Running head: MEMORY STRATEGIES

A Study of Multiplication Memory Strategies

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Abstract

This paper examines the memory strategies of adolescents age 15 to 19 on basic multiplication problems. The experiment is to survey the long-term memory multiplication strategies of adolescents. The strategies of memorizing the multiplication tables taught in elementary grades are a basic skill useful in high school and for the rest of their life. The memorization of multiplication tables includes multiple strategies that are implemented on an individual need basis (Siegler, 1998; Siegler, 1999). The multiplication memory strategies in this study also include automatic recall, writing the problem, repeated addition, and counting objects (Siegler, 1999). An individual needs to use memory strategies that can depend on the complexity of the problem being solved or the age of the individual. In memorizing basic multiplication tables the strategies are not complex, but multiple strategies are more frequently used by elementary students than adolescents as one solves basic multiplication problems. This study shows that automatic recall is unapparent as one grows older using basic memorization of multiplication tables in long-term memory. This research disproves Robert S. Siegler overlapping wave’s theory that different memory strategies of basic multiplication problems change with age.

**Keywords:** overlapping wave’s theory, memory strategies

A Study of Basic Multiplication Strategies

Remember memorizing the times table in 3rd grade? Memorizing the multiplication table is an essential part of elementary curriculum and is a foundational skill. This type of operant conditioning early on provides the memory strategy of an automatic recall response frees up mental resources for solving more difficult problems (Siegler, 1998; Jarema, 2009). Memorizing is a practice that everyone encounters throughout their life. Memorizing can be automatic or studied and sometimes it doesn’t matter whether you wanted to do so or not. For example, childhood memories are with us the rest of our life, we did not memorize them, and we just remember them. They stand out for reasons of good or bad situation that lead us to remember. It is the old adage “Practice makes Perfect” implying that repeated performance and exercise would enhance proficiency of a skill (Dictionary.com, 2009). The memory process of memorizing of the multiplication table takes a great deal of attention at first but practice reduces the amount that is needed later creating a process called automation (Siegler, 1998). The term automation is used where skills once learned early on helps free up mental resource for solving other problems. Memorization of multiplication tables allows for this automation would automate the answer to solve more complex problems and increasing the speed into adolescence (Kail, 1992) and increasing performance (Siegler, 1998).

 This study includes memory strategies adolescents use in solving basic multiplication problems. Multiplication is a basic skill all students in high school should have. Multiplication skills are taught in third grade at the age of 8 to 9 years old and continually practiced through 4th through 12th grade at the age of 10 to 19 years old. Robert S. Siegler suggests that students apply more than one strategy to solve a mathematical problem including retrieval, writing the problem, repeated addition, and counting objects. This study will statistically compare the total scores, gender scores, and age of the scores based on a three minute timed one-hundred basic one digit multiplication facts solving multiplication problems to show Robert S. Siegler’s overlapping wave theory, where automatic recall is used more often as a memory strategy as children grow older (Siegler, 1999).

Method

*Participates*

For this study, 40 male and 27 female students in 10th, 11th, and 12th grade ranging from 15 to 19 years of age participated. Students enrolled in a business education course tested within the classroom setting. The researchers are 48 and 58 year old and business education teachers researching mathematical recall strategies of high school students using basic mathematical multiplication functions. Students are tested on multiplication strategies of automatic recall used to solve the problems correctly.

*Procedure*

Students will solve 100 basic multiplication problems. The survey will be tested for one day. All students will start the test at the same time and stop after three minutes. The test is on paper and students are allowed to write on their test. The students are directed to answer only the problems they know through automatic recall first and the data was recorded as a retrieval method strategy. Students may use multiply memory strategies to solve the problem. This study is based on memory strategies on automatic recall only and calculators were not used in this study.

*Materials*

Students had the same multiplication times test provided by a third grade elementary teacher, see Appendix A. Students were timed and observed for academic integrity purposes and validity of doing their own work.

Results

Participants in this study showed that only three students completed all 100 multiplication problems using automatic recall of memorized multiplication tables learned in elementary school (Interview, 2010). The results analyzed scores, scores between gender, and scores between student ages.

