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Accommodative facility: Assessment of variables limiting performance

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Abstract

Evaluation of available normative data and protocols for accommodative facility testing in school aged children shows a lack of agreement among authors, and many studies failed to include or consider the unique conditions under which this age group must be tested. This study was designed to assess variables which have been implicated in previous research as having an impact upon testing in children, and ultimately limits their usefulness. Specifically, these variables are linguistic/cognitive processing (visual-verbal automaticity), and the motor response act of turning the lens flipper. The purpose of this study was to determine the potential impact these two variables have upon the measurement of relative accommodative response time during lens rock facility testing with school children. Methods include presentation of a new testing paradigm and a unique target (Modified Landolt C). Forty-nine fourth graders and twenty-two first graders participated in a within- subjects design where each subject's response time was measured for each of five separate test conditions. These conditions were designed to assess both the impact and effect the above variables may have upon performance during accommodative facility testing at these two grade levels. Results indicate: (1) Use of a flipper slows performance at both first and fourth grade levels; (2) There was no significant difference in performance either when the examiner or the subject was manipulating the flipper. This was true for both our samples of first and fourth graders. Therefore, motor dexterity is not an issue in performance; (3) Although visual-verbal response time plays a significant role in lens rock performance, relative accommodative response is a major limiting variable with each grade level; and (4) Relative accommodative response time may improve between first and fourth grade.

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ACCOMMODATIVE FACILITY: ASSESSMENT OF VARIABLES LIMITING PERFORMANCE

BY

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ABSTRACT

Evaluation of available normative data and protocols for accommodative facility testing in school aged children shows a lack of agreement among authors, and many studies failed to include or consider the unique conditions under which this age group must be tested. This study was designed to assess variables which have been implicated in previous research as having an impact upon testing in children, and ultimately limits their usefulness. Specifically, these variables are linguistic/cognitive processing (visual-verbal automaticity), and the motor response act of turning the lens flipper. The purpose of this study was to determine the potential impact these two variables have upon the measurement of relative accommodative response time during lens rock facility testing with school children. Methods include presentation of a new testing paradigm and a unique target (Modified Landolt C). Forty-nine fourth graders and twenty-two first graders participated in a with-in-subjects design where each subject's response time was measured for each of five separate test conditions. These conditions were designed to assess both the impact and effect the above variables may have upon performance during accommodative facility testing at these two grade levels. Results indicate: (1) Use of a flipper slows performance at both first and fourth grade levels; (2) There was no significant difference in performance either when the examiner or the subject was manipulating the flipper. This was true for both our samples of first and fourth graders. Therefore, motor dexterity is not an issue in performance; (3) Although visual-verbal response time plays a significant role in lens rock performance, relative accommodative response is a major limiting variable with each grade level; and (4) Relative accommodative response time may improve between first and fourth grade.

Key words: Accommodative facility, accommodative flexibility, accommodative stimulus, accommodative response, relative accommodative response time, accommodative posture, lens rock, visual-verbal automaticity.

INTRODUCTION

Patients frequently present to optometric offices for routine eye exams with various accommodative complaints which may include blur at far and/or near, poor sustaining ability or fatigue with near work, slow reading, frequent headaches, and unusual postures and/or working distances. These symptoms are not entirely unique to accommodative infacility, and may be caused by anyone or more visual inefficiencies. Yet when accompanied by certain analytical findings, the problem is most likely accommodative inflexibility.[1-4] Accommodative inflexibility (infacility) may be defined as the inability to quickly and accurately enact and inhibit the accommodative posture while maintaining a fixed angle of convergence in a non-presbyopic patient.[4] Analytical findings which may be clinical signs or manifestations of accommodative infacility include: variability in static or dynamic retinoscopy reflex, large lag of accommodative posture found during dynamic retinoscopy (ie: Book, MEM, etc.) or on cross-cylinider tests, variable phorias on Keystone DB9 and DB9B stereograms, large esophoric or exophoric postures, and low positive-relative accommodation and/or low negative-relative accommodation.[4]

Typically, only two of three aspects of accommodative functioning are sampled during the routine analytical exam: accommodative amplitude and posture. The third, accommodative facility is usually not measured unless the signs and symptoms previously mentioned make the clinician suspect a problem with this visual skill. When facility is suspected, lens rock (alternating +2.00 D and -2.00 D lenses binocularly) is the widely used diagnostic testing procedure for differentially diagnosing asthenopic patients. The results of this test, like many optometric tests, depend heavily upon accepted norms derived from research. Since many clinical judgements involve the future management of the patient's condition, it is imperative to determine if these norms accurately represent reasonable and acceptable performance while providing a valid and efficient procedure for screening out asthenopic patients with accommodative facility problems.

Many authors[5-10] have proposed standards and protocol for accommodative facility assessment of children. There is however, very little agreement in either the methods or the normative findings. Yet a common thread in all facility measurement studies is that the subjective accommodative response time and postural accuracy are not measured directly, but inferred based upon vocalization of the subject. Because of this, the test, like other subjective measures of human performance, may be potentially influenced by both intrinsic and extrinsic variables. Intrinsic variables include: age, expressive language ability, memory skills, motivation, cognitive/linguistic processing speed (ie: automaticity), binocular status, suppression, wrist/arm nuero-motor facility, eye movement/fixational ability, and motivation. Extrinsic variables include: refractive error, instructional set, lighting, target stimuli, etc.

Of the normative accommodative facility studies reviewed by the authors (see table 1) two stand out (Scheiman et. al.[11] and Argenbright & Beaudoin12), as having controlled for the greatest number of potential confounders. Both of the previous mentioned studies reported accommodative facility performance of elementary school children to be age dependent. Other investigators have either not tested elementary school children, or have grouped them with adults for normative purposes.[10,11]

Table 1
Summary of previous studies including school aged children as test subjects.

Author(Year)	Mean Binocular cycles/min.	Standard Deviation	Pre-Screening of Test Subjects?	Suppression Controlled?	Power of Test Lens	Test Subjects Age or Grade Level	Total # of Subjects	Published?	Comments
Mackner & Onorato (1989)	3.50 7.37	1.33 1.92	Yes Yes	Yes Yes	± 2.00 D + 2.00 D	1st Grade 4th Grade	22 49	No No	Small population sample for first graders.
Argenbright & Beaudoin (1987)	4.86 7.28	1.18 1.56	Yes Yes	Yes Yes	± 2.00 D + 2.00 D	1st Grade 4th Grade	33 34	No No	Failure to consider variables of automaticity & motor impact of lens flipping. Reported data for same elememtary school as Mackner and Onorato.
Scheiman et. al. (1988)	3.35 4.72	2.74 2.35	Yes Yes	Yes Yes	± 2.00 D ± 2.00 D	7 years 10 years	N/A N/A	Yes Yes	Ages 6 yrs. - 12 yrs. tested. Results reported here are for comparable ages in this study. Target/instrument not available, problems with design/utilization.
Schlange et. al. (1979)	7.00	3.00	No	No	± 2.00 D	6 yrs. through 11 yrs.	266	No	Design problems, failure to control or consider memorization of target.
Burge (1979)	7.05	4.25	Yes	Yes	± 2.00 D	6 yrs. through 30 yrs.	30	Yes	Failed to consider children by age or grade level for mean cpm.
McKenzie et. al. (1987)	NA	NA	NA	Yes	± 2.00 D	8 yrs. through 12 yrs.	66	Yes	Reliability study, data given for individual & sub-group. Questionable data based on instructional set.
Hoffman, et. al. (1978)	1-2	NA	Yes	No	± 2.50 D	6 yrs. through 12 yrs.	80	No	Failed to monitor suppression. Did not use standard ± 2.00 D flipper.

