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The prevalence of visual disorders in the juvenile delinquency population

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Abstract

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Conclusions: There appears to be a significant need for plus nearpoint lenses and vision training for visual perception and ocular motilities among the juvenile delinquent population.

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THE PREVALENCE OF VISUAL DISORDERS IN THE JUVENILE DELINQUENCY POPULATION

By

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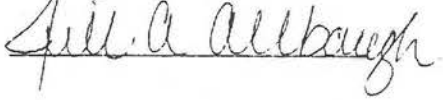

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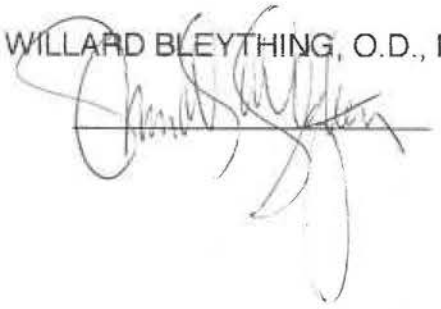

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INTRODUCTION

Juvenile Delinquency Social Issue

In the United States a half million children, approximately 2.3% of all children in the age group of 10-17, are referred to juvenile courts each year. Between 1979 and 1989 the overall youth population declined by 11% but the overall juvenile population in private and public detention facilities increased 46%. *

According to the Council on Scientific Affairs,[1] there has been a 10% increase in the number of juveniles in custody since 1983. In 1987, 208 per 100,000 juveniles were in custody. Results of longitudinal studies showed that 25%-35% of adolescents will have committed a legal offense by the age of 19 years. In short, juvenile delinquency (JD) is a major problem and continues to be one of the main social issues of today.

The problem with juvenile delinquency has been recognized for an entire century! Cook County, Illinois in the year 1899 created the first juvenile court. The motivation came from the recognition that children are not like adults with regard to responsibility. They felt that an attitude of humanness versus one of punishment should characterize society's dealing with youths who violate the law. They also felt that unlawful acts committed by youths were due to problems with understanding, guidance, and protection rather than an issue of criminal responsibility, guilt, or punishment.[2] While this is where it all began, in many cases this statement does not correctly describe the JD as we know them today.

*The legal definition of a JD is as follows: "one who commits a delinquent act as defined by law and who is adjudicated as such by an appropriate court".

The biggest question our society is left with is "What can we do to keep children from becoming JDs?" In order to answer this question, one must take a closer look at who these JDs are and try and understand when and where things went wrong in their lives. Once these questions are answered we will be in a better position to identify those children at risk and develop criteria for intervention.

Who is the Juvenile Delinquent?

Gender: According to a publication put out by the US Department of Justice, during a 1-day count in all juvenile facilities, 81% of the juveniles were male and 19% were female.[3]

Kaseno[4] established a pilot project in 1979 to determine the extent of the visual and perceptual deficits among the wards of the San Bernardino Juvenile Hall. The population was found to be to be 90% male and 10% female. Likewise, the Council on Scientific Affairs[1] found that juveniles in correctional facilities are predominately male (>85%).

Another study was composed of a population from the Harris County Juvenile Detention Home in Houston, Texas.[5] Wong found this population to be composed of 76.9% males and 23.1% females.

Age: An early look at delinquency prevention was done in 1960 by the US Department of Health, Education, and Welfare. The study looked at juveniles between 1940 and 1957. The study's profile of a JD indicated that the odds are 5:1 that they will be males aged 14-15.[6]

In 1987 The Council on Scientific Affairs[1] reported the characteristics of the average population of juveniles in public correctional facilities. Eighty-two

percent of the youths in correctional facilities were between the ages of 14 and 17 years, with the average age of first arrest being 12.5 years.

The age range of the population in Kaseno's JD study was 9 to 18 years, with the average being 16.2 years.[4]

Wong[5] found the Harris County JD population to have an average age of 14.7 years for males and 14.5 years for females.

Ethnicity: Kaseno[4] established that the JD population in San Bernardino consisted of 14% Black, 56% Caucasian, 24% Hispanic, and 6% mixed or other races. According to the US Department of Justice publication, between 1985 and 1989 the proportion of African-American JDs increased 9%, the proportion of Hispanic JDs increased 4%, and the proportion of Caucasian JDs declined 13%.[3] The Council on Scientific Affairs[1] reported that the average population of juveniles in public correctional facilities were of racial or ethnic minority (>55%).

Home and Social Environment: A longitudinal study of 411 London youth from 8 to 18 years of age was conducted in an attempt to define the predictors of teenage antisocial behavior and adult social dysfunction.[7] They found the most important predictors were measures of economic deprivation, poor parenting, antisocial families, hyperactivity, impulsively, and attention deficits. The most important independent childhood predictors of teenage antisocial behavior were: having a convicted parent, large family size (four or more siblings), few or no friends, nervous mother, low non-verbal intelligence, and being highly dared. In addition, convictions were predicted quite well with the following childhood factors: large family size, a convicted parent, poor housing, few friends, separation from a parent, low junior high school attainment, and being highly dared.

Dzik[8,9] did many studies with JDs in the 1960's. His work led him to determine five general factors that are involved in delinquency: improper supervision, improper discipline, absence of family projects, aggressiveness, and non-achievement in the classroom.

Academic Achievement: Kaseno[4] found in the San Bernardino Juvenile Hall population that, based on age, the average JD should be in 11th grade. However, the actual reading level of the population was found to be an average of 6 years behind grade level. According to the US Department of Health, Education, and Welfare,[6] most JDs have difficulties with school and reading abilities. In addition, most possess an attitude of hostility, defiance, and suspicion.

Health History: National statistics have shown that certain groups of socioeconomic juveniles have a greater number of unmet health needs. A study conducted at the Child Study Center of Yale University by Lewis[10,11] showed that JDs had a higher rate than nondeliquent juveniles of accidents, particularity head traumas. It was also noted that JDs were more likely to have more hospital visits before the age of four and between the ages of 14 and 19 than non-delinquents. In one study by Palfrey, et al[11] it was reported that parents of JDs listed more accidents and hospitalizations of their sons on a questionnaire than parents of nondeliquent boys.

Lewis[11] has also demonstrated that the JD population has an increased incidence of perinatal difficulties and has postulated that this early neurological trauma predisposes some children to a situation of an at-risk physical status in an at-risk environment. A study done in Finland examined 5966 males of which 355 were delinquents. Of the health factors considered, the only one that had a

statistically significant association with JD was Central Nervous System (CNS) trauma occurring before age 14. One may argue, however, whether the CNS trauma was causal, or whether the behavior of JDs will expose them to more CNS accidents.[12]

A review of research in the area of health problems in JDs was done by Penner,[13] where it was reported that hearing problems are around four times more prevalent in the delinquent population than in the normal school population. In addition, speech and language problems are three times more prevalent. A connection between neurological impairment resulting from prenatal or perinatal problems or trauma was also reported. The health problems were believed to be largely pregnancy or childbirth related, and tended to develop in the early childhood years or in the years preceeding the delinquent behavior.

Neurodevelopmental: A study by Karniski et al[14] examined the possible implications of early neurological trauma. It assessed the possible association of neurodevelopmental delays and JD populations. The JDs and a comparison group were tested in the areas of neuromaturation, gross motor function, fine motor function, temporal-sequential organization, visual processing, and auditory-language function. The comparison group did significantly better in fine motor function and temporal-sequential organization. In the areas of visual processing and auditory-language function the comparison group again did significantly better. In a study by Voorhees,[15] JDs had the most difficulty in tasks requiring sustained levels of concentration and attention such as visual, autoverbal, arithmetic, and speech tasks.

A study by Kandel et al[16] suggested that CNS malformation caused by the disruption of fetal neural development along with other factors may compromise an adult's ability to inhibit impulsive, aggressive behavior.

One study involving 1,962 urban delinquents proposed a developmental biopsychosocial model as to the origin of juvenile delinquency.[17] The study compared offenses, medical conditions, and test score performances. The study found that the juveniles who commit more assults are those with CNS or birth conditions and educational difficulties as well as orphans and one-parent youths with retardation, hyperactivity, or Attention Deficit Dysfunction (ADD). In addition, delinquents with CNS or birth conditions and retardation, hyperactivity, or ADD committed more property damage type crime. An interesting note is that myopia, astigmatism, and one-eye blindness were listed as conditions of the CNS medical subgroup.

Summary: Males outnumber females in the JD population by at least a 4:1 ratio.[1,3-5] The ages of JDs range from 9-18 years, with the average being around 14-15 years.[1,4,5] Caucasians make up about half the JD population, with the other half consisting of minority groups such as Blacks and Hispanics.[1,3,4]

JDs typically come from less than ideal home and social environments. [6-8] In addition, academic achievement is generally sub-standard, and is often accompanied by a bad attitude towards school and society.[4,9]

JDs often have medical histories of head trauma, perinatal difficulties, hearing problems, speech and language problems, and neurological impairments leading to a variety of neurodevelopmental delays.[10-17]

Juvenile Delinquency and Learning Disabilities

LD Definition: Sufficient evidence exists to establish a link between juvenile delinquency and learning disabilities (LD). In order to compare the two, one must first understand what the term "LD" entails. "Learning disabilities are defined as impairments of perceptual, thinking, and communicative processes which are manifested by a significant discrepancy between a child's expected achievement (based on intelligence test scores) and his or her actual achievement".[18] A difference between intelligence potential and school achievement of 2-4 years is considered a significant discrepancy.[19] The discrepancy exists even though the child's intelligence, vision, hearing, and motor abilities appear normal.[20,21] Dowis[22] believes there is some underlying organic nature to learning disabilities such as allergenic, nutritional, auditory, or visual which may all affect emotions, behavior, and learning. Others feel that only those with such conditions as perceptual handicaps, brain injury, minimal brain dysfunction, dyslexia, and developmental aphasia should be included in the category of learning disabilities.[23]

Historical link: The concern about a possible link between juvenile delinquency and learning disabilities has been with us since the late 1960's when parents and professionals in education and juvenile justice began to notice a higher incidence of delinquency among the learning disabled.[18,19]

Since that time the link has been studied and substantiated by many.[21,24-26] Dowis,[22] in his paper, cited the work of Poremba, Critchely, and Tarnopol. Poremba's study on a population of JDs at Juvenile Hall in Denver, Colorado estimated that 50% demonstrated significant learning disabilities. In New York and France, Critchely found that at least 75% of JDs were illiterate. In addition,

Tarnopol, in studying 102 male youths age 16-23, found that two-thirds of the JD school drop-outs had an abnormal Bender Visual-Motor Gestalt Test, a test to determine the presence of perceptual-motor dysfunction. While the link between juvenile delinquency and learning disabilities has been established, the strength of the relationship and its causes are not so clear cut.[21] It must also be mentioned that while there is a link, it is not always the case. Not all delinquents are learning disabled and not all learning disabled are JDs.

Gender: According to work done by Mauser,[21] both LD and JD groups have been predominately male, with males outnumbering females by a ratio of at least 4:1.

IQ: IQ is another area in which the two groups are similar as noted by Mauser.[21] While half of learning disabled and delinquent youth fall into the average mental ability, the average IQ according to Koppitz, is 92, a "low normal".

Academic Achievement: Most JDs and children with LDs tend to have difficulties in school beginning in the primary grades. The issue involving school performance and juvenile delinquency is a broad one. Research has indicated that juvenile delinquency may be directly or indirectly related to the child's past educational experiences. In many cases the delinquent dislikes school and/or the teacher. The teacher plays a large role in the delinquent's life, and must be able to communicate acceptance, define limits, and develop the student's self-concept.[21]

Reading is one of the foremost areas in which these students have difficulties. Several studies have confirmed reading under-achievement among

delinquents. Zinkus, Gottlieb, and Zinkus[27] cited the works of Margolin et al, Critchley, Tarnapol, and Mulligan. Margolin et al reported that 84% of delinquents were behind in reading by two or more years. However, Critchley and Tarnapol each found that number to be 60%. Mulligan found delinquents aged 15 to 18 years with average intelligence to be behind in reading by about 5.2 grade levels .

The question remains, however, as to just how juvenile delinquency and reading problems are related.[23] This area was studied by Hogenson[28] in 1974 where it was found that reading under-achievement and aggression were significantly correlated. However, as was found by those studying the area earlier, it was impossible to determine which factor is the cause of the other. Hogenson hypothesized, based on objective findings, that early reading failure leads to frustration, which in turns eventually manifests itself as aggression.

Other characteristics: Directional orientation problems and minimal brain dysfunction are two more characteristics shared by both LD and JD populations. In addition, both groups exhibit a negative self-concept and a low frustration tolerance.[21]

Possible causes of LD/JD link: While it is clear that there is a link between juvenile delinquency and learning disabilities, possible reasons or causes for this link remain unclear. The different treatment rationale (DTR) has been proposed by researchers as one way to explain the link. It suggests that police and court officials treat learning disabled delinquent youth differently than those delinquents who are non-learning disabled, even though they may not evidence any more delinquent behavior than the non-learning disabled.[20,25,29] A possible explanation for this was suggested by Perlmutter.[30]

He feels that learning disabled youth do not have the skills to negotiate in the juvenile justice system and therefore are more vulnerable to formal processing by the juvenile system than their non-learning disabled peers. Other researchers agree with this hypothesis and believe that the learning disabled have more difficulties expressing themselves, and may often evoke a negative response from others. Another factor is their inability to comprehend abstract ideas, thus affecting their understanding of the juvenile justice system, and their interactions with it.[25]

Another possible explanation for the juvenile delinquency and learning disability link deals with the adaptation of compensatory skills. Perlmutter[30] feels that research done by Pickar and Tori suggests that there are two types of learning disabled youth: those whose disabilities grow into more serious problems, and those who adapt by learning to compensate for their disabilities. The group which adapts somehow learns to focus on their strengths and abilities, thereby gaining better peer relations, school achievement, and self-esteem in the teen years. Those who do not adapt tend to develop low self-esteem, do poorly in school, and are more likely to fall into the behavioral patterns associated with juvenile delinquency. Perlmutter suggested that early identification of learning disabled youth is important so that adaptation skills can be nurtured .

Compensatory skills are often developed for coping with learning disabilities, however, there are many factors which may stand in the way of this adaptation. The visual system may definitely be one of these factors.

In both the LD and JD populations, it is impossible to find a single cause or a single cure. A variety of etiological factors and treatment strategies are associated.[21]

Summary: Sufficient evidence exists to link juvenile delinquency and learning disabilities.[21,22,24-26] Both populations are predominately male with "low normal" IQ.[21] Academic achievement is less than desired for both groups as well.[21,23,27,28] In addition, low self-esteem, low frustration tolerance, minimal brain dysfunction, and directional orientation problems have been found in each population.[21]

Proposed causes for the LD/JD link include the "different treatment rationale" and the lack or development of compensatory skills associated with early learning disabilities.[20,25,29,30]

Vision and Learning Disabilities

Vision and LD link: The idea that vision affects reading and may be linked to juvenile delinquency has been around for a long time. The printed page demands that we focus our attention at about 12 to 16 inches, while our visual system is better equipped to view distant objects. This can pose a problem for many individuals. It has been understood for some time that near focusing ability, eye movements, eye-teaming skills, eye-hand coordination, visual perception, visual imagery, and visual memory play a significant role in the ability to gather and understand information off the written page.[8]

Symptoms: There are symptoms presented by patients which optometrists often link to near point visual stress. A study that illustrates this was undertaken by Grisham et al.[31] In their study of 78 first and second year optometry students (42 females and 36 males), subjects were to fill out a survey listing 24 visual symptoms before and after administration of the Nelson-Denny reading test, a test used to rate school achievement along three measures--

vocabulary, comprehension and reading rate. Using data from the pre-test surveys to divide the subjects into quartiles, the study compared reading test scores between highly symptomatic subjects (representing the upper quartile) and subjects reporting few if any symptoms (representing the lower quartile). A significant difference was found in vocabulary and comprehension scores between the two groups, such that highly symptomatic subjects had lower scores in both areas. When looking at the subject pool as a whole, a significant negative correlation was found between the number of symptoms reported post-testing and reading rate. The more symptoms reported by a subject, the more likely that subject was to read slower than other subjects reporting less symptoms. Symptoms reported by more than 50% of the subjects after administration of the Nelson-Denny test included tired eyes, fatigue, sore eyes, dry eyes, distance blur, headache, sleepiness, eyestrain, losing place, skipping words and rereading.

Refractive problems: Grisham and Simons[32] presented a comprehensive review of studies concerned with the relationship between refractive error and reading. They limited their review to studies that followed scientific procedures.

Grisham and Simons cite eleven studies that investigate the relationship between hyperopia and reading. Eight of these studies found a significant relationship between hyperopia and reading. In four studies, a greater prevalence of hyperopia was found in populations of poor readers, and in four studies, hyperopes were found to have poorer reading skills than emmetropes or myopes.

Grisham and Simons also cited twelve studies that explored any link between myopia and reading ability. Only one of the twelve studies show

myopia to interfere with reading ability. Interestingly, the remaining eleven studies actually show a link between myopia and good reading ability.

Astigmatism was also addressed in Grisham and Simons' literature review. They found only one out of ten studies to show a link between high uncorrected astigmatism and low reading grades. Grisham and Simons pointed out the difficulty in constructing studies in which astigmatism is under investigation. Variables such as amount, orientation and association with a spherical refractive error must be addressed.

Grisham and Simons also reported on three comparative studies analyzing the relationship between academic achievement and correction of refractive error. One of the three studies found a statistically significant difference between improvement in English scores of a group corrected for refractive error and a group of emmetropes. The subjects corrected for refractive error showed greater improvement than the emmetropes. Another study did not find a statistically significant difference but did find a trend showing greater gains in reading for corrected hyperopes and uncorrected myopes. A final study measured change in speed of word recognition for corrected hyperopes and myopes. Percentage of subjects showing increased speed were calculated for several categories. One hundred percent of corrected hyperopes with hyperopia greater than 2.00D and corrected myopes with myopia greater than 3.00D showed increased speed of word recognition. This study suggests that the amount of refractive error to be corrected is an important factor to consider when measuring academic achievement.

Studies examining the relationship between anisometropia and reading ability are few as noted by Grisham and Simons in their literature review. However, they did point out a well constructed study by Eames[33] in which a group of uncorrected anisometropes were compared to a group of non-

anisometropes. At the onset of the study, both groups were given the Gates Silent Reading Test. It was found that the group with uncorrected anisometropia had a median score one year behind the group of non-anisometropes. Any existing refractive error was then corrected. Six months later, the Gates Silent Reading Test was repeated. It was found that both groups had improved scores, and interestingly, the median score for both groups was the same. Since during the six month interval, both groups were given the same academic instruction, Eames believed the anisometropic group's improvement in score was partly due to the correction of their anisometropia. The strength of this study was that the groups were matched in age, sex and IQ.

Visual acuity: In Grisham and Simons'[32] literature review of LD studies, they found two out of eleven studies that suggest a relationship between distance visual acuity and academic achievement. One study was a comparative study, in which a statistically significant difference was found between the distance visual acuity of a group of LD subjects and a group of non-LD subjects. The LD subjects were measured to have lower distance visual acuities than the non-LD subjects. The other study was a correlational study that found a statistically significant relationship between binocular distance visual acuity and reading ability. Both studies used subjects that were in the second or third grades, and Grisham and Simons suggested that distance visual acuity may influence measures of reading ability if reading instruction was conducted primarily at a far-point demand, such as on a chalkboard.

Grisham and Simons also reported on four studies that address near-point acuity's role in academic achievement. Two of the four studies found statistically significant results. Both were comparative studies that showed poor readers to have decreased binocular visual acuity when compared to good

readers. Grisham and Simons pointed out that decreased binocular near acuity could have several etiologies such as a refractive, accommodative or vergence problem.

Accommodation: The role of accommodation in academic achievement is documented in several types of studies. In correlational studies, accommodation is one of several visual components measured against achievement scores. One such study was conducted by Hall and Wick[34]. In this study, accommodative facility and accommodative amplitude were measured along with nine other visual functions as they related to the Stanford Achievement Test (SAT). Subjects were screened from a population of 125 children ranging from grades one through six to result in a subject pool of 111. Those excluded were kids who had strabismus, high uncorrected refractive errors, or an IQ score of less than 70. No significant relationship was found between SAT reading score and any single ocular function.

Another correlational study was performed by O'Grady[35]. In this study accommodative facility was one of 16 visual skills measured against four measures of academic performance. The subject pool consisted of 227 second grade students who were measured in 16 visual skills and given the Peabody Picture Vocabulary Test, Edwards Diagnostic Reading Test (sub scores in accuracy, comprehension and reading rate), and the Basic Numeracy Test. O'Grady combined the scores for the reading test with the numeracy test to get a composite score against which each individual visual skill was measured. A subject was given separate scores for negative accommodation and positive accommodation. A passing score was given if the subject could clear and image through +/-3.00D, respectively. No significant correlation was found

between accommodative facility and the composite academic performance score.

Although no significant correlation was found between accommodation and academic scores in the Hall and Wick or the O'Grady correlational study, there are comparative studies that document significant differences between learning disabled and non-learning disabled populations regarding accommodation skills. In a study conducted by Robinson[36], a group of JD subjects found to be two or more grade levels behind in reading ability was compared to a group of non-JD subjects reading at their expected grade level. The groups were matched with respect to age (13-17), IQ ("normal") and emotional state ("stable"). Each group consisted of 13 subjects. All subjects were given a comprehensive optometric exam as defined by the Optometric Extension Program. The frequency of a positive relative accommodation (PRA) of -1.25 D or less was compared between the two groups. A low PRA was measured more frequently in the reading delayed group than in the reading normal group. This difference in frequency was statistically significant at the 0.01 confidence level. Accommodative range was also compared between the two groups. Accommodative range was defined by the PRA and NRA findings (accommodative range = IPRA-NRAI). A comparison of the accommodative range mean shows a statistically significant difference at the 0.09 level of confidence, with the reading delayed group having a lower mean than the reading normal group. Finally, the two groups were compared regarding the prescription of a plus lens for near tasks. A plus lens that would place the accommodative demand at the midpoint of the accommodative range was calculated for each subject and was prescribed when a value of 0.50 D or more was calculated. A statistically significant difference ($p < 0.01$) was found when comparing the number of plus lenses prescribed for the reading delayed group

to the number of plus lenses prescribed for the reading normal group. The reading delayed group was prescribed plus lenses more often than the reading normal group.

