 11 evaluated together) or if no correct responses.

Tests #8 and #9 - Color tests. No referral. Advise teacher and parents.

Tests #10 and #11 - Same criteria as tests #3 and #4.

Test #12 - Refer when they fail to correctly identify three or more letters in the 20/40 column.

Keystone View, Division of Mast/Keystone . 2212 East 12th Street Davenport, IA 52803

APPENDIX E

The CA, Sex, and Grade of Subjects

Table XVI

Classification of Subjects by Age and Sex

AGE	SEX: males	SEX: females	total per age
6-0 to 6-11	3	8	11
7-0 to 7-11	6	15	21
8-0 to 8-11	10	8	18
9-0 to 9-11	16	4	10

Table XVII

Classification of Subjects by Age and Grade

AGE	GRADE: kindergarten	one	two	three	four
6-0 to 6-11	2	8	1		
7-0 to 7-11		9	11	1	
8-0 to 8-11		1	6	10	1
9-0 to 9-11				6	4
total per grade	2	18	18	17	5

Note. N=60