Differences in research methods and criteria for studies including children are listed in table 1. Only two of the published studies, Scheiman et. al.[11] and Burge[6] list binocular facility means for school aged children, yet they disagree on what is expected performance. Burge's[6] study did not consider age as a factor and grouped ages 6-30 years making the results inappropriate for use in school children. Scheiman et. al.[11] used a back illuminated polarized target which was possibly the most effective continuous suppression control, but it is currently unavailable to clinicians. Three of the studies [5,7,8] on children reviewed did not pre-screen subjects for refractive errors and/or binocular status (suppression). In the latter case, lens rock may be measuring different skills and/or behaviors between suppressing and non-suppressing subjects. If the subject is suppressing, monocular facility which is normally higher, may be measured rather than binocular facility.[6] All studies in table 1, except for Argenbright & Beaudoin,[12] failed to control in one way or another, any one or more of the intrinsic and extrinsic variables mentioned earlier.

Since there is little agreement among authors and norms vary so much as shown in table 1, it is therefore important to establish a standardized clinical testing procedure which accounts for the variables mentioned previously which may invalidate the test. Some of these variables, eye movement/fixational ability and memory factors in conjunction with previously utilized targets were identified as potential confounders by Argenbright & Beaudoin.[12] Previous studies [5-10] used either the same target continuously (vectographic #9 card with polaroids), or a series of letters/numbers, with the response of "now" or "clear." Such testing failed to consider repetition whereby the targets could be memorized, or the subject looking ahead and remembering future targets from a previous accommodative posture. In addition, such testing introduced the Halo Effect, whereby the subjects response was to please the examiner. To reduce the effect of these variables Argenbright & Beaudoin[12] introduced a new target (Modified Landolt C) and testing protocol. This easily administered clinical test requires a verbal response by the subject which is followed by the precise placement of a new target/card over the previous card during the lens change. This method minimizes the demand for eye-movement ability by the subject and eliminates long and short term memorization factors stemming from target redundancy, or from the subject looking ahead and remembering future targets from a previous accommodative posture.

Argenbright & Beaudoin's[12] targets and testing protocol were the first attempts to control and minimize the effect of the previously mentioned intrinsic/extrinsic variables. Yet, the role of visual-verbal automaticity and its effect upon performance in accommodative facility testing was still unknown. In fact, none of the studies reviewed by the authors were designed to assess the impact of cognitive/linguistic processing response times or expressive language abilities(visual-verbal automaticity). Stanovich et. al.[13] reported that a child's ability to name a number seen becomes more automatic with age. These factors were first described in the Optometric literature by Richman et.al.[14] as potential confounders associated with the King Devick eye movement test. Scheiman et. al.[11] were the first to report the role this variable may play in accommodative facility testing. Scheiman et. al.[11] suspected automaticity as the influencing factor for the decreased performance observed during accommodative facility testing on children and indicated that further study was needed investigating its relationship to performance.

Since accommodative facility testing involves visual and cognitive demands, the visual-verbal automaticity factors must be considered when measuring accommodative facility if valid results are to be obtained. For example, the subject may have a low facility rate, but it may be due strictly to his/her ability to quickly process and verbally vocalize the letter/number and not due to his/her accommodative ability. "Automaticity or automatic processing implies the ability to carry out certain mental operations, such as number, letter or word naming without significant awareness or attention as compared to controlled, effortful processing which requires conscious attention to the task."[15] "The rapid, repetitive serial responses required by these tests are a direct measure of automaticity."[16] Fourth graders and older students may simply be better at these automaticity type tests due to maturation, or because they have had more exposure to numbers/letters than younger children.

Other researchers[5-10] may have consciously or unconsciously reduced the impact of automaticity factors by having the subject merely say "now" or "clear" without identifying the target stimuli. Thus the decreased visual/cognitive demand tradeoff with automaticity may have inadvertently introduced motivational variables. In this paradigm, a subject could say "now" or "clear" even if it wasn't because the subject is aware the examiner is unable to verify whether the response is correct. By responding in this manner, the subject can more easily "please the examiner" (ie: Halo Effect) during the lens rock trial. Argenbright & Beaudoin's[12] strategy for reducing the influence of this effect was to introduce a new target stimuli (ie: Modified Landolt C) which required a verbal response by the subject, and whereby accuracy could be monitored.

"Modified" Landolt C symbols were chosen as a target stimuli to reduce confounding variables inherent to letters or numbers which require symbolic letter/number fluency (ie: automaticity).[12] With letters or numbers, exposure history is a function of age or years in school. Keeping this in mind, some researchers, such as Scheiman et.al.,[11] attempted to minimize the effect of automaticity by eliminating numbers 2 & 5, and 6 & 9 which are easily confused. However, from the standpoint of optical and psycho-physiological factors the "Landolt C" target has been reported to be superior to either letters or numbers.[14,17] This is because the overall shape of the target provides much less information, thereby requiring more accurate and reliable accommodative posturing for resolution. More importantly, the Landolt C is equally familiar or unfamiliar to both younger and older children. Consequently, by using the Landolt C one is not inadvertently penalizing first graders or benefiting fourth graders for their letter/number fluency (automaticity). In addition, results obtained from Landolt C targets should allow for a more valid accommodative facility comparison between different age groups and allow one to tease out maturational and automaticity factors.

The reason that the targets are called "modified" Landolt C's is because the C's which open either to the right or left were eliminated. These were eliminated due to the fact that with typical "Landolt C" targets, there is a confounding variable related to laterality/directionality skills and concepts. The child who has difficulty discriminating whether the opening is to the right or left will be handicapped on a time-dependent test, and it is questionable as to whether a normal population of children in grade one are developmentally capable of rapid, reliable performance.[8] Yet, what about using the concepts of up and down in order to avoid directionality? According to Suchoff, the concept of "up and down" definitely evolves by the age of three years.[8,19] With this in mind these orientations were used by Argenbright and Beaudoin [12] with the options of left and right opening Landolt C's being substituted by a closed circle, and a circle with two openings both up and down. Hence, the modified Landolt C's consist of four distinct symbols: (1) opening oriented up, (2) down, (3) closed circle, and (4) two openings up and down.

The purpose of this study was to address the impact visual, motor and cognitive processing variables may have on limiting performance in children. To achieve this, Argenbright and Beaudoin's[12] targets and testing protocol were adopted for use in this study. Using this protocol, five test conditions/sub-tests were designed to isolate and factor out the various components of visual, motor and cognitive processing (automaticity). Table 2 shows the variables involved for each of the five test conditions.

Test condition one is cards only. This automaticity baseline measure represents the maximum speed at which the subject can take the information in visually, process it cognitively, and then vocally identify the target. In test conditions 2 and 3, a plano/plano lens flipper is incorporated. These two tests were designed to look at motor dexterity (ie: flipper turning) and the impact it may have on performance in children. When these are compared to test condition one, both demonstrate the impact the flipper has upon performance. When test conditions 2 and 3 are compared to each other they demonstrate whether or not who manipulates the flipper (examiner or subject) has an impact upon performance, and comparing results between grades demonstrates whether or not motor dexterity (flipper turning) is an issue in performance between first and fourth grade. Test conditions 4 and 5 were designed to evaluate the interrelationship between automaticity and motor dexterity at each grade level, as well as evaluating the effect the $\pm$2.00 D (4.00 D) change in the accommodative stimulus has upon performance, and whether or not this is the main limiting factor for accommodative facility testing in children. In other words, test conditions 4 and 5 look at the validity of the test. In addition these confirm conditions 2 and 3 regarding motor dexterity. By isolating these variables the tests allow one to identify and separate "true" primary accommodative infacility problems (poor accommodative focusing and response skills), from both primary automaticity deficits, and/or primary problems with gross/fine motor coordination. With such a differential diagnosis, appropriate optometric therapy can be recommended.

