LEVEL OF DETAIL IN WRITTEN INSTRUCTIONS

A thesis submitted in partial satisfaction of the requirements for the degree of Master of Arts in Psychology

by

Gary Steven Diffley

May, 1975
The thesis of Gary Steven Diffley is approved:

California State University, Northridge

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ABSTRACT

LEVEL OF DETAIL IN WRITTEN INSTRUCTIONS

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Master of Arts in Psychology

May, 1975

Research in a variety of fields for measures of comprehensibility of written material has indicated the importance of content variables, in addition to the more commonly measured textual variables. Content variables include: the amount of information, the type of subject material, level of detail, etc., while textual variables are, for example, grammatical variations, linguistic, stylistic, and format variables. In particular, a number of studies have indicated that level of detail (or number of inferences) appears to have an effect on comprehension. Congruent with this empirical observation is the common assumption that people with little knowledge need explicit, more detailed directions and that people with more knowledge need less detail.

This study sought to measure the performance effects of different levels of detail in instructions and interactions of level of detail with levels of familiarization with a task. Eighty-one subjects were given different instructions written at three levels of detail for the
task of calculating the Pearson $r$ on a desk calculator. Subjects were also differently familiarized with the electronic desk calculator and were given varying amounts of information as to the meaning of correlation.

A greater number of correct responses were obtained from the more familiarized subjects and from all subjects on the second trial. No significant differences were found in performance due to level of detail in the instructions. Subjects with the briefest and middle instructions did, however, indicate a preference for more information. It was concluded that, given a fixed body of information to be presented to people of widely varying abilities, altering the number of statements used to present that information will not significantly affect performance, provided a consistent format is used. Further, inadequate detail is suggested as an insufficient descriptor of the cause of errors in following written instructions.
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INTRODUCTION

Purpose

The purpose of this study is to measure the effect of different levels of detail in written instructions on the performance of directed behavior as a function of user familiarization. It has been suggested that the major sources of comprehension failure in following written directions are the "inferences and the implicit rules that are required for a reader to relate the informational units to each other and to the task" (Kammann, 1972). In other words, two problem areas are the degree of content explicitness and the amount of internal referencing.

Decisions regarding appropriate level of detail in instructions are typically based on subjective estimates of reader capabilities. If level of detail is a significant variable, changing the degree to which a procedure is "spelled out" for users of different degrees of familiarization should show systematic effects on performance, and provide the beginnings of an empirical basis for specifying the style requirements for technical instructions.

A distinction is to be made here between level of detail in a set of instructions and ambiguity. In situations where reader knowledge is judged to be high, instructions can be less detailed and non-specific without being ambiguous. The question is: Can directions be so elaborated as to hinder the accomplishment of the task? Conversely, at what point does excessive brevity leave the reader puzzled or lost? Information from this study might be used to develop objective guidelines for writing to the proper level of detail.
Background

Introduction. It has been suggested that accuracy in communication is determined by five sets of independent variables: attributes of the communicator, of the addressee, of the channel, of the communication, and of the referent (Mehrabian and Reed, 1968). The present study examines two of these variables, an attribute of the addressee (familiarization) and an attribute of the communication (level of detail) for their effect on communicability as measured by task performance.

Much recent research has been conducted into non-written aspects of communication: audio, visual, and audio-visual methods. This research may assume increasing importance as film, slides, and recordings become more frequently used tools in education and training. However, at least two studies have shown that written instructions and illustrations are as effective as any combination of film and slide presentation (Calder, 1972; Serendipity, Inc., 1969). Further, a survey of instructional media studies (text, radio, television, programmed instruction, computer-assisted instruction) found few studies indicating significant differences as a function of medium (Jamison, et al., 1973). Regardless of which is best, a study of written information can benefit the audio-visual methods as well since they are all largely language oriented.

Several diverse areas dealing with language have made reference to the problem addressed in this study.

Readability. The first attempts at improving written material began in the 1920's when teachers found that textbooks intended for classroom use contained a vocabulary level which was beyond that of
the students. Consequently a variety of objective measures for "reading ease" were developed and refined. In the 1940's Rudolph Flesch refined the existing readability formulas for use by journalists and widespread interest subsequently developed in writing more clearly. One early Flesch formula measured four factors supposed to affect readability: 1) average sentence length, 2) average word length, 3) percent of personal words (pronouns, words of masculine or feminine form, and group words, e.g. "folks"), and 4) percent of personal sentences. Two scores were derived. The first two factors revealed "reading ease" and the second two the degree of "human interest."

Shortening sentences and shortening words have been the traditional means of simplifying writing, but the "human interest" measure is peculiar to the Flesch formulas. It has been demonstrated that text containing more personal words and personal sentences is read more quickly, although retention appears to remain unchanged. Acceptability is the limiting factor; technical writing in particular can be judged unacceptable by readers if it is too "personal" (Klare, 1955).

A major assumption of all readability formulas is that the content is adequate and arranged logically. The formulas only measure "ease of reading" by sentence and word length, or some variation on this (Siegel, 1974; Klare, 1963). They do not tell if the material is comprehensible, or easy to understand.

The formulas deal with one of the symptoms of reading difficulty without fathoming the cause. Consequently they cannot be reversed and used as writing guides, as is frequently done. That is, shorten-
ing sentences and words will not itself necessarily insure communicability. Admittedly, the effort made by the writer to shorten sentences and words generally results in more comprehensible writing. When isolated from other factors, however, sentence length has little effect on readability or comprehension (Schlesinger, 1968; Coleman, 1962). The Coleman (1962) study indicated that readability is more directly related to clause and phrase length, and sentence structure, which themselves constitute sentence length. In other words, there may be potentially stronger indicators of reading ease in syntactic variables.

**Psycholinguistics.** A new approach to the search for readability variables has been made possible with the development of a new theory of language (Chomsky, 1957). Rather than selecting supposed variables from existing text, linguistic variables, originating from Chomsky's transformational grammar have been isolated and experimentally manipulated.

A description of the derivation of linguistic variables used for psychological research is beyond the scope of this introduction, but some examples depicting forms of sentence transformation should give the idea. A left-branching sentence is of the form: "Very smartly dressed girls like boys." Presumably this form requires more memory storage than does a passive transformation to a right-branching form: "Boys are liked by very smartly dressed girls." (Greene, 1972) ("Right" and "left" refer to the structure of a sentence diagram that Chomsky calls a "phrase marker." )

Another variable supposed to have effect on comprehension of a sentence is embedding. Observe the following sentence as it proceeds
to an unlikely number of embedded dependent clauses: "The rat ran. The rat the cat chased ran. The rat the cat the dog teased chased ran. The rat the cat the dog the man kicked teased chased ran; and so on." (Greene, 1972, p. 25). A more realistic example and the type used in experiments is the following doubly embedded sentence: "John, whom June detests, loves Mary." Supposedly this is simplified by a passive transformation to, "Mary is loved by John who is detested by June."

Schlesinger (1968) reports experiments on the effects of syntactic complexity using branching, embedding, and other variables. It was expected that the strain imposed on the memory by various sentence structures would affect reading and comprehension. He found, however, that in ordinary reading situations these variables had "practically no effect on reading rates or comprehension." (Schlesinger, p. 106) Schlesinger added that the supposed "complexity" of sentences that makes reading difficult may be due to the interaction of sentence structure with content and style.

Support is given to this idea by Kintsch and Monk (1972) who concluded from their experiments that information is stored in the same form in the memory regardless of the complexity of the text. They suggest that information is stored in an abstract form which relates a particular message to a person's general knowledge, and that this process is independent of semantic or syntactic complexity. In their experiment, however, reading rates were retarded by syntactic complexity, in contrast to Schlesinger's finding.

