The Role of Short Term Memory and Academic Achievement

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ABSTRACT: In order to see the affects of short-term memory on standardized achievement scores, this study compared the auditory and visual digit spans of 546 students from a private school located in the Southeastern part of the United States, to their scores on the Stanford Achievement Test (SAT). The data showed that as digit span increased, so did performance on the SAT.

INTRODUCTION

How well an individual learns is a reflection of how well he receives, processes, scores and utilizes information. The concept of processing refers to short-term memory (Doman, 1986; Doman, 1996; Jaquith, 1996).

There is support in the literature for the use of the digit span test as a measure for visual and auditory short-term memory (Vance & Singer, 1979). Recently, it has even been found to be, in part, a reliable tool for assessing short-term memory with younger children (Gathercole & Adams, 1993). Also in part, the digit span has been found to be a reliable predictor for reading and math achievement (Arcia, Ornstein & Otto, 1991).

Digit spans relating to specific problems and achievement have also been noted. A link seems to be found between poor readers and low digit spans (Spafford, 1989; Koppitz, 1975). In addition to reading and read related disabilities, a low digit span ha been correlated with a specific spelling disability) Newman, Field & Wright, 1993). In a study by Rumsey & Hamburger (1990), a two-digit difference was found between a "regular" group of students and a "dyslexic" group of students, with the latter group having the lower average. A 2-3-digit difference was found between a group of "normal" students and a group with language related learning problems, with the latter group having the lower score. Conversely, a case study explored the possible explanations to a thirteen-year-old girl with exceptional math skills, which found her, among other attributes, to have a high digit span.

The study attempts to show the relationship between digit span and standardized achievements test scores among a cross section of an entire school. The standardized test given to the student was the Stanford Achievement Test (SAT). The scores were arranged first according to auditory or visual digit span, and then according to the span itself. If a difference in achievement test score is shown among different digit span scores among all students, then we can postulate that short-term memory reflects upon student achievement.

METHOD

Subjects

The participants of this study were 546 students from a private school located in the Southeastern part of the United States. The overall number of students represents the total school population who met the following criteria: a) student was present for testing of auditory and visual digit spans and, b) student had taken the Stanford Achievement Test (SAT) in the spring of 1996. A breakdown of students per grade can be found in table 1.

Data Collection

Data was collected from tow sources for comparison. The first was a testing of each child's auditory and visual digit span. The principal of the school was trained by the National Association for Child Development, Inc. (NACD) on how to collect this data, which in turn trained who other individuals to aid in data collection. Procedures were provided in writing to all examiners to help with inter-rate reliability. The second source of data was from each child's school records. Grade point averages and SAT scores reported in grade-equivalent form were recorded. Permission was obtained from each child's parents for the use of said data for this study.

Table 1.
Number of Subjects per Grade Level

Kindergarten	45
Grade 1	54
Grade 2	56
Grade 3	57
Grade 4	56
Grade 5	41
Grade 6	60
Grade 7	37
Grade 8	32
Grade 9	33
Grade 10	24
Grade 11	31
Grade 12	20
TOTAL	546 students

Each child's visual digit span was tested in the same way. Each student was presented with a card with a sequence of three numbers for a total of three seconds. The student was then asked to repeat the sequence back to the examiner. If the sequence was repeated accurately and in the same order, the examiner marked it correct, and moved onto a longer sequence of numbers that was one digit longer that the previous. The procedure was then repeated (same exposure time) until the student responded incorrectly. For an incorrect response, the examiner gave a sequence that was one digit shorter than the first. If two responses were incorrect for any given sequence length, the test was stopped and the digit span was recorded as the highest sequence length responded to correctly.

Auditory digit spans were tested by the examiner dictating a sequence of numbers to the student. Each digit was dictated monotone with an interval of one second. The student was then asked to repeat the sequence back to the examiner. Procedures for accepting correct answers and determining digit span was the same as with the visual digit span.

Analysis

Data was analyzed by NACD. Data on each child's grade point average, sub-test scores of the SAT and composite scores of the SAT were separated by grade and digit span. Data on auditory digit span was compiled separately from data on visual digit span.