Table 2

Break down of components involved in each test condition using break down system analogous to Maddox's components of accommodation.

Test Condition	Components Involved (accommodative + cognitive + motor)				
1. Cards(ie: targets) Only	A_S - unchanged	+	visual-verbal processing		
2. Plano/plano flippers: Student flipping	A_S - unchanged	+	visual-verbal processing	+	motor (flipping of lenses)
3. Plano/plano flippers: Examiner flipping	A_S - unchanged	+	visual-verbal processing		
4. $\pm$ 2.00 D flippers: Student flipping	A_S - manipulated	+	visual-verbal processing	+	motor (flipping of lenses)
5. $\pm$ 2.00 D flippers: Examiner flipping	A_S - manipulated	+	visual-verbal processing		

A_S=Accommodative stimulus.

The following questions are to be addressed by this study: 1. Is the flipper a factor in performance? 2. Should the subject or the examiner turn the flipper during lens rock testing? 3. If having the subject turn the flipper influences performance, is it age dependent? 4. Is lens rock primarily measuring target naming speed with children or their relative accommodative response time? 5. Is relative accommodative response time the same with first and fourth graders? 6. Does our lens rock testing method (utilizing the modified Landolt C targets) have acceptable test/re-test reliability?

METHODS

Seventy one elementary school children participated in the study: twenty two first graders and forty nine fourth graders.* Subjects were recruited from a local elementary school in Forest Grove, Oregon. The school is located in a predominantly suburban, middle income socioeconomic area and was a participant in the Pacific University College of Optometry Vision Screening Program. Data was collected only from those students who had first passed the standard Pacific University College of Optometry Vision Screening Battery (see Appendix A).

Subject performance was evaluated on five separate accommodative facility test conditions. To better understand the factors involved in each of these test conditions, see table 2. These five test conditions were:

1. Cards(ie: targets) Only.
2. Plano/plano flippers: Student flipping.
3. Plano/plano flippers: Examiner flipping.
4. ± 2.00 D flippers: Student flipping.
5. ± 2.00 D flippers: Examiner flipping.

Although it has been demonstrated by previous investigations[11] that the order of the tests have no significant effect upon one another, administration was randomized in order to eliminate any preset influence. The randomization was such that one subject may have started with test condition 1, (ie: cards only), then proceeded to test conditions 2, 3, 4, and 5. Another subject may have started with test condition 2, and then proceeded to test conditions 4, 3, 5, and 1. Each subject had a probability of 1/625 of receiving the identical testing order as another subject.

Targets used in the five test conditions were the modified "Landolt C's" developed by Argenbright and Beaudoin.[12] The targets were loaned to the investigators for use in this study. These targets create a 20/40 visual acuity demand at 40 cm. Options of left Ɔ, and right C opening targets, were excluded in order to reduce subject laterality/directionality processing demand. Two novel modifications of the "Landolt C" were developed based upon the concepts of up and down in order to modify this unique target such that four options were available and include:

1. No opening(ie: ring or circle): O
2. A single opening facing up: U
3. A single opening facing down: ∩
4. Two openings - one up & one down: ( )

* **NOTE:** Data concerning numbers of male/female participants was not collected, nor considered significant by the investigators due to the fact that other researchers have found no statistically significant differences in gender performance.[10,12,20]

The targets were produced with the aid of a *MacIntosh(Plus)* computer using "FullPaint v1.0" software, and printed on an Apple Laserwriter. Targets were produced in pairs with the direction of the opening(s) randomly selected by the computer. The two modified "Landolt C" targets on each card were separated by 5.5 arc minutes to minimize the need for eye movements. "The reason two modified "Landolt C's" were presented on each card was to reduce from 1 in 4 to 1 in 16 the odds of correctly guessing the target during each" lens flip.[12] Finally, after the targets were printed, they were pasted to the center of a 4" x 5" card and then laminated for target/card protection.[12]

The flippers used in this study were similar to those available through the Bernell Corporation (ie: BC 4F). A total of six flippers were produced: three flippers of $\pm$ 2.00 D and three of plano/plano (ie: no power) power. Flipper powers were verified before use in the study using a Baush & Lomb Vertometer. All $\pm$ 2.00 D flippers were verified as $\pm$ 2.00 D in power. Plano/plano flippers were verified as + 0.12 D, and within ANSI Z80.1 standards. Although all four lenses in these flippers actually had + 0.12 D of power, there was no accommodative stimulus change from the top to the bottom of the flipper. Therefore, these flippers could be considered as being plano/plano for all practical testing purposes.

Before testing each subject was seated comfortably at the testing station on an adjustable back support stool so that the viewing distance could be maintained at 40 cm. Each subject was then asked to wear their habitual prescription for all of the test conditions. Illumination at the target plane was verified to be 100 foot candles, and this was maintained throughout the testing sequence. Illumination control was achieved through the use of an adjustable lamp with a 50 watt incandescent bulb in conjunction with standard room illumination to yield 100 foot candles at the target plane (measured with a GE Light Meter).

Testing began by first assessing suppression behaviors. This was accomplished by having the subject wear a pair of polaroid glasses and reading aloud letters (20/50 visual acuity demand at 40 cm) through a polaroid bar reader. The polaroid materials are of the type available through the Bernell Corporation (BC PG, and BC 1315). Subjects were instructed on how to properly hold the flipper in their preferred hand so the lenses could be quickly and easily flipped after calling out the target. Suppression was checked through both the + 2.00 D and - 2.00 D sides of the flipper. Any subject demonstrating suppression at this point was dismissed from the study and the examiners proceeded to the next participant. If no suppression was exhibited, the testing sequence continued with the instructional set.

The instructional set used was adopted from Argenbright and Beaudoin,[12] with one minor change. Rather than using four separate cards with a single enlarged (58 mm diameter) target per card, the authors used two (25 mm diameter) targets drawn on 4" x 5" cards (the same size as the actual test cards) with the same orientations as would be encountered during actual testing. Several different demonstration cards were presented to allow subjects a more realistic understanding of what was expected of them during the subsequent tests.

The instructional set was read aloud to each subject (see Appendix B for a copy of the instructional set). Instructions and demonstrations were repeated as necessary until the subject fully understood before any actual testing was done, or any data collected. Once the subject understood what was expected of him/her, the appropriate lens power (when applicable) was handed to the subject or other examiner. Testing followed the proper pre-assigned order. Before starting each test condition the examiner would encourage and remind the child to "Go as quickly as possible, trying not to make any mistakes. If you call out a target incorrectly do not go back and correct it, but proceed to the next target or card. Remember to flip the lenses (if applied to test condition), call out aloud the direction of both targets on each card when they are clear and single. Continue identifying targets until I tell you to stop." Testing continued for 60 seconds as timed with a stopwatch (Innovative Time Corporation, Model #L331B). At the end of the one minute test period the total number of cards presented was divided by two giving the cycles per minute. "This was recorded along with the total number of errors committed. An error was defined as an addition, omission, repetition, or incorrect response of the target orientation"[12] Any subject committing more than five errors on any condition was excluded from the final data analysis. This was done in order to be consistent with Argenbright and Beaudoin's[12] protocol.

