1-1-1967

The development of the primary school child's ability to reproduce short time intervals.

Keith Travis
University of Windsor

Follow this and additional works at: https://scholar.uwindsor.ca/etd

Recommended Citation
Travis, Keith, "The development of the primary school child's ability to reproduce short time intervals." (1967). Electronic Theses and Dissertations. 6503.
https://scholar.uwindsor.ca/etd/6503

This online database contains the full-text of PhD dissertations and Masters' theses of University of Windsor students from 1954 forward. These documents are made available for personal study and research purposes only, in accordance with the Canadian Copyright Act and the Creative Commons license—CC BY-NC-ND (Attribution, Non-Commercial, No Derivative Works). Under this license, works must always be attributed to the copyright holder (original author), cannot be used for any commercial purposes, and may not be altered. Any other use would require the permission of the copyright holder. Students may inquire about withdrawing their dissertation and/or thesis from this database. For additional inquiries, please contact the repository administrator via email (scholarship@uwindsor.ca) or by telephone at 519-253-3000 ext. 3208.
THE DEVELOPMENT OF THE PRIMARY SCHOOL

CHILD'S ABILITY TO REPRODUCE SHORT

TIME INTERVALS

by

KEITH TRAVIS

B.A., University of Windsor, 1966

A Thesis
Submitted to the Faculty of Graduate Studies
through the Department of Psychology in
Partial Fulfillment of the Requirements
for the Degree of Master of Arts at the
University of Windsor

Windsor, Ontario, Canada

1967
INFORMATION TO USERS

The quality of this reproduction is dependent upon the quality of the copy submitted. Broken or indistinct print, colored or poor quality illustrations and photographs, print bleed-through, substandard margins, and improper alignment can adversely affect reproduction.

In the unlikely event that the author did not send a complete manuscript and there are missing pages, these will be noted. Also, if unauthorized copyright material had to be removed, a note will indicate the deletion.
ABSTRACT

This study investigated the development in the ability of children to reproduce short time intervals using two methods of reproduction. Possible sex differences in ability to reproduce time intervals were also investigated. An evaluation of the reliability of the method of reproduction over sessions, and an evaluation of the method of reproduction as a technique for studying the development of time was investigated.

The experimental group consisted of 60 Ss, including 30 male and 30 female Ss, in grades three through eight. The Ss were tested in three stages. The first stage was concerned with the ability to reproduce three short time intervals using an auditory stimulus; the second stage, with the reliability of the method of reproduction over a period of two weeks and which was an attempt to ascertain whether, with increasing age, there was differential employment of counting as an auxiliary aid during reproductions;
the third stage with the efficacy of allowing Ss to reproduce the duration of the auditory stimulus interval by drawing a straight line to represent the length of that interval.

Analysis of variance of mean reproductions in the first stage, yielded non-significant developmental differences which would be related to the age of Ss. Analysis of variance of intra-subject ranges did, however, yield developmental differences. Reproduced intervals approximated Weber's Law. Sex differences in reproduction of time intervals were observed. The method of reproduction was found to be very reliable over sessions. Finally, it was found that older Ss tended to employ counting as an auxiliary aid during reproduction of time intervals.
PREFACE

Interest in the present investigation originated from the merging of two trends of thought; the first, resulting from discussion with Mr. R. Pinto of the phenomenon of time, and the second, following from the reading of The Psychology of Time by Professor Paul Fraisse.

The author expresses gratitude to Drs. A. A. Smith and B. P. Rourke for their direction and criticism of this investigation, and to Mr. R. Pinto for his part in instigating the study from the philosophical point of view.

