1986

The effect of order of presentation and experience on problem solving

Edward Bruce Versteeg
Portland State University

AN ABSTRACT OF THE THESIS OF Edward Bruce Versteeg for the Master of Science in Psychology presented May 21, 1986.

Title: The Effect of Order of Presentation and Experience on Problem Solving.

APPROVED BY MEMBERS OF THE THESIS COMMITTEE:

[redacted]

Adriane Gaffuri, Ph.D., Chair

[redacted]

Barry F. Anderson, Ph.D.

[redacted]

Hugo Maynard, Ph.D.

The effects of order of presentation and amount of experience on errors and solution time were investigated. An interactive narrative puzzle was presented on a computer screen to 60 undergraduate students. Solution of the problem involved the integration of two path segments. Subjects in the Forward Condition were presented the path segments in the order in which they had to be traversed for solution. Subjects in the Backward Condition were exposed to the opposite order of presentation. Amount of experience was varied by permitting one, three, or five readings of the narrative.

The results supported the literature to date suggesting that given a moderate amount of exposure (three trials) to a problem component, people form a imaginal representation of the stimulus which facilitates solution. In addition, the Backward order of presentation of the problem components was more conducive to this strategy. With both minimal exposure and with extensive exposure the Forward order of presentation produced fewer errors. The results were consistent and significant in terms of both number of errors and solution times associated with the six treatment conditions.

THE EFFECT OF ORDER OF PRESENTATION AND EXPERIENCE ON PROBLEM SOLVING

by

EDWARD BRUCE VERSTEEG

A thesis submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE
in
PSYCHOLOGY

Portland State University

1986

TO THE OFFICE OF GRADUATE STUDIES AND RESEARCH:

The members of the Committee approve the thesis of Edward Bruce Versteeg presented May 21, 1986.

[redacted]

Adriane Gaffuri, Ph.D., Chair

[redacted]

Barry F. Anderson, Ph.D.

[redacted]

Hugo Maynard, Ph.D.

APPROVED:

[redacted]

Roger Jennings, Ph.D., Head, Department of Psychology

[redacted]

Bernard Ross, Ph.D., Dean of Graduate Studies and Research

ACKNOWLEDGEMENTS

It is to my parents and my wife that this thesis is dedicated. I acknowledge the unending support, pride, and love that only parents can provide, and I am truly appreciative that I am their son. I am also blessed by being the recipient and of Polly's love (and thankful of the serendipity of being wedded to a great "proofer").

Special appreciation goes to my committee members: Adriane Gaffuri, for the warmth of her support and prudential guidance, allowing me the latitude to express my ideas without consternation while providing the needed criticism; Barry Anderson, for his wisdom, creativity, and exuberance; and, Hugo Maynard, for his sharing the talent of adhering to the rigors of scientific pursuits without sacrificing personal agendas and feelings, and doing so with the generosity and kindness that is uniquely his.

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CHAPTER I

INTRODUCTION

This paper is concerned with the effects of order of presentation and amount of experience on reasoning. Problem solution is influenced by the order in which data are presented and the amount of experience of the subject. The relationship of these two factors to problem solution will be developed, first as independent factors, and then in their interaction with one another. Finally, a research design will be presented that examines the pattern of interaction of order of presentation and experience in a problem solving situation.

Order of Presentation

Work on the topic seems to have begun with Maier (1929) and Hull (1935). Hull (1935) sought to account for the assembly of novel response sequences by rats within the framework of S-R theory. According to his account, during the acquisition of a habit segment, the subject acquires a fractional detachable antedating goal response (r_g) appropriate to the goal object, in addition to the overt response. Utilizing a modified and conventionalized graphic representation of a maze devised originally by Maier (1929), Hull outlined the following response sequences, describing the mechanism of their assembly in terms of S-R tendencies (See Figure 1).

According to Hull's sequence, a hungry rat, with repeated exposure to pathway W_1-F, will learn to anticipate food when placed in

compartment W_1. This same animal is also exposed to pathways S-W_1 and S-W_2 when thirsty. With continued exposure, compartment W_1 and its pathway will not only elicit r_g drinking appropriate to the water reward as will W_2, but also r_g eating apppropriate to the goal box F.

In the problem situation the rat is placed in S hungry. The direct route, S-F, is blocked at b leaving the rat with options S-W_1 and S-W_2. Hull predicted that the animal would select pathway S-W_1, since the response of running down path S-W_1 was associated with both the r_g for eating and the r_g for drinking, whereas the response for running down path S-W_2 was associated only with the r_g for drinking.

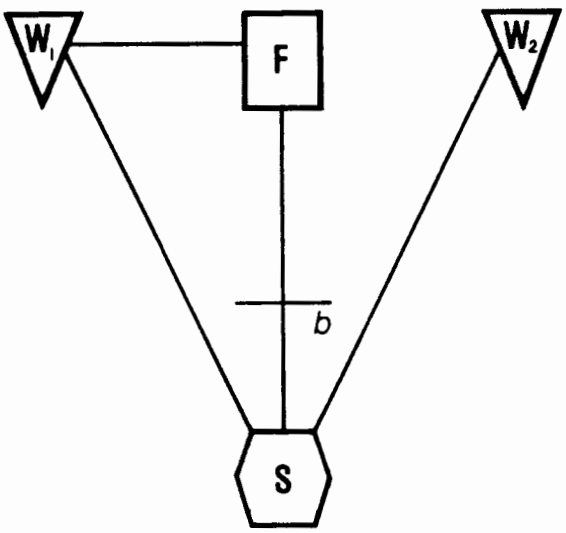

Figure 1. Maze proposed by Hull.

