Written Versus Tape Recorded Presentation of a Short Intelligence Test: Differences in Reliability and Validity

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WRITTEN VERSUS TAPE RECORDED PRESENTATION
OF A SHORT INTELLIGENCE TEST;
DIFFERENCES IN RELIABILITY AND VALIDITY

BY

DENNIS ROY WELLER
B.E., Vanderbilt University, 1967

THESIS

Submitted in partial fulfillment of the requirements
for the degree of Master of Science
in the Graduate Studies Program of
Florida Technological University

Orlando, Florida
1973
Acknowledgement

I would like to express my appreciation to the members of my committee, Dr. F. D. Frank, Dr. W. A. Burroughs, and Dr. E. C. Shirkey for their guidance and advice throughout the course of this study.

I would also like to thank Miss Nancy L. Hartman for her encouragement and assistance in the preparation of this thesis.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIST OF TABLES</td>
<td>v</td>
</tr>
<tr>
<td>Introduction</td>
<td>1</td>
</tr>
<tr>
<td>Preliminary Study</td>
<td>7</td>
</tr>
<tr>
<td>Main Study</td>
<td>20</td>
</tr>
<tr>
<td>Method</td>
<td></td>
</tr>
<tr>
<td>Results</td>
<td></td>
</tr>
<tr>
<td>Discussion</td>
<td></td>
</tr>
<tr>
<td>Appendix A</td>
<td>38</td>
</tr>
<tr>
<td>Appendix B</td>
<td>39</td>
</tr>
<tr>
<td>Appendix C</td>
<td>48</td>
</tr>
<tr>
<td>Appendix D</td>
<td>55</td>
</tr>
<tr>
<td>Appendix E</td>
<td>62</td>
</tr>
<tr>
<td>Appendix F</td>
<td>69</td>
</tr>
<tr>
<td>References</td>
<td>76</td>
</tr>
<tr>
<td>VITA</td>
<td>78</td>
</tr>
</tbody>
</table>
# LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Mean Item Difficulties: Math Items</td>
<td>15</td>
</tr>
<tr>
<td>2. Mean Item Difficulties: Verbal Items</td>
<td>16</td>
</tr>
<tr>
<td>3. Means and Standard Deviations of Test Scores and Grade Point Averages</td>
<td>23</td>
</tr>
<tr>
<td>4. Score Differences Between Form A and Form B</td>
<td>24</td>
</tr>
<tr>
<td>5. Mean Score Differences Between Tape and Written Administration Modes</td>
<td>26</td>
</tr>
<tr>
<td>6. Alternate Forms Reliabilities</td>
<td>28</td>
</tr>
<tr>
<td>7. KR-20 Internal Consistency</td>
<td>29</td>
</tr>
<tr>
<td>8. Validity: Test Scores Versus Grade Point Average</td>
<td>30</td>
</tr>
<tr>
<td>9. Validity: Test Scores Versus Grade Point Average, Corrected for Test Unreliability</td>
<td>33</td>
</tr>
</tbody>
</table>
Short, written intelligence tests, such as the Otis Quick Scoring Mental Abilities Tests and the Wonderlic Personnel Test, are in wide use in industrial, educational, counseling, and other settings. The advantages of such tests over longer and more complex intelligence tests are many, and include: shorter administration and scoring time, ease of scoring, and little need for highly trained administrators. One major drawback of the shorter tests, however, is their lower reliability and validity when compared to longer tests of similar content.

One reason for the lower reliability of shorter tests is explained by Magnusson (1967, p. 72) as follows: "Reliability is determined by the proportion of the total variance which is made up of the true score variance.... when the test increases in length, the true variance represents a greater share of the total variance. This in turn means that the test will become more reliable." The length Magnusson refers to is in terms of the number of items, not time.

The lower validity of shorter tests is primarily the result of their lower reliability. Low reliability tends to obscure, or attenuate, the relationship between test scores and a criterion. The nature of the relationship between reliability and validity can be seen in the

It is therefore of importance to investigate methods of increasing the reliability and validity of such tests without increasing their administration time. The method investigated in this study is the administration of test items by sound tape recording.

Tape administration should have an effect on two factors which are known to be related to reliability. One factor is the number of items (length) mentioned above. The other factor is the standardization of test conditions.

Tape administration should result in a larger number of items attempted by the average subject than written administration. In the typical short intelligence test, the average subject does not attempt all of the items on the test. For example, in research with the Personnel Research Institute Classification Test, a 15 minute multiple-choice test, only four percent of the college level subjects attempted all of the items before the time limit (J. R. Glennon in Buros, 1965, p. 485). Therefore, there is a discrepancy between the number of items on the test and the number of items attempted by the average subject. In a taped format, however, each person would be exposed to every item on the test and, in effect, each item would be attempted, assuming that there is sufficient time for the comprehension of each item. Thus, the average number of items attempted in the taped format would be equal to the total
number of test items, leading to a higher reliability.

The reliability of a test can also be expected to increase as its administration becomes more standardized. Tape administration can be expected to increase the standardization of testing conditions. In the typical written format, the entire test, or large parts thereof, are timed; and many decisions regarding the taking of the test are left to the discretion of the examinee. For instance, the examinee is free to decide how much time to allot to various types of items, and even to vary the time spent on similar items on various parts of the test. Heckman, Tiffin, and Snow (1967), for example, found a tendency for subjects to spend a decreasing amount of time on each item of a multiple-choice achievement test as the time limit came nearer. This could lead to decreased reliability as a result of increased chance responding (causing increased error variance) near the end of the test. With tape administration, however, the time allotted for each item would be the same for each subject, and subjects would not be free to vary the amount of time spent on similar items on various parts of the test. Furthermore, any variance due to differences between test administrators would also be decreased by tape administration.

Tape administration should result in higher validity for two reasons. First, any increases in reliability should be accompanied by increases in validity. Second, the increased standardization of the tape format could be
expected to have a direct effect on validity. In the typical written test, each subject is free to solve a given item in any way he chooses. Therefore, different subjects can apply different skills and knowledges to the solution of a single item. The tape format, however, assures that each subject is limited to the same amount of time for each item. This time limitation will reduce, to some extent, the variety of skills and knowledges which subjects can apply to a single item. Therefore, a given item in the tape format should measure the same ability across subjects to a greater extent than the same item in the written format. For validity purposes, it is important that a test measure the same attributes in all persons who take it. Therefore, the tape format should have a higher validity.

Little research has been published on taped objective tests. One such test, the Oral Directions Test, has been used in industry. It is a thirty-item test with a thirty minute time limit containing a wide variety of items. No data is available on test-retest or alternate forms reliability. The test manual (Langmuir, 1969) reports a number of odd-even reliability studies which yield an average reliability of .77. No written form of the test is available, so it is not possible to compare the reliability or validity across the two modes of administration.

Several studies have compared written, taped, slide presented, and combination slide and tape presented tests given to grade school children (Ferris & Nichols, 1969;
Burr, 1963; Curtis & Kropp, 1961). These studies presented no reliability or validity data, but they generally found that total test scores did not differ significantly between modes of administration. Studies comparing tape recorded and written presentations of the Minnesota Multiphasic Personality Inventory (Urner, Clark, & Wendland, 1960; Wolf, Freiner, & Schaffer, 1964) also presented no reliability or validity data, but generally found no significant differences in scale scores between the two modes of administration.

In the preceding studies, the failure to find significant differences in test scores between taped and written formats suggests that the two modes of administration are roughly equivalent. However, this finding provides no evidence concerning differences in reliability or validity between the two modes.

A study by Heckman, Tiffin, and Snow (1967) compared written and slide presented formats for an achievement test given to college students. Once again, no significant difference was found in total test scores between the two modes of administration. However, the slide presented form was found to have a higher internal consistency (KR-20). Since taped and slide presented tests have many features in common, this result might be considered a minor piece of evidence in favor of higher reliability for tape administered tests.

Taken as a whole, the previous research offers little evidence regarding the relative advantages of a tape
administered intelligence test.

The main hypotheses of this study are that a short, multiple-choice intelligence test will have a higher reliability, as measured by the alternate forms method, and a higher validity, with respect to college grade point average, when administered by tape recording as opposed to the usual written fashion.
Preliminary Study

A preliminary study was carried out for the purpose of developing the instruments to be used in the main study. This study was designed to develop two equivalent forms of a short, multiple-choice intelligence test.

Method

Item Selection

It was decided to use items similar to those found on standard, short, intelligence and personnel tests. The Otis Quick Scoring Mental Abilities Test, the Wonderlic Personnel Test, the Wesman Personnel Classification Test, and others were examined for types of items which appeared adaptable to tape presentation. Three general types of items were used. These were mathematical items, consisting of short mathematical problems; and verbal items, consisting of synonyms and opposites.

One hundred short mathematical problems were written to cover the following areas: addition, subtraction, multiplication, and division with whole numbers; operations with fractions; operations with decimals; operations with percentages; powers and roots; and simple algebra. For each specific item type (for example, addition of simple fractions), four similar items were written. This was done to provide a sufficient number of items for later separation into two alternate forms.