Greatest appreciation is expressed to Mr. Albert Baker, the Principal, and to the staff and students of the Prince of Wales Public School for their assistance during the testing phases. Finally, the author expresses gratitude to Mrs. S. DeRose and Mrs. E. Cusinato for their contributions in typing this investigation.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>PREFACE</td>
<td>iv</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>vi</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>vii</td>
</tr>
<tr>
<td><strong>Chapter</strong></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>INTRODUCTION.</td>
</tr>
<tr>
<td></td>
<td>Background of Related Research</td>
</tr>
<tr>
<td></td>
<td>Purpose of Present Research</td>
</tr>
<tr>
<td>II</td>
<td>METHODOLOGY AND PROCEDURE</td>
</tr>
<tr>
<td></td>
<td>Subjects</td>
</tr>
<tr>
<td></td>
<td>Apparatus</td>
</tr>
<tr>
<td></td>
<td>Experimental Procedure</td>
</tr>
<tr>
<td>III</td>
<td>RESULTS</td>
</tr>
<tr>
<td></td>
<td>Stage I</td>
</tr>
<tr>
<td></td>
<td>Stage II</td>
</tr>
<tr>
<td></td>
<td>Stage III</td>
</tr>
<tr>
<td>IV</td>
<td>DISCUSSION OF RESULTS</td>
</tr>
<tr>
<td>V</td>
<td>SUMMARY</td>
</tr>
<tr>
<td>BIBLIOGRAPHY</td>
<td>50</td>
</tr>
<tr>
<td>VITA AUCTORIS</td>
<td>52</td>
</tr>
<tr>
<td>Table</td>
<td>Description</td>
</tr>
<tr>
<td>-------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>Analysis of Variance of Mean Reproductions</td>
</tr>
<tr>
<td>2</td>
<td>Analysis of Variance for Simple Effects of Grade x Time Interval Interaction</td>
</tr>
<tr>
<td>3</td>
<td>Analysis of Variance of Intra-Subject Ranges of Reproductions Obtained</td>
</tr>
<tr>
<td></td>
<td>During Trials in Stage I</td>
</tr>
<tr>
<td>4</td>
<td>Analysis of Variance for Simple Effects of Sex x Time Interval Interaction</td>
</tr>
<tr>
<td>5</td>
<td>Summary of Responses Regarding the Use of Counting in Reproduction of Time</td>
</tr>
<tr>
<td></td>
<td>Intervals</td>
</tr>
<tr>
<td>6</td>
<td>Analysis of Variance of Means Obtained in Production of a One Second Interval</td>
</tr>
<tr>
<td>7</td>
<td>Analysis of Variance of Means of Spatial Representations of Time Intervals</td>
</tr>
<tr>
<td></td>
<td>in Stage III</td>
</tr>
<tr>
<td>8</td>
<td>Analysis of Variance of Transformed Durations of Means from the Standard</td>
</tr>
<tr>
<td></td>
<td>Interval During Spatial Representation of Time Intervals in Stage III</td>
</tr>
</tbody>
</table>
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Layout of the testing apparatus.</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>Electrical diagram of testing apparatus.</td>
<td>11</td>
</tr>
<tr>
<td>3</td>
<td>Profile of simple effects of time interval for level of grade in reproduction (Stage I).</td>
<td>23</td>
</tr>
<tr>
<td>4</td>
<td>Profile of simple effects of sex x time interval interaction (Stage I).</td>
<td>23</td>
</tr>
<tr>
<td>5</td>
<td>Graph of mean reproductions and mean ranges by time intervals (Stage I).</td>
<td>24</td>
</tr>
<tr>
<td>6</td>
<td>Graph of mean reproductions and mean ranges by grades in Stage I.</td>
<td>25</td>
</tr>
<tr>
<td>7</td>
<td>Profile of simple effects of sex x grade interaction of reproduced means (Stage III).</td>
<td>32</td>
</tr>
<tr>
<td>8</td>
<td>Profile of simple effects of sex x grade interaction of transformed discrepancies of means from standard (Stage III).</td>
<td>36</td>
</tr>
</tbody>
</table>
CHAPTER I

INTRODUCTION

Background of Related Research

Research dealing with the estimation of time intervals has been well represented in the literature since the turn of the century. Bindra (1956, p. 155) has reported that, "The studies in the area of time estimation are concerned primarily with the relative magnitudes of, and the general relations between the standard and the corresponding judgment." Bindra (1956) has also noted that the literature concerning time estimation studies is confusing to read and interpret due largely to two facts--firstly, that different investigators are using different methods and secondly, that different terminologies are employed to describe results.

Three main methods are commonly used in time estimation experiments. In the method of verbal estimation, E delimits a given interval operatively (i.e., demonstrates the duration of the standard), and S is asked to estimate verbally its duration.
(the judgment) in terms of seconds or minutes. In the method of production, S is instructed to delimit operatively an interval (the judgment) of a given duration (the standard) stated verbally by E. In the method of reproduction, E operatively delimits an interval (the standard) and then asks S to reproduce operatively an interval (the judgment) of the same duration (Bindra, 1956, p. 155).

Doehring (1961) more specifically described as many as four methods of reproduction. It is obvious that neither of the terms "estimation" nor "reproduction" qualify as univocal terms. Great caution must, therefore, be exercised in interpreting past experimentation and in making generalizations based on merely superficial comparisons of experiments.

Developmental studies (for example, Ames, 1946; Springer, 1952) have shown that children do not learn the use of symbolic units like the second before the age of eight; however, there is abundant evidence of subjective time experience before that age. Common to the method of verbal estimation and production is the employment of such symbolic units in estimation.
rendering both methods unsuitable for investigations of the developing ability of the younger child to estimate time accurately. The method of reproduction, on the other hand, eliminates conceptualized time units (i.e., so long as Ss are not counting as an auxiliary aid) and may be advantageous as a technique for use in developmental time estimation studies—particularly with younger children.

However, the method of reproduction has been criticized. Clausen (1950) and DuPreez (1964) have stated that the method of reproduction is not as reliable as the method of verbal estimation, and, therefore, concluded that the methods of verbal estimation and production are to be preferred for estimation studies. Recent evidence suggests, however, that this is not invariably so. Danziger (1963) has presented data indicating that the method of reproduction is at least as reliable as other methods; furthermore, he has pointed out that the high reliability of the verbal estimation method is not a sufficient condition for establishing its validity as
a measure of subjective time experience. Richards (1964) has stated that the method of reproduction most directly attacks the problem of time perception and encounters the fewest additional parameters. The experimental conditions under which the reliability of the method of reproduction is sufficient are far from being exhaustively specified, and remain to be investigated before adequate studies of the development of time perception can be made.

Additionally, Guilford (1926), with another related consideration, has presented experimental evidence showing a relationship between spatial images and time experience.

The images given to represent the passing of time in the present are, for the most part, images of movement or, of traversing of space. Thus it would seem proper to say that time is in a psychological sense 'traversed space'. This would not mean that space experience is more primary than time experience, for other data might show the converse also to be true, that the perception of space is dependent upon temporal images, or that space is 'lived time'. Whether the 'lived time'
during a bodily movement is more or less primary than the 'traversed space' we cannot say; both depend upon kines-
thesis for their content and meaning (p. 423).

