

NORTHEASTERN STATE UNIVERSITY

COLLEGE OF OPTOMETRY'S OCULOMOTOR NORMS



- W.C. Maples, O.D.
- Jody Atchley, O.D.
- Tim Ficklin, Ph.D.

ABSTRACT

The NSUCO Oculomotor Test, which evaluates pursuits and saccades, is reviewed. This test has been previously reported to differentiate learning-disabled from normal and gifted children as well as above and below average readers. On each of these studies an arbitrary failure criteria was used. This study reports normative data for a large number of children of both sexes and of different ages. This data will enable the clinician to use age-appropriate behaviors for this test rather than depending on an arbitrary failure criteria.

KEY WORDS

oculomotor testing, pursuits, saccades, developmental norms, interrater reliability, head movement, body movement, learning disabled, gifted

T

Three distinct methods are employed by optometrists to test oculomotor function (pursuits and saccades)—electrodiagnostic, psychometric and traditional chair skill testing. Chair skill testing is used extensively, but until recently little has been done to standardize the test for pursuits or saccades and to develop acceptable norms.

A previous paper has reviewed different methods of evaluating oculomotor skills.¹ Variables which are at work in these test procedures and which might cause the data to be relatively unreliable between and within examiners were identified and discussed. Those variables can be seen in Table 1. Briefly, the clinician should be aware that any variation of these 10 items could cause measurement errors and reduce reliability.

The Northeastern State University

College of Optometry (NSUCO) Oculomotor Test has standardized procedures and scoring criteria.¹ (See Appendixes A and B.) Four areas of performance are graded in both the pursuit and saccade portions of the NSUCO Test. These areas are: 1. ability (sustaining power), 2. accuracy, 3. the degree of head movement the patient uses to perform the task and 4. the degree of body movement used. Consequently a total of eight areas of performance are evaluated, four areas for pursuits and four areas for saccades. The protocol rates each area from one to five, with five being optimal performance.

In the five of the eight areas (four areas x two tests [pursuits-saccades]) of performance, the scorer makes qualitative judgments. Thus, when evaluating, 1. saccade accuracy, 2. head movement during saccade, 3. body movement during saccade, 4. head movement during pursuit and, 5. body movement during pursuit

TABLE 1

IDENTIFIED VARIABLES OF REVIEWED OCULOMOTOR TESTS

1. POSTURE (Standing, Seated)
2. HEAD MOVEMENT (Instructions to the patient)
3. TARGET CHARACTERISTICS AND DIMENSIONS
4. MOVEMENT OF THE TARGET
 - A. Direction
 - B. Limits of excursion
5. TEST DISTANCE FROM PATIENT
6. OCULAR CONDITION (Monocular, Biocular, Binocular)
7. AGE OF THE PATIENT
8. INSTRUCTIONS
9. OBSERVATIONS
10. SCORING METHODS

testing, the tester must decide whether performance is grossly, moderately, or slightly less than optimal, or optimal. The score corresponding to that performance is noted, except for the "slight" category. If the test is judged to be slightly less than optimal, a further judgment must be made in terms of whether the behavioral characteristic is seen more than 50% of the time (scored as three) or less than 50% of the time (scored as four).

In the remaining three areas of performance the scorer makes quantitative judgments. For the ability aspect of saccades, the patient's performance is evaluated by counting the number of fixations during a total of five horizontal "round trips" between the targets as specified by the examiner's instructions. The ability aspect of pursuits is judged by counting the number of rotations during which the patient maintains accurate fixation on the specified target during a clockwise and then a counterclockwise rotation. The third quantitative aspect relates to pursuit accuracy. The number of re-fixations the patient makes during the pursuit portion of the test is counted and scored accordingly.

Inter-rater and intra-rater reliability tests were performed on the NSUCO Oculomotor Test.¹ Video tapes were made during the testing of 21 children. Twenty-four third year optometry student clinicians, who had been previously taught the test procedure, graded the behavior on two different occasions. *Exact* matching of the score was required for the scores to be considered in agreement. The first and second evaluations were one month apart.

All clinicians scored all the subjects by observing the video tape. Inter-rater reliability was calculated for each child and each clinician on all eight performance aspects of the NSUCO Oculomotor Test. These percentages were then averaged for clarity and brevity. The subsequent scores can be found in Table 2. *Average exact* agreement of the four aspects of the pursuit scores among 21 clinicians was found 73.5% of the time. *Average exact* agreement of scores on the four aspects of the saccade test was exhibited 75% of the time.