Osgood (1953) observed that one prediction that derives from Hull's explanation is that the segments, or components, must be learned in the backward order, the component nearer the goal being learned before that farther from the goal. This is necessary in order to permit the fractional antedating goal response, which begins at the goal, to move back to the start where the "reasoning" takes place.

In a preliminary experiment, the author tested the ability of rats to combine discrete components and utilize that assembly in the solution of a novel problem. The order with which these components were presented directly affected the rats' performances in the problem situation. In a problem similar to the one suggested by Hull, rats trained in the backward order out-performed rats trained in a forward order condition ($p<.05$). The maze was modified to be perfectly symmetrical from the Start Box axis, whereas Hull's and Maier's was not (See Figure 2 representing maze modifications) (Versteeg, unpublished manusript).

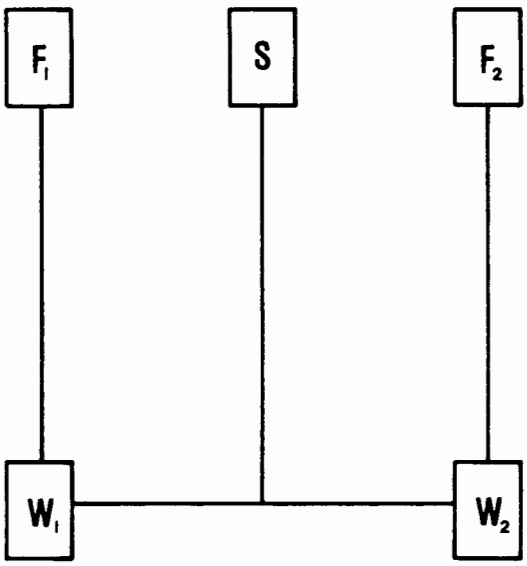

Figure 2. Maze used by Versteeg.

Kendler and Kendler (1961) tested Osgood's prediction and found no difference between forward and backward orders. However, their subjects were children who were beginning to achieve some control over verbal processes, which may have influenced the results. Verbal processes facilitate the representation and organization of data. The

effect of these capacities and their relationship to problems of seriation will be discussed later.

Perhaps nowhere has the debate involving the influence of order of presentation been more lively than in the arena of relational inferences. For instance, when dealing with three-term series problems, is it easier to combine, A is greater than B, and B is greater than C, in that order or in the reverse order, B is greater than C, followed by, A is greater than B? Support for the former comes from DeSoto, London, and Handel (1965) and Hunter (1957), while support for the latter was produced by Clark (1969 a,b) and Huttenlocher (1968). The two approaches involved are the Image theory (DeSoto, et al., 1965) and the Linguistic theory (Clark, 1969 b), respectively. The fundamental contrast between these competing theories lies in the representation of the premises. The Image theory assumes that the two premises are combined into a unified representation of the three items; the Linguistic theory assumes that information about the items is stored separately. DeSoto found subjects made fewer errors when solving three-term series problems presented in the order A is greater than B, and B is greater than C (subsequently referred to as the Forward order of presentation). In contrast, Clark found subjects made fewer errors when the series of premises were presented as B is greater than C, and A is greater than B (subsequently referred to as the Backward order).

Wason and Johnson-Laird (1972) have suggested a possible resolution of these discrepant theories and findings. They suggest that something like images are used early in practice when the subject is trying to get an overall understanding of the problem, but that

later, when she knows exactly what is required in the situation, the process becomes automatized in terms of something like a shorthand linguistic representation. One fact that supports this interpretation is that DeSoto's subjects, judging by the number of errors they made, seem to have been less practiced than Clark's. Findings consistent with this hypothesis were reported by Wood in his doctoral thesis (1969) and reported by Wason and Johnson-Laird (1972, p.122). This possibility will be considered fully in the section on interaction of order of presentation and experience.

Shaver, Pierson, and Lang (1975) studied the significance of imagery in problem solving from the perspective of Clark's postulated linguistic principles and Huttenlocher's and DeSoto's visual-spatial imagery postulations. Shaver, et al., report two experiments in which three different classes of operations are brought to bear on the problem: (1) Manipulation of stimulus attributes (characteristics of problems), (2) manipulation of variables that selectively encourage or inhibit the use of imagery (facilitating instructions; the suppression of visualization by reading), and (3) measurement of relevant individual differences (spatial-reasoning ability).

They presented premises and questions both auditorily and visually. Three different relations (spatial, social, and hair color) were presented in the form of linear syllogisms. The three types of relations differed in difficulty, spatial being the easiest to handle, social more difficult, and hair-color most difficult. Reading presentation proved more difficult than listening. This latter finding is well supported by Driesen (1977) using a comparable design focusing on syllogistic reasoning.

Dreisen explained the better performance associated with stimuli presented auditorily as being related to competition between sensory modalities. Reading interferes with the organization of the premises into visual-spatial imagery. He inferred that the solution seemed dependent on the manipulation of images. Neuropsychological evidence provided additional support for an image theory. Luria (1973) described patients with lesions of the parieto-occipital region of the dominant hemisphere, a region adjoining the visual association area. They could not find their bearings within a system of spatial coordinates, and they could no longer distinguish right from left. Luria's findings would seem to support the idea that reasoning is spatial in form, as his patients with parieto-occipital lesions of the dominant hemisphere associated with spatial processing lost the ability to reason logically.

