Maximum Available Desk-to-Eye Distance for Students in Grades One and Two: Regional Norms and Statistical Comparison to Distance Used for Near Point Screening

Chapter II

Main Thesis Page

Chapter II:

Review of the Literature

Over the last 100 years, investigators in the field of eye care have conducted research that has resulted in normative data. Replication of these studies to update or extend the findings has involved using the viewing distances found in the earlier research. These distances have become standards for testing the same visual functions.

Viewing distance is a component of all visual tasks, research in vision and reading, vision screening, and a child's performance in the classroom. The visual demand of a task is more than what may easily be apparent. The visual demand varies with changes in the viewing distance and may also vary according to a child's age and visual development.

It is important to look at the normal developmental sequence of the visual system and visual skills. It is also important to look at the viewing distances used in investigations by eye care and reading specialists; to explore for studies which determine the work distance of young students; and to consider vision screening, its components, and its administration. It is equally important to look at school furniture and handwriting and their involvement with near viewing distance.

The review of the literature for this study is divided into six main areas. These are:

- the development of vision,
- research by eye care professionals,
- research by reading professionals,
- vision screening,
- school furniture, and
- handwriting.

Developmental Aspects of the Eye and Vision

The refractive status of the eyes is developmental in that it is expected to vary with age in ways that can be predicted. Some investigators consider that at ages 8 to 9 years a child's vision has completed its major transition and has settled into being predominantly farsighted (hyperopic), predominantly nearsighted (myopic), or properly correlated between the refractive system of the eye and the axial length of the eyeball (emmetropic) *(Borish 1970)* *(Michaels 1985)* *(Sheie and Albert 1977)* . Vision professionals also recognize that an individual's refractive status seldom remains static over a period of time.

In order to differentiate between expected normal vision and abnormal vision, one needs to know the developmental sequence of the maturing visual system. Valadian and Porter *(Valadian and Porter 1977)* described the refractive capacity of the newborn as being typically hyperopic due to the growth of the eyeball and to the refractive powers of the cornea and lens. They further reported that the tendency toward hyperopia increases slowly through about age 8 as the curvatures of the cornea and lens decrease relative to the growth of the eyeball. The refractive status varies from +0.1 D in newborns to +1.5 D in children at age 8. After age 8, the tendency is growth toward emmetropia, with +0.0 D common at ages 11 to 20. After age 20, there is a tendency toward myopia, which decreases after age 30. Valadian and Porter's statement that "refractive power goes through a developmental cycle" (p. 215) reinforces the need to recognize that changes of refractive status should be expected at all ages in life.

Brent and Arstikaitis *(Brent and Arstikaitis 1983)* stated that as a child grows, so do the child's eyes, and that after 5 or 6 years of age, hyperopia decreases. Pringle and Ramsey *(Pringle and Ramsey 1982)* emphasized that visual problems continue to develop during both the elementary years and adolescence because of growth and the developmental changes that occur. Sheridan *(Sheridan 1979)* discussed the visual functioning of a child from the age of 2 weeks to 2 to 3 years. She stated that the ability to pay visual and auditory attention at the younger age is confined to nearby environment within 10 to 12 inches from the child's eyes and ears, and is observed to expand spherically over time until the mature range is reached at 2 to 3 years of age. Sheridan also commented that a similar developmental process is observed in young children who are responding to treatment for amblyopia (suppressed vision): near vision, rather than distant vision, improves first.

A child's visual acuity may be spoken of in three ways:

- an acceptable level of acuity which allows the child to participate in activities appropriate for the child's age,
- the level of acuity which is expected at a given age, and
- the age at which emmetropic (20/20) vision is first expected.

Opinions among eye care professionals vary. For children under five years of age, 20/40 acuity is acceptable in that it allows them to participate in age-appropriate activities: beyond age five, visual acuity should be 20/20 *(Brent and Arstikaitis 1983)* . From school age through adolescence, visual acuity should be 20/20 *(Pringle and Ramsey 1982)* . Keeney *(Keeney 1966)* indicated an expectation of 20/20 vision as young as 4 years of age. Borish *(Borish 1970)* indicated that maximum acuity is achieved at approximately age 10. Valadian and Porter *(Valadian and Porter 1977)* listed an expected acuity of 20/70 at age 2, 20/30 at age 5, and 20/20 at age 7; however, they considered 20/30 to be adequate up to 8 years of age. In Keeney's *(Keeney 1966)* opinion, increases in concentration and crowding of the cones, which take place until puberty, underlie the enhancement of central acuity seen during childhood. These changes usually cease at about age 14.

In addition to acuity, other elements of visual functioning are developmental in nature. Pringle and Ramsey *(Pringle and Ramsey 1982)* developed a guide for caretakers and health care professionals in which they described the procedure that a caregiver may use to determine the presence of accommodation and control of the eye muscles:

> Ask the child to follow an object, such as the examiner's finger as it is moved to the left, right, up, and down, and close to the child's nose. Binocular motion should be present. If one eye tends to deviate in the opposite direction of the other eye it usually is indicative of weak eye

> muscles. This is a common problem in children and should be treated immediately. Eye accommodation may be tested with a flashlight. The pupil will constrict when the bright light is brought into focus. (p. 177)

Binocular vision should be apparent at age 4 or 5. Absence of this visual skill at these ages indicates the need to refer the child for professional care *(Pringle and Ramsey 1982)* .

Stein and Fowler *(Stein and Fowler 1982)* noted that the child's ability to monitor eye position is "necessary long before reading begins, but to read successfully a new degree of precision is demanded" (p. 332). They found eye dominance to be developmental in nature and that a dominant eye helps to define "visual direction when eye position signals provided each eye disagree" (p. 333).

Borish *(Borish 1970)* referred to the acquisition of a dominant or lead eye as being characteristic of a child's development. He spoke of neurological development at ages common to children in Grades 1 and 2 and its effect on some elements of visual development:

> The child matures neurologically between the ages of 7 to 8, and dominancy is fully established in terms of control, sighting, and function, although in cases of heterophoria, the other eye may assume temporary dominancy. Correct dominancy is restored when the heterophoria is corrected. (p. 436)

Pringle and Ramsey *(Pringle and Ramsey 1982)* referred to developmental changes in visual skills and the ages at which they are expected:

> By five years of age, true stereopsis is present. Central acuity is unconditionally entrenched at age six. The gross attention span has lengthened to nearly 20 minutes, and detailed attention extends to about two minutes. The physiological hyperopia of earlier life begins to decrease and emmetropia is established between the ages of nine and 11. (p. 463)

Whittington *(Whittington 1958)* perceived visual behaviors or skills to be abnormal when certain elements of normal visual development are missing at the expected ages.

Greater accommodation is required with hyperopia than with emmetropia. Borish *(Borish 1970)* defined accommodation as a function of the converging power of the optical system so that light from a near source is brought to a focus upon the retina. Accommodation is linked with both convergence and pupillary miosis (constriction) through near reaction or near synkinesis. Whenever accommodation occurs, the near synkinesis causes the eyes to converge and the pupils to constrict *(Dale 1982)* . Dale gave four possible stimuli for accommodation:

1. a blurred image coming to focus behind the retinal plane,
2. disparate retinal images,
3. conscious awareness that a near object is being viewed, or
4. a deliberate attempt to imagine that a near object is being viewed.

He spoke of the blurred vision experienced at the near point of convergence: "The blurred zone occurs before the break point when fusional convergence amplitudes are measured. The blurring is due to the induced myopia caused by the increased plus power resulting from accommodation" (p. 69). He also explained that the conscious awareness of a screening machine may result in proximal convergence and cause difficulties in using some of the automatic refractors or screening machines.

As a viewed object is brought closer to the eyes, convergence increases. As convergence increases, the stimulus to accommodate also increases. Convergence can become so great that accommodation is forced to change and the viewed target becomes blurred but remains single. As convergence is increased, the limit of fusional convergence is reached and the visual target appears doubled (diplopia). At this point, the subjective endpoint of convergence is reached. When the full limit is reached, the fusion reflex is lost and one eye moves outward. At this point, the objective endpoint of convergence is reached. With outward movement of the target, the fusion reflex is reintroduced, the eyes converge, and the visual target is perceived as single again. Dale *(Dale 1982)* noted that fatigue or emotional stress can lessen fusional reserve. Convergence is considered deficient when the near point convergence (NPC) distance is greater than 10 cm (approximately 4 inches). Subjective NPC is described as frequently being outside the range of normal NPC, being greater than 10 cm (3.94 inches), or up to 30 cm (11.81 inches) or more *(Dale 1982)* . The 30 cm remote distance of abnormal NPC is greater than the mean 6-inch working distance Hurst *(Hurst 1964)* found for his subjects in Grades 1 and 2.

Dale *(Dale 1982)* explained that in living persons the ever-present gravitational stimulus results in postural reflexes which provide balanced tonus to the extraocular muscles. The position of the eyes using only the minimal tonus is called the functional position of rest and can be demonstrated by suspending fusion while observing the occluded eye, as in the screening cover test. Dale explained the contribution of the child's tonus and nervous system to what appears to be a visual muscle problem: "Tonic innervation is excessive in early childhood but diminishes with age. This probably accounts for the so-called esotropia that develops in children secondary to poor vision in one eye" (p. 76). He stated that the excessive tonic innervation is not present in adults, indicating that with development the excessive innervation may be expected to disappear.

Brent and Arstikaitis *(Brent and Arstikaitis 1983)* stated that hyperopia begins to decrease at 5 to 6 years of age. Michaels *(Michaels 1985)* , however, found that the higher the degree of hyperopia at the time of entrance into school, the less likely the chance that a child would outgrow it. He pointed out that expected hyperopia tends to change 2 to 3 years later in boys than in girls, and that "the child who cannot see comfortably cannot read efficiently" (p. 477). Cashell and Durran *(Cashell and Durran 1971)* explained that the complex coordination of the eyes rests upon a series of conditioned binocular reflexes and becomes fixed by age 8.

Eames *(Eames 1961)* conducted a study of the amplitude of accommodation for school-aged children, with subjects as young as 5 years of age. He was responding to the assertion made by educators that children were entering school and learning to read at a period in their lives when their eyes were not mature enough to cope with the visual demands placed on them by the curriculum. He had found no historical data for a population below 8 years of age.

Eames' *(Eames 1961)* study measured both urban and nonurban subjects. He found the mean amplitude of accommodation to be larger than what he deemed to be the critical diopters of accommodation, that is, greater than +8.00 D. His selection of 8 diopters (the accommodation required for clear viewing at 4.92 inches or 12.5 cm when there is no accommodation in reserve) was somewhat arbitrary. He stated that it allowed for a reserve of accommodation when the child read at 25 cm (9.84 inches, which requires +4 D with no accommodation in reserve). He did not report, however, how this reading distance was related to visual demands in the school. He did find some urban subjects, aged 5, 6, and 7 years, who had less than this amplitude of accommodation. He made no suggestion as to how these individuals would, or could, cope with the visual demands of the curriculum or how the visual demands could be changed to meet their visual development.