When each subject completed all five test conditions they were again tested for suppression. Any participant demonstrating suppression at this time was omitted from the final data analysis. It has been shown that monitoring suppression during accommodative facility testing significantly slows performance.[4,6] Thus, the rationale for monitoring suppression before and after testing was to establish criteria under "realistic" (ie: real world) conditions with the premise that any individual exhibiting a suppression behavior, prior to or after testing will demonstrate that behavior during the suppression testing.

Upon completion of all data collection, all information was compiled, tabulated and statistically analyzed with the aid of a *MacIntosh SE 30* computer using the statistical software, Statview 512+. Analysis involved both One-Way and Two-Way analysis of variance (ANOVA) as well as unpaired t-Tests.

RESULTS

Of the 71 elementary school children who participated in this study, 12 first graders and 2 fourth graders were excluded from the final data analysis because they did not meet the inclusion criteria. Eleven out of the twelve excluded first graders committed more than 5 errors on one or more of the five test conditions. The other first grader was excluded for suppression. Two fourth graders who were excluded because they could not clear the -2.00 D lenses during either the ± 2.00 D examiner or ± 2.00 D student flipping test conditions.

Statistical analysis of the data involved one-way ANOVA-repeated measures, two-way ANOVA, and unpaired t-tests. The means and standard deviations in cycles per minute (cpm) for each grade (first N=10, fourth N=47), as well as each of the five test conditions is shown in table 3.

TABLE 3

Mean Cycles per Minute (cpm)

Test Condition	First Graders (N = 10) Mean cpm	First Graders (N = 10) SD	Fourth Graders (N = 47) Mean cpm	Fourth Graders (N = 47) SD
1. Cards (ie: targets) only.	7.00	±1.52	10.54	±1.69
2. Plano/plano flippers: student flipping.	5.60	±0.94	9.69	±2.12
3. Plano/plano flippers: examiner flipping.	5.55	±1.41	9.93	±1.73
4. ±2.00 D flippers: student flipping.	3.50	±1.33	7.37	±1.91
5. ±2.00 D flippers: examiner flipping.	3.20	±1.25	7.45	±2.48

To evaluate the impact the flipper has upon performance, a one-way ANOVA-repeated measures was used to compare condition 1 versus conditions 2 and 3. Results indicate the introduction of the flipper significantly decreased performance (post-hoc Fisher PLSD, $p \leq 0.05$) when comparing both test conditions against cards only. This was true for both grade levels. The Scheffe F-test, however, shows insignificant influence at the first grade when comparing both test conditions with cards only. At the fourth grade level the Scheffe F-test shows insignificant influence when comparing cards only versus plano/plano examiner flipping, but significance ($p \leq 0.05$) when comparing cards only versus plano/plano student flipping.

Further evaluation of the data using the same one-way ANOVA to determine if performance is influenced by who flips the lenses, and if so is it age dependent was done by comparing test conditions 2, 3, 4, and 5. Post-hoc testing utilizing the Fisher PLSD, Scheffe F-test, and the Dunnett t, show that at both grade levels there were no significant differences in mean performance when the examiner or the subject was manipulating the flipper. This was confirmed by a two-way ANOVA comparing who flipped versus flipper power. As expected there was a significant difference in performance between the $\pm$ 2.00 D and plano/plano conditions ($p \leq 0.0001$) at both grade levels. However, no significant differences ($p \leq 0.6$) in performance were found in either condition or either grade level between examiner or subject manipulating the flipper.

Evaluation of the impact the $\pm$ 2.00 D (4.00 D change in the accommodative stimulus) had upon performance was done using a one-way ANOVA-repeated measures by comparing all the possibilities of who flipped and lens power (test conditions 2, 3, 4, and 5). Since results were the same whether examiner or subject manipulated the flipper all could be compared as a check of internal reliability. Results demonstrate that accommodative response time, associated with a 4.00 D change in the accommodative stimulus, is the major limiting factor in performance at both grade levels (Scheffe F-test $p \leq 0.05$). However, visual-verbal (vocal articulation) automaticity factors also play a role in limiting performance of first and fourth graders during facility testing. Visual-verbal factors had less influence upon performance with fourth graders than with first graders. This was demonstrated in comparing the cards only test condition (maximum for automaticity) between the two grade levels using a 2-tailed unpaired t-test. The speed of the visual-verbal responses are significantly different between these two grades ($p \leq 0.0001$). In fact, comparisons of all five test conditions between grade levels is significant ($p \leq 0.0001$). These differences between grade levels can clearly be seen by comparing the means for each grade in table 3. This effect is also evident when looking at table 4 which shows the means and standard deviations of the data in units of time/response (ie: seconds per cycle).

Conversion of the resulting data into a unit of time as shown in table 4 was done to indirectly evaluate the relative amount of time spent during each cycle. If one assumes that at a given grade level both visual-verbal automaticity and motor influence are constants, then the values in table 4 for the $\pm$ 2.00 D flipper test conditions represent an indirect measurement of the relative accommodative response time. These values may represent the average amount of time a first or fourth grader spends accommodating and readjusting their posture to the 4.00 D change in the stimulus. In other words, these time values represent the time utilized by the accommodative/vergence systems in re-posturing to give a clear single image so the subject may identify the targets. Statistical analysis of this utilized a 2-tailed unpaired t-test with a significant difference between grade levels of $p \leq 0.0001$.

TABLE 4

Mean Seconds per Cycle (sec/c)

Test Condition		First Graders (N = 10) Mean sec/c	SD	Fourth Graders (N = 47) Mean sec/c	SD
1.	Cards (ie: targets) only.	9.03	±2.44	6.76	±1.10
2.	Plano/plano flippers: student flipping.	11.05	±2.35	7.00	±5.06*
3.	Plano/plano flippers: examiner flipping.	11.29	±2.68	6.22	±1.08
4.	±2.00 D flippers: student flipping.	18.81	±6.14	8.80	±2.77
5.	±2.00 D flippers: examiner flipping.	21.24	±8.06	9.24	±4.15

* The wide standard deviation is attributed to a single value for a fourth grader whose individual score, when converted to seconds/cycle, results in much more variability in the data than what would be expected as compared to when the performance is left in cycles/minute. This individual was included in the data analysis because the subject met our inclusion/exclusion criteria established before the study began. It should be noted however, when the data is analyzed all statistical data is at a probability level of $p < 0.001$ irregardless if the subject is included or excluded,s the only difference being the mean and standard deviation are much more consistent with what would be expected and are respectively 6.29 ±1.24 (N=46).

Reliability of the testing paradigm described was established by comparing the mean cycles per minute (cpm) and standard deviations (sd) for the first and fourth graders who participated in this study to those of Argenbright and Beaudoin's[12] study which was performed two years previously. Results of a 2-tailed unpaired t-test show that at the fourth grade level, this testing paradigm has excellent reliability. There were no significant differences between the means of the two studies at the fourth grade level. However, the mean performance of first graders in the present study was lower. Proportionally many more first graders were identified and excluded for target identification errors in this study. The means and standard deviations differed significantly at the first grade level ($p \leq 0.01$).

DISCUSSION

The five condition testing paradigm described here was designed to isolate several potential confounders limiting performance. These test conditions were designed to answer the following questions: 1. Is the flipper a factor in performance? 2. Should the subject or the examiner turn the flipper during lens rock testing? 3. If having the subject turn the flipper influences performance, is it age dependent? 4. Is lens rock primarily measuring target naming speed with children or their relative accommodative response time? 5. Is relative accommodative response time the same with first and fourth graders? and 6. Does our lens rock testing method (utilizing the modified Landolt C targets) have acceptable test/re-test reliability?