Intra-rater reliability scores were calculated by comparing individual clinician scores. The first score of each clinician was compared to that same clinician's second score for each child. This intra-

TABLE 2
INTER-OBSERVER AGREEMENT PERCENTAGE FOR EACH OBSERVATION ON THE NSUCO OCULOMOTOR TEST

Observations	Ability	Accuracy	Head Movement	Body Movement	Total
PURSUI TS	88.1	68.6	63.7	73.5	73.5
SACCADES	98.0	55.5	68.4	78.2	75.0

TABLE 3
PERCENT AND NUMBER OF SPECIAL CHILDREN WHO FAILED (SCORED THREE OR LESS) FOR VARIOUS ASPECTS OF SACCADE AND PURSUIT TESTS

	Ability		Accuracy		Head Movement		Body Movement	
	LD	G	LD	G	LD	G	LD	G
Saccades								
Percent	10.3	0.0	31.0	18.8	41.4	18.8	24.1	6.2
(Number)	(3)	(0)	(9)	(6)	(12)	(6)	(7)	(2)
P Value	* < .08		NS		* < .07		* < .06	
Pursuits								
Percent	6.9	3.1	75.9	68.7	39.5	15.6	34.5	6.2
(Number)	(2)	(1)	(22)	(22)	(13)	(5)	(10)	(2)
P Value	NS		NS		** < .015		** < .008	

LD = Learning Disabled, n = 29

G = Gifted, n = 32

NS = Not Significant

* = Approached significance

** = Statistically significant at the .05 level or better

rater reliability for exact scoring varied for pursuits from a low of 76% for head movement to 100% for body movement. Saccade testing was slightly lower than the pursuits varying from a low of 62% for accuracy to a high of 95% for body movement. The average intra-rater reliability for the four aspects of each test was 83% for saccades and 90% for pursuits.

Test retest reliability of the NSUCO Oculomotor Test was calculated.² A Wilcoxon signed-rank statistic which allows comparison between two samples, as well as the direction and magnitude of the change, was used. This test did not show significant improvement on retest except for saccade head movement. When compared to the King-Devick Test, in the same study, it was concluded that the NSUCO Test was less sensitive to learning since only the head movement on saccades appeared to improve significantly on retest.

Studies have been performed to investigate the construct validity of the NSUCO Oculomotor Test to academic performance.^{3,4} The first study,³ com-

pared normal, learning-disabled and gifted children to their scores on the NSUCO Oculomotor Test. A gifted child is defined by the Oklahoma State Department of Education as being one who demonstrates an unusually great potential in intellectual, creative thinking, leadership, visual and performing areas, and/or a specific ability aptitude. The learning-disabled child is defined as one who shows a disorder in one or more processes involved in understanding. Children who scored three or less on any of the eight subtests were compared. Although the difference between the number of gifted and learning-disabled children was statistically significant in only two tests, three approached significance. Gifted and normal children were found to be very similar. Table 3 demonstrates these differences between the gifted and learning-disabled group.

The second study⁴ used third-year optometric student clinicians as evaluators. The students had been instructed and evaluated on the NSUCO

TABLE 4
PERCENTAGES OF GOOD AND POOR READERS SCORING ONE, TWO, THREE (LOW) OR FOUR, FIVE (HIGH) ON THE NSUCO OCULOMOTOR TEST

(All are significantly different at the .05 level or better)

N = 38, 21 Poor Readers
 17 Good Readers

OCULOMOTOR CATEGORY	PURSUITS	
	GOOD READERS	POOR READERS
ABILITY		
LOW	0.2	11.9
HIGH	99.8	88.1
ACCURACY		
LOW	13.3	29.3
HIGH	86.7	70.7
HEAD MOVEMENT		
LOW	16.1	32.7
HIGH	83.9	67.3
BODY MOVEMENT		
LOW	8.6	13.7
HIGH	91.4	86.3
SACCADES		
ABILITY		
LOW	0.0	0.0
HIGH	100.0	100.0
ACCURACY		
LOW	12.0	29.5
HIGH	88.0	70.5
HEAD MOVEMENT		
LOW	19.0	43.4
HIGH	81.0	56.6
BODY MOVEMENT		
LOW	8.1	14.7
HIGH	91.9	85.3

method of testing and scoring. Video tapes were made of the oculomotor behavior of both good readers (average 1 year, 9 months above grade placement) and poor readers (average 1 year, 3 months below grade placement) in a third grade class, as determined by the Gates McGinitie or SRA Achievement Reading Test. The oculomotor skills of both groups were graded by the optometry students in this blind study. The study revealed that the failure rate of the poor readers on the NSUCO Oculomotor Test was significantly higher than for good readers. A failure score of three or less was again arbitrarily used in grading this test (see Table 4). The data for the second experiment, analyzed by two methods (Mann-Whitney U Test and Independent T Test), indicated that the two groups demonstrated significantly ($p < .05$) dif-

ferent performance on the NSUCO Test for this grade level. Even though the failure rates for the *ABILITY of SACCADE* was the same for the two groups, analysis was performed using the five-point scale. That accounts for the seemingly exact scores being statistically significant.

