

NORMS & TEST-RETEST RELIABILITY of THE DAVIS SCAN TEST

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Abstract

The goal of the Davis Visual Scan Test (DST) is to provide a quick and inexpensive evaluation of a person's visual scanning behavior.

In the present study, the DST was administered three times on two separate days, to children from first grade to sixth grade (ages 6 to 13). The testing days were two weeks apart. The object of the study was to investigate: the test-retest reliability of the DST; whether there were performance developmental trends; and the relation of DST scores to reading performance.

Test-retest reliability was poor; scores generally increased significantly with each of the three administrations on both testing occasions, and overall, from the first to the second test day. Scan patterns were analyzed and found not to differ between gender, grades or ages. Mean performance scores by grade and age were not found to be predictive of standardized reading scores. The presence of a robust learning curve in the DST makes it unlikely that this test could be used with any confidence on elementary school children.

Key Words

Davis Scan Test, developmental norms, reading performance, saccades, test-retest reliability, visual scan, visual search

INTRODUCTION

Visual search allows one to find an object of interest within the visual environment. During visual search a number of processes take place to direct the eyes to a target. These processes require an intact oculomotor system and a visual space sense or internal map, to make decisions about the direction and amplitude of a saccade. Once fixated, the object of regard can be analyzed /synthesized for information.¹⁻²³

Numerous studies concerning visual scanning have been published.^{1-19,24-29}

These studies emphasize the importance of oculomotor function in gathering information in external visual space. The most basic of all visual motor function in the search process is the fixation. When two fixations are combined, a saccade results. Saccades are eye movements that rapidly change gaze position from one region in the visual field to another. Saccadic behavior is believed to be an essential factor in a person's reading ability and indeed, all visual information processing.^{3-12,24,25}

In the process of making a saccade, there are three sequential questions:

1. What am I seeing at the moment?
2. Where must I move next to continue my search (direction and magnitude)?
3. When must I begin my move?¹⁵

The "what am I seeing at this moment?" is object identification during a fixation. "Where must I move next?" is based on information peripheral to the area of fixation. The "when must I begin my move?" question includes how long a fixation should last and when the next saccade should be made. Visual scanning of the environment is indeed an important as-

pect of visual information gathering and information processing.^{9, 11, 30-34}

A visual scan test was proposed by Dr. Morton Davis in 1972 and has become known as the Davis Visual Scan Test (DST).^{b,35} It was pragmatically developed and based on clinical observations, but was not standardized. Maples et al proposed a standard method of presentation and scoring protocol.³⁶ They administered the test to 68 optometry students. The DST consists of an 8.5' by 11' sheet of paper with 435 letters, numbers and symbols. The 56 types of letters, numbers and symbols are randomly arranged on the sheet, and within the test there are 66 imbedded zeros (O's). See Appendix A. The testing was administered in the Maples et al study under normal classroom lighting.³⁶ Their adult optometry student subjects were required to circle as many O's as possible in one minute, without picking up their pens. This resulted in a visual trace, or scan pattern.

The purpose of the current study was to use a sample of elementary school students to investigate: the test-retest reliability of the DST, whether the DST varied by gender, age and grade (developmental trends), and the relationship of the DST to reading performance.

PROCEDURES

Permission was obtained from the Keys elementary school, in Keys, Oklahoma to approach their students to participate in this study. This is a county school that serves a suburban area of Tahlequah and Cherokee County, Oklahoma. The school consistently scores average or above average on standardized academic tests. Permission was also obtained from the Northeastern State University, Oklahoma's human experimentation advisory committee to conduct the study.

Permission was also requested from each student (assent) and their parent/guardian (consent). These assent and consent forms were given to 114 candidates from Grade 1 thru Grade 6. Parents or guardians of 65 students gave consent (57%). Each of the 65 children also agreed to participate. Before the DST was administered, a visual screening was performed by the first author. The screening test consisted of near point evaluations of visual acuity, stereopsis and phoria. Criteria for participating in this study were: visual acuity of at least 20/30 with each eye, at least 50 arcsec of stereo with the Wirt Circles,^a and near phoria measures from 2 eso to 8 exo (near Howell Card^b). Four students who failed the screening test were excluded from the study.

The following instructions were given to the subjects before administering the test: *Before you is a sheet of paper. On the other side of the sheet there are letters, numbers and symbols. (tester holds sheet up to class) When I say go, turn your sheet over and circle the first "O" that you see, and then without picking up your pencil, draw a line to the next "O" you see and circle it. Continue drawing lines and circling all of the "O's" you see on the paper until you are told to stop. Are there any questions?*

The procedure was then illustrated on the chalkboard. The time given to complete the test was 1 minute. None of the individual teachers observed the testing.