Words for the verbal items were selected from The Teacher's Word Book of 30,000 Words (Thorndike & Lorge, 1944).
This book presents the frequency of occurrence, in a variety of printed matter, of 30,000 of the more common English words. Twenty words were selected from each of the following categories:

(a) words occurring 5 times per 18,000,000 words,
(b) words occurring 10 times per 18,000,000 words,
(c) words occurring 1 time per 18,000,000 words,
(d) words occurring 5 to 10 times per 1,000,000 words,
(e) words occurring over 15 times per 1,000,000 words.

This was done to obtain a substantial range of difficulty, and to facilitate later division of items into alternate forms.

From each group of 20 words, 10 were selected for synonym items and 10 for opposite items. This resulted in a total of 50 synonym items and 50 opposite items, or 100 verbal items in all. Correct responses for these items were selected with the help of Webster's New Collegiate Dictionary (1961) and Webster's Dictionary of Synonyms (1951).

For each of the 200 items, three incorrect alternatives were written. The correct alternative for each item was randomly assigned to one of the four possible positions. The actual items and alternatives can be seen on the written test forms from the main study, Appendix C and Appendix D. The correct alternatives are marked by asterisks.
Interval Selection

Before making up the final test forms, it was necessary to obtain data on the difficulty of each item at various response intervals. The response interval is the time period during which the subject must select and mark an alternative, and is defined as the elapsed time between the last word of an item and the first word of the next item. The 200 items were recorded on three preliminary tapes to investigate the effects of various response intervals on item difficulties. A general assumption in this preliminary study was that the items would become more difficult as the response intervals were shortened.

The strategy in the preliminary study was to vary the response interval for each item in order to find an interval at which approximately half of the subjects would be able to solve the item. This was done to avoid items which were either extremely easy or extremely difficult, since such items would add little to test score variance.

Subjects. Subjects for the preliminary study were undergraduate psychology students at Florida Technological University. They participated in the study to fulfill a course requirement. Seventy-six subjects participated.

Procedure. The procedure was the same for all three preliminary tapes. Testing was done in a small room, capable of seating 16 subjects. A good quality tape recorder (Wollensak, Model 6200) was used, and two extension speakers were placed at opposite sides of the room to provide
uniform sound level.

The tests were administered to groups of subjects ranging in size from 1 to 14. Subjects were given printed answer sheets which included the instructions, sample items, and the four alternatives for each of the 200 test items. The alternatives were presented in the same manner as in the main study, tape forms, which are presented in Appendix E and Appendix F.

After the subjects had read the instructions, any questions which they had were answered. Then the sample items were presented via tape recording. After a short pause, the test itself was administered. The subjects heard each item on tape, and then responded by circling the letter in front of one of the alternatives for that item on the answer sheet.

Tape format. Each of the three preliminary tapes included the 200 items in the following order: 50 mathematical problems, 50 synonyms, 50 mathematical problems, 50 opposites. For each item, the tape included the item number, the item, and a blank space corresponding to the response interval. At the end of each response interval, a short tone appeared on the tape to warn the subjects that the next item was about to begin. Details of the procedure used to record these tapes are given in Appendix A.

At the beginning of each 50 item group, one of the following statements appeared on the tape: "The next 50 items are mathematical problems", "For the next 50 items,
select the word which has the same meaning as the word you hear", "For the next 50 items, select the word which has a meaning opposite to the word you hear". These same statements were printed on the answer sheets at the beginnings of the appropriate groups of items. The answer sheets for preliminary tapes II and III also had the response intervals printed on them at the beginnings of the appropriate groups of items. Specific details of the format of each tape are given below.

Tape I was recorded with a five-second response interval for each of the 200 items. It was administered to 28 subjects. The degree of difficulty for each item was determined (degree of difficulty = the number of subjects responding correctly, divided by the total number of subjects). The number of subjects responding correctly to each item was corrected for guessing by the following formula (Magnusson, 1966, p. 229):

$$R = F_i - \frac{F}{m - 1}$$

where:

$R$ = the number of subjects who know the solution to item $i$.

$F_i$ = the number of subjects recording a correct response to item $i$.

$F$ = the number of subjects who record an incorrect response to item $i$.

$m$ = the number of alternative responses.
Tape II was recorded with either a three-second, four-second, or seven-second response interval for each item based on the data from Tape I as follows:

(a) If the degree of difficulty for an item was .82 or higher on Tape I, the item was given a three-second interval on Tape II.

(b) If the degree of difficulty for an item was between .50 and .82 on Tape I, the item was given a four-second interval on Tape II.

(c) If the degree of difficulty for an item was less than .50 on Tape I, the item was given a seven-second interval on Tape II.

The items were grouped according to response interval on Tape II, which necessitated some regrouping from Tape I. The items within each 50-item block were the same as before, but their order was changed. Overall, 71 items were given a three-second interval, 75 items were given a four-second interval, and 54 items were given a seven-second interval.

Tape II was administered to 28 subjects and the degree of difficulty was determined for each item as before, using the correction for guessing.

Tape III was recorded with either a one-second, two-second, or three-second response interval for each item, based on the data from Tape I and Tape II. Results from Tape I and Tape II indicated that very few items would benefit from intervals longer than seven seconds, so no such
intervals were used. One second was chosen as the shortest interval because it was felt that intervals shorter than one second might cause the factor of manual dexterity (in the actual marking of the answers) to influence test scores to a significant extent. Intervals were assigned to the items on Tape III according to the following rules.

For items which were given three-second intervals on Tape II:

(a) If the degree of difficulty at three seconds was greater than .82, the item was given a one-second interval on Tape III.

(b) If the degree of difficulty at three seconds was less than .82, the item was given a two-second interval on Tape III.

For items which were given four-second intervals on Tape II:

(a) If the degree of difficulty for an item was equal to or greater than .71 at both four seconds (Tape II) and five seconds (Tape I), the item was given a two-second interval on Tape III.

(b) If the degree of difficulty for an item was less than .71 at either four seconds (Tape II) or five seconds (Tape I), the item was given a three-second interval on Tape III.

Items which were given a seven-second interval on Tape II were given a three-second interval on Tape III. This interval was selected arbitrarily, since the degree of
difficulty of these items was not expected to become closer to .50 with a decrease in response interval. However, it was considered to be desirable to retain these items on the test in order to maintain the same test length.

Tape III was administered to 20 subjects, and the degree of difficulty was calculated for each item as before.

**Results.** The degree of difficulty for each item at the interval selected for the final test forms is presented in Appendix B. These intervals were chosen by a method to be explained in the following section.

Summary data concerning the effects of variations in response interval on item difficulties are presented for math and verbal items separately in Tables 1 and 2, respectively. Items are separated into five categories depending on the combination of intervals at which they were run.

The data in Table 1 generally support the assumption that items become more difficult as the response interval is shortened. In Table 2, however, the relationship is much less clearcut. In fact, the largest category, category E, shows a relationship which is the reverse of what was expected. These items appear to become less difficult as the response interval is shortened. No explanation is apparent for this finding.

**Selection of Intervals for Final Test Forms**

The response interval to be used with each item on the final test forms was selected primarily on the basis of its degree of difficulty. The preferred interval for each
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<thead>
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<th>Category</th>
<th>Number of items</th>
<th>Intervals used (sec)</th>
<th>Mean degree of difficulty</th>
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<td></td>
<td></td>
<td>3</td>
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<td>5</td>
<td>.954</td>
</tr>
<tr>
<td>B</td>
<td>12</td>
<td>2</td>
<td>.654</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
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<td>5</td>
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### TABLE 2
Mean Item Difficulties:

Verbal Items

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<th>Intervals used (sec)</th>
<th>Mean degree of difficulty</th>
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<td>.143</td>
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</table>
item was that which yielded a degree of difficulty closest to .50. As a secondary criterion, the correlation between the scores for an item at the interval which yielded a degree of difficulty closest to .50 and total test scores was calculated. If this correlation was +.10 or greater, the interval was used. If this correlation was less than +.10, the correlation was calculated for the item at the interval yielding the next best degree of difficulty. If the correlation did not improve, the first interval was used. If the correlation did improve, a decision was made concerning which interval to use based on a subjective weighing of the difference in degrees of difficulty and the difference in correlations.

This criterion of item correlations was used to avoid the problems associated with tests which have low inter-item correlations. These problems, as discussed by Magnusson (1966, pp. 218-220) and Nunnally (1967, pp. 250-254), include low reliability.

In some cases, intervals were chosen by extrapolation from the data. For instance, if all of the degree of difficulty values for an item were well above .50, a shorter interval was chosen for the final test forms. Of course, in these instances, no degree of difficulty values or correlations were determined.

The interval selected for each item can be seen on the final test forms, tape mode, presented in Appendices E and F. The degree of difficulty and correlation with total
test score for each item are presented in Appendix B, along with the degree of difficulty values found in the main study. The item numbers in Appendix B correspond to the numbers used on the final test forms. The mean degree of difficulty for all math items in the preliminary study was .61, and for all verbal items .49.

Although some items yielded no degree of difficulty values near .50, no items were dropped from the sample. It was felt that dropping items on the basis of data obtained from tape presentation might bias the final test forms in favor of the tape presentation mode.