School records were used to gather the remaining data. Grade point average was recorded (0.0 to 4.0). SAT sub test scores were recorded for Total Reading, Math, Listening (Grade k-2), Thinking (Grades 3-12), Word Reading (Kindergarten), Language (Grades 1-12), Letters/Sounds (Kindergarten), and Spelling (Grades 1-12). SAT composite scores were also recorded. Scores were reported in a grade equivalent form. Any score listed as PHS (post-high school level) was recorded as grade 13.0 for the purpose of finding an average.

An average grade point average and grade equivalent for each sub-test and composite score of the SAT based upon auditory and visual digit span (separately) were calculated. An overall school average for each were (G.P.A., sub test and composite scores) also calculated. It is the latter that is reflected in the results section of this report. The grade level range represented for each digit span is presentation table 2.

Table 2
Grade Level Range per Digit Span

AUDITORY	
Span:	**Grade Levels**
3	**K-1**
4	**K-8**
5	**K-12**
6	**K-12**
7	**2-12**
8	**5-12**
9	**9-12**
10	**9**
VISUAL	
3	**K**
4	**K-5**
5	**1-7**
6	**1-12**
7	**1-12**
8	**2-12**
9	**3-12**
10	**5-12**
11	**9-12**

RESULTS

The average grade point average and SAT score is presented in Figure 1. All averages were rounded to the nearest tenth. The results are similar for both auditory and visual digit span comparisons.

Figure 1.
Whole School Average G.P.A. and S.A.T. Scores by Digit Span

Auditory

Digit Span:	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
G.P.A	**3.2**	**3.4**	**3.4**	**3.5**	**3.4**	**3.5**	**3.4**	**4.1**
Total Reading	**1.4**	**3.7**	**5.9**	**8.9**	**11.3**	**12.4**	**13.0**	**13.0**
Math	**1.0**	**3.9**	**6.1**	**8.9**	**11.1**	**12.3**	**12.3**	**13.0**
Listening/ Thinking	**1.5**	**3.9**	**5.7**	**8.9**	**10.8**	**12.4**	**12.6**	**13.0**
Word Reading/ Language	**1.0**	**4.0**	**6.3**	**9.2**	**11.7**	**12.8**	**12.4**	**13.0**
Letters/Sounds/ Spelling	**1.5**	**4.3**	**6.3**	**8.7**	**11.3**	**12.1**	**13.0**	**13.0**
Composite	**1.2**	**3.8**	**5.8**	**8.9**	**11.2**	**12.6**	**12.9**	**13.0**

Visual

Digit Span:	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
G.P.A	**2.9**	**2.8**	**3.1**	**3.4**	**3.4**	**3.1**	**3.4**	**3.3**	**4.0**
Total Reading	**1.0**	**2.7**	**3.8**	**6.1**	**8.9**	**10.3**	**12.0**	**12.0**	**13.0**
Math	**0.9**	**2.4**	**3.6**	**7.1**	**8.9**	**9.7**	**11.9**	**12.6**	**13.0**
Listening/ Thinking	**1.5**	**2.6**	**3.7**	**5.8**	**8.4**	**10.2**	**11.8**	**12.1**	**13.0**
Word Reading/ Language	**1.0**	**2.5**	**3.8**	**6.3**	**9.3**	**11.0**	**12.7**	**12.6**	**13.0**
Letters/Sounds/ Spelling	**0.9**	**3.2**	**4.4**	**6.4**	**8.3**	**10.7**	**11.7**	**13.0**	**13.0**
Composite	**1.0**	**2.5**	**3.5**	**6.2**	**7.8**	**10.0**	**12.0**	**12.5**	**13.0**

With the exception of grade point average, as digit spans increased, so did the average grade equivalent. This is true of both auditory and visual digit spans.

Results on grade point averages vary. For visual digit spans, a span of 3 or 4 shows an average G.P.A in the 2-point region. Spans of 5 through 10 show an average G.P.A of 3.1, 3.3 or 3.4 with the order varying as digit span increased. A digit span of 11 shows an average G.P.A of 4.0. For auditory digit spans, a span of 3 shows an average G.P.A of 3.2. Average G.P.A scores very between 3.4 and 3.5 between digit spans of 4 and 9.