Experience

The assembly of data, or problem components, to meet a goal criterion involves skills, whether they are as simple as remembering which way to turn in a maze or as complicated as composing an algorithm for a computational task. The solution to a problem most often rests on the cultivation of new skills. Fitts (1964) has identified three stages of skill development: a cognitive stage, an associative stage, and an automatization stage.

The cognitive stage depends heavily on the verbal executive system, the high-order cognitive processor which is central to achieving abstraction and independence from the environment. It is during this stage that instructions and demonstrations are the most helpful (Fitts, 1964).

The rules and goals of the task become known and information is organized into short sequences of items, a process known as "chunking" (Miller, 1956). The associative stage describes the period in which internal representation of the relationships of these data chunks crystalize and are available for manipulation or sorting.

It has been indicated that verbal memory images are particularly well suited for retaining information about the serial order of events (Paivio & Csapo, 1969). Early in serial learning, items in a list seem to be bound together by pairwise associations. However, later in serial learning, items appear to be located within some overall pattern rather than bound to one another. Late in learning, transfer is greater to a list that preserves item positionality as opposed to item pairing, indicating that some sort of spatial representation has been accomplished (Young, 1962; Youssef, 1967). It seems as though this spatial organization serves as a kind of "glue" to hold features together.

A study that ties together the problems involving relational inferences with the problems of seriation described above is provided by Trabasso (1975). In the examination of strategies of transitive inference, the subject is repeatedly shown the adjacent pairs of a series of different length sticks, A > B, B > C, C > D, D > E, each stick identifiable by its color. The data suggest that, in the course of these presentations, the subject gradually constructs from these adjacent pairs an internal, possibly image-like representation of the entire ordered array A > B > C > D > E.

When then asked to compare a pair of lengths he has never seen together before, e.g., B and D, the subject does not work out the

answer through a step-by-step process of logical inference. Rather, he simply "reads" B > D off his internal representation, much as though the five sticks were all lined up in order of length before his eyes. If logical inference were the solution process, questions about the relative lengths of widely-seperated pairs that had never been experienced, e.g., B ? D or B ? E, should certainly take longer to answer than questions about pairs that are adjacent and had been previously experienced, e.g., A ? B or C ? D. But if the solution process were akin to comparing lengths perceptually, the opposite should be true since, for example, A and D are more different in length and are farther apart in the subject's internal A ... E linear representation than are say B and C. Trabasso (1975) found that the opposite is, in fact, true: the farther away one length is from another in the A ... E series, the shorter the solution time. It is harder to achieve this sort of quasi-spatial internal representation in preschool children than older subjects, e.g., more presentations of the adjacent pairs are required. Once achieved, however, preschool children can solve transitive inference problems, and they appear to solve them in the very same, essentially noninferential fashion (suggestive of an Image process akin to that described by DeSoto above). Previously, investigators, such as Kendler and Kendler (1961) noted above, had not found that children this young could solve transitive inference problems.

As experience with a task increases, we move from the associative stage where stimuli are being translated into associative representation, into the automatization stage (Fitts, 1964). This is, of course, true of our activities in daily living; responses, "...because

of the great deal of early practice devoted to them, have become largely automatized" (Anderson, 1975, p. 169). This process seems to be true of all mature organisms. Rats tested early in training show place learning while rats tested late in learning show response learning (Restle, 1957).

> Thus, what tends to be in the central processor/short-term memory (CP/STM) are environmental goals, e.g., where in the maze the food is located, rather than what particular responses to make to get there. As a consequence of repeated practice, however, the behavior becomes automatized. Instead of being guided by a test-operate-test-exit (TOTE) process toward distant goals in external memory (EM) or STM that require the attention of CP, large series of responses are now elicited by immediately preceding conditions, either in the environment or in the response system, itself. The practiced rat leaves the start box and initiates a sequence of responses that will, with very little attention, take him to the correct goal box, thus leaving CP/STM free for, perhaps, happier thoughts about the food itself (Anderson, 1975, p. 169).

To summarize, it seems that one of the most important, though neglected, independent variables in a cognitive task is the amount of experience the subject has in the problem situation. As experience increases we expect to see subjects follow the transitions through the stages delineated by Fitts. Initially, the problem-solver orients him/herself to the situation, processing instructions, looking for patterns, developing strategies, and perhaps developing partial images (Fitts, 1964). Next, the problem-solver begins forming a representation of the problem parts into whole images (Young, 1962; Youssef, 1967; Trabasso, 1975). After a good deal of experience with the problem situation, the problem-solver develops more economical and efficient strategies, such as non-image coding, and performance becomes automitized (Wood, 1969).

Interaction of Order of Presentation and Experience

Wood (1969) used series problems involving up to six premises and giving rise to many different types of array. All the premises involved the comparative term taller; and the question was always of the form "who is taller X or Y?" A typical problem was:

(1) D is taller than E

(2) C is taller than D

(3) A is taller than C

(4) A is taller than B

(5) B is taller than C

Who is taller B or E?

Wood predicted that subjects would initially solve such problems after the fashion of DeSoto's Image theory: they would build up an internal representation of the items. However, he suspected that with experience they would develop a more sophisticated strategy.