Investigations by Eye Care Professionals

Several disciplines have developed investigations that are involved with vision or its use for tasks which are primarily components of school tasks. These tasks are reading and writing, the basic learning of the primary grades. Among the disciplines are the eye care professions of optometry, ophthalmology, and orthoptics.

Eye care professionals have been concerned with elements of the eye and vision that have become a part of eye examinations and vision screening *(Borish 1970)* . Among the visual elements that are involved in a child's handling of near school tasks are accommodation and convergence *(Wold 1967)* . These tasks are involved in the clarity and ease with which near vision is sustained. Refinements of both accommodation and convergence occur as the distance of a visual target decreases. When target letters of a given size are brought closer to the eyes, accommodation and convergence increase. Letters whose sizes are kept constant occupy a larger part of the visual field as the distance decreases. This causes them to appear larger and to be discriminated more easily.

For several tests, eye care professionals commonly utilize a chart with lines of letters, numbers, or symbols which become increasingly smaller in size from one line to the next. Letter charts are commonly used for both adults and children who have some reading experience. In order for the use of such a chart to be valid, the chart must be placed at a distance that allows the size of the letters on any of several given lines to occupy the standardized minutes of an arc in a visual field *(Borish 1970)* .

Some eye care professionals stipulated a distance to be used in testing near vision or the components involved in near vision. In some cases, however, although the test used is named, the distance is not stated *(Stein and Fowler 1982) (Stein and Fowler 1985) (Stein, Riddel, and Fowler 1986)* , leading the reader to assume that a distance commonly accepted by the eye care profession is involved.

Richards *(Richards 1973)* made no differentiation in techniques or methods in testing visual acuity at far distance and near distance. The only difference was the target distance. The near distance was stipulated as being 14 inches. In speaking of the near distance of specific work and styles of glasses, he mentioned by occupation the variations from 14 inches that may be needed. He indicated that "a careful determination of the distance of various tasks is very helpful" (p. 16). He did not give consideration to the available near distance for children, which may be shorter than that of adults.

Zellers, Alpert, and Rouse *(Zellers, Alpert, and Rouse 1984)* conducted a study to establish normal accommodative facility, that is, the rate at which accommodation can be stimulated and inhibited repeatedly during a specific period of time. Their sample was composed of adults, and their review of the literature left them with the following conclusion: "Unfortunately, a review of the literature shows little agreement on what constitutes a 'normal' accommodative facility finding" (p. 31). The analysis of accomodative facility is, in their opinion, to be included in "the complete evaluation of nearpoint visual skills of nonpresbyopes" (p. 31). The distance used was 40 cm (16 inches). The authors neither excluded nor included children as nonpresbyopes. They referred, however, to two studies of accommodative facility in children 6 to 12 and 6 to 11 years of age in which the near distance was also 16 inches. They did not comment on the usual near work distances of children in copying from the board while seated at their desks, a task involving accommodative facility.

Gilmartin and Hogan *(Gilmartin and Hogan 1985)* investigated the role of the sympathetic innervation of the ciliary muscle in determining tonic accommodation (TA); that is, determining the resting position of accommodation and convergence under darkroom conditions. They felt that some degree of smooth-muscle tone is retained after a sustained fixation over time and that this accommodative hysteresis will become evident in TA measurements taken immediately afterward. Their concern was based on what is described as simple or school myopia:

> If cognitive stress does indeed induce anomalies of autonomic function, it is conceivable that this, combined with excessive amounts of close work and a predisposition to hysteresis effects, may actually induce manifest myopia. Simple or "school" myopia may fall in this category, and most ophthalmic practitioners will be familiar with the depressing prospect of an initial -1 D correction at 10 or 11 years of age, progressing to, and stabilizing at, around -3 D at 12-13 years of age. (p. 92)

The -D refractive status indicates a degree of myopia or nearsightedness. They found a nonlinear hysteresis effect which they felt was enhanced by the association with a high level of concurrent parasympathetic activity during a nearpoint fixation. They did not indicate whether the distance for the near point was a standardized distance or one established for the individual. A standardized distance would likely have been 14 to 16 inches *(Borish 1970) (Rosner 1982)* .

The emmetropic individual is required to converge and accommodate simultaneously as binocular vision is maintained at near distance. The act of converging the eyes brings about some degree of accommodation. Mason *(Mason 1962)* found that convergence dominates and controls accommodation. He described the linkage between accommodation and convergence in a perfectly balanced emmetrope:

> To look at an object 1 m away, the eyes converge 1 M.A. and accommodate 1.0 D. When looking at an object 1/2 m away, the eyes converge 2 M.A. and accommodate 2.0 D, and so on. The efforts of convergence and accommodation are equal and therefore in perfect balance. . . . The amount by which he [the patient] is able to alter his accommodation is, of course, his relative amplitude of accommodation for the convergence being exerted during the test. Beyond the limits of the relative amplitude the patient has a choice of clear vision with diplopia or single but blurred vision. He cannot have both. (pp. 586, 587)

He spoke of plus lenses not always relaxing accommodation. This is of concern in screening children for hyperopia.

Daum *(Daum 1984)* studied the effect of using prismatic lens to improve convergence insufficiency. He described convergence insufficiency as a syndrome in which

> . . . (1) the angle of exodeviation is generally latent, and at a distance is much smaller than that at near; (2) the AC/A ratio is low; (3) the positive vergence at near is generally insufficient to compensate for the angle of deviation; (4) the nearpoint of convergence value is receded; (5) the accommodative amplitude is reduced by about 1 D from the minimum level for the age; (6)

> the stereopsis threshold is normal; and (7) suppression, if present, is likely to be intermittent in nature. (p. 21)

Convergence insufficiency adversely affects accommodation and may affect visual ability or comfort at near distance.

Convergence of the eyes at the distance a child uses for reading is required in order for the child to use binocular vision. Letourneau, Lapierre, and Lamont *(Letourneau, Lapierre and Lamont 1979)* completed a study designed to show the possible relationship between convergence insufficiency and school achievement for subjects in Grades 3 through 6, ages 7 to 14 years. Near point of convergence (NPC) was measured from the bridge of the nose. Subjects were observed as the penlight target was moved toward the eyes. The subjective NPC was reached when the subject judged the object viewed to appear doubled, and the objective NPC was reached as one eye began to diverge. The target was then moved away from the eyes to the points of recovery. The points at which binocular vision was regained were judged both objectively by the examiner as both eyes again focused on the object, and subjectively when the target was again seen as a single object. The investigators found no significant correlation between convergence insufficiency and school achievement. The data were not presented in a form which allows comparison of break and recovery points for individuals, but the group's three ranges for break (< 10 cm, 10 to 15 cm, and > 15 cm) and recovery (< 15 cm, 15 to 20 cm, and > 20 cm) were presented. Since no maximum and minimum points were given by Letourneau et al., the distances must be inferred from the midranges. The break midrange was from approximately 4 to 6 inches, and the recovery midrange was from approximately 6 to 8 inches. The recovery range distances were greater than the mean working distances found by Hurst *(Hurst 1964)* for students in Grades 1 and 2.

Although the study by Letourneau et al *(Letourneau, Lapierre and Lamont 1979)* involved diplopia, there is no indication that the authors investigated coping mechanisms that a child might have developed to avoid diplopia. Borish *(Borish 1970)* discussed suppression of vision as a means of avoiding diplopia. Suppression cannot always be determined by observing movement of the eye, nor can it always be recognized subjectively by the viewer. Letourneau et al *(Letourneau, Lapierre and Lamont 1979)* did not determine and eliminate subjects who might have developed suppression to avoid diplopia. Failure to exclude these subjects could have an effect on the correlation of convergence insufficiency and reading achievement. They dealt with this possibility by stating: "In this study no distinction was made between children who suppressed and those who did not. It may well be that children who suppressed were not impaired in reading, while those who did not suppress were" (p. 22). Suppression of one eye affects accommodation. The nonfixating or nondominant eye is usually the suppressed eye.

When one eye is suppressed, only monocular vision is being used. The amplitude of accommodation is not the same for monocular and binocular vision. Monocular amplitude is generally considered to be less than binocular amplitude because convergence is lacking *(Borish 1970)*.

The discussion by Letourneau et al *(Letourneau, Lapierre and Lamont 1979)* stipulates that testing for voluntary convergence should include sustained convergence. To test children's sustained convergence, the authors suggested use of the drop test. In this test, an object is used as a stimulus, first at a distance at which the child can focus. The object is then brought toward the child while focus is maintained:

> When the fixation object has been brought to the reading distance, the patient is asked to

> maintain convergence after the fixation object has been taken away; it is probably better to measure voluntary convergence this way to evaluate accommodative and fusional convergence. (p. 22)

The linear distance to be used as the reading distance was not defined. The reading distance may have been a standardized distance. Borish *(Borish 1970)* used 16 inches as the standard near distance in his chart of convergence when discussing esophoria and exophoria. He described the adult reading range as 13 to 16 inches. The reading distance could be established for the individual by means of the reading cards used in evaluating vision for possible lens correction (refraction). The reading distance for a child might be the individual's desk-to-eye distance, the Harmon distance from the child's knuckle to elbow, or the child's working distance. Rosner *(Rosner 1982)* spoke of a child's Harmon distance (the distance from the point of the elbow to the middle knuckle on the back of the fisted hand) as being as short as 9 inches. Hurst *(Hurst 1964)* found that some students in first and second grade had working distances as short as 4 and 5 inches. Sheridan *(Sheridan 1979)* found that the self-selected reading distances of most children ranged between 10 and 12 inches. The maximum length of a child's reading distance at a desk is limited and can be determined only by measuring the space while the child is seated at a desk.

Difficulties are inherent in using tests which involve a child's judgment of when an object is seen with blurred or diplopic vision, such as the tests by Letourneau et al. *(Letourneau, Lapierre and Lamont 1979)* . These difficulties are clarified in the discussion by Davis *(Davis 1959)* when he described orthoptic training for children with esotropia, a condition in which only one eye fixes on the target and the other eye turns inward. During the time of therapeutic training, the child learns to recognize when both eyes are gazing at the stimulus and to distinguish when seeing blurred, doubled, or single images.

Davis described the necessity for the patient to pass through a stage of blurred vision while the eyes are straight. He felt that a child, as a rule, has no problem tolerating 20/100 vision during outside activities. Later, the child is taught that blurred vision is unsatisfactory, and he must learn to see more clearly while keeping the eyes straight. Special devices are required to train near vision and involve the child in near tasks, such as drawing, writing, and coloring at the child's near work distance. Davis did not discuss determination of the work distance.