Average grade equivalents for total reading scores increase as digit spans increase for both auditory and visual digit spans. The only exception is no difference in average score between a span of 9 and 10. The greatest gains in average score visually are shown between a digit span of 5 and 6, and 6 and 7. The largest gains in average score for auditory digit spans are sown between 4 and 5, 5 and 6, and 6 and 7.

Large jumps in average score were also seen for Math. The largest gain between auditory digit spans are found between a span of 5 and 6. For visual digit spans, large gains are shown between a span of 5 and 6, and a larger gain between a span of 6 and 7.

The Listening sub-test and Thinking sub-tests results are shown together. Large gains are shown between a visual span of 5 and 6, and 6 and 7. With the auditory digit spans, an average gain of two years is shown among the spans 3-5 as the digit span increases, with a larger gain between an auditory digit span of 5 and 6.

Similarly, the Word Reading and Language sub-test results are also reported together. For the auditory digit spans, there is an average gain of 2-3 years between digit spans as the digit spans increase among spans 3-7. For visual digit spans, the largest average gains are found between digit span of 5 and 6 and 6 and 7.

Letters, Sounds, and Spelling sub-test are reported together. Large gains are shown with average scores between digits among the auditory digit spans of 3-7. Visually, there is an average gain of 2 years in average score between digit spans of 3 and 8.

For composite scores, average scores increased as the digit spans increased both auditory and visual digit spans. For visual digit spans, a 2.7-year average gain is shown between digit spans of 5 and 6 as well as a 2.2-year average increase between a digit span of 7 and 8. With auditory digit spans, a 2.0 to 3.6 average score gain was made from span for digit spans of 3 to 7.

DISCUSSION

In general, the data shows a correlation between digit spans and standardized test scores. The higher the digit span, the higher the test scores. As demonstrated earlier, digit spans reflect processing. The correlation that the better one's auditory or visual processing, the better one's standardized tests scores should be.

The data also suggests that there are points at which a one's digit increase with digit spans represents a significant increase in one's auditory or visual processing.

By looking at the data for auditory digit spans in Figure 1, we can see and illustration with composite scores. There is a 3.1-year difference between an auditory digit span of 5 and an auditory digit span of 6. Looking at the same data with visual digit spans, we see a difference of 2.7 years. In each case, it represents one of the largest gains in average test score between digits (the only exception being between an auditory digit span of 3 and 4, which represents a 3.6 year difference).

The largest gain in average test scores from digit to digit is 3 ½ academic years between a visual digit span of 5 and 6. The implication is that from an average 3rd grader's work to that of a seventh grader.

In general, comparing SAT sub-test scores, there is an average of 1 year 7 month grade level improvement from auditory digit span to auditory digit span. For visual digit spans, there is an average 1 year 4 month grade level improvement with a one-digit increase. In other words we could say a one-digit increase represents an average 1-½ year increase in grade level function.

The data also suggests that a one-digit increase among those with a lower digit span represents a major increase in grade level function. From digit to digit between auditory and visual digit spans of 3 and 8, the data shows increases in grade level function one to almost three grade levels of improvement. The data also shows for all categories, that the highest digit spans, represented the highest grade point average and the highest possible score on the SAT.

The implication of this data is that as one improves one's auditory and visual digit span, and thus auditory and visual processing, the individual's academic function relative to grade level will improve. It can be implied from the data that the more information one can process at one time, ultimately enables he or she to do higher levels of academic work.

A future study should be conducted to see the effects of improving digit span on achievement test scores. The will also extend the work of Kaufman & Kaufman (1979), and Hatano, Amaiwa & Shimizu (1987) in which a specific protocol of activity and repetition was used to increase the digit span of individuals.

Caution should be taken for those interpreting this data. Digit spans, while shown here to a projected indicator of academic success, are not the only factor that is involved in the success of any student. If individuals have a specific concern about function, they should try to identify the problem, by looking at the root cause (Doman, 1996). The root cause may be processing as we have discussed in this study, but there may be other factors affecting that child's learning. As such, it is important to explore the root cause of learning difficulties, and find a way to address and eliminate the problem.

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