Another comparative study finding a difference in accommodative ability between a LD and non-LD population was undertaken by Hoffman[37]. This study was conducted in two phases. Phase one consisted of the optometric examination of 107 learning disabled subjects that had been referred to the Southern California College of Optometry (SCCO) by educators, school and private psychologists and reading specialists. There were 87 males and 20 females covering an age range of 5 to 14. The diagnosis of a learning disability was determined previously by the referring source. The optometric exam included an assessment of accommodative facility which had the third highest failure rate among visual skills measured. Phase two consisted of measuring the four visual skills that had the highest failure rates in the LD population in a population of non-LD subjects. Non-LD subjects were selected from SCCO's general patient pool based on two criteria--the patient's age and the availability of time to run the necessary supplemental testing. In total, 25 non-LD subjects were assessed for comparison with the LD subjects. It was found that the LD subjects had a higher failure rate for accommodative facility than the non-LD subjects, 83.18 % versus 44%.

Hoffman's comparative study was based on a prevalence study conducted by Sherman[38] six years prior. Sherman's goal was to present which visual deficiencies occurred most frequently in a subject pool of 50 learning disabled kids. The subjects included 39 males and 11 females, covered an age range of 6 to 13, attended public school and had been labeled learning disabled by an educator, psychologist or reading teacher. Accommodative facility was found to have a failure rate of 88%.

Another study that examined the frequency of accommodative dysfunction in a LD population was that of Hammerberg and Norn[39]. Near point of accommodation was measured binocularly and monocularly on 78 subjects attending a school that admitted only dyslectic children. A subject failed the near point of accommodation test if the target blurred at or before 10 cm. The target used had N 5 print. Twenty seven percent of the subjects failed the near point of accommodation test.

Binocularity: A variety of tests can be administered to assess a subject's level of binocularity. These tests include near point of convergence (NPC), ocular motility, stereopsis, Keystone skills, cover and vergence system testing.

NPC: In a study by Weber,[40] high achievers were found to have significantly better NPC break and recovery scores when compared to low achievers ($p < 0.01$). Level of achievement was based on scores from the Comprehensive Test of Basic Skills - high achievers had scores in the upper quartile of score distributions, while low achievers had scores in the lower quartile. Criteria for passing the NPC test was defined as a break less than or equal to 2" from the nose and a recovery less than or equal to 5" from the nose.

Hall and Wick,[34] Helveston[41] and O'Grady,[35] all conducted correlational studies looking at the relationship between discrete visual skills and academic achievement. When NPC was specifically considered, no significant difference was found between high achievers and low achievers regarding performance on NPC. However, in Hall and Wick's study, pass/fail criteria for NPC was not defined. Although O'Grady and Helveston gave a number to define a "normal" NPC score, they did not give a separate break and recovery number. The number given for a "normal" NPC finding was 10 cm which is a little over four inches.

Ocular Motilities: In a recent study, Johnson and Zaba[42] compared the visual profile of an illiterate group of 54 adults (31 males and 23 females) with a literate group of 54 graduate students (9 male and 45 female). The study examined eight visual attributes. A significant difference in score was found with the tracking sub-test. Sixty one percent of the illiterate group failed the tracking sub-test compared to zero percent of the literate group ($p < 0.01$). The specific test used to measure tracking skills was not described, however the authors defined tracking as "the ability to move one's eyes across a line of print." The authors suggested literacy training programs including vision training which addresses oculomotor skills.

In a study by Rounds et al,[43] the value of such oculomotor training is assessed using a population of first year optometry students. Subjects were selected from members of the first year class who did not pass the California Basic Educational Skills Test (CBEST). The CBEST assesses three reading skills--literal, critical and logical comprehension. Once selected, all study members were given the Iowa Silent Reading Test (ISRT) level III 'E' and were tested on the Visagraph Eye-Movement Recording system at level 13. The subjects were then divided into two groups, matched for reading performance, such that one group received vision training in oculomotor skills and the other did not. After a four week interval in which the experimental group received a total of three hours of visual training per week, the subjects were again given the ISRT and tested on the Visagraph. Novel text was used for the second administration of the Visagraph test. The ISRT scores along two criteria--comprehension and reading efficiency. No significant difference was found between gains made in ISRT scores when comparing the experimental to the control group. The Visagraph test scores along seven criteria--comprehension, relative efficiency, number of regressions, number of fixations per 100 words,

fixation length, speed and span of recognition. A significant difference was found in gains made by the experimental group versus the control group in four of the Visagraph criteria--the experimental group showed greater improvement in relative efficiency, number of regressions, number of fixations and span of recognition when compared to the control ($p < .05$). The authors concluded oculomotor training is effective in improving reading skills.

In a study of pursuit movements as they relate to academic achievement, Weber[40] looked at a group of 26 boys and 24 girls ranging from second through fifth grade. All students were given the Comprehensive Test of Basic Skills (CTBS) from which scores were used to divide the students into quartiles. Pursuit ability was tested by asking the student to look at a fixation bead as it was moved in five circular rotations. A loaded pursuit was also measured by asking the students simple questions during the pursuit excercise. When pursuit alone was measured, 100% of the students whose CTBS score placed them in the upper quartile passed the pursuit test, as compared to 76% of the students in the lower quartile. When a loaded pursuit was measured, the difference was even more dramatic. Eighty-eight percent of those in the upper quartile passed while only 36% of those in the lower quartile passed. A significant difference was found between pursuit scores of the upper quartile group and the lower quartile group ($p < 0.01$).

While the three studies described above showed a significant correlation between oculomotor skills and reading ability, there are studies with results showing no such correlation. In a study conducted by Black et al,[44] a group of 35 normal readers and a group of 35 poor readers were selected from an inner suburban primary school. The normal readers volunteered for the study and had no history of reading failure. The poor readers were referred by various school officials. Both groups were given the Peabody Picture Vocabulary Test

and were found to be intellectually normal. The subjects were also given the reading component of the Wide Range Achievement Test and then tested with an electro-oculograpic technique developed by Black. The electro-oculographic testing device recorded eye movements which were then analyzed by computer to extract information such as the number of saccades, number of progressive saccades, number of regressive saccades, number of big saccades, mean saccade spacing, standard deviation in saccade spacing, total angle covered by saccade, mean angle covered per saccade, and mean peak saccadic velocity. Comparison of electro-oculographic evaluation results show no significant difference in findings between the group of normal readers and the group of poor readers. When the groups were divided into especially good and especially poor readers using the WRAT test, again no significant difference was found in their electro-oculographic performance.

A second study where no correlation was found between oculomotor skill and academic achievement was in the O'Grady[35] study where motility was one of sixteen visual skills assessed in a group of 227 second grade students. Subjects were given a passing score if they had smooth motilities and were given a failing score if they had jerky motilities. No significant relationship was found between the score on motility testing and a composite achievement score based on the Edwards Diagnostic Reading Test and the Basic Numeracy Test.

A third study which did not find a link between oculomotor skill and academic achievement used the King Devick test to assess oculomotor skills. In this study, Hall and Wick[34] measured visual skills against the Stanford Achievement test using a subject pool of 111 children ranging from grade one through six.

Conflicting results among these oculomotor studies may be due to the different ages of the subject pools, different tests used to evaluate oculomotor

performance, different oculomotor skills tested and different tests used to evaluate reading ability.

Stereopsis: In studies evaluating the relationship between stereopsis and academic achievement, measures of stereopsis are often included in a visual battery rather than presented alone. Two studies in which the Titmus stereotest was incorporated into a visual battery found no significant correlation between stereopsis and achievement score. In the study by Helveston,[41] 1910 first through third graders were given a visual test battery of 20 items and given three achievement tests--Metropolitan Readiness Test, Cognitive Abilities Test and the Iowa Test of Basic Skills. In the study by Hall and Wick,[34] 111 first through sixth graders were given a visual test battery of 11 items and the Stanford Achievement Test. The Hall and Wick study also tested stereopsis using the Randot stereotest and again did not find a significant correlation to achievement score.

Johnson and Zaba[42] included stereopsis in their battery of eight visual tests given to 54 illiterate adults (31 male and 23 female) and 54 literate graduate students (9 male and 45 female). No significant difference was found in steropsis scores between the two groups. However, no explanation was given on what test was used to measure stereopsis.

In a study by O'Grady,[35] no significant correlation was found between stereoacuity and the composite achievement score based on the Edwards Diagnostic Reading Test and the Basic Numeracy Test.

Keystone Skills: No LD study was found that reported a prevalence of failure with Keystone Skills testing by itself. However, one LD study, conducted by Sherman,[38] used Keystone Skills testing in combination with cheiroscopic and duction testing to assess binocular fusion. A high percentage of the LD

subjects were found to have a binocular dysfunction when measured with these criteria.

Cover Testing: One LD study was found to employ cover testing with a group of reading retarded subjects. Alder and Grant[45] used the cover test to determine the prevalence of strabismus in a group of subjects reading at age level, and a group of subjects reading below age level. In the group of subjects reading at age level, 4% were found to be strabismic. In the group of subjects reading below age level, 9.1% were found to be strabismic. Unfortunately, Alder and Grant do not define the testing distance they used for cover testing.

Lateral Phoria: In a study by Hall and Wick,[34] 111 kids representing first through sixth grade were evaluated with a battery of visual skills, one of which was heterophoria. When measured against the Stanford Achievement Test, heterophoria showed no significant correlation with achievement score. However, the authors left some unknown variables, such as what test was used to measure heterophoria, at what distance was it measured, and if they considered esophoria separately from exophoria or only used the amount of deviation.

Silbiger and Woolf[46] conducted a study where esophoria and exophoria were considered as separate endpoints. They did not explicitly define the test they used to measure lateral phoria, but they did provide the reader with the instruction set given. The instruction set implies use of a stereoscope set at both distance and near. Subjects were selected from a university freshman class, all of whom were given the Cooperative English Test (CET) during orientation week. A random sample of 78 was available for vision testing along with 35 students selected from a Reading and Study Skills Course (offered to students scoring low on the CET). Out of this group of 113, Silbiger and Woolf selected 25 to be in the High Reading Group (CET score > 170) and 38 to be in

the Low Reading Group (CET score < 159). No significant difference was found when comparing lateral phoria measurement between the two groups. One weakness of this study was that it was not noted if the test of significance was applied to the distance or near lateral phoria finding.

In a literature review concerned with the relationship between reading and vision, Suchoff[47] presented the idea that a lateral phoria finding in and of itself may not be as important as knowing if supporting vergence ranges are in place.

Vergence Ranges: Atzmon[48] found improved school performance as reported by 85% of subjects given training to increase absolute and relative vergence. The subject pool consisted of 150 kids (114 boys and 36 girls) randomly selected from 800 who had been previously diagnosed as learning disabled. The subjects ranged from 4 to 18 years of age, with the mean age being 9.5. A total of 109 subjects completed the training program. The goal of the program was to increase absolute convergence to 60$^{\Delta}$ at distance and increase relative convergence to 30$^{\Delta}$ at distance and near.

Visual Perception: The role of visual perception in academic achievement was explored by Shorr and Svagr[49] using a group of 31 second graders given a visual perception battery devised by the authors and the Gilmore Reading Test. The authors' visual perception battery covered aspects of visual perception such as gross motor performance, directional orientation, figure-ground relationship, form perception, hierarchy of visual or tactual perception, visual efficiency and eye-hand coordination. The Gilmore Reading Test was scored on comprehension and accuracy. A correlation at the 0.05 confidence level was found between total score on the visual perception battery and both sub scores of the Gilmore Reading Test.

In another study, an indirect relationship between visual perception and academic achievement was portrayed. Seiderman[50] selected 36 subjects out of 43 students attending a private school for the learning disabled. Criteria for selection required failure on four out of seven visual perceptual tests given. The seven perceptual tests were as follows: Winterhaven Copy Forms Test, Southern California Figure-Ground Test, Frostig Perceptual Constancy Sub-test, Getman Divided Form Board, directionality, alternate hopping, and alternate ball bouncing. The 36 subjects were randomly assigned into one of two groups. One group was to receive individually tailored vision training 30 minutes per day, four days a week, for nine months, along with daily specialized reading instruction. The other group was only given the daily specialized reading instruction. Both groups were given three achievement tests before and after the nine month training period. The three tests included the Stanford Achievement Test (SAT), Informal Reading Inventory Test (IRIT), and Individual Word Recognition Test (IWRT). The group receiving vision training along with reading instruction showed significant gains in two SAT sub-tests and in the IRIT when compared to the group receiving only reading instruction. Difference in gains between the two groups were at the 0.05 confidence level. The examiners concluded from their study that vision training is effective in improving academic achievement scores when a visual-perceptual problem exists.

A third study, conducted by Coleman,[51] measured the prevalence of visual perception dysfunction in a population of 87 students (61 males and 26 females) found to be two or more years below grade level in reading ability. The students ranged from grade one to six and were assessed on reading ability by psychological testing, guidance evaluations and teacher assessment. Visual perception skills measured include form concepts, visual memory and

recall, spatial orientation and laterality. Thirty percent of the students were found to have a visual perception dysfunction.

Perhaps the most intriguing paper on visual perception and reading ability is the study published by Kavale[52] in which the results from 161 studies were reviewed using meta-analysis. Kavale described meta-analysis as "the analysis of analyses as a procedure for integrating statistically a domain of literature." All studies reviewed were correlational studies exploring the link between visual perception and reading ability. Kavale stated that the existing literature on visual perception and reading ability has not produced solid conclusions because of the problem in defining the various components of visual perception and those of reading ability. Studies vary in which aspects of visual perception and reading ability they measure. For his meta-analysis, Kavale collected correlation coefficients reported by the studies in question and assembled them into categories to represent correlation coefficients between eight visual perception skills and six reading skills. The visual perceptual skills include visual discrimination, visual memory, visual closure, visual spatial relationships, visual-motor integration, visual association, figure ground discrimination and visual-auditory integration. Reading skills included general reading, reading readiness, word recognition, reading comprehension, vocabulary and spelling. Meta-analysis of the correlation coefficients collected from the 161 studies indicated that visual perception, when considered as individual skills or as a composite ability, was a strong correlate of reading achievement. Unfortunately, Kavale did not provide a complete list of the studies included in his meta-analysis.

Summary: Many studies have probed the question regarding the relationship between vision and learning disabilities. Symptoms such as tired

eyes, fatigue, sore eyes, dry eyes, distance blur, headaches, sleepiness, eyestrain, losing place, skipping words and rereading are often associated with poor reading abilities.[31] With regard to refractive error, hyperopia and anisometropia have been correlated with learning disabilities, however, studies have shown that myopia and astigmatism are not related to learning disabilities.[32,33] Distance visual acuity does not appear to be related to academic achievement although near visual acuity may be linked to academic achievement.[32] Accommodative amplitude and facility were found to have no significant correlation to learning disabilities.[34,35] However, learning disabled populations appear to have high failure rates when measuring accommodative range, facility and near point of accommodation, especially when compared to non-learning disabled populations.[36-39] Results vary between the studies on NPC as related to achievement level.[34,35,40,41] Likewise, studies comparing ocular motilities to learning disabilities have mixed results.[34,35,40,42-44] Three studies demonstrated a significant correlation between ocular motilities and reading ability, while others did not. No correlation was found between stereopsis and academic achievement.[34,35,41,42] Studies found no correlation between lateral phorias and learning disabilities.[34,46] Vergence ranges have not been directly linked to LD, however, a training program to increase ranges was shown to improve school performance.[48] Poor visual perception skills appear to be related to learning disabilities.[49-52]

Vision and Juvenile Delinquency

Symptoms: In 1947 Brooks[53] presented a report to the staff of the Napa State Hospital in Imola, California. In that report he quoted from the 1942 Life magazine which published the results of an experiment done by the Toledo,

Ohio juvenile courts. Brooks stated that these individuals often experience problems such as blur, headaches, skipping words, misreading words, and reading slowly when doing near work. Brooks also summarized the results of a study of 58 delinquents which was done by the State Hospital. They found a 79% failure on ocular history.

Kaseno[4,54] began a project in 1980 at the San Bernardino, California Juvenile Hall. Between July 1980 and June 1985, 2948 wards were screened. Eighty-three percent of those screened failed symptomatology based on an in-depth case history.

In 1989 a research team from The Optometric Center of Maryland performed vision exams on 132 subjects from the Charles H. Hickey, Jr. School for Boys in Baltimore County, Maryland, and 77.3% of the subjects failed the symptoms checklist.[55]

Refractive problems: Vision has been considered a factor in juvenile delinquency as early as 1932 when a visual study was conducted by the Northern Illinois College of Optometry on a population at the Chicago Parental School. The most significant finding of the study was that 93% of the delinquents had a refractive problem to some correctable degree. In contrast, only 50% to 60% of a typical population of children have a refractive anomaly.[56]

One of the conclusions in Brooks'[53] report as mentioned above was that 40% of delinquency was due to bad eyes which handicapped children's activities. Brooks also stated that "the vast majority of non-achievers are usually low hyperopes who demonstrate an absorption of available tolerance in both the accommodative and convergence faculties."

The Colorado Optometric Association studied the inmates of the Colorado State Industrial School for Boys in Golden.[57] The results of the study

indicated that 44 of the 72 subjects were found to have refractive errors. Twenty eight of the 44 were treated with vision training, and 15 were prescribed glasses.

Wong[5] compared optometric data from 633 JDs to data from the general population. The prevalence of refractive errors for the JDs was as follows: 45.0% hyperopia, 33.3% emmetropia, 21.6% myopia, and 34.9% astigmatism. The largest percentage of individuals in each of the refractive categories had refractive measurements in the amount of 1.00 diopter or less. Of the JDs tested, 27.5% were referred for further optometric or medical care.

The Optometric Institutes and Clinic in Detroit, Michigan was part of "Volunteers in Prevention",[58] a program set up by the Wayne County Juvenile Court system. They examined 37 youths in 1983 and obtained the following results: 70% had low hyperopia, less than 10% had a refractive error greater than 3.00 diopters, and less than 50% had astigmatism of 0.50 diopters or more with the most common being with-the-rule.

In Kaseno's study[4,54] of JD youth in San Bernardino, California, 2,013 of those screened (68%) were given complete 21-point exams, and 779 were given a "visual abilities evaluation" which consisted of developmental and perceptual tests designed to evaluate the individual's ability to take in visual information and process it. Five hundred and six wards completed an optometric visual therapy program. Five hundred forty-six were prescribed glasses of which 20% were for refractive error and 80% were designed to relieve near point visual stress.

In the Optometric Center of Maryland's[55] study, 22.7% of the JD population were found to have either myopia of -0.26 or greater, hyperopia of +1.26 or greater, or astigmatism of -1.01 or greater.

Visual Acuity: In 1981 vision screenings were performed on 253 youths at the Juvenile Court Center in Akron, Ohio. The screenings resulted in a referral rate of 58%. Of those referred, 18% had distance visual acuity of worse than 20/40.[9]

The "Volunteers in Prevention"[58] program found that 75% had a habitual visual acuity of 20/20 or better at distance and near; less than 10% had visual acuity worse than 20/50; over 90% had a best corrected visual acuity of 20/20 at distance and near.

Data obtained by the research team from the Optometric Center of Maryland who studied JDs in Baltimore County, Maryland showed a visual acuity of 20/40 or worse in either eye at distance and near in 6.0% of the subjects.[55] In contrast, Brooks[53] reported a much higher prevalence of poor acuity among delinquents. Thirty percent of the subjects had 20/40 visual acuity or worse.

Accommodation: The Colorado Optometric Center began a contract with the Colorado Division of Youth Services[59] in July of 1970 to examine data from the youth service's initial evaluations. As a result, 78 cases were reviewed resulting in the following test means: accommodative facility (plano to +2.00) 7.5 cycles/min., (plano to -2.00) 7.1 cycles/min.; #20 (PRA) -3.12/-2.42; #21 (NRA) +2.62/+2.08.

The "Volunteers in Prevention"[58] program found that 32% of those tested failed accommodative facility testing with +2.00/-2.00 diopter flippers. Kaseno's[4,54] project resulted in 60% failing the accommodative facility testing measured with near to far focusing at varying distances.

Binocularity: Brooks[153] summary of the work done by the State Hospital on 58 delinquent children included tests of binocularity. The following table summarizes the results.

Test	Failure	Borderline failure
rotations	43%	20%
versions	27%	7%
fixations	58%	21%
cover test	14%	
near point of convergence	18%	7%
distance phoria	44%	24%
near phoria	39%	31%

Findings from the Colorado Optometric Center[59] included the following tests of binocularity along with the means.

Test	Mean
near point of convergence	3.3/6.3 inches
#8 (distance phoria)	0
#9 (BO blur at dist.)	13.5
#10 (BO break/recov. at dist.)	24.3/7.8
#11 (BI break/recov. at dist)	11.9/4.2
#13b (near phoria)	3.6 XO
#16a (BO blur at near)	16.6
#16b (BO break/recov. at near)	26.6/10.6
#17a (BI blur at near)	17.9
#17b (BI break/recov. at near)	23.3/11.1

Vision Screenings performed at the Juvenile Court Center[9] in Akron, Ohio resulted in a referral rate of 58%. Seventy-three percent of those referred were due to improper eye muscle coordination of which two thirds showed excessive phorias at near (usually exophoria).

In the "Volunteers in Prevention"[58] program, more that 40% demonstrated a convergence insufficiency pattern on cover testing; over 75% pass stereopsis criteria of a 100 arc second threshold on Wirt Circles; 20% showed jerky patterns on eye movement testing.

In addition, Kaseno's[4,54] project in San Bernardino, California resulted in 62% of the JDs failing eye aiming abilities, and 60% failing eye pursuits. Similarly, the research team from The Optometric Center of Maryland discovered that 69.7% of the subjects exhibited motilities with head movement.[55] In the same study, 39.4%-71.9% failed the King-Devick test of eye movements (depending on the criteria applied). Cover testing showed strabismus or phorias of greater than 15$^{\Delta}$ to occur in 3.0% of the subjects, while a near point of convergence of greater than two inches happened in 37.8% of the subjects.