The near tasks employed by Davis *(Davis 1959)* for training deviant convergence at near distance can be considered typical for young students and are part of their occupation as students. Eye care professionals have conducted studies focused on meeting the visual demands of adult occupations *(Fox 1973) (Waters 1952)* . Students in school should be considered workers who share the common environment of working while seated at their desks. The occupational distance for near work by the student may vary from class to class during the day due to changes in the size and style of furniture at which the student is seated while working. The viewing distance may also vary from year to year due to the student's physical growth. Additionally, there may be forced differences of viewing distance brought about by the task, the illumination and luminance of the environment, and the use of one or both hands at the same time to complete the task. The distance may also be varied as the angle between the lower arm and the upper arm changes with use of the hands *(Harmon 1958)* .

The yearly difference which results with growth does not occur in the adult, although adult viewing distance may change due to postural variations that often come about with age. Investigations to determine the mean working distance for given adult occupations have been pursued. Borish *(Borish 1970)* reported that the distance span commonly used for evaluating the needed strength of bifocal lenses (14 to 16 inches) is considered the adult reading distance. Hurst *(Hurst 1964)* was concerned that the adult reading-working distance was used for evaluation of children's vision. He had found the mean working or vocational distance for 86 children in Grades 1 and 2 to be 5.7 inches.

Waters *(Waters 1952)* researched several vocations which involve near work, the typical vocational distances, and the sizes of the visual fields. For adults engaged in general or full desk work, he gave the visual fields as 12 x 18 inches and the work distance as 10 to 16 inches. For those involved in special desk work, the visual field was cited as 18 x 30 inches and the work distance as 12 to 28 inches.

Fox *(Fox 1973)* also discussed vocational distances. He referred to 14 to 18 inches as the most common vocational distances for general usage. The near work distances he cited ranged from 5 inches for tool and dye makers to 20 inches for punch operators. He did not include students of any age among his subjects.

Waters' *(Waters 1952)* data show that as viewing distance shortens, the visual field decreases. The shortest viewing distance in Waters' data is 10 inches. Children, being shorter than adults, are likely to have an even shorter viewing distance. Consequently, their working fields may be smaller than those of adults. This may be of concern in terms of the peripheral visual field for reading *(Ikeda and Saida 1978)* .

Hurst's *(Hurst 1964)* investigation in 1961 involved determination of the near working distances of 692 Canadian children, aged 60 through 180 months (5 through 15 years), in 35 classes, Grades K-8. He determined working distance range for reading while holding a book and while writing at a desk, the habitual working distance for each condition, and the mean habitual work distance for ages and grades. Hurst found the writing distance to be approximately 2 inches shorter than the reading distance for children in the primary grades. He found that neither of the mean working distances fell within one standard deviation (±3 cm) of the mean Harmon distance *(Harmon 1958)* determined for male subjects and that their writing and reading distances were shorter than their elbow-to-knuckle Harmon distances. The mean nearpoint working distances in Hurst's study are presented in Table 1.

Table 1: **Mean Nearpoint Working Distances According to Age Group in Hurst's study (in inches)***(Hurst 1964)*

Task by Gender		**Age in**	**Months**	
		(Midpoint	**Interval)**	
	65	75	85	96
Eye-to-desk		**Distance**	**in Inches**	
Girls	7.2	6.3	6.7	7.3
Boys	6.9	6.2	7.7	6.9
Eye-to-Book				
Girls	---	8.0	8.1	10.0
Boys	---	7.1	8.6	9.0

NOTE: From "Vision and Reading Achievement", by William Arthur Hurst, 1964, Canadian Journal of Optometry: Revue Canadienne d'Optomtrie, 25(4), 3-19. Copyright 1964 by the Canadian Association of Optometrists. Adapted by permission of the publisher.

The mean working distances while writing for ages 70 through 89 months (approximately 6 to 8 years) were shorter than were the mean working distances while writing or drawing for the younger ages, 60 through 69 months. The mean working distances became larger for the older ages, 90 through 99 months, returning to approximately the same as those for ages 60 through 69 months. Hurst also pointed out that the mean desk-to-eye distance while writing for one Grade 2 class was 4.5 inches. No age span was indicated for this class.

Hurst *(Hurst 1964)* postulated that some factor other than the size of the child affects the working distance. He was concerned about the effect that short working distances, especially those found for primary-age children, can have on children's visual reflexes:

> Working at this distance, vision reflexes are subject to a completely different array of requirements than at 13 to 16 inches, the working distance accepted as normal in all near point tests. For example, when the horizontal phoria, a measurement of the postural balance of the eyes, was correlated with reading achievement at 16 inches, and then compared with the same correlation at 6 inches, the Pearson Product-Moment r was found to be opposite. *(Hurst 1967)* (pp 52-53)

The negative correlation for both boys and girls at the 16-inch distance was expected by Hurst, but the positive correlation for girls at 6 inches was unexpected. He felt this change in direction of correlation for girls at 6 inches indicated a major change in the postural balance of the eyes. The negative correlation at 16 inches showed that low phorias were related to good readers when reading at this distance. The positive correlation for girls at 6 inches, however, indicated that high phorias produced the good readers when reading was done at so close a distance. Hurst postulated that the girls had a greater adaptive power for the stress situation at 6 inches and stated that the visual stress is many times greater at 6 inches than it is at 16 inches. Hurst *(Hurst 1967)* indicated that vision screening and examination of children at the adult nearpoint distances are inadequate in terms of the visual demands which school tasks place on children in Grades 1 and 2. He recommended that further studies establish the normal nearpoint work distances of primary children and investigate how primary children maintain single, comfortable, clear binocular vision at the 6-inch and shorter distances found in his study.

Michaels' *(Michaels 1985)* statement helps clarify the difficulty in assessing the adequacy of a child's accommodation in terms of near work distance in a classroom. Michaels stated that only one-half of the relative accommodative amplitude should be used for reading: "The principle is that relative accommodation is equally divided into the amount in use and in reserve" (p.422). He stressed knowing the exact distance the patient uses in order to meet the visual requirement. He would have the patient measure near viewing distance, and then give the measure to the clinician. The clinician would then use the same distance during the evaluation. Michaels emphasized that faulty vision in a child is seldom recognized by either child or parent. Michaels also indicated that cover/uncover tests should be done at both near and far and at habitual seeing distances. Michaels gave no clues as to how habitual seeing distances are to be determined.

Lebensohn *(Lebensohn 1958)* felt that in persons with uncorrected vision, acuity tests should be done at both 20 feet (standardized far distance) and at reading distance. He did not define reading distance, although he mentioned 14 inches as the viewing distance to be used in a high standard near vision test. He felt that tests at near distance were just as valuable in schools as in industry. He also discussed the favorable effect larger type at a given near distance can have on the ability to read the presented target material.

Awareness that children's vision is developmental and not the same as that of adolescents and adults lends caution to generalizing results of any study to children of primary age until the ages of the study subjects are known. Investigators have used the terms **young subjects** or **students** without qualifying the terms. Clarification of these terms is necessary in order to determine if the subjects' ages will allow application of the findings to primary-age children. Similarly, clarification is needed in studies that investigate aspects of vision which are considered part of the physiological changes of nearpoint work when the distance is not stated or is so great that it may not be available to primary-age children.

Inquiry was made of two authors regarding the ages of the subjects or the distances used for their studies. Ehrlich clarified the reason for his use of the term "young subjects" in his 1987 study that employed a stressful 2-hour nearpoint reading task having a near distance of 20 cm (7.87 inches) as a factor which contributed to the stress. Ehrlich explained that the young subjects were optometry students, ages 18 to 30, with active accommodation of over 10 diopters, as opposed to elderly with reduced amplitude *(David Ehrlich, personal communication, July 25, 1988)* . Ehrlich described the subjects as young because of their degree of active accommodation. The ages of Ehrlich's subjects indicate that his findings should not be applied to primary-age children. Ehrlich added in his letter, however, a comment that has implications for future studies of children and their vision. "Children's working distance is very important in determining their habitual accomodation v. convergent 'stress'. It will probably be difficult to measure without disturbing the 'natural posture' which probably varies a great deal during classes and also with tasks" *(David Ehrlich, personal communication, July 25, 1988)* . Ehrlich stated that regardless of the optical correction for even moderate or greater levels of myopia, reading distances of children and adults usually increase with age *(David Ehrlich, personal communication, July 25, 1988)* .

The problem inherent in investigating near vision in children was discussed by Pickwell *(Pickwell 1988)* in personal correspondence. He explained the reason for the distance used in the investigation *(Pickwell, Jenkins, and Yekta 1987)*

> We chose the working distance of 40 cm [15.74 inches] as that generally used in clinical investigation. Of course it is a nominal distance and even with adults varies from patient to patient, according to their predominant near visual task. It is clearly not an appropriate working distance for young children. *(David Pickwel, personal communication, July 20, 1988)*

Pickwell explained that the distance of 40 cm is an artifact of the design of the apparatus used. In regard to children's working distance and using the 40 cm distance and apparatus with children in making a clinical assessment, he said:

> We cannot conclude that the apparatus is inappropriate for a clinical assessment, even though children normally work at much closer distance. It is clearly an area of study that we would have to consider some time in the future. There are important questions to be answered *(David Pickwel, personal communication, July 20, 1988)*

The nearpoint distance available to children while working at desks is unknown. Adult reading distances continue to be employed when evaluating elements of vision in children. Therefore, it is not appropriate to generalize the findings of prior studies to classroom situations for childhood populations.

Investigations by Reading Specialists

Reading specialists have shown particular interest in the physiological aspects of vision that can be determined externally during the act of reading. In order for their findings to be generalizable to students in the classroom, the studies need to be examined for an indication of the relationship of the subject's reading distance during the investigation with the subject's available reading distance in the classroom. The distance used in the investigation should not differ significantly from that available or used in the classroom.

In past years, technology allowed reading specialists, as well as eye care professionals, to design investigations which incorporated the act of reading and elements of the visual system thought to be involved in reading problems. Whether or not the distance from the eyes to the target was controlled, reading specialists did not consider distance a factor in these studies *(Gilbert 1940) (Gilbert 1959) (Gilbert and Gilbert 1942) (Marr and Kamil 1981) (Spache 1976)* . More recently, reading specialists have produced fewer studies that involve reading and vision.

Prior to the 1940s, development of an eye camera permitted reading specialists to use noninvasive techniques to explore eye movements during the act of reading. The interest varied from general (to determine the types of movements used by good readers) to specific (to determine regressive eye movements of readers).

An eye camera photographs a reflection of light from the eye. The changing position of the reflection is traced on film during each fixation and saccadic movement (movement of the eyes as they turn from one fixation point to another). The position of the head must be kept constant. This is done by having the reading card in a holder attached to the camera and the subject's forehead against a brace attached to the camera. There is only one adjustment that can be made: the height of the front of the machine can be raised or lowered in order to accommodate subjects of different heights. An adjustment upward does not change the distance from the subject's eyes to the reading card but can cause the subject's gaze to be at a more downward angle.

