

Predicting Accommodative Insufficiency and Academic Problems Using the Conlon Visual Discomfort Survey

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ABSTRACT

Background: Identifying symptoms associated with near work is an essential part of diagnosing and treating non-strabismic binocular disorders. Several well-constructed surveys exist, but validity studies are lacking that can help define criteria for their use. In this paper, two validity studies are conducted using academic performance and accommodative function to define threshold criteria for the Conlon Visual Discomfort survey. The first study presented a new survey to assess academic problems. The second study measured accommodation insufficiency (AI). Data from both measures are correlated with Conlon survey scores to determine a Conlon cut-off value that is predictive of both AI and academic problems.

Method: In the first study, the Conlon survey and an Academic Problems Survey (APS) were administered to 68 college students and logistic regression was used to identify a threshold value for the Conlon that predicted academic problems. In the second study, accommodative lag data was objectively recorded for 23 college students using an autorefractor. A third of the students had weak accommodation, symptomatic

of AI. A logistic regression analysis determined a Conlon cut-off score that was predictive of AI.

Results: Rasch analysis showed the APS is reliable and unidimensional. The Conlon strongly correlated with the APS, accounting for 62% of variance in self-reported academic problems. A cut-off score of 28 or more was established as a good predictor for problems with grades, homework, and reading. A cut-off score of 27 or more was predictive of AI.

Conclusions: The Conlon survey is a useful tool to identify students with near work problems that negatively affect academic performance or are associated with AI. Further study is needed to determine if a cut-off score of 28 or more is robust with other populations such as younger children.

Keywords: accommodation, accommodative insufficiency, academic performance, visual discomfort, autorefractor

Introduction

Standardized symptom surveys are essential tools for the evaluation of non-strabismic binocular disorders. Identifying conditions such as convergence insufficiency (CI) or accommodation insufficiency (AI) usually start with patient complaints of visual discomfort while doing near work, and treatment success is evaluated by changes in these symptoms. Over the years, different surveys have been developed for this purpose.¹⁻⁴ Conlon's visual discomfort survey contains 23 items that cover a broad range of symptoms, including reading performance, glare, headaches and soreness, and perceptual distortions. The Convergence Insufficiency Treatment Trial (CITT) group developed a 13-item child³ and 15-item adult version⁴ of their Convergence Insufficiency Symptom Survey (CISS). The CISS asks questions

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about symptoms related to reading, including fatigue, headaches, reading performance, and perceptual distortions.

Both the Conlon and CISS have been found to have high reliability and internal consistency.^{2,4-6} Using a cut-off score of 16 or higher, the CISS has been shown to differentiate children with CI from those with normal binocular vision,^{5,7} and a score of 22 or higher differentiated between adults with CI from those with normal binocular vision.⁴

The Conlon survey has not yet been studied in selected groups of patients with CI or AI, but studies showed that Conlon symptom severity negatively correlated with reading rate and that as symptoms increased, performance suffered on tasks requiring rapid visual discrimination, such as the Digit-Symbol subtest from the Wechsler IQ test.² Recent studies also found AI to be prevalent among college students with high Conlon discomfort scores.⁸⁻⁹

In previous studies, students with high and low Conlon discomfort scores have been grouped using statistical distribution criteria.^{2,6,8-11} A high discomfort score has been defined as one standard deviation above the mean or a cut-off score of 24 or more.¹⁰ However, these criteria have yet to be validated with reference to other measures of oculomotor or near work function. In this study, we present a new academic performance survey designed to measure problems related to near work and examine Conlon survey responses to determine an empirical cut-off score that predicts academic problems. We also measured accommodative function with an autorefractor to identify students with AI and correlated AI status with Conlon scores.

Experiment 1 Methods

Students from the Claremont Colleges (Claremont McKenna, Harvey Mudd, Pitzer, Pomona, and Scripps) were randomly solicited to participate in this study by student research assistants in college dorms and dining commons. These colleges are highly selective small liberal arts institutions located adjacent to one another in Claremont, CA. Informed consent was obtained prior to survey completion, and study procedures were approved by the Claremont McKenna College Institutional Review Board that were consistent with the Helsinki Declaration. Subjects were not screened for visual anomalies or learning disabilities.