Current psycholinguistic research in this area is focused on analyzing the cognitive processes of sentence decoding. The relation-
ships between memory load, comprehension, and syntactic or semantic variables have been examined (Harris, 1974; Klee & Eysench, 1973; Mistler-Lachman, 1972), but content and format variables have received little attention.

**Programmed Instruction.** One method of information presentation that has manipulated content level is programmed instruction. The amount of research in this field has decreased since its peak from the late 1950's and early 1960's. Current research seems to have changed from direct comparative studies to detailed studies of how to improve programs, how to increase student interest, etc.

Programmed instruction is a means of presenting information that requires correct responses before the reader goes on to subsequent information. As a variation of textual presentation, it does two things: 1) It separates content into small steps and arranges them logically; 2) it demands an active response from the reader. Arranging the format of a presentation into segmented steps is analogous to shortening sentences. For programmed instruction purposes, however, the content is altered as well to enable a quick and easy response from the reader on that segment.

The original investigators of programmed instruction agreed that optimal learning occurred with simple steps (or frames) that provided a high level of reinforcement (Coulson and Silberman, 1960; Skinner, 1958). The small-step principle was later carried to an extreme, resulting in some programs with "insulting, oversimplified" steps: "Paris is the capital of France. What city is the capital of France? _______" (Markle, 1969, p. 75). Markle identified the problem as defining "step" by its form rather than by its function and presented
ways (based only on her experience) of obtaining an appropriate content level and acceptable style.

Early research into size-of-step (with various measures of step size) indicated that greater learning does occur with small steps (Coulson & Silberman, 1960) although the increased number of steps requires more time. However, other studies have indicated that intermediate step-size is better than the small steps (Evans, Glaser, Homme, 1960).

Another test of programmed learning by Moore and Smith (1965) varied the content level of program frames in several ways and used students of differing ability. They found that students above average in ability were hindered by frames either too small or too large, and that students below average in ability did best with the smallest content level.

The principle of small steps is now listed as an "optional" technique in program writing (Markle, 1969; O'Day, 1971) to be used depending on format (linear or branching) and other factors dealing with presentation style.

The object of the areas discussed to this point has been concept learning. The goal of another field within written communications is the direction of behavior. This includes traffic direction (road signs, pedestrian warnings), procedural information (school registration, department store directories, tax forms), and all types of assembly, operation, maintenance, and repair activities (technical manuals, job aids, step-by-step instructions).

Technical Writing. Written instructions are within the domain of technical writing. Many technical writing texts present writing
style rules (Mitchell, 1962; Ward, 1968; Morris, 1966; Fear, 1973; Jordan, 1971), but few specifications are provided for instructions or directional information. The recommendations that exist are based on precedent or the "best authority" available and are sometimes arbitrary where there are no clear-cut preferences. Virtually none of the existing rules have been empirically validated. Davis (1967) is apparently the first technical writer to suggest the experimental method for determining the effectiveness of written messages. He states that despite existing regulations and conventions, success depends largely on a writer's "feeling for the effect that will be caused by his product." The results of incorrect "feelings" in composing written directions can be disastrous. A $900,000 Gemini spacecraft failure, for example, has been attributed to written procedures which were "insufficiently detailed" (Vandenberg, 1967). Technical writing handbooks refer again and again to adequate detail (Jordan, p. 79, 83; Fear, p. 36; Hays, p. 22), but no measures are provided and only anecdotal examples are given.

**PIMO.** The first major experimental effort to refine procedural information was a U.S. Air Force project in 1968-69, Project PIMO (Presentation of Information for Maintenance and Operation) (Serendipity, 1969; Wilmot, et al., 1969). The approach to composing instructions in this study consisted of 1) an extensive planning phase, and 2) a highly specified writing phase.

The PIMO presentation format is based on a repeated cycle of reading and action that is planned to occur within the short-term memory span. In a typical cycle the user 1) reads a short direct sentence containing familiar words, 2) refers to an illustration.
designed for quick location of the relevant part, and 3) performs the action on the equipment.

This format is designed to facilitate user action in several ways: 1) Content is limited to 3 or 4 related items per statement to enable retention in the short-term memory. 2) Illustrations have a maximum of 7 to 9 indicators (callouts) to optimize scanning time. 3) Text and illustrations are adjacent to each other to eliminate page turning.

Job guides in this format were drafted for Air Force maintenance technicians and field tested. The consistent format, and the close match between the instructions and the tasks resulted in an increase in overall maintenance efficiency. In particular, no measurable amounts of error were detected in the performance of either apprentices or experienced specialists when both used the PIMO job guides (Serendipity, 1969).

Summary of Background.

a. Readability formulas are post hoc measures and do not indicate the causes of misunderstanding of textual material.

b. No syntactic factors have been found which directly determine reading difficulty. Content is indicated as a potentially more direct indicator.

c. Programmed instruction research has indicated that small to intermediate size steps result in better learning, and that step size is related to ability level.

d. Technical writers are only beginning to examine instructions experimentally.

e. The PIMO format has demonstrated significant reductions in task performance errors.
The effectiveness of the PIMO format has been found also in non-military environments (Inaba, 1974), but empirical information is yet lacking on the relationship between the levels of detail and the skill of the user. Technical writing texts emphasize that writers should "know the reader," but how this awareness should affect the composition of the instructions is not stated. The common assumption is that instructions need to be more specific when the user is inexperienced; and conversely, that they can be more inferential when the skill of the reader is judged to be high. To what extent is performance affected by either type of instruction? The PIMO format was followed as well by both experienced and inexperienced technicians. However, the previously mentioned programmed instruction study (Moore & Smith, 1965) found that different ability levels necessitated use of different step sizes.

Two experiments have treated closely related problems. Kalt and Barrett (1973) examined the effect of format organization on learning from a technical manual. Written "concrete illustrations" (presumably resulting in greater detail) was one feature of the experimental manual, but the effect of these could not be determined independently of other variables. Additionally, their measure of effectiveness was not direct work performance but recall tests and tests of ability to retrieve information from the manual.

Another study (Kammann, 1972) sought to discover sources of comprehension failure in instructions. Two experimental paragraphs and two flowcharts presented information for telephone dialing problems. The results suggested that comprehension failure can be
traced to inferences that the reader must make to relate the instructions to the task. Readability factors (word frequency, sentence length), again, did not appear to be significant variables. The indication is that the number of inferences, i.e. the level of detail, can be examined for its effect on performance.

Kammann's conclusion that comprehension failure can be traced to unclear inferences indicates (if more indication is needed) that there may often be little "fit" between an author's feeling for the reader's information need and the reader's actual need. Communication can only be assured when these coincide.

There are a large number of variables that pertain to this problem, and they range from the perspective taken in approaching the subject matter, to minor points of presentation format. Level of detail is but one of these. Nevertheless, as developed herein, it has been pointed to by a number of sources as a relevant aspect.

Hypotheses

This experiment is an attempt to measure the effects of varying the level of detail in written instructions across a range of familiarization with the task. The findings should indicate, within the confines of the task employed, if the assumption is valid that naive readers need more explicit directions; and the opposite, if more experienced readers can perform well with inferential information. Secondly, in the course of experimentation subjective impressions will be gathered of the effect of brief instructions on inexperienced users (perhaps confusion and frustration) and, more importantly, how experienced users reach to directions which are, for them, perhaps over-explicit. The finding that over-explicit instructions do not
hinder experienced users would be important, indicating that
directions for any population should be explicit and complete.
METHOD

Subjects

Eighty-one subjects were selected, all being unfamiliar with the correlation coefficient and never having used the CompuCorp 100 calculator. They were CSU Northridge freshmen or sophomores, Psychology 150 or 250 students, male and female, none declared math majors.