Bayle *(Bayle 1942)* studied the nature and causes of regressive eye movements in reading. She used an eye camera to photograph the eye movements of thirty-five 9th- and 10th-grade students while they read five selections created to determine the effect of different material content on eye movements. No mention was made of the subjects' reading abilities; however, Bayle stated that 3 of the 35 subjects did so much re-reading that it was impossible to plot the film of their reading. These subjects were removed from the study. Bayle did not mention the physical or optical reading distance created by the eye camera.

Viewing distances used were not mentioned by Tinker *(Tinker 1958)* when reporting on earlier studies which involved visual findings conducted by reading specialists. He did not comment on either the presence or the absence of information about viewing distance, although he did discuss the different types of eye cameras used.

Taylor *(Taylor 1962)* prepared a script to accompany a filmstrip used to introduce his moving eye camera and its use in eye movement photography. He traced the various devices developed over a period of about 80 years and described how each was used. He concluded with specific instructions for the use of the eye camera produced by Educational Developmental Laboratories, Inc. *(EDL 1962)* , findings which could be disclosed by its use, and applications of those findings. A line drawing of a subject being tested with the device clearly shows that the subject was forced to use a downward gaze: The height of the device which held the visual target was adjustable only at the front, near the subject. The increased triangulation for a taller subject forced the individual to use a more downward gaze than that required by a shorter subject. Instructions for use of the camera did not provide a means for maintaining a constant viewing angle for all subjects. A downward gaze, as opposed to a more straightforward gaze, affects the visual system and accommodation *(Borish 1970)* .

Photographs in the promotional material provided by EDL for the EDL/Biometric Reading Eye II *(EDL 1962)* show a subject with the reading distance and head movement firmly controlled by bars on three sides of the head. The subject was required to maintain contact with these three bars at all times. There was no indication of lenses imposed between the subject and the visual stimulus, and the visual target was almost straight ahead. As did descriptions in Taylor's *(Taylor 1962)* script, this material also did not mention the reading distance, although it was clearly a controlled distance and appeared to be a real, not optical, distance.

Reading specialists have utilized other types of technology which incorporate elements of distance, viewing angle, angle of presentation of stimulus, and sometimes, a controlled exposure time. Often some, but not necessarily all, aspects of these elements which influence accommodation or acuity were reported for each part of an investigation.

Solan's *(Solan 1962)* investigation of visual sensory maturation utilized a tachistoscope. Subjects in regular Grade 1 classes were to identify several digits presented tachistoscopically at different exposure times. Solan concluded that "the tachistoscope exposure testing 3 digits at 0.1 and 0.02 seconds distinguishes at an early level those youngsters whose visual sensory maturation is lagging" (p. 36). Solan did not investigate differences that might be found when using a hand-held tachistoscope as compared to a tachistoscopic projector. The hand-held tachistoscope covers and uncovers the stimulus and is a near visual task of no set distance and no set line of gaze. The tachistoscopic projector blurs and focuses the stimulus and is a far visual task, requiring a more forward gaze. When projected for a group, the distance will vary for different members of the group.

Solan *(Solan 1962)* gave no indication of viewing distance, nor did he indicate the relation of the distance or distances used to near-distance school tasks. The assumption should not be made that his norms can be generalized as indicators for visual sensory maturation appropriate for a child's available or habitual reading distance while seated at a desk.

Rubino and Minden *(Rubino and Minden 1973)* completed a study of the analysis of eye movements in children with reading disabilities. The 23 subjects were 11-year-old participants at a camp for children with learning disabilities. Eye movements were recorded by an EDL-Biometrix Reading Eye Movement Monitor. Mention is made of proper adjustment of equipment, but no details are given about reading distance, angle of viewing, or use of lens to simulate reading distance.

Stennett, Smythe, Pinkney, and Fairbairn *(Stennett et al 1973)* investigated the relationship of eye movement measures to psychomotor and other skills involved in learning to read. They used numbers, rather than letters or words, and employed an EDL Reading Eye, Model II camera. Although they gave findings and conclusions for eye movements as well as descriptions of equipment and procedures, the authors did not include information on the forced reading distance.

Doehring *(Doehring 1976)* completed an investigation of the acquisition of rapid reading responses with 150 children in Grades K-11. The procedure included 7 visual matching, 7 auditory-visual matching, 11 oral reading, and 10 visual scanning subtests. The youngest children did not complete those tests involving multiletter stimuli. All subjects were selected by their teachers as normal readers. For items which required pushing a window displaying the chosen answer, the stimuli were displayed on a sloping panel approximately

11 3/4 to 15 3/4 inches (30 to 40 cm) from the child's eyes. Items which required reading cards had the cards placed on a stand in front of the child. The author concluded that the results evidenced differences in rates of reading development over a period of years and "differences among such skills in both the rate of acquisition, and the final limits of achievement" (p. 39). The distance for the cards was not given, there was no description of the placement or surface angle of the booklets in which the child underlined a target stimulus, and there was no description given for the fit of the furniture across Grades K-11. Each of these can affect viewing distance.

The study by Ikeda and Saida *(Ikeda and Saida 1978)* concentrated on the span of recognition in reading and the critical width at which readers maintain their best rate of reading. The viewing distance of 1 m was kept constant by the subject's use of a small board attached to the apparatus which is placed in the subject's mouth and on which the subject maintains a bite (a bite board). This procedure kept the light reflection from the pupil in the small area required by the equipment which controlled the text exposure. The authors stated that the fixations suggested preprocessing of letters at the outer edge of the critical span of recognition. They did not discuss the possible effect shorter distances might have had on the findings. Shorter viewing distance can decrease the visual field *(Waters 1952)* and change the visual demand of the task *(Hurst 1967)* .

Research by some reading specialists was found to use distances that were greater than the adult reading range discussed by Borish *(Borish 1970)* . Use of an eye camera created a controlled distance that was not given. Different angles of viewing were created as the machine was adjusted for subjects of different heights. Use of hand-held stimuli, such as tachistoscopes, caused variations of the near distance and line of gaze that were not taken into account. In the study that used subjects in Grades K-11, the uncontrolled reading distances were described as 30 to 40 cm (11.41 to 15.74 inches) for all ages *(Doehring 1976)* . In all the studies, there was no investigation as to the effect that changes of distance might have on the outcome or whether the distance used was related to a young student's near work distance.

Screening

Vision screening is a limited process that surveys certain aspects of vision. The purpose of screening is to identify individuals who may need further vision care and those who do not when judged by predetermined objective criteria *(Committee on School Health 1977) (Petrie, Tumblin, and Miller 1979)* . Screening is not intended to be diagnostic *(Lippmann 1962) (Myrowitz 1984) (Peters 1984) (Petersen 1974)* . Ideally, a screening procedure should be fast, simple, inexpensive in terms of equipment and skilled personnel, valid, reliable with a minimum of missed cases and over-referrals, and productive in yielding a worthwhile number of cases *(Lippmann 1962)* . A screening instrument must be standardized, be based on normative data, and have established criteria that are to be met. In setting the level of the criteria, the intent of the screening must be established. Vision screening is needed for all children and must include a follow-up which ensures that the child who fails any screening will receive professional examination and care to enable that child to function visually in an educational setting *(Lippmann 1962) (Myrowitz 1984) (Peters 1984) (Petersen 1974)* .

Any screening process is related to the functioning ability of the individual in a given environment. In the case of schools being responsible for screening, the pass criteria of the screening instrument should be those which indicate that the individual has a level of visual functioning which allows that person to benefit appropriately from educational instruction in the school environment according to other abilities *(Committee on School Health 1977) (Francis 1973) (Gray 1963) (Lebensohn 1958)* . A screening instrument's strength or efficiency is associated with its percentage of positive referrals. A referral is considered positive when a professional examination verifies that a condition does exist which should receive professional care. This verification is based on the eye care professional's viewpoint and subsequent criteria. For many conditions, there may be criteria held in common by most professionals. This results in consistent agreement as to the accuracy of referral when a follow-up examination is given. A negative referral is one for which a professional follow-up examination reveals a condition or degree of problem that, according to the professional's criteria, does not need professional care. Another strength of screening which is seldom known is the percentage of all those screened who were accurately identified as being in need of professional examination and care. False nonreferrals, or failure to refer when a condition exists that needs professional evaluation, can be determined only by giving a complete examination to each person after screening. Few formal studies of screening instruments have included the examinations necessary for this determination *(Haag 1972) (Michaels 1985) (Myrowitz 1984) (Peters 1984) (Petrie, Tumblin, and Miller 1979)* .

Figure 1 graphically shows the relationship of selected criteria to the screening strengths mentioned. Use of low power fogging lenses to screen for hyperopia is considered a high standard for passing. A low power fogging lens is intended to discriminate between the emmetrope and the individual with a small degree of hyperopia. Use of low power will result in referrals of some students who may be found not in need of care for the degree of hyperopia present (low referral efficiency, high overreferral, and low underreferral). This criterion, however, will identify most of those who are hyperopic (high identification efficiency). When high power fogging lenses are used, only those with a high degree of hyperopia will be identified and referred. Most eye care professionals will agree that the referred individual needed care (high referral efficiency), while other patients with lesser degrees of hyperopia who might also benefit from professional care would not be identified and, therefore, not referred (low identification efficiency, low overreferral, and high underreferral).

```
                                 Figure 1

           Relationship of Selected Criteria (+D Fogging Lens) to Screening Strengt

                                                  High           High            Hig
                                                  Passing        Over-           Eff
                                  Correct
                                  Referrals
Low             Low
Under-          Referral
referrals       Efficiency

Low Power  +D Fogging Lens:  Identifies mild, moderate, and high degrees of hyperop
-----------------------------------------------------------------------------------
High Power +D Fogging Lens:  Identifies high-moderate to severe degrees of hyperopi

High            High
Under-          Referral
referrals       Efficiency
                                  Correct
                                  Referrals
                                                  Low              Low             L
                                                  Passing          Under-          E
```

For any power of fogging lens, there will be some incidence of correct, incorrect, and lack of identification and referral. Screening pass/fail criteria established for any visual anomaly can vary across a range. When criteria are set at an extreme at either end of a range, efficiencies of identification and referral similar to those described can result.

When a child fails a screening test, the parent or guardian is notified that that professional examination and care are needed. To be effective, the communication must be followed up to ensure that professional help is received, whether it is implemented by the family, the school, or a social agency *(Rosner 1982)* .

The success of a screening program involves a degree of public relations. Good public relations rest upon the lay and professional communities' feeling that the cost of the screening program is justified by approved criteria for referral, positive referral, effective identification, and affirmation that the criteria for referral is such that referral is automatic for the conditions and degree of conditions that interfere with the individual's functioning in the environment.