Furthermore Danziger has stated the following:
"The reliability of time estimates using the method of reproduction should be improved by allowing S to translate the perceived temporal interval into bodily movement in space". (1963, p. 881). He has presented evidence that the use of extensive arm movements of subjects to indicate duration raised the reliability of time estimates to a level at least comparable to that of the method of verbal estimation.

Many developmental studies of time perception have been published (for example, Ames, 1945; Gilliland, 1943; and Smythe, 1957). There is, however, a paucity of developmental studies systematically investigating year-by-year differences in time estimation. Gilliland (1943), for example, compares fifth-grade children with college students and, as strongly expected, found significant differences. However, such differences, due to the lack of representation of intermediate age
groups and the wide spread between ages which were represented, did not yield information concerning the shape of the curve of improvement in ability to estimate time intervals. Smythe (1957), however, studied age differences more systematically. One major shortcoming of the study was that only one time interval was employed as standard—that of one second. The literature yields no systematic age-by-age investigation of estimation of a series of time intervals employing the method of reproduction.

The concern with sex differences in time estimation has not been given much recent emphasis. MacDougall (1904) reported that women had a strong tendency to overestimate and were much less accurate than men in verbally estimating time intervals. Yerkes and Urban (1906) have reported similar sex differences. It is to be noted that the time intervals employed ranged between 15 seconds and 4 minutes. Shorter intervals were not represented. Gilliland (1943), more recently, failed to find significant sex differences in his investigation. A summary of studies
investigating the influence of sex in time estimation has been presented by Fraisse (1963, p. 249) who concludes that, "More experiments will have to be made in varied conditions to settle the question before it can be interpreted."

MacDougall (1904) stated that he "would be glad to learn whether judgments of children of the two sexes present a closer approximation in character than those embodied in the preceding tables (i.e., his data revealing highly significant sex differences); and in case they do whether any systematic test has been made of their progressive differentiation with advance in age. (p. 708)." For the current study, such an investigation had not been made.

Purpose of Present Research

This study attempted to investigate the following: (1) the developmental differences of children in grades three through eight in reproducing short time intervals; (2) the developmental differences of children in translating short time intervals into spatial representations (i.e., drawing straight
lines); (3) the reliability in reproduction of short time intervals over testing sessions; (4) the development of the child's notion of the length of a one second interval by the method of production; (5) the existence of sex differences in reproductions of short time intervals and in productions of a one second interval; (6) the age at which the child begins to employ counting as an auxiliary aid in the reproduction of short time intervals.
CHAPTER II
METODOLOGY AND PROCEDURE

Subjects

Ten children were selected from each of grades three, four, five, six, seven, and eight from a Windsor Public School. There were 5 boys and 5 girls in each age-grade group. Ss were selected from class lists of birthdates to ensure that they were as close as possible to that age most appropriate for their grade group. All Ss, by the principal's estimation, were of average intelligence. Ss repeating their present grade were not included.

Apparatus

A Hunter Timer, an 8-10 Volt A.C. buzzer, an 8 Volt transformer, and recording clock were mounted at one end of a table divided by a vertical screen 16 inches high. A telegraph key was mounted at the other end of the table.
The Hunter Timer controlled the onset, duration, and offset of the auditory stimulus, a buzzer sounding with clearly audible, yet not noxious, intensity.

The telegraph key, when pressed by Ss, activated the auditory stimulus for a continuous duration till pressure was released. The recording clock, in circuit with the telegraph key, was employed to measure the durations reproduced by Ss.

Figure 1: Layout of testing apparatus.
Figure 2: Electrical diagram of testing apparatus.
Experimental Procedure

During Stages I and II, Ss were tested individually in a quiet comfortable conference room to minimize distractions from the school setting. Ss were tested in a classroom during Stage III.

During Stage I, S was seated at the testing table directly in front of the telegraph key and was instructed as follows:

In front you'll see a telegraph key. Please press it up and down to see how it works (S was allowed to manipulate the buzzer via the key. E demonstrated if necessary). Notice that, when you press the key, the buzzer goes on and, when you let the key go, the buzzer stops. In this experiment you will hear the buzzer sound for a length of time. I want you to listen to the buzzer carefully. When I say, 'Begin', I want you to press the buzzer for the same length of time as my buzzer.

(Repeat) Are there any questions?

Two practice trials were administered to ensure that S understood the instructions. To maintain interest during the test, Ss were told that they would be given a reward for trying their best. A chocolate bar
was given to S following the session regardless of his performance. Ss were asked not to discuss the experiment with their peers.

During the testing proper, the durations between onset and offset of the auditory stimulus (buzzer) were 2.0, 8.0, and 15 seconds. There were six reproduction trials for each interval setting presented in a random sequence. During trials E switched interval settings on the Hunter Timer in accordance with the random sequence and recorded reproduced durations measured on the recording clock.

The signal to begin reproduction of the stimulus duration was given clearly by E, after an interval of approximately 3 seconds following the offset of the auditory stimulus.

After two weeks (Stage II) the same Ss were employed in a test session identical to Stage I. Following Stage II, Ss completed the following questionnaire verbally:
(1) What is the date today?

(2) How many months are there in a year?

(3) How many minutes are there in an hour?