To answer these questions, we will be looking at the results in tables 3 and 4 vertically for each grade separately, and then go on to compare horizontally between grade levels. The reader is encouraged to refer to tables 2, 3, and 4, if necessary, as we will also be discussing what the results of each test condition is telling us regarding accommodative facility testing in school aged children.

The answer to the first question, "Is the flipper a factor in performance?," was obtained by comparing the cards only (maximum for visual-verbal automaticity) to the two test conditions where the plano/plano flipper was introduced. Recall that the second and third testing conditions were designed to evaluate the possible inter-relationship of visual-verbal automaticity and motor dexterity, as related to the introduction of the flipper alone with no accommodative stimulus change present. These were also designed to look at the effect this inter-relationship may have had upon accommodative facility performance in children. Comparing these test conditions (ie: condition 1 versus 2 and 3) shows that the flipper has an effect upon performance at both grade levels. Regardless, the authors maintain that "statistically" yes it can be shown the introduction of the flipper affects performance, but from a clinical point of view, that influence is insignificant. This to say the "true" significance is over shadowed by the fact that who manipulates the lenses, the subject or the examiner, was shown to be insignificant.

In other words, when we posed the second and third questions to statistical analysis; "Should the subject or the examiner turn the flipper during lens rock?," and "If having the subject turn the flipper influences performance, is it age dependent?;" it was shown that there was no significant difference in performance either when the examiner or the subject was manipulating the flipper. This was true for both the plano/plano and $\pm$ 2.00 D test conditions when comparing conditions 2, 3, 4, and 5 at each grade level, as well as between the two grades. Since it does not make a difference who manipulated the lenses, and it is not age dependent, then manual dexterity in flipping the lenses is not a issue in performance unless it is obvious that the child has some other type of gross/fine motor difficulties.

By answering the first three questions above, we have now raised two new questions: (1) "Why is there a difference in performance on the plano/plano test conditions when the flipper is introduced as compared to cards only?," and (2) "Why the difference in performance between grade levels?" Explanations for the first question are attributed to a combination of factors. These include the added factor of simply manually manipulating the flipper in general, the introduction of purely having the lenses (glass) in front of the eyes, or combination of the two may contribute to the lowered performance. Differences in performance between grade levels are not from motor dexterity introduced by the flipper. In comparing tables 3 and 4 for the first three test conditions only, it is obvious that performance is reduced proportionally the same (1-2 cpm or approximately 1-2 sec/c) for both grade levels when the flipper was introduced. Thus, since the decrease in performance was proportional at both grade levels and motor dexterity is not an issue, then the difference observed when comparing performance horizontally in tables 3 and 4 on the plano/plano test conditions may be attributed to just visual-verbal automaticity. This proportional difference in performance was observed on the cards only test condition as well.

Despite the fact that manual dexterity was shown not to be an issue, the authors recommend that in the clinical setting the subject be allowed to flip the lenses (turn the flipper) during accommodative facility testing. When manual dexterity is suspect with a child who has demonstrated gross/fine motor coordination problems, it is recommended the examiner do the flipping. Why is this advocated despite the fact that who flips is insignificant, and it is not age dependent. Simply, from a clinical point of view, as one looks at the means and standard deviations in tables 3 and 4, it becomes clear that the variability, as seen in the standard deviations, although not significant, is much less. The increased variability observed when the examiner is manipulating the flipper is attributed to the fact that the child does not have control over the instrument, and by having the examiner turn the lenses adds more variables. Those being the examiner may be inadvertently intimidating the subject by being so close and having control over the flipper, the examiner may not be turning the flipper with placement accuracy in front of the subjects eyes, or simply not turning the flipper at the exact moment when the subject is ready. All of these may contribute to the added variability as shown in the wider standard deviation observed during the examiner flipping test conditions. Thus, by having the subject manipulate the flipper as advocated, these variables are minimized. This should translate into a more consistent range of acceptable versus nonacceptable clinical performance.

The fourth question proposed by this study is: "Is lens rock primarily measuring target naming speed with children (ie: visual -verbal automaticity), or truly measuring what it has been designed to evaluate: relative accommodative response time?" In other words, is the test valid? This question was answered by test conditions four and five, which were designed to look at the inter-relationships of visual-verbal automaticity, manual dexterity, and the $\pm$ 2.00 D accommodative stimulus change. Again, manual dexterity was shown not to be an issue at either grade level. In fact, this confirmed the findings observed on the plano/plano test conditions, and demonstrated that both automaticity and motor dexterity are constants. Thus, if these constants are factored out, the resulting time values in table 4 show the average amount of time a first and fourth grader spend during each cycle in readjusting their accommodative posture. The results show that simply introducing the accommodative stimulus change significantly slows performance at each grade level. The average first grader utilizes approximately 8-10 seconds while the average fourth grader only 2-3 seconds to re-adjust their accommodative posture. Thus, accommodative facility is a valid test measuring what it has been designed to evaluate: relative accommodative response time.

This brings up question number five: "If this is a valid test, then is relative accommodative response time different between first and fourth graders?" Yes, because as stated above, the mean values for the two grades after factoring out the constants (automaticity and motor dexterity) are different. But is the observed decrease in time/cycle between the two grades related to visual-verbal automaticity factors, or is there a decrease in time/cycle due to the relative amount of time the accommodative system utilizes in re-adjusting the accommodative posture in order to provide a clear retinal image? In other words, is the difference due to automaticity, or does the speed of the fine sensory neuro-motor control over the human focusing system actually improve/develop with use/age?

It may be argued that automaticity is the main reason for the observed significant difference in performance, and not a decrease in relative accommodative response time. In fact, to some it might seem that the results of this factor analysis are artifacts of testing related to our inability to accurately measure response time, because accommodation was not directly measured, nor was monocular data collected for comparison. Granted, accommodative response time was not directly measured/assessed. To have objectively measured actual accommodative response times would have required equipment unavailable to the authors, such as an infrared or badal optometers. Such studies with these two age groups utilizing such instrumentation are encouraged as they might provide some definitive answers to whether the response time of the accommodative system may actually improve with age. Future studies may prove that the improved accommodative response time seen with the older children in this study is actually related to automaticity or other unspecified variables. Such studies may demonstrate that a combination of other factor(s) such as accommodation and convergence interactions may account for the observed improvement with age.

Yet, of these possibilities, is visual-verbal automaticity the only answer, or can the speed of the fine sensory neuro-motor control over the human focusing system actually improve/develop with use/age, much like overall development proceeding from acquiring general to specific skills? Is it not accepted by the optometric community that vision is a learned process involving both motor and sensory information integration and processing? Is it not true that there is an active transitional period between these two grades during which the child progresses from learning to read in first grade, to reading to learn in fourth grade? If we do a visual task analysis of first versus fourth grade, is it not true, that as a child progress through the educational system between these two grades, that there is also a gradual increase in the scholastic demands of children in order to be able to quickly and accurately shift their visual attentional demands between desk (near point) and chalkboard (infinity)? Moreover, do not such tasks indirectly relate to the type of visual skills being evaluated by lens rock testing along with other optometric tests such as distance rock? If this is plausible, then why can it not also be true for the speed of the fine sensory neuro-motor control over the human focusing system to actually improve/develop with age, much like overall development, and which accounts for the significant difference in the observed group performance.