Task

Task selection for this experiment was crucial for several reasons. First, the task had to be one which could be subdivided into a number of observable steps that could be scored for correctness in terms of the written instructions, i.e. errors had to be directly attributable to misunderstanding of the directions. Secondly, it had to be possible to write instructions for the task at varying levels of detail. Finally, the task had to help distinguish between the performance of naive and experienced people.

The selected task was the calculation of a correlation coefficient on an electronic desk calculator. This task required the subjects to perform a number of steps in proper sequence, and the results of each step could be recorded. The instructions can potentially range from very brief general directions to several pages of explicit detailed actions. Finally, familiarization with the calculator can be varied and measured closely.

Definition of Independent Variables

Level of Detail. The instructions were varied in terms of the number of directing statements: 23, 50, and 77 statements for the
least detailed, middle, and most detailed instructions respectively. For example, performing the algebraic operation $\frac{(6)^2}{2}$ and placing the result on line $\frac{-A}{-A}$ of the answer sheet would be treated as follows for each level of detail:

- Short, inferential instructions: "Complete calculation and record answer on line A."

- Middle set of instructions: "Square 6 and divide by 2. Write result on line A of answer sheet."


While some statements in the instructions did not lend themselves easily to this treatment, the overall effect resulted in three sets of instructions with the 23, 50, and 77 statements. Internal sequencing directions, i.e. "continue," "stop," were not counted as steps. The actual sets of instructions are contained in Appendixes A, B, and C.

To calculate the correlation coefficient with the particular formula selected and with the calculator used, 111 operations were required. This number includes each button press and the writing down of each partial answer. In composing the instructions, however, repetitive information was eliminated so that even the detailed set would yet be realistic.

This method of varying the detail of the instructions was the most practical. The task required the same number of calculator operations regardless of the instructions, thus fewer directing statements necessarily meant that more was implied in each. However,
only necessary information was included for each of the three sets of instructions.

The same words were used (as near as possible) in all sets of instructions to minimize the effect of vocabulary.

The same format was used for all instructions so that difficulties in following the instructions could be more directly attributable to the primary variable, level of detail. The format adhered to was that developed by the PIMO studies and further defined by the XYZ Corporation (Inaba, 1974). The information from these sources dictated the following conditions: 1) The instructions were not presented in narrative-type paragraphs but were segmented, spaced, and sequentially numbered. 2) The instructions were contained in a manila folder that, when opened, provided an illustration of the calculator face (Appendix D) on the right and instructions on the left. The illustration had callouts indicating the buttons used in the calculations. 3) Familiar, common words were used. The only guideline from the above sources not followed was that restricting the amount of information per statement, since that was coincident with level of detail, a manipulated variable.

It should be pointed out that the same basic information was presented in each set of instructions. The least detailed (short) set can be considered a condensed version, while the most detailed (long) set can be considered expanded.

Familiarization. Familiarization for this study has been operationally defined in terms of the amount of time the subjects spend operating the calculator or learning about the concept of correlation. It is thus an artificially constructed state.
Typically, familiarization at a task will result in the following: 1) a set of expectations concerning the task, 2) a degree of comfort with the immediate environment, 3) improved task performance, and 4) a cognitive map of the procedure, i.e. a hypothetical mental outline of how to proceed. These states should result in varying degrees in proportion to the time subjects spend becoming familiar with the operation of the calculator and repeating sequences that are necessary for calculation of the correlation coefficient.

This method of defining familiarization isolates it from the confounding variables which usually accompany it. For example, people more familiar with a task are also generally older than the inexperienced, or originally had some greater ability, or perhaps are more or less educated. It is these confounding variables that mitigated against selection of subjects from successively advanced statistics classes.

The first group was left unfamiliar with the operation of the calculator and correlation. The second group was given a 10-minute training familiarization session. The third group was given a 25 minute training/familiarization session.

The goals of these training sessions were: 1) to give subjects an orientation to the calculator and the room; 2) to provide information about the calculator and correlation; and 3) to all subjects to practice operation of the calculator.

Procedure

The introductory comments (Appendix E) told the subjects what to expect and approximately how long each part of the experiment
would take. The subjects knew what overall time would be required of them, having signed up for one of three time periods of 1, 1½, or 2 hours.

The subjects were then given a 2-minute mathematical abilities test (Appendix F) which was scored immediately. This test contained items from the Snader General Mathematics test and the Lankton First Year Algebra test, and was validated separately on a group of 41 CSUN Psychology 150 students. The scores from this test were used to control for subject differences by blocking and then randomly assigning subjects.

The scoring of the math test was followed immediately by the training/familiarization session, except for the no-familiarization group who proceeded to the instructions. The 10-minute session (Appendix G) provided subjects with the basic operational information and guided them through an example demonstration of the calculator's memory. In demonstrating the memory, a series of numbers was entered and subjects were shown how to retrieve the sum, the sum of squares, and n. This is a more abstract operation than the simple arithmetical operations and was necessary for solving the correlation coefficient by the method used in the written instructions. Exposure to this operation was felt to differentiate between this and the no-familiarization group.

The 25-minute training session (Appendix H) continued where the 10-minute session stopped. Subjects were allowed to practice operation of the described memory procedure for an additional 5 minutes and were given reinforcing instruction about its meaning and use. This was followed by a 10-minute lecture on the concept of correlation.
and some examples of its use. This group did not, however, actually calculate the correlation coefficient.

The training/familiarization sessions were not presented as "hurried" or "pressure" courses, but as familiarization. Subjects were given time to practice every operation as it was described, and efforts were made not to overload them with information at any one time.

After the training/familiarization session, the subjects were given the written instructions. Table 1 describes the time schedule and rest breaks for each group. Subjects were given 13 minutes to complete each trial and were stopped if not finished.

The subjects were asked to record answers on three successive score sheets (Appendix I). The second and third sheets had the correct answers to that point of calculation so that the subjects would not make successive cumulative errors, and also to allow closer determination of problem areas. Subjects were told not to turn ahead to the next answer sheet or to look back.

The measures obtained were: the number of answers completed, and the number of errors, a maximum of 35 possible of each. The same answer sheets were used for each level of detail and for all subjects, thus permitting direct comparison of responses from different instructions.

The attitude survey (Appendix J) was a Likert-scale with 8 items pertaining to feelings about the instructions (#1, #2, #3, #5, #6, #8, #9, #10), and 2 items relating to the amount of effort subjects were giving (#4, #7). At the end of the survey sheet were two questions which asked the subjects directly if they would have preferred more
**TABLE 1**

Order of Experimentation and Time Schedule

<table>
<thead>
<tr>
<th>Levels of Familiarization</th>
<th>None</th>
<th>10 Min.</th>
<th>25 Min.</th>
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<tr>
<td>Approx. Time (Min)</td>
<td>Task</td>
<td>Approx. Time (Min)</td>
<td>Task</td>
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<tr>
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<td>Greeting, Math ability test.</td>
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<td>Greeting, Math ability test.</td>
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<tr>
<td>15</td>
<td>1st set of instructions.</td>
<td>10</td>
<td>Training/ familiarization.</td>
</tr>
<tr>
<td>5</td>
<td>Break</td>
<td>15</td>
<td>1st set of instructions.</td>
</tr>
<tr>
<td>15</td>
<td>2nd set of instructions.</td>
<td>5</td>
<td>Break</td>
</tr>
<tr>
<td>5</td>
<td>Attitude survey.</td>
<td>15</td>
<td>2nd set of instructions.</td>
</tr>
<tr>
<td>5</td>
<td>Attitude survey.</td>
<td>5</td>
<td>Attitude survey.</td>
</tr>
<tr>
<td>45 minutes.</td>
<td>55 minutes.</td>
<td>75 minutes.</td>
<td></td>
</tr>
</tbody>
</table>
or less information.