Visual perception: The Optometric Center of Maryland[55] conducted extensive visual perception testing. The following results are the percentages of failure in each area: Groffman Visual Tracing 53.0%-71.9% depending on the criteria applied; Wold Sentence Copy 30.3%; Jordan Left-Right 75.0%; and the Motor-Free Vision Perception Test 26.5%.

Kaseno's[4,54] San Bernardino study discussed visual perception in more general terms. Results showed that 95% of the youths entering the study had an undetected, undiagnosed and previously untreated visual perception problem.

Summary: The above mentioned studies reveal a wide array of visual characteristics among JDs. However, some conclusions can be drawn. To begin with, symptomatology criteria tends to have a high failure rate among JDs in many of the studies.[4,53,54] Thus, it seems an extensive case history exploring visual symptoms may be helpful in revealing the types of patients with potential delinquent behavior. On the other hand, visual acuity may not be as revealing, as its failure rate was quite variable (30%, 25%, 18%, and 6%).[9,53,55] Likewise, unspecified refractive error among the JDs was quite variable (93%, 61%, and

20%).[4,54-57] However, hyperopia seems of significance since every study but one reported it to have high prevalence among the JD population.[5,58]

In addition, exophoria was demonstrated consistently in various studies, as well as convergence insufficiency. Accommodative amplitude and facility were also reduced consistently.[4,9,53-55,58]

The most repeatable and conclusive findings throughout the literature included failed symptomatology, hyperopia, and near point problems (exophoria, convergence insufficiency, and decreased accommodative amplitude and facility).

Vision, Juvenile Delinquency, and Learning Disabilities

Juvenile delinquency continues to be a major problem in the US, and we are faced with a lack of solutions for dealing with the issue. The population contributing most highly to the situation include youths with an average age of 14-15 years who are predominately male Caucasians, with Blacks and Hispanics following closely behind. This population often has a medical history of head trama, perinatal difficulties, hearing problems, speech and language problems, and neurological impairments which often lead to a variety of neurodevelopmental delays. Less than ideal home and social environments impact these youth, who are left with low self-esteem and a negative attitude. Academic achievement is generally less than desired as well.

The poor academic achievement in delinquent youth has been shown to be linked with learning disabilities in studies conducted over the past three decades. Both the JD population and the LD population share many of the same characteristics. Each of them are predominately male with "low normal" IQ who have low self-esteem, low frustration tolerance, minimal brain

dysfunction, and directional orientation problems. Researchers have been working to find an explanation as to why learning disabled youth have a tendency to become delinquent. While no direct causes have been found, the "different treatment rationale" and "compensatory skills" arguments have been proposed as possible explanations.

It is clear that vision and associated skills definitely play a large role in the near point demands associated with learning. Learning disabilities have been found to be associated with near point visual symptoms, hyperopia, anisometropia, poor perceptual skills, and poor oculomotor skills. Visual characteristics of JDs which parallel those of LDs include near point visual symptoms and hyperopia.

When vision problems exist, they interfere with the learning disabled individual's ability to develop the skills necessary for coping with his/her every day situation. It is important that these visual problems be identified and remedied so that their vision will not be responsible for holding them back from succeeding in school and becoming productive citizens.

PURPOSE OF THIS STUDY

This particular study was undertaken to further define the visual profile of delinquent youth. We hope to clarify some of the inconsistencies in the literature currently addressing this topic. This study has the advantage of a large number of subjects who were all tested by one examiner over a period of five years.

METHODS

For this study 477 records of optometric exams were obtained from Stanislaus County Juvenile Hall in Folsom, California. The juveniles in the facility had committed serious offenses. Only 33% stayed in the facility longer than 72 hours and the average stay was 14 days. During the intake process the juveniles participated in a vision screening. Failure on the screening or other concerns, such as a lost pair of glasses, resulted in a complete vision exam. The screening consisted of Vision Symptom Questionnaire, Keystone Visual Skills, Winterhaven Copy Forms/ Visual Organization, Winterhaven Visual Memory, and Motor-Free Visual Perception Test (see appendix A). All exams were administered by Daniel Ulseth, OD from 1990 to 1995. Records were obtained for male and female subjects ages ranging from 10 to 19 years old. Data were entered into a data base created on Claris Filemaker. Each case was assigned a file number and the following data entered: name; date of birth; age; gender; ethnic group; history; time since last exam; distance and near visual acuity, both aided and unaided; cover test distance and near; book retinoscopy; far point retinoscopy; refractive status; distance, near, and gradient phorias; distance and near lateral vergence ranges; near vertical vergence range; gradient positive relative and negative relative accommodation; and new distance and/or near prescription. The Vision Symptoms Questionnaire results, Keystone Visual Skills, Winterhaven Copy Forms/ Visual Organization, Winterhaven Visual Memory, and Motor-Free Visual Perception Test were entered as a pass or fail score (Table 1). Pursuits, saccades, stereopsis, near point of convergence, accommodative facility, internal and external ocular health were also entered as a pass or fail score. Results were entered exactly as they appeared on the exam forms when possible. Ethnicity was entered as

the subject had listed it, however categories were developed later and the entries were grouped as appropriate (Table 2).

Table 1 Failure Criteria

Symptom Questionaire	3 or more yes responses
Keystone Skills	2 or more responses other than "expected"
Winterhaven Copy Forms/ Visual Organization	performance at least 1 year below age level
Winterhaven Visual Memory	performance at least 1 year below age level
Motor-Free Visual Perception Test	performance at least 1 year below age level

Table 2 Ethnic Categories

African American:	African American Black
Assyrian:	Assyrian
Cambodian:	Cambodian
Caucasian:	Caucasian White
East Indian:	Indian
Hispanic:	Hispanic Mexican Latino Puerto Rican
Native American:	Native American American Indian
Oriental:	Oriental
Pacific Islander:	Filipino Hawaiian Samoan
Portuguese:	Portuguese
Spanish:	Spanish

Stereopsis, near point of convergence, and accommodative facility were entered as pass or fail, so in cases where actual findings were recorded we applied a pass/fail set of criteria. Stereopsis was a pass if it was 20 arc seconds or better, near point of convergence was a pass if it was 3 inches or closer, and accommodative facility was a pass if it was 3 seconds per cycle or faster with +/- 2.00 D flippers. Book retinoscopy was often recorded as a range, for instance 0.75 to 1.00 diopters; in those cases we entered the first number of the range in

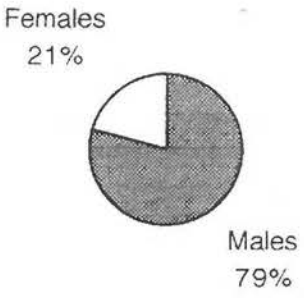
the data base. Internal and external ocular health were recorded according to the structures examined and their results. We entered all unremarkable health records as a pass. The negative and positive relative accommodation were recorded as gross findings. To determine the net we subtracted the OD subjective refraction sphere power from the recorded negative and positive relative accommodation. The anisometropia for the refraction and new prescription was found by subtracting the OD sphere from the OS sphere in each case.

RESULTS

The purpose of this study was to develop a visual profile of the juvenile delinquent; this was done by drawing information from the data base. From the frequency information, the prevalence, mean, and standard deviation were calculated. In some cases maximums and minimums were also calculated. Below are details on various profile factors. It is well to remember that the subjects in this study were selected on the basis of them failing a vision screening which included a vision symptom questionnaire, Keystone Visual Skills, Winterhaven Copy Forms/ Visual Organization, Winterhaven Visual Memory, and Motor-Free Visual Perception Test. Those juveniles receiving a vision exam represented 62% of the total population entering the facility.

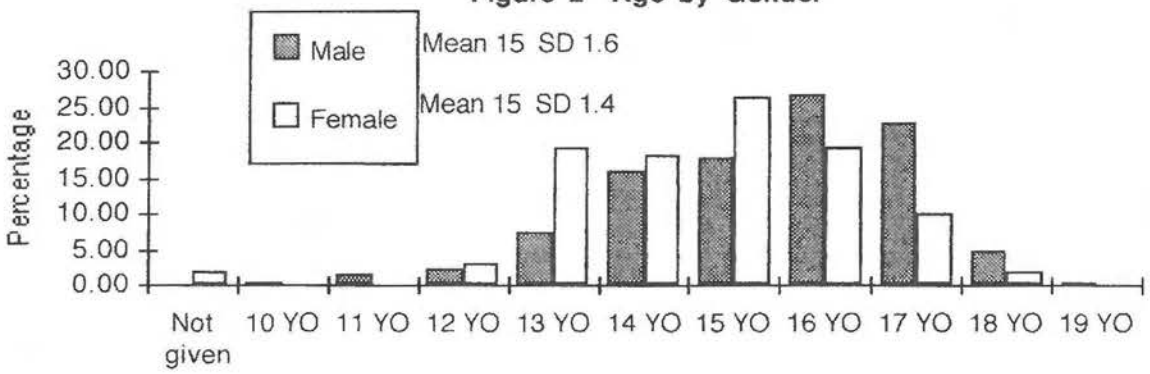
Gender: Separating the group into males and females we find 378 males and 99 females, which is a ratio of 3.81: 1 (Figure 1).

Figure 1 Gender Representation



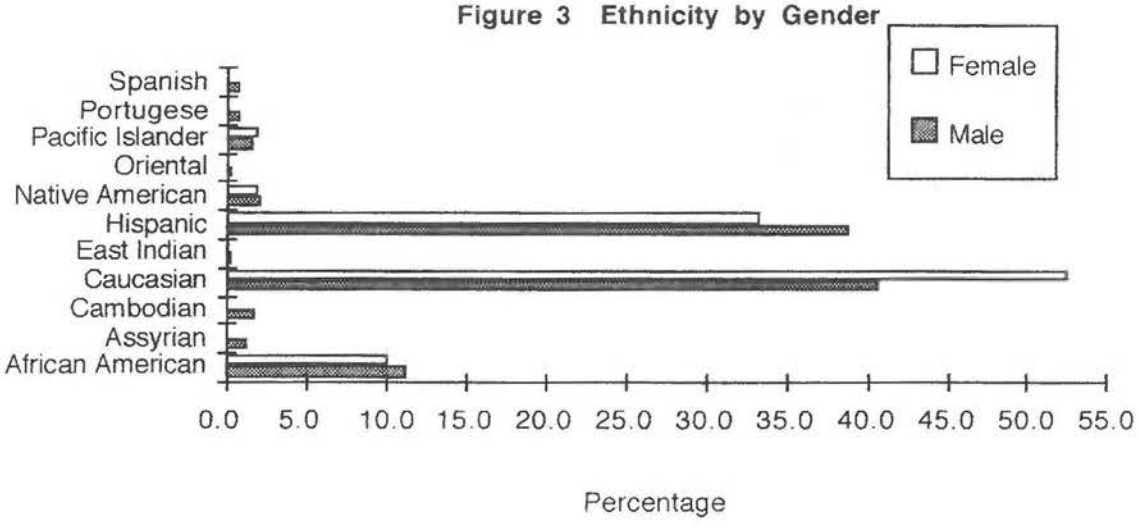
Age: The JDs ranged from 10 to 19 years old with the mean age being 15 years. If we look at the age by gender the mean is again 15 for both male and females (Figure 2).

Figure 2 Age by Gender



Ethnicity: Assessing ethnicity by gender we find a difference between males and females. The percentage of males in each ethnic group in descending order is: Caucasian 40.7%, Hispanic 38.9%, African American 11.4%, and other 9%. The percentage of females is as follows: Caucasian 52.5%, Hispanic 33.3%, African American 10.1%, and other 4.1%. The male population has nearly equal percentages of Caucasian and Hispanic juveniles, but the female population has a higher percentage of Caucasian juveniles vs Hispanic juveniles (Figure 3).

Figure 3 Ethnicity by Gender



Symptoms: We also counted the frequency of key words in the case history. Some of the more commonly found words were *reading, blur, headaches, words blur, loses/losing place, and eyes water.* See Table 3 for a frequency distribution of words found in the history.

Table 3 Common Case History Words

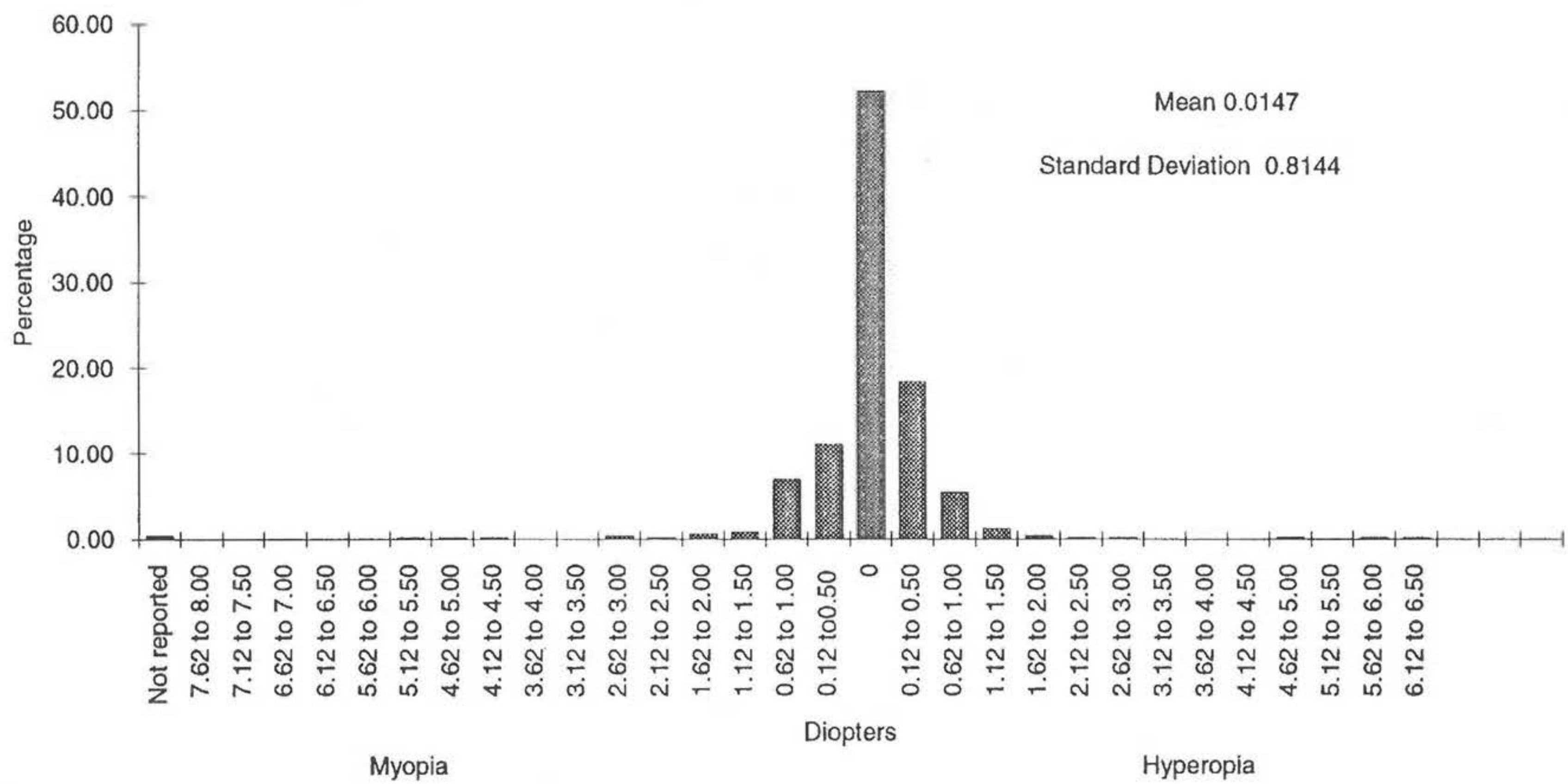
Asthenopia		Performance	
Word used	no. of cases	Word used	no. of cases
Headaches	215	Reading	349
Water	116	Blur	283
Eyes tire	69	Loses/losing place	179
Eyes hurt	51	Words blur	167
Eyes ache	41	Glasses, specs,SRx	59
Burn	38	Diplopia/double	40
Rubs eyes	13	Distance blur	35
Eyestrain	8	Words shift	25
Itch	6	Uses/used finger	20
Irritate	2	Skips lines/words	17
Eyes sting	2	Concentration	16
		Words swim	10
		Words move	10
		Holds book close	4

Refractive problems: The mean refractive status was 0.015 diopters (OD sphere power). Over half of the JDs were emmetropes (52.2%), while 26.6% were hyperopes and 20.8% were myopes. Of the hyperopes and myopes, approximately 90% have refractive measurements of 1.00 D or less (Figure 4). Twenty percent of the JDs have astigmatism -- 9.4% were with the rule, 8.6% were against the rule, and 1.5% were at an oblique axis. Results were calculated for OD and OS but to simplify discussion, only the OD information has been used. The anisometropia was determined by calculating the difference between OD and OS spheres. There was anisometropia in 23.3% of the cases. Of those with anisometropia, 76.6% had a difference of 0.50 D or less.

Far point prescriptions were given to 17% of the JDs (13% myopes, and 4% hyperopes). Eight percent of the JDs had an astigmatic component to their prescription (3.6% WTR, 3.6% ATR, and 0.8% oblique). The anisometropic component of the prescriptions was calculated, and it was found that 5.9% of the population received this correction. Over 80% of the anisometropia prescribed was 1.00 D or less.

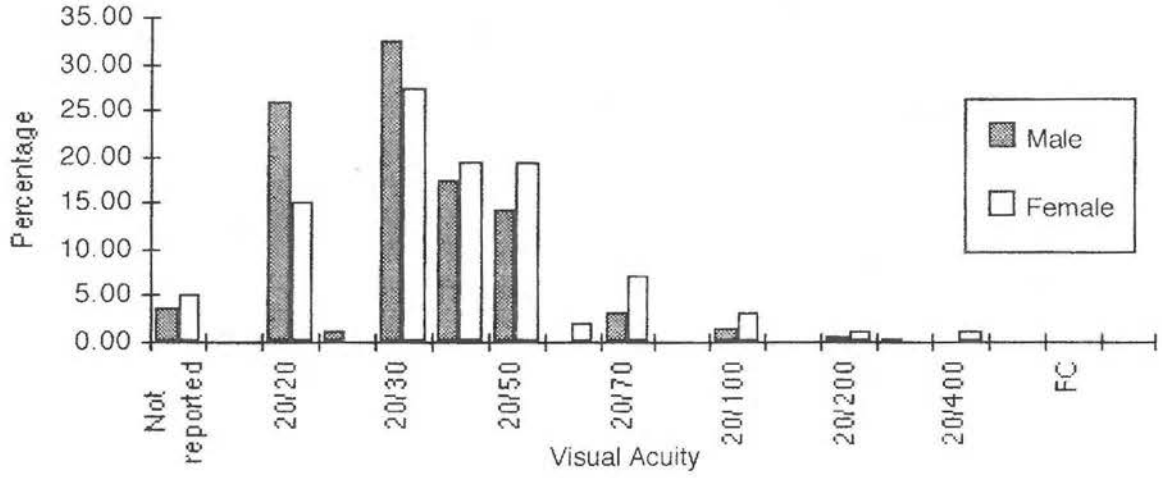
An interesting note is that while 17% of the JDs were given a prescription to correct a refractive problem, 82.8% of the JDs were prescribed an add for near -- either in conjunction with their distance prescription or as separate reading glasses. Over 70% of the near adds were from 0.62 to 1.00 diopters in power.

Figure 4 Subjective Refraction (#7a) OD Sphere



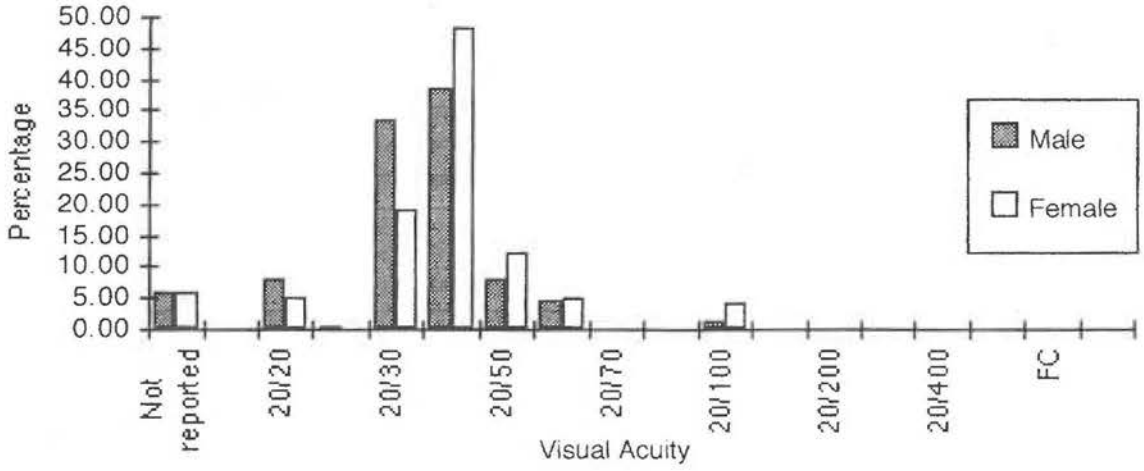
Visual Acuity: Tabulation was by total population and by gender. Aided acuities were unavailable on most of the subjects, thus calculations were completed on unaided visual acuity performed OU, OD, and OS at distance and near. The percentage of JDs having distance visual acuity of worse than 20/40 OU is 19.6% for males and 33.4% for females (Figure 5).

Figure 5 Unaided Distance VA OU



The percentage of JDs having near visual acuity of worse than 20/40 OU is 13.8% for males and 21.2% for females (Figure 6).

Figure 6 Unaided Near VA OU



Applying the visual acuity criteria of worse than 20/40 to both OD and OS at distance and near, results in the following: males OD distance 25.4%, OS distance 27.3%, OD near 20.4%, and OS near 19.1%; females OD distance 34.4%, OS distance 37.4%, OD near 31.3%, and OS near 27.3% (Figures 7,8,9,10).