Visual-verbal automaticity can not be overlooked however. Despite being a constant factor at each grade level, it is a factor when comparing performance between grade levels. Therefore, automaticity must be considered as a contributing variable attributed to the fact such studies as Scheiman et. al.,[11] Argenbright & Beaudoin,[12] and this one, all demonstrate an active transitional period between these two age groups on accommodative facility testing. This active transitional period is very evident in the box plots in figures 1 & 2. These two box plots demonstrate that these are two distinct groups. Because these are two distinct groups, previous researchers may have overlooked the a significant age dependent performance factor by grouping children together, and not considering the unique testing conditions under which these age groups may need to be tested.[9]

In any case, the answer to question number five lies within the fact that clinically both automaticity and relative accommodative response time both appear to improve with age. Moreover, by utilizing a testing protocol similar to the one used in this study the clinician can measure both automaticity (ie: cards only) and relative accommodative response time (ie: $\pm$ 2.00 D stimulus). With the results of these two tests, the practitioner can differentially diagnose the asthenopic patient as having a primary automaticity deficit, a primary accommodative infacility problem, or a combination of the two.

The answer to the final question proposed by this study: "Does our lens rock testing method (utilizing the modified Landolt C targets) have acceptable test/retest reliability?," was answered by comparing the performance of the first and fourth graders in this study to that of Argenbright and Beaudoin.[12] At first glance the two studies appear to differ with one another as mean performance at both grade levels appears to be significantly different. Yet, it should be noted that Argenbright and Beaudoin's[12] data was collected at four separate elementary schools, only one of which was utilized by this study. Argenbright and Beaudoin[12] found significant differences between the means of the four separate schools from which they gathered data. Consequently, the most valid comparison may be to only look at the results of the same school where the data was gathered in both studies.

Results of the comparison demonstrate that this testing paradigm, at the fourth grade level has excellent reliability. No significant differences were found between mean accommodative facility performance between the two studies which were performed by separate examiners at two separate periods in time. However, the mean performance of first graders in this study was significantly lower ($p \leq 0.01$), with proportionally many more first graders being identified and excluded for target identification errors.

Explanations for differences observed at the first grade level may be attributed to any one or more of the following: (1) One of the studies may of had a group of subjects who were "poorer"/"better" responders as a whole. (2) This study may have had better monitoring of each test subject's performance as two examiners worked closely with each subject. (3) Two examiners per subject, in this study may have had added a "distraction" or "intimidation" factor which may have altered subject performance compared to Argenbright and Beaudoin.[12] (4) Argenbright and Beaudoin[12] included other norming tests of vergence rock and distance rock in conjunction with the accommodative rock test. Despite test randomization they may have taxed the attentional demand of their first grade subjects. Nonetheless, the primary explanation for the observed differences is most likely a combination of the above. These, in conjunction with the smaller population of first graders in both studies, resulted in an inability to verify the reliability of this testing paradigm at the first grade level. Consequently reliability still needs to be established for this age group, and for this testing procedure utilizing a larger population of first graders.

Explanations for differences observed between the two studies concerning overall performance among the various schools from which Argenbright and Beaudoin[12] collected data include the following. First, the explanations given above for first graders, can also be applied to both grade levels as well as the various schools from which data was collected by Argenbright and Beaudoin.[12] Furthermore, there may be unaccounted factors not considered by them as to why they measured significant differences in performance between the schools from which they collected data. Secondly, despite both studies using the same protocol, it is not stated directly that the standardized instructional sets were read to each subject word for word in Argenbright and Beaudoin's[12] study. Add the fact that the schools from which Argenbright and Beaudoin[12] collected data had significant differences in performance, it seems highly likely, that Argenbright and Beaudoin's[12] mean values for all four schools have been artificially altered. This because of the off set introduced by the differences/factors described above, and a so called "practice" effect on the instructional presentation. Moreover, it becomes clear why differences appear between the two studies.

It is highly unlikely, in the view point of the authors, that the variable of suburban versus rural school had any effect upon the variable school performance observed by Argenbright and Beaudoin.[12] This is because cluster sampling, as done in both studies, is based upon the premise that any such given stratum or subgroup, such as an elementary school, is itself composed of all variables which may affect performance. These include such things as socioeconomic level, sex, age, etc. and would be represented.[20] Thus, urban versus rural schools can not be a factor influencing the variability observed as advocated by Argenbright and Beaudoin.[12] Also, considering the previously described considerations, differences, explanations, and subject totals, these as a whole, in any combination are the most likely reasons for differences observed between this study and Argenbright and Beaudoin.[12]

In spite of these differences, it should be pointed out that this testing paradigm, at the fourth grade level has excellent reliability. But because of the previously described differences found at the first grade level, reliability still needs to be established for this age group, and for this testing procedure utilizing a larger population.

Next, in comparing this study with that of Scheiman et. al.,[11] the only published study reporting on subjects of similar ages, the reader is first reminded of some major design differences. These must be considered before comparing the results of the two studies. These design differences may explain observed differences in mean values for accommodative facility performance in these age groups as found in each study. Experimental design differences include: (1) Scheiman et. al.[11] used continuous suppression monitoring where this study monitored suppression behaviors before and after testing. (2) Scheiman et. al.[11] did not subcategorize subjects who could not call off the targets even once through the plus or minus lenses, those who suppressed or reported diplopia. The results of these individuals were recorded as zero (0 cpm), and the values included in the final tabulation of the mean. Thus the reported values by Scheiman et. al.[11] may be biased (ie: artificially lowered). In this study such individuals were omitted as it was believed the validity of such subjects performance was questionable if they could not clear either set of lenses, suppressed, or reported diplopia. Such subjects may have manifested some type of general binocular dysfunction , accommodative spasm or insufficiency which prevented them from performing. Moreover, if ones goal to establish values for "expected" performance, the inclusion of these individuals in the final data analysis only biases the results towards artificially lower values. (3) Targets used in the two studies were entirely different. Scheiman et. al.[11] used combinations of three numbers (0, 3, 4, 7, and 8). Despite the fact that numbers 2, 5, 6, and 9 were omitted because they may be easily confused, the use of numbers in general may have inadvertently penalized most first, and some fourth graders on the basis of their number fluency. In this study any combination of two "modified" Landolt C targets were used, which are unique to each grade level, thereby not biasing the study by penalizing either age group. Consequently, Scheiman et. al.[11] values, may be artificially low. (4) Scheiman et. al.[11] used a back illuminated hand held instrument to present their target stimuli. The instrument presented the same three targets for which the role of potential memorization by the subject was not considered, and it was not mentioned if background illumination was standardized for contrast. In addition there were added variables related to steadiness of the target held in the hand of the examiner during target presentation and plus the fact that the targets were polarized may have contributed[4,6] to reduced performance. That leaves open to question Scheiman et. al.[11] mean values. In contrast, this study utilized fixed targets presented on a stable table top. These minimized the need for eye movements and the decreased possibility of target memorization. Other variables such as working distance and illumination were controlled.

With these differences in mind a direct comparison between Scheiman et. al.[11] and this study is at best speculative. However, in making a comparison, the importance lies within the difference between the values for each age group between the separate studies. Both show a significant difference between age groups. In addition, comparison of the results in this study with Scheiman et. al.[11] points out clearly that the validity of applying accepted adult norms of accommodative facility testing to children should be questioned.[11,12] Comparison also demonstrates "that the expected mean values used to diagnose accommodative dysfunction in children should be considerably lower."[11] There is an active transitional period going on between age groups as shown in the box plot figures 1 and 2. These figures also demonstrate the two populations represent two distinct groups.