Construction of Final Test Forms

After the response intervals had been selected for all items, the two test forms for the main study were constructed. In assigning items to the two parallel forms, the objective was to avoid any systematic differences between the forms while assuring roughly equivalent content.

Mathematical items. As mentioned before, four mathematical items of each specific type were written. From each group of four items, two were randomly selected to be on Form A of the final test, leaving the other two for Form B. The mean difficulty for the items selected for Form A was .62, while in Form B the mean difficulty was .61.

Verbal items. As mentioned before, 20 words were selected from each of five frequency levels, using the Teacher's Word Book of 30,000 Words (Thorndike & Lorge, 1944). From each group of 20 words, 10 were selected for
synonym items, and 10 for opposite items. For the final test forms, 5 items were randomly selected from each group of 10 to be on Form A, leaving the other 5 for Form B. The mean difficulty for the verbal items selected for Form A was .46, while in Form B the mean difficulty was .51.

Test format. Copies of the two resulting forms are given in Appendices C and D (as presented in the written mode) and Appendices E and F (as presented in the tape mode). Instructions in the two modes were kept as similar as possible. The order of items was the same in both modes. Items were grouped according to response interval, and the response intervals were printed on the answer sheets for the tape mode. Time limits for the various sections of the tests were given in the instructions to the written forms. These time limits were the same as the running times for the corresponding tape sections, which are given below.

Tape format. The tape recordings for the final test forms followed the same general format as the preliminary tapes. Statements appearing on the answer sheets at the beginning of each group of items, such as "The next 25 are opposites" also appeared on the tape. Running times for the four sections of the final test tape were:

Form A, math items.....5:32
Form A, verbal items....4:25
Form B, math items.....5:34
Form B, verbal items....4:26
Main Study

Method

Subjects

Subjects for this study were undergraduate psychology students at Florida Technological University. They participated in the study to fulfill a course requirement. A total of 108 subjects participated.

Procedure

Tape presentation. Testing was done in the same room as was used for the preliminary study. The equipment used was also the same. The tests were administered to subjects in groups ranging in size from 2 to 14.

Form A was administered first. Subjects read the instructions, and then any questions which they had were answered. The sample questions were then administered via tape. After a short pause, the first 50 items (math problems) were administered. Following this first group of items, the subjects read a second instruction sheet which repeated the instructions for the verbal items. Then the second 50 items (verbal items) were administered.

At the conclusion of Form A, the tests were collected and Form B was distributed. Form B was administered in the same manner as Form A, except that Form B included no sample items. Fifty-four subjects were given the tests in the tape mode.

Written presentation. Testing was done in the same room as was used for the preliminary study. A Universal
Lab Timer (Model 171) was used to time the tests. The tests were administered to groups ranging in size from 1 to 14.

Form A was administered first. Subjects read the instructions, and then any questions which they had were answered. They were then instructed to complete the sample items. Following this, they began the first 50 items of the test. When the time limit for the first 50 items had expired, the subjects turned to the second instruction sheet, which repeated the instructions for the verbal items. When they had read these instructions, they began the second 50 items.

When the time limit for the second 50 items had expired, the subjects were told to stop, and the tests were collected. Form B was then distributed and administered in the same manner as Form A, except that Form B included no sample items. The time limit for each section of the two forms was the same as the running time for the corresponding section of the tape used in the tape administration mode.

Fifty-four subjects were given the test in the written mode. Each of these subjects, as well as the subjects in the tape mode, reported their college grade point average on the test form for validity purposes.
Results

Item difficulties for all items in both modes are presented in Appendix B. The means and standard deviations of the scores on each section of the test, in both presentation modes, are presented in Table 3. It can be seen in this table that the standard deviations in the tape mode are equal to or greater than the standard deviations in the written mode for all test scores. Table 3 also contains the means and standard deviations of the grade point averages.

All of the test scores were corrected for guessing before means and standard deviations were calculated. This was done to reduce the unwanted variance in the test scores. The correction was made according to the following formula (Magnusson, 1966, p. 227):

\[ R = t_j - \frac{F}{m - 1} \]

where:

- \( R \) = the number of items which subject \( j \) has been able to solve without guessing.
- \( t_j \) = the number of items marked correctly for subject \( j \).
- \( F \) = the number of items marked incorrectly for subject \( j \).
- \( m \) = the number of alternative responses.

Table 4 presents the differences in mean scores between Form A and Form B for both presentation modes, along with the t-values and significance levels. The t-test for correlated data was used. Significance levels are based on two-tailed tests.
### TABLE 3
Means and Standard Deviations of Test Scores and Grade Point Averages

<table>
<thead>
<tr>
<th></th>
<th>Tape Administration</th>
<th>Written Administration</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Form A</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>math items</td>
<td>Mean 29.5</td>
<td>Mean 35.9</td>
</tr>
<tr>
<td></td>
<td>S.D. 9.9</td>
<td>S.D. 8.2</td>
</tr>
<tr>
<td><strong>Form A</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>verbal items</td>
<td>Mean 19.6</td>
<td>Mean 19.2</td>
</tr>
<tr>
<td></td>
<td>S.D. 7.0</td>
<td>S.D. 7.0</td>
</tr>
<tr>
<td><strong>Form A</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>total score</td>
<td>Mean 49.1</td>
<td>Mean 55.1</td>
</tr>
<tr>
<td></td>
<td>S.D. 13.0</td>
<td>S.D. 12.2</td>
</tr>
<tr>
<td><strong>Form B</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>math items</td>
<td>Mean 33.4</td>
<td>Mean 40.0</td>
</tr>
<tr>
<td></td>
<td>S.D. 9.0</td>
<td>S.D. 7.2</td>
</tr>
<tr>
<td><strong>Form B</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>verbal items</td>
<td>Mean 23.9</td>
<td>Mean 23.4</td>
</tr>
<tr>
<td></td>
<td>S.D. 7.1</td>
<td>S.D. 6.0</td>
</tr>
<tr>
<td><strong>Form B</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>total score</td>
<td>Mean 57.3</td>
<td>Mean 63.3</td>
</tr>
<tr>
<td></td>
<td>S.D. 12.5</td>
<td>S.D. 10.6</td>
</tr>
<tr>
<td><strong>Grand total</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>score</td>
<td>Mean 106.4</td>
<td>Mean 118.4</td>
</tr>
<tr>
<td></td>
<td>S.D. 24.4</td>
<td>S.D. 21.2</td>
</tr>
<tr>
<td><strong>Grade point average</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mean 2.7</td>
<td>Mean 2.6</td>
</tr>
<tr>
<td></td>
<td>S.D. .7</td>
<td>S.D. .6</td>
</tr>
</tbody>
</table>
TABLE 4
Score Differences Between Form A and Form B

<table>
<thead>
<tr>
<th></th>
<th>Tape Administration</th>
<th>Written Administration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Difference</td>
<td>t</td>
</tr>
<tr>
<td>Form B math minus Form A math</td>
<td>3.9</td>
<td>5.2 *</td>
</tr>
<tr>
<td>Form B verbal minus Form A verbal</td>
<td>4.3</td>
<td>7.0 *</td>
</tr>
<tr>
<td>Form B total minus Form A total</td>
<td>8.2</td>
<td>8.2 *</td>
</tr>
</tbody>
</table>

* p < .001.
Table 4 clearly indicates that mean scores on Form B were higher than mean scores on Form A, for both administration modes. One possible explanation is that Form B was actually easier than Form A. The average difficulty values from the preliminary study do not generally support this explanation. The average degree of difficulty for math items was virtually the same across forms (.62 for Form A and .61 for Form B), while there was only a small difference in average degree of difficulty for verbal items (.46 for Form A and .51 for Form B).

A more likely explanation for the score differences across the two forms is the presence of a practice effect. This explanation is supported by the fact that there was only a short interval between the two forms. It is also supported by the consistency of the mean score increases, since both verbal and math scores went up by approximately four points from Form A to Form B, in both modes.

Table 5 presents the difference in mean scores between the two presentation modes, along with the t-values and significance levels (based on two-tailed tests). This table indicates that subjects' math scores were significantly higher in the written presentation mode than in the tape presentation mode, but that no significant difference existed on verbal scores. Also, the difference in grade point average between the two groups was not significant.
### TABLE 5

Mean Score Differences
Between Tape and Written Administration Modes

<table>
<thead>
<tr>
<th>Score</th>
<th>Difference: tape mode minus written mode</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Form A math</td>
<td>-6.4</td>
<td>3.6 **</td>
</tr>
<tr>
<td>Form A verbal</td>
<td>+0.4</td>
<td>0.3</td>
</tr>
<tr>
<td>Form A total</td>
<td>-6.0</td>
<td>2.5 *</td>
</tr>
<tr>
<td>Form B math</td>
<td>-6.6</td>
<td>4.1 **</td>
</tr>
<tr>
<td>Form B verbal</td>
<td>+0.5</td>
<td>0.4</td>
</tr>
<tr>
<td>Form B total</td>
<td>-6.0</td>
<td>2.7 **</td>
</tr>
<tr>
<td>Grand total</td>
<td>-12.0</td>
<td>2.7 **</td>
</tr>
<tr>
<td>Grade point average</td>
<td>+0.1</td>
<td>0.6</td>
</tr>
</tbody>
</table>

* p < .05  
** p < .01
Reliability

Table 6 presents the alternate-forms reliabilities of the total and part scores for both presentation modes. These values were obtained by correlating a given score on Form A with the corresponding score on Form B. All scores were corrected for guessing before the correlations were calculated.