After a subject had solved a certain number of conventional problems, he would be given a special test problem in which, having answered the main question, he would be asked a further unexpected question such as "who is taller A or D?" These supplementary questions were so formed that they could be readily answered only by those subjects who had formed a unified representation of the premises. By varying the number of conventional problems encountered before the test problem, Wood was able to confirm that subjects began by using the representational strategy but rapidly abandoned it in favor ofmore specialized non-representational procedures. What was particularly striking was the rapidity of this development. He found the biggest drop in the ability to answer the supplementary question was from

those subjects who had previously encountered two conventional problems to those who had previously encountered three.

The effect of practice is probably to induce a more "mechanized" approach to the problem, which minimizes effort and which is appropriate to the particular constraints of the material. At the same time, such an approach is likely to be less flexible and may make it harder to solve an unexpectedly novel type of problem.

Some people seem to discover the imagery technique only after practice with several problems. Johnson-Laird was thus correct to argue that we "can no longer ask how an individual solves a three-term series problem without asking when in his intellectual development within the experiment it was given to him" (Wason and Johnson-Laird, 1972, p.128).

It seems that the forward order of presentation is preferable when subjects are naive and are involved in a sort of cognitive orienting operation. When the components are bound by direct antedating associations, working from the goal toward the givens seems to be preferable. The apparent corollary is that with some experience with a situation, such as the three-term series problem or the maze problem, the backward order should be more facilitative. However, with considerable experience, responses seem to become automatized and this should favor the forward order of presentation.

The present study

In the present experiment subjects are presented a narrative game that involves two distinct components and are then placed in a test situation which requires synthesis of the parts. Experience with the parts and their order of presentation is manipulated. Three hypo-

theses are to be tested. First, with minimal exposure to the story, there will be poor performance, but subjects will be more successful with the forward presentation. Secondly, with moderate experience, there will be fewer errors, faster reaction times, and greater success with backward presentation. Finally, with extended exposure to the story, performance is more rapid, with little-to-no errors, and discernably higher performance with those subjects given the forward modality.

In other words, a shift in strategy, much like that suggested by Wood (1969), is expected to occur. Namely, the subject will benefit from a forward order of presentation initially, as he/she orients to the situation. The forward order is less likely to lead to confusion as the problem unfolds simply because in the test situation the parts are presented in the same fashion, thus facilitating recall of "chunks" of data. After some experience with the problem parts, the subjects encountering those parts in a backward order will be better able to assemble a unified representation and will benefit from this strategy (this moderate experience treatment condition coincides with Wood's subjects encountering one or two conventional problem(s) prior to the supplementary problem). Finally, the task demands become automatized with extended experience (coinciding with Wood's subjects experiencing three or more conventional problems). Like Wood's subjects, those encountering the forward order of presentation will be better able to shift strategies and will be more likely to benefit from this flexibility.

CHAPTER II

THE STUDY

Method

Design. Two independent variables, Order (Forward, Backward) and Experience (Minimal, Moderate, and High) were varied factorially to create six experimental conditions.

Subjects. Subjects were obtained through undergraduate psychology courses where, after a brief explanation of the study and its purpose to the class, volunteers were solicited. Informed Consent was obtained prior to actual involvement (see Appendix 1). Ten undergraduate students were randomly assigned to each of the six conditions, for a total of 60 subjects.

Apparatus. The narration game was presented on a ten inch monochromatic computer monitor, and responses to story demands were indicated via the keyboard of an Apple IIc computer. The narrative game was written in AppleSoft Basic by the author (see Appendix 2 for the computer program).

Procedure. Subjects in the forward order of presentation were given Part A of the story line to read and respond to first, and subsequently given Part B with its corresponding choice of responses second (see Appendix 3). Subjects in the Backward order of presentation were given Part B followed by Part A. Amount of exposure to the components (Parts A and B) varied as follows: one reading for the minimal condition, three readings for the moderate condition, and

five readings for the high experience condition. When the subject had completed the number of readings assigned, he/she was presented once again with the story's Introduction, but then was given the problem (or test) situation, i.e., incorporating both vignettes. The time to solution and the number of errors made during the test situation served as measures of performance.

Pilot Study. A preliminary study, (subsequently referred to as Experiment A1), was conducted. Subjects were solicited in the same manner, and with the same attention to protection of the rights of the participants as described above for the main study, (subsequently referred to as Experiment A2). The procedure of execution and data collection was the same as that of Experiment A2. In the pilot study a directed debriefing interview was done on completion of the subject's task (see Appendix 4). The amount of experience included one, two, three, and five readings (trials). An equal number of subjects was assigned to both Forward and Backward conditions. Therefore, there were eight conditions with four subjects randomly assigned to each condition (N=32). An inspection of the data revealed that the "two-trial" condition did not appreciably add to the pattern of interaction between the independent variables, and was deleted from Experiment A2. No further revisions were made, consequently the main study being reported here is essentially identical with the exception of the elimination of the Two-Trial Condition.

Results

There were seven points in the story at which the subject had to choose directions. Therefore, the maximum number of errors was

seven. Errors ranged from zero to six (N=60, $\bar{X}$=1). Following the story's Introduction (see Appendix 2), time recording of the subject's performance began with the presentation of the first vignette. The number of seconds the subjects took to complete the problem ranged from 89 to 195 (N=60, $\bar{X}$= 128 sec). (See Appendix 5 for subject data.)

Figure 3 presents the means for the number of errors and time to solution for each condition as a function of order of presentation and experience.