**Experimental Design**

As represented by the matrix in Figure 1, the experimental design is a three-way factorial analysis of variance (3x3x2), the first factor being level of detail, the second levels of familiarization, and the third trials, a repeated measure.
### FIRST TRIAL

**Levels of Detail in Instructions**

<table>
<thead>
<tr>
<th>Levels of Familiarization</th>
<th>23 steps</th>
<th>50 steps</th>
<th>77 steps</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 min.</td>
<td>S₁......S₉</td>
<td>S₁₀......S₁₈</td>
<td>S₁₉......S₂₇</td>
</tr>
<tr>
<td>10 min.</td>
<td>S₂₈......S₃₆</td>
<td>S₃₇......S₄₅</td>
<td>S₄₆......S₅₄</td>
</tr>
<tr>
<td>25 min.</td>
<td>S₅₅......S₆₄</td>
<td>S₆₅......S₇₂</td>
<td>S₇₃......S₈₁</td>
</tr>
</tbody>
</table>

### SECOND TRIAL

**Levels of Detail in Instructions**

<table>
<thead>
<tr>
<th>Levels of Familiarization</th>
<th>23 steps</th>
<th>50 steps</th>
<th>77 steps</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 min.</td>
<td>S₁......S₉</td>
<td>S₁₀......etc.</td>
<td></td>
</tr>
<tr>
<td>10 min.</td>
<td>S₂₈......S₃₆</td>
<td>S₃₇......S₄₅</td>
<td>S₄₆......S₅₄</td>
</tr>
<tr>
<td>25 min.</td>
<td>S₅₅......S₆₄</td>
<td>S₆₅......S₇₂</td>
<td>S₇₃......S₈₁</td>
</tr>
</tbody>
</table>

**Figure 1.**

Experimental design: 3x3x2 factorial with repeated measures.
### Table 2

#### Cell and Marginal Means for Number of Correct Responses*

<table>
<thead>
<tr>
<th>Familiarization (minutes)</th>
<th>Inferential</th>
<th>Middle</th>
<th>Explicit</th>
<th>1st TRIAL</th>
<th>2nd TRIAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>19.0</td>
<td>19.4</td>
<td>20.3</td>
<td>19.5</td>
<td>27.5</td>
</tr>
<tr>
<td>10</td>
<td>22.5</td>
<td>28.3</td>
<td>27.1</td>
<td>26.0</td>
<td>30.1</td>
</tr>
<tr>
<td>25</td>
<td>24.0</td>
<td>29.1</td>
<td>29.4</td>
<td>27.5</td>
<td>32.2</td>
</tr>
<tr>
<td></td>
<td>21.9</td>
<td>25.6</td>
<td>25.6</td>
<td>24.4</td>
<td>29.8</td>
</tr>
</tbody>
</table>

#### 2nd TRIAL

<table>
<thead>
<tr>
<th>Familiarization (minutes)</th>
<th>Inferential</th>
<th>Middle</th>
<th>Explicit</th>
<th>2nd TRIAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>26.4</td>
<td>26.6</td>
<td>29.4</td>
<td>27.5</td>
</tr>
<tr>
<td>10</td>
<td>27.3</td>
<td>31.6</td>
<td>30.2</td>
<td>29.7</td>
</tr>
<tr>
<td>25</td>
<td>28.9</td>
<td>34.2</td>
<td>33.6</td>
<td>32.2</td>
</tr>
<tr>
<td></td>
<td>27.6</td>
<td>30.8</td>
<td>31.1</td>
<td>29.8</td>
</tr>
</tbody>
</table>

*Maximum possible = 35.*
### TABLE 3

Summary Table for Analysis of Variance of Performance Score

<table>
<thead>
<tr>
<th>SOURCE</th>
<th>S.S.</th>
<th>d.f.</th>
<th>M.S.</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>10252.79</td>
<td>161</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Between subjects</td>
<td>7599.79</td>
<td>80</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Familiarization (F)</td>
<td>1130.46</td>
<td>2</td>
<td>565.23</td>
<td>6.95**</td>
</tr>
<tr>
<td>Detail (D)</td>
<td>460.46</td>
<td>2</td>
<td>230.23</td>
<td>2.83</td>
</tr>
<tr>
<td>FxD</td>
<td>149.65</td>
<td>4</td>
<td>37.41</td>
<td>0.46</td>
</tr>
<tr>
<td>Error_b</td>
<td>5859.22</td>
<td>72</td>
<td>81.38</td>
<td>-</td>
</tr>
<tr>
<td>Within subjects</td>
<td>2653.00</td>
<td>81</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Trial (T)</td>
<td>1195.06</td>
<td>1</td>
<td>1195.06</td>
<td>65.77**</td>
</tr>
<tr>
<td>TxF</td>
<td>128.98</td>
<td>2</td>
<td>64.49</td>
<td>3.55*</td>
</tr>
<tr>
<td>TxD</td>
<td>2.09</td>
<td>2</td>
<td>1.04</td>
<td>0.06</td>
</tr>
<tr>
<td>TxFxD</td>
<td>18.54</td>
<td>4</td>
<td>4.64</td>
<td>0.26</td>
</tr>
<tr>
<td>Error_w</td>
<td>1308.33</td>
<td>72</td>
<td>18.17</td>
<td>-</td>
</tr>
</tbody>
</table>

* p < .05
** p < .01
Figure 2. Mean number of correct responses as a function of the interaction between familiarization and trials.
that the difference in performance due to experience tended to be less in the second trial. However, this effect appears to be due primarily to the improvement of the zero-familiarization group, whose performance on the second trial became roughly equal to that of the 10-minute familiarization group on the first trial.

The availability of the math ability score for each subject and the interaction of ability with step-size indicated by Moore and Smith (1965), led to a post hoc analysis of variance of the data with ability level added as a blocked independent variable. This resulted in a 3x3x2x2 ANOVA, ability level being a dichotomous variable, the four highest and the four lowest subjects being selected from the nine in each cell. The remaining middle subject was not used to maintain equal n's in the high and low groups. Ability level showed significant effects ($F(1,54)=16.49, p < .001$) in the expected direction: higher ability resulted in better performance. The mean number correct for the high ability subjects was 30.0 and for the low ability subjects 24.3. The ability by detail interaction, however, was not significant ($F(2,54)=2.52, p > .05$). As contrasted with the findings of Moore and Smith (1965), the present data showed no tendency for differing levels of detail to be effective for different ability levels.

The attitude survey, given to subjects after they had completed both trials, was scored and the results analyzed by a 3x3 ANOVA (detail by familiarization). There were no significant differences in opinions towards the instructions due to the amount of familiarization ($F(2,72)=1.90, p > .05$) or level of detail ($F(2,72)=1.69, p > .05$), nor was there a statistically significant interaction.
\( F(4,72) = 0.77, p > .05 \).

The 'effort' items from the attitude scale, also analyzed by a 3x3 ANOVA, showed no significant differences due to familiarization level \( F(2,72) = 0.97, p > .05 \), detail level \( F(2,72) = 1.83, p > .05 \), nor was there a significant interaction \( F(4,72) = 0.85, p > .05 \). Thus all subjects reportedly put a similar amount of effort into the task.

The final question on the survey asked directly if the subjects would have preferred more information. The results are displayed in Table 4. A test for the significance of a difference between proportions (nonparametric z) was calculated, collapsing over familiarization levels. Significantly more positive responses (see Table 4), indicating a desire for more information, were received from subjects with the short and middle instructions as compared to the long set.
Responses to the question: "Would you have preferred more information?"