Greater reliability was obtained in the tape mode for all scores. However, only the verbal score shows a significantly higher reliability ($z = 2.2, p < .05$). The significance of the differences was tested by first taking the square root of each reliability in order to obtain an estimate of the correlation between test scores and true scores, and then applying one-tailed tests to the resulting values, using Fisher's $r$ to $z$ transformation.

Table 7 presents internal consistency data determined by the Kuder-Richardson Formula 20 (KR-20). No differences of practical significance were found in KR-20 values between the two presentation modes.

Validity

Table 8 presents the validity data. Each value in the table represents the correlation between a particular test score and college grade point average. The grade point averages, as mentioned before, were obtained by having the subjects report their own averages on their test forms. It is recognized that there is a possibility of error and falsification in these self reports. However, it is assumed
TABLE 6
Alternate Forms
Reliabilities

<table>
<thead>
<tr>
<th>Score</th>
<th>Reliability: tape mode</th>
<th>Reliability: written mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>Math</td>
<td>.832</td>
<td>.810</td>
</tr>
<tr>
<td>Verbal</td>
<td>.799</td>
<td>.580</td>
</tr>
<tr>
<td>Total</td>
<td>.837</td>
<td>.719</td>
</tr>
</tbody>
</table>
### TABLE 7

**KR-20**

**Internal Consistency**

<table>
<thead>
<tr>
<th>Score</th>
<th>KR-20 tape mode</th>
<th>KR-20 written mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>Form A math</td>
<td>.912</td>
<td>.924</td>
</tr>
<tr>
<td>Form A verbal</td>
<td>.875</td>
<td>.891</td>
</tr>
<tr>
<td>Form A total</td>
<td>.907</td>
<td>.924</td>
</tr>
<tr>
<td>Form B math</td>
<td>.910</td>
<td>.895</td>
</tr>
<tr>
<td>Form B verbal</td>
<td>.866</td>
<td>.827</td>
</tr>
<tr>
<td>Form B total</td>
<td>.904</td>
<td>.892</td>
</tr>
<tr>
<td>Grand total</td>
<td>.953</td>
<td>.951</td>
</tr>
</tbody>
</table>
### TABLE 8

**Validity:**

Test Scores Versus Grade Point Average

<table>
<thead>
<tr>
<th>Score</th>
<th>Tape mode</th>
<th>Written mode</th>
<th>z</th>
</tr>
</thead>
<tbody>
<tr>
<td>Form A, math</td>
<td>.313 *</td>
<td>.067</td>
<td>1.23</td>
</tr>
<tr>
<td>Form A, verbal</td>
<td>.490 ***</td>
<td>.320 *</td>
<td>1.03</td>
</tr>
<tr>
<td>Form A, total</td>
<td>.500 ***</td>
<td>.229</td>
<td>1.60</td>
</tr>
<tr>
<td>Form B, math</td>
<td>.244 *</td>
<td>.011</td>
<td>1.20</td>
</tr>
<tr>
<td>Form B, verbal</td>
<td>.478 ***</td>
<td>.077</td>
<td>2.24 *</td>
</tr>
<tr>
<td>Form B, total</td>
<td>.447 **</td>
<td>.051</td>
<td>2.17 *</td>
</tr>
<tr>
<td>Math total, Form A+B</td>
<td>.293 *</td>
<td>.043</td>
<td>1.31</td>
</tr>
<tr>
<td>Verbal total, Form A+B</td>
<td>.511 ***</td>
<td>.232 *</td>
<td>1.66 *</td>
</tr>
<tr>
<td>Grand total</td>
<td>.495 ***</td>
<td>.157</td>
<td>1.94 *</td>
</tr>
</tbody>
</table>

*p < .05

**p < .01

***p < .001
that such errors will not significantly alter the relationships between test scores and grade point average.

All validities in the tape mode are positive and significant at the .05 level or better, using one-tailed tests. Only two validities in the written mode are significant (Form A verbal and verbal total). The difference between the validity in the tape mode and in the written mode is significant for four of the test scores (Form B verbal, Form B total, verbal total, and grand total), using one-tailed tests. The z-values are presented in Table 8. These z-values were determined using Fisher’s r to z transformation.

In evaluating the data in Table 8 (and Table 9, which follows), it must be remembered that all correlations and z-values are not independent, since some of the scores which went into these correlations are the sums of other scores which are involved in other correlations.

Some of the differences in the correlations in Table 8 are partly due to differences in the reliability of the test scores. By using the correction for attenuation, it is possible to estimate the correlation between a test and a criterion which would be obtained if the test scores were perfectly reliable. The formula for this correction is given below (Nunnally, 1967, p. 218).

\[ \tilde{r}_{12} = \frac{r_{12}}{\sqrt{r_{11}} \sqrt{r_{22}}} \]

where:
\( \bar{r}_{12} \) = the estimated correlation if test scores were perfectly reliable.

\( r_{12} \) = the obtained correlation between test and criterion.

\( r_{11} \) = the reliability of the test.

Application of this formula to the data in Table 8, using the reliability data of Table 6, yielded the values in Table 9. Reliabilities of combined scores (math total, verbal total, and grand total) were estimated using the Spearman-Brown formula.

It can be seen in Table 9 that the differences which were found to be significant in Table 8 are still significant. Furthermore, one other score shows a significant difference in Table 9 (Form A total). It can be concluded from these results that the validity differences are not entirely due to reliability differences. Other factors are apparently contributing to the validity differences, such as the greater equivalence of items across subjects in the tape format which was mentioned earlier.
TABLE 9

Validity:
Test Scores Versus Grade Point Average, Corrected for Test Unreliability

<table>
<thead>
<tr>
<th>Score</th>
<th>Tape mode</th>
<th>Written mode</th>
<th>z</th>
</tr>
</thead>
<tbody>
<tr>
<td>Form A, math</td>
<td>.343 **</td>
<td>.074</td>
<td>1.43</td>
</tr>
<tr>
<td>Form A, verbal</td>
<td>.548 ***</td>
<td>.420 **</td>
<td>0.85</td>
</tr>
<tr>
<td>Form A, total</td>
<td>.547 ***</td>
<td>.270 *</td>
<td>1.70</td>
</tr>
<tr>
<td>Form B, math</td>
<td>.268 *</td>
<td>.012</td>
<td>1.33</td>
</tr>
<tr>
<td>Form B, verbal</td>
<td>.535 ***</td>
<td>.101</td>
<td>2.50</td>
</tr>
<tr>
<td>Form B, total</td>
<td>.489 ***</td>
<td>.060</td>
<td>2.40</td>
</tr>
<tr>
<td>Math total, Form A + Form B</td>
<td>.307 *</td>
<td>.045</td>
<td>1.38</td>
</tr>
<tr>
<td>Verbal total, Form A + Form B</td>
<td>.542 ***</td>
<td>.271 *</td>
<td>1.92</td>
</tr>
<tr>
<td>Grand total</td>
<td>.519 ***</td>
<td>.172</td>
<td>2.03</td>
</tr>
</tbody>
</table>

*p < .05

**p < .01

***p < .001
Discussion

The hypotheses of this study were that taped presentation of a short, multiple-choice intelligence test would result in higher reliability and validity than written presentation. The hypothesis concerning reliability was supported for verbal scores, but not for mathematical scores. This may have been due to the fact that the verbal items had a mean degree of difficulty closer to .50 than the mathematical items (.49 versus .61, in the preliminary study). This would tend to result in a better score distribution, and higher reliability, for verbal scores.

The hypothesis concerning validity received some support for both verbal and math scores, although only verbal and combined scores showed significant validity differences across modes. Furthermore, the data indicated that the validity differences were not simply the result of the reliability differences. One possible explanation for the differences in validity is the greater equivalence of test items across subjects in the tape mode. As mentioned before, the time limitation placed on each item in the tape mode should reduce, to some extent, the variety of skills and knowledges which different subjects can apply to a given item. Thus, a given item in the tape format should measure the same ability across subjects to a greater extent than the same item in the written format, leading to higher validity.

Another possible reason for the higher validity in the tape mode is the fact that different modes of perception
were used in the two modes of presentation. Written presenta-
tion required only visual perception, while tape presenta-
tion required auditory as well as visual perception. It is possible that, for the sample of subjects used, college grades were related to auditory perception. This could explain part of the difference in validity, since the tape presentation measured this variable while the written presentation did not. A relationship between auditory perception and college grades is quite plausible, since lectures are a major part of most college courses. However, if auditory perception were a major factor in this study, it would be expected that the math items, which were the more complex stimuli, would show greater validity differences across modes than the verbal items. Actually, the greater differences were found in verbal scores. Therefore, mode of perception is probably not a primary factor in the validity differences.