Errors. Because there was concern about violating the assumptions of the parametric statistics, due to the skewness of the error scores, both parametric and nonparametric tests were performed. Both showed the same pattern of significance. The interaction between the two treatment variables, i.e., order of presentation and amount of experience with the parts of the problem, was significant for errors ($F_{(2,54)}$=7.41, p<.01). The Forward group made fewer errors than the Backward group after one practice trial. A t-test for two independent means indicated that this difference was significant (Group F1, $\bar{X}$=2.2, s.d.=1.14, s.d.=1.14; Group B1, $\bar{X}$=3.6, s.d.=1.43; t=2.39, df=18, p<.05). The Backward group made fewer errors than the Forward group with three practice trials. A t-test for two independent means indicated that this difference was also significant (Group B3, $\bar{X}$=0.6, s.d.=0.97; Group F3, $\bar{X}$=1.8, s.d.=1.48; t=2.13, df=18, p<.05). Finally, the Forward group tended to do better after five practice trials. A t-test for two independent means indicated that this difference was marginally significant (Group F5, $\bar{X}$=0.0, s.d.=0.0; Group B5, $\bar{X}$=0.3, s.d.=0.67; t=1.42, df=18, p<0.1). A ceiling effect

may explain why this difference was not very significant; most subjects in both groups made no errors.

Time. The pattern of interaction between the two treatment variables, i.e., order of presentation and amount of experience with the parts of the problem, was also significant for time to solution ($F_{(2,54)}=3.51$, $p<.05$). There was high variability in the time scores (as indicated by the standard deviations). There was no real difference between the Forward and Backward groups in the Low experience condition. A t-test for two independent means was insignificant for this condition. However, the Backward group showed significantly faster times to reach the solution after three trials. A t-test for two independent means indicated that this difference was significant (Group B3, $\bar{X}=123.4$, s.d.=15.65; Group F3, $\bar{X}=139.4$, s.d.=18.52; $t=2.17$, df=18, $p<.05$). The Forward Group showed significantly faster times after five trials. A t-test for two independent means indicated that this difference was also significant (Group F5, $\bar{X}=100.7$, s.d.=8.97; Group B5, $\bar{X}=124.8$, s.d.=27.11; $t=2.65$, df=18, $p<.05$). (See Appendix 6 for a complete review of descriptive statistics).

Figure 3 highlights the similarity in the crossover in performance, as measured by both dependent variables (errors and time), as a function of order of presentation and experience (see Appendix 7 for a complete review of the parametric and nonparametric statistics).