The DST was administered on two separate days that were two weeks apart. During each day, the test was administered three consecutive times, approximately five minutes between administrations. All testing was done in group settings and under usual classroom lighting conditions. Subjects were seated at their desks. The number of O's were counted and recorded for each subject after each test administration.

SUBJECTS

The initial pool consisted of 31 girls and 29 boys. Table 1 gives the distribution by age, and Table 2 by grade. Four of the students were absent on the first or second occasion and one student was absent for both test periods. The total number of subjects tested on the initial administration (T1) was 58, and was 57 on the retest (T2). Fifty-five students performed the DST on both test days. The performances of only these students were used in our calculations.

Table 1.
Means and Standard Deviations on Test (T1) and Retest (T2) scores for DST by Age

N	Age	T1		N	Age	T2		Significance p =
		Mean	Standard Deviation			Mean	Standard Deviation	
2	6	22.3	0.9	2	6	26.2	1.2	*
12	7	26.2	9.2	11	7	31.8	10.6	.002
11	8	26.0	4.5	10	8	29.1	3.8	.055**
11	9	34.8	8.9	11	9	40.4	9.0	.003
6	10	33.6	11.3	7	10	42.5	8.6	.006
8	11	34.0	8.2	8	11	43.5	11.4	.009
5	12	32.3	6.7	5	12	41.6	9.8	.003
3	13	31.6	3.3	3	13	46.1	7.4	.05

* Signifies inadequate number of subjects to calculate significance
** Not statistically significant

Table 2
Means and Standard Deviations on Test (T1) and Retest (T2) scores by Grade

N	Grade	T1		N	Grade	T2		Significance p =
		Mean	Standard Deviation			Mean	Standard Deviation	
13	1	24.3	7.4	13	1	30.4	9.3	<.001
12	2	27.4	6.4	10	2	29.8	5.7	.092*
8	3	30.8	6.1	8	3	37.1	6.8	.019
9	4	42.2	8.1	10	4	47.3	8.8	<.001
8	5	28.2	5.8	8	5	38.5	7.9	.004
8	6	32.7	4.9	8	6	44.9	9.7	.001

* Not statistically significant

RESULTS

The range of performance for the number of circled O's was from 8 to 63 on T1 and from 11 to 63 on T2. There was no significant difference in DST scores between genders within the six tests by age and grade.

Overall Performance by Age

Table 1 presents the average means and standard deviations by age for T1 and T2 scores. The general trend was for the T1 mean score to increase until age 10, at which point it stabilized. The T2 mean score generally continued to increase from age 6 to age 13. Figure 1 graphically depicts these trends. The T2 scores were significantly higher than the T1 scores, except for the 8 year-old group, where it did approach statistical significance.

Overall Performance by Grade

The data in Table 2 indicates that the T1 mean score increased until the fourth

grade, after which it decreased. The same trend was followed for the T2 mean score. See Figure 2. Except for the 2nd grade group, the mean T2 score was significantly higher than the T1 score.

Comparison of T1 and T2 Scores

We performed a statistical analysis of the change in performance between the consecutive three scores of T1 and the consecutive three scores of T2. Table 3 shows that except for the improvement between test 4 and 5 in the T2 sequence, all other improvements were significantly different.

Performance Comparison for Yearly Age Increments

Table 4 shows the results of multiple t tests comparing scores by age. The only significant increase in performance occurred between the 8 year old and 9 year old groups (p=.004).