Problems may exist as to the content of a screening instrument, as well as to criteria to be used. Concepts of appropriate content and criteria are affected by different professional training and differing viewpoints of professionals with the same training. Lippman *(Lippmann 1962)* also spoke of the difficulty experienced by professionals in agreeing upon criteria levels. The continuing lack of consensus as to the content of vision screening for given grades or ages is explained at least in part by Rosner's *(Rosner 1982)* comment: "The professional community itself has not come to grips with the importance or nonimportance of binocular problems" (p. 19).

There is always compromise with regard to screening content and pass/fail criteria because eye care professionals know that there will be both under- and overreferral and under- and overidentification *(Haag 1972)* *(Michaels 1985)* *(Myrowitz 1984)* *(Peters 1984)* *(Spache 1976)* . One common compromise is employment of a screening instrument that has criteria for the most common interfering conditions of a degree that may seriously interfere with the individual's functioning in, and benefiting from, the environment. In addition, screening is limited to those conditions for which available care, treatments, aids, or modifications of the environment will benefit the individual *(Myrowitz 1984) (Verma 1984)* .

The New Mexico Health Manual for Elementary and Secondary Schools *(School Nursing Advisory Committee and State Department of Education, State of New Mexico 1986)* offers among its guidelines for screening programs admonitions that the condition being screened must have significant effect on the quality or quantity of the learning process, the condition must be present in the age group being screened, and treatment in the asymptomatic phase must produce a therapeutic result. In the case of vision screening, the term **therapeutic results** may be applied to the acquisition of learning as well as physical or visual changes that may otherwise develop or occur in the future.

New Mexico's guidelines continue by stipulating that the therapeutic results should be superior to results obtained by delaying treatment. The application of these criteria to learning is supported by statements in other states' guidelines which indicate that students who are in remedial reading classes, are experiencing academic failure, have reading problems, have repeated a grade, or have learning problems should be screened annually, as opposed to the less frequent screening of students without these problems (Arizona, Colorado, Florida, Minnesota, Nevada, New Jersey, New York, North Dakota, South Carolina, Utah, and Wisconsin). (See

Appendix A for a listing of states and published guidelines.)

A student being screened may be exhorted to do his or her best or to guess when hesitant in responding *(Ohio Department of Health 1982)* . Michaels *(Michaels 1980)* commented on the effect that strong encouragement by the screener or the examiner may have on the result of the evaluation and pointed out that the result may not reflect the accommodative status of the individual during usual daily work:

> We sometimes push and coax our patients into more effort on the clinical test than they are willing to expend at home or on the job. The difference between "easy" and "hard" 20/20 may tip the balance toward an unhappy patient. The effort to see involves attention, accommodation, miosis, and fixation and can produce significant improvement. (1975, p. 171)

When strong encouragement during screening has this effect, the result may be a false nonreferral. Subsequently, a student does not receive a professional evaluation which might result in help that could ease the stress of close work in the classroom.

Doster *(Doster 1971)* discussed the then-new booklet about school vision screening produced cooperatively by the National Society to Prevent Blindness and the American School Health Association. She pointed out that the short time element for reading a near card is not sufficient to allow the child with mild to moderate hyperopia to demonstrate the eye strain which might come about with a longer period of reading, and that near point acuity therefore, should not be screened. Köhler and Stigmar *(Köhler and Stigmar 1981)* considered that various visual conditions which are of a degree to warrant professional care are often accompanied by decreased distance acuity sufficient to cause failure. Others, however, disagreed: "Research has shown that less than half of the children with clinically significant visual disorders will be identified by use of distance visual acuity alone" *(Petrie, Tumblin, and Miller 1979, p. 3)* . In his 1982 review of the Orinda Study, in which he was a participant, Peters *(Peters 1984)* expresses the opinion that retinoscopy, cover test, and ophthalmoscopy should be done for the individual child before depending solely on the far distance Snellen for vision screening. He stated that "nearly one-half of all the children with referable problems, problems that interfere with their educability and their health status, are undetected by Snellen testing and are unknown to children's parents, teachers, or to the children themselves" (p. 362).

Petrie, Tumblin, and Miller *(Petrie, Tumblin, and Miller 1979)* provided a chart showing the percentage of incidence for 15 of the more common visual conditions. The percentage varied according to age spans and across types of conditions. For some conditions, such as hyperopia, squint, and amblyopia, the percentage remained almost static across age groups. The largest variation was found in acuity. Most of this variation was accounted for by the incidence of diagnosed myopia increasing through age 20. Incidence of hyperopia exceeded that of myopia for ages 0 to 9 years, being 6% versus 3% at ages 5 to 9. The trend reversed for ages 10 to 19 years, with myopia being twice as frequent as was hyperopia at ages 10 to 14 years, and myopia almost three times as frequent at ages 15 to 19 years. This reversal of incidence, and the magnitude of increase in incidence of myopia, have probably been the bases for statements that use of only the Snellen far charts for screening is adequate for all school children. When all ages are considered together, this statement appears to be true, but with the incidence of hyperopia being two times that of myopia for ages 5 to 9, there is a need to have other tests in addition to those for far acuity for children of these ages. Acknowledgement of the differences in the incidence of hyperopia and myopia at ages 5 to 9 could provide a basis for vision screening instruments designed for use with primary-age children in order to identify anomalies and elements of vision common or specific to children of these ages.

Verma *(Verma 1984)* discussed vision screening of special populations, of which children are one such group. Vision screening of special populations is the one type of health screening in which it may not be true that all tests remain the same. Verma maintained:

> In a specialized vision screening, the conditions most prevalent in each of the categories should be tested. . . . Because prevalence of pathology in a pediatric population is negligible as opposed to the geriatric population, it is most beneficial to screen for a strabismic condition in a pediatric screening as opposed to a geriatric screening. (pp 367, 368).

Verma *(Verma 1984)* also felt that in checking refractive error and acuity in children and athletes, retinoscopy must be performed even if visual acuity is normal. "For children and athletes, the concentration [in a screening] is more on functional problems" (p. 369) .

Belloc *(Belloc 1962)* surveyed all the states, the District of Columbia, and four U.S. territories in order to obtain data concerning vision screening practices. Her published report gives only a summary of information. The 1984 update of a 1967 survey of the 50 states, the District of Columbia, and New York City sponsored by the National Society for the Prevention of Blindness (NSPB) and the American School Health Association (ASHA) also resulted in summarized information with regard to screening practices and content *(Bromberg et al 1984)* . This report gives types of tests used for visual acuity (Snellen and HOTV), color blindness, stereopsis, muscle balance, and hyperopia. No specific information on near target distance or power of plus lens is made available. The authors commented on the variability of the referral criteria but spoke specifically only to distance visual acuity. They stated that differences in the critical or pass/fail line, in line differences when tested monocularly, and in criteria for different ages are not easily explained. They indicated that criteria variations are expected when different tests are used, but not when the same test is used.

Screening instruments and their content are based on investigations made by vision professionals *(Borish 1970) (Wold 1967)* . The Snellen distance acuity chart was one of the earliest screening instruments. As early as 1908, Shaw, in his book on school hygiene, provided Snellen letters of the appropriate sizes for a teacher to use in constructing a screening chart. The instructions for screening include having the student stand with toes on the 20-foot line and moving the student closer to or farther from the homemade chart to determine farsightedness or nearsightedness. Shaw *(Shaw 1908)* cautioned that in administering the test, "a case of long-sightedness might at first be regarded as short-sightedness because the pupil would be unable to make out the letters of the lowest line at 20 ft. distance" (p. 194). Shaw's purpose for screening was different from that of screening today: The teacher was to seat the child at a distance nearer to or farther from the chalkboard, according to the screening results. Today, the Snellen letter chart is still a part of many vision screening instruments and is the standard against which other screening instruments are compared *(Bromberg et al 1984) (Committee on School Health 1977) (Francis 1973) (Rosner 1982)* .

Köhler's and Stigmar's *(Köhler and Stigmar 1981)* study concerned the dilemma that confronts those who have the responsibility of establishing screening content and pass/fail criteria. They examined the relationship of reading and writing difficulties, as estimated by the teachers, to the objective refractive status of 118 second-grade children in Sweden who had been previously screened extensively at age 4. They found more children with these reading difficulties with approximately +0.5 D and +1.0 D status than with other dioptric status. The only severe reading and writing difficulties indicated were for students in the +1.0 D group. Köhler and Stigmar were concerned about the power of plus lens used to screen for hyperopia. They felt that a +1.5 D lens would overrefer:

> On the other hand, with a +2.0 sphere, too few of the hypermetropic children were detected, i.e., the sensitivity too low. It was obvious that fogging with +2.0 lenses does not induce relaxation of the accommodation enough to reveal most of the hypermetropics in a screening situation. (p. 375)

They stated that factors of age, degree of phoria (an eye's line of sight), as well as hypermetropia, are involved. Their findings indicate a need to use fogging lens of an effective power for students in kindergarten and Grades 1 and 2 because hypermetropia is the most common eye disorder found at ages 4 and 7.

In comparing the visual needs of children to those of adolescents and adults, Goss *(Goss 1986)* expressed the view that "the visual needs of a young child are usually less" (p. 148). This view may be influenced by the large amplitudes of accommodation and convergence that children are thought to have, the visual changes which occur in children between the ages of 5 and 9, and the unknown visual demands of near school tasks for children in the primary grades.

Cashell and Durran *(Cashell and Durran 1971)* designated 33 cm (12.99 inches) as the normal near reading distance to be used for screening or examination. They cautioned that

> . . . nearpoint may appear normal on first testing, but will recede on further measurement. . . . The nearpoint of accommodation should always be tested three times in succession in all cases of complaining or asthenopic [uncomfortable, painful, and irritable vision] symptoms. The clarity of the near test type will be improved by a small convex lens but will again blur after a few moments. (p. 36)

In addition, Mason *(Mason 1962)* stated that the use of plus (convex) lens does not always ensure relaxation of accommodation. These cautions must be taken into consideration when supporting the use of plus lens of any specific power to completely relax accommodation when screening vision.

Recommendations vary as to the power of plus lens to be used as fogging lens in vision screening. Köhler and Stigmar *(Köhler and Stigmar 1981)* indicated a lens greater than +2.00 D would be needed to relax the accommodation at age 8. Others recommended +2.25 D for all ages *(Committee on School Health 1977) (NSPB 1982)* or +2.00 D *(Petrie, Tumblin, and Miller 1979)* . An inquiry of the 50 states and the District of Columbia was conducted as part of this study. Responses received indicate that fogging lens power used to screen for hyperopia ranges from +1.00 D through +2.50 D (see Table 2).