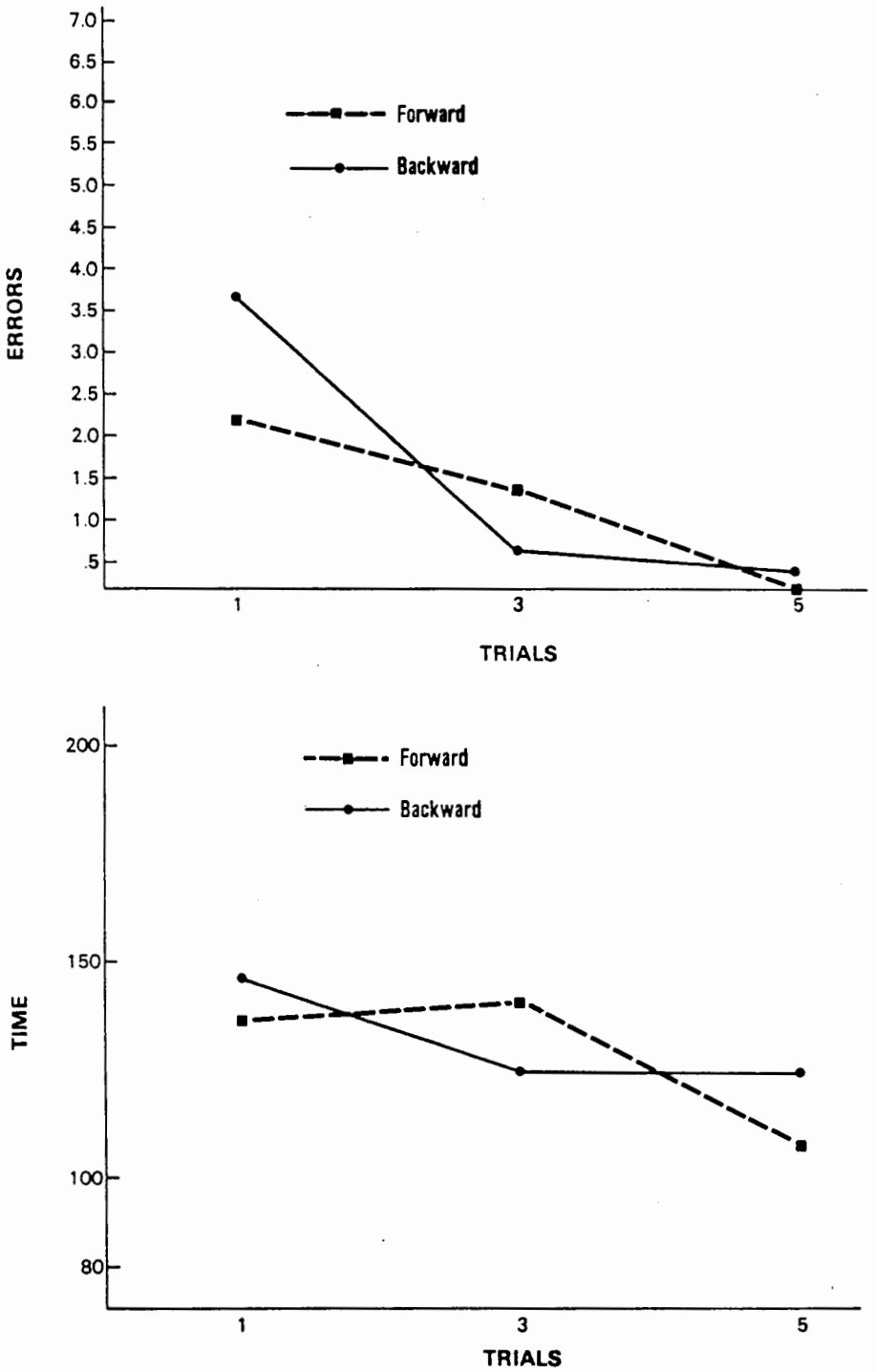

Figure 3. Graphs highlighting the similarity between the interactive patterns of both measures (A2).

Pilot Study. Further support for this pattern of interaction was found in the results of Experiment A1 (pilot study). A relatively large sample size was used in Experiment A1 (N=32) (see Appendix 8 for A1 data), and differed with the subsequent study (A2) only in the elimination of the two-trial experience level. Confidence in the reliablility of the interactive pattern was further enhanced.

Figure 4 highlights the similarity in the crossover in performance in the pilot study, as measured by both dependent variables (errors and time), as a function of order of presentation and experience. There is a striking similarity of this crossover pattern with the pattern for A2 (Figure 3).

The interaction between the two treatment variables, i.e., order of presentation and amount of experience with the parts of the problem, was significant ($F_{(2,24)}=2.41$, $p<.05$) for the number of errors in Experiment A1. However, the interaction between the two treatment variables was insignificant with regard to time to solution as measured by both parametric, as well as, nonparametric tests (see Appendix 9 for the descriptive statistics; see Appendix 10 for a complete review of the parametric and nonparametric statistics for A1).

The Backward group in Experiment A1 showed significantly fewer errors after three trials. A t-test for two independent means indicated that this difference was significant (Group B3, $\bar{X}=0.75$, s.d.=0.96; Group F3, $\bar{X}=2.75$, s.d.=0.96; $t=2.95$, df=14, $p<.05$).

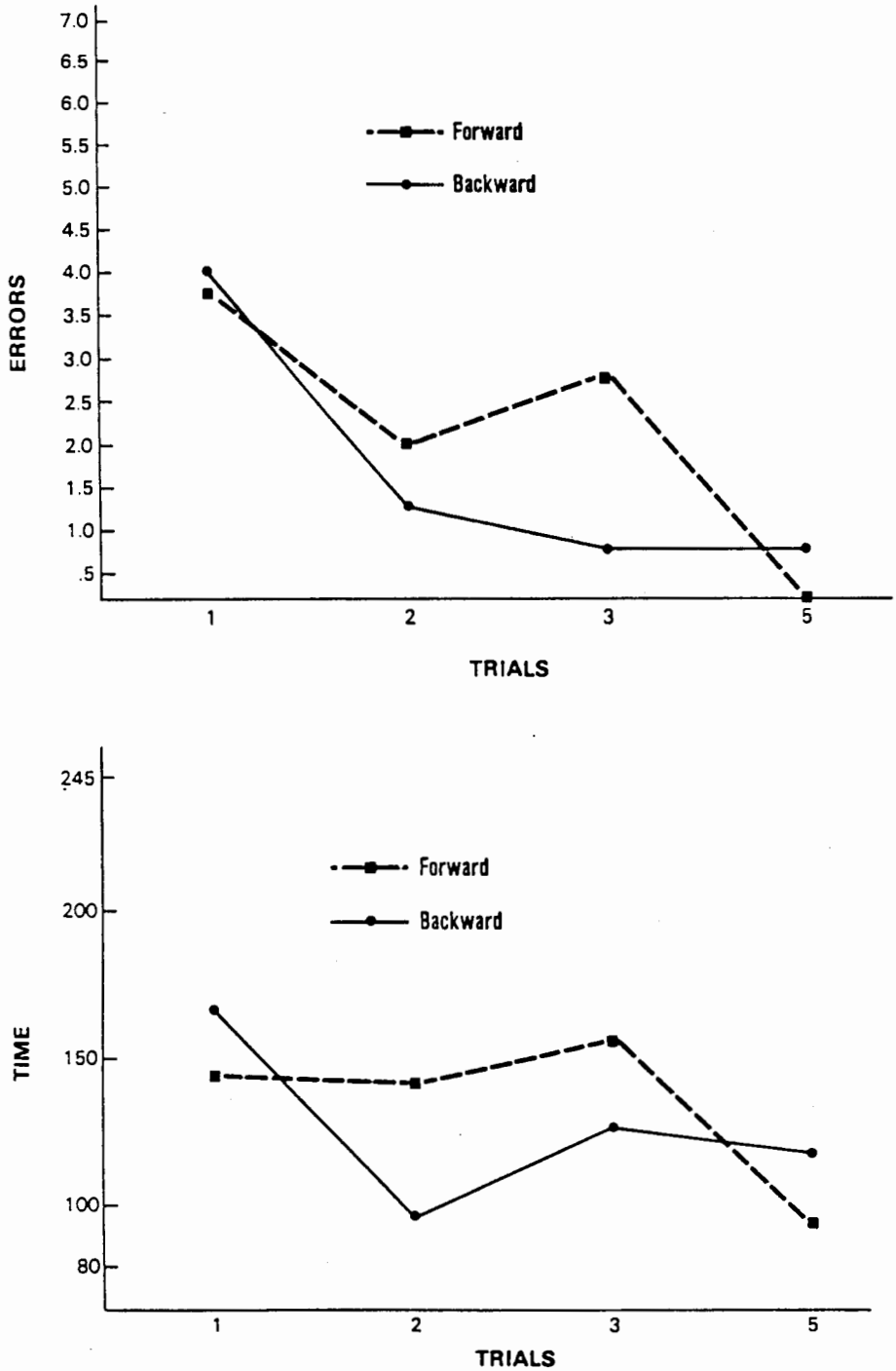

Figure 4. Graphs highlighting the similarity between the interactive patterns of both measures (A1).