FIGURE 1

Box Plot of Means and Standard Deviations from Table 3

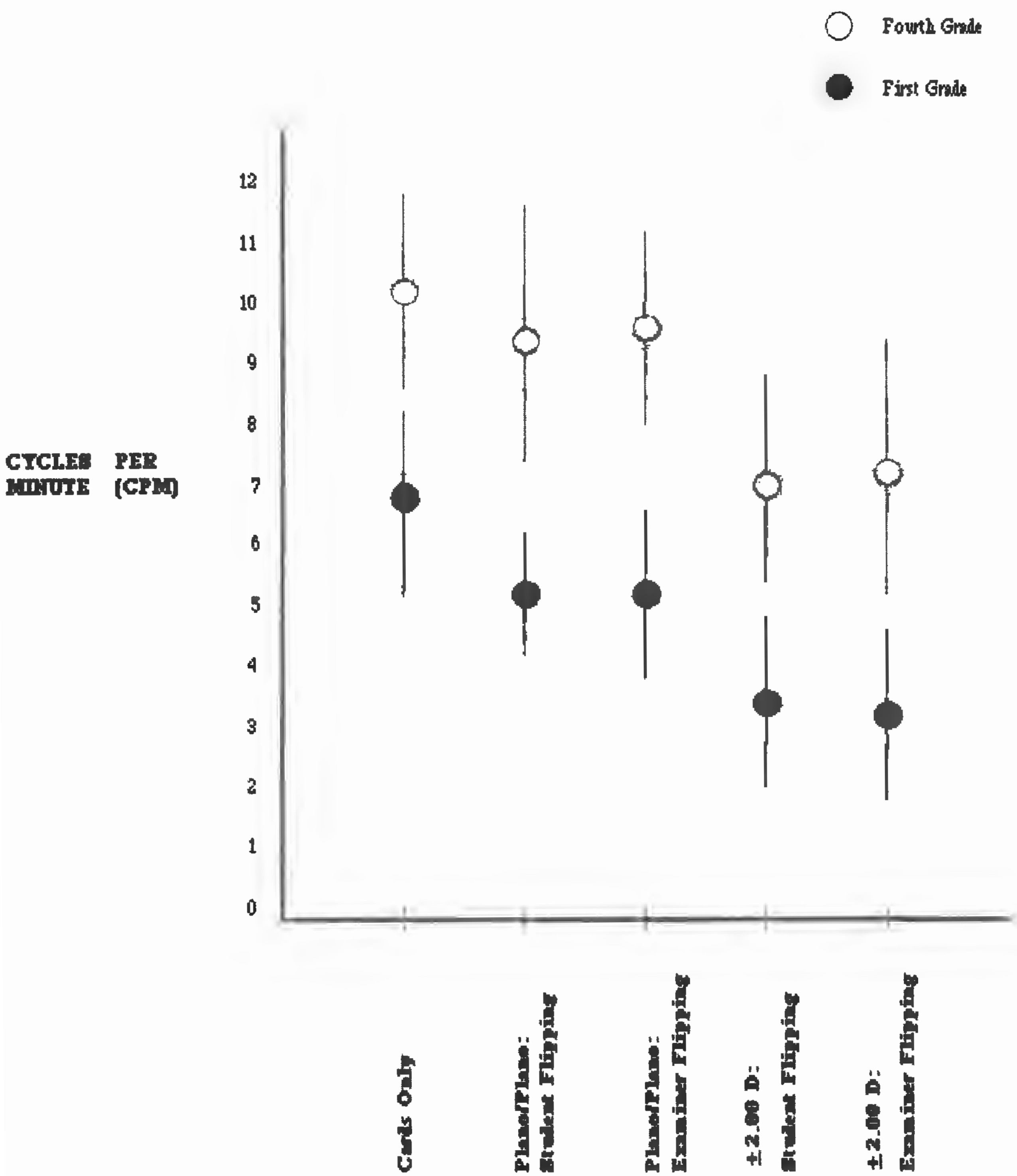
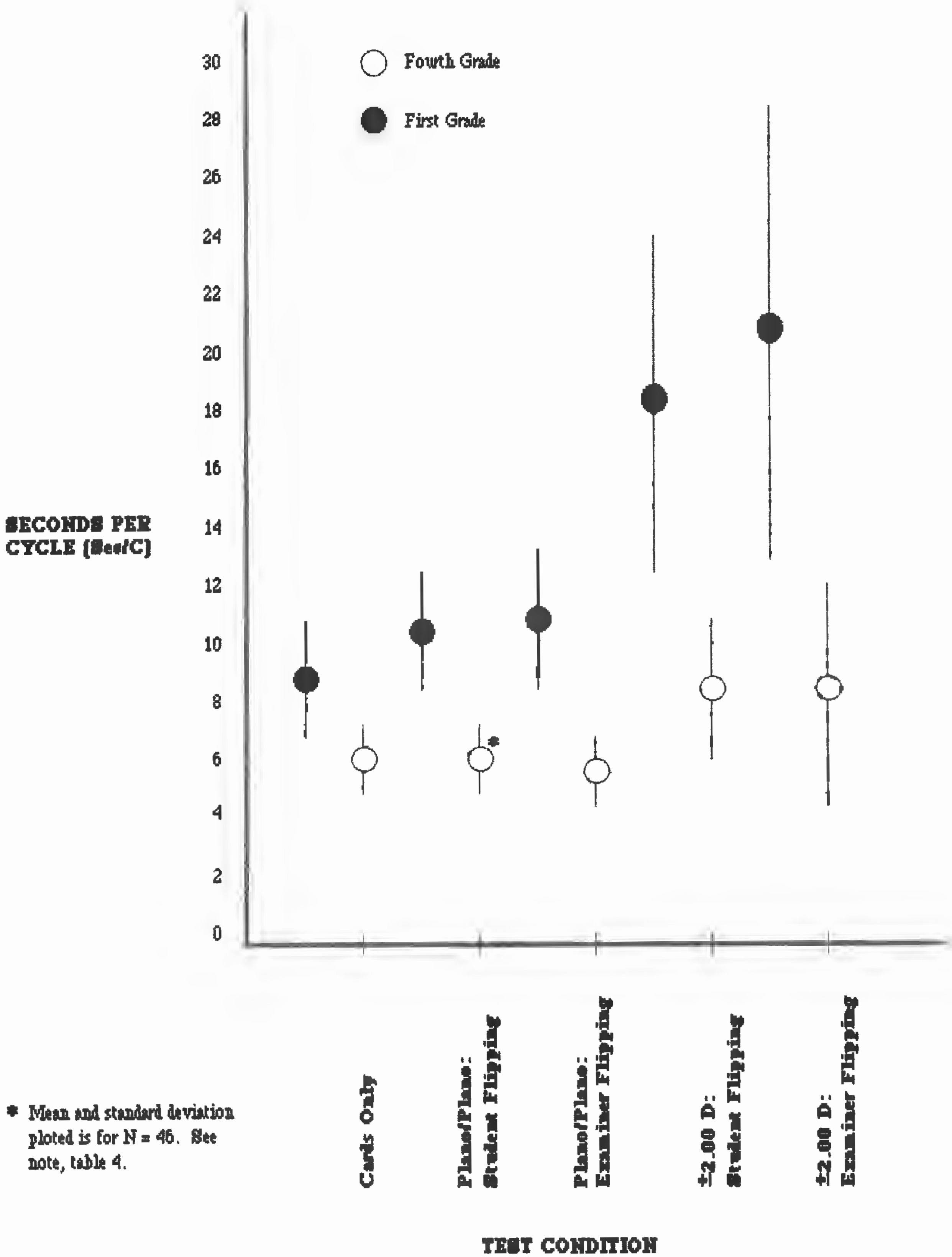


FIGURE 2

Box Plot of Means and Standard Deviations from Table 4



* Mean and standard deviation ploted is for N = 46. See note, table 4.