(4) What time does this watch say?

(5) How many seconds are there in two minutes? (If S cannot answer he is asked, "How many seconds are there in one minute?")

(6) Do you know how long a second is? Please press on the buzzer for one second when I say 'Begin'. (Repeat).

(7) Can you tell me how you tried to remember how long the buzzer sounded?

If S spontaneously admits counting ask:

(a) What did you count?

(b) What was the highest number you counted?

(c) What was the lowest number you counted?

If S doesn't spontaneously admit counting ask:

(d) Did you count?
During Stage III, it was found administratively convenient to test Ss in three groups of 20 rather than individually. Approximately one week after Stage II, arrangements were made to have 20 Ss at a time seated in a classroom. The Stage III test papers, pencils, and plain straight sticks were distributed and E read the instructions as follows:

Please print your name, grade, age, and birthdate in the spaces on all three papers. (Time is allotted to allow completion)
Now notice this line in the upper left corner of each page. Is there anyone who does not see it? Now let us suppose that this line is as long as this sound. (Buzzer is activated for 2 seconds)
(Repeat) In this experiment I am going to make some sounds of different lengths with the buzzer and want you to listen to them carefully. As soon as my buzzer stops I want you to draw a straight line as long as you think the sound is. Remember that this sound is as long as the line on your page (Repeat 2 second buzzer). Are there any questions?

Two practice trials were administered before beginning Stage III proper. E switched the auditory stimulus time intervals in accordance with a previously selected sequence of presentation. Intervals of
2, 4, 6, 8, 10, and 15 seconds were employed. Three trials for each interval were presented. Each trial was completed on a separate page. Following each reproduction drawing, E designated an ordinal number and ensured that this was written beside each line. After each complete trial the pages were collected.
CHAPTER III

RESULTS

The results of test stages I, II and III are presented in sequence.

Stage I

The means and ranges of reproductions of time intervals in Stage I were calculated. Possible differences in the means of the reproductions of time intervals were assessed by means of a three-way analysis of variance (summarized in Table 1) with sex, grade and time interval as the main effects. This analysis indicated that, while there were no statistically significant sex differences, there were highly significant differences (at the .01 level of confidence) in effects of variation of time intervals. As expected the reproductions of long time intervals were longer than those of shorter intervals. There was a grade x time interval interaction effect,
### TABLE 1

Analysis of Variance of Mean Reproductions

(Stage I)

<table>
<thead>
<tr>
<th>Source of Variance</th>
<th>df</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Between Subjects</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A (Sex)</td>
<td>1</td>
<td>3.24</td>
<td></td>
</tr>
<tr>
<td>B (Grade)</td>
<td>5</td>
<td>5.48</td>
<td>2.12*</td>
</tr>
<tr>
<td>AB (Sex x Grade)</td>
<td>5</td>
<td>1.86</td>
<td></td>
</tr>
<tr>
<td>Error between</td>
<td>48</td>
<td>2.58</td>
<td></td>
</tr>
<tr>
<td><strong>Within Subjects</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C (Time Interval)</td>
<td>2</td>
<td>1860.79</td>
<td>1525.24***</td>
</tr>
<tr>
<td>AC (Sex x Time Interval)</td>
<td>2</td>
<td>2.44</td>
<td>2.00**</td>
</tr>
<tr>
<td>BC (Grade x Time Interval)</td>
<td>10</td>
<td>2.44</td>
<td>2.00**</td>
</tr>
<tr>
<td>ABC (Sex x Grade x Time Interval)</td>
<td>10</td>
<td>.59</td>
<td></td>
</tr>
<tr>
<td>Error within</td>
<td>96</td>
<td>1.22</td>
<td></td>
</tr>
</tbody>
</table>

* \( F_{.90} (5, 48) = 1.98 \)  

** \( F_{.95} (10, 96) = 1.93 \)  

### Additional Information

*** \( F_{.99} (2, 96) = 4.90 \)
significant at the .05 level, and a grade effect, significant at only the .10 level. The $F$ ratios for the other main effects and interactions were non-significant.

Analysis of simple effects was employed to determine the sources of variation contributing to the significant grade x time interaction. A summary of this analysis appears in Table 2. The simple effects of variation of grade levels was found to be statistically significant (at the .01 level) for only the 15 second time interval. The simple effects of time interval variation was significant (at the .01 level) for all grades.

A trend analysis of grade totals obtained during the task indicated a linear relationship ($F = 27.19$), significant at the .01 level. No significant non-linear trend component was found. Thus the rise in total reproduction scores between grade three and grade eight was significant.

The intra-subject range of reproduced intervals obtained during the six test trials at each time
<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>df</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>B for C1 (Grade for 2 second interval)</td>
<td>5</td>
<td>.15</td>
<td></td>
</tr>
<tr>
<td>B for C2 (Grade for 8 second interval)</td>
<td>5</td>
<td>4.20</td>
<td></td>
</tr>
<tr>
<td>B for C3 (Grade for 15 second interval)</td>
<td>5</td>
<td>47.45 ***</td>
<td></td>
</tr>
<tr>
<td>Error (pooled)</td>
<td>144</td>
<td>2.51</td>
<td></td>
</tr>
<tr>
<td>C for B1 (Time for Grade 3)</td>
<td>2</td>
<td>253.67 ***</td>
<td></td>
</tr>
<tr>
<td>C for B2 (Time for Grade 4)</td>
<td>2</td>
<td>253.60 ***</td>
<td></td>
</tr>
<tr>
<td>C for B3 (Time for Grade 5)</td>
<td>2</td>
<td>298.83 ***</td>
<td></td>
</tr>
<tr>
<td>C for B4 (Time for Grade 6)</td>
<td>2</td>
<td>387.93 ***</td>
<td></td>
</tr>
<tr>
<td>C for B5 (Time for Grade 7)</td>
<td>2</td>
<td>334.40 ***</td>
<td></td>
</tr>
<tr>
<td>C for B6 (Time for Grade 8)</td>
<td>2</td>
<td>344.38 ***</td>
<td></td>
</tr>
<tr>
<td>Error (within)</td>
<td>48</td>
<td>2.58</td>
<td></td>
</tr>
</tbody>
</table>