Logic would dictate that an arbitrarily set failure score is probably not the best method to determine adequate performance on this test. If the skills tested by the NSUCO Oculomotor Test are sensitive to maturation and learning, one would expect these failure scores to change in relationship to age and quite possibly to sex.

There are several ways to choose a failure criterion. Several behavioral tests which are in optometric use define one standard deviation below the mean as their failure point.^{5,6} Since the NSUCO Test deals with ordinal level data, criterion of

one standard deviation is not possible.

Stanines have been recommended as a method to judge such data.⁷ There is precedence in the optometric literature for such a method. Gesell⁸ considers the first time at least half of a sample of children demonstrate a particular behavior to be the normative for that particular performance item. The Denver Developmental Screening Test⁹ also sets percentage norms for behavior. Ames et al.¹⁰ consider the lowest 25% of a class of students as being seriously immature in the particular skills being considered. All of these methods utilize a smoothed percentage score in their calculation of a failure criterion. A smoothed percentage takes into account that for some ages there may be a slight regression in the percent of the subjects exhibiting a particular score. That regression is ignored and the curve is smoothed much as a "best fit" line might be constructed.

Consider the area under a normal or bell curve. The mean of the sample separates this curve into two equal halves. It is known that the interval from plus one to minus one standard deviations occupies just over 68% of the area under the curve (34% on each side of the mean). The portion of the curve outside this first standard deviation area is about 32%, or 16% on each side of one standard deviation. Considering only the low side of the curve (one-tailed), then 16% of the population would fall below one standard deviation below the mean, and 84% would fall above one standard deviation below the mean. This thinking forms the basis of interpreting data according to accumulative percentages and is the system we used in this study.

METHODS

NSUCO saccade and pursuit testing was performed on 1,714 children ages 5 to 14. The sample consisted of approximately equal numbers of boys ($N = 878$, 51%) and girls ($N = 836$, 49%). Table 5 shows the number of children in this study by age and sex.

The sample was primarily Caucasian (971) with the others being a mix of Caucasian and Native American, or full-blooded Native American. An earlier study¹¹ had demonstrated that there were no differences in the oculomotor scores between these three populations.

TABLE 5
SCHOOL POPULATION BY AGE AND SEX

Age	Percent Of Total Sample	Male	Female
5	5.3	44	47
6	9.9	81	88
7	12.3	104	107
8	11.9	119	85
9	13.5	111	121
10	14.0	122	118
11	14.5	134	115
12	10.2	90	84
13	5.8	56	43
≥14	2.6	17	28
		N = 878	N = 836

Data were gathered for this study as part of school screenings regularly administered by supervised optometry students of Northeastern State University College of Optometry. The screenings were performed in the individual schools as part of the NSUCO school screening program and involved three city elementary schools in Tahlequah, Oklahoma, as well as several rural schools surrounding the city. All schools included kindergarten through sixth grade. Some children in higher grades were available at the rural schools. The only criteria for inclusion in the screening was that the student be present the day testing was performed.

The data were organized into frequency distribution tables by sex and age. The frequency scores were converted into percentile scores. A normal distribution table was consulted.¹² Since only lowered behavior is of clinical concern for a failure criterion, the score representing the lower 16% is considered failing and a score falling within the upper 84% is considered passing. This criterion would work well if each of the scoring categories were cleanly demarcated at 16%. This was not the case with this data. Since ordinal data scores cannot be interpolated for the purposes of this paper, the passing category will be defined as the first score attained by 84% of the population. This necessarily will in most cases result in more than 84% of the population being included in the passing category and less than 16% being included among the failures. This fact then will tend to err on the side of passing. The scores which represent failure in any of the eight categories will tend to be true failures as defined by these failure criteria.

The clinician could consider the lower 31% of a classroom or of performance as the failure criteria as Solan and

Ficarra have done,¹³ or as Solan and Suchoff have suggested.¹⁴ This would define a failing performance as falling at or below 0.5 standard deviation below the mean. Minimal passing performance would then be defined as the first score attained by 69% of that population. The clinician would then be required to find the first column which contained the 69th cumulative percentage.