Figure 7 Unaided Distance VA OD

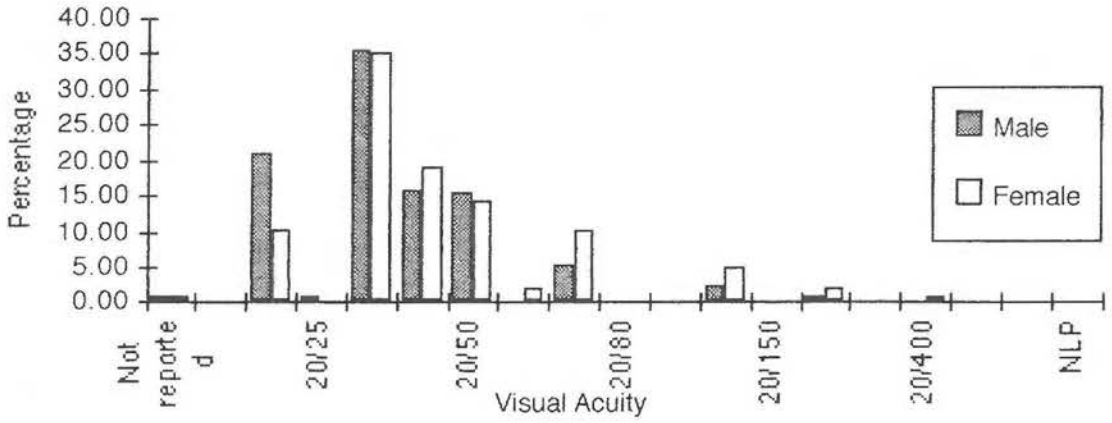


Figure 8 Unaided Distance VA OS

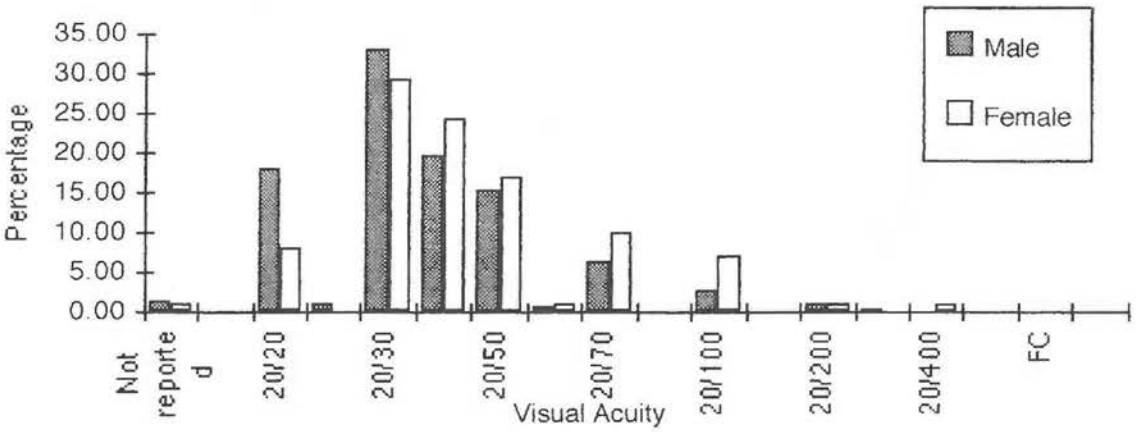


Figure 9 Unaided Near VA OD

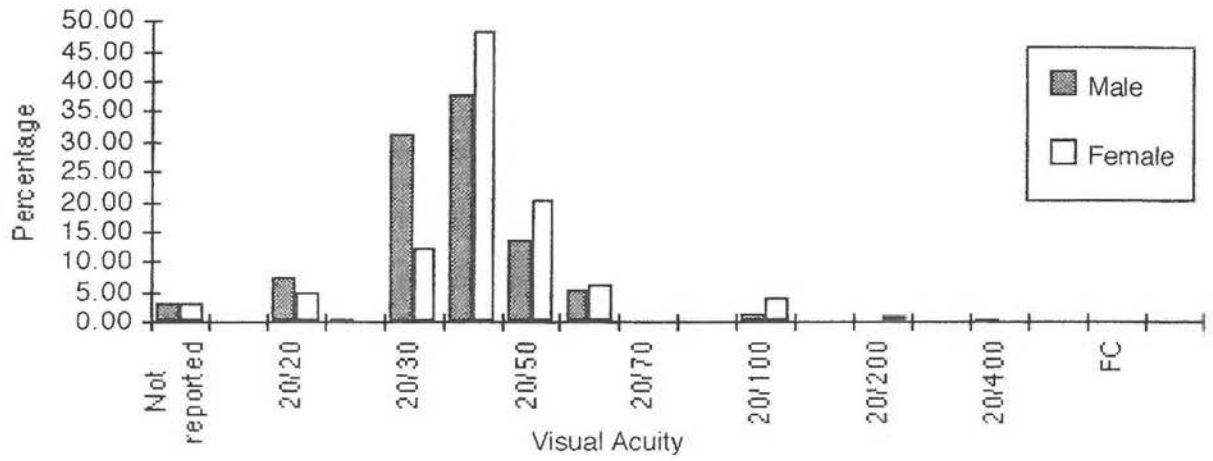
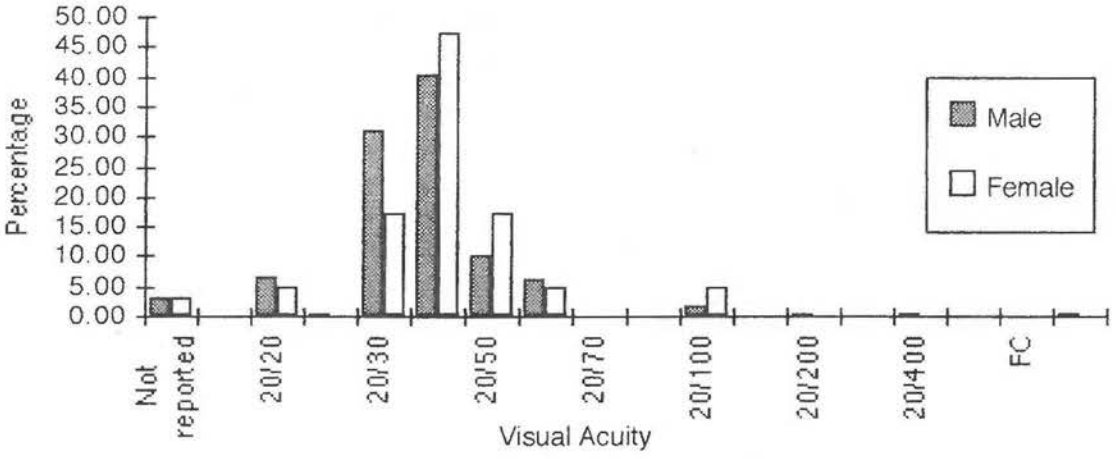


Figure 10 Unaided Near VA OS



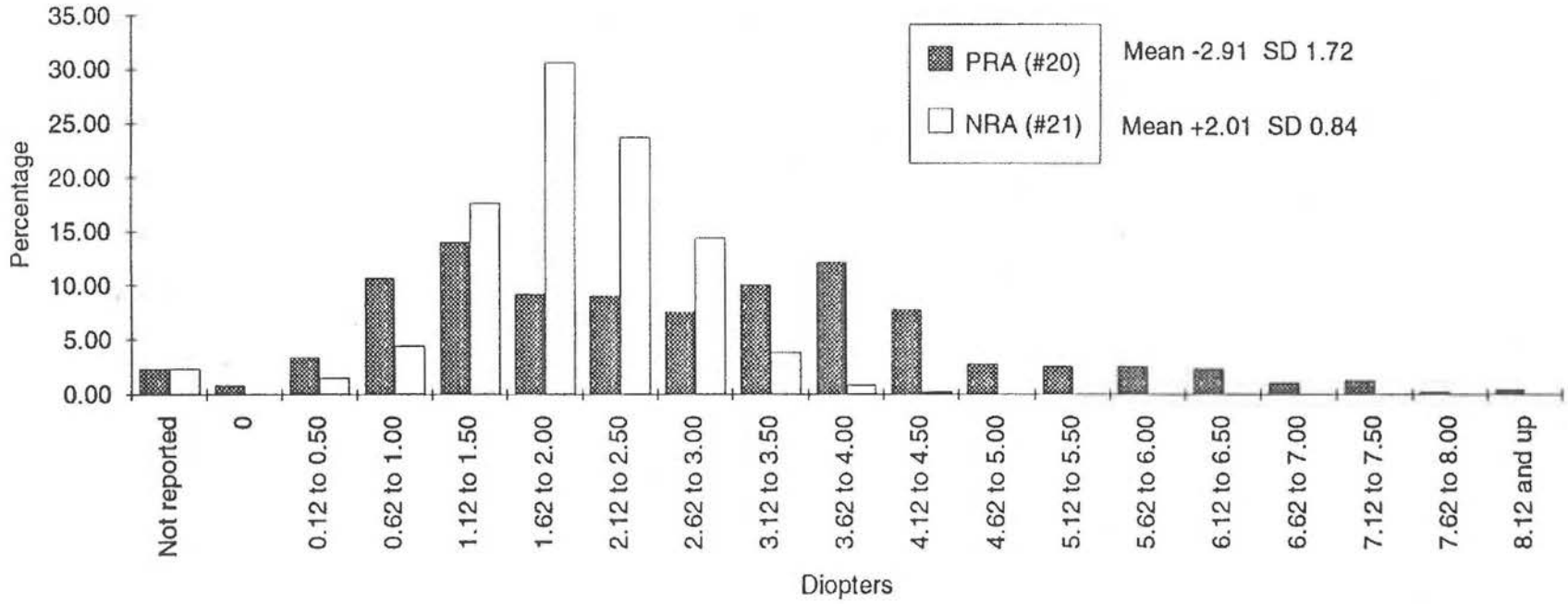
Accommodation: The accommodative tests performed were book retinoscopy, and accommodative facility and ranges. In book retinoscopy the highest percentage fell between 0.75 to 0.87 diopters (49.5%); the next highest percentage fell between 1.00 and 1.12 diopter (27.0%) (Table 4). The percentage of JDs failing accommodative facility was 66.9%.

Positive (PRA) and negative (NRA) relative accommodation had very different results. While the NRA had a mean of +2.01 with a standard deviation of 0.84, the PRA had a mean of -2.91 with a standard deviation of 1.72. Figure 11 illustrates the greater scattering of responses in the PRA range compared to the NRA range.

Table 4 Book Retinoscopy

		% of Total
Not reported	83	17.40
plano to 0.37	0	0.00
0.50 to 0.62	23	4.82
0.75 to 0.87	236	49.48
1.00 to 1.12	129	27.04
1.25 to 1.37	3	0.63
1.50 to 1.62	3	0.63
1.75 to 1.87	0	0.00
2.00 to 2.12	0	0.00
Total	477	100.00
Mean	0.68	
SD	0.34	

Figure 11 PRA (#20) and NRA (#21) Net



Binocularity: The results of the entrance testing showed many high failure rates (Figure 12). The lowest occurred in near point of convergence (NPC) testing with 46.1% failing. Motilities had an increasing number of failures: saccades 58.9% and pursuits 62.3%. Stereopsis and Keystone skills were determined on pass/ fail criteria with the following percentage of failures: 65.8% and 91.4% respectively. Cover testing was categorized at near and distance as either an orthophoria, esophoria, exophoria, constant esotropia, intermittent esotropia, constant exotropia, or intermittent exotropia. At distance the greatest number of JDs were orthophoric (92.0%), while at near the greatest number were exophoric (59.8%). Strabismus occurred in 4.4% of subjects in the distance and in 13.4% at near. Constant exotropia at distance (2.3%) and near (7.1%) occurred more often than any other form of tropia (Table 5).

Table 5 Cover Test

	Distance	% in Total	Near	% in Total
Orthophoric (O)	439	92.03	102	21.38
Exophoric (XO)	13	2.73	285	59.75
Exotropic (XT, XTA, XTH)	11	2.31	34	7.13
Exotropic [X(T), X(T)A]	1	0.21	19	3.98
Esophoric (SO)	3	0.63	22	4.61
Esotropic (ST, STA, STH)	7	1.47	8	1.68
Esotropic [S(T), S(T)A]	2	0.42	3	0.63
Not Reported	1	0.21	4	0.84
Totals	477	100.00	477	100.00

O = Ortho X = Exo S = Eso T = Tropic (T) = Intermitant
A = Alternating H= Hyper, Hypo

The vergence system was assessed with phoria and vergence range measurements. Results include lateral phorias at distance and near, along with a gradient phoria. The mean of the distance phoria was 0.1 prism diopters exophoric, ranging from 14 exo to 20 eso. The distance vertical phoria had a mean of 0, a maximum and minimum of 0. The near lateral phoria mean was 2.4 prism diopters exophoria, ranging from 15 exo to 20 eso. The gradient phoria

was done through a +1.00 over the far point subjective and had a mean of 5.0 prism diopters exophoria, ranging from 15 exo to 15 eso.

Vergence ranges were tested at distance and near. The base out prism distance ranges had a blur mean of 7.5, maximum 28 and minimum 0; break mean of 17.4, maximum 36 and minimum -1; and recovery mean of 4.8, maximum 28 and minimum -9. The base in prism distance ranges had a break mean of 8.9, maximum 20 and minimum 0; and a recovery mean of 1.6, maximum 16 and minimum -10. The base out prism near ranges had a blur mean of 6.9, maximum 28 and minimum -16; break mean of 18.5, maximum 32 and minimum -4; and recovery mean of 6.8, maximum 24 and minimum -20. The base in prism near ranges had a blur mean of 3.4, maximum 22 and minimum 0; break mean of 17.6, maximum 30 and minimum 0; and a recovery mean of 5.8, maximum 24 and minimum -10 (Table 6).

Visual perception: Tests used were the Winterhaven Visual Memory, Winterhaven Copy Forms/ Visual Organization, and Motor-Free Visual Perception Test (MFVPT). The percentage of failures were 92.5% on the Winterhaven combined testing and 93.1% on the MFVPT (Figure 12).

Ocular Health: Nearly all of the juveniles passed internal (99.6%) and external (98.5%) ocular health examinations (Figure 12).

Figure 12 Failure Profile

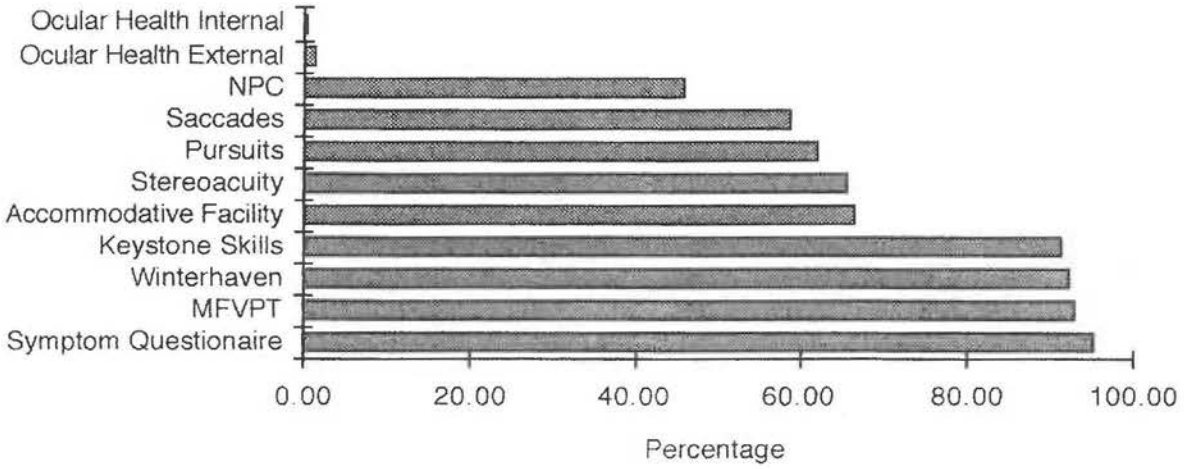


Table 6 summarizes the results tabulated from the 477 JD records.

Table 6 Juvenile Delinquent Visual Profile

Age 15

Gender 3.8:1 Male:Female

Ethnicity				
Caucasian	Male 40.7%	Hispanic	Male 38.9%	
	Female 52.5%		Female 33.3%	
African American	Male 11.4%	Other	Male 9.0%	
	Female 10.1%		Female 4.1%	

	Percentage Failed		Percentage Failed
Symptom Questionnaire	95.4%	Pursuits	62.3%
MFVPT	93.1%	Saccades	58.9%
Winterhaven	92.5%	NPC	46.1%
Keystone Skills	91.4%	Ocular Health - External	1.5%
Accommodative Facility	66.9%	Ocular Health - Internal	0.4%
Stereoacuity	65.8%		

Unaided Visual Acuity	Distance	Near	**Cover Test**	Distance	Near
20/20	23.7%	7.3%	Orthophoric	92.0%	21.4%
20/30	32.3%	30.8%	Exophoric	2.7%	59.8%
20/40	17.6%	40.6%	Esophoric	0.6%	4.6%
Worse than 20/40	22.4%	15.3%	Tropic	4.4%	13.4%

Subjective Refraction (#7a)	Sphere	Cylinder	Anisometropia
Mean	0.01	-0.2	0.04
SD	0.81	0.58	0.51

Accommodative Status	PRA	NRA	Book Retinoscopy	Accommodative Facility
Mean	-2.91	+2.01	0.68	66.9% Failed
SD	1.72	0.85	0.34	

Vergence Posture	Distance Phoria (#8)	Near Phoria (#13b)	Gradient Phoria (+1.00)	Distance Vertical (#12)
Mean	0.1 exo	2.44 exo	4.99 exo	0
SD	2.40	4.48	3.69	0

Vergence Ranges	Distance Base Out Prism			Distance Base In Prism		
	Blur (#9)	Break (#10)	Recovery (#10)	Break (#11)	Recovery (#11)	
Mean	7.48	17.35	4.84	8.92	1.64	
SD	7.60	9.78	4.38	2.99	2.43	
	Near Base Out Prism			Near Base In Prism		
	Blur (#16)	Break (#16)	Recovery (#16)	Blur (#17)	Break (#17)	Recovery (#17)
Mean	6.87	18.52	6.77	3.38	17.63	5.83
SD	8.72	9.93	5.70	5.54	7.00	5.16

Typical Rx	Sphere	Cylinder	Add		
Mean	-0.07	-0.1	0.74	No Anisometropia	94.1%
SD	0.59	0.45	0.39		

DISCUSSION

Comparison of Folsom JD Study to Other JD and LD Studies

Socio-demographic Profile: The juvenile delinquent population profiled in this study is a fair representation of a general juvenile delinquent population in terms of gender, age and ethnic distribution. The percentage of male subjects in this study (79%) is similar to that found by the Council on Scientific Affairs[1] (>85%), the US Department of Justice[3] (81%), and Kaseno[4] (90%). A juvenile delinquent subject participating in this study is close to 15 years of age which agrees with information given by the Council on Scientific Affairs[1] (14-17), Kaseno[4] (16.2), and the US Department of Health Education and Welfare[6] (14-15). Caucasians were the most represented ethnic group in this study (42.98%) as was the case in the Council on Scientific Affairs[1] study (<45%) and the Kaseno[4] study (56%).

The ethnic composition of this JD population was also compared to that of the county in which they resided, using data compiled by the US Census Bureau[60]. Compared to Stanislaus County, the Folsom JD population had a smaller representation of Caucasians (71% vs 43%) and a larger representation of African Americans (11% vs 2%) and Hispanics (38.9% vs 22%). Note that the Stanislaus County data was based on census information covering all ages. Census information presenting ethnic breakdown by age was available, but unfortunately, Hispanic individuals were incorporated in the general categories of Caucasian, African American, American Indian, Asian or other.

In summary, the subjects profiled in this study are likely to be a fair representation of a general juvenile delinquent population although differ as to ethnic representation of the county of their residence.

Symptoms questionnaire: Common symptoms expressed by the JDs in this study (blur, headaches, loses/losing place) parallel those found by the JDs in Brooks'[53] study (blur, headaches, skipping words, misreading words). Percentage of JDs failing a symptom questionnaire in this study (95.4%) is slightly higher than that found in other studies of JD populations, for example in the Kaseno[4,54] study (83%) and the Optometric Center of Maryland study[55] (77.3%). However, as noted in the results section, failure of the symptom questionnaire was one criteria for selection into the current study. The other criteria for inclusion into the current study was loss of glasses.

Grisham et al[31] analyzed the relationship between symptomology and academic achievement using a subject pool consisting of optometry students. It was found that those reporting the most symptoms scored lower on the academic achievement test.

In summary, studies, including this one, show the JD population as a highly symptomatic group and highly symptomatic people have been shown by one study to score lower on an academic achievement test.

Refractive Problems: This study investigated three areas of refractive problems--far point ametropia, far point anisometropia and near point prescription. Data concerning refractive status was compiled using technical criteria (i.e. how many absolute ametropes) as well as clinical criteria (i.e. how many ametropes were given a prescription). Examining the data from these two viewpoints is helpful when comparing this study to other JD studies, since some

studies only consider refractive status from a technical standpoint while others only from a clinical standpoint.

Far Point Ametropia - Technical: From a technical standpoint, the Folsom JD population had a higher prevalence of emmetropia (52.2%) than the JD populations studied by the Colorado Optometric Association[57] (39%) and Wong[5] (33.3%). The study by Wong also lends itself to comparison of distinct categories of ametropia. The Folsom JD study found a lower prevalence of hyperopia (26.6%) than Wong (45%), a similar prevalence of myopia (20.8%) to Wong (21.5%) and a lower prevalence of astigmia (20%) than Wong (34.9%). Like Wong, this study also found that the majority of cases in each category measured 1.00 D or less.

The refractive data found in this study can also be compared to data found in LD studies. In a literature review, Grisham and Simons[32] cite eleven studies that investigate the relationship between hyperopia and reading. Four of these studies found a greater prevalence of hyperopia in populations of poor readers and four other studies found hyperopes to have poorer reading skills than emmetropes or myopes. Regarding myopia, Grisham and Simons cite twelve studies, of which only one found myopia to interfere with reading ability. The remaining eleven studies show a link between myopia and good reading ability. Astigmatism is also addressed in Grisham and Simons' literature review. They found only one out of ten studies to show a link between high uncorrected astigmatism and low reading grades.

In summary, this study found a higher percentage of emmetropes among its JD population than found in other JD studies. Over half the subjects in this study were found to be emmetropic. Several studies among the LD literature indicate reading ability may be hindered by hyperopia, while only a few found myopia or astigmatism to be linked with poor reading ability.