A third potential explanation for the validity differences involves short-term memory. Subjects in the tape mode were required to remember the items for short periods of time while they selected their answers, while subjects in the written mode were able to refer back to the items as much as they wished. If college grades were related to short-term memory ability in the sample of subjects used, this could explain some of the validity differences, since the tape presentation measured this variable while the written presentation did not. However, as with the factor of
auditory perception, it would be expected that the math items, which are the more complex stimuli, would show greater validity differences, since verbal learning studies have shown that more complex stimuli are more difficult to retain (Martin & Roberts, 1966). Since the greater validity differences were found in verbal scores, it may be concluded that short-term memory is probably not a primary factor in this study.

In future research on taped tests, it would be informative to measure both short-term memory and auditory perception independently of the taped test itself. The relationships between these two variables and the test scores, as well as criterion scores, could then be investigated.

This study demonstrated that taped tests offer the advantages of higher reliability and validity, as compared to written tests. Combined with the practical advantages, such as greater simplicity of administration, greater simplicity of test forms, and elimination of the necessity of timing tests, taped tests are an attractive alternative to the traditional written tests.

One possible area of future research concerns the factor of reading comprehension. Written test scores are always dependent, to some extent, on the examinee's reading ability. Taped test administration could remove this factor from test scores. A taped test designed for this purpose would have all instructions, questions, and alternatives presented by tape, eliminating any requirement for reading
on the part of the examinee.

Another area of investigation where taped tests might be of use is the reduction of racial bias in testing. Studies have shown that the race of a test administrator can affect the scores on an intelligence test. Specifically, it has been found that blacks make lower scores on intelligence tests when they are administered by whites than when they are administered by blacks (Forrester & Klaus, 1964). Tape administration of a test, including the instructions, might reduce this effect, since no administrator would actually be present. However, since the race of the person who recorded the test might be determined by speech characteristics, it would be of value to record the test in different dialects, so that a given group of examinees could be given the test in their own dialect. Giving a taped test in the dialect of the examinees might also facilitate their understanding of the test.

The use of taped administration with other types of tests, apart from intelligence tests, would also be of interest. Personality tests, for example, often have low validity with respect to practical criteria such as job performance (Guion, 1965, pp. 303-305) and they might benefit significantly from taped administration.

The generalizability of the results of the present study are limited by the item sample used, the criterion used, and the subjects used, as explained below.

The test forms used in this study consisted of 200
items of three basic types: math problems, synonyms, and opposites. Further research is necessary to determine whether the same results would be obtained with different items within these three types and with items of different types.

Only a single criterion was used for validity purposes in this study, college grade point average. Further research could determine whether tape administration would yield higher validity than written administration with respect to other criteria. Of practical importance would be criteria such as job performance, which has historically shown only modest correlations with written intelligence tests (Guion, 1965, 236-237).

The subjects used in this study were all college students. Further research is needed to determine whether the results of this study would be obtained with subjects from other populations. Of special interest would be research using subjects of lower intellectual levels, since college students are well above average in intelligence.
Tape Recording Procedure

In the recording of the tapes used in this study, it was important to assure that the response intervals following the questions were accurately timed. This was accomplished with the use of two electronic timers (Lafayette, Model 1001 and Hunter, Model 115). A timer of this type can be set for various time intervals. At the end of the interval for which it is set, it will either open or close a circuit.

A pushbutton switch was used to trigger one of the timers. This timer was set at an interval equal to the desired response interval minus one second. At the end of this interval, the timer closed a circuit which triggered the second timer, and also caused an electronic tone to sound. The second timer was set at an interval of one second, at the end of which it opened a circuit, causing the electronic tone to stop. Thus, the total interval from the pressing of the button to the end of the tone was equal to the desired response interval.

As the last word of each item was read onto the tape, the button was pressed. The tone apparatus was placed near the microphone, so the tone was also recorded. When the tone stopped, the next item was read, and the process was repeated.
## APPENDIX B

### Item Difficulties and Correlations

<table>
<thead>
<tr>
<th>Test form</th>
<th>Item number</th>
<th>Preliminary Study</th>
<th>Main Study</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Correlation with total test score</td>
<td>Degree of difficulty</td>
</tr>
<tr>
<td>A 1</td>
<td></td>
<td>.15</td>
<td>.75</td>
</tr>
<tr>
<td>A 2</td>
<td></td>
<td>*</td>
<td>*</td>
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<tr>
<td>A 3</td>
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<td>.31</td>
<td>.75</td>
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<td>A 4</td>
<td></td>
<td>.61</td>
<td>.80</td>
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<td>A 5</td>
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<td>1.00</td>
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<td>A 6</td>
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<td>A 22</td>
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### APPENDIX B (cont.)

<table>
<thead>
<tr>
<th>Test form</th>
<th>Item number</th>
<th>Preliminary Study</th>
<th>Main Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
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<td>A</td>
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<td>B</td>
<td>100</td>
<td>.27</td>
<td>.32</td>
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</table>

* intervals selected for these items were different from the intervals used in the preliminary study, therefore, no correlation or degree of difficulty data was available.
APPENDIX C

Written Mode

Form A
In this experiment, you will be given two tests of verbal and mathematical achievement. The first of these tests is attached to these instructions. All questions on this test are multiple choice. There are three basic types of question on this test:

Questions 1-50... short math problems (select the correct answer from the choices given)
Questions 51-75... synonyms (select the word which means the same thing as the given word)
Questions 76-100... opposites (select the word which has a meaning opposite to the given word)

The test is divided into two parts (questions 1-50; and questions 51-100) and there is a time limit for each part. Work as rapidly as you can. If you have no idea of the correct answer to a question, please leave it blank. Do not guess wildly. You may use any blank spaces on the test for scratch paper. Mark your answers by circling the letters next to them.

**Sample Questions**

<table>
<thead>
<tr>
<th>Math</th>
<th>Synonyms</th>
<th>Opposites</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) 25 + 20</td>
<td>3) incomplete</td>
<td>5) accept</td>
</tr>
<tr>
<td>a. 35</td>
<td>a. overdone</td>
<td>a. reject</td>
</tr>
<tr>
<td>b. 50</td>
<td>b. unfinished</td>
<td>b. regret</td>
</tr>
<tr>
<td>c. 45</td>
<td>c. incorrect</td>
<td>c. display</td>
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<td>d. 40</td>
<td>d. improper</td>
<td>d. annoy</td>
</tr>
<tr>
<td>2) 4 x 12</td>
<td>4) ordinary</td>
<td>6) Destroy</td>
</tr>
<tr>
<td>a. 48</td>
<td>a. unusual</td>
<td>a. erase</td>
</tr>
<tr>
<td>b. 60</td>
<td>b. repulsive</td>
<td>b. ignore</td>
</tr>
<tr>
<td>c. 36</td>
<td>c. strange</td>
<td>c. create</td>
</tr>
<tr>
<td>d. 42</td>
<td>d. common</td>
<td>d. exude</td>
</tr>
</tbody>
</table>

You will have 5½ minutes to do the first 50 questions (math problems). Do not begin until the signal is given.
1) 18 + 17
   a. 35*
   b. 29
   c. 25
   d. 32
2) 51 - 6
   a. 57
   b. 45*
   c. 38
   d. 47
3) 7 x 9
   a. 56
   b. 63*
   c. 72
   d. 68
4) 6 \frac{1}{10} =
   a. 6.10*
   b. 6.20
   c. 6.12
   d. 6.25
5) 8^2 =
   a. 49
   b. 64*
   c. 81
   d. 55
6) \sqrt{36} =
   a. 6*
   b. 9
   c. 4
   d. 7
7) \sqrt{85} =
   a. 9.22*
   b. 6.48
   c. 11.09
   d. 7.11
8) if X + 14 = 18, X =
   a. 5
   b. 4*
   c. 7
   d. 2
9) if X(6) = 30, X =
   a. 2
   b. 5*
   c. 6
   d. 4
10) if \( X \div 4 = 12 \), \( X = \)
    a. 56
    b. 48*
    c. 3
    d. 4
11) \frac{1}{4} x \frac{1}{5}
    a. 1/20*
    b. 1/9
    c. 5/9
    d. 9/20
12) if \( \sqrt{X} = 4 \), \( X = \)
    a. 2
    b. 16*
    c. 64
    d. 36
13) \( X^4(x^3) = \)
    a. \( X^{12} \)
    b. \( X^7 * \)
    c. \( X^8 \)
    d. \( X^{4/3} \)
14) 80 \div 11
    a. 5.091
    b. 7.271*
    c. 9.12
    d. 10.06
15) \frac{1}{3} + \frac{1}{4}
    a. 2/7
    b. 2/12
    c. 4/7
    d. 7/12*
16) 5 \div \frac{1}{4}
    a. 1.2
    b. 20*
    c. 40
    d. 10
17) 1.9 \times 5.1
    a. 9.69*
    b. 14.29
    c. 6.49
18) 20% of 300
    a. 80
    b. 40
    c. 60*
    d. 90
19) \sqrt{114} =
    a. 10.68*
    b. 8.43
    c. 13.91
    d. 9.89
20) if \( \sqrt{X} = 3 \), \( X = \)
    a. 2.32
    b. 27
    c. 1.73
    d. 9*
21) \frac{1}{5} + \frac{1}{3}
    a. 8/25
    b. 6/15
    c. 8/15*
    d. 2/15
22) .01 \times .2
    a. .02
    b. 2
    c. 20
    d. .002*
23) if \( .1(X) = 20 \), \( X = \)
    a. 2
    b. .20
    c. 200*
    d. .02
24) 11% of 18
    a. 1.18
    b. 1.98*
    c. .88
    d. .68
25) 9% of 21
    a. 4.21
    b. 3.69
    c. 3.29
    d. 1.89*