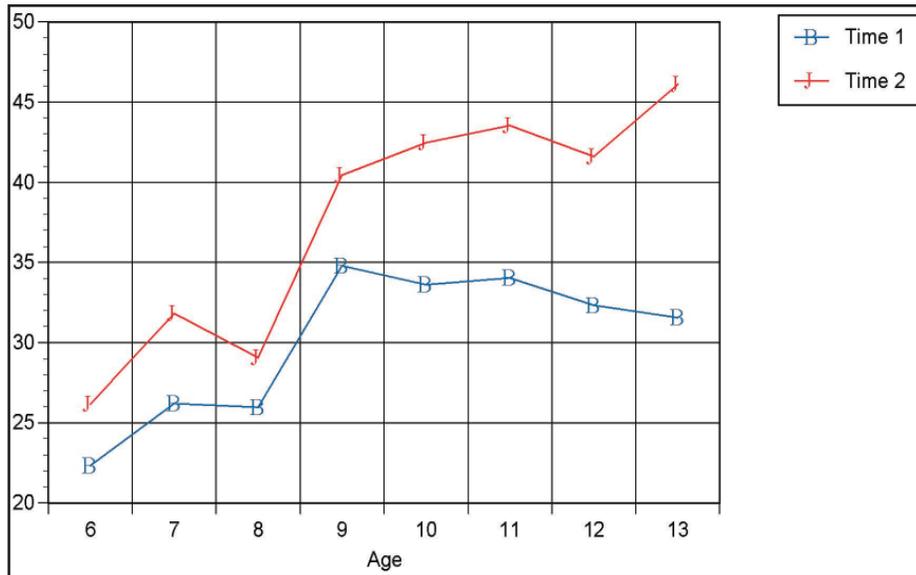


Figure 1. Means for Test and Retest of the DST by Age

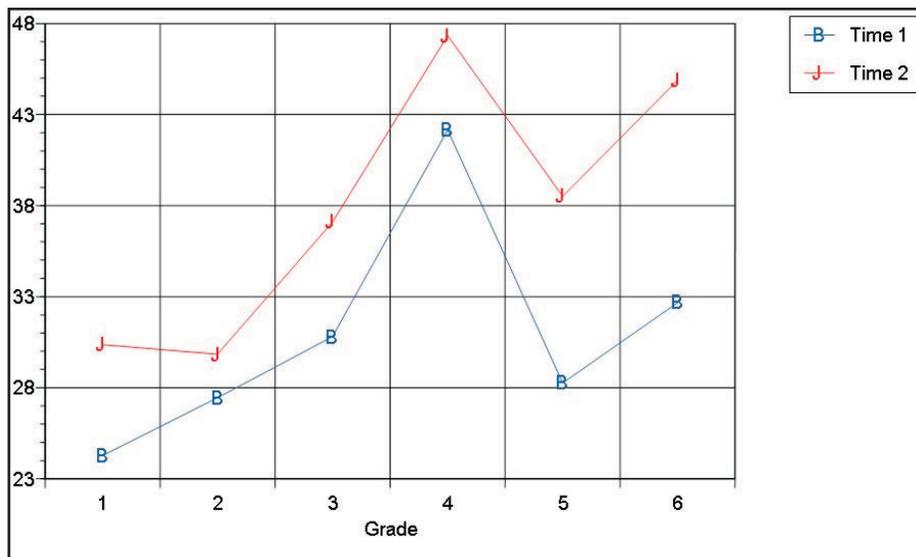


Figure 2. Means for Test and Retest of the DST by School Grade

Table 3.
Improvement in Scores Between Trials 1-6 on the DST Scores

Test to Retest	Improvement In Scores	Standard Deviation	Lower/Upper 95% Confidence Limits		Significance p =
1 to 2	7.7	6.8	9.5	6.0	<.001
2 to 3	3.7	6.9	5.5	1.9	<.001
4 to 5	2.5	8.0	4.6	0.4	.020
5 to 6	3.8	5.7	5.4	2.3	<.001

Test 1 to 2 and 2 to 3 compares the improvement in DST scores for each of the three T1 administrations. Test 4 to 5 and 5 to 6 compares the improvement of DST scores for each of the three T2 administrations.

Performance Comparison for Yearly Grade Increments

Our analysis indicated a significant improvement when the 4th grade was compared to the 3rd grade (p=.008) but a sig-

nificant decrease in performance was seen when the 5th grade was compared to the 4th grade (p=.008) See Table 5.

Comparison of T1 and T2 Scores to Reading Scores

The grade equivalent reading scores were obtained from the school for the first three grades. A Pearson Product correlation was performed to ascertain if there were predictive values in the T1 or T2 scores when compared to the reading scores. The correlation was calculated to be .200 for the average T1 scores to reading scores and .053 when the reading scores were compared to the average T2 scores. Neither correlation approached meaningful significance.

Analysis of Scan Patterns

The first author separated all completed DST tests according to the subject and all T1 and T2 presentations. A subjective, visual best-fit decision was made as to whether the scan pattern moved horizontally, vertically or in a random manner. The analysis revealed that 41.4% of the subjects exhibited the same scan pattern all T1 times. This consistency of scan path increased to 64.9% on all T2 presentations.

The most frequent pattern on both test days was random. Five subjects showed a consistent vertical pattern on T1 presentations, which decreased to three on T2. None of the children showed a consistent horizontal pattern on T1 and only one showed a consistent horizontal pattern on T2. There were no significant differences for the number of O's circled for any of the scan path categories.

DISCUSSION

Scan paths have been implicated as an important ingredient in perception and reading.^{3,9-11,28,35} However, currently there is not a valid, reliable and easily administered clinical test to evaluate these paths. Maples et al³⁶ utilized the DST with their group of optometry students. They reported that the males scored significantly higher than the females. Likewise, they found significant differences in the scan paths (horizontal, vertical or random) between individuals; the horizontal and random scan paths scored significantly higher than the vertical path. They did not, however, perform test-retest analysis.