Far-Point Ametropia - Clinical: From a clinical standpoint, the JD literature reports varied prevalence of clinically significant refractive error. In this study, 17% of the JD population was given a far point prescription. This is similar to the percentage reported by the Optometric Center of Maryland[55] (22.7%) and the Colorado Optometric Association[57] (21%). However, it is considerably lower than the percentage reported by the Northern Illinois College of Optometry[56] (93%) and considerably higher than the percentage reported by Kaseno[54] (5.4%).

In a literature review, Grisham and Simons[32] report on three comparative studies analyzing the relationship between academic achievement and correction of refractive error. One study found that subjects corrected for refractive error showed a statistically greater improvement in English scores when compared to emmetropes of the same study. Another study did not find a statistically significant difference but did find a trend showing greater gains in reading for corrected hyperopes and uncorrected myopes when compared to emmetropes of the study. A final study measured change in speed of word recognition for corrected hyperopes and myopes. One hundred percent of corrected hyperopes with hyperopia greater than 2.00 D and corrected myopes with myopia greater than 3.00 D showed increased speed of word recognition, suggesting that the amount of refractive error to be corrected is an important factor to consider when measuring academic achievement.

In summary, comparison of this JD study to other JD studies yields various percentages of clinically significant refractive error.[5,57] This may be due to variance in definition of what is clinically significant. In this particular study, close to one-fifth of its JD subjects were given a far point prescription, while close to four-fifths were given a near-point prescription. LD studies hint that

academic achievement may be improved by correcting refractive errors, especially when the subject is hyperopic.[32]

Anisometropia: Anisometropia is another aspect of refractive status to consider. In the Folsom JD population, 23.3% were calculated to have anisometropia and 5.9% were given a correction for their anisometropia. The amount of anisometropia was measured to be less than or equal to 0.50 D in the majority of the cases. No other JD studies were found that reported the prevalence of anisometropia in their populations.

Data can be found regarding the role of anisometropia in a LD population. In Eames'[33] study, it was found that when a group of uncorrected anisometropic children were corrected for their anisometropia, their reading score caught up to the scores of non-anisometropic children after a six month period.

In summary, close to one-fourth of the subjects in this study were found to have some degree of anisometropia, but no other JD studies were found to allow for comparison. One LD study demonstrates an improvement in reading score after correction for anisometropia.

Near Point Prescription: The JD subjects in this study were also evaluated for the need of a near point prescription. The percentage of subjects given a near point prescription was found to be higher (82.8%) than that reported by Kaseno[54] (21.6%). However, in both studies, near point prescriptions were given about five times more often than far point prescriptions. In the Folsom JD population, 82.8% were given near point prescriptions while only 17% were given far point prescriptions. In Kaseno's study, 21.6% were given near point prescriptions while only 5.4 % were given far point prescriptions.

In a study conducted by Robinson[36] a near point prescription was given with greater frequency to a reading delayed group than to a reading normal group. No other studies were found among the LD literature which examined the link between near point prescription and academic achievement.

Visual Acuity: Vision screenings often use a 20/40 score to define the minimum pass criteria for visual acuity. The data from this study is likewise presented in this manner to allow for comparison against other JD studies.

Distance Visual Acuity: Similar results are found in this study and other JD studies when calculating the percentage of subjects with unaided binocular distance visual acuity of worse than 20/40. In this study, 19.6% of male subjects and 33.4% of female subjects had unaided binocular distance visual acuity of worse than 20/40 as compared to 18% of all subjects in the Akron, Ohio study[9], and 30% of all subjects in Brook's[53] study.

In Grisham and Simons'[32] literature review of LD studies, they found two out of eleven studies that suggest a relationship between distance visual acuity and academic achievement. One comparative study found a statistically significant difference between the distance visual acuity of a group of LD subjects and a group of non-LD subjects. The LD subjects were measured to have lower distance visual acuities than the non-LD subjects. A correlational study found a statistically significant relationship between binocular distance visual acuity and reading ability.

In summary, JD studies thus far show that 18% to 30% of a JD population can be expected to have unaided binocular distance visual acuity of worse than 20/40. The majority of LD studies do not show a significant relationship between distance visual acuity and academic achievement.

Near Visual Acuity: In this study, visual acuity at near point was also measured. It was found that 13.8% of male subjects and 21.2% of female subjects had unaided binocular near visual acuity of worse than 20/40. Other JD studies are not available for direct comparison to this study's data for various reasons. For example, in the Optometric Center of Maryland[55] study and the "Volunteers in Prevention"[58] study, near visual acuity data and distance visual acuity data were presented together as a single percentage. Both studies reported the percentage of subjects who have a particular visual acuity at both distance and near. Comparison to the "Volunteers in Prevention" study is further complicated because it did not use 20/40 as a defining parameter.

In a literature review of LD studies, Grisham and Simons[32] report four studies that address near point acuity's role in academic achievement. Two of the four studies find statistically significant results. Both are comparative studies that show poor readers to have decreased binocular near visual acuity when compared to good readers.

In summary, this study found close to one-fifth of its male subjects and close to one-fourth of its female subjects to have near-point visual acuity of worse than 20/40, but comparison to other JD studies was not possible due to differences in tabulation of data. Two of four LD studies found statistically significant data concerning near-point acuity's role in academic achievement, suggesting that decreased near-point acuity may be linked to poor reading ability.

Accommodation: This study inspected several aspects of accommodation. For each subject, accommodative facility, book retinoscopy, and positive and negative relative accommodation was measured.

Accommodative Facility: Accommodative facility was measured using +2.00 D/-2.00 D flipper lenses. Subjects were given a passing score if they could clear both lenses in 3 seconds or less. With this criteria in place, 66.9% of the Folsom JDs failed accommodative facility testing. Accommodative facility was also measured in three other JD studies. Only one is directly comparable to this study, as the other two either used different testing methods or failed to describe testing methods. The "Volunteers in Prevention"[58] study used the same testing protocol as this study and found a lower failure rate of 32%. The Colorado Optometric Center[59] tested accommodative facility with two subtests. A mean of 7.5 cycles per minute was found when testing with +2.00 D / plano flipper lenses, and a mean of 7.1 cycles per minutes was found when testing with -2.00 D / plano flipper lenses. Kaseno[4,54] reported a 60% failure rate on accommodative testing but did not describe the testing procedure or pass/fail criteria used.

Four LD studies measured accommodative facility. Two studies were correlational studies and neither found a statistically significant relationship between accommodative facility and academic achievement. Hall and Wick[34], used +2.00 D/-2.00 D flipper lenses and the other conducted by O'Grady[35], used +3.00 D/-3.00 D flipper lenses. The two other studies were comparative studies conducted by Hoffman[37] and Sherman[38] and report 83.2% and 88% failure rates respectively. Hoffman defines failure as the inability to perform at least 15 cycles per second with +2.50 D/-2.50 D flipper lenses. Sherman did not define the testing procedure used or the failure criteria.

In summary, accommodative facility has been measured in both JD and LD studies. However, the testing apparatus are varied and not always defined. This study found close to two-thirds of its JD population to fail accommodative

facility testing. High failure rates for accommodative facility testing has been found by other JD and LD studies.

Book Retinoscopy: In this study, a potential near-point prescription was measured for each JD subject using the book retinoscopy method. Using this method, a mean value of +0.68 D was calculated. No other JD or LD studies were found that reported findings on book retinoscopy.

Positive Relative Accommodation (PRA, #20): In this study, positive relative accommodation was found to have a mean blur out of -2.91 D. This is similar to the mean found by the Colorado Optometric Center[59] which found a mean of -3.12 D.

In regards to PRA in LD populations, only one study was found that addressed PRA specifically. Robinson[36] found that a low PRA, defined as less than or equal to -1.25 D, was found more frequently in a group of JD subjects one to two years behind in reading ability than in a group of non-JD subjects who were reading at the expected age level. A test similar to PRA is the test of push up accommodative amplitude. In a correlational study, Hall and Wick[34] did not find a statistically significant relationship between push up accommodative amplitude and academic achievement.

In summary, not enough JD studies have reported PRA to allow for a consensus to be made regarding an expected mean value.[59] There is one comparative LD study that found a low PRA score more frequently in a reading delayed group when compared to a reading normal group but no correlational LD studies that show a low PRA to have a significant relationship to poor academic achievement.[34,36]

Negative Relative Accommodation (NRA, #21): This JD population yielded a mean NRA of +2.01 D. This value is lower than that found by the

Colorado Optometric Center[59] which found a mean of +2.62 D. No other JD or LD studies were found that reported NRA values.

Binocularity: Included in this portion of testing were assessment of NPC, ocular motility, stereopsis, Keystone skills, cover test and the vergence system.

Near Point of Convergence: The failure rate for NPC testing was higher for the Folsom JD population (46.1%) than for the JD population studied by Brooks[53] (18% fail and 7% borderline fail) or the JD population studied by the Optometric Center of Maryland[55] (37.8%). The varied results may be attributable to differing failure criteria. For this study, a subject was considered to fail the NPC test if convergence broke down before 3 inches. In the Brooks study, no failure criteria was given and in the Maryland study failure criteria was breakdown of convergence before 2 inches.

Four LD studies were found that examined the possibility of a link between NPC performance and academic achievement. One study by Weber[40] found a significant correlation between NPC performance and academic achievement, linking poor NPC performance to poor academic achievement ($p < 0.01$). NPC failure criteria was defined as breakdown of convergence before 2 inches or recovery after 5 inches. In contrast, studies by Hall and Wick[34], O'Grady[35] and Helveston[41] found no correlation between NPC and academic achievement. However, Hall and Wick did not define their failure criteria and O'Grady and Helveston used a failure criteria of a 4 inch break in convergence.

In summary, close to half the subjects in this JD study failed NPC testing. There are only two other JD studies that present the prevalence of poor NPC performance in a JD population[53,55] Comparison of these three JD studies yield varied results perhaps due to differing failure criteria. Regarding NPC and learning disability, one correlational study found a significant relationship

between poor NPC performance and poor academic achievement while three did not.[34,35, 40,41] As with the prevalence studies of NPC in the JD population, the correlational studies of NPC in the LD population do not use consistent failure criteria. Benefit could be gained by conducting future studies of NPC in the JD and LD populations in which failure criteria were kept consistent. NPC testing could be a valuable component in a JD or LD remediation program due to the ease of testing, diagnosing and treating a poor NPC.

Ocular Motilities: In this study, ocular motilities were assessed by asking JD subjects to perform saccades and pursuits. A high failure rate was noted for both, with 58.9% of subjects failing saccades and 62.3% failing pursuits.

Four other JD studies were found that address ocular motilities. Only one of these studies is directly comparable to data found in this study. Kaseno[4,54] reports a 60% failure rate in pursuit ability among the JD population he studied which supports the data found with the Folsom JD population. The other three studies use terms other than "pursuit" or "saccade" to measure ocular motility. Brooks[53] reports a 58% failure rate in "fixation" ability and a 43% failure rate in "rotation" ability. The "Volunteers in Prevention"[58] study found a 20% failure rate in "eye movement" ability. Finally, the Optometric Center of Maryland[55] reports a 69.7% failure rate in "motilities" using head movement as criteria for failure.

Ocular motilities were investigated in six LD studies. Three of these studies found results suggesting ocular motility efficiency is an important factor to consider in the learning disabled population. One of these studies, conducted by Johnson and Zaba[42], used a comparative design and reports prevalence of "eye tracking" failure in a group of illiterate adults as compared to a group of literate adults. 61% of the illiterate adults fail "eye tracking" as compared to none of the literate adults. This high failure rate agrees with the high failure rates found in the JD studies. The other two studies do not offer

prevalence data but do provide worthwhile information. Rounds et al[43] conducted a comparative study measuring the improvement in reading efficiency and achievement test score of a group of subjects receiving oculomotor training and a group of subjects who did not receive any oculomotor training. Although no statistically significant difference was found between the groups regarding gains made in achievement test score, there was a statistically significant difference found between the groups regarding reading efficiency as measured by the Visagraph. In a correlational study, Weber[40] found a statistically significant correlation between achievement score and poor pursuit ability.

The three remaining LD studies that addressed the issue of ocular motility are all correlational studies and did not find a statistically significant relationship between ocular motor ability and academic achievement. Hall and Wick[34] measured King Devick performance against achievement test score, O'Grady[35] measured "jerky" motilities against achievement score and Black et al[44] measured saccadic patterns against reading ability,

In summary, a high failure rate on ocular motility testing is found in this study and in several other JD studies. However, various terms and tests are used to assess ocular motility among these JD studies. In this particular study, close to three-fifths of the subjects failed ocular motility testing as measured by pursuit and saccadic ability. Regarding ocular motility in the LD literature, half of the LD studies reviewed suggest a link between poor ocular motility ability and poor reading ability. As with the JD studies, the LD studies use a variety of terms and tests to define ocular motility skills.

Stereopsis: This study required 20 arc seconds of stereoacuity to receive a passing score for stereopsis. With this criteria, this study found a failure rate of 65.8%. Only one other JD study was found to measure stereopsis. The

"Volunteers in Prevention"[58] study required 100 arc seconds of stereoacuity on a Wirt Circle test to receive a passing score, resulting in a failure rate of 25%.

Four LD studies included stereoacuity testing in their protocol and none revealed a statistically significant relationship between stereopsis and academic achievement or reading ability. Hall and Wick[34] used a Titmus and Randot stereopsis test. Helveston[41] used a Titmus stereopsis test. O'Grady[35] and the Johnson and Zaba[42] study did not describe the stereopsis test they used.

In summary, in this JD study, close to two-thirds of the subjects failed a stereopsis test. Only one other JD study was found that measured stereopsis and it used different pass criteria than that used in this study. No LD studies reveal any correlation between poor stereopsis and low academic achievement or reading ability.

Keystone Skills: In this study, a failure score was given on Keystone Skills if two or more of the findings fell out of the expected range. This criteria yielded a failure rate of 91.4%. No other JD studies were available for comparison, as no other JD studies reported data on Keystone Skills. One LD study used Keystone Skills testing in addition to cheiroscopic testing and duction testing to assess binocular fusion of its subjects . Sherman[38] found 92% of his subjects to fail binocular fusion testing as measured by these three subtests.

Cover Testing: In this study, a cover test was performed at both distance and near to determine if a subject was orthophoric, heterophoric or tropic at distance and near. It was found that the majority of subjects were orthophoric at distance (92.0%) and exophoric at near (59.8%). It was also found that 4.4% of the subjects were strabismic at distance and 13.4% were strabismic at near. Other JD studies in which cover test was performed do not lend themselves to

comparison with the data found in this study because they present cover test data in a different manner. For example, Brooks[53] reports a 14% failure rate on cover testing, but does not define criteria for failure. The Optometric Center of Maryland[55] study found 3% of its JD population to exhibit a phoria or tropia in excess of 15 prism diopters upon cover testing. The "Volunteers in Prevention" study[58] found 40% of its JD population to show convergence insufficiency pattern with cover testing.

One LD study was found to employ cover testing with a group of reading delayed subjects. Alder and Grant[45] use the cover test to determine the prevalence of strabismus in a group of subjects reading at age level and a group of subjects reading below age level. A higher percentage of subjects reading below age level were found to be strabismic when compared to subjects reading at age level, with percentages of 9.1% and 4% respectively. Unfortunately, Alder and Grant do not define the test distance they used for cover testing.

In summary, in the Folsom JD study, cover test was used to measure the prevalence of orthophoria, heterophoria and tropia in the Folsom JD population. Almost all the Folsom JD population was found to be orthophoric at distance and two-thirds were found to be exophoric at near. Cover testing was used in other JD and LD studies, however, these studies did not present data in a manner to allow for comparison with the Folsom JD study.

Vergence System: In this study, the vergence system was assessed by measuring lateral phoria at far and near, vergence range at far and near, vertical phoria and gradient phoria. One JD study was found against which the Folsom JD data for lateral phoria and vergence ranges could be compared. The data reported by the Colorado Optometric Center[59] is presented alongside the Folsom JD data in the following table:

Table 7 Folsom JD Means vs Colorado Optometric Center (COC) Means

Distance Tests	Folsom JD Means	COC Means
Lateral Phoria (#8)	0.1 exo	0
BO Blur (#9)	7.5	13.5
BO Break (#10)	17.4	24.3
BO Recovery (#10)	4.8	7.8
BI Break (#11)	8.9	11.9
BI Recovery (#11)	1.6	4.2
Near Tests		
Lateral Phoria (#13b)	2.4 exo	3.6 exo
BO Blur (#16a)	6.9	16.6
BO Break (#16b)	18.5	26.6
BO Recovery (#16b)	6.8	10.6
BI Blur (#17a)	3.4	17.9
BI Break (#17b)	17.6	23.3
BI Recovery (#17b)	5.8	11.1

In all cases, the Colorado Optometric Center had higher mean values except in the case of lateral phoria at far.

One other JD study included information regarding lateral phoria, however, failure rates rather than mean values are reported. Brooks[53] found 44% of his JD subjects to fail a test for lateral phoria at far and 39% of his JD subjects to fail a test for lateral phoria at near. Unfortunately, Brooks does not define the criteria used to result in a failing score.

Two LD studies were found that addressed lateral phoria. Hall and Wick[34] conducted a LD correlational study and did not find a statistically significant correlation between lateral phoria at near and academic achievement. Silbiger and Woolf[46] carried out a comparative study that did not find a statistically significant difference in lateral phoria at near between a group of subjects identified as good readers and a group of subjects identified as poor readers.

One LD study was found that discussed vergence ranges. Atzmon[48] reports that LD subjects noted improved school performance after participating in training that increased convergence ability at both far and near.

In summary, only one other JD study was found that calculated mean values for phoria and vergence range measurements and all but one of the values were higher than the values found in the Folsom JD population. A couple LD studies suggest that no link exists between an out-of-norm lateral phoria measurement and academic achievement. One LD study suggests that increasing the convergence range at far and near may improve academic performance of LD individuals.

Visual Perception: The JD subjects in this study were given three visual perception tests. The Winterhaven Visual Memory and Copy Forms/Visual Organization Tests yielded a combined 92.5% failure rate and the Motor Free Visual Perception Test (MFVPT) yielded a 93.1% failure rate. Failure on all tests was defined as performance at least one year below age level.

Two other JD studies address visual perception issues. The study by the Optometric Center of Maryland[55] tested its subjects on the MFVPT, among other visual perception tests, but found a much lower failure rate of 26.5% for the MFVPT. Kaseno[4,54] reports a prevalence of visual perception dysfunction more similar to the prevalence found in the Folsom JD population but does not specify how the conclusion is reached that 95% of JDs in his San Bernardino study had a visual perceptual problem.

Four LD studies were found that explore the relationship of visual perceptual dysfunction and academic achievement. A correlational study by Shorr and Svagr[49] found a statistically significant relationship between visual perception and score and reading skill, such that subjects scoring poorly on a visual perception battery were also likely to do poorly on a reading test. A comparative study by Seiderman[50] found that subjects with a visual perception deficit scored higher on a reading test when given vision training. A prevalence

study by Coleman[51] found a visual perception problem in 30% of a reading delayed population. A statistical analysis of results from 161 visual perception correlational studies was conducted by Kavale[52] and indicated that visual perception is a strong correlate of reading achievement.

In summary, high rates of visual perception dysfunction has been found in the JD population of this study and that of Kaseno's San Bernardino study. LD studies show a possible link between visual perception dysfunction and poor academic achievement.

Ocular Health: This study also considered the number of subjects with ocular health problems. It was found that very few subjects had an ocular health problem, either internally or externally. No other JD or LD studies were found that addressed prevalence of ocular health problems in their respective subject pools.

Comparison of Folsom JD Means to OEP's Expected Values and Morgan's Normative Values

Folsom JD means on sixteen tests of the analytical exam were compared to the Optometric Extension Program's (OEP's) expected values and Morgan's normative values. OEP and Morgan's values are associated with tests that measure vergence and accommodation skills. A two-tailed t-test run on StatVue was used to compare the Folsom JD means to OEP and Morgan values.

The Folsom JD means were compared to both OEP and Morgan's values because OEP and Morgan values represent two distinct visual profiles, as described by Birnbaum in Optometric Management of Nearpoint Vision

Disorders.[61] OEP values are "expected" values and reflect A.M. Skeffington's theories of optimum values descriptive of an efficient visual system. Morgan's values are "normative" values and were derived from a clinical patient base of 800 pre-presbyopic subjects. Furthermore, OEP and Morgan utilize different case analysis systems.

Comparison of the Folsom JD means to established values was undertaken in order to discover if the Folsom JD subjects represented a population different from what is considered "expected" or "normal" and if such a difference existed, to what degree did it exist.

Folsom JDs vs OEP: Four out of seven distance tests analyzed showed a statistically significant difference between the Folsom JD mean and the OEP expected value (Table 8). These four distance tests include lateral phoria (#8), base out break (#10), base out recovery (#10), and base in recovery (#11). Folsom JD means were lower than OEP expected values in all four tests and were found to be statistically different from the OEP expected value with confidence levels ranging from $p < 0.0003$ to $p < 0.0001$. Three distance tests in which no statistically significant difference were found were base out blur (#9), base in break (#11), and vertical phoria.

All nine near tests analyzed showed a statistically significant difference between the Folsom JD mean and the OEP expected value. The Folsom JD mean was lower than the OEP expected value in eight near tests including lateral phoria (#13b), base out blur (#16a), base out break (#16b), base out recovery (#16b), base in blur (#17a), base in break (#17b), base in recovery (#17b) and negative relative accommodation (#21). The Folsom JD mean was higher than the OEP expected value in one near test, the positive relative accommodation test (#20). All near tests showed a statistically significant

difference between the Folsom JD mean and the OEP expected value with confidence levels ranging from $p < 0.0004$ to $p < 0.0001$.