RESULTS

The results are summarized in Tables 6, 7, 8 and 9. Tables 6 through 9 show the cumulative percentages with pass and failure criteria for each age group and sex. Two numbers are found under each score for each area. The top number of the two represents the percentage of subjects at the indicated age earning that score for the particular test area. The bottom number represents the cumulative percentage beginning at the highest score (5) and continuing downward to the lowest score (1). The cumulative percentage numbers are used to decide the demarcation for pass and fail in each category.

The scores were smoothed. This involved a slight modification of the 13-year-old males *HEAD AND BODY MOVEMENT of PURSUIT* and the 7-year-old female *BODY MOVEMENT of SACCADE*. Otherwise a cumulative percentage of 84% or more of the sample was used as the critical score for each age. *This means that a score to the right of the bold line constitutes age-appropriate behavior while scores to left of the bold line represent a failure.*

Differences were found in the pass/fail scores between the sexes at several age levels on the various tasks. Separate tables for males and females

were therefore developed. Any score below 5 for the *ABILITY* portion of both *SACCADE* and *PURSUIT* tests was found to constitute failure for both boys and girls at every age, except for 5- and 6-year-old males in the *PURSUIT* test, where 4 or more passes.

The minimal *ACCURACY of PURSUIT* pass score was 2 for males aged 5 and 6. At age 7 years up through age 9 years, a score of at least 3 constitutes a pass. At age 10 years to 13 years, a score of at least 4 is acceptable and 5 is the passing score for boys at 14 years and above. Girls should score on *ACCURACY of PURSUIT* at least 3 from age 5 years through age 8 years; 4 is the minimal score from age 9 years and above.

ACCURACY of SACCADE is consistent for both sexes. A score of at least 3 should be considered acceptable throughout all ages and both sexes, except males 14 years and above (where 4 is the minimal passing score).

A minimal acceptable score for *HEAD MOVEMENT of PURSUITS* was found to be 2 for 5- and 6-year-old males. At age 7 years through 9 years, the minimal acceptable scores for boys is 3, and from age 10 years onward a score of at least 4 constitutes a pass. Female scores again are better by showing an acceptable score of 3 and above in this aspect from age 5 years through 9 years. At age 10 years and above the passing score is 4 or better.

HEAD MOVEMENT of SACCADES passing score for 5- and 6-year-old boys and 5-year-old girls is 2 or more. At age 7 years, 3 becomes the minimal acceptable score for males and never improves. Girls show a score of 3 or better from age 6 years through 9 years and from age 10 years onward, 4 or more is passing.

An acceptable performance on *BODY MOVEMENT of PURSUITS*, for males should be at least 3 from age 5 years through 7 years. From age 8 years through 11 years, a minimal passing score for a boy is 4, and above this age, a score of 5 passes. Girls exhibit an acceptable score of 4 for ages 5 years through 9 years, and from 10 years on, 5's are expected as passing scores in this category.

On *BODY MOVEMENT of SACCADES*, 3 is a minimal passing score for boys age 5 years through 7 years. From age 8 years through 12 years, it is a score of 4. For age 13 and above, a score less

TABLE 6
NSUCO PURSUIT TEST SCORES OF MALE SUBJECTS ARRANGED BY CUMULATIVE PERCENT

AGE	ABILITY					ACCURACY					HEAD MOVEMENT					BODY MOVEMENT				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
5	0 100	2 98	7 92	7 84	77 77	2 100	21 98	29 77	43 48	5 5	7 100	11 93	27 82	44 55	11 11	2 100	5 98	11 93	27 82	55 55
6	4 100	5 96	7 91	10 84	74 74	2 100	19 98	22 79	36 52	16 16	7 100	10 93	21 83	42 62	20 20	2 100	4 98	15 94	17 79	62 62
7	0 100	4 100	5 96	2 91	89 89	3 100	10 97	19 87	36 68	29 29	5 100	9 95	23 86	30 63	33 33	1 100	4 99	15 95	28 80	52 52
8	0 100	2 100	3 98	3 96	93 93	0 100	12 100	10 86	22 78	56 56	2 100	8 98	18 90	37 72	35 35	1 100	2 99	5 97	18 92	74 74
9	0 100	1 100	1 99	2 98	96 96	0 100	11 100	12 89	26 77	51 51	5 100	4 95	11 91	42 80	38 38	0 100	1 100	3 99	16 96	80 80
10	0 100	0 100	1 100	1 99	98 98	0 100	5 100	8 95	38 87	49 49	0 100	5 100	10 95	37 85	48 48	0 100	0 100	5 100	15 95	80 80
11	0 100	0 100	0 100	1 100	99 99	1 100	2 99	7 97	34 90	56 56	0 100	4 100	11 96	30 85	55 55	0 100	1 100	2 99	16 97	81 81
12	0 100	0 100	0 100	1 100	99 99	0 100	3 100	4 97	38 93	55 55	0 100	2 100	12 98	43 86	43 43	0 100	0 100	5 100	8 95	87 87
13	0 100	2 100	5 98	5 93	88 88	0 100	5 100	0 95	16 86	70 70	2 100	7 98	12 91	36 79	43 43	0 100	0 100	7 100	11 93	82 82
>14	0 100	0 100	0 100	6 100	94 94	0 100	5 100	0 95	6 95	89 89	0 100	0 100	6 100	44 94	50 50	0 100	0 100	0 100	0 100	100 100