Summary of results. With minimal exposure to the story, subjects performed poorly overall, but subjects experienced fewer errors with the forward order of presentation. Secondly, with moderate experience, fewer errors and faster solution times were evident, yet with greater success with the backward order of presentation. With extended exposure to the story, subjects' performance became rapid, with little-to-no errors, yet the subjects in the forward condition performed better.

DISCUSSION

With minimal practice, subjects in the Forward condition, being exposed to the vignette involving the primary goal (i.e., Part B) last, did better than the subjects in the Backward condition. As noted in the Introduction, early in serial learning, items in a list seem to be bound together by pairwise associations (Paivio & Csapo, 1969). "Chunking" of the direction choices involved in Part A was partly (or wholely, dependent on the individual's ability) accomplished. Yet with the presentation of Part B and the direction choices that needed to be made, it is likely that this associative process of chunking became overwhelmed. Memory capacity was overloaded, for most, if not all, subjects. Conversely, subjects in the Backward condition on the first exposure were able to chunk some or all of the choices in Part B and then became overloaded and confused when the choice points of Part A were encountered. Consequently, in the test situation in which Part A was combined with Part B, the subjects in the Forward condition had a distinct advantage--in terms of being more likely to be cognitively oriented to the situation. In other words, the Forward condition subjects were more likely to have encoded the information necessary for success with Part A, while subjects in the Backward condition were starting the test with the vignette in which they had likely experienced the most confusion (i.e., Part A).

This explanation would account for the significant difference in performance between the two groups exposed once to the problem compo-

nents. The group exposed to Part A first (Forward Order, One Trial condition [Group F1]) demonstrated fewer errors and less variance inperformance than subjects exposed to Part B first (Backward Order/ One Trial condition [Group B1]).

Measurements of performance for the Forward group who received three readings (Moderate Experience condition) showed that they benefitted from the increased exposure to the problem's parts, but not to the degree realized by the Backward group. This result is consistent with the rationale proposed by Trabasso (1975) as presented in the Introduction. With experience with a problem a spatial representation is formed. Place-learning supercedes pair-wise associations, and being exposed to parts of a problem as they regress from the goal facilitates this process. In other words, the subject gradually constructs from the pairs of responses, an imaginal representation of the entire array of choice responses.

Driesen (1977) showed that people use spatial processes when engaged in logical reasoning. Shaver, Pierson, and Lang (1975) presented a convincing arguement that people tend to use images when possible and this strategy tends to improve problem solving. In other words, this rapid improvement by the Backward group is suggestive of the implementation of those visual/spatial imagery representations. This analysis is consistent with that proposed by (Paivio & Csapo, 1973), and noted in the Introduction (in terms of the development of an alternate coding system independent of language and expanding short-term memory).

There was a "ceiling effect" that occured after extended exposure (five trials) in which there were few errors. Time-to-completion

for those in the Forward condition seemed dependent on motor skills alone, which is congruent with the progression noted by Fitts (1964), as described in the Introduction. Yet, those in the Backward condition with extended practice showed a good deal of variability with regard to performance time. They knew the solution, but were slower responders. It is plausable that those depending on the imaginational tools found it difficult to break set, progressing to a more expedient representational system, e.g., remembering key alternations.

With minimal practice, the forward condition subjects had fewer errors and faster solution times. With moderate practice, the Backward condition was superior. With a high level of practice the Forward condition was, again, superior, but then such a pattern is consistent with the existence of stages of learning.

The intial superiority of the forward order suggests, in line with the reasoning of Wood regarding the differences in order effects found by DeSoto and Clark, an initial image stage. This would be consistent with the findings of Fitts on an early cognitive stage in which spatial ability is important.

The subsequent superiority of the backward order suggests, in line with the reasoning of Osgood regarding Hull's analysis of Maier's reasoning problem, an associative stage. This would be consistent with the findings of Fitts on an associative stage, following the cognitive stage.

The tendency for the forward order to be superior with high levels of practice is difficult to explain. Fitts postulates a third automatization stage, yet it is difficult to see what implications such a stage might have for order of presentation of problem segments.

A recommendation for further study would include replicating this experiment with additional data on individual skill level, perhaps as reflected by intelligence, and a variety of problem situations.

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APPENDIX 1

INFORMED CONSENT

I, _____, hereby agree to serve as a subject in the research project on The Effect of Order of Presentation and Experience on Problem Solving under the supervision of Edward B. Versteeg.