<table>
<thead>
<tr>
<th>FAMILIARIZATION</th>
<th>INSTRUCTIONS</th>
<th>Inferential</th>
<th>Middle</th>
<th>Explicit</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td>8 Yes</td>
<td>8 Yes</td>
<td>4 Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 No</td>
<td>1 No</td>
<td>5 No</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>7 Yes</td>
<td>6 Yes</td>
<td>2 Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 No</td>
<td>3 No</td>
<td>7 No</td>
</tr>
<tr>
<td>25</td>
<td></td>
<td>7 Yes</td>
<td>3 Yes</td>
<td>2 Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 No</td>
<td>6 No</td>
<td>7 No</td>
</tr>
</tbody>
</table>

22/27 Yes (81%) 17/27 Yes (63%) 8/27 Yes (33%)

NS Sig. (.05) Sig. (.001)
DISCUSSION

This study sought to measure the effects of different amounts of detail in instructions and the interactions of detail with amount of familiarization. The results indicate, for the conditions specified, that level of detail does not significantly affect performance on a task, nor does it interact with level of familiarization.

This finding can be compared with one of the programmed instruction studies reported by Moore and Smith (1965) and to an experiment on syntactic variables by Kintsch and Monk (1972). The Moore and Smith (1965) experiment altered step-size by units of information per frame but found no significant differences due to step-size in any of three criterion measures used. Their study aimed for and measured concept learning, but the results nevertheless appear to be similar for procedural information and task accomplishment.

Similar results were obtained from a previously mentioned study by Kintsch and Monk, although a slightly different but analogous independent variable was used. Kintsch and Monk studied inferences made from simple and complex paragraphs. They asked a question about a paragraph that required an inference from the presented information and found no difference in the likelihood of a correct inference between their syntactically simple and complex versions. They concluded, as mentioned earlier, that information is stored in the same form in the memory regardless of the complexity of the text.

The present experiment, as in the Kintsch and Monk study, held
the amount of information constant. Here, however, the level of
detail (rather than syntax) was manipulated producing essentially,
condensed and expanded versions of the instructions. In addition,
task performance rather than question-answering was the dependent
variable. No difference was found here in performance due to the
level of detail, suggesting that, given a fixed body of subject
material, the information is understood and acted upon independently
of excessive or minimal detail.

The results appear to contradict the common assumption that
naive readers require more detail and informed readers require less.
The contradiction is only partial, however, since this assumption
can be interpreted in a variety of ways. It may refer either to the
amount of information presented or to the type of subject matter and
how they are related to reader sophistication. It can only be
concluded that level of detail does not appear to have a significant
relation to reader sophistication within the confines of this study.

A conflict is evident in that while performance was not signifi-
cantly different at each level of detail, the subjects with the
inferential and middle sets of instructions did indicate a preference
for more information. Although the value of greater detail may
not have been beneficial in terms of performance, neither was it
detrimental, and would have been preferred, in this case, by 81% of
those with the short (inferential) instructions and by 63% of those
with the middle set.

The desire for more information at the short and middle levels
of detail indicates that the optimum amount, in terms of reader
preference would be more explicit. If the ultimate consideration
is cost of written instructions or publication expedience, however, a presentation of only the basic information may be adequate for goal accomplishment.

Results of this study also suggest that length of written procedures in itself does not indicate their suitability for people of a particular experience or ability level.

This experiment was an attempt to correlate a factor of written instructions with task performance. Previously, the measures used to evaluate the effectiveness of instructions have largely been written comprehension tests. Kalt and Barrett (1973) used a "look-up" test as a measure for their technical manual. In a look-up test hypothetical problems are presented and the correctness and the time taken to find the appropriate information is measured. A look-up test simulates the task closely and thus obtains measures more related to it, but where it is possible a direct measure of task performance should be regarded as the ideal criterion.

Using task performance, however, introduces a number of other factors. Task variables, environmental variables, and a greater number of subject variables must be accounted for. Additional potential measures appear, such as those that are operator oriented, and those that are system oriented. There are advantages also in that inadequacies are more likely to be highlighted during task performance, and that subjective responses are more likely to generalize to the work situation.

The time limit for completing the instructions in each trial (13 minutes) was imposed to stress the subjects and thus to increase
task difficulty and likelihood of errors.

The subjective measures (attitude survey, post-questions) were seen as necessary because of the often voluntary nature of using written instructions. If a reader finds the instructions irksome for whatever reason, he might disregard them regardless of their supposed effectiveness.

It could be suggested that the absence of a main effect for levels of detail was due to the subject's differential response to the various levels. Subjects with the most detailed instructions may have proceeded slowly, obtaining all correct answers, while subjects with the shorter more inferential set may have proceeded quickly, completing more answers but making more errors. By the measure used (total number correct) both would thus have equal scores. That this is not so is indicated by an analysis of variance for total number completed in which there was no main effect for levels of detail ($F(2,72)=3.13$, $p>0.05$). The means for the total number completed were 28.1, 30.0, and 30.5 for the short, middle, and long instructions respectively.

The use of an optimum format for the instructions may have acted to minimize the effect of detail. The PIMO format dictates a certain amount of segmentation of material; directing statements were numbered and separated, thus resulting in more clarity even for the shortest instructions than would be the case with a more traditional, i.e. paragraphed, format.

The fact that several variables in different studies have independently shown no significant effects on comprehension indicates
that either a major determinant of comprehensibility is yet undiscovered, or, more likely, that various combinations of these variables need examination for their interactive effect. A study similar to that of Kalt and Barrett (1973) mentioned previously, could manipulate, for example, syntax variables, format variables, and content variables, in different ways in the same instructions to measure their effect on performance.

As mentioned in the introduction, level of detail is only one variable relating to the correspondence between written instructions and reader knowledge and abilities. Others of potentially greater impact include the perspective taken in approaching the subject matter (theoretical or practical), the quantity of information that is relevant to the task, and the degree of similarity of subject matter to the reader's interests.

Often, writers or critics name "inadequate detail" as the cause of mistakes (e.g. the Gemini failure mentioned previously). In view of the results of this study, it might be an oversimplification to name detail as the culprit. Mistakes might generally be more attributable to ambiguities that are recognized as such by neither the author nor the reader. The ambiguity may go unnoticed, but then an error in procedure results from it, then lack of detail is falsely claimed as the cause. Unfortunately, ambiguities take as many forms as there are words and sentence structures and may be examined only by instances and prevented perhaps only by multiple authorship.
REFERENCES


Harris, R. Memory and comprehension of implications and inferences of complex sentences. Journal of Verbal Learning and Verbal Behavior, 1974, 13, 626.


Inaba, K., President, XYZIX Information Corporation, 21116 Vanowen St. Canoga Park, California. Personal conversations on March 11, 22, and April 29, 1974.


Kammann, R. Analysis and improvement of general purpose instructions. 16th Annual Meeting of the Human Factors Society, Los Angeles, October 1972, 214.


Vandenberg, J.D. Improved operating procedures manuals. Ergonomics, 1967, 10(2), 214.


APPENDIX A

Short, Inferential Instructions
It is said that, "Milk drinkers make better lovers." To see if there is a correlation, suppose we ask five people how many glasses of milk they drink each day. And suppose we also discover how each person rates as a "lover" (from an undisclosed source) on a scale from 1 to 10. You will be given two sets of "make believe" numbers from this experiment.

You are to calculate the degree of relationship between these two sets of numbers. The instructions will tell you how to do this. Please follow them closely.

Write partial results on the score sheets when directed to. Round off to whole numbers. Please work as fast and as accurately as you can.