TURN PAGE
AND CONTINUE
26) 16 + 15
   a. 21
   b. 24
   c. 31*
   d. 37

27) 8 x 7
   a. 48
   b. 56*
   c. 63
   d. 72

28) 3 1/5 =
   a. 3.25
   b. 3.20*
   c. 3.10
   d. 3.33

29) 62 =
   a. 64
   b. 49
   c. 25
   d. 36*

30) $\sqrt{81}$ =
   a. 18
   b. 3
   c. 9*
   d. 12

31) $\sqrt[3]{36} \times 2^2$
   a. 18
   b. 24*
   c. 28
   d. 32

32) if $x + 15 = 19$, $x =$
   a. 4*
   b. 6
   c. 3
   d. 5

33) if $X(9) = 36$, $X =$
   a. 4*
   b. 6
   c. 5
   d. 8

34) if $X^2 = 96$, $x =$
   a. 7.79
   b. 8.04
   c. 9.78*
   d. 6.98

35) if $X(9) = 30$, $X =$
   a. 5.13
   b. 4.93
   c. 2.23
   d. 3.33*

36) 50% of 200
   a. 100*
   b. 60
   c. 90
   d. 80

37) $X^3(X^3) =$
   a. $X^9$
   b. $X^6*$
   c. $X^3$
   d. $X^{12}$

38) 38 - 9
   a. 31
   b. 29*
   c. 27
   d. 24

39) 70 ÷ 9
   a. 4.69
   b. 5.12
   c. 11.24
   d. 7.77*

40) $\frac{1}{3} \times \frac{1}{4}$
   a. 2/7
   b. 2/12
   c. 1/12*
   d. 12/7

41) 13 x 100
   a. 0.013
   b. 1.3
   c. 13
   d. 13*

42) 4.1 x 3.9
   a. 15.99*
   b. 19.29
   c. 10.29
   d. 23.49

43) $\sqrt[3]{5} \times 4^2$
   a. 36
   b. 48*
   c. 34

44) if $X(12) = 50$, $X =$
   a. 6.31
   b. 2.96
   c. 0.21
   d. 4.17*

45) if $x^2 = 42$, $x =$
   a. 5.04
   b. 6.48*
   c. 8.21
   d. 5.56

46) 0.49 x 1000
   a. 49
   b. 490*
   c. 0.049
   d. 0.049

47) .3 x .02
   a. .006*
   b. .06
   c. .6
   d. .0006

48) if $x \div 3 = 12$, $x =$
   a. 8
   b. 24
   c. 4
   d. 36*

49) 5 ÷ 1/3
   a. 3/5
   b. 25
   c. 5/3
   d. 15*

50) if .2(X) = 20, $X =$
   a. 100*
   b. 200
   c. .10
   d. .20

STOP
The next 50 questions are synonyms and opposites.

questions 51-75....synonyms: select the word which has the same meaning as the given word.

questions 76-100....opposites: select the word which has a meaning opposite to the given word.

You will have 4½ minutes to do the next 50 questions. Do not begin until the signal is given.
51) surplus
   a. excess*
   b. last
   c. obsolete
d. dearth

52) permeable
   a. necessary
   b. penetrable*
c. naive
d. mystic

53) utmost
   a. nearest
   b. greatest*
c. complete
d. null

54) grotesque
   a. huge
   b. hateful
   c. bizarre*
d. inert

55) transitory
   a. moving
   b. lasting
c. transition**
d. halting

56) monger
   a. eel
   b. swindler
c. canine
d. dealer*

57) rubric
   a. retort
   b. proverb
c. heading*
d. idiom

58) abode
   a. house*
   b. goal
c. indulgence
d. quay

59) perceive
   a. protect
   b. persevere
c. notice*
d. acquire

60) hermit
   a. eccentric
   b. tyrant
c. cynic
d. recluse*

61) repast
   a. occasion
   b. celebration
c. meal*
d. rest

62) visage
   a. vision
   b. image
c. face*
d. mirage

63) witticism
   a. harangue
   b. fantasy
c. jest*
d. deposition

64) sparse
   a. meager*
   b. lively
   c. thick
d. scattered

65) ramification
   a. consequence*
   b. balustrade
c. parapet
d. stabilization

66) connubial
   a. exotic
   b. blissful
c. communal
d. matrimonial*

67) phantasm
   a. ghost*
   b. mystery
c. deity
d. allegory

68) collate
   a. reject
   b. correct
c. compare*
d. adjust

69) incommodious
   a. illicit
   b. inconvenient*
c. irregular
d. impossible

70) simian
   a. witty
   b. warlike
c. ape-like*
d. silent

71) diverse
   a. different*
   b. similar
c. split
d. intact

72) malady
   a. ailment*
   b. falsehood
c. invection
d. alloy

73) palatable
   a. concrete
   b. acceptable*
c. disagreeable
d. expansive

74) occlude
   a. delay
   b. obstruct*
c. shrink
d. spurn

75) remunerate
   a. restructure
   b. rebuild
c. reimburse*
d. repeat

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AND CONTINUE
THE NEXT 25 ARE OPPOSITES

76) absorb
   a. expel*
   b. delete
   c. expound
   d. imbibe

77) obscure
   a. clear*
   b. close
   c. faint
   d. acute

78) defective
   a. loyal
   b. proper
   c. perfect*
   d. flawed

79) colossal
   a. timid
   b. tiny*
   c. irregular
   d. enormous

80) mediocre
   a. outstanding*
   b. sudden
   c. infinite
   d. voluminous

81) circumspect
   a. angular
   b. foolhardy*
   c. adept
   d. active

82) tenuous
   a. abrupt
   b. external
   c. joyful
   d. dense*

83) prolix
   a. silent*
   b. inept
   c. adept
   d. sparse

84) achromatic
   a. diffuse
   b. white
   c. diffracted
   d. colored*

85) beatify
   a. praise
   b. sadden*
   c. worship
   d. condemn

86) mirth
   a. gaiety
   b. sadness*
   c. obscurity
   d. boredom

87) expand
   a. contract*
   b. decline
   c. display
   d. reject

88) loathe
   a. love*
   b. detest
   c. tolerate
   d. ignore

89) compassion
   a. arousal
   b. quietude
   c. sympathy
   d. indifference*

90) lethargy
   a. sympathy
   b. vigor*
   c. cleanliness
   d. intolerance

91) incarcerate
   a. destroy
   b. create
   c. defame
   d. free*

92) venality
   a. selfishness
   b. virtue*
   c. truthfulness
   d. curiosity

93) acquiescent
   a. helpless
   b. disinterested
   c. generous
   d. rebellious*

94) sapience
   a. ambience
   b. rudeness
   c. ignorance*
   d. energy

95) latent
   a. aware
   b. hidden
   c. active*
   d. patent

96) omnipotent
   a. ignorant
   b. powerless*
   c. evil
   d. agreeable

97) nonchalant
   a. annoyed
   b. pleasant
   c. anxious*
   d. devious

98) lofty
   a. lowly*
   b. beneath
   c. high
   d. boastful

99) tumid
   a. moist
   b. malignant
   c. deflated*
   d. obese

100) stultify
    a. expound
    b. flourish*
    c. declaim
    d. destroy
APPENDIX D

Written Mode

Form B
This test follows the same format as the previous test.

- questions 1-50...math problems
- questions 51-75...synonyms
- questions 76-100...opposites

You will have 5\frac{1}{2} minutes to do the first 50 questions (math problems). Do not begin until the signal is given.
1) $19 + 12$  
   a. 37  
   b. 21  
   c. 27  
   d. **31**  

2) $24 - 7$  
   a. 15  
   b. **17**  
   c. 21  
   d. 19  

3) $8 \times 6$  
   a. 64  
   b. **48**  
   c. 56  
   d. 54  

4) 30% of 300  
   a. 145  
   b. 150  
   c. **120**  
   d. 90*  

5) $4 \frac{1}{2}$  
   a. 4.15  
   b. 4.20  
   c. **4.33**  
   d. 4.25  

6) $9^2$  
   a. **81**  
   b. 64  
   c. 121  
   d. 96  

7) $\sqrt{49}$  
   a. 9  
   b. **7**  
   c. 8  
   d. 5  

8) if $X + 11 = 16$, $X =$  
   a. 6  
   b. **5**  
   c. 11  
   d. 7  

9) if $X(7) = 21$, $X =$  
   a. **5**  
   b. 3*  
   c. 6  
   d. 2  

10) if $\sqrt{X} = 8$, $X =$  
    a. 81  
    b. 2.83  
    c. **64**  
    d. 3.23  