Table 8 Comparison of Folsom JD Means to OEP Expected Values

Distance Tests	Folsom JD Means	OEP Expected Values	t-value	Probability
Lateral Phoria (#8)	0.10 exo	0.50 exo	-3.63	0.0003
BO Blur (#9)	7.48	7	1.39	0.1664
BO Break (#10)	17.34	19	-3.73	0.0002
BO Recovery (#10)	4.84	10	-25.87	0.0001
BI Break (#11)	8.91	9	-0.66	0.5119
BI Recovery (#11)	1.64	5	-30.26	0.0001
Vertical Phoria (#12)	0.02 hyper OS	0	0.93	0.3512
Near Tests				
Lateral Phoria (#13b)	2.44 exo	6 exo	-17.43	0.0001
BO Blur (#16a)	6.88	15	-20.43	0.0001
BO Break (#16b)	18.50	21	-5.52	0.0001
BO Recovery (#16b)	6.77	15	-31.70	0.0001
BI Blur (#17a)	3.39	14	-42.01	0.0001
BI Break (#17b)	17.61	22	-13.73	0.0001
BI Recovery (#17b)	5.83	18	-51.75	0.0001
PRA (#20)	-3.03	-2.25	-3.57	0.0004
NRA (#21)	+2.00	+2.50	-12.60	0.0001

Folsom JDs vs Morgan: All six distance tests analyzed showed a statistically significant difference between the Folsom JD mean and the Morgan normative value (Table 9). These six distance tests include lateral phoria (#8), base out blur (#9), base out break (#10), base out recovery (#10), base in break (#11), and base in recovery (#11). Folsom JD means were statistically lower than the Morgan normative values for these six tests with confidence levels ranging from $p < 0.001$ to $p < 0.0001$.

Eight of nine near tests analyzed showed a statistically significant difference between the Folsom JD mean and the Morgan normative value. The Folsom JD mean was statistically lower than the Morgan normative value in seven near tests including lateral phoria (#13b), base out blur (#16a), base out break (#16b), base out recovery (#16b), base in blur (#17a), base in break (#17b), and base in recovery (#17b). The Folsom JD mean was statistically

higher than the Morgan normative value in one near test, the positive relative accommodation test (#20). These eight near tests showed a statistically significant difference between the Folsom JD mean and the Morgan normative value with confidence levels ranging from $p < 0.0064$ to $p < 0.0001$. The near test in which no statistically significant difference was found between the Folsom JD mean and the Morgan normative value was the negative relative accommodation test (#21).

Table 9 Comparison of Folsom JD Means to Morgan's Normative Values

Distance Tests	Folsom JD Means	Morgan's Normative Values	t-value	Probability
Lateral Phoria (#8)	0.10 exo	1 exo ± 2	-8.18	0.001
BO Blur (#9)	7.48	9 ± 4	-4.38	0.0001
BO Break (#10)	17.34	19 ± 8	-3.73	0.0002
BO Recovery (#10)	4.84	10 ± 4	-25.87	0.0001
BI Break (#11)	8.91	7 ± 3	13.94	0.0001
BI Recovery (#11)	1.64	4 ± 2	-21.26	0.0001
Near Tests				
Lateral Phoria (#13b)	2.44 exo	3 exo ± 5	-2.74	0.0064
BO Blur (#16a)	6.88	17 ± 5	-25.47	0.0001
BO Break (#16b)	18.50	21 ± 6	-5.52	0.0001
BO Recovery (#16b)	6.77	11 ± 7	-16.30	0.0001
BI Blur (#17a)	3.39	13 ± 4	-38.05	0.0001
BI Break (#17b)	17.61	21 ± 4	-10.60	0.0001
BI Recovery (#17b)	5.83	13 ± 5	-30.50	0.0001
PRA (#20)	-3.03	-2.37 ± 1.12	-3.02	0.0026
NRA (#21)	+2.00	+2.00 ± 0.50	-0.05	0.9633

Summary: Folsom JD means were compared to OEP expected values and Morgan's normative values in distance and near test selected from the analytical exam. The selected tests measured vergence and accommodation skills.

Regarding the comparison to OEP values, the trend was to find a statistically significant difference between the Folsom JD mean and the OEP expected value, such that the Folsom JD mean was lower than the OEP expected value at a $p < 0.0001$ confidence level. This trend was especially

evident when comparing Folsom JD means to OEP expected values of analytical tests measured at near.

Regarding the comparison to Morgan's normative values, the trend was to find a statistically significant difference between the Folsom JD mean and the Morgan expected value, such that the Folsom JD mean was lower than the Morgan expected value at a $p < 0.0001$ confidence level. This trend was evident when comparing Folsom JD means to Morgan expected values of analytical tests measured at distance as well as analytical tests measured at near.

Case Analysis of Folsom JD Means

In addition to the statistical comparison of the Folsom JD means to OEP expected and Morgan's normative values, the Folsom JD means were also analyzed using several case analysis systems. The case analysis systems used include Duane-White classification, Sheard's criterion, Percival's criterion, Morgan's syndrome analysis, Grisham's analysis based on Morgan's values and OEP case analysis.

The Folsom JD means were assembled together to create a hypothetical patient representative of a typical Folsom JD subject. Use of a central tendency measure, such as the mean, has the inherent problem of a loss of accuracy, and there will be some individuals and perhaps groups of subjects who will not be represented by the case profile generated by the hypothetical Folsom JD subject. However, use of a central tendency measure, such as the mean, makes application of various case analysis systems a practical feat when dealing with a large number of data points.

Case analysis of the hypothetical Folsom JD subject was undertaken in order to uncover a generalized visual diagnosis of the typical Folsom JD subject. From this visual diagnosis, treatment modalities that would aid a typical JD subject could be suggested.

Duane-White (DW) Classification: Based on analysis of mean values, the Folsom JD subject can not be classified into any of the Duane-White vision syndromes as defined in the Dictionary of Visual Science[62] (Table 10). Classification into a Duane-White syndrome implies a problem with the vergence system.

The Folsom JD subject does not fit the profile of either far point syndrome of divergence insufficiency (DI) or divergence excess (DE). DI is defined as "esophoria up to 8$^{\Delta}$ at far and esophoria at near" for primary DI or "esophoria over 8$^{\Delta}$ at far and high esophoria at near" for secondary DI. DE is defined to be "marked exophoria at far and equal or less exophoria at near."

The Folsom JD subject does not fit the profile of either near point syndrome of convergence insufficiency (CI) or convergence excess (CE). CI is defined to be "slight exophoria at far and marked exophoria at near," and CE is defined to be "orthophoria or moderate esophoria at far and esophoria at near."

As reported in the results section, the Folsom JD mean phoria is found to be exophoric at both distance and near, and as stated earlier in the comparison of the Folsom JD means to OEP and Morgan's expected values, the amount of this exophoria is statistically lower than either OEP or Morgan's expected value at both distance and near.

Table 10 Duane-White Classification of Folsom JD Mean Phorias

Duane-White (DW) Syndromes	Distance Lateral Phoria (#8)	Near Lateral Phoria (#13b)
DW Divergence Insufficiency	Esophoria	Esophoria
DW Divergence Excess	Marked exophoria	Equal or less exophoria
DW Convergence Insufficiency	Slight exophoria	Marked exophoria
DW Convergence Excess	Ortho to moderate esophoria	Esophoria
Folsom JD Means	0.10 exo	2.44 exo

In summary, the Folsom JD data does not support classification into any of the Duane-White syndromes of divergence insufficiency, divergence excess, convergence insufficiency or convergence excess.

Comfort Criterion: The Folsom JD means were analyzed against Sheard's criterion and Percival's criterion. Both criteria suggest parameters to be met to avoid visual aesthenopia. Failure to meet either criteria implies a problem with the vergence system. According to Birnbaum[61] Sheard "postulated that to maintain comfort, the fusional reserve (compensating vergence) should be at least twice as great as the fusion demand (phoria)." If a blur finding is available, as it is with the Folsom JD data, it can be used for comparison to the lateral phoria. Graphical and mathematical analysis of the Folsom JD data show that Sheard's criterion is met at both distance and near (Figure 15, Table 11).

Figure 15 Graphical Analysis

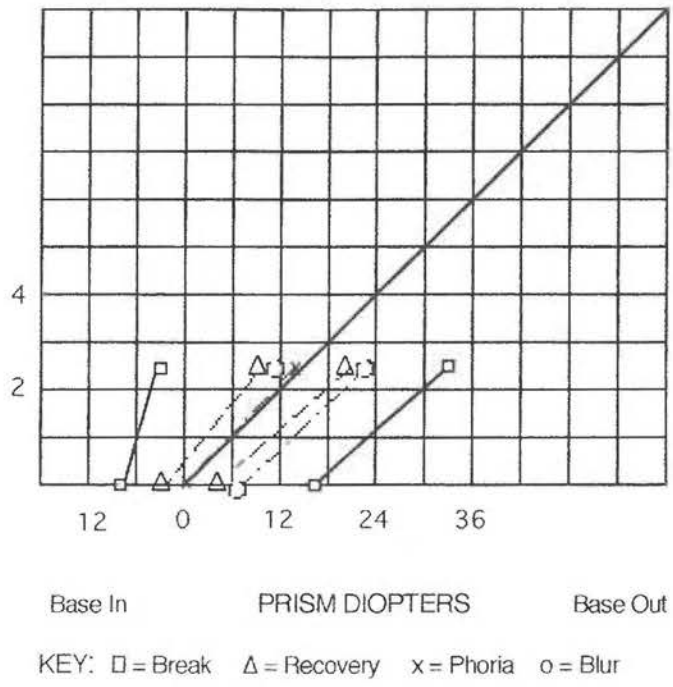


Table 11 Mathematical Application of Sheard Criterion to Folsom JD Means

Criterion met at distance:	Criterion met at near:
2(phoria) ≤ compensating vergence 2(#8) ≤ (#9) 2(0.10) ≤ 7.48 0.20 ≤ 7.48	2(phoria) ≤ compensating vergence 2(#13b) ≤ (#16a) 2(2.44) ≤ 6.87 4.88 ≤ 6.87

Birnbaum[61] also discusses Percival's criterion, and states that Percival "postulated that the middle third of the zone of clear, single binocular vision is an area of comfort. To determine whether Percival's criterion has been met, the base in and base out blur limits are added to determine the total width of the zone of clear, single binocular vision, and this width is divided by 3 to determine the width of the zone of comfort. If either the base in or base out blur is less than the width of the comfort zone, Percival's criterion has not been met." If a blur finding is not available, a break finding can be used in its place and is compared to the break finding in the opposite direction. Graphical and

mathematical analysis of the Folsom JD data shows that Percival's criterion is met at distance but not at near (Figure 15, Table 12).

Table12 Mathematical Application of Percival's Criterion to Folsom JD Means

Criterion met at distance:	Criterion not met at near:
$\frac{\text{BO break + BI break}}{3}$ = width of comfort zone	$\frac{\text{BO blur + BI blur}}{3}$ = width of comfort zone
$\frac{(\#10) + (\#11)}{3}$ = width of comfort zone	$\frac{(\#16a) + (\#17a)}{3}$ = width of comfort zone
$\frac{17.33 + 8.91}{3} = 8.74$	$\frac{6.88 + 3.39}{3} = 3.42$
BO break (#10) ≥ width of comfort zone 17.33 ≥ 8.74	BO blur (#16a) ≥ width of comfort zone 6.88 ≥ 3.42
BI break (#11) ≥ width of comfort zone 8.91 ≥ 8.74	BI break (#17a) ≤ width of comfort zone 3.39 ≤ 3.42

In summary, the Folsom JD data met Sheard's criterion at distance and near and met Percival's criterion only at distance. However, as pointed out by Birnbaum, a study conducted by Sheedy and Saladin found that Sheard's criterion is more likely to predict aesthenopic symptoms among exophores, while Percival's criterion is more likely to predict aesthenopic symptoms among esophores. Since the Folsom JD means show an exophoric posture at both distance and near, the implications of failure on Percival's criterion should be viewed with caution.

Morgan's Syndrome Analysis: Birnbaum[61] describes the analysis system designed by Morgan to identify the existence of an accommodative disorder or convergence insufficiency. Morgan's system divided analytical exam findings into two groups (Table 13). Group A findings reflect the ability to shift accommodation nearer than vergence. Group B findings reflect the ability to shift vergence nearer than accommodation.

Table 13 Morgan's Syndrome Analysis Groups

Group A Findings	Group B Findings
BI break and recovery at distance (#11) BI blur at near (#17a) BI break and recovery at near (#17b) Amplitude of accommodation (#19) PRA (#20)	Dynamic retinoscopy (#5) BO blur at distance (#9) Monocular cross cylinder (#14a) Binocular cross cylinder (#14b) BO blur at near(#16a) BO break and recovery at near (#16 b) NRA (#21)

In accommodative disorders, Group A tests tend to run low and Group B tests tend to run high. In convergence insufficiency, Group A tests tend to run high and Group B tests tend to run low. A finding is considered low if it falls below one standard deviation of Morgan's normative value. A finding is considered high if it falls above one standard deviation of Morgan's normative value.

Analysis of the Folsom JD data according to Morgan's system is reflected in the table below and hints at an accommodative problem with three of the five Group A findings scoring low (Table 14). However, since one of the values in Group A and three of the values in Group B were not available for analysis, interpretation of the Morgan analysis should be viewed with caution.

Table 14 Morgan's Syndrome Analysis on Folsom JD Means

Group A Findings	Group B Findings
L BI break and recovery at distance (#11) L BI blur at near (#17a) L BI break and recovery at near (#17b) N Amplitude of accommodation (#19) M PRA (#20)	N Dynamic retinoscopy (#5) M BO blur at distance (#9) N Monocular cross cylinder (#14a) N Binocular cross cylinder (#14b) L BO blur at near(#16a) M BO break and recovery at near (#16 b) M NRA (#21)
Key: H = High finding L = Low finding M = Met normative value N = Not available	

Birnbaum[61] reports that Grisham developed another method of analysis using Morgan's expected values. If any of the findings were found to be lower than one standard deviation of Morgan's expected values, a binocular

dysfunction was to be suspected. Analysis of the Folsom JD data according to Grisham indicates a binocular dysfunction (Table 15).

Table 15 Grisham's Analysis on Folsom JD Means

Distance Tests	Folsom JD Means	Morgan's Norms	Scoring
Lateral Phoria (#8)	0.10 exo	1 exo ± 2	M
BO Blur (#9)	7.48	9 ± 4	M
BO Break (#10)	17.34	19 ± 8	M
BO Recovery (#10)	4.84	10 ± 4	L
BI Break (#11)	8.91	7 ± 3	M
BI Recovery (#11)	1.64	4 ± 2	L
Near Tests			
Lateral Phoria (#13b)	2.44 exo	3 exo ± 5	M
BO Blur (#16a)	6.88	17± 5	L
BO Break (#16b)	18.50	21 ± 6	M
BO Recovery (#16b)	6.77	11 ± 7	M
BI Blur (#17a)	3.39	13 ± 4	L
BI Break (#17b)	17.61	21 ± 4	M
BI Recovery (#17b)	5.83	13 ± 5	L
PRA (#20)	-3.03	-2.37 ± 1.12	M
NRA (#21)	+2.00	+2.00 ± 0.50	M
Key: H = High finding L = Low finding M = Met normative value			

In summary, Morgan's analysis of the Folsom JD means hints at an accommodative dysfunction. However, interpretation of Morgan's analysis must be regarded with some caution because four of the twelve tests used to determine a diagnosis were not performed on the Folsom JD subject. Grisham's analysis of the Folsom JD means also utilizes Morgan's normative values and indicates the presence of a binocular dysfunction.

OEP Case Analysis: The steps involved in OEP case analysis are described by Birnbaum.[61] OEP case analysis separates subjects into one of three case types--A, B or C. Classification as an A case indicates a toxic problem affecting the accommodation's relationship to vergence. Such cases should be referred for medical treatment. On the other hand, B and C case types suggest a functional interference of the relationship between

accommodation and vergence. In B cases, accommodation is the visual system in dysfunction, and in C cases, the vergence system is the visual system in dysfunction.

OEP case analysis has three main steps known as checking, chaining and typing. In checking, findings are first checked against OEP expected values to determine if they are high or low in relation to the OEP expected value. After findings are determined high or low, findings are arranged above or below a horizontal line in a step known as chaining. The arrangement of the findings on the chain allows the examiner to then assign a case type, in the step known as typing. This is a simplified explanation of a case analysis system which is more involved than can be explained in the present study. Further detail is available in the cited text.

OEP case analysis of the JD Folsom means results in a B case subtype known as B1. (Table 16) The other subtype is known as B2. Both indicate an accommodative inefficiency based on a tendency for the vergence system to posture closer than the accommodation system. To compensate for the vergence system's tendency to over converge, the accommodation system tends to underact in order to decrease the amount of accommodative convergence in play. Differentiation between a B1 case and a B2 case is made according to the arrangement of the #16b and #17b findings along the OEP chain. A low #16b indicates a B1 case and a low #17b indicates a B2 case. A low #16b is also found in C type cases, however, to be a true C type case, #17a must be higher on the chain sequence than #16a and #20 higher than #21.

Table 16 OEP Case Analysis of JD Folsom Means - Chaining Sequences

Typical A:	4-11-13b-17b
Early Stage B1:	_7_/_5-10-17b_ /__14a__/__16a-21__/_19_ / 11-16b / 15a / 17a-20 /
Late Stage B1:	_7_/__11-17b_ /__15a__/__16a-20__/____ /5-10-16b / 14a / 17a-21 / 19
Early Stage B2:	_7_/_5-10-16b_ /__14a__/__16a-21__/_19_ / 11-17b / 15a / 17a-20 /
Late Stage B2:	_7_/__11-16b_ /__15a__/__16a-20__/____ /5-10-17b / 14a / 17a-21 / 19
Typical C:	_7_/__11-17b_ /__15a__/__17a-20__/_19_ /5-10-16b / 14a / 16a-21 /
Folsom JD Means:	_7_/__11-17b___/_____/__16a-20___/___ / 10-16b / / 17a-21 /

Clinical relevance of the differentiation between B cases has to do with the treatment plan called for. B1 cases call for full plus prescription at distance and near, while B2 cases call for cutting of plus at distance and prescribing full plus at near. It is theorized that B2 cases do not accept full plus at distance because B2 cases try to compensate for the mismatch between accommodation and vergence by bringing accommodation in toward the vergence system. Full plus at distance then interferes with this coping mechanism. On the other hand, B1 cases attempt to bring vergence out towards accommodation, thus are aided by full plus at distance.

As noted in the table, not all findings used in OEP case analysis were available from the Folsom JD data. These findings include dynamic retinoscopy (#5), monocular near cross cylinder (#14a), binocular near cross cylinder (#14b), and accommodative amplitude (#19). These findings are not necessary for case typing, but rather help describe the level of degeneration of the visual

system in question. In OEP analysis, degeneration is concerned with the level of adaptation the subject has reached in response to the visual dysfunction. Other findings that are used to determine the level of degeneration are #20 and #21. If the NRA (#21) finding is lower than the PRA (#20) finding, this indicates a higher level (or later stage) or degeneration. The Folsom JD findings appear to show a late stage degeneration.

At any level of degeneration, embeddedness can occur. A high level of embeddedness indicates a visual system that is reorganizing itself and in which adaptations are heading towards permanence. A low level of embeddedness indicates a visual system that is in flux or disorganization and in which adaptations are reversible. One measure of embeddedness is the state of the vergence recovery values. High recovery values indicate a high level of embeddedness and reorganization. Low recovery values, as seen in the Folsom JD means, indicate a low level of embeddedness and a visual system in flux.

Summary of Case Analysis Systems: Case analysis systems were applied to the Folsom JD means for the purpose of diagnosing a hypothetical Folsom JD subject. Several case analysis systems were employed in order to gain a comprehensive view of the hypothetical subject's visual system.

Duane-White's classification, Sheard's criterion and Percival's criterion attempt to identify the presence of a vergence problem. Analysis of the hypothetical Folsom JD subject with these three systems did not reveal a vergence problem.

Morgan's syndrome analysis is designed to identify the presence of an accommodative problem or a convergence insufficiency problem. Analysis of the hypothetical Folsom JD subject with the Morgan system hints at an

accommodative problem. Grisham uses Morgan's normative values to identify the presence of a binocular dysfunction. According to Grisham's analysis, the hypothetical Folsom JD subject has a binocular dysfunction.

Finally, OEP case analysis is designed to identify the presence of an accommodative or convergence problem. OEP analysis of the hypothetical Folsom JD subject reveals an accommodative problem known in OEP terminology as a nonembedded, late stage B1 case type. The OEP diagnosis is especially important because all data required to differentiate between an accommodative problem and a vergence problem were available.

Optometric Treatment of the Folsom JD Subjects

Treatment Suggested by Case Analysis: Folsom JD means were statistically compared to Morgan's normative values and OEP's expected values in sixteen tests selected from the analytical exam. The tests selected measure accommodation and vergence skills. The comparison uncovered a trend in which the Folsom JD means were statistically lower than corresponding Morgan's norms or OEP's expecteds. This indicates that the Folsom JD population represents a population distinct from the clinical population defining Morgan's norms and the theoretical population defining OEP's expecteds.

These same mean values were then used in various case analysis systems in order to define this distinct Folsom JD population in optometric terms. The means were assembled to represent a hypothetical Folsom JD subject for which an optometric diagnosis could be made and treatment modalities suggested. Case analysis indicated the presence of an underlying nonembedded accommodative problem.

The most common treatment of an accommodative problem is the prescription of a plus lens for nearpoint activities, and statements made by Birnbaum indicate such a treatment would be timely for the hypothetical Folsom JD subject. Birnbaum states, "In nonembedded cases, plus lens application has significant potential to restore visual efficiency, prevent adverse adaptation, and reverse adaptation that has already occurred. As deterioration and embedding proceed, plus lens acceptance diminishes and there is greater likelihood that vision therapy will be required to restore efficient function."[61] In light of this statement, it is interesting to note the high percentage (82%) of Folsom JD subjects given a nearpoint plus prescription.

Treatment Suggested by Entrance Test Results: Are there other treatment modalities which could benefit the Folsom JD population? Case analysis was helpful in identifying an accommodative problem in the hypothetical Folsom JD subject. However, case analysis focuses only on the findings of the analytical exam that are concerned with accommodation and vergence ability. A survey of the high failure rates on entrance testing indicates that a Folsom JD subject may have a number of other visual problems (Figure 16) Entrance tests that had a failure rate of 50% or more include the symptom questionnaire, MFVPT, Winterhaven Visual Perception Tests, Keystone skills, accommodative facility, stereoacuity, pursuits and saccades. As reported in the literature review, visual perception and ocular motilities are visual skills which have been found to correlate with improved reading performance when addressed with vision therapy.[33,42] This would imply that the Folsom JD subjects who fail the MFVPT and/or Winterhaven visual perception tests would benefit from vision therapy designed to improve visual perception and those failing

pursuit and/or saccade testing would benefit from vision therapy designed to improve ocular motility.