The scores used a one-mean *t*-test to analyze the data. The scores are listed in Appendix B. As we know, the average basic multiplication score of the hypothesis population is 100. High school students’ should be able to solve basic multiplication problems using automatic recall quickly and correctly. We would like to test whether the sample mean of 100 differs from the hypothesized population mean of 100. After calculations, the mean and standard deviation for the 67 students are 54.5970 and 18.9937, respectively. The result found that the sample mean (54.60) significantly differs from a hypothesized value 100. If we set alpha (α) to .05 with degree of freedom (*df*) of 66 (n-1=67-1) then critical *t* = ±2.00. Since the obtained t-value -19.57 is not within ±2.000 (i.e., not in the critical region), we reject the null hypothesis (H0). There is a significant difference in adolescent students recalling basic multiplication. Students can only answer 54% of basic multiplication learned in elementary school. The value for Pr > | *t* | in SAS outputs is the p-value, the *p*-value represents the proportion under the *t*-distribution curve that corresponds to the obtained *t* value. Since the *p*-value (0.0001) is less than the alpha level (0.05), we reject the null hypothesis. The result indicates that the sample mean (54) significantly differ from the hypothesized population mean (100), *t* (67) = -19.57, *p* = .0001. See Appendix C for SAS data results.

The scores used in the independent means t-test analyzed the difference scores of boys

and girls. The value for Pr > | t | in SAS outputs is the p-value. The p-value represents the
proportion under the *t*-distribution curve that corresponds to the obtained t value. Since the *p*-value (0.7742) is greater than the alpha level (0.05), we fail to reject the null hypothesis. There is no significant difference between the basic multiplication scores between boys (group 1) and girls (group 2). This statistical examination for the two groups meet the homogeneity assumption used in the “Folded F test”, whereby the *p*-value (0.7742) in our case is greater than the alpha level (0.05), so we fail to reject the null hypothesis. That is, our data for two groups meet the homogeneity assumption. Sample effect size for a male group (1) and a female group (2) from the SAS output, mean score for a male group is 55.15 and for a female group is 53.77. The pooled standard deviation is 19.1270. The mean of group 1 is .07 standard deviations higher than the mean of group 2. See Appendix C for SAS data results.

The scores used ANOVA F-test to analyze the scores among the ages of 16, 17, 18, and 19. We are interested in knowing if there is a statistically significant difference between the scores among the four age groups on basic multiplication test scores. The obtained *F* value is 1.20. The critical *F* value with dfs of (4, 62) is 2.52. Since the obtained *F* value of 1.20 is less than the critical *F* value of 2.52, we fail to reject the null hypothesis. The obtained *p*-value is .3213. If the alpha is set to be .05, the obtained *p*- value of .3213 is greater than the alpha level (0.05). So we fail to reject the null hypothesis. There were no significant differences with the test scores of the age groups: 16, 17, 18, and 19. A one-way analysis of variance was conducted to evaluate the memory performance of four age groups included in this study. The independent variable, the scores, included four ages: 16, 17, 18, and 19. The dependent variable is the scores between the ages. The ANOVA was not significant, F (3, 62) = 2.52, p = .3213. This result indicated that the scores among these four ages were not different. See Appendix E for SAS data results.

Discussion

The results proved that students are not able to perform long-term memory automatic recall strategies in basic one digit multiplication facts. Students at a high school level should be able to complete basic multiplication facts quickly and correctly. The results proved that high school students could only answer the questions correctly on an average of 54% accuracy. The data is not consistent with Kail (1992) and Siegler (1998) research on adolescents automates answers faster and solves more complex problems.

The results of the scores showed that there were no significant differences among boys and girls, which disproves the notion that boys outperform girls in mathematic. The mean of group of boys was not significant with standard deviations only .07 higher than the mean of the group of girls. The difference may result based on the higher ratio of boys to girls, 40 to 27.

The result of the scores showed that there were no significant differences among age groups: 16, 17, 18, and 19. If students are to increase their performance with automatic recall faster and solve more complex problems was not reflective of the four ages analyzed. However, the ratio of ages did vary with most students being 17 and 18 years of age. This result indicated that the scores among these four ages were not different.

In conclusion, further research on a larger scale should be done to help substantiate the evidence that this small study found; that our students are performing mathematically below where they should at their age level. In addition, even though our sample was small, we would recommend that additional research be done to disprove the theory that male students outperform female students in mathematics.

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APPENDICES

Appendix A

**Multiplication Memory Strategy Survey**

You will have three minutes to complete the following 100 problem multiplication test. Answer only the problems that are recalled automatically first. If time permits go back and circle the problem, solve the problem, and write down what memory strategy used to solve the problem. Label your strategies: M for multiplying numbers different then in the problem, an A for adding numbers, and a C for counting objects.