11) $14 + 13$  
    a. **27**  
    b. 37  
    c. 21  
    d. 29  

12) $90 \div 8$  
    a. **11.3**  
    b. 7.1  
    c. 20.8  
    d. 6.7  

13) $.1 \times .02$  
    a. **.2**  
    b. **.002**  
    c. 2  
    d. .02  

14) $\sqrt{25} \times 2^2$  
    a. 32  
    b. 25  
    c. **20**  
    d. 30  

15) if $X(11) = 48$, $X =$  
    a. **7.03**  
    b. 6.11  
    c. **4.36**  
    d. 0.23  

16) $\frac{1}{5} \times \frac{1}{3}$  
    a. **15/30**  
    b. **1/15**  
    c. **2/15**  
    d. **2/8**  

17) $\sqrt{16} \times 3^2$  
    a. 24  
    b. **36**  
    c. 48  
    d. 32  

18) if $X^2 = 70$, $X =$  
    a. **6.41**  
    b. 7.00  
    c. **8.37**  
    d. 10.21  

19) $X^4(X^2) =$  
    a. $X^{16}$  
    b. $X^{1/2}$  
    c. **$X^8$**  
    d. **$X^{6}$**  

20) $2.1 \times 6.9$  
    a. 9.69  
    b. **11.29**  
    c. **14.49**  
    d. 17.49  

21) if $X \div 4 = 16$, $X =$  
    a. **4**  
    b. 36  
    c. **64**  
    d. 8  

22) 15% of 9  
    a. **.68**  
    b. 3.25  
    c. **1.35**  
    d. 4.05  

23) $\sqrt{33} =$  
    a. **5.74**  
    b. 4.83  
    c. **1.83**  
    d. 3.98  

24) $6 \div \frac{1}{3}$  
    a. **3**  
    b. 12  
    c. **18**  
    d. 2  

25) $.31 \times 1000$  
    a. **310**  
    b. 31  
    c. **.0031**  
    d. 3100  

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**AND CONTINUE**
35) if $x^2 = 38$, $x =$
   a. 3.15
   b. 4.92
   c. 6.16*
   d. 8.76

36) $100 \div 7$
   a. 4.9
   b. 22.1
   c. 6.8
   d. 14.3*

45) if $2(x) = 10$, $x =$
   a. 50
   b. 500
   c. 50*
   d. .05

46) $\frac{1}{6} + \frac{1}{2}$
   a. 8/12*
   b. 10/12
   c. 2/12
   d. 6/18

47) 12% of 11
   a. .68
   b. 1.32*
   c. 2.22
   d. 3.42

48) if $x \div 3 = 21$, $x =$
   a. 49
   b. 14
   c. 63*
   d. 7

50) $3.9 \times 5.1$
   a. 12.49
   b. 16.39
   c. 19.89*
   d. 24.89

**STOP**
The next 50 questions are synonyms and opposites.

Questions 51–75.....synonyms: select the word which has the same meaning as the given word.

Questions 76–100.....opposites: select the word which has a meaning opposite to the given word.

You will have $4\frac{1}{2}$ minutes to do the next 50 questions. Do not begin until the signal is given.
<table>
<thead>
<tr>
<th>SYNONYMS</th>
<th>SYNONYMS</th>
<th>SYNONYMS</th>
</tr>
</thead>
</table>
| **51) desolate**<br>a. sinful<br>b. sickly<br>c. foreign<br>d. deserted *<br><br>**52) immortal**<br>a. everlasting *<br>b. sinful<br>c. ephemeral<br>d. vast<br><br>**53) frail**<br>a. fragile *<br>b. corrupt<br>c. ill<br>d. adept<br><br>**54) paternal**<br>a. basic<br>b. hidden<br>c. evil<br>d. fatherly *<br><br>**55) nucleus**<br>a. periphery<br>b. atomic<br>c. center *<br>d. locus<br><br>**56) bondage**<br>a. obedience<br>b. imprisonment<br>c. slavery *<br>d. mastery<br><br>**57) imbue**<br>a. perjure<br>b. ordain<br>c. infuse *<br>d. guard<br><br>**58) vituperative**<br>a. poisonous<br>b. condemnatory *<br>c. laudatory<br>d. serpentine<br><br>**59) banish**<br>a. forget<br>b. exile *<br>c. reject<br>d. repel<br><br>**60) impale**<br>a. thrust<br>b. frighten<br>c. pierce *<br>d. condemn<br><br>**61) emulate**<br>a. dominate<br>b. imitate *<br>c. enable<br>d. falsify<br><br>**62) nefarious**<br>a. supernatural<br>b. infamous *<br>c. obstinate<br>d. lavish<br><br>**63) educe**<br>a. give in<br>b. bring out *<br>c. enact<br>d. emit<br><br>**64) mime**<br>a. heretic<br>b. impersonator *<br>c. fool<br>d. prodigal<br><br>**65) obduracy**<br>a. disagreement<br>b. stubbornness *<br>c. annoyance<br>d. acceptance<br><br>**66) umber**<br>a. brown *<br>b. to char<br>c. black<br>d. to destroy<br><br>**67) esoteric**<br>a. pious<br>b. innane<br>c. occult *<br>d. mundane<br><br>**68) mesmerize**<br>a. hypnotize *<br>b. ossify<br>c. blend<br>d. harden<br><br>**69) cavort**<br>a. prance *<br>b. hidden<br>c. celebrate<br>d. cease<br><br>**70) striated**<br>a. curved<br>b. grooved *<br>c. stretched<br>d. split<br><br>**71) retort**<br>a. rebuild<br>b. answer *<br>c. echo<br>d. argue<br><br>**72) denote**<br>a. decline<br>b. reject<br>c. signify *<br>d. inscribe<br><br>**73) harass**<br>a. ridicule<br>b. aid<br>c. annoy *<br>d. destroy<br><br>**74) mundane**<br>a. worldly *<br>b. infinite<br>c. celestial<br>d. foreign<br><br>**75) iterate**<br>a. mete<br>b. evince<br>c. forgive<br>d. repeat *

**TURN PAGE**

**AND CONTINUE**
<table>
<thead>
<tr>
<th>THE NEXT 25 ARE OPPOSITES</th>
<th>OPPOSITES</th>
</tr>
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<tbody>
<tr>
<td>76) thrive</td>
<td>85) crude</td>
</tr>
<tr>
<td>a. increase</td>
<td>a. base</td>
</tr>
<tr>
<td>b. die *</td>
<td>b. refined *</td>
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<tr>
<td>c. assist</td>
<td>c. perfect</td>
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<td>d. extend</td>
<td>d. correct</td>
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<td>77) chaos</td>
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<td>b. righteous</td>
<td>b. fervent</td>
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<td>c. sturdy *</td>
<td>c. valid *</td>
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<td>b. offspring</td>
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<td>c. uneducable</td>
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<td>b. annoy</td>
<td>b. healthy</td>
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<td>c. obey *</td>
<td>c. youthful</td>
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<tr>
<td>d. discuss</td>
<td>d. honest</td>
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OPPOSITES

94) gauche
   a. inept
   b. intelligent
   c. graceful *
   d. adverse

95) undulatory
   a. depressed
   b. emitting
   c. wavering
   d. unmoving *

96) relume
   a. extinguish *
   b. weave
   c. repeat
   d. reply

97) loquacity
   a. brilliance
   b. taciturnity *
   c. affluence
   d. dullness

98) benign
   a. insensate
   b. kind
   c. malignant *
   d. healthful

99) retentive
   a. careless
   b. sinful
   c. forgetful *
   d. pleading

100) distal
    a. abstract
    b. upper
    c. beneath
    d. near *
APPENDIX E

Tape Mode

Form A
In this experiment, you will be given two tests of verbal and mathematical achievement. The questions on these tests will be presented by tape recording. All questions are multiple choice. After hearing a question, you will select an answer from the choices printed on the answer sheets. The answer sheets for the first test are attached to these instructions. There are three basic types of question on this test:

questions 1-50......short math problems (you will hear each problem and then select an answer from the choices on the answer sheet)
questions 51-75......synonyms (you will hear a word, and then select the word on the answer sheet which means the same thing as the given word)
questions 76-100....opposites (you will hear a word, and then select the word on the answer sheet which has a meaning opposite to the given word)

The test is divided into two parts (questions 1-50; and questions 51-100). You will have from 1 to 7 seconds to answer each question. Questions with the same time limit are grouped together, and the time limits are printed on the answer sheets at the beginning of each group. At the end of the answer period for each question, you will hear a short tone. This is to warn you that the next question is about to begin.

If you have no idea of the correct answer to a question, please leave it blank. Do not guess wildly. You may use any blank spaces on the test for scratch paper.
Mark your answers by circling the letters next to them.