Subjects completed the Conlon Visual Discomfort Survey² and then a 10-item Academic Performance Survey (APS) developed for this study. The APS asked questions related to reading and study habits using a four-point rating scale. The APS was developed using a focus group of high symptomatic college students from the Claremont Colleges. A variety of questions were constructed in discussion with the student group. Questions were chosen to cover the variety of situations in which college students have problems performing their academic work due to their discomfort symptoms. Academic questions were worded to complement the Conlon survey; that is, subjects were asked about academic problems that were associated or caused by their visual discomfort symptoms. The list was then refined and reduced to the items on the APS. See Table 1 for further details.

In addition, an eleventh question was asked about the impact of these visual problems on course grades and used as an outcome measure in logistic regressions described below. This item was “Do you think these problems have affected your grade in some classes?” Students responded on the same four-point scale as the APS: 0=Never occurs; 1=Occasionally, couple of times a year; 2=Often, every few weeks; 3=Almost always. This question was constructed with feedback from the student focus group.

Results

Sixty-eight students completed both surveys. Subjects were between the ages of 18 and 22. No further identifying information about the students was available.

Conlon survey scores had a mean of 21.2 and a SD of 13.1. This result was higher than in previous studies of this student population that found a mean of 15.4 and standard deviation of 10.2.¹⁰ T-test comparisons between the two studies showed a significant difference between the samples ($t(77) = 3.55$, $p = .0007$), suggesting this sample had students with more severe symptoms than seen in our previous studies.

Academic Performance Survey (APS)

Descriptive results for the APS are presented in Table 1. On most of the items, 25-40% of the sample reported academic problems that occurred often or almost always.

Using the WinSteps 3.64.0 program,¹² a Rasch model was applied to the APS data to determine how

Table 1: Descriptive statistics for the Academic Problems Survey. Percentages refer to the proportion of subjects who endorsed the rating.

Question	Never Occurs	After an hour (1) of reading	After a half-hour (1/2) of reading	After 15 minutes of reading	Mean	SD
1. When these problems occur, how long have you been reading?	13.2%	48.5%	23.5%	14.7%	1.40	0.90
	Never Occurs	Occasionally, couple of times a year	Often, every few weeks	Almost always		
2. Do these problems interfere with taking a test under time pressure?	39.7%	27.9%	22.1%	10.3%	1.03	1.02
3. Do these problems interfere with doing homework?	35.3%	29.4%	17.6%	17.6%	1.18	1.11
4. Do these problems interfere with writing a paper?	42.6%	29.4%	17.6%	10.3%	0.96	1.01
5. Do these problems interfere with using a computer?	36.8%	32.4%	19.1%	11.8%	1.06	1.02
6. To cope with these problems, do you read for shorter periods of time?	33.8%	23.5%	25.0%	17.6%	1.26	1.11
7. To cope with these problems, do you ask others for help with homework?	83.8%	10.3%	4.4%	1.5%	0.24	0.60
8. To cope with these problems, do you avoid classes with a lot of reading?	66.2%	22.1%	5.9%	5.9%	0.51	0.86
9. To cope with these problems, do you spend more time than other students doing homework?	42.6%	20.6%	26.5%	10.3%	1.04	1.06
10. To cope with these problems, do you skip reading assignments?	51.5%	17.6%	23.5%	7.4%	0.87	1.02

well items fit a unidimensional scale. Fit statistics help to identify items or subjects that do not fit the Rasch model. In the latter case, a misfit subject may have symptom patterns that are unique from others in the sample or responded erratically. Two fit statistics are used – infit and outfit. Outfit measures are more sensitive to extreme scores. Expected fit values are 1.0, where scores above 1.0 indicate greater variance than predicted from the model and scores below 1.0 less variance. On average, both APS item fit (infit = 1.07, SD = 0.24; outfit = 0.96, SD = 0.17) and person fit statistics (infit = 1.02, SD = 0.54; outfit = 0.96, SD = 0.55) were close to the model’s prediction, suggesting the APS is unidimensional. A Cronbach alpha of 0.92 showed the internal consistency of the APS is high.