The symptom questionnaire, Keystone skills and stereoacuity testing do not identify specific visual skills that have been statistically correlated to reading skills or academic achievement. Rather, the high failure rates on the symptom questionnaire, Keystone skills and stereoacuity testing may be indicative of a visual system in distress. It is possible that following treatment of a diagnosable visual dysfunction such as an accommodation, vergence, visual perception or ocular motility dysfunction, performance on the symptom questionnaire, Keystone skills and stereoacuity testing would improve.

Other entrance tests that were addressed but had failure rates of less than 50% include NPC, cover testing and ocular health evaluation. Almost 50% of Folsom JD subjects failed the NPC test despite the fact that case analysis methods did not uncover a convergence insufficiency problem for the hypothetical Folsom JD patient. However, as mentioned earlier, case analysis was executed on a hypothetical Folsom JD patient so does not rule out a convergence insufficiency problem for an individual Folsom JD subject. On an individual level, failure on the NPC test should signal the examiner to perform further testing and perhaps utilize case analysis methods to determine the presence of convergence insufficiency.

Cover testing and ocular health evaluation uncovered low failure rates when compared to rates of other entrance tests. However, if any tropia or condition of ocular pathology is found, proper treatment should be considered.

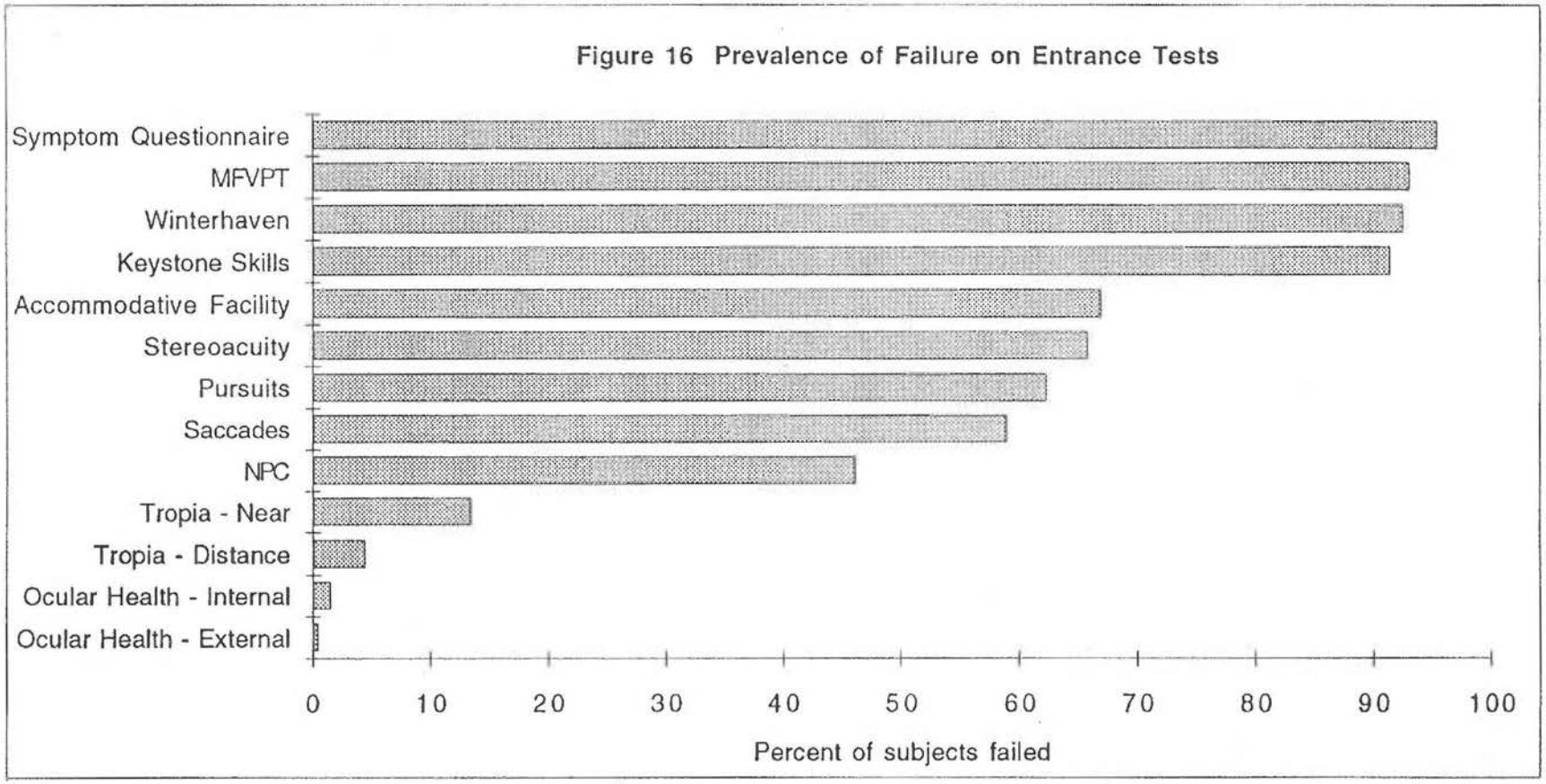


Figure 16 Prevalence of Failure on Entrance Tests
Symptom Questionnaire
MFVPT
Winterhaven
Keystone Skills
Accommodative Facility
Stereoacuity
Pursuits
Saccades
NPC
Tropia - Near
Tropia - Distance
Ocular Health - Internal
Ocular Health - External
0
10
20
30
40
50
60
70
80
90
100
Percent of subjects failed

Treatment Suggested by Visual Acuity and Refractive Error: In addition to treatment modalities suggested by case analysis and entrance test results, treatment modalities suggested by visual acuity and refractive error need to be considered. A survey of the prevalence of decreased visual acuity, technical refractive error and clinically significant refractive error in the Folsom JD population shows that decreased visual acuity is more prevalent at nearpoint than at distance. (Figure 17) Likewise, more prescriptions are given for nearpoint use than for distance.

An interesting observation is that hyperopia is the most prevalent refractive error found, but is the refractive error least prescribed for when considering prescriptions for distance. It is likely that subjects with low amounts of hyperopia were given nearpoint prescriptions only.

It is also interesting to note the difference between the prevalence of technical refractive error and the prevalence of nearpoint prescriptions given. The percentage of Folsom JD subjects found to have any refractive error is actually less than the sum of the prevalence data for myopia, hyperopia and astigmatism, since some of the subjects found to have astigmatism are also likely to be accounted for under the categories of myopia or hyperopia. Still, even if the prevalence data for myopia, hyperopia and astigmatism are summed up, the sum is less than the prevalence of nearpoint prescriptions given. This implies that some emmetropes were given nearpoint prescriptions.

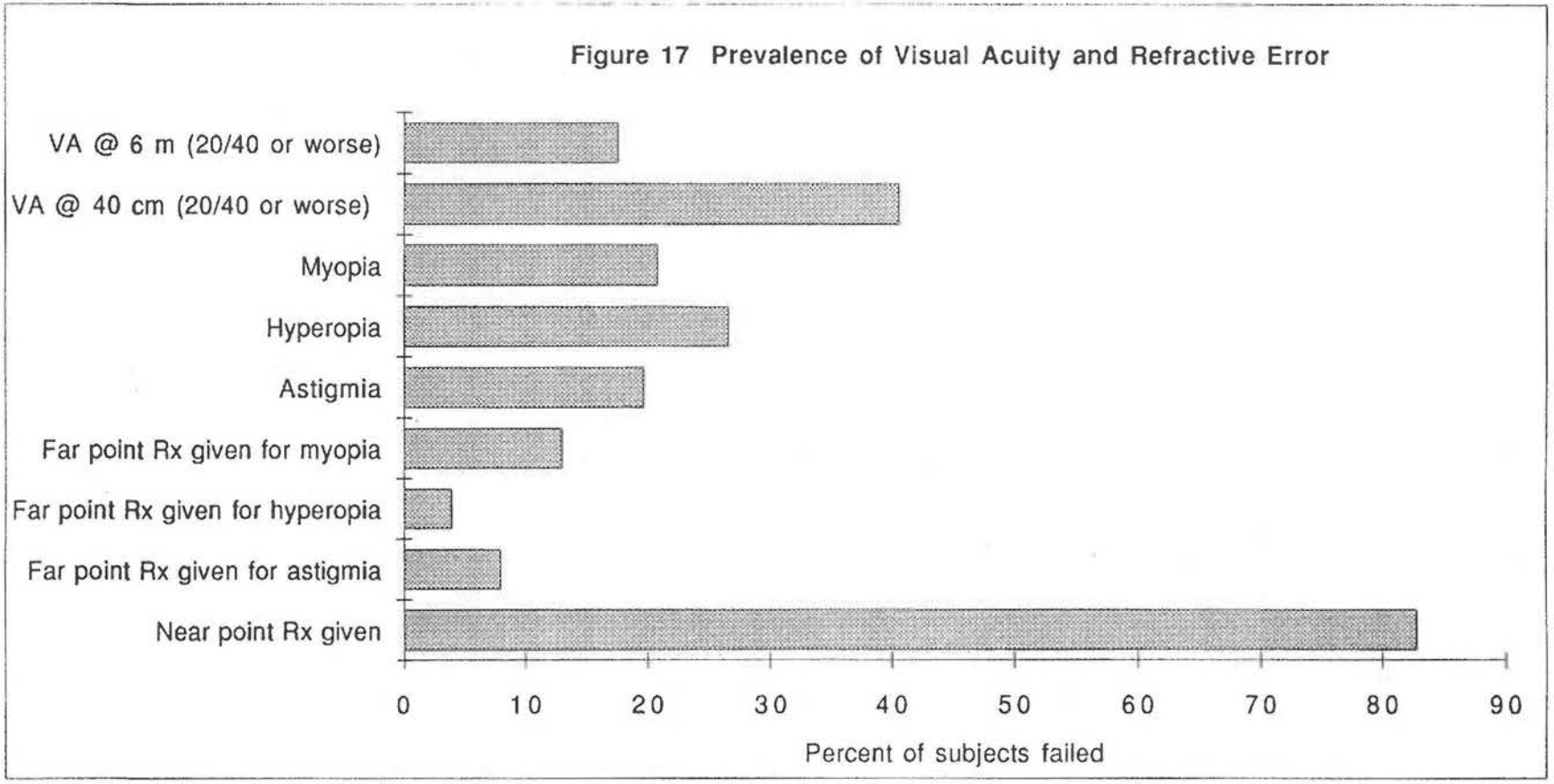


Figure 17 Prevalence of Visual Acuity and Refractive Error
VA @ 6 m (20/40 or worse)
VA @ 40 cm (20/40 or worse)
Myopia
Hyperopia
Astigmia
Far point Rx given for myopia
Far point Rx given for hyperopia
Far point Rx given for astigmia
Near point Rx given
0
10
20
30
40
50
60
70
80
90
Percent of subjects failed

Summary: JD subjects of this study were given a comprehensive optometric exam that included entrance testing and an analytical exam in order to gather information on a variety of visual skills and attributes.

Various treatments are suggested by the data collected. There appears to be a significant need for plus nearpoint lenses and vision training for visual perception and ocular motilities. Less prevalent but equally important is the need for refractive error correction and treatment of strabismus and ocular pathology.

CONCLUSIONS

Comparison of Folsom JD Study to other JD and LD studies

• The subjects profiled in this study are likely to be a fair representation of a general juvenile delinquent population although differ as to ethnic representation in the county of their residence.

• JD studies, including this one, show the JD population as a highly symptomatic group.[53,54,55] Highly symptomatic people have been shown by one LD study to score lower on an academic achievement test.[31]

• Comparison of this JD study to other JD studies yields various percentages of clinically significant refractive error.[5,57] This may be due to variance in definition of what is clinically significant. In this particular study, close to one-fifth of its JD subjects were given a far point prescription, while close to four-fifths were given a near-point prescription. LD studies hint that academic achievement may be improved by correcting refractive errors, especially when the subject is hyperopic.[32]

• Close to one-fourth of the subjects in this study were found to have some degree of anisometropia, but no other JD studies were found to allow for comparison. One LD study demonstrates an improvement in reading score after correction for anisometropia.[33]

• In this study and one other JD study, a near point prescription was given five times more often than a far point prescription.[54] One LD study was found in

which a near point prescription was given with greater frequency to a reading delayed group than to a reading normal group.[36]

• JD studies thus far show that one-fifth to one-third of a JD population can be expected to have unaided binocular distance visual acuity of worse than 20/40.[9,53] The majority of LD studies do not show a significant relationship between distance visual acuity and academic achievement.[32]

• This study found close to one-fifth of its male subjects and close to one-fourth of its female subjects to have near-point visual acuity of worse than 20/40, but comparison to other JD studies was not possible due to differences in tabulation of data. Two of four LD studies found statistically significant data concerning near-point acuity's role in academic achievement, suggesting that decreased near-point acuity may be linked to poor reading ability.

• Accommodative facility has been measured in both JD and LD studies. However, the testing apparatus are varied and not always defined. This study found close to two-thirds of its JD population to fail accommodative facility testing. High failure rates for accommodative facility testing has been found by other JD and LD studies.[4,37,38,54]

• This JD study measured a near point add for its subjects using book retinoscopy. A mean value of +0.68 D was calculated from the data. Book retinoscopy was not found to be used in other JD or LD studies.

• In this JD study, a mean value of -2.91 D was calculated for PRA. However, not enough JD studies have reported PRA to allow for a consensus to be made

regarding an expected mean value.[59] There is one comparative LD study that found a low PRA score more frequently in a reading delayed group when compared to a reading normal group but no correlational LD studies that show a low PRA to have a significant relationship to poor academic achievement.[34,36]

• This JD population yielded a mean NRA of +2.01 D. This value is lower than that found by the Colorado Optometric Center[59] which found a mean of +2.62 D. No other JD or LD studies were found that reported NRA values.

• In this JD study, close to half of the subjects failed NPC testing. There are only two other JD studies that present the prevalence of poor NPC performance in a JD population[53,55] Comparison of these three JD studies yield varied results perhaps due to differing failure criteria. Regarding NPC and learning disability, one correlational study found a significant relationship between poor NPC performance and poor academic achievement while three did not.[34,35, 40,41] As with the prevalence studies of NPC in the JD population, the correlational studies of NPC in the LD population do not use consistent failure criteria.

• A high failure rate on ocular motility testing is found in this study and in several other JD studies.[53-55,58] However, various terms and tests are used to assess ocular motility among these JD studies. In this particular study, close to three-fifths of the subjects failed ocular motility testing as measured by pursuit and saccadic ability. Regarding ocular motility in the LD literature, half of the LD studies reviewed suggest a link between poor ocular motility ability and poor reading ability.[35,34,40,42-44] As with the JD studies, the LD studies use a variety of terms and tests to define ocular motility skills.

• In this JD study, close to two-thirds of the subjects failed a stereopsis test. Only one other JD study was found that measured stereopsis and it used different pass criteria than that used in this study.[58] No LD studies reveal any correlation between poor stereopsis and low academic achievement or reading ability.[34,35,41,42]

• Almost all of the Folsom JD subjects failed Keystone Skills testing. No other JD studies were found to report prevalence of failure on Keystone Skills testing. In one LD study, almost all LD subjects failed binocular fusion testing as measured by a combined score on Keystone Skills, cheiroscopic and duction testing.[38]

• In the Folsom JD study, cover test was used to measure the prevalence of orthophoria, heterophoria and tropia in the Folsom JD population. Almost all the Folsom JD population was found to be orthophoric at distance and two-thirds were found to be exophoric at near. Cover testing was used in other JD and LD studies, however, these studies did not present data in a manner to allow for comparison with the Folsom JD study.[45,53,55,58]

• Only one other JD study was found which calculated mean values for phoria and vergence range measurements and all but one of the values were higher than the values found in the Folsom JD population.[59] A couple LD studies suggest that no link exists between an out-of-norm lateral phoria measurement and academic achievement.[34,46] One LD study suggests that increasing the convergence range at far and near may improve academic performance of LD individuals.[48]

• Almost all JD subjects of this study failed both the MFVPT and Winterhaven visual perception tests. Two other JD studies were found which reported prevalence data on visual perception. One of these found a high failure rate similar to this study and the other found a considerably lower failure rate.[54,55] LD studies reviewed show a possible link between visual perception dysfunction and poor academic achievement.[49-52]

• This study also considered the number of subjects with ocular health problems. It was found that very few subjects had an ocular health problem, either internally or externally. No other JD or LD studies were found which addressed prevalence of ocular health problems in their respective subject pools.

Comparison of Folsom JD Means to OEP's Expected Values and Morgan's Normative Values

• Folsom JD means were statistically compared to Morgan's normative values and OEP's expected values in sixteen tests selected from the analytical exam. The tests selected measure accommodation and vergence skills. The comparison uncovered a trend in which the Folsom JD means were statistically lower than corresponding Morgan's norms or OEP's expecteds. This indicates that the Folsom JD population represents a population distinct from the clinical population defining Morgan's norms and the theoretical population defining OEP's expecteds.

Case Analysis of Folsom JD Means

• The Folsom JD means were assembled to represent a hypothetical Folsom JD subject for which an optometric diagnosis could be made. Diagnosis was based on several analysis systems including Duane-White classification, Sheard's criterion, Percival's criterion, Morgan's syndrome analysis, Grisham's modification of Morgan's analysis and OEP case analysis. Case analysis indicates the presence of a nonembedded accommodative problem.

Optometric Treatment of the Folsom JD Subjects

• Various treatments are suggested by the data collected. There appears to be a significant need for plus nearpoint lenses and vision training for visual perception and ocular motilities. Less prevalent but equally important is the need for refractive error correction and treatment of strabismus and ocular pathology.

APPENDIX A
Exam Recording Forms

UNIT: _____ DATE: [illegible]

STANISLAUS COUNTY JUVENILE HALL VISION PROJECT QUESTIONNAIRE

NAME: _____ DOB: 10 2 78 AGE NOW: 13

HOME CITY: _____ STATE: _____ RACE: White

This questionnaire has been developed to ask the youth about their vision as it relates to classroom performance. This is designed to help accurately identify those youth who have a high probability of vision input problems that can interfere with classroom performance

DIRECTIONS: Have the youth read and answer the following questions or, if they are unable, ask the youth the following questions and record the results. Circle 'Y' for YES, 'N' for NO.

Do you avoid reading and/or close work?	Y	(N)
If forced to read for 15 minutes, do your eyes: hurt or feel tired?	Y	N
burn or ache?	(Y)	N
water?	(Y)	N
When forced to read do you: lose your place often?	Y	N
use your finger as a marker?	Y	N
rub your eyes?	(Y)	N
mouth or mumble the words?	Y	N
develop a headache?	(Y)	N
notice the print blurring?	(Y)	N
notice the words swimming on the page?	Y	(N)
see double or cover one eye?	Y	(N)

********** TEACHERS OR STAFF **********

Do you notice:

Obvious or severe head turn when writing, reading or talking?	Y	(N)
Paper not centered but pushed to one side?	Y	(N)
Decreased comprehension when reading?	Y	(N)
Resting head on table or arm when doing school work?	Y	(N)
Severely decreased attention span?	Y	(N)

** If youth answers 'N' to most questions but staff is seeing poor performance in school - check off areas that apply and refer anyway.

***CRITERIA FOR FURTHER TESTING:
Affirmative answer on three (3) or more of the questions. Rm Hz

STANISLAUS COUNTY JUVENILE HALL VISION PROJECT
VISION PERFORMANCE RECORD SHEET

PRE: POST:

NAME: _____ SCREENING DATE: 5-28-92 | _____

DOB: 10-2-78 AGE: Years 13 Mo. 7 SEX: M (F) EXAM DATE: 5/28/92

GRADE: _____ DIAGNOSIS: ↓ depth perception, ↓ convergence, myopia

The following tests were conducted and scored to indicate this youth's current level of performance. The tests were chosen to accurately identify those youth who have a high probability of vision in-put problems that can interfere with classroom performance.

TEST ITEMS	RESULTS
1. SYMPTOM QUESTIONNAIRE Referral criteria: 3 or more 'Yes' responses indicating visual fatigue or youth's own desire to be seen by Doctor.	P (F)
2. KEYSTONE TELEBINOCULAR Criteria: 2 or more responses other than 'Expected'.	P (F)
3. WINTERHAVEN COPY FORMS/VISUAL ORGANIZATION Raw Score 17/21 Age Equivalent 10	*P (F*)
4. WINTERHAVEN VISUAL MEMORY Raw Score 15/21 Age Equivalent 10	*P (F*)
5. MOTOR-FREE VISUAL PERCEPTION TEST Raw Score 25/36 Age Equivalent 8	*P (F*)

NOTE: *P - indicates performance equal to a 12 year old youth.
*F - indicates performance at least 1 year below age level.

VISION THERAPY VISITS: 1. 11-20-92 2 2-19-93 3 2-23-93 4 6/3/94 5 6/7/94 6 6/10/94 7 6/17/94 8 6/22/9
9 6/24/94 10 6/29/94 11 7/1/94 12 _____ 13 _____ 14 _____ 15 _____ 16 _____ 17 _____ 18 _____
19 _____ 20 _____

VISUAL ACUITY:

Far, without lenses	R 20/70 L 20/70 B 20/70	Far, with lenses	R 20/20 L 20/20 B 20/20	Near, without lenses	R 20/50 L 20/50 B 20/50	Near, with lenses	R 20/25 L 20/25 B 20/25

	SPH.	CYL.	AXIS	PRISM	BASE	ADD	SEG.HT.	SEG.W.
R	-100	DS				+100	25	22
L	-075	DS				+100		

TEMPLE	SIZE-EYE-BOX	SHAPE	PD DIST. 62 / NEAR 58	SINGLE VISION
135	52			BIFOCAL Rd 22
FRAME Kenmark - Elite demi green $			DBL 18	TRIFOCAL
SPECIAL LENS DETAIL			GLASS / PLASTIC ✓ / OVERSIZE / RIMLESS / TINT	

GLASSES ORDERED: 5/28/92 (#44078)

GLASSES DELIVERED: 44078 6/5/92

USE:

NEAR ____ FAR ____ FULLTIME ✓

pr #2 ordered 2/11/93 (#49647) dup
del. 2/18/93

2/18/93 2nd pair delivered.