*Age:* \_\_\_\_\_\_\_\_ *Gender:* Male or Female

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 2x 9 | 0x 8 | 6x 8 | 7x 5 | 6x 3  | 4x 9 | 2x 7 | 8x 8 | 3x 9 | 1x 6 |
| 8x 9 | 3x 8 | 6x 4 | 8x 7 | 7x 4 | 9x 7 | 6x 6 | 4x 6 | 5x 9 | 7x 6 |
| 9x 4 | 3x 5 | 5x 8 | 4x 5 | 7x 7 | 9x 3 | 2x 6 | 4x 7 | 7x 9 | 9x 2 |
| 6x 2 | 4x 8 | 6x 9 | 8x 2 | 5x 6 | 4x 4 | 6x 7 | 9x 5 | 8x 3 | 9x 9 |
| 6x 5 | 8x 6 | 4x 3 | 8x 4 | 9x 8 | 8x 5 | 9x 6 | 5x 7 | 4x 2 | 7x 8 |
| 2x 5 | 3x 9 | 8x 8 | 3x 7 | 4x 9 | 3x 3 | 7x 5 | 6x 8 | 5x 3 | 2x 9 |
| 7x 6 | 5x 9 | 5x 4 | 6x 6 | 9x 7 | 7x 4 | 8x 7 | 5x2 | 3x 8 | 8x 9 |
| 9x 2 | 7x 9 | 4x 2 | 2x 4 | 9x 3 | 7x 7 | 3x 6 | 5x 8 | 5x 5 | 9x 4 |
| 9x 9 | 8x 3 | 9x 5 | 6x 7 | 7x 3 | 5x 6 | 3x 4 | 6x 9 | 4x 8 | 7x 2 |
| 7x 8 | 9x 0 | 5x 7 | 9x 6 | 8x 5 | 9x 8 | 8x 4  | 2x 8 | 8x 6 | 6x 5 |

Figures

Appendix B

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Sex | Age | Correct |  | Sex | Age | Correct |
| M | 15 | 40 |  | F | 17 | 53 |
| M | 15 | 37 |  | M | 17 | 63 |
| M | 15 | 44 |  | F | 17 | 67 |
| F | 15 | 51 |  | M | 17 | 87 |
| F | 15 | 93 |  | M | 17 | 79 |
| M | 15 | 46 |  | F | 17 | 32 |
| M | 15 | 63 |  | F | 17 | 38 |
| F | 15 | 42 |  | M | 17 | 43 |
| M | 16 | 62 |  | F | 17 | 38 |
| F | 16 | 82 |  | M | 17 | 34 |
| M | 16 | 71 |  | M | 17 | 68 |
| M | 16 | 59 |  | F | 17 | 49 |
| F | 16 | 65 |  | M | 17 | 68 |
| M | 16 | 54 |  | M | 17 | 38 |
| M | 16 | 69 |  | M | 17 | 57 |
| M | 16 | 91 |  | F | 17 | 46 |
| M | 16 | 26 |  | F | 17 | 57 |
| M | 16 | 31 |  | F | 17 | 77 |
| M | 16 | 57 |  | F | 17 | 57 |
| F | 16 | 59 |  | F | 17 | 80 |
| F | 16 | 26 |  | M | 17 | 100 |
| M | 16 | 73 |  | M | 17 | 31 |
| F | 16 | 61 |  | M | 17 | 100 |
| F | 16 | 36 |  | F | 17 | 35 |
| F | 16 | 77 |  | M | 18 | 41 |
| M | 16 | 42 |  | M | 18 | 48 |
| M | 16 | 57 |  | F | 18 | 40 |
| M | 16 | 38 |  | F | 18 | 32 |
| M | 16 | 40 |  | M | 18 | 27 |
| F | 16 | 63 |  | M | 18 | 73 |
| M | 16 | 65 |  | M | 18 | 36 |
| F | 16 | 47 |  | F | 19 | 49 |
| M | 16 | 59 |  | M | 19 | 69 |
|  |  |  |  | M | 19 | 20 |

Appendix C

SAS INPUT

**Data** one;

input SCORES;

cards;

 40

 37

 44

 51

 93

 46

 63

 42

 62

 82

 71

 59

 65

 54

 69

 91

 26

 31

 57

 59

 26

 73

 61

 36

 77

 42

 57

 38

 40

 63

 65

 47

 59

 53

 63

 67

 87

 79

 32

 38

 43

 38

 34

 68

 49

 68

 38

 57

 46

 57

 77

 57

 80

100

 31

100

 35

 41

 48

 40

 32

 27

 73

 36

 49

 69

 20

;

**Proc** **ttest** data=one h0=**100**;

TITLE "Basic Multiplication Scores"

var SCORES;