Adjusted for the sample size, items are considered to be misfits when the outfit statistic is above 1.24 or

below 0.76 or the infit statistic is above 1.73 or below 0.27.¹³ Based on these ranges, Item 25, testing under timed pressure, had a low outfit value, showing less variable responses than predicted. Item 24, time spent reading before symptomatic, had a high outfit value, suggesting more variable responses than predicted from the model. All of the items were in the acceptable infit statistical range. Table 2 presents the fit statistics for each item along with the Rasch logit measure for the item. This measure has a mean of 50 with 10 units per logit. The scale indicates the likelihood of an item being endorsed.

Item difficulty or the frequency of item endorsement is also listed in Table 2. In a Rasch model, the item frequency score is the point on the Rasch logit scale where the highest and lowest ratings have an equal probability of being endorsed. A lower score

means the item is more likely to be endorsed. The most commonly reported symptom (lower score logit score) was “when these problems occur, how long have you been reading?” The question “to cope with these problems, do you ask others for help with homework?” was infrequently endorsed (higher logit score).

To determine if the sample provides a broad distribution of scores, person and item separation scores were examined. Item separation was equal to 4.12 with a reliability coefficient of 0.94. Person separation was equal to 2.34 with reliability of 0.85, showing there were significantly broad distributions of responses.¹⁴

Table 2: Rasch Item Statistics. Rasch measures are on a logit scale with a mean of 50 and 10 units per logit. Higher logit values mean the item was less likely to be endorsed. Rasch fit statistics have an expected model value of 1.0. Higher values indicate greater response variance than predicted.

Question	Item	Rasch Measure	Infit Statistic	Outfit Statistic
When these problems occur, how long have you been reading?	Q1	39.20	1.12	1.30
Do these problems interfere with taking a test under time pressure?	Q2	47.05	0.68	0.65
Do these problems interfere with doing homework?	Q3	43.95	0.85	0.85
Do these problems interfere with writing a paper?	Q4	48.81	0.89	0.91
Do these problems interfere with using a computer?	Q5	46.35	0.99	1.01
To cope with these problems, do you read for shorter periods of time?	Q6	42.59	0.93	0.88
To cope with these problems, do you ask others for help with homework?	Q7	72.63	1.55	0.89
To cope with these problems, do you avoid classes with a lot of reading?	Q8	61.39	1.35	0.91
To cope with these problems, do you spend more time than other students doing homework?	Q9	47.05	1.11	1.15
To cope with these problems, do you skip reading assignments?	Q10	50.98	1.20	1.03

Correlation and Logistic Regression between Conlon and APS

A correlation between the Conlon and APS was significant ($r = 0.79$, $p < .0001$), accounting for 62% of the variance in academic performance. Figure 1 shows a scatter plot with the linear regression line between these two measures.

Logistic regressions were performed to determine cut-off scores on the Conlon survey that would predict academic problems. In this analysis, the Conlon scores were used as the independent variable and several different dependent variables were examined. For the logistic regression, student responses were sorted into two groups: responses of 0 or 1 were low impact, whereas responses of 2 or 3 were considered to have a high impact on grades.

A significant correlation was found between the Conlon score and grade impact. A logistic likelihood test produced a Chi-square = 28.93, $p < .0001$. Using a Conlon cut-off score of 28 or greater produced 75.0% sensitivity and 86.4% specificity with an overall classification accuracy of 82.4%. Sensitivity indicates the proportion of students with high symptom scores who also reported a high impact on their grades.