DO NOT TURN THIS PAGE UNTIL GIVEN THE SIGNAL TO START.
INSTRUCTIONS

NOTE: The numbers in ( ) refer to the illustration.

The numbers in [ ] refer to the numbers on the calculator.

1. Turn on calculator and indicate on score sheet if all zeros appear.

   NOTE:
   If "ERROR" or "OVERFLOW" appear (3 and 5) during any calculation, press [RESET] (13) and then press [Clear] (12). Then begin that section again.

   *HYPOTHETICAL RESULTS*

<table>
<thead>
<tr>
<th>Glasses of Milk (X)</th>
<th>&quot;Lover&quot; (Y)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
</tr>
</tbody>
</table>

2. Six numbers are needed before you can compute the answer: n, \( \sum X \), \( \sum Y \), \( \sum X^2 \), \( \sum Y^2 \), \( \sum XY \). (\( \sum \) means "sum of")

   You can get these numbers without figuring each one (and without knowing about \( \sum \)).

   Do the following exactly for each set of X and Y.

   1. Enter first number, X.
   2. Press \([XY]\) Button (10)
   3. Enter first number, Y.
   4. Press \([=]\) (11)
   5. The last value (Y) should still be on the display. (4)

   Write this value on score sheet, starting with line B.

   Continue this procedure for each of the 5 sets of numbers.

   Do not press [Clear] between sets.

   If you have pressed a wrong button, press [RESET] and start again.
3. The calculator has now "stored" the sums and squares of these numbers. These can be found by pressing \( \text{RCL}_n \) (1) and then a number.

\( \text{RCL}_n \) then 1 brings n (Write this on line G of score sheet)

Repeat this using 2, 3, 4, 5, 6 and writing the results on subsequent lines of score sheet.

4. Press \( \text{RESET} \) and indicate on score sheet if all zeros appear.

Turn to score sheet #2.

The new score sheet has the correct answers to this point.

Continue, using these numbers.

5. This is the formula for computing the answer:

\[
r = \frac{\sum XY - \left( \frac{\sum X}{} \right) \left( \frac{\sum Y}{} \right)}{n}
\]

\[
\sum X^2 - \left( \frac{\sum X^2}{} \right) \left( \sum Y^2 - \left( \frac{\sum Y^2}{} \right) \right)
\]

Use the framework of Boxes #1 and #2 on the score sheet to show your progress.

If you need help, you may check the calculator handbook, p. 12.

When Box #2 is filled in, turn to score sheet #3.

The new score sheet has the correct answers to this point.

Continue, using these numbers.
APPENDIX B

Middle Set of Instructions
It is said that, "Milk drinkers make better lovers." To see if there is a correlation, suppose we ask five people how many glasses of milk they drink each day. And suppose we also discover how each person rates as a "lover" (from an undisclosed source) on a scale from 1 to 10. You will be given two sets of "make believe" numbers from this experiment.

You are to calculate the degree of relationship between these two sets of numbers. The instructions will tell you how to do this. Please follow them closely.

Write partial results on the score sheets when directed to. Round off to whole numbers. Please work as fast and as accurately as you can.

DO NOT TURN THIS PAGE UNTIL GIVEN THE SIGNAL TO START.
INSTRUCTIONS

NOTE: The numbers in ( ) refer to the illustration.
The numbers in [ ] refer to the numbers on the calculator.

1. Turn on calculator switch (2) and press [RESET] button (13).
   Mark on the score sheet if all zeros appear.

   -------------------------~------
   NOTE:

   If "ERROR" or "OVERFLOW" (3 and 5) appear during any calculation, press [RESET] (13) and then press [Clear] (12). Then begin that section again.

   *HYPOTHETICAL RESULTS*

   Glasses
   of Milk  "Lover"
   (X)    (Y)
   4 ---- 5
   6 ---- 2
   8 ---- 1
   5 ---- 4
   2 ---- 8

2. Six numbers are needed before you can compute the answer: \( n, \leq x, \leq x^2, \leq y, \leq y^2, \leq xy \). (\( \leq \) means "sum of")

   You can get these numbers without figuring each one (and without knowing about \( \leq \)).

   Enter values of \( X \) and \( Y \) as follows:
   1. Enter first number, \( X \).
   2. Press [XY] button. (10)
   3. Enter first number, \( Y \).
   4. Press [=] (11)
   5. The last value (\( Y \)) should still be on the display.

   Write this value on score sheet, starting with line B.

   Continue this procedure for each of the 5 sets of numbers.

   Do not press [Clear] between sets.

   If you have pressed a wrong button, press [RESET] and start again.

   CONTINUE
3. The calculator has now "stored" the sums and squares of these numbers. These can be found by pressing \[\text{RCL}_n\] (1) and then a number.

\[
\begin{array}{cccc}
\text{RCL}_n & \text{then} & 1 & \text{brings} \quad n \quad (\text{for line G}) \\
 & 2 & \text{"} & \equiv x \quad (\text{for line H}) \\
 & 3 & \text{"} & \equiv x^2 \quad (\text{for line I}) \\
 & 4 & \text{"} & \equiv y \quad (\text{for line J}) \\
 & 5 & \text{"} & \equiv y^2 \quad (\text{for line K}) \\
 & 6 & \text{"} & \equiv xy \quad (\text{for line L}) \\
\end{array}
\]

Write these values on the score sheet on the appropriate lines.

4. Press \[\text{RESET}\] and indicate on score sheet if all zeros appear.

Turn to score sheet #2.

The new score sheet has the correct answers to this point.
Continue, using these numbers.

5. Box #1 on the score sheet contains the framework for getting the final answer.

Fill in Box #1 with numbers from lines G to L.

Write the number from line G on the line above \[\frac{G}{G}\], etc.

Box #2 is the next step in solving the formula.

Copy the values of L, I, and K to Box #2.

6. To get \[\frac{N}{N}\] for Box #2, multiply \[\frac{H}{H}\] by \[\frac{J}{J}\], and divide by \[\frac{G}{G}\].

To do this: Enter \[\frac{H}{H}\]
Press \[X\] (8)
Enter \[\frac{J}{J}\]
Press \[=\]
Press \[÷\]
Enter \[\frac{G}{G}\]

Write the result on line \[\frac{N}{N}\] of Box #2.

Press \[\text{Clear}\] after this operation.

CONTINUE
7. To get \( \frac{0}{0} \) for Box #2, square \( \frac{H}{H} \) and divide by \( \frac{G}{G} \).

To find \( \left(\frac{H}{H}\right)^2 \):

Enter \( \frac{H}{H} \)
Press \( \times \)
Press \( = \)

Then without pressing \( \text{Clear} \), press \( \frac{1}{x} \) and then \( \frac{G}{G} \).

Write the result on \( \frac{0}{0} \), Box #2.

Fill in the remainder of Box #2.

Turn to score sheet #2.

The new score sheet has the correct answers to this point.

Continue, using these numbers.

8. Fill in the blanks of Boxes #3 and #4 in the same manner as for Boxes #1 and #2.

(To find \( \sqrt{\text{--}} \), enter number and press \( \sqrt{\text{--}} \) button (9).)
(To enter a negative number, press \( \text{Chg Sgn} \) first.)

Put final answer in box.

STOP
APPENDIX C

Long, Explicit Instructions
It is said that, "Milk drinkers make better lovers." To see if there is a correlation, suppose we ask five people how many glasses of milk they drink each day. And suppose we also discover how each person rates as a "lover" (from an undisclosed source) on a scale from 1 to 10. You will be given two sets of "make believe" numbers from this experiment.

You are to calculate the degree of relationship between these two sets of numbers. The instructions will tell you how to do this. Please follow them closely.

Write partial results on the score sheets when directed to. Round off to whole numbers. Please work as fast and as accurately as you can.