Table 2:
Inquiry Responses, 1985-86:
Frequency of Fogging Lens Power by Grade and Age

Power (+D) of Fogging Lens	**Grade(s)**	**Age(s) in years**	**Number of States**[a]
1.00	9-12	---	1
1.50	6-8	---	1
1.50/1.75	K-12	NS	1
1.50-2.50	K-12	NS	1

1.75	K/1	NS	2
	K-1	NS	1
	1-12	---	1
	3-up	---	1
	4-up	---	4
	NS	6-up	1
	NS	> 7[b]	1
1.75-2.25	NS	NS	2
2.00	1/3	NS	1
	1-5	---	1
	2-up	NS	1
	NS	AA	1
2.25	K	---	1
	K-2	---	2
	K-3	---	3
	K-12	NS	1
	1	NS	1
	1-3	NS	1
	NS	> 7[b]	1
VSM-PNS	NS	NS	3
PNS	ANY-TWR	NS	1
PNS	NS	NS	3
No Test	---	---	22

NOTES:	
a	Some states report different powers for different grades: total does not equal 51
b	Once determined, record and do not repeat.
AA	= all ages;
ANY	= all ages;
NS	= not specified;
PNS	= power not specified;
TWR	= if trouble with reading;
VSM	= vision screening machine;
>	= greater than;
/	= or;

In terms of screening for aspects of vision which affect functioning in a classroom, researchers' statements reflected concepts which support the inclusion of plus lenses. Francis *(Francis 1973)* studied the correlation of reading problems with visual status. He reported: "The findings of this study indicate that several visual factors--hyperopia, astigmatism, exophoria, and aniseikonia [the impression which reaches consciousness]--appear to be associated with reading disability, while myopia and correction tend to result in reading success and/or progress" (p. 358) . Michaels *(Michaels 1980)* stated that "the reserve [of accommodation] would clearly need to be greater for prolonged than intermittent reading, and amplitudes are affected by many variables (illumination, acuity, binocularity, depth of focus, etc.)" (p. 573), as well as his opinion that "a child's vision is seldom critical beyond 3 feet" (p. 520). These opinions indicate a need to look at distances involved in vision screening.

Responses to the inquiry also provided information on target distances used for near tests. The target viewing distances used for near tests varied from 10, to 12 through 18 inches. One test distance was given as 60 inches, with no indication of it being considered as near or intermediate distance (see Table 3).

Table 3:
Inquiry Responses, 1985-86:
Target Distances Used in Nearpoint Vision Screening (TDNPVS)

-

TDNPVS	**Number of Tests**
(in inches)	**(n not equal to 51)**
10	1
12	2
12-14	1
12-18	3
@13[a]	1
13	2
13-14	2[b]
13-16	4
@14	2
14	5
14-16	7[c]
15	1
15-18	1
@16	5
16	4
60	1
at reading position[d]	1
at reading distance[e]	2
at average reading distance[e]	1
at arm's length[b, c]	3
Distance not specified[f]	25

NOTES:	
a	Approximately;
b	Arm's length = 13 to 14 inches;

c	Used as arm's length, 14 to 16 inches;
d	Distance and angle not given;
e	Distance not specified;
f	Specific test indicated

Distance is involved in both screening and examination of an individual's vision. Six meters, or approximately 20 feet, is accepted as the testing/screening distance for distant vision. At these distances, light rays are parallel as they enter the eyes and are focused on the retina, and the eyes are straight forward as when viewing a visual stimulus at infinity. It is significant that there is no similar commonality of one or two distances which has been agreed upon for screening or examining near vision. Some of the screening tests which may be used and which incorporate near distance presentation are muscle balance, stereopsis or fusion, and near vision acuity (see Table 16 , Appendix Q) .

Harwood *(Harwood 1984)* conducted a survey of vision screening and the involvement of private optometric practitioners. The responses indicated only the areas of vision function screened and not procedures or tests used. In response to a question about content of vision screening, over one third of the respondents indicated that they did not know about screening programs other than the one in which they were actively involved. Other survey reports did not specify a near distance when discussing near screening *(Belloc 1962) (Committee on School Health 1977)* or recommended against near vision acuity tests *(NSPB 1982)* . Screening machines which are used in some states (see Table 16, Appendix Q) provide simulated or optical near distances: the Telebinocular, 16 inches; the Sight-Screener, 14 inches; and the Ortho-rater, 13 inches *(Lebensohn 1958)* . Lebensohn cited 10 inches as his choice for near testing distance. He reasoned that passing a near screening of 10 inches (25.4 cm) indicates that the individual has the reserve of accommodation and convergence which is needed to read comfortably at 14 inches (35.56 cm). The near viewing distances used in the screening machines and the distance chosen by Lebenshohn are all greater than the working distances Hurst *(Hurst 1964)* found for primary-age children.

Over the years, and in many states, vision screening has become a responsibility or co-responsibility of schools. Vision advisory committees have been created by states to work with the assigned bureau or department within the state administration to aid in the development of vision screening requirements and standards. Screening is often conducted at schools by trained or certified nonprofessionals, volunteers, or by school personnel, including teachers. Awareness and observation of symptoms are part of several screening instruments. The content of different screening instruments may not be the same, or the criteria for referring a student who fails any given screening instrument may be different from the criteria of another screening instrument.

Screening recommendations often include instructions for teachers to observe and report children who evidence described symptoms (see Appendix B). The combination of teacher observation and the Snellen distance chart is thought by some to be the most efficient screening *(Committee on School Health 1977) (NSPB 1982)* . None of the state guidelines provide training for teachers to recognize such symptoms or to be knowledgeable about how and when there will be occasions to observe them. Doster *(Doster 1971)* pointed out the hazard for students when teachers and screeners are not knowledgeable about these symptoms and complaints:

> Vision-screeners, whether they be pediatricians, school nurses, teachers, volunteers or aides, must learn also to observe pupils carefully and to solicit eye complaints, because a small

> minority of children should be referred to eye specialists even though they pass the acuity and other simple school tests. (p. 665).

The symptoms include physical symptoms that are easily visible, such as crusted or red eyelids; verbal complaints, such as statements that the words become fuzzy or doubled after reading a while; and observed behaviors, such as frequent changing of the viewing distance from very close to relatively far. (See Appendix B for a more complete listing) .

Individuals vary greatly in regard to the number of symptoms experienced and to the degree of symptoms, even when visual status is similar or the same. Brent and Arstikaitis *(Brent and Arstikaitis 1983)* felt that low astigmatism can cause more symptoms than can higher astigmatism. They stated:

> Children with astigmatic errors between 0.50 D and 1.00 D may have more complaints of ocular fatigue than those with higher errors. With mild astigmatism a child makes a persistent effort to clear his vision; with higher errors, no such effort is made and the child accepts unclear vision, experiencing less ocular discomfort and fatigue. (p. 37)

Pringle and Ramsey *(Pringle and Ramsey 1982)* stated that "the child with hypermetropia up to 4.00 D with normal visual acuity and no ocular symptoms does not usually require glasses" (p. 36). They emphasized the possibility of symptoms: "As school work increases, the need for sustained accommodation increases. Here, even a cycloplegic finding [determination of the refractive status after administration of a drug which paralyzes the muscles of the eye responsible for visual accommodation] as low as +3.00 D may be of significance in the presence of symptoms of ocular fatigue" (p. 37). The purpose of cycloplegic findings is to determine the power of accommodation the individual requires to see clearly at given distances when there is no possibility of latent accommodation. In vision screening fogging lenses of different plus power, instead of a drug, are used to relax the accommodation.

According to Peters *(Peters 1984)* , who was a member of the multidisciplinary Orinda research group, the Orinda study made available for the first time information which indicated that "hyperopia of approximately 1.75 D or more does not decrease with age" (p. 362). A complete vision examination was made of each subject. This made it possible to report on the reliability, true positives, and effectiveness of each screening instrument. The Modified Clinical Technique (MCT) had an effectiveness of 90% or greater in each area. Determination of far acuity using only the Snellen far chart had an effectiveness of 41% in identifying visual problems needing professional care and 71% in identifying true positives. The study reported a reliability of 84% for use of the Snellen far chart alone: it is this figure which is used most often in justifying the limitation of vision screening to the Snellen far chart and teacher observation. True positives indicate the percentage of the entire group who, when given a complete visual examination, had correctly been referred. In this case, the 71% true positives also indicated that screening using only the Snellen far chart failed to refer 29% of those who needed care.

The MCT screens for organic problems, using a hand magnifier and ophthalmoscope; for visual acuity, using an acuity chart; for refractive problems, using a retinoscope; and for binocular coordination problems, using a cover test and a 5 D prism *(Peters 1984)* . The criteria for pass/fail of the MCT are acuity of 20/40 or less and hyperopia of +1.50 or more. It should be noted that the distances used in different retinoscopies are not identical. For example, the Monocular Estimate Method (MEM) of retinoscopy is intended to be used at a child's customary working distance. The MEM differs from the standard dynamic retinoscopy in one of two ways:

> The testing distance is not the same for all patients; it is determined by the unique characteristics of the patient: his physical size or his preferred reading distance. . . . Testing may be done as close as 9 inches with small children [when the child's Harmon distance is used]. *(Rosner 1982) p. 154*

The distance could be as short as the 6 inches or less that was the working distance found in Hurst's *(Hurst 1964)* study.

Other retinoscopic techniques may leave the practitioner a choice of distance, e.g., 14 to 16 inches *(Kruger 1977) (Kruger 1978) (Zellers, Alpert, and Rouse 1984)*. In light of Michaels' *(Michaels 1985)* position that boys' refractive status changes from an expected condition of hyperopia to one approaching emmetropia 2 to 3 years later than does that of girls, separate criteria should be available for males and females if the eye care professional considers that what is usual at these ages does not need referral.

It is Peters' *(Peters 1984)* contention that two publications seem to have influenced the content of screening requirements. These are the Orinda study report and the Children's Eye Health Guide, developed and published by the National Society to Prevent Blindness (NSPB) *(NSPB 1982)*. Peters' discussion of the Orinda study indicates that the procedures used have become known as the MCT.

The recommendation in the Health Guide *(NSPB 1982)* is for distance acuity using the Snellen chart with full line exposure while a helper uses a pointer to indicate the letter or symbol to be read. Additional tests, classified as low-yield tests, carry the caution that their use might result in overreferrals and that a highly trained, competent screener is required. These optional tests are plus lens of 2.25 D for all ages, muscle balance with target at both 13 to 14 inches and far distance, stereopsis test, and color discrimination in sixth or seventh grades. The near vision acuity test is discouraged because it does not provide for any indication of the degree of accommodation in reserve. In its place is recommended the plus lens test at far distance. The plus lens at far is considered to indicate the greater-than-emmetropic power of accommodation used at the distance at which virtually no accommodation should be required *(Borish 1970)*.

Borish *(Borish 1970)* defined the **standardized arm's length** at which the Ishihara color plates are to be viewed as 75 to 100 cm or 30 to 40 inches (rounded up to the next inch). He stated that a closer viewing distance can improve the subject's performance. This distance of 30 to 40 inches as an arm's length is clearly not available to children, and is in contrast to Harmon's arm length from the individual's middle finger knuckle on the back of the fisted hand to the point of the elbow and the 13 to 14 inches and 14 to 16 inches reported by some states as being an arm's length.