TABLE 7
NSUCO PURSUIT TEST SCORES OF FEMALE SUBJECTS ARRANGED BY CUMULATIVE PERCENT

AGE	ABILITY					ACCURACY					HEAD MOVEMENT					BODY MOVEMENT				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
5	0 100	4 100	4 96	4 92	88 88	0 100	10 100	25 90	52 65	13 13	2 100	2 98	19 96	48 77	29 29	0 100	2 100	6 98	19 92	73 73
6	0 100	3 100	4 97	8 93	85 85	0 100	10 100	10 90	41 72	31 31	2 100	5 98	30 93	39 73	34 34	0 100	2 100	10 98	27 88	61 61
7	0 100	0 100	0 100	99 3	96 96	0 100	8 100	11 92	34 81	47 47	0 100	5 98	24 93	33 69	36 36	1 100	2 99	14 98	15 84	69 69
8	0 100	0 100	0 100	97 3	84 84	3 100	4 97	16 93	36 77	41 41	2 100	4 98	16 94	43 78	35 35	0 100	0 100	8 100	20 92	72 72
9	0 100	0 100	0 100	2 100	98 98	0 100	7 100	9 93	24 84	60 60	0 100	2 100	15 98	33 83	50 50	1 100	1 99	3 98	19 95	76 76
10	0 100	0 100	1 100	1 99	98 98	0 100	4 100	9 96	23 87	64 64	1 100	4 99	7 95	35 88	53 53	0 100	1 100	3 99	8 96	88 88
11	0 100	1 100	1 99	1 98	97 97	0 100	4 100	9 96	30 87	57 57	1 100	2 99	4 97	23 88	65 65	0 100	2 100	1 98	13 97	84 84
12	0 100	0 100	0 100	0 100	100 100	0 100	5 100	3 95	17 92	75 75	0 100	4 100	2 96	37 94	57 57	0 100	0 100	1 100	7 99	92 92
13	0 100	0 100	0 100	0 100	100 100	0 100	2 100	7 98	21 91	70 70	0 100	0 100	7 100	36 93	37 37	0 100	0 100	5 100	11 95	84 84
>14	0 100	3 100	0 97	4 97	93 93	0 100	4 100	3 96	11 93	82 82	0 100	4 100	10 96	32 86	54 54	0 100	3 100	0 97	4 97	93 93

TABLE 8
NSUCO SACCADDE TEST SCORES OF MALE SUBJECTS ARRANGED BY CUMULATIVE PERCENT

AGE	ABILITY					ACCURACY					HEAD MOVEMENT					BODY MOVEMENT				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
5	2	3	4	7	84	2	3	12	47	14	11	12	31	31	5	2	98	19	31	46
	100	98	95	91	84	100	98	93	61	14	100	89	77	36	5	100	98	96	77	46
6	0	2	8	6	84	0	10	32	46	12	5	17	27	30	21	1	6	15	24	54
	100	100	98	90	84	100	100	90	58	12	100	95	78	51	21	100	98	93	78	54
7	0	0	7	5	88	0	4	30	35	31	8	7	27	35	23	1	4	17	21	55
	100	100	100	93	88	100	100	96	66	31	100	92	85	58	23	100	99	95	78	55
8	0	2	2	2	94	100	3	23	50	24	5	9	18	41	27	1	1	5	21	72
	100	100	98	96	94	100	100	97	74	24	100	95	86	68	27	100	99	98	93	72
9	0	0	1	8	91	0	1	27	37	35	3	6	21	42	28	0	0	5	20	75
	100	100	100	99	91	100	100	99	72	35	100	97	91	70	28	100	100	100	95	75
10	0	0	1	4	94	1	4	21	38	37	2	7	18	35	38	0	0	7	21	72
	100	100	99	98	94	100	99	96	75	37	100	98	91	73	38	100	100	100	93	72
11	0	1	1	1	97	0	3	16	46	35	0	6	12	36	46	100	1	3	17	79
	100	100	99	98	97	100	100	97	81	35	100	100	94	82	46	100	100	99	96	79
12	0	0	0	1	99	0	3	18	46	33	1	4	17	38	40	0	0	6	14	80
	100	100	100	100	99	100	100	97	79	33	100	99	95	78	40	100	100	100	94	80
13	0	2	2	7	89	2	2	23	35	38	2	4	21	35	38	0	0	2	12	86
	100	100	98	96	89	100	98	96	73	38	100	98	94	73	38	100	100	100	98	86
>=14	0	0	0	6	94	0	0	12	53	35	6	6	6	53	29	0	0	0	0	94
	100	100	100	100	94	100	100	100	88	35	100	94	88	82	29	100	100	100	100	94