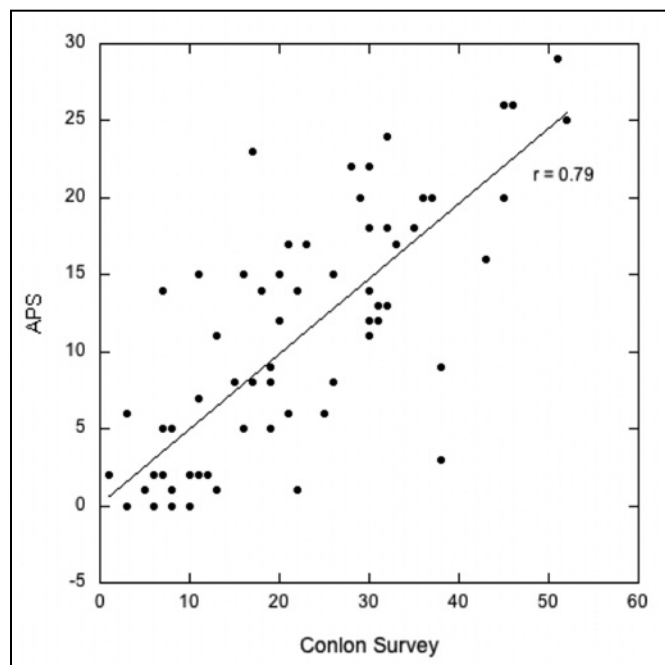


Figure 1: Scatter plot of total Conlon and APS scores with a regression line.

Specificity measures the proportion of students with low symptom scores who reported low grade impact.

For comparison purposes, two items from the APS were separately examined as dependent measures in logistic regression. These items relate to problem with homework (Q3) and time spent reading (Q6). Using the same criteria, item responses of 0 or 1 were grouped as low impact, and responses of 2 or 3 as high impact. Logistic likelihood tests produced a Chi-square = 29.20, $p < .0001$ for homework impact (Q3) and a Chi-square = 12.49, $p = .0004$ for reading time impact (Q6).

Conlon cut-off scores were the same as used for the grade impact item. For homework impact (Q3), logistic regression used a Conlon cut-off score of 28 or greater, producing sensitivity of 70.8%, specificity of 84.1% and overall accuracy of 79.4%. For reading time impact (Q6), a Conlon cut-off of 28 or greater was used to produce a sensitivity of 58.6%, specificity of 76.9%, and overall accuracy of 69.1%. These results suggest that students with Conlon scores of 28 or more are more likely to report problems related to homework and reading, and those with scores below the cut-off are less likely to do so.

Logistic Regression between APS and Grade Impact

To determine a cut-off threshold for the APS, a logistic regression was performed with the APS total score as the independent variable and the grade impact question as the dependent measure. The logistic likelihood test produced a Chi-square = 50.05, $p < .0001$. A cut-off score of 13 or greater on the APS predicted a negative impact on grades with 86.4% sensitivity and 75% specificity.

The APS cut-off score of 13 also predicted Conlon scores of 28 or more. A logistic regression produced a Chi-square = 30.03, $p < .0001$ with an overall prediction accuracy of 79.4%, sensitivity of 84.1% and specificity of 70.8%.

Experiment 2 Methods

Another sample of over 100 students from the Claremont Colleges were recruited for study to assess the relationship between AI and Conlon survey scores. Solicitation was randomly conducted by student research assistants in college dorms and dining commons. Students from Experiment 1 also were

invited to participate. Students were administered the Conlon Visual Discomfort Survey and APS at the time of recruitment.

To develop an experimental sample with a broad distribution of discomfort symptoms, subjects were randomly selected from the larger sample with the constraint that there were roughly equal numbers of students with high and low scores on the Conlon survey. Based on previous work,¹⁰ scores at or above 24 were considered high and scores below 24 as low. The experimental sample was screened for conditions other than AI or CI that might induce visual discomfort or interfere with reading. Testing occurred on two separate visits. Participants first received an optometric evaluation, and on another day completed accommodation testing with an autorefractor. Procedures for each of these visits is described below.

Exclusion criteria including reading disabilities, certain medical conditions (i.e., epilepsy, head trauma, migraines, MS, thyroid ophthalmopathy, myasthenia gravis, diabetes, Parkinson's disease), or taking medications that can affect accommodative function. All subjects also were screened for normal visual acuity at both near and distance (20/25 or better in each eye), had no strabismus, normal stereopsis (appreciation of random dot targets and stereoacuity of 70 seconds of arc or better), no significant uncorrected refractive error (myopia > 0.50 D, astigmatism and anisometropia > 1.00 D, and hyperopia > 1.50 D), no significant ocular pathology, and no color deficiency (pass the Ishihara test and the L'Anthony D-15 test).