Sample Questions

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<th>Opposites</th>
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<td>d. common</td>
<td>d. exude</td>
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<td>c. 8/15</td>
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<td>b. 1.98</td>
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<td>b. 3.69</td>
<td>c. 3.29</td>
<td>d. 1.89</td>
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**1 second**

1) a. 35  
   b. 29  
   c. 25  
   d. 32  

2) a. 57  
   b. 45  
   c. 38  
   d. 47  

3) a. 56  
   b. 63  
   c. 72  
   d. 68  

4) a. 6.10  
   b. 6.20  
   c. 6.12  
   d. 6.25  

5) a. 49  
   b. 64  
   c. 81  
   d. 56  

6) a. 6  
   b. 9  
   c. 4  
   d. 7  

7) a. 9.22  
   b. 6.48  
   c. 11.09  
   d. 7.11  

8) a. 5  
   b. 4  
   c. 7  
   d. 2  

9) a. .2  
   b. 5  
   c. 6  
   d. 4  

**2 seconds**

10) a. 56  
    b. 48  
    c. 3  
    d. 4  

11) a. 1/20  
    b. 1/9  
    c. 5/9  
    d. 9/20  

12) a. 2  
    b. 16  
    c. 64  
    d. 36  

13) a. \( x^12 \)  
    b. \( x^7 \)  
    c. \( x^8 \)  
    d. \( x^{4/3} \)  

**3 seconds**

14) a. 5.91  
    b. 7.27  
    c. 9.12  
    d. 10.06  

15) a. 2/7  
    b. 2/12  
    c. 4/7  
    d. 7/12  

16) a. 1.2  
    b. 20  
    c. 40  
    d. 10  

17) a. 16.19  
    b. 14.29  
    c. 9.69  
    d. 6.49  

18) a. 80  
    b. 40  
    c. 60  
    d. 90  

**4 seconds**

19) a. 10.68  
    b. 8.43  
    c. 13.91  
    d. 9.89  

20) a. 2.32  
    b. 27  
    c. 1.73  
    d. 9  

21) a. 8/25  
    b. 6/15  
    c. 8/15  
    d. 2/15  

22) a. .02  
    b. .2  
    c. 20  
    d. .002  

23) a. 2  
    b. .20  
    c. 200  
    d. .02  

**2 seconds**

24) a. 1.18  
    b. 1.98  
    c. .88  
    d. .68  

**7 seconds**

25) a. 4.21  
    b. 3.69  
    c. 3.29  
    d. 1.89  

TURN PAGE AND CONTINUE
26) a. 21  
  b. 24  
  c. 31  
  d. 37  

35) a. 5.13  
  b. 4.93  
  c. 2.23  
  d. 3.33  

27) a. 48  
  b. 56  
  c. 63  
  d. 72  

36) a. 60  
  b. 6  
  c. 90  
  d. 80  

38) a. 31  
  b. 29  
  c. 27  
  d. 24  

39) a. 4.69  
  b. 5.12  
  c. 11.24  
  d. 7.77  

40) a. 2/7  
  b. 2/12  
  c. 1/12  
  d. 12/7  

41) a. .013  
  b. 1.3  
  c. .13  
  d. 13  

42) a. 15.99  
  b. 19.29  
  c. 10.29  
  d. 23.49  

43) a. 36  
  b. 42  
  c. 48  
  d. 34
The next 50 questions are synonyms and opposites.

questions 51-75.....synonyms: select the word which has the same meaning as the word you hear.

questions 76-100....opposites: select the word which has a meaning opposite to the word you hear.

Please do not turn the page until you are told to.
### SYNONYMS

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<td>75) a. restructure</td>
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THE NEXT 25 ARE OPPOSITES

1 second

76) a. expel
b. delete
c. expound
d. imbibe

77) a. clear
b. close
c. faint
d. acute

78) a. loyal
b. proper
c. perfect
d. flawed

79) a. timid
b. tiny
c. irregular
d. enormous

80) a. outstanding
b. sudden
c. infinite
d. voluminous

2 seconds

81) a. angular
b. foolhardy
c. adept
d. active

82) a. abrupt
b. external
c. joyful
d. dense

83) a. silent
b. inept
c. adept
d. sparse

84) a. diffuse
b. white
c. diffracted
d. colored

3 seconds

85) a. praise
b. sadden
c. worship
d. condemn

86) a. gaiety
b. sadness
c. obscurity
d. boredom

87) a. contract
b. decline
c. display
d. reject

88) a. love
b. detest
c. tolerate
d. ignore

89) a. arousal
b. quietude
c. sympathy
d. indifference

90) a. sympathy
b. vigor
c. cleanliness
d. intolerance

91) a. destroy
b. create
c. defame
d. free

92) a. selfishness
b. virtue
c. truthfulness
d. curiosity

93) a. helpless
b. disinterested
c. generous
d. rebellious

94) a. ambience
b. rudeness
c. ignorance
d. energy

95) a. aware
b. hidden
c. active
d. patent

96) a. ignorant
b. powerless
c. evil
d. agreeable

97) a. annoyed
b. pleasant
c. anxious
d. devious

5 seconds

98) a. lowly
b. beneath
c. high
d. boastful

99) a. moist
b. malignant
c. deflated
d. obese

7 seconds

100) a. expound
b. flourish
c. declaim
d. destroy
APPENDIX F
Tape Mode
Form B
This test follows the same format as the previous test.

questions 1-50...math problems
questions 51-75...synonyms
questions 76-100...opposites

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The next 50 questions are synonyms and opposites.

questions 51-75....synonyms: select the word which has the same meaning as the word you hear.

questions 76-100....opposites: select the word which has a meaning opposite to the word you hear.

Please do not turn the page until you are told to.
SYNONYMS

1 second

51) a. sinful
   b. sickly
   c. foreign
   d. deserted

52) a. everlasting
   b. sinful
   c. ephemeral
   d. vast

53) a. fragile
   b. corrupt
   c. ill
   d. adept

54) a. basic
   b. hidden
   c. evil
   d. fatherly

55) a. periphery
   b. atomic
   c. center
   d. locus

2 seconds

56) a. obedience
   b. imprisonment
   c. slavery
   d. mastery

57) a. perjure
   b. ordain
   c. infuse
   d. guard

58) a. poisonous
   b. condemnatory
   c. laudatory
   d. serpentine

3 seconds

59) a. forget
   b. exile
   c. reject
   d. repel

4 seconds

60) a. thrust
   b. frighten
   c. pierce
   d. condemn

61) a. dominate
   b. imitate
   c. enable
   d. falsify

62) a. supernatural
   b. infamous
   c. obstinate
   d. lavish

63) a. give in
   b. bring out
   c. enact
   d. emit

64) a. heretic
   b. impersonator
   c. fool
   d. prodigal

65) a. disagreement
   b. stubbornness
   c. annoyance
   d. acceptance

66) a. brown
   b. to char
   c. black
   d. to destroy

67) a. pious
   b. innane
   c. occult
   d. mundane

68) a. hypnotize
   b. ossify
   c. blend
   d. harden

5 seconds

69) a. prance
   b. hidden
   c. celebrate
   d. cease

70) a. curved
   b. grooved
   c. stretched
   d. split

71) a. rebuild
   b. answer
   c. echo
   d. argue

72) a. decline
   b. reject
   c. signify
   d. inscribe

73) a. ridicule
   b. aid
   c. annoy
   d. destroy

5 seconds

74) a. worldly
   b. infinite
   c. celestial
   d. foreign

75) a. mete
   b. evince
   c. forgive
   d. repeat

TURN PAGE
AND CONTINUE
THE NEXT 25 ARE OPPOSITES

1 second

76) a. increase
   b. die
   c. assist
   d. extend

77) a. silence
   b. disarray
   c. order
   d. tumult

78) a. bitterness
   b. suavity
   c. extravagance
   d. cheerfulness

2 seconds

79) a. wealth
   b. haste
   c. hunger
   d. feast

80) a. concrete
   b. indefinite
   c. vast
   d. common

81) a. weak
   b. common
   c. special
   d. notable

82) a. woeful
   b. righteous
   c. sturdy
   d. careless

3 seconds

83) a. adjustable
   b. obedient
   c. uneducable
   d. steerable

84) a. allude
   b. annoy
   c. obey
   d. discuss

85) a. base
   b. refined
   c. perfect
   d. correct

86) a. sadness
   b. respect
   c. evil
   d. awe

87) a. augment
   b. repel
   c. seal
   d. decrease

88) a. obedient
   b. huge
   c. wise
   d. arrogant

89) a. worldly
   b. immense
   c. distinct
   d. mundane

90) a. verbose
   b. involved
   c. relevant
   d. vigorous

91) a. unsound
   b. fervent
   c. valid
   d. pleasant

92) a. immobile
   b. offspring
   c. falling
   d. abrasive

93) a. approving
   b. healthy
   c. youthful
   d. honest

94) a. inept
   b. intelligent
   c. graceful
   d. adverse

95) a. depressed
   b. emitting
   c. wavering
   d. unmoving

96) a. extinguish
   b. weave
   c. repeat
   d. reply

97) a. brilliance
   b. taciturnity
   c. affluence
   d. dullness

98) a. insensate
   b. kind
   c. malignant
   d. healthful

99) a. careless
   b. sinful
   c. forgetful
   d. pleasing

100) a. abstract
    b. upper
    c. beneath
    d. near

OPPOSITES
References


V I T A

Dennis Roy Weller was born in Ann Arbor, Michigan on November 8, 1945. He attended grade schools in Lincoln Park, Michigan and Utica, New York, and high school in Nashville, Tennessee. In 1963, he entered Vanderbilt University Engineering School where he received a Bachelor of Engineering Degree in mechanical engineering in 1967.

After employment in the aerospace industry, he entered the graduate program in industrial psychology at Florida Technological University in September, 1971.