***F .99 (5,144) = 3.11 ***F .99 (2,48) = 5.10
interval in Stage I was chosen as a measure of variability for reasons of simplicity in computation. The analysis of intra-subject ranges is summarized in Table 3. This analysis indicated that the time interval effects were a statistically significant source of variation at the .01 level of confidence. This means that the variability of reproduced intervals is greater at longer intervals than at shorter ones. Grade effects were found to be statistically significant at the .10 level. The $F$ ratios for the other main effects and interactions were non-significant.

The Newman-Keuls procedure was used to test the differences among the totals of ranges in grades three through eight. Totals of ranges of both grades three and four differed significantly (at the .05 level) from totals of ranges in grades five, six, seven and eight. A test for trends of grade totals of ranges yielded a linear relationship ($F = 18.99$), significant at the .01 level of confidence. No significant non-linear component was found.
TABLE 3
Analysis of Variance of Ranges of Reproductions Obtained During Trials in Stage I

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>df</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Between Subjects</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A (Sex)</td>
<td>1</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>B (Grade)</td>
<td>5</td>
<td>16.53</td>
<td>4.59***</td>
</tr>
<tr>
<td>AB (Sex x Grade)</td>
<td>5</td>
<td>6.74</td>
<td></td>
</tr>
<tr>
<td>Error between</td>
<td>48</td>
<td>3.60</td>
<td></td>
</tr>
<tr>
<td><strong>Within Subjects</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C (Time Interval)</td>
<td>2</td>
<td>266.08</td>
<td>129.17***</td>
</tr>
<tr>
<td>AC (Sex x Time Interval)</td>
<td>2</td>
<td>5.42</td>
<td>2.63*</td>
</tr>
<tr>
<td>BC (Grade x Time Interval)</td>
<td>10</td>
<td>3.32</td>
<td></td>
</tr>
<tr>
<td>ABC (Sex x Grade x Time Interval)</td>
<td>10</td>
<td>2.65</td>
<td></td>
</tr>
<tr>
<td>Error within</td>
<td>96</td>
<td>2.06</td>
<td></td>
</tr>
</tbody>
</table>

***F .99 (5,48) = 3.43  *F .90 (2,96) = 2.42
***F .99 (2,96) = 4.90
Figure 3: Profile of simple effects of time interval for level of grade in reproduction (Stage I).

Figure 4: Profile of simple effects of sex x time interval interaction.
Figure 5: Graph of mean reproductions and mean ranges of reproductions by time intervals. (Stage I) (vertical lines represent magnitudes of ranges).
Figure 6: Graph of mean reproductions and mean ranges by grades in Stage I (vertical lines represent magnitude of ranges).
The summary of analysis of simple effects of the sex x time interval interaction appears in Table 4. The effects of variation of time interval was significant for both male and female Ss at the .01 level. Differences between ranges of males and females were statistically significant (at the .05 level) in reproduction of the 15 second interval. There were no significant sex differences in reproduction of two and eight second intervals.

Stage II

The means of reproduced time intervals obtained by Ss during Stage II were calculated. A Pearson Product-Moment correlation of means for 2, 8, and 15 second intervals obtained in Stages I and II yielded a reliability coefficient of .96. This indicates that the ability to reproduce short-time intervals in this procedure was extremely reliable over a period of two weeks.

Analysis of the results of the questionnaire, which was administered following Stage II, indicated
TABLE 4

Analysis of Variance for Simple Effects of Sex x Time Interval Interaction

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>df</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>A for C1 (Grade for 2 second interval)</td>
<td>1</td>
<td>.38</td>
<td></td>
</tr>
<tr>
<td>A for C2 (Grade for 8 second interval)</td>
<td>1</td>
<td>.84</td>
<td></td>
</tr>
<tr>
<td>A for C3 (Grade for 15 second interval)</td>
<td>1</td>
<td>10.63</td>
<td>3.03*</td>
</tr>
<tr>
<td>Error (pooled)</td>
<td>144</td>
<td>2.64</td>
<td></td>
</tr>
<tr>
<td>C for A1 (Time Interval x Male)</td>
<td>2</td>
<td>167.62</td>
<td>***</td>
</tr>
<tr>
<td>C for A2 (Time Interval x Female)</td>
<td>2</td>
<td>103.86</td>
<td>***</td>
</tr>
<tr>
<td>Error (within)</td>
<td>48</td>
<td>3.59</td>
<td></td>
</tr>
</tbody>
</table>

***F_{.99} (2,48) = 5.10

*F_{.90} (1,144) = 2.74
that very few Ss were unable to answer correctly the questions concerned with the use of time units (i.e. questions 1 through 5). No subject above grade four answered any of these questions incorrectly.