On the first visit, students were screened using the exclusionary criteria, and then accommodation and vergence were assessed by one of the researchers (EB) using standard clinical procedures.¹⁵ EB was masked to the subject's score on the Conlon survey and used a standardized set of instructions during assessment. Vergence was evaluated with four tests: (1) a cover test at 3 meters and 40 cm with prism neutralization to assess phoria; (2) prism bar negative fusional vergence (NFV) and positive fusional vergence (PFV) at 40 cm; (3) near point of convergence using an Astron Rule with reduced Snellen letters (NPC); and (4) vergence facility (12 BO/3 BI). Accommodation was evaluated with four tests: (1) posture of accommodation using the monocular estimation method (MEM), (2) negative relative accommodation (NRA) and positive relative accommodation (PRA), (3) amplitude of accommodation (push up method), and (4)

monocular and binocular accommodative facility (AF) using ± 2.00 flippers at 40 cm. A mean of three measurements was used except for facility testing, cover test and MEM.

On the second visit, accommodative stimulus-response functions were measured using a Grand-Seiko WAM-5500 autorefractor. For accommodation measures, subjects sat in a darkened room for five minutes to minimize any residual accommodation transients before being tested in a well-lit room (85 cd/m² luminance for a white paper). Monocular recordings were made from the right eye with a patch worn over the left eye for the duration of the testing. Viewing distance was controlled with a chin and forehead rest. Spherical refraction was sampled five-times per second and continuous recordings were made for approximately two minutes.

Subjects fixated on a star symbol, two cm in height, and were instructed to keep the target in clear focus during the recording. Target luminance was 31 cd/m² with a Michelson contrast of 0.79. Targets were presented at five viewing distances in a fixed order: 300 cm, 50 cm, 33 cm, 25 cm, and 20 cm. Between each recording, subjects took a one-minute break to view the top line of a Snellen eye chart six meters away.

Results

Twenty-three students (7 male, 16 female) participated in this experiment, including five students from Experiment 1. The sample had a broad range of Conlon symptom scores, ranging from 3 – 51 with a mean of 20.4 and SD of 13.6. Ages of the group ranged from 18 – 22.

Autorefractor data was trimmed for outliers from eye blinks by eliminating data points 3 SD above or below the mean for each subject at each viewing distance. The average accommodation response was then calculated using the first 90 seconds of data to assure complete recordings for all subjects. Accommodation lag, the difference between the target distance and a subject's accommodative response, was calculated for each subject at the different viewing distances.

Accommodation lag data are shown in Figure 2. On average, subjects' lag for near targets stabilized in the 0.6 – 0.9 D range for near targets but with considerable variability. Accommodation is rarely perfect, and most individuals maintain a small lag with near targets. The range within which blur can be resolved is called the Depth of Focus. Estimates vary

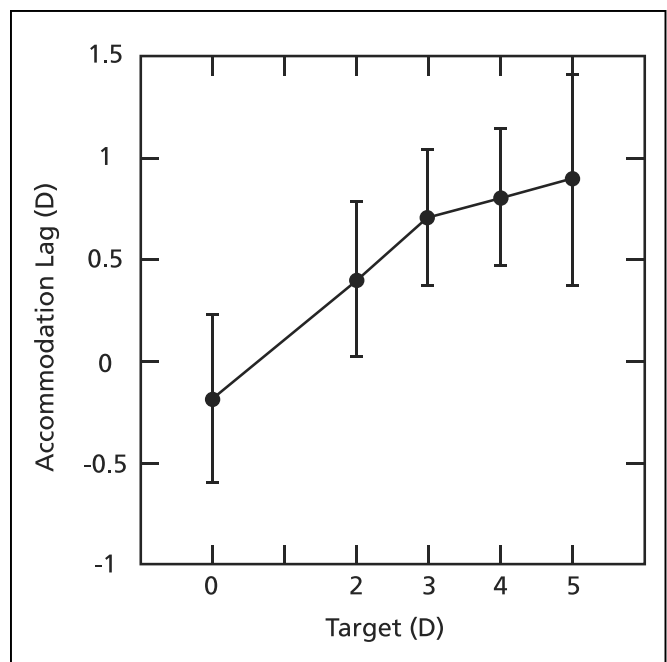


Figure 2: Accommodation lag at different viewing distances. Distance and lag are measured in diopters and error bars are SD.