NAME _____ DATE 5/28/92 DOB 10/2/78 SEX F

SC	FAR	NEAR
R	20/70	R 20/50
L	/70	L /50
B	/70	B /50

VA CC	FAR	NEAR
R	20/	R 20/
L		L
B		B

HISTORY:
Pt c/o distance blur eyes sting when read also loses place.

CT: FAR Ø
NEAR Ø

PURSUITS: smooth, (jerky), inaccurate
head mvmt: Y (N)
automated: (Y) N
adequate / (inadequate)

SACCADES: accurate, (under)/overshoots
head mvmt: Y (N)
early release: (Y) N
adequate / (inadequate)

STEREO: 400"
CNP: 3"/5" adequate / (inadequate)
± 2:00 flipper: 4-6 seconds to clear both

ADDITIONAL NEAR TESTING

1) BOOK RET: +0.75 → +1.00 best Comfort

2) NEAR STEREO: 1 to 100" c +1.00 over to SRK

3)

HEALTH

PERRLA (Y) N /-MG (Y) N

INTERNAL:
C/D- 0.2 media- Clr.
A/V- 4/5 x'gs- normal
fundi- homog FR: (+)

EXTERNAL:
lids – lashes – conj – cornea – } all clr. OU

LEE: none (school)

ANALYTICAL

#4 R -1.00 DS
L -1.25 DS

#7 (ay) R -1.00 DS 20/2
#7 L -0.75 20/2

#8 2 Sep control 7/(7a)

#9 20 SILO

#10 28+/18

#11 4/0 SILO

#12 Ø

#13 b _____ control 7/7a/(9)

Gradient +1.00

#15 b 1 Sep

#16 a 20 S(I)LO
b 28/no bk

#17 a _____ SILO
b 16/0

#20 R -3.00 L -2.00 (G) A

#21 R +1.50 L +1.50 (G) A

NEW RX:
R -1.00 DS Add FD 624
L -0.75 DS +1.00
pg 25

Doctor's Signature:
Daniel Blakely OD

APPENDIX B
Additional Tables and Figures

Unaided Distance Visual Acuity OU						
	Male	% of Total	Female	% of Total	Total	% of Total
Not reported	14	3.70	5	5.05	19	3.98
20/15	0	0.00	0	0.00	0	0.00
20/20	98	25.93	15	15.15	113	23.69
20/25	4	1.06	0	0.00	4	0.84
20/30	123	32.54	27	27.27	150	31.45
20/40	65	17.20	19	19.19	84	17.61
20/50	54	14.29	19	19.19	73	15.30
20/60	0	0.00	2	2.02	2	0.42
20/70	12	3.17	7	7.07	19	3.98
20/80	0	0.00	0	0.00	0	0.00
20/100	5	1.32	3	3.03	8	1.68
20/150	0	0.00	0	0.00	0	0.00
20/200	2	0.53	1	1.01	3	0.63
20/300	1	0.26	0	0.00	1	0.21
20/400	0	0.00	1	1.01	1	0.21
20/2000	0	0.00	0	0.00	0	0.00
FC	0	0.00	0	0.00	0	0.00
NLP	0	0.00	0	0.00	0	0.00
Totals	378	100.00	99	100.00	477	100.00

Unaided Distance Visual Acuity OD						
	Male	% of Total	Female	% of Total	Total	% of Totals
Not reported	4	1.06	1	1.01	5	1.05
20/15	0	0.00	0	0.00	0	0.00
20/20	80	21.16	10	10.10	90	18.87
20/25	4	1.06	0	0.00	4	0.84
20/30	134	35.45	35	35.35	169	35.43
20/40	60	15.87	19	19.19	79	16.56
20/50	59	15.61	14	14.14	73	15.30
20/60	1	0.26	2	2.02	3	0.63
20/70	20	5.29	10	10.10	30	6.29
20/80	0	0.00	0	0.00	0	0.00
20/90	1	0.26	0	0.00	1	0.21
20/100	9	2.38	5	5.05	14	2.94
20/150	0	0.00	0	0.00	0	0.00
20/200	3	0.79	2	2.02	5	1.05
20/300	1	0.26	0	0.00	1	0.21
20/400	1	0.26	1	1.01	2	0.42
20/2000	1	0.26	0	0.00	1	0.21
FC	0	0.00	0	0.00	0	0.00
NLP	0	0.00	0	0.00	0	0.00
Totals	378	100.00	99	100.00	477	100.00

Unaided Distance Visual Acuity OS						
	Male	% of Total	Female	% of Total	Total	% of Total
Not reported	5	1.32	1	1.01	6	1.26
20/15	0	0.00	0	0.00	0	0.00
20/20	68	17.99	8	8.08	76	15.93
20/25	4	1.06	0	0.00	4	0.84
20/30	124	32.80	29	29.29	153	32.08
20/40	74	19.58	24	24.24	98	20.55
20/50	58	15.34	17	17.17	75	15.72
20/60	3	0.79	1	1.01	4	0.84
20/70	24	6.35	10	10.10	34	7.13
20/80	0	0.00	0	0.00	0	0.00
20/100	10	2.65	7	7.07	17	3.56
20/150	0	0.00	0	0.00	0	0.00
20/200	4	1.06	1	1.01	5	1.05
20/300	2	0.53	0	0.00	2	0.42
20/400	1	0.26	1	1.01	2	0.42
20/2000	0	0.00	0	0.00	0	0.00
FC	0	0.00	0	0.00	0	0.00
NLP	1	0.26	0	0.00	1	0.21
Totals	378	100.00	99	100.00	477	100.00

Unaided Near Visual Acuity OU						
	Male	% of Total	Female	% of Total	Total	% of Total
Not reported	22	5.82	6	6.06	28	5.87
20/15	0	0.00	0	0.00	0	0.00
20/20	30	7.94	5	5.05	35	7.34
20/25	1	0.26	0	0.00	1	0.21
20/30	127	33.60	19	19.19	146	30.61
20/40	146	38.62	48	48.48	194	40.67
20/50	30	7.94	12	12.12	42	8.81
20/60	18	4.76	5	5.05	23	4.82
20/70	0	0.00	0	0.00	0	0.00
20/80	0	0.00	0	0.00	0	0.00
20/100	4	1.06	4	4.04	8	1.68
20/150	0	0.00	0	0.00	0	0.00
20/200	0	0.00	0	0.00	0	0.00
20/300	0	0.00	0	0.00	0	0.00
20/400	0	0.00	0	0.00	0	0.00
20/2000	0	0.00	0	0.00	0	0.00
FC	0	0.00	0	0.00	0	0.00
NLP	0	0.00	0	0.00	0	0.00
Totals	378	100.00	99	100.00	477	100.00

Unaided Near Visual Acuity OD						
	Male	% of Total	Female	% of Total	Total	% of Total
Not reported	11	2.91	3	3.03	14	2.94
20/15	0	0.00	0	0.00	0	0.00
20/20	28	7.41	5	5.05	33	6.92
20/25	1	0.26	0	0.00	1	0.21
20/30	118	31.22	12	12.12	130	27.25
20/40	143	37.83	48	48.48	191	40.04
20/50	51	13.49	20	20.20	71	14.88
20/60	20	5.29	6	6.06	26	5.45
20/70	0	0.00	0	0.00	0	0.00
20/80	0	0.00	0	0.00	0	0.00
20/100	5	1.32	4	4.04	9	1.89
20/150	0	0.00	0	0.00	0	0.00
20/200	0	0.00	1	1.01	1	0.21
20/300	0	0.00	0	0.00	0	0.00
20/400	1	0.26	0	0.00	1	0.21
20/2000	0	0.00	0	0.00	0	0.00
FC	0	0.00	0	0.00	0	0.00
NLP	0	0.00	0	0.00	0	0.00
Totals	378	100.00	99	100.00	477	100.00

Unaided Near Visual Acuity OS						
	Male	% of Total	Female	% of Total	Total	% of Total
Not reported	11	2.91	3	3.03	14	2.94
20/15	0	0.00	0	0.00	0	0.00
20/20	25	6.61	5	5.05	30	6.29
20/25	1	0.26	0	0.00	1	0.21
20/30	117	30.95	17	17.17	134	28.09
20/40	152	40.21	47	47.47	199	41.72
20/50	38	10.05	17	17.17	55	11.53
20/60	24	6.35	5	5.05	29	6.08
20/70	0	0.00	0	0.00	0	0.00
20/80	0	0.00	0	0.00	0	0.00
20/100	7	1.85	5	5.05	12	2.52
20/150	0	0.00	0	0.00	0	0.00
20/200	1	0.26	0	0.00	1	0.21
20/300	0	0.00	0	0.00	0	0.00
20/400	1	0.26	0	0.00	1	0.21
20/2000	0	0.00	0	0.00	0	0.00
FC	0	0.00	0	0.00	0	0.00
NLP	1	0.26	0	0.00	1	0.21
Totals	378	100.00	99	100.00	477	100.00

Subjective Refraction (#7a)									
OD Sphere	Not Reported	% In Total	Emmetrope	% of Total	Myope	% of Total	Hyperope	% of Total	Total
Not reported	2	0.42							
plano			249	52.20					
0.12 to 0.50					53	11.11	88	18.45	
0.62 to 1.00					33	6.92	26	5.45	
1.12 to 1.50					4	0.84	6	1.26	
1.62 to 2.00					3	0.63	2	0.42	
2.12 to 2.50					1	0.21	1	0.21	
2.62 to 3.00					2	0.42	1	0.21	
3.12 to 3.50					0	0.00	0	0.00	
3.62 to 4.00					0	0.00	0	0.00	
4.12 to 4.50					1	0.21	0	0.00	
4.62 to 5.00					1	0.21	1	0.21	
5.12 to 5.50					1	0.21	0	0.00	
5.62 to 6.00					0	0.00	1	0.21	
6.12 to 6.50					0	0.00	1	0.21	
6.62 to 7.00					0	0.00	0	0.00	
7.12 to 7.50					0	0.00	0	0.00	
7.62 to 8.00					0	0.00	0	0.00	
8.12 and up					0	0.00	0	0.00	
Totals	2		249		99	20.75	127	26.62	477
Mean	0.01								
SD	0.81								

Subjective Refraction (#7a)							
OD Cylinder	Not Reported	% In Total	Nonastigmat	% of Total	Astigmat	% of Total	
Not reported	2	0.42					
0			381	79.87			
0.12 to 0.50					40	8.39	
0.62 to 1.00					31	6.50	
1.12 to 1.50					13	2.73	
1.62 to 2.00					3	0.63	
2.12 to 2.50					1	0.21	
2.62 to 3.00					1	0.21	
3.12 to 3.50					2	0.42	
3.62 to 4.00					0	0.00	
4.12 to 4.50					2	0.42	
4.62 to 5.00					0	0.00	
5.12 to 5.50					0	0.00	
5.62 to 6.00					1	0.21	
6.12 to 6.50					0	0.00	
6.62 to 7.00					0	0.00	
7.12 to 7.50					0	0.00	
7.62 to 8.00					0	0.00	
8.12 and up					0	0.00	
Totals	2		381		94	19.71	477
Mean	-0.20						
SD	0.58						

Subjective Refraction (#7a)		
OD Axis		% of Total
WTR (1 to 30 and 150 to 180)	45	9.43
OBLIQUE (31 to 59 and 121 to 149)	7	1.47
ATR (60 to 120)	41	8.60
Not reported	2	0.42
Nonastigmates	382	80.08
Total	477	100.00

Subjective Refraction (#7a)									
OS Sphere	Not Reported	% of Total	Emmetrope	% of Total	Myope	% of Total	Hyperope	% of Total	Total
Not reported	4	0.84							
plano			248	51.99					
0.12 to 0.50					62	13.00	77	16.14	
0.62 to 1.00					34	7.13	28	5.87	
1.12 to 1.50					5	1.05	6	1.26	
1.62 to 2.00					3	0.63	0	0.00	
2.12 to 2.50					0	0.00	2	0.42	
2.62 to 3.00					1	0.21	1	0.21	
3.12 to 3.50					0	0.00	0	0.00	
3.62 to 4.00					2	0.42	0	0.00	
4.12 to 4.50					1	0.21	0	0.00	
4.62 to 5.00					0	0.00	0	0.00	
5.12 to 5.50					2	0.42	0	0.00	
5.62 to 6.00					0	0.00	0	0.00	
6.12 to 6.50					0	0.00	1	0.21	
6.62 to 7.00					0	0.00	0	0.00	
7.12 to 7.50					0	0.00	0	0.00	
7.62 to 8.00					0	0.00	0	0.00	
8.12 and up					0	0.00	0	0.00	
Totals	4		248		110	23.06	115	24.11	477
Mean	-0.03								
SD	0.76								

Subjective Refraction (#7a)							
OS Cylinder	Not Reported	% of Total	Nonastigmat	% of Total	Astigmat	% of Total	Total
Not reported	4	0.84					
sphere			378	79.25			
0.12 to 0.50					44	9.22	
0.62 to 1.00					30	6.29	
1.12 to 1.50					8	1.68	
1.62 to 2.00					7	1.47	
2.12 to 2.50					1	0.21	
2.62 to 3.00					3	0.63	
3.12 to 3.50					0	0.00	
3.62 to 4.00					0	0.00	
4.12 to 4.50					1	0.21	
4.62 to 5.00					0	0.00	
5.12 to 5.50					0	0.00	
5.62 to 6.00					1	0.21	
6.12 to 6.50					0	0.00	
6.62 to 7.00					0	0.00	
7.12 to 7.50					0	0.00	
7.62 to 8.00					0	0.00	
8.12 and up					0	0.00	
Totals	4		378		95	19.92	477
Mean	-0.19						
SD	0.55						

Subjective Refraction (#7a)		
OS Axis		% of Total
WTR (1 to 30 and 150 to 180)	45	9.43
OBLIQUE (31 to 59 and 121 to 149)	6	1.26
ATR (60 to 120)	44	9.22
Not reported	4	0.84
Nonastigmates	378	79.25
Total	477	100.00

New Prescription							
OD Sphere	Emmetrope	% of Total	Myope	% of Total	Hyperope	% of Total	Total
plano	396	83.02					
0.12 to 0.50			25	5.24	5	1.05	
0.62 to 1.00			27	5.66	9	1.89	
1.12 to 1.50			5	1.05	0	0.00	
1.62 to 2.00			2	0.42	2	0.42	
2.12 to 2.50			0	0.00	1	0.21	
2.62 to 3.00			1	0.21	1	0.21	
3.12 to 3.50			0	0.00	0	0.00	
3.62 to 4.00			0	0.00	0	0.00	
4.12 to 4.50			0	0.00	0	0.00	
4.62 to 5.00			1	0.21	0	0.00	
5.12 to 5.50			1	0.21	0	0.00	
5.62 to 6.00			0	0.00	1	0.21	
6.12 to 6.50			0	0.00	0	0.00	
6.62 to 7.00			0	0.00	0	0.00	
7.12 to 7.50			0	0.00	0	0.00	
7.62 to 8.00			0	0.00	0	0.00	
8.12 and up			0	0.00	0	0.00	
Totals	396		62	13.00	19	3.98	477
Mean	-0.07						
SD	0.59						

New Prescription					
OD Cylinder	Nonastigmat	% of Total	Astigmat	% of Total	Total
0	439	92.03			
0.12 to 0.50			11	2.31	
0.62 to 1.00			14	2.94	
1.12 to 1.50			7	1.47	
1.62 to 2.00			2	0.42	
2.12 to 2.50			0	0.00	
2.62 to 3.00			1	0.21	
3.12 to 3.50			1	0.21	
3.62 to 4.00			0	0.00	
4.12 to 4.50			1	0.21	
4.62 to 5.00			1	0.21	
5.12 to 5.50			0	0.00	
5.62 to 6.00			0	0.00	
6.12 to 6.50			0	0.00	
6.62 to 7.00			0	0.00	
7.12 to 7.50			0	0.00	
7.62 to 8.00			0	0.00	
8.12 and up			0	0.00	
Totals	439		38	7.97	477
Mean	-0.1				
SD	0.45				

New Prescription		
OD Axis		% of Total
WTR (1 to 30 and 150 to 180)	17	3.56
OBLIQUE (31 to 59 and 121 to 149)	4	0.84
ATR (60 to 120)	17	3.56
Nonastigmates	439	92.03
Total	477	100.00

New Prescription							
OS Sphere	Emmetrope	% of Total	Myope	% of Total	Hyperope	% of Total	Total
plano	398	83.44					
0.12 to 0.50			25	5.24	5	1.05	
0.62 to 1.00			25	5.24	8	1.68	
1.12 to 1.50			5	1.05	1	0.21	
1.62 to 2.00			2	0.42	1	0.21	
2.12 to 2.50			1	0.21	0	0.00	
2.62 to 3.00			0	0.00	1	0.21	
3.12 to 3.50			0	0.00	0	0.00	
3.62 to 4.00			1	0.21	0	0.00	
4.12 to 4.50			1	0.21	0	0.00	
4.62 to 5.00			0	0.00	0	0.00	
5.12 to 5.50			2	0.42	0	0.00	
5.62 to 6.00			0	0.00	1	0.21	
6.12 to 6.50			0	0.00	0	0.00	
6.62 to 7.00			0	0.00	0	0.00	
7.12 to 7.50			0	0.00	0	0.00	
7.62 to 8.00			0	0.00	0	0.00	
8.12 and up			0	0.00	0	0.00	
Totals	398		62	13.00	17	3.56	477
Mean	-0.09						
SD	0.63						

New Prescription					
OS Cylinder	Nonastigmat	% of Total	Astigmat	% of Total	Total
sphere	434	90.99			
0.12 to 0.50			12	2.52	
0.62 to 1.00			17	3.56	
1.12 to 1.50			7	1.47	
1.62 to 2.00			3	0.63	
2.12 to 2.50			1	0.21	
2.62 to 3.00			1	0.21	
3.12 to 3.50			1	0.21	
3.62 to 4.00			0	0.00	
4.12 to 4.50			0	0.00	
4.62 to 5.00			0	0.00	
5.12 to 5.50			0	0.00	
5.62 to 6.00			1	0.21	
6.12 to 6.50			0	0.00	
6.62 to 7.00			0	0.00	
7.12 to 7.50			0	0.00	
7.62 to 8.00			0	0.00	
8.12 and up			0	0.00	
Totals	434		43	9.01	477
Mean	-0.11				
SD	0.46				

New Prescription		
OS Axis		% of Total
WTR (1to 30 and 150 to 180)	21	4.40
OBLIQUE (31 to 59 and 121 to 149)	2	0.42
ATR (60 to 120)	20	4.19
Nonastigmates	434	90.99
Total	477	100.00

New Prescription					
Add Power	No Add	% of Total	Add	% of Total	Total
none	82	17.19			
0.12 to 0.50			20	4.19	
0.62 to 1.00			335	70.23	
1.12 to 1.50			39	8.18	
1.62 to 2.00			1	0.21	
2.12 to 2.50			0	0.00	
2.62 to 3.00			0	0.00	
Totals	82		395	82.81	477
Mean	0.74				
SD	0.39				

Subjective Refraction (#7a)							
Anisometropia	Not Reported	% of Total	No Anisometropia	% of Total	Anisometropia	% of Total	Total
Not reported	4	0.84					
none			366	76.73			
0.12 to 0.50					82	17.19	
0.62 to 1.00					14	2.94	
1.12 to 1.50					4	0.84	
1.62 to 2.00					2	0.42	
2.12 to 2.50					1	0.21	
2.62 to 3.00					1	0.21	
3.12 to 3.50					1	0.21	
3.62 to 4.00					0	0.00	
4.12 to 4.50					0	0.00	
4.62 to 5.00					1	0.21	
5.12 to 5.50					0	0.00	
5.62 to 6.00					1	0.21	
6.12 to 6.50					0	0.00	
6.62 to 7.00					0	0.00	
7.12 to 7.50					0	0.00	
7.62 to 8.00					0	0.00	
8.12 and up					0	0.00	
Totals	4		366		107	22.43	477
Mean	0.04						
SD	0.51						

New Prescription					
Anisometropia	Nonanisometrope	% of Total	Anisometrope	% of Total	Total
0	449	94.13			
0.12 to 0.50			17	3.56	
0.62 to 1.00			6	1.26	
1.12 to 1.50			2	0.42	
1.62 to 2.00			1	0.21	
2.12 to 2.50			0	0.00	
2.62 to 3.00			0	0.00	
3.12 to 3.50			1	0.21	
3.62 to 4.00			0	0.00	
4.12 to 4.50			0	0.00	
4.62 to 5.00			0	0.00	
5.12 to 5.50			0	0.00	
5.62 to 6.00			0	0.00	
6.12 to 6.50			0	0.00	
6.62 to 7.00			0	0.00	
7.12 to 7.50			1	0.21	
7.62 to 8.00			0	0.00	
8.12 and up			0	0.00	
Totals	449		28	5.87	477
Mean	0.02				
SD	0.42				

Accommodative Amplitude				
	PRA (#20)	% of Total	NRA (#21)	% of Total
Not reported	11	2.31	11	2.32
0	4	0.84	0	0.00
0.12 to 0.50	16	3.35	7	1.48
0.62 to 1.00	51	10.69	21	4.43
1.12 to 1.50	67	14.05	84	17.72
1.62 to 2.00	44	9.22	146	30.80
2.12 to 2.50	43	9.01	113	23.84
2.62 to 3.00	36	7.55	69	14.56
3.12 to 3.50	48	10.06	18	3.80
3.62 to 4.00	58	12.16	4	0.84
4.12 to 4.50	37	7.76	1	0.21
4.62 to 5.00	13	2.73	0	0.00
5.12 to 5.50	12	2.52	0	0.00
5.62 to 6.00	12	2.52	0	0.00
6.12 to 6.50	11	2.31	0	0.00
6.62 to 7.00	5	1.05	0	0.00
7.12 to 7.50	6	1.26	0	0.00
7.62 to 8.00	1	0.21	0	0.00
8.12 and up	2	0.42	0	0.00
Totals	477	100.00	474	100.00
Mean	-2.913		2.0128	
SD	1.7219		0.8458	

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