The results of responses to question seven, the inquiry concerning the use of counting as an aid to reproduction appear in Table 5.

### Table 5

**Summary of Responses Regarding the Use of Counting in Reproduction of Time Intervals**

<table>
<thead>
<tr>
<th>Grade</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spontaneously Admitted Counting</td>
<td>Boys</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Girls</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Admitted Counting When Asked</td>
<td>Boys</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Girls</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Denied Counting When Asked</td>
<td>Boys</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Girls</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
Older Ss tended to spontaneously admit employing counting as an auxiliary to reproduction, whereas younger Ss tended not to. Older Ss, when asked "What did you count?", tended to admit counting seconds. Several of the grade seven and grade eight students asked specifically if they were allowed to count prior to testing proper.

Productions of a one second interval tended to show extremely high intra-subject and inter-subject variability throughout the entire grade range of Ss. Generally estimates were greatly under-estimated. For example, the mean production of grade eight Ss was found to be .65 seconds and the inter-subject range of estimates was 3.26 seconds. This means that even the oldest Ss in this investigation were not able to estimate a one second interval accurately. However, analysis of variance of mean productions of a one second interval indicated that females tended to produce significantly longer estimates than males (at the .05 level). No grade differences were observed.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
TABLE 6
Analysis of Variance of Means Obtained in Production of a One Second Interval

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>df</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (Sex)</td>
<td>1</td>
<td>6.47</td>
<td>4.07*</td>
</tr>
<tr>
<td>B (Grade)</td>
<td>5</td>
<td>2.59</td>
<td></td>
</tr>
<tr>
<td>AB (Sex x Grade)</td>
<td>5</td>
<td>1.07</td>
<td></td>
</tr>
<tr>
<td>Within cell</td>
<td>48</td>
<td>1.59</td>
<td></td>
</tr>
</tbody>
</table>

*F.99 (1,48) = 4.04

Stage III

The reproduced length of line for each time interval was measured for each subject and the mean lengths over three trials were calculated for each S. The three-way analysis of variance with sex, grade and time interval as main effects, summarized in Table 7, indicated that the effects due to time interval were statistically significant at the .01
### TABLE 7

Analysis of Variance of Means of Spatial Representations of Time Intervals (Stage III)

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>df</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Between Subjects</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A (Sex)</td>
<td>1</td>
<td>1.10</td>
<td></td>
</tr>
<tr>
<td>B (Grade)</td>
<td>5</td>
<td>152.29</td>
<td>2.25*</td>
</tr>
<tr>
<td>AB (Sex x Grade)</td>
<td>5</td>
<td>240.76</td>
<td>3.55***</td>
</tr>
<tr>
<td>Error within</td>
<td>48</td>
<td>67.73</td>
<td></td>
</tr>
</tbody>
</table>

| **Within Subjects**               |    |        |      |
| C (Time Interval)                 | 5  | 1395.06| 62.45***|
| AC (Sex x Time Interval)          | 5  | .40    |      |
| BC (Grade x Time Interval)        | 25 | 17.69  |      |
| ABC (Sex x Grade x Time Interval) | 25 | 18.97  |      |
| Error between                     | 240| 22.34  |      |

* $F_{.90} (5,48) = 1.98$  
*** $F_{.99} (5,240) = 3.02$  
*** $F_{.99} (5,48) = 3.43$
level of confidence. A sex x grade interaction, significant at the .01 level, was found. The effects of the grade factor were significant (at the .10 level). The F ratios for all other main effects and interaction effects were non-significant. The interaction of sex x grade effects appears in Figure 7.

![Figure 7: Profile of simple effects of sex x grade interaction of reproduced means (Stage III).]
A test for trends of totals among grade groups for male Ss, female Ss, and combined male and female Ss was carried out. A significant quadratic trend \((F = 7.06)\), significant at the .05 level was found among male grade groups and a linear trend \((F = 3.08)\), significant at the .10 level, was found among female grade groups. A significant quadratic trend \((F = 5.16)\), significant at the .05 level was indicated among grade groups for combined totals of both male and female Ss. No other statistically significant trends were found.

The conclusion may be drawn from this trend analysis, that the grade by grade development is different for males and females in this reproduction task. Especially notable were the extremely long reproductions of grade five male Ss.

To assess the accuracy of mean reproductions in Stage III, the discrepancies of the means from the standard interval was calculated for Stage III data. Since some of the means were of negative value with respect to the standard, meaning that these means were under-estimated with respect to the length of the
standard, a constant value of ten seconds was added to all scores to transform all scores to a positive value.

Analysis of variance of these transformed discrepancies of means from the standard was carried out. The results of this analysis appear in Table 8. The grade effects (F=2.23), significant at the .10 level were indicated. There was a significant interaction of effects of sex and grade (F=3.65) at the .01 level of confidence. There were highly significant grade x time interval and sex x grade x time interval interactions, significant at the .01 level. Figure 8 shows the profile of simple effects of the sex x grade interaction.

A trend analysis of transformed means by grades for male Ss, female Ss, and combined male and female Ss was carried out.