between 0.5 - 1.5 D at the fovea with an average of about 0.6 – 0.8 D.¹⁶ The American Optometric Association reports that a lag of 1.0 D or greater at a normal nearwork distance is often associated with AI.¹⁷

AI is most commonly diagnosed by measuring accommodative amplitude using the push-up test or retinoscopy methods.¹⁵ However, recent studies^{8,18-20} have shown these testing procedures significantly overestimate accommodative function by as much as 2.0 D on average when compared to autorefraction.¹⁹ Therefore, in this study AI was defined as an average accommodative lag of 1.0 D or greater during the 90 sec autorefractor recording with the 5D target (20 cm), or an accommodative response that is 20% below the target demand. These AI criteria are well outside the Depth of Focus for most individuals, and the 5D target required sufficient accommodative effort to stress the system.

Eight out of 23 students (34.8%) were identified as suffering from AI. T-test comparisons between the AI and non-AI students showed significant group differences on dynamic accommodation measures (facility) but not on static accommodation measures (amplitude, MEM, NRA, PRA) or measures of vergence function (see Table 3). Optometric testing data was missing for one AI student.

A logistic regression was performed with the AI groups used as the dependent measure and students' Conlon score as the independent variable. The size of

Table 3: t-test comparisons between accommodative insufficiency (AI) and non-AI subjects on clinical optometric tests of accommodation and vergence. Groups were defined based on 90 sec autorefractor recordings made with a WAM-5500 using a 5 D target. AI subjects had an average 1.0 D accommodative lag or greater. PD=prism diopters, D=diopter, cpm=cycles per minute, XP=exophoria.

Test	AI Mean (SD) N=7	Non-AI Mean (SD) N=15	df	t-value	one-tailed p-value
Accommodation					
Amplitude (D)	10.2 (2.6)	10.4 (2.5)	20	0.13	0.45
Facility OD (cpm)	4.4 (4.6)	10.4 (4.9)	20	2.90	0.005
Facility OS (cpm)	5.9 (5.6)	11.8 (4.0)	20	2.86	0.005
Facility OU (cpm)	2.4 (3.0)	7.2 (5.5)	20	2.15	0.02
Facility scaled Amplitude (cpm)	7.5 (2.9)	11.8 (4.4)	20	2.34	0.02
Monocular Estimation Method Retinoscopy (D)	0.7 (0.4)	0.7 (0.5)	20	0.18	0.43
Negative Relative Accommodation (NRA) (D)	2.1 (0.5)	2.4 (0.4)	20	1.40	0.09
Positive Relative Accommodation (PRA) (D)	2.4 (1.5)	2.7 (1.2)	20	0.43	0.34
Vergence					
Heterophoria at far (PD)	0.9 XP (0.9)	1.5 XP (3.1)	20	0.50	0.31
Heterophoria at near (PD)	3.4 XP (1.5)	3.5 XP (4.5)	20	0.06	0.53
Near Point of Convergence Break (cm)	4.3 (3.5)	5.1 (2.4)	20	0.63	0.22
Positive Fusional Vergence Break (PD)	17.5 (11.2)	16.3 (7.9)	20	-0.31	0.38
Negative Fusional Vergence Break (PD)	12.5 (2.9)	13.5 (3.7)	20	0.65	0.26
Vergence Facility(cpm)	8.6 (5.3)	10.3 (4.3)	20	0.84	0.20
Fixation Disparity	0.6 (2.5)	0.7 (2.0)	20	.06	0.53

the accommodation lag at 5D was positively correlated with the Conlon score ($r = 0.47$, $p = .02$), accounting for 21.9% of the variance. A logistic likelihood test showed a significant correlation between AI status with a 5D target and Conlon scores (Chi-square = 11.06, $p = .0009$). A Conlon cut-off score of 27 or greater produced an overall classification accuracy of 78.3%, 75% sensitivity and 80% specificity; in other words, 75% of students with AI had a Conlon score of 27 or more, and 80% of students without AI had a score below 27.