DO NOT TURN THIS PAGE UNTIL GIVEN THE SIGNAL TO START.
INSTRUCTIONS

NOTE: The numbers in ( ) refer to the illustration.

The numbers in [] refer to the numbers on the calculator.

1. Turn on calculator by switch (2).

Press [RESET] (13)

Mark on the score sheet if all zeros appear.

NOTE:

If "ERROR" or "OVERFLOW" appear (3 and 5) during any calculation, press [RESET] (13) and then press [Clear] (12). Then begin that section again.

*HYPOTHETICAL RESULTS*

<table>
<thead>
<tr>
<th>Glasses of Milk</th>
<th>&quot;Lover&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>(X)</td>
<td>(Y)</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
</tr>
</tbody>
</table>

2. Six numbers are needed before you can compute the answer: n, \( \leq X \), \( \leq X^2 \), \( \leq Y \), \( \leq Y^2 \), \( \leq XY \). (\( \leq \) means "sum of")

You can get these numbers without figuring each one (and without knowing about \( \leq \)).

The X and Y values will first be entered into the calculator:

- Enter the first X value by pressing [4]
- Then press [XY] button (10)
- Enter first Y value by pressing [5]
- Then press [=] (11)

The last value of Y should still be on the display. (4)

Write this number on score sheet, line B.

Do not press [Clear] between sets of numbers.

If you have pressed a wrong button, press [RESET] and start again.
3. The second set of X and Y values are entered in the same manner.
   For the next set,
   Press 6
   Press XY
   Press 2
   Press =
   Record the last value from display on score sheet, line C.
   (Again, do not press Clear)

4. Continue this sequence for all sets of X and Y.
   After each set of X and Y values, write the displayed value on the subsequent line on the score sheet.
   Do not read further until you have done this and line F on the score sheet is filled in.

5. The calculator has now added and squared the entered numbers.
   To get the results:
   Press RCLn (1)
   Press 1
   The value on display is how many numbers are in each column, X and Y. Write this number on line G of score sheet.

6. Next, press RCLn
   Press 2
   This is the total of the X values.
   Write this number on line H of score sheet.

7. Continue this sequence with the numbers 3, 4, 5, 6.
   Write the value that appears after each number on the score sheet, lines I, J, K, and L.

8. When line L on the score sheet is filled in, you can clear the calculator of these numbers.
   Press Clear Then Press RESET
   Check box on score sheet to indicate if all zeros appear.

CONTINUE
Turn to score sheet #2.
The new score sheet has the correct answers to this point.
Continue, using these numbers.

9. Box #1 on the score sheet shows the framework of the formula for getting the final answer.
   Find the number on line L of the score sheet.
   Copy that number onto \( \frac{L}{L} \) in Box #1.
   Fill in all of the blanks of Box #1 in the same way.

10. On the calculator, enter the value of \( \frac{H}{H} \).
    Press \( \frac{X}{X} \) (8)
    Then enter the value of \( \frac{J}{J} \).
    Press \( \frac{=}={} \)
    Press \( \frac{1}{1} \) (7)
    And enter the value of \( \frac{G}{G} \).
    Then press \( \frac{=}={} \) again.
    Write the resulting value in Box #2, line N.

11. Press \( \text{Clear} \).
    Enter value of \( \frac{H}{H} \) from Box #1.
    Press \( \frac{X}{X} \)
    Then press \( \frac{=}={} \)
    (This results in \( \frac{H}{H}^2 \))
    Press \( \frac{1}{1} \)
    Enter \( \frac{G}{G} \)
    Press \( \frac{=}={} \) (This is \( \frac{H}{H}^2 \) )
    Write this value on line \( \frac{0}{0} \), Box #2.

12. Repeat the above procedure for \( \frac{J}{J}^2 \)
    Write the result of this on line \( \frac{0}{0} \), Box #2.
    Copy values of L, I, and K from Box #1 to Box #2.
Turn to score sheet #3.
The new score sheet has the correct answers to this point.
Continue, using these numbers.

   Enter $L$ and subtract $N$ from it. (6)
   Write result on line $Q$ of Box #3.

   Enter $T$ and subtract $0$
   Write result on line $R$ of Box #3.
   Clear calculator.
   Enter $K$ and subtract $P$
   Write result on line $S$ of Box #3.

15. Copy the value of $Q$ from Box #3 to Box #4.
   Multiply $R$ by $S$.
   Then press $\sqrt{}$ (9)
   Write result on line $T$, Box #4.
   Divide $Q$ by $T$.
   Write result in box.

STOP
APPENDIX D

Sketch of Calculator Face
APPENDIX E

Introductory Comments
INTRODUCTION TO EXPERIMENT

This experiment is going to require a fair amount of mental effort. Very simply, I am going to ask you to follow some instructions that tell you how to do some figuring and calculations using this calculator. This is going to be "work," but I will really appreciate your giving it an honest try.

- Have any of you ever used this calculator before? (If YES, do not use that subject.)
- Are any of you familiar with the correlation coefficient, or the concept of correlation? (If YES, do not use that subject.)

The first thing I'd like you to do is to take a short 2-minute math test. I'm then going to give you some written instructions that tell you how to calculate the correlation coefficient. After you follow these, we'll take a short break and then I'd like you to do the same thing, only with different numbers. And, finally, I have a short questionnaire I'd like you to fill out.

(Verbal instructions given while handing out written instructions.)

There are three different sets of instructions, each written at a different level of detail. You may get any set, so you may find the instructions too easy or too difficult. Please do the best you can with whichever set you get.

Please do not turn ahead to the second or third score sheets until you have finished the first ones.
APPENDIX F

Math Abilities Test
1. Which of the following numbers is less than -5?
   a. -4
   b. -3
   c. 0
   d. none of the above

2. The difference between these numbers is
   \[ \frac{726}{325} \]
   a. 309
   b. 301
   c. 401
   d. 398

3. If -9 is added to a certain number \( n \), the new number is
   a. \( n - 9 \)
   b. \( n + 9 \)
   c. \( -9n \)
   d. \( 9n \)

4. The number 62.768 rounded off to the nearest whole number is
   a. 62
   b. 62.77
   c. 62.8
   d. 63

5. If John can do a job in \( n \) days and his father works twice as fast, his father can do the job in
   a. \( 2n \) days
   b. \( \frac{n}{2} \) days
   c. \( (n-2) \) days
   d. \( (2-n) \) days

6. \( \sqrt{16} \) equals
   a. 3
   b. 4
   c. 5
   d. 8

7. If \( x=7, y=3, \) and \( z=2 \), then \( x+yz \) equals
   a. 12
   b. 13
   c. 20
   d. 27
8. If 13 is subtracted from 5, the answer is
   a. 8
   b. -8
   c. -18
   d. none of the above

9. The sum of -5a and +6a is
   a. 1
   b. a
   c. -11a
   d. 11a

10. If 4 is subtracted from a certain number \( n \), the result is 6.
    An equation which expresses this relationship is
    a. \( 4 - n = 6 \)
    b. \( 6 - n = 4 \)
    c. \( n - 4 = 6 \)
    d. none of the above

11. If 10x equals some number, then x is
    a. 10 times the number
    b. the number divided by 10
    c. 10 less than the number
    d. none of the above

12. If \( n + 2n = 12 \), then the value of n is
    a. 1
    b. 2
    c. 3
    d. 4

13. \( n^3 \) has the same meaning as
    a. \( n \times 3 \)
    b. \( n + 3 \)
    c. \( n \times n \times n \)
    d. \( n + n + n \)

14. The cost in dollars of \( n \) shirts at \( d \) dollars is
    a. \( dn \)
    b. $1.00
    c. \( \frac{dn}{100} \)
    d. none of the above

15. A simplified form of the expression \( A = p + prt \) is
    a. \( A = 2p + rt \)
    b. \( A = p(1 + rt) \)
    c. \( A = p(rt) \)
    d. none of the above
APPENDIX G

10-Minute Training Session
I want you to become familiar with the operation of this calculator. Most of the functions are very easy to learn. Let's go through several basic operations one step at a time so that you can see how it works.