The totals of males indicated a non-significant linear trend but a quadratic relationship was found among grade groups (F=6.03), which was significant at the .05 level. On the other hand, the female totals
TABLE 8
Analysis of Variance of Transformed Durations of Means from the Standard Interval During Spatial Representation of Time Intervals (Stage III)

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>df</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Between Subjects</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A (Sex)</td>
<td>1</td>
<td>5.16</td>
<td></td>
</tr>
<tr>
<td>B (Grade)</td>
<td>5</td>
<td>149.28</td>
<td>2.23**</td>
</tr>
<tr>
<td>AB (Sex x Grade)</td>
<td>5</td>
<td>244.61</td>
<td>3.65***</td>
</tr>
<tr>
<td>Error between</td>
<td>48</td>
<td>67.07</td>
<td></td>
</tr>
<tr>
<td><strong>Within Subjects</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C (Time Interval)</td>
<td>5</td>
<td>8.60</td>
<td>1.39</td>
</tr>
<tr>
<td>AC (Sex x Time Interval)</td>
<td>5</td>
<td>.95</td>
<td></td>
</tr>
<tr>
<td>BC (Grade x Time Interval)</td>
<td>25</td>
<td>22.39</td>
<td>3.63***</td>
</tr>
<tr>
<td>ABC (Sex x Grade x Time Interval)</td>
<td>25</td>
<td>23.96</td>
<td>3.88***</td>
</tr>
<tr>
<td>Error within</td>
<td>240</td>
<td>6.17</td>
<td></td>
</tr>
</tbody>
</table>

**F.99 (5,48) = 3.43**

**F.90 (5,48) = 1.98**

**F.99 (25,240) = 1.79**

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
Figure 8: Profile of simple effects of sex x grade interaction of transformed discrepancies of means from standard (Stage III).
indicated a linear trend ($F = 2.87$), significant at the .10 level but a non-significant quadratic trend was found. Trend analysis of combined male and female totals by grades indicated a non-significant linear trend and a quadratic trend ($F = 5.39$) which was significant at the .05 level of confidence. From these analyses of trends, the following may be concluded: (1) that the relationship of totals by grades, with respect to accuracy of reproductions, is different for males and females; (2) that the development of ability to reproduce time intervals accurately, as the grade of Ss increases, is not uniform. It appears that the extremely long reproductions of grade four male Ss contributed most to the quadratic relationships found.
CHAPTER IV

DISCUSSION OF RESULTS

This study attempted to investigate the following: (1) the developmental differences of children in grades three through eight in reproducing short time intervals; (2) the developmental differences of children in translating short time into spatial representations (i.e., drawing straight lines); (3) the reliability in reproduction of short time intervals over testing sessions; (4) the development of the child's notion of the length of a one second interval by the method of production; (5) the existence of sex differences in reproductions of short time intervals and in productions of a one second interval; (6) the age at which the child begins to employ counting as an auxiliary aid in the reproduction of short time intervals.

Grade differences in mean reproduction were noted. It was expected, on an a priori basis, that with increasing age of subjects, the mean reproductions
would more closely approximate the length of the standard interval. In Stage I, since grade six subjects most closely approximated the standard interval, the a priori expectation was not supported. However, in Stage III the expectation was supported. Variability of reproductions, however, decreased with age.

There were no overall sex differences in analysis of results in the first and third stages. There were, however, highly significant sex differences in the third stage, when these were considered with respect to grade level. Significant sex differences were also found in mean productions of a one second interval, with female subjects producing longer estimates than male subjects.

No significant differences were noted among grade levels in mean productions. There was generally a considerable underestimation of the standard in both male and female subjects and a great variability of productions throughout the entire grade range.
Older subjects tended to employ counting as an aid in reproduction.

The fact that there was only a minimal change in magnitude of means over grades three through eight in Stage I, together with the fact that significant changes in variability about the means did occur, emphasizes the need for measures of both central tendency and variability in assessing differences in developing ability to reproduce time intervals.

Since both measures of central tendency and variability of grade seven and grade eight subjects indicate a decrement, the question is raised whether another factor, not within experimental control, was operating to contribute to this decrement. Additionally it is possible that there is some genuine developmental consideration to be investigated to account for it.

The distinct impression was that the general style and bearing of subjects in this sample chosen from grade seven and grade eight was somewhat dull and subdued compared with subjects in lower grades. Several possibilities are presented, in the light of these
doubts, to account for the observed decrement, which remains for further investigation before conclusions may be drawn. Such possibilities are decreased attention, lack of intelligence, and lack of proper motivation. It is suggested that future studies specifically control for such factors or employ greater numbers of subjects to randomize their effects.

Concerning the results of analysis of Stage III, similar questions are raised about the factors operating to account for the extremely long grade five reproductions of male subjects and somewhat long grade six female reproductions, which must be investigated before adequate conclusions can be reached concerning development in this reproduction task. Analysis of the seating plan of the testing situation does not reveal any obvious social communication for comparison of lines among these individuals, but this cannot be excluded as a possibility to be considered in future research.
Since subjects of grade five and six were tested together, and a strikingly jovial atmosphere prevailed with this group, there is a question whether this atmosphere contributed in a significant way to diffusing of attention required for the task. A meaningful motivation may be advisable in the future, in order to render such vicissitudes as atmosphere and experimenter effects constant.