For comparison, a second logistic regression analysis was conducted using accommodation responses with the 4D (25 cm) target. Adjusting for viewing

distance, subjects were identified as AI when their average response was 20% below the target demand during a 90 sec recording, or in this case a lag of 0.8 D or greater. These criteria were more stringent, identifying eleven out of 23 students (47.8%) as AI. A significant correlation was found between the 4D target lag and Conlon scores ($r = 0.41$, $p = .05$), accounting for 16.7% of the variance. A logistic likelihood test showed a significant correlation between AI status with the 4D target and Conlon scores (Chi-square = 6.16, $p = .01$). A Conlon cut-off score of 26 or greater produced overall classification accuracy of 69.6% with a sensitivity of 70.0% and specificity of 69.0%.

The 4D and 5D criteria both identified AI in six subjects with high Conlon scores (range 27 – 51) and two subjects with low Conlon scores (both with 17), but disagreed on three others. Two had low Conlon scores (7 and 8) but relatively high lags with the D4 target (0.82 and 0.94, respectively); the other subject

had a high Conlon score of 27 and an accommodative lag of 0.85 for both the D4 and D5 targets.

Discussion

This study provides evidence for the validity of using the Conlon survey to identify college students who may be at risk for academic problems or AI. Conlon scores accounted for 62% of the variance on the APS. Results from logistic regression analyses suggest that a Conlon cut-off score of 27-28 or more produces good sensitivity and specificity to identify students with academic difficulties or AI. This value is a few points higher than used in previous studies to group students on the basis of high and low discomfort

symptoms but is based on empirical evidence whereas the lower cut-off of 24 was statistically derived.

Specificity was higher than sensitivity on most measures, suggesting the Conlon survey was better at predicting true negative cases. For example, this pattern indicates that students who obtain low scores on the Conlon are less likely to have visually related academic problems, whereas those who score high on the Conlon may still perform well academically despite their discomfort symptoms.

In developing diagnostic criteria for AI, better sensitivity and specificity was found using a 1.0 D or greater lag with a 5D target. This viewing distance (20 cm) is closer than distances normally used to assess near work acuity (40 cm) but may be a good distance to assess accommodation dysfunction, particularly fatigue. A previous study⁹ showed that students with high visual discomfort maintained a normal accommodation response for 2D and 3D targets (33 - 50 cm) over a 90 sec time span. However, they showed fatigue with a 4D target (25 cm) and began to lag after 40-50 sec. A 5D target produced accommodation fatigue after 10-20 sec. These results suggest that with sufficient demand (4D or 5D), AI or accommodation fatigue may be apparent early in testing, but at greater viewing distances more prolonged near work (e.g., reading for 15 min or more), may be required before fatigue sets in.

Comparisons between the autorefraction and clinical measures of accommodation suggest that facility tests rather than amplitude can do a better job screening for AI. AI subjects were significantly weaker on dynamic measures of accommodation but not static ones.

There are several issues that limit the results of this study. First, the outcome measure of negative grade impact was based on self-report and could be biased. Future studies need to look at students' actual grades to obtain an independent outcome measure.

Second, in this small sample there were only a few students with AI. The sample was stratified by visual discomfort symptoms for the purpose of determining a cut-off score on the Conlon survey, and therefore this study could not assess the prevalence of AI in a college population. Further study of AI is needed that uses objective autorefraction methods to determine prevalence in a random sample.

Third, this study sample came from selective small liberal arts colleges that may not be representative of other populations. In previous studies, we found

that 17% of students from these colleges reported moderate to severe visual discomfort symptoms,¹⁰ but other researchers report much higher proportions in their university sample.² No studies have looked at the prevalence of visual discomfort in younger children with the Conlon survey. This study needs to be replicated with younger children and a larger and different college sample to determine if the APS survey is robust and if these cut-off scores need to be adjusted for different populations.

The Conlon survey would best be used as a screening tool for predicting AI since 25% of those who scored 27 or more were false positives (2 out of 8). A study with a larger sample of AI subjects is needed to provide a more robust measure of the Conlon's sensitivity. Precise determination of a cut-off score is difficult when the regression is based on only a few cases in the critical range. Nevertheless, based on these results we recommend that college students who score 27 or more on the Conlon survey be referred for a comprehensive vision examination that includes an evaluation of accommodation function.

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