The performance of a selected adult sample cannot be compared to a more random sample of elementary school children; therefore, this study was undertaken. Unlike the adult study, no differences were found between genders in this study. Neither were there any differences in scores

Table 4
Multiple t-tests by age for averaged T1 and T2 DST Scores

Age in Years	N	Mean	Standard Deviation	Significance
6	2	24.2	0.1	NS
7	12	28.9	9.4	
7	12	28.9	9.4	NS
8	11	27.3	3.7	
8	11	27.3	3.7	.004
9	12	37.1	9.1	
9	12	37.1	9.1	NS
10	7	37.8	8.9	
10	7	37.8	8.9	NS
11	8	38.8	9.2	
11	8	38.8	9.2	NS
12	5	37.0	8.3	
12	5	37.0	8.3	NS
13	3	38.8	4.9	

Table 5
Multiple t-tests by grade for averaged T1 and T2 DST Scores

Grade	N	Mean	Standard Deviation	Significance
1	1	27.3	8.1	NS
2	12	28.4	5.7	
2	12	28.4	5.7	NS
3	9	33.6	6.8	
3	9	33.6	6.8	.008
4	10	44.2	8.4	
4	10	44.2	8.4	.008
5	8	33.4	6.0	
5	8	33.4	6.0	NS
6	8	38.8	6.9	

a similar type of trend when the data is analyzed by grade. The only statistically significant difference in the averaged T1 and T2 scores by age was from the 8th to the 9th year (Table 4). When the averaged T1 and T2 scores were compared by grade, there was a significant increase between the 3rd and 4th grades, but a significant decrease and between the 4th and 5th grades as shown in Table 5.

There were several problems with the data gathering aspect of this study that might have clouded the data. In spite of careful instructions not to remove the pencil from the paper, once the study had started, this behavior was noted on several occasions. Although the number of circled "O's" could be counted, the scan paths were not always clear. The determination of the scan path is a very difficult and arbitrary aspect of this type of study and without knowing the exact start and finish of the test, scan path direction does not appear to be a valuable aspect of the DST with elementary school children.

Conclusions

It is concluded from this study of an elementary school sample that:

1. There were no gender differences in scores found for the DST.
2. Test-retest reliability was poor for the DST and there was a clear learning curve between sequential administrations as well as mean test-retest data.
3. There was a small increase in averaged T1 and T2 scores from ages six to eight. A significant improvement occurred at age nine. These scores appear to be the ceiling, as they basically continued to age 13 on T1 and T2.
4. The dominant scan path was random. Owing to the many variables inherent in the results of this study, any conclusions concerning the scan path data of this sample should be discounted. There were no significant differences found between the performances on any of the scan path.

The authors have no financial or other interest in the Davis Scan Test.

The Davis Scan Test is available from OEP. (See Products on page 51.)

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between identified scan paths. Of course, the placement of a particular performance into a vertical, horizontal or random pattern is subjective and that could have had some influence on these calculations.

It is clear from the present study that test-retest reliability of the DST with our sample of elementary school children is very poor. There were statistically significant differences in virtually all age and grade groups between the T1 and T2 scores as indicated in Tables 1 and 2. This was also

apparent between individual sequential test administrations, as indicated in Table 3. We also did not find a significant correlation between reading scores and DST scores. Based upon these findings one can say that for the ages represented here, the DST has poor reliability, and poor predictability for reading scores.

Our results by age indicated a general, but uneven developmental trend for both the T1 and T2 presentation, as shown in Table 1 and Figure 1. Table 2 and Figure 2 show

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APPENDIX A.

VISUAL SCAN TEST

M J O L b 2 O 17 & M 12 V O A E & O
O J A & L 2 O 17  M S O A E I O
V  O K +S R Z V O k O E X + A J I D V
2 A O G & Y * h  % W L O F M V
W + O N W H 14 O T N O X J &  O E R O H B
O Z & O + K 14 O T N O X 3 % S I O O A
T & F O ? 2 ? J O Z I K % S I D O A
L S 3 L ? a O & + G V 17 # & B F N
M O % 5 ? H O 6 14 K O ? V S O L N 4
A H S % Z O R 7 12 N 6 4 V &  7
S S & Z O  F O X M O ? V 17 S O H J Y 2
E O M L X O Z E H R H 7 O  + I M N F I
Y L + J H I A & O % * O N G A
S J & S A H + N 12 O & * O K 1/2 L S O
M X 14 M H A O O Y S O A W D O
? F FA L A N G H H S J A H M O I T O
J D Z O S + ?  A O) 1/2 Y H U N
A O G A G O K M R N O X C M & V D
O 1 Y 7 K M R N O X O X & S A V I
r O H N O 18 H J &  O
W 2  E & L V V H Z 3 + W R 11
H O # & H 5 A N A 6 + W R 11
H G O I +4 15 B L O B 12 5 A K 5
() 3 & E T 2 H D W  I M V A Z
k O L E 3 U W  " L + O Y
M