The publication, Guidelines for Developing Eye Health Programs for Children from the National Association of Vision Program Consultants *(NAVPC 1981)*, includes recommendations that are much like those of the NSPB. Exceptions are in the minimum level of screening for school-aged children, which includes plus lens of +2.25 D, eye alignment by cover/uncover or stereoscopic testing at near distance and at 20 feet, and color vision testing advised for elementary grades but urged by Grade 7. The NAVPC guidelines provide for a higher level of screening which limits eye alignment to cover/uncover at near and far distances (eliminates stereoscopic testing) and emphasizes that specially qualified personnel are required to administer this level.

Found among the studies reviewed were descriptions of training vision screeners. Trained screeners are necessary for effective and efficient vision screening. Trained screeners were described as varying from volunteers with a few hours training and volunteers with some college course credit to eye care professionals who carry out a screening that is not an examination *(Helveston and Ellis 1984) (NSBP 1982) (Petrie, Tumblin, and Miller 1979) (Trobe 1975) (Whittington 1958)* .

Much of the material concerning vision screening has reflected interest in screening preschool children *(Hatfield 1979) (Petersen 1974) (Radke and Blackhurst 1978)* . The emphasis has become one of preventing development of, or increase in, visual problems which may be prevented, maintained without increase, or decreased as to the adverse impact that the condition may have on the individual's development and learning.

Over the years, there have been efforts to develop new test charts. Eye care professionals have acknowledged the effect of styles of print and the fact that some letters are more easily recognized than others *(Committee on School Health 1977) (Henson 1977) (Lebensohn 1936) (Lebensohn 1958) (Michaels 1975) (Mehr and Freid 1976) (Potts 1972) (Von Noorden 1980)* .

Testing and screening charts are created and standardized to be used at exact distances. Sloan *(Sloan 1959)* discussed her newly created vision charts for near distances to be used with both children and adults. She indicated that in order to test at 35 cm (approximately 14 inches) or 40 cm (approximately 16 inches), different charts are required. The visual angle size of the letters must be kept comparable. The need for the different distances is caused by reports which must be recorded in required terminology that indicates the relationship of the near distance to a designated far distance.

Eye care professionals caution that using the full line of print versus covering and providing a window to expose only one letter has an effect termed the crowding phenomenon and influences the result of the screening *(Buncie 1983) (Radke and Blackhurst 1978)* . Helveston and Ellis *(Helveston and Ellis 1984)* stated that this phenomenon may strongly affect the result for the individual with amblyopia. The exposure of a single letter is less like a normal reading situation than is the exposure of the entire line: "Often a child with functional amblyopia will see the first and last letters correctly on a line but will be unable to correctly identify the central letters for the next several large lines of optotypes" (p. 12). Responses from the states disclosed that some specified one or the other be used, that is, full line or window (Arizona, Kansas).

Research has provided new information for an aspect of vision that is now recognized as critical in some occupations and for individuals with impaired acuity. That aspect is contrast sensitivity. Ginsburg *(Ginsburg 1984)* created a contrast sensitivity screening chart which utilized black bars of different widths positioned at different angles within a white circle. The impact of contrast sensitivity within the classroom must be taken into consideration in terms of the quality of contrast of large print books supplied to the visually handicapped and the quality of contrast for printed or duplicated worksheets which all students are expected to read. Based on Borish's *(Borish 1970)* comments on the effect of distance on perception of color, it is possible that lessened contrast may contribute to a child's viewing distance being different than it would be for reading a visual stimulus with greater contrast.

Hennessey, Iosue, and Rouse *(Hennesey, Iosue and Rouse 1984)* studied accommodative infacility. Questions about symptoms were asked of the 60 male and female subjects, aged 8 to 14 years. Of those examined, questioned, and considered asymptomatic, 60% passed, 20% failed, and 20% were suspect for failing criteria of adequate accommodative facility. The researchers concluded, "It appears that the addition of accommodative facility testing to a vision screening may help identify those symptomatic subjects who would otherwise pass the screening and constitute an underreferral" (p. 183). Findings and symptoms of accommodative infacility have direct bearing on the way a child functions during classroom tasks. A child makes frequent changes of accommodation and convergence as the overhead screen or chalkboard across the room and near desk work alternately are the visual targets.

Adams, Haegerstrom-Portnoy, Brown, and Jampolsky *(Adams et al 1984)* sought to develop a means to assess visual acuity in schools, industry, aviation, drivers' licensing, and ocular health examination. Adams et al stated that there is a need for a rapid, simple, and interpretation-free measure of visual acuity to overcome some of the problems of the conventional screening of visual acuity. They listed problems of conventional measurement of visual acuity:

> . . . lack of standardization in lighting, letter form or type, interpretation of the target by the subject, and the response by the examiner as well as possible problems of malingering (false high and false low), problems of learning and memorization in test repetition, and potential errors in recording. (p. 371)

They sought a "measure [which] would allow assessment of vision capabilities without the overlay of 'cortical factors"' (p. 371). Although Adams et al. indicated that they found a lack of standardization in lighting and letter form or type, some screening instruments do designate the degree of illumination of the background and the target *(Committee on School Health 1977) (NSPB 1982) (Tansill 1985)* .

Present screening instruments may include nearpoint convergence and accommodation. When evaluating nearpoint convergence and accommodation, the presence of fine detail in a target is required. Mason *(Mason 1962)* interpreted the results of an experiment in which he determined that convergence dominates and controls accommodation as demonstrating

> . . . the importance of having fine detail on charts used to measure near distance muscle balance. If the patient does not accommodate fully when presented with fine detail, how much less he may accommodate on a coarse chart is a matter of conjecture. (p. 588)

Other tests also require a target with fine detail. Borish *(Borish 1970)* emphasized the type of target required for a push-up nearpoint convergence test:

> The target, of whatever sort, must be fine enough to indicate diplopia readily and is slowly moved, pushed towards the patient's nose while the patient is requested to report the onset of diplopia (p. 428)

Cashell and Durran *(Cashell and Durran 1971)* stated that a target with small detail is required to bring about accommodation effort.

The content of vision screening instruments is not all the same. Different instruments which include the same or similar near tests to screen the same aspect of vision may have variations in target viewing distance. Screening instruments that include the same far test may describe different procedures for administering the test. These differences in procedures can affect a student's screening score.

Explorations of visual demand, such as contrast sensitivity and facility of accommodation, suggest that studies of the content of vision screening instruments should include these, as well as other areas which are sometimes optional in vision screening instruments currently in use. Emphasis is placed on the type of target used for different tests done at near distance, tests for which no standardized target is provided.

Vision Screening Practices

Because the literature review did not reveal any specific data concerning standard distances used for nearpoint vision screening of primary-age children in public schools, it was necessary to obtain the detailed information from each state on an individual basis. An inquiry concerning current screening practices in the 50 states and the District of Columbia was undertaken. Data were collected by letter and telephone from appropriate personnel at the state level for each of the 50 states and the District of Columbia (see Appendix C for respondents).

The provision for vision screening of school-age children ranged from no screening to coverage of acuity, muscle balance, stereopsis or fusion, color blindness, nearpoint convergence, hyperopia, and other areas. There was a lack of standardization in the terms or descriptions given in replies to the inquiry.

The two areas of interest used in this study were the distances used for presenting targets for nearpoint screening and the power of the plus diopter (+D) fogging lens used to screen for hyperopia. The specified target distances used in nearpoint vision screening varied from 10 to 18 inches, with the exception of 11 inches. The power of +D lenses ranged from +1.00 D through +2.50 D. The critical pass/fail line sometimes varied according to the +D power or the grade being screened. Consideration of critical line was not a part of this study.

Several states included teacher/screener observation of student appearance and behaviors and student complaints as part of the screening process. Most guidelines included lists of symptoms or complaints (see Appendix B). Notably missing were provisions to train teachers to employ effectively their own observations of the listed symptoms of eye or vision problems or to educate parents to recognize the symptoms and the child's need for professional care.

Responses to the inquiry clearly indicate that there is no uniformity among the states regarding requirement of vision screening of school-age children (see Table 17 , Appendix Q). Among the states that recommended or required vision screening, there was no uniformity as to the tests to be included in a screening instrument. Among the states that screened the same areas of vision or used the same tests, such as the cover/uncover test, there was no uniformity of the target distance. The factors which contribute to the lack of uniformity were not investigated.

Furniture

In 1908, Shaw discussed the effect of school furniture upon the posture and growth patterns of children, their handwriting, and their lines of sight while writing. He maintained that the recommended writing position could be maintained only when the "desk is of exactly the right height for the pupil sitting at it" (p. 213). He indicated that providing "seats and desks with proper slant and adjustable not only as to height but also as to minus distance" (p. 215) would constitute a great advance. He advocated use of furniture with these advantages, along with the use of vertical-slant writing. Vertical-slant writing has the slant, but not the letter formation, of manuscript writing presently used in Grades 1 and 2.

A classroom attended by every school child at least once each week, such as a music room, is supplied with only one set of furniture. The sizes of desks, chairs, or combination desk-chairs must be of a size that serves children in every grade level. The logical solution is to have chairs large enough to fit the larger children. The result is that the furniture is so large that the younger students must climb into it. For classrooms that are used for only one grade level, the situation is improved. A review of catalogs provided by manufacturers of school furniture disclosed that desks and chairs are available in variety of styles and in sizes that are suggested for specific grade levels.

The 1985 catalogues of the American Desk Manufacturing Company (Temple, Texas) and Carter Craft, Division of Smith Systems (Plano, Texas) were sources of information regarding different styles and designs of chairs and desks for use in this study. Listed chair sizes referred to the distance of the chair seat from the floor. Chairs were not adjustable, but were available in several sizes. A chair's height was cited as the distance from the crest of the seat to the floor. The dimensions from the front to the back and across the seat varied and were specific according to the chair's height. Traditional chairs have the seats parallel to the floor. The Balans chair, designed by A. C. Mandal of Denmark and offered in this country by Carter Craft, is the only adjustable chair shown in the school furniture catalogue. Its cost of over $250 precludes its use in most public schools.

Desks are manufactured in four designs. Of concern in this study were the two with attached storage facilities. These desks are produced in sizes appropriate for primary-age children. The distinguishing feature of these desks is the placement of the storage facility, which affects the height of the desk top from the floor. The side desk has a large top which covers the student's legs; the storage facility is set at the right or left side. This desk also comes in a design for two students, with both storage facilities in the center. The across desk has book-box storage which extends from side to side immediately under the desk top. The book box is described as being 5 inches in height. When each of these styles is adjusted to the same clearance above a child's knees, the side desk will have a shorter overall height than will the across desk. The difference in height may have an effect on the child's viewing distance.