**run**;

SAS OUTPUT

 Basic Multiplication Scores var SCORES 2

 The TTEST Procedure

 Variable: SCORES

 N Mean Std Dev Std Err Minimum Maximum

 67 54.5970 18.9937 2.3204 20.0000 100.0

 Mean 95% CL Mean Std Dev 95% CL Std Dev

 54.5970 49.9641 59.2299 18.9937 16.2338 22.8930

 DF t Value Pr > |t|

 66 -19.57 <.0001

Appendix D

SAS INPUT

**Data** one;

 input group **1** scores **3**-**5**;

cards;

1 40

1 37

1 44

2 51

2 93

1 46

1 63

2 42

1 62

2 82

1 71

1 59

2 65

1 54

1 69

1 91

1 26

1 31

1 57

2 59

2 26

1 73

2 61

2 36

2 77

1 42

1 57

1 38

1 40

2 63

1 65

2 47

1 59

2 53

1 63

2 67

1 87

1 79

2 32

2 38

1 43

2 38

1 34

1 68

2 49

1 68

1 38

1 57

2 46

2 57

2 77

2 57

2 80

1 100

1 31

1 100

2 35

1 41

1 48

2 40

2 32

1 27

1 73

1 36

2 49

1 69

1 20

;

**proc** **ttest**;

 class group;

 var scores;

TITLE "Boys vs Girls Scores"

run;

SAS OUTPUT

 Boys vs Girls Scores 3

 The TTEST Procedure

 Variable: scores

 group N Mean Std Dev Std Err Minimum Maximum

 1 40 55.1500 20.1387 3.1842 20.0000 100.0

 2 27 53.7778 17.5002 3.3679 26.0000 93.0000

 Diff (1-2) 1.3722 19.1270 4.7640

 group Method Mean 95% CL Mean Std Dev 95% CL Std Dev

 1 55.1500 48.7093 61.5907 20.1387 16.4968 25.8588

 2 53.7778 46.8549 60.7006 17.5002 13.7817 23.9828

 Diff (1-2) Pooled 1.3722 -8.1422 10.8866 19.1270 16.3297 23.0899

 Diff (1-2) Satterthwaite 1.3722 -7.8962 10.6407

 Method Variances DF t Value Pr > |t|

 Pooled Equal 65 0.29 0.7742

 Satterthwaite Unequal 60.845 0.30 0.7682

 Equality of Variances

 Method Num DF Den DF F Value Pr > F

 Folded F 39 26 1.32 0.4557

Appendix E

SAS INPUT

**data** one;

 input age scores;

cards;

15 40

15 37

15 44

15 51

15 93

15 46

15 63

15 42

16 62

16 82

16 71

16 59

16 65

16 54

16 69

16 91

16 26

16 31

16 57

16 59

16 26

16 73

16 61

16 36

16 77

16 42

16 57

16 38

16 40

16 63

16 65

16 47

16 59

17 53

17 63

17 67

17 87

17 79

17 32

17 38

17 43

17 38

17 34

17 68

17 49

17 68

17 38

17 57

17 46

17 57

17 77

17 57

17 80

17 100

17 31

17 100

17 35

18 41

18 48

18 40

18 32

18 27

18 73

18 36

19 49

19 69

19 20

;

**PROC** **ANOVA** data=one;

 class age;

 model scores = age;

 means age;

TITLE "AGE OF BASIC MULTIPLICATION SCORES"

Run;

SAS OUTPUT

 AGE OF BASIC MULTIPLICATION SCORES Run 8

 19:48 Friday, December 3, 2010

 The ANOVA Procedure

 Class Level Information

 Class Levels Values

 age 5 15 16 17 18 19

 Number of Observations Read 67

 Number of Observations Used 67

 AGE OF BASIC MULTIPLICATION SCORES Run 9

 19:48 Friday, December 3, 2010

 The ANOVA Procedure

Dependent Variable: scores

 Sum of

 Source DF Squares Mean Square F Value Pr > F

 Model 4 1706.44678 426.61170 1.20 0.3213

 Error 62 22103.67262 356.51085

 Corrected Total 66 23810.11940

 R-Square Coeff Var Root MSE scores Mean

 0.071669 34.58338 18.88149 54.59701

 Source DF Anova SS Mean Square F Value Pr > F

 age 4 1706.446784 426.611696 1.20 0.3213

 AGE OF BASIC MULTIPLICATION SCORES Run 10

 19:48 Friday, December 3, 2010

 The ANOVA Procedure

 Level of ------------scores-----------

 age N Mean Std Dev

 15 8 52.0000000 18.4080728

 16 25 56.4000000 17.0880075

 17 24 58.2083333 21.0051322

 18 7 42.4285714 15.0649388

 19 3 46.0000000 24.6373700