TABLE 9
NSUCO SACCADDE TEST SCORES OF FEMALE SUBJECTS ARRANGED BY CUMULATIVE PERCENT

AGE	ABILITY					ACCURACY					HEAD MOVEMENT					BODY MOVEMENT				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
5	0	4	2	9	85	2	2	13	62	21	11	6	11	44	28	2	0	9	10	79
	100	100	96	94	85	100	98	96	83	21	100	89	83	72	28	100	98	98	89	79
6	0	1	5	5	89	1	10	23	20	46	7	2	34	35	32	1	3	8	27	61
	100	100	99	94	89	100	99	89	66	46	100	93	91	67	32	100	99	96	86	61
7	0	0	3	4	93	0	5	28	36	31	1	9	35	27	38	0	2	18	17	63
	100	100	100	97	93	100	100	95	67	31	100	99	90	65	38	100	100	98	80	63
8	0	1	2	3	94	0	3	22	47	28	4	3	25	34	34	0	1	13	19	67
	100	100	98	97	94	100	100	97	75	28	100	96	93	68	34	100	100	99	86	67
9	0	0	6	4	90	1	1	15	51	32	2	5	14	41	33	0	1	5	24	70
	100	100	100	94	90	100	99	98	83	32	100	98	93	74	33	100	100	99	94	70
10	0	0	2	2	96	0	3	16	36	45	1	4	10	32	53	0	1	4	9	86
	100	100	100	98	96	100	100	97	81	45	100	99	95	85	53	100	100	99	95	86
11	0	0	1	1	98	1	2	14	35	48	0	2	7	27	64	0	1	1	8	90
	100	100	100	99	98	100	99	97	83	48	100	100	98	91	64	100	100	99	98	90
12	0	0	0	1	99	0	0	19	36	45	0	2	4	33	61	0	0	1	5	94
	100	100	100	100	99	100	100	100	81	45	100	100	98	94	61	100	100	100	99	94
13	0	0	0	0	100	0	4	26	35	37	0	2	7	54	37	0	0	2	12	86
	100	100	100	100	100	100	100	98	72	37	100	100	98	91	37	100	100	100	98	86
>=14	0	0	0	4	96	0	4	14	36	46	0	3	4	33	50	0	0	0	4	96
	100	100	100	100	96	100	100	96	82	46	100	100	97	93	50	100	100	100	100	96

than 5 fails for boys. Girls require a score of at least 4 to be acceptable from ages 5 years through 9 years, and from 10 years and above, 5 constitutes a pass. Tables 10 and 11 collapse Tables 6-9 into minimal acceptable scores for each specific age and gender.

DISCUSSION AND CONCLUSIONS

A clear developmental trend is seen in virtually all of the performance aspects of the NSUCO Oculomotor Test. Girls show better scores earlier than boys and, therefore, show a developmental lead over boys in these oculomotor skills. Boys do, however, appear generally to catch up after age 9.

This method of defining a pass/fail, using the concept of cumulative percentages on the NSUCO Oculomotor Test, is more valid than the random assignment of the score of 3. One can easily note that for some aspects (Tables 10 and 11), 3 is a more stringent failure criterion, while for other areas, a score of 3 is too lenient.

With the exception of 5- and 6-year-old boys, all children should be expected to obtain the maximum score of 5 in the *ABILITY of PURSUITS and SACCADES*. Since the *ABILITY* portion can be hypothesized as being a barometer of the child's attention skills, a score less than 5 would appear to indicate a real problem in attention.