Both Carter Craft and the American Desk Manufacturing Company recognize that students in any given grade are varied in size. As an aid to schools, they include in their catalogues information that suggests sizes, and percentage of those sizes, appropriate for specific grades. The recommendations match a desk size with a chair approximately 10 inches lower than the desk top when the desk is adjusted to its lowest setting. While not identical, information from the two companies indicate similar sizes and percentages of those sizes for Grades 1 and 2 (see Table 4).

Table 4:
Manufacturers' Suggested Desk/Chair Heights and Percentages by Grade

Furniture/Suggested Distribution	**Manufacturer's**	**Suggested**	**Size**	**(Inches)**	
	American	**Desk**		**Carter**	**Craft**
Chair	**11.5**	**11.5**	**13.5**	**11.5**	**13.5**
Grade 1	---	50 %	50 %	50 %	50 %
Grade 2	---	---	100 %	---	100 %

Desk/Table	21.0	22.0	23.0	21.5	23.5
Grade 1	---	50 %	50 %	50 %	50 %
Grade 2	---	---	100 %	---	100 %

The stipulated size of a desk is the height of its lowest setting. The desks are adjustable for an increase of 6 to 8 inches in height, in increments of 1 inch. Chairs are not adjustable; therefore, the suggested 10-inch space between chair seat and desk top cannot be maintained. Without going into the classroom and measuring the current heights of desks, there is no way to determine the heights of work surfaces being used by students, regardless of the desk sizes ordered. In addition, the students may not be using chairs that are one of the two recommended heights or that allow the 10-inch differential in space.

The fit of a chair and desk is affected by several factors. The size of available furniture pieces and the styles of desks are basic. The size of the child and the height of the top surface of his thighs above the floor when seated affect the height setting for the desk. A child's preference of desk and chair size may influence choice of size and the adjustment of the desk. Young children may feel that using a taller desk indicates that they are more mature. Although children change in size during a school year, it is unusual for desk and chair assignments to be changed or for desks to be readjusted frequently. Given the fact that the child's physique and the size of the furniture at which the child works affect nearpoint viewing and working distances, it would follow that the available desk-to-eye distance for any child will vary during the year, will vary among children, and will allow a child a limited range of desk-to-eye distance during any given task.

Mandal *(Mandal 1984)* stated that "school children have a visual distance of approximately 20 cm to 40 cm [8 to 16 inches]" (p. 48). He traced the history of the design of chairs and desks and the skeletal model used to determine sizes. He found no consideration for the downward gaze that is required for viewing material on the desk. His Balans chair and slanted desk are the result of his interest in reducing stress on the body while the child is seated for work at a desk.

Although persons interviewed at the manufacturing companies cited in this study could not give a scientific bases for the furniture sizes recommended, past studies have provided data for functional measurements of reach at different types of work stations and of body parts for Grades K-12 school children *(Martin 1954)*. Martin's study was a joint effort of the U.S. Office of Education, the University of Michigan, and the National School Service Institute. The study was based on an awareness that the growth patterns and norms for children had changed across the years. There has been no update of this information. The striking aspect of Martin's study is the design of two measuring stations which were staffed by a trained crew and allowed 55 different measurements to be taken and recorded for an individual within 4 minutes. From these measurements, the dimensions of other body parts were calculated.

One use intended for information from Martin's *(Martin 1954)* study was as an aid to manufacturers in deciding upon the sizes of chairs and desks to manufacture and recommend for given grades. Interviews of personnel at manufacturing companies and of a school purchasing agent who was ordering furniture to equip a new elementary building did not indicate that any such scientific data were the basis for recommending or ordering desks and chairs of given sizes for specified grades. The manufacturers reported making and offering sizes that are requested by the schools. The schools order what is currently considered satisfactory in their districts *(R. Barnes, Advertising Department, American Desk Manufacturing Company, Temple, Texas, personal communication, May 8, 1985) (J. Siebenthal, Purchasing Agent, Carrollton-Farmers Branch*

ISD, Carrollton, Texas, personal communication, February 20, 1984) (H. Taylor, General Manager, Carter Craft Division, Plano, Texas, personal communication, May 23, 1985) . It was not possible to determine what influenced the first order of furniture in the district, which was made many years earlier.

Handwriting

Handwriting texts adopted for use in the State of Texas often incorporate the following lessons among others in their curricula: teaching the child to utilize specific paper position, hand grasp of the writing instrument, and sitting posture. Each of these elements alone, as well as in combination, has an effect on nearpoint visual distance. The size of the child's desk, chair, and the appropriate fit of the furniture to the child's size and physique affect the demands of a nearpoint visual task. The material presented to teachers in terms of children's writing posture and viewing distance were reviewed in several of the handwriting texts offered for adoption by school districts in Texas. In Grades 1 and 2 all texts use manuscript writing (printing) .

Photographs or line drawings of children posed as if writing at desks or tables were used in some of the handwriting texts to provide examples of described writing posture, paper position, and grasp of the pencil. For the primary grades, similar models of writing at a chalkboard also were provided. In every text examined, there were discrepancies between the description in the text and the illustrations or photographs. The discrepancy of the hand and arm position in relation to the position of the paper is widespread *(Barbe et al 1987) (King 1987) (Johnson 1987)* . There were also discrepancies in the distance from the chalkboard *(Barbe et al 1987) (Bell et al 1978)* as described and illustrated or photographed.

Posture affects the distance of a student's eyes from the visual target. In the handwriting texts the authors describe the writing posture children should use. Several authors are not specific, but indicate some element of posture, such as "hips touching the back of the chair, back not touching" (Barbe et al., 1987, p. vi); "The children should be expected to maintain a healthful, yet comfortable, position for all written work. The necessary factors to keep in mind are a comfortable, relaxed position, room to write, and eyes not too close to work" *(Bell et al 1978, p. 4)* ; "The children should be encouraged to sit with their feet flat on the floor and their backs straight. Bodies may be inclined forward slightly from the hips" *(Foerster 1979, p. 7)* ; and "If one shoulder is higher than the other as a child writes, it is an indication that a desk of different height should be used" *(Townsend 1978, p. 8)* . Townsend also indicates that a chair of correct height allows the feet to rest on the floor. King *(King 1987)* is the only author who stipulates a viewing distance:

> If pupils are taught to assume upright, healthful postures and to hold papers in correct position, the position of the head should not cause trouble. Heads should be reasonably erect so that the eyes will be far enough from the writing to permit a clear view. This is about 12 inches. (p. T8)

Johnson *(Johnson 1987)* spoke to posture, height of the writing surface, and the position of the arms in relation to the body and the height of the writing surface:

> Children should sit with both feet on the floor and with hips to the back of the chair. The children should lean forward slightly but not slouch. The writing surface should be smooth and flat and at a height which allows the upper arms to be perpendicular to the surface and the elbows to be under the shoulders. The children should not reach up to or slouch down to the writing surface. (p. T52)

Thurber *(Thurber 1987)* , the author of the only text which uses a slanted printing style, recommended a healthful posture, with no details given.

Photographs in the various texts show the height of the desks or tables from being slightly above the waist to being even with the armpit *(Barbe et al 1987) (Bell et al 1978) (Foerster 1979) (Johnson 1987) (King 1987) (Thurber 1987) (Townsend 1978)* . Only one text provides the suggestion that a child monitor his or her own visual distance. This is to be done by asking, "Are my eyes far enough away from my work?" (Bell et al., 1978, p. 5). No criterion is given for judging what distance is far enough away.

Harmon *(Harmon 1949)* examined the relationship of the physical environment of the classroom to "children's distortions of writing, drawing, and other educational performances" (p. 1). The physical environment included lighting, seating, and work surface equipment.

Research by Harmon *(Harmon 1949)* dealt with the interaction and cross-effect of trunk, head, and neck with vision. Over a 3-year period, 160,000 elementary school children in over 4,000 Texas classrooms were measured, and the physical environment was evaluated, as well as was its impact on the growth and development of the students. The physical environment and body condition of the students included lighting (illumination and luminance of the surrounding environment), restraining seating equipment, functional visual difficulties, postural defects, and other health problems. Harmon examined the relationship among all of these factors, as well as their effect on children's distortions of writing, drawing, and other educational performances.

Harmon's early study *(Harmon 1949)* seems outdated on the surface because of the advent of air-conditioned classrooms, some without windows, and use of fluorescent lighting. The increase in school population in some geographic areas, however, has resulted in the use of portable buildings. These buildings usually have windows and produce the same problems of illumination and luminance that Harmon investigated in 1949. The pendulum has completed its swing and brought us to the same position of earlier days: Where the child sits, the type of furniture used, and the child's position in relationship to illumination and luminance affect posture.

In a 1958 report, Harmon emphasized the interaction and use of the same nervous pathways for holding the body balanced in a relationship with the body's gravitational system and in "balancing the body with centers of visual attention" (p. A-18). As the viewing and work distance became shorter, the organic stresses produced by body-balancing reflexes were intensified. Harmon felt that "80% of a child's time in school is devoted to such tasks" (p. A-19) and that these tasks were those "where the actions of the body-balancing reflexes are at maximum intensification (p. A-19). Harmon's *(Harmon 1965)* address emphasized that awareness of position in space is based on gravitational reflexes and also establishes a foveal axis.

Instructions given in the teachers' manuals that accompany handwriting texts indicate that the authors are aware that viewing distance and posture at a desk can affect a child's ability to work effectively. Discrepancies between the descriptions of posture, paper position, use of the arms, and fit of furniture and the representation of these factors as presented in illustrations intended to model these elements indicate difficulty in attaining the true maximum desk-to-eye distance.

Summary of Review

No studies which established the maximum available desk-to-eye distance for students in Grades 1 and 2 were found. In view of Hurst's *(Hurst 1964)* findings that work distances for primary-age students were less than half of the standard distance given as adult reading distance by Borish *(Borish 1970)* and that the target distance used in near vision screening varied across tests and among similar testing across states, it was of interest to determine the maximum available desk-to-eye distance (MA-DED) for students in Grades 1 and 2 and to test for significant differences between means of the MA-DED and each target distance used in nearpoint screening (see Table 3).

Studies concerning the use of plus diopter (+D) fogging lens (FL) to screen for hyperopia disclosed that different powers are used, as did responses to the inquiry of the 50 states and the District of Columbia (the states) (see Table 2). In view of these differences, it was of interest to test for significance of differences between the dioptric equivalent of each Side or Across MA-DED means (D_S or D_A) and the sum of each D_S or D_A and each fogging lens power (D_{SFL} or D_{AFL}).

No studies were found which indicated the effect that growth might have on the available desk-to-eye distance of primary-age children. In view of this apparent lack, it was of interest to test for significant differences between measured and remeasured MA-DED means at each style of desk for two adjacent semesters, fall to spring (Time 1) and spring to fall (Time 2).

Main Thesis Page