- The ON-OFF switch is in the upper left corner.
- The adding, subtracting, multiplying, and dividing are done exactly as you would expect. Let's do a simple one. Enter a number, say 5. Then press the $+$ button. Then enter a second number, say 7. Then press the $=$ button. The answer should appear.

- There is a button at the bottom left that says $\text{Clear}$. This removes the numbers from the display.
- Subtracting, multiplying, and dividing are done by the same procedure. Do one of each of these with simple numbers and let me know if you have any trouble. Do a simple subtraction problem, then multiply a couple of numbers, then some divisions. Use easy numbers so you can see if you are getting the correct answers. (Wait. Help those with problems.)

- If you have to use negative numbers, you press the $\text{CHG SIGN}$ button.

Suppose you are multiplying $(-9)(8) = ?$ Press $\text{CHG SIGN}$ $\begin{array}{c}9 \end{array}$ Then $\begin{array}{c}X \end{array}$ Then $\begin{array}{c}8 \end{array}$ Then $\begin{array}{c}= \end{array}$ Answer should be $-72$.

- Now let's try some sequences of operations. Suppose you
want to know, \( \frac{(3)(4)}{2} = ? \) You can do this in one sequence on this calculator: \[ 3 \times 4 \div 2 = \] Answer.

- Squaring a number: \[ 5 \times = \] Answer. Try it with several numbers.
- Finding square roots is the easiest yet.

Enter the number.

Then press \( \sqrt{} \). And you get the answer.

Notice that finding the square root of a negative number results in "error."

This calculator also has a memory. That is, it can store long sequences of numbers that you put in. You can enter a column of numbers and the calculator will give you the total and the total of each of the numbers squared, which is needed for some calculations. It can also do the same for two columns of numbers. Let's do one so you can see it happen. You don't have to remember this or understand it. I just want you to see how it works. (Demonstrate XY key.)

\[
\begin{align*}
3^2 & \rightarrow (9) \quad 4^2 \rightarrow (16) \quad 12 \\
5^2 & \rightarrow (25) \quad 6^2 \rightarrow (36) \quad 30 \\
6^2 & \rightarrow (36) \quad 7^2 \rightarrow (49) \quad 42 \\
\sum & = 14 \quad = 70 \quad = 17 \quad = 101 \quad = 84
\end{align*}
\]

\[ \text{RCl} \]

\[
\begin{array}{c}
1 \quad -3 \\
2 \quad -14 \\
3 \quad -70 \\
4 \quad -17 \\
5 \quad -101 \\
6 \quad -84
\end{array}
\]
APPENDIX H

25-Minute Training Session
25 MINUTE TRAINING SESSION

(Continue with 10 minute session until memory procedure using XY key is done correctly, or about 15 minutes. Then the following 10 minute lecture is given.)

Now let me explain when you might need to do all those calculations.

Suppose you are interested in the amount of relationship between two things. For example, maybe you notice as you walk around campus that some students carry an armful of books around with them all the time, and others don't carry any. You think that maybe the more books a person carries around, the higher his G.P.A. tends to be.

There is a way to describe the relationship between things numerically. It is called the correlation coefficient and it is somewhat complicated to compute. This last operation on the calculator using the XY key makes the figuring of this correlation much easier. But I am not going to ask you to do that right now. That is what the written instructions are for. But I would like you to understand this idea of "correlation" before I give you the instructions. Let me explain some more about it.

Suppose you asked a lot of students what their G.P.A. is and counted the number of books they were carrying. If you made a diagram with these two numbers, you might get something like this:

```
   4
  /|
 G.P.A. / |
  3 /  |
  2 /   |
  1 /    |
  0       0 1 2 3 4

Number of Books
```

Those who carry more books tend to have a higher G.P.A. If you could draw a straight line through all the points the correlation would be close to +1. This would be a direct positive relationship: The more books a person carried, the higher his G.P.A. was.
Then again you might get just the opposite:

<table>
<thead>
<tr>
<th>G.P.A.</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Books</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

Those who carry fewer books get a higher G.P.A. If a straight line could be drawn through these points, the correlation would be -1. This would be a direct negative relationship: The fewer books a person carried, the higher his G.P.A. was.

Finally, there may be no relation at all:

<table>
<thead>
<tr>
<th>G.P.A.</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Books</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

Points on the diagram are all over. People with no books sometimes have a high G.P.A., sometimes a low one. People who carry a lot of books sometimes have a high G.P.A., sometimes a low one. It may seem reasonable that the correlation number representing this condition is zero. There is no relation.

So you can see that the value of a correlation coefficient can range from -1 to +1. And the size of the coefficient indicates the strength of the relationship. A perfect +1 or -1 correlation is not usually found. A real-life example: the correlation between H.S. G.P.A. and college G.P.A. is usually between +.35 and +.50.

The correlation coefficient is only a measure of relationship. It does not imply CAUSE. For example, carrying books by itself, of course, does not cause higher or lower G.P.A.
APPENDIX I

Answer Sheets
SCORE SHEET #1

Step

A. Do all zeros appear on display? Yes No
   □ □
   B. ______
   C. ______
   D. ______
   E. ______
   F. ______

G. ______
H. ______
I. ______
J. ______
K. ______
L. ______

M. Do all zeros appear on display? Yes No
   □ □
SCORE SHEET #2

Step
A. Do all zeros appear on display? Yes No
B. 5
C. 2
D. 1
E. 4
F. 8
G. 5
H. 25
I. 145
J. 20
K. 110
L. 76
M. Do all zeros appear on display? Yes No

Box #1
\[ r = \frac{L - \frac{(H)(J)}{G}}{\sqrt{\left(\frac{I}{G} - \frac{(\frac{H}{G})^2}{K} - \frac{(\frac{J}{G})^2}{L}\right)}} \]

Box #2
\[ r = \frac{L - N}{\sqrt{\left(\frac{I}{O} - \frac{P}{K}\right)}} \]
Box #2

\[ r = \frac{76}{L} - \frac{100}{N} \]

\[ \sqrt{\frac{I - 0}{K - P}} \]

Box #3

\[ r = \frac{Q}{\sqrt{R - S}} \]

Box #4

\[ r = \frac{Q}{T} = \text{ANSWER} \]
APPENDIX J

Attitude Survey
1. The instructions were confusing.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Uncertain</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

2. The instructions enabled me to obtain the answer easily.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Uncertain</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

3. I didn't have any "feel" for what I was doing.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Uncertain</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

4. I tried to follow the instructions exactly.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Uncertain</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

5. Instructions are generally more trouble than they are worth.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Uncertain</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

6. If I were given a class assignment to calculate a correlation coefficient, I would want to use these instructions.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Uncertain</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

7. It was difficult for me to concentrate on what I was doing.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Uncertain</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

8. I was able to follow the instructions without any major problems.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Uncertain</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

9. If I had my choice, I'd have someone show me how to do this rather than read the directions.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Uncertain</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

10. The information was presented in a straightforward and logical manner.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Uncertain</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

1. Did any one section of the instructions cause you more trouble than another? Circle: Yes No If so, which section? 1st 2nd 3rd

Comment: ____________________________

2. Would you have preferred more information? Yes No

3. Were the instructions too detailed, or bothersome? Yes No

Comment: ____________________________