Since the method of reproduction has been criticized by such investigators as Clausen (1950) and DuPreez (1964) as being not very reliable from session to session, it is particularly interesting to note that in Stages I and II, a test-retest reliability of .96 was obtained between test sessions spaced two weeks apart. It is to be noted that this high reliability may be in part attributable to the fact that scores for the three time intervals were not correlated separately, but rather, were computed in the same correlation. Regardless, it appears that the obtained correlation is sufficiently high to warrant the conclusion that the scores obtained by this method
of reproduction are reliable from session to session. Furthermore, it is regretted that, due to administrative considerations within the school, it was not possible to retest in the Stage III task, so that a measure of reliability over time could be provided.

The admission of the use of counting as an auxiliary aid in reproduction was given by the majority of subjects, either spontaneously or following direct inquiry. The question that is raised, in the light of this fact, is as follows: Is reproduction really reproduction if the subject counts using conceptualized time units such as a second? It would seem that the case of reproduction using counting as an aid may be, in effect, another sub-category of the method of production or, at least, an intermediate category between the method of reproduction and the method of production.

Since there was considerable underestimation and wide intra-subject and inter-subject variability in productions of a one second interval, it is clear that subjects in the grades between three and eight
have not attained either a stable or accurate notion of the length of one second. Upon questioning it was found that when subjects were asked for the highest and lowest numbers counted during the task, the range of numbers tended to be two or three times as high as the number of seconds of the standard interval. The fact that subjects counted so fast (if they counted at all) seems to suggest that subjects in this grade range tend to put their trust in the regularity of beats of the rhythm rather than in the rudimentary time unit which represents the interval between beats. By increasing the numbers counted, one may decrease the uncertainty regarding the interval between beats. It is suggested that older subjects may decrease the number of units counted during reproduction to the degree that the notion of what constitutes one second becomes more stable and accurate. This remains to be investigated.

At least as interesting as the group results were the individual differences in approach during the reproduction task of Stages I and II. In one
subject there was a pronounced foot tapping observed. Questioning elicited the fact that this young subject was a skilled musician and the accuracy and reliability of his reproductions reflected this skill. Finger tapping was observed in several subjects. One subject reported holding his pulse, a fact which indicates an implicit awareness of the need for some type of anchor upon which to base reproductions. Another subject mentioned that he had used the second hand of his watch. This subject was removed from the study and an amendment to the instructions concerning removal of watches was made. Several other subjects manifested the idiosyncracy of persistently peeking around the testing apparatus during the task, presumably either to satisfy curiosity about the testing apparatus or to gain cues from the experimenter. Such individual differences in approach suggest that the number and nature of cues which are integrated during reproductions are very numerous and complex.

Since it was within the purpose of this study to evaluate the method of reproduction as a technique
for studying development of ability to estimate time intervals, it is suggested, in the light of the results of this investigation, that this method shows promise of adequacy. Firstly, it appears to be manageable for all grade three subjects. Indications are that the task would not be too difficult for lower grades. Secondly, the method of reproduction in Stage I is highly reliable between sessions two weeks apart. The test-retest reliability for the reproduction task in Stage III remains to be investigated. If sufficient reliability for this task can be demonstrated, this reproduction task will offer the advantage of possibility for mass testing for the establishment of age norms upon which to base further investigations regarding the underlying cognitive mechanisms in the development of this ability.
CHAPTER V
SUMMARY AND CONCLUSIONS

This study investigated the development of ability of children in grades three through eight to reproduce short time intervals using two methods of reproduction. In the first method of reproduction the subject was required to press a buzzer for the same duration as that of the auditory stimulus. In the second method the subject was required to draw a straight line to represent the length of the auditory stimulus. Sex differences in reproduction were investigated. An evaluation of the reliability of the first method of reproduction over sessions and an evaluation of the method of reproduction as a technique for studying the development of time perception was presented.

The experimental group consisted of 60 subjects, 30 males and 30 females, drawn from grades three through eight who were tested in three stages. In the first stage, the subjects were required to
reproduce time intervals of two, eight and fifteen seconds using an auditory stimulus. The second stage, identical to the first was carried out two weeks after the first, so that a measure of reliability over sessions could be obtained. Following the second stage, a questionnaire was verbally administered to determine the facility of use of common time concepts, the ability to produce a one second interval, and whether the auxiliary aid of counting was employed during the reproduction task. In the third stage, the subjects were required to reproduce time intervals of two, four, six, eight, ten and fifteen seconds by drawing a straight line to present the duration of the auditory stimulus.

In the first stage, analysis of scores of central tendency (means) indicated minimal evidence of development. However, analysis of variance of variability scores yielded significant grade differences with less variability being manifest in older subjects. Significantly longer reproductions were found when longer stimulus time intervals were used.
Reproduced lengths of intervals approximated Weber's Law. For only the fifteen second interval were sex differences observed, with males making the longer reproductions.

The reliability of reproductions over the first two stages was very high. It was found that subjects were generally able to use common time concepts, but had a very inaccurate notion of the length of a one second interval. However, female subjects made significantly longer productions of a one second interval than male subjects. With increasing age of subjects, there was increasing tendency to employ counting as an auxiliary aid during reproduction.

In the third stage significant grade, time interval and sex by grade interactions were observed with extremely high scores being found in grade five males and grade six females.

Shortcomings in experimental control were discussed for future research.
BIBLIOGRAPHY


VITA AUCTORIS

1941

1944-61

1966
Graduated with Honours B.A. in Psychology from the University of Windsor. Enrolled as full-time graduate student at the University of Windsor

52