ACCURACY of SACCADES for both sexes never varies from the minimal pass score of 3 (except boys age 14 and above, where a score of at least 4 is acceptable). Since this is the only place where boys lead girls, this is probably an artifact and not a true difference in the performance between sexes. *ACCURACY of PURSUITS* is more variable in the younger children. However, the minimal passing score becomes 4 for all children age 10 and above.

Male *HEAD MOVEMENT of SACCADES* scores generally lag those of girls. It appears normal for males to have slight intermittent head movement on saccades after age 6, while this is normal behavior with girls only until age 9. After that age, no head movement should be expected from girls.

HEAD MOVEMENT of PURSUITS follows the same trend seen between the sexes. Boys start lower (2 is acceptable for 5- and 6-year-olds), but catch girls at 7

TABLE 10
NSUCO PURSUIT TEST MINIMAL ACCEPTABLE SCORE BY AGE AND SEX

AGE	ABILITY		ACCURACY		HEAD MOVEMENT		BODY MOVEMENT	
	M	F	M	F	M	F	M	F
5	4	5	2	3	2	3	3	4
6	4	5	2	3	2	3	3	4
7	5	5	3	3	3	3	3	4
8	5	5	3	3	3	3	4	4
9	5	5	3	4	3	3	4	4
10	5	5	4	4	4	4	4	5
11	5	5	4	4	4	4	4	5
12	5	5	4	4	4	4	5	5
13	5	5	5	4	4	4	5	5
≥14	5	5	5	4	4	4	5	5

TABLE 11
NSUCO SACCADE TEST MINIMAL ACCEPTABLE SCORE BY AGE AND SEX

AGE	ABILITY		ACCURACY		HEAD MOVEMENT		BODY MOVEMENT	
	M	F	M	F	M	F	M	F
5	5	5	3	3	2	2	3	4
6	5	5	3	3	2	3	3	4
7	5	5	3	3	3	3	3	4
8	5	5	3	3	3	3	4	4
9	5	5	3	3	3	3	4	4
10	5	5	3	3	3	4	4	4
11	5	5	3	3	3	4	4	5
12	5	5	3	3	3	4	4	5
13	5	5	3	3	3	4	5	5
≥14	5	5	4	3	3	4	5	5

years and the two sex's scores are identical from there. Female *BODY MOVEMENT of SACCADES and PURSUITS* are identical to one another, but boys again show a lag, reaching optimum performance only later and generally lagging the girls by at least two years in reaching this optimum performance.

If the clinician uses the NSUCO Oculomotor Test to evaluate oculomotor skills, he should be aware that there are these differences between sex and age and employ the developmental tables presented here (Tables 6-9) to evaluate NSUCO Oculomotor performance.

A reasonable failure criterion is at the 84th cumulative percentile and future research should apply these failure criteria to ascertain if this more specific benchmark is more helpful in identifying children with learning problems who are also found to exhibit oculomotor dysfunction by the NSUCO Oculomotor Test.

If one wishes to use another failure

criterion (lower 30% of a sample), this is possible by simply referencing Tables 6 - 9 to discover the appropriate score for each of these eight factors.

APPENDIX A STANDARD SET OF THE NSUCO OCULOMOTOR TEST

1. Posture:
Standing, with feet shoulder width apart, directly in front of the examiner
2. Head:
No instructions are given to the patient to move or not to move his head
3. Target characteristics:
Small (approximately 1/2 cm. in diameter) colored reflective spheres (balls) mounted on dowel sticks. One target is used for pursuits, two for saccades. For those unwilling or unable to be tested with the colored ball targets (red and green), substitute different colored Disney targets* (clowns) on pencils (one for pursuits, two for saccades).

4. Movement of the target:
 - A. Directional:
 - a. Saccades are performed in the horizontal meridian only
 - b. Pursuits are performed rotationally, both clockwise and counterclockwise
 - B. Extent:
 - a. Saccade extent should be at approximately 10 cm. on each side of the patient's midline (20 cm. total)
 - b. Pursuit path should be approximately 20 cm. in diameter. The upper and lower extent of the circular path should coincide with the patient's midline
5. Test distance from the patient: No more than 40 cm. and no less than the Harmon distance, i.e., the distance from the subject's middle knuckle to his elbow
6. Ocular condition: Binocular only
7. Age of the patient: 5 years to adult
8. Instructions:
 - A. Saccades: "When I say red, look at the red ball (clown). When I say green, look at the green ball (clown). Remember, don't look until I tell you to."
 - B. Pursuits: "Watch the ball (clown) as it goes around. Try to see yourself in the ball (watch the clown's eyes). Don't ever take your eyes off the ball."