As found in this study automaticity and relative accommodative response time both play a role in facility testing with these age groups, and both skills appear to improve with age. Because of this the authors advocate the use of a cards only test be used in conjunction with the standard $\pm$ 2.00 D clinical testing protocol described here. More importantly, the use of a cards only and $\pm$ 2.00 D. flipper test would aid the clinician in differentially diagnosing the asthenopic patient as having a primary automaticity deficit, primary accommodative infacility problem, a combination of the two, and/or having some other general binocular dysfunction(s). Without this context the clinician may overlook significant factors inherent to the unique testing conditions which these age groups need to be tested.

CONCLUSIONS

This study raises some interesting and intriguing questions based upon the following conclusions: (1) Use of a flipper significantly ($p < 0.05$) slows performance at both the first and fourth grade levels. (2) There was no significant difference in performance either when the examiner or the subject was manipulating the flipper. This was valid for both our samples of first and fourth graders. Consequently, motor dexterity is not an issue in performance at either grade level. (3) Relative accommodative response time appears to play a major role in limiting performance of first and fourth graders during lens rock testing. However, visual-verbal factors also play a role in relative response times obtained during facility testing from these grade levels. Visual-verbal automaticity factors have less influence with fourth graders than first graders. (4) Through indirect assessment, relative accommodative response time appears to improve between first and fourth grade. (5) The accommodative facility testing paradigm described here has excellent reliability when testing fourth graders. There was no significant difference between the mean of this study and the original 1987 norming study using the same protocol. However, the mean performance of first graders in this study was lower. Proportionally many more first graders were identified and excluded for target identification errors in the current study.

The questions raised by these conclusions which need to be addressed in future research are: (1) If relative accommodative response time decreases between first and fourth grade, at what age does it plateau? (2) At what age do automaticity factors achieve minimum influence? (3) Is the influence of automaticity less when using modified Landolt C's versus letters or numbers with school children?

Clearly, more normative data from children is needed. Relative accommodative response time and visual verbal response time norms are needed for different age groups so both relative accommodative response time and automaticity can be separately assessed with each youngster. In addition further study with a larger population is needed in order to establish the reliability of this testing paradigm with first graders.

Some limitations of this study include: (1) Suppression was not monitored continuously throughout the testing. Despite the theory and rationale behind monitoring suppression before and after testing it would be useful to know if continuous suppression monitoring yields different results. (2) Monocular facility test results with these targets needs to be gathered for comparison to binocular findings. Monocular test results in accommodative facility testing would help the clinician in better identifying a true accommodative problem related to facility from a related convergence problem. (3) The small population of first graders. A larger population sample is needed to help establish the reliability of this testing protocol for this age group. (4) Results from this testing paradigm utilizing numbers and letters needs to be compared to results using modified Landolt C's. Direct comparison may answer the question whether these targets truly reduce the impact of age related number/letter fluency. (5) Accommodative response time was not be directly assessed. Instruments or methods to directly assess the response time of the accommodative system were not used to determine if the speed of the neuro-sensory motor control over the human focusing system actually improves with age. Such studies with these two age groups utilizing such instrumentation are encouraged as they might provide some definitive answers to whether the response time of the accommodative system may actually improve with age. Future studies may prove that the improved accommodative response time seen with the older children in this study is actually related to automaticity or other unspecified variables. Such studies may demonstrate that a combination of other factor(s) such as accommodation and convergence interactions may account for the observed improvement with age. However, it should be pointed out that such studies may be more academic or scientific in nature, rather than clinically useful. This is because such instrumentation is very bulky, expensive, and time consuming to use versus the standard clinical methodology of assessing relative accommodative response times with a $\pm$ 2.00 D flipper.

Despite these limitations, the results presented here appear to be in general agreement with previous studies utilizing similar testing protocol and targeting similar age groups. In each case, the data show that there is a very active transitional period of maturity and visual skill level occurring between these two age groups. It is during this period when children progress from "learning to read" to "reading to learn" when many of the common symptoms of general binocular dysfunction become manifest.[12] Consequently, because of this obvious transitional period, it is clear that the validity of directly applying adult normative data for accommodative facility testing to young children should be questioned.

Continuing research into this area should be directed into satisfying the limitations of this study as discussed above. More work is clearly needed in this area to satisfy the questions and considerations raised by this study in this particular area before any firm conclusions can be drawn. In addition, development of a standardized testing protocol and set of normative data for accommodative facility testing in children needs to be established. Current protocols may be overlooking the unique testing conditions under which the performance of these age groups may need to be evaluated on accommodative facility tests.

APPENDIX A

VISION SCREENING PROGRAM--CRITERIA FOR PASS/FAIL/REFERALL

A* VISUAL ACUITY (NEAR OR FAR)
  1. PRE-SCHOOLERS__________20/40 OR POORER, EITHER EYE
  2. OTHERS__________________20/40 OR POORER, EITHER EYE

B* REFRACTIVE ERROR
  1. HYPEROIA
    a. PRE-SCHOOL___________ +2.00 D OR MORE
    b. FIRST GRADE AND UP___+1.50 D OR MORE
  2. MYOPIA__________________-.75 D OR MORE WITH ACUITY LOSS.
  3. ASTIGMATISM_____________+/- 1.00D OR MORE
  4. ANISOMETROPIA__________+/-1.00 D OR MORE

C* TWO-EYED COORDINATION
  1. AT DISTANCE (20 FEET)
    a. TROPIA_________________ANY TROPIA
    b. ESOPHORIA_____________5^ OR MORE
    c. EXOPHORIA_____________5^ OR MORE
    d. HYPEROPIA_____________2^ OR MORE

D. OCULAR HEALTH._______________ ANY VERIFIED PATHOLOGY OR MEDICAL ANOMALY OF EYE AND/OR ADNEXA

E. OCULAR PRESSURE (IF TESTED).
  1. MEASURED IOP____________26 mm Hg OR GREATER
     (BORDERLINE IOP: 22-25 mm Hg)
  2. IOP RIGHT - IOP LEFT_______6 mm Hg OR GREATERDIFFERENCE

*CATEGORIES A,B,C TESTED WITH HABITUAL CORRECTIVE LENSES IN PLACE

APPENDIX B

INSTRUCTIONAL SET AS READ TO EVERY SUBJECT

1. "The purpose of the following test is to see how may targets you can correctly identify."

2. "I'm going to show you some enlarged examples of the targets which will be used in these tests."

3. "There are targets which may have gaps in them, or they may look like a "C" to you. Tell me which way the gaps or the opening seems to be pointing." **DEMONSTRATION:** The examiner now used the demonstration cards described earlier and pointed to each target, assisted the child in correctly identifying the target opening as "up," "down," "both" or "up and down," and "circle" or "ring." This continued until the subject completely understood the "correct" responses before the examination continued. **NOTE:** It should be pointed out that each child was allowed to use his/her preferred way of responding to the targets. For example, some would say "top" or "bottom" rather than "up" or "down," or some would say "zero," "O," or "none" for the target with no openings.

4. "After you have read aloud each of the two targets on the card to me, I will place a new card on the table with two new targets on it."

5. "In some of these test you will be holding one of the flippers, or the other examiner will be holding them for you. When looking through the lenses and the targets are clear and single, call out aloud the direction the gaps are pointing." **NOTE:** The examiner demonstrated to the subject how to hold and flip the lenses. Most subjects caught on very quickly as a result of being exposed to this during the suppression testing.

6. **DEMONSTRATION:** Each subject went through a practice run using the plano/plano flippers while calling out the orientations of the targets on the demonstration cards.

7. "Do you understand what we would like you to do?" (Instructions and demonstrations were repeated until the subject fully understood before any actual testing was done.)

8. "We are now going to begin the testing."

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