* Disney targets (Pen-Pal Fixators) available from Bernell Company, 750 Lincolnway East, PO 4637, South Bend, Ind. 46634.

**APPENDIX B
NSUCO METHOD OF SCORING
SACCADES AND PURSUITS
ABILITY**

(Can the patient keep his attention under control to complete five round trips for saccades and two clockwise and then two counterclockwise rotations for pursuits?)

SACCADES

1. Completes less than two round trips
2. Completes two round trips
3. Completes three round trips
4. Completes four round trips
5. Completes five round trips

PURSUIITS

1. Cannot complete 1/2 rotation in either the clockwise or counterclockwise direction
2. Completes 1/2 rotation in either direction
3. Completes one rotation in either direction but not two rotations
4. Completes two rotations in one direction but less than two rotations in the other direction
5. Completes two rotations in each direction

ACCURACY

Both Pursuits and Saccades are graded alike

(Can the patient accurately and consistently fixate so that no noticeable correction is needed in the case of saccades, or track the target so that no noticeable re-fixation is needed when doing pursuits?)

SACCADES

1. Large over- or undershooting is noted one or more times
2. Moderate over- or undershooting noted one or more times
3. Constant slight over- or undershooting noted (greater than 50% of the time)
4. Intermittent slight over- or undershooting noted (less than 50% of the time)
5. No over- or undershooting noted

PURSUIITS

1. No attempt to follow the target or requires greater than 10 re-fixations
2. Re-fixations five to 10 times
3. Re-fixations three or four times
4. Re-fixation two times or less
5. No re-fixations

HEAD AND BODY MOVEMENT

(Can the patient accomplish the saccade or pursuit test without moving his head or body? Both saccade and pursuit scoring use the same criteria for this aspect of the testing.)

1. Large movement of the head (body) at any time
2. Moderate movement of the head (body) at any time
3. Slight movement of the head (body) (greater than 50% of the time)
4. Slight movement of the head (body) (less than 50% of the time)
5. No movement of the head (body)

References

1. Maples WC, Ficklin TW. Inter-rater and test-retest reliability of pursuits and saccades. *J Am Optom Assoc*, 1988, 59: 549-52.
2. Maples WC, Ficklin TW. Test retest reliability of the King-Devick saccade and the NSUCO oculomotor tests. *Behavioural Optom (Australia)*, Aug, 1991: 209-14.
3. Maples WC, Ficklin TW. A preliminary study of the oculomotor skills of learning-disabled, gifted and normal children. *J Optom Vis Devel*, 1989, 20: 9-14.
4. Maples WC, Ficklin TW. Comparison of eye movement skills between above average and below average readers. *J Behav Optom*, 1990, 1: 87-91.
5. King AT, Devick S. The proposed King and Devick test and its relation to the Pierce saccade test and reading levels. Independent student research study, Illinois College of Optometry, Chicago, Ill., 1976.
6. Groffman S. Groffman's visual tracing forms and age norms. (Available from Vision-Extension, 2912 So. Daimler, Santa Ana, Calif 91705), 1967.
7. Groffman S. Optometric utilization of objective, standardized perceptual tests. *Am J Optom Physio Opt*, 1971, 48: 825-33.
8. Gesell A, Ilg FL, Bullis GE, Ilg V, Getman GN. *Vision: its development in infant and child*. New York: Harper, 1949.
9. Frankenburg WK, Dobbs JB. *Denver Developmental Screening Test*. (Available from University of Colorado Medical Center, Denver, Colo.), 1969.
10. Ames LB, Gillespie C, Streff JW. *Stop school failure*. New York, Harper and Row, 1972.
11. Maples WC. NSUCO oculomotor norms. Mid-America Vision Conference. (Available from Caryl Croisant, 2796 S. Main, Lebanon, OR 97355).
12. Dixon WJ, Massey FJ. *Introduction to statistical analysis*, 4th edition. New York: McGraw-Hill, 1983.
13. Solan HA, Ficarra AP. A study of perceptual and verbal skills of disabled readers in grades 4, 5, and 6. *J Am Optom Assoc*, 1990, 61: 628-34.
14. Solan HA, Suchoff IB. *Tests and measurements for the behavioral optometrist*. *Optom Extension Prog*, Santa Ana, Calif., 1991.

Corresponding author:

W.C. Maples, O.D.
Northeastern State University
College of Optometry
Tahlequah, OK74464

Date accepted for publication:
August 15, 1992