I understand that as a participant I will be asked to combine information involving a character in an adventure story in order to solve a problem presented to the character in the course of the story. The story is presented on a computer monitor. The progression of the story depends on decisions made by me. Within the story are two vignettes, or "mini-stories", in which I direct the travel of the protagonist. In each vignette the protagonist is navigating a cave in which there are decisions to be made as to direction. I will be asked to make, and then enter the decision by pressing the appropriate key on the computer's keyboard. The story continues as I make these responses. The order in which the vignettes are presented will be one of two variables to be manipulated. The other variable is the number of times a subject, like myself, will be allowed to read the vignettes. Following the vignettes, the protagonist is placed in a situation requiring the navigation of both parts of the story. The problem task I will be faced with, then, is to synthesize the direction decisions.

I understand that the possible risks to me are minimal and it will cost me approximately 20 minutes of my time.

It has been explained to me that the purpose of the study is to learn how performance in solving problems is influenced by the order of presentation and the amount of experience with parts to a problem situation.

Mr. Versteeg has offered to answer any questions I may have about the study. I have been assured that all information I give will remain anonymous.

I may not receive any direct benefit from participation in this study, but my participation may help to increase knowledge which may benefit others in the future.

I understand that I am free to withdraw form participation in this study at any time without jeopardizing my grade in any class or my relationship with Portland State University.

I have read and understand the foregoing information.

Date ___/___/_____ Signature_____.

If you experience any problems that are a result of your participation in this study please contact Director of Spnsored Research, Office of Graduate Studies and Research, Neuberger Hall, Portland State University, 229-3423.

APPENDIX 2

NARRATIVE GAME PROGRAM/PROBLEM STIMULUS

```
]list 0-570

 5  REM  PROBLEM STIMULUS AND SUBJECT RESPONSE PROGRAM
 10  HOME : VTAB (2): PRINT  TAB( 13);"'PLANE DOWN'"
 20  PRINT : PRINT : PRINT  TAB( 6);"A COMPUTER NARRATION GAME": PRINT
 30  VTAB (11): PRINT  TAB( 4);"DIRECTIONS:": PRINT : PRINT
 40  PRINT  TAB( 4);"Read the following story at a"
 50  PRINT  TAB( 4);"comfortable speed.": PRINT
 60  PRINT  TAB( 4);"Type the appropriate key in"
 70  PRINT  TAB( 4);"response to questions.": PRINT
 72  FOR Y = 1 TO 9000: NEXT Y
 74  HOME
 76  VTAB (6): PRINT  TAB( 4);"For instance, type the 'SPACE BAR'"
 77  PRINT  TAB( 4);"to continue.": PRINT : PRINT
 78  PRINT  TAB( 4);"Type 'L' for LEFT and 'R' for RIGHT"
 80  PRINT  TAB( 4);"then press the 'RETURN' key after"
 82  PRINT  TAB( 4);"choosing 'L' or 'R'.": PRINT : PRINT : PRINT
 84  PRINT  TAB( 4);"Relax and most importantly, HAVE FUN!"
 90  FOR Y = 1 TO 9000: NEXT Y
 100  HOME
 110  READ A$
 120  IF A$ = "PAGE 1" THEN 210
 130  IF A$ = "PAGE 2" THEN 210
 140  IF A$ = "PAGE 3" THEN 210
 150  IF A$ = "PAGE 4" THEN 210
 160  IF A$ = "PAGE 5" THEN 210
 170  IF A$ = "END OF THE COVER STORY" THEN 250
 180  SPEED= 150
 190  PRINT A$
 200  GOTO 110
 210  PRINT
 220  SPEED= 255
 230  GOSUB 10000
 240  GOTO 100
 250  GOSUB 10040
 500  REM   COVER STORY
 510  DATA   "PLANE DOWN!"
 520  DATA   " "
 530  DATA   " "
 540  DATA   " "
 550  DATA   "In this narration game you play the part"
 560  DATA   "of a pilot flying to Rio to pick up",
 570  DATA   "several corporate executives.  There is",
```

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]list 580-1060

 580  DATA   "a tremendous cloud burst.  The torren-",
 590  DATA   "tial rains are like nothing you've ever",
 600  DATA   "encountered.  Suddenly you lose one",
 610  DATA   "engine due to water infiltration.  Then",
 620  DATA   "PAGE 1"
 630  DATA   " "
 640  DATA   " "
 650  DATA   " "
 660  DATA   "the other prop sputters and dies.  Look-"
 670  DATA   "ing over to your copilot you beg her to",
 680  DATA   "find a decent clearing in the jungle",
 690  DATA   "below.  As you struggle with the con-",
 700  DATA   "trols the copilot points to a river.",
 710  DATA   "There are small expanses of river bank",
 720  DATA   "which may be just wide enough to put the"
 730  DATA   "craft down.  The bank is so drenched",
 740  DATA   "that it will probably engulf the landing",
 750  DATA   "PAGE 2"
 760  DATA   " "
 770  DATA   " "
 780  DATA   " "
 790  DATA   "gear clear up to the fuselage, if not",
 800  DATA   "bury the entire plane.  At least you",
 810  DATA   "will only need a couple of hundred feet",
 820  DATA   "of that sludge to stop.  It beats the",
 830  DATA   "alternative of ditching in the river or",
 840  DATA   "trees.  The copilot frantically broad-",
 850  DATA   "casts MAYDAY.  You are going down in",
 860  DATA   "the remote jungles of southeast Brazil!"
 870  DATA   "PAGE 3"
 880  DATA   " "
 890  DATA   " "
 900  DATA   " "
 910  DATA   "The emergency locator sounds out its cry"
 920  DATA   "for help, but you are in the middle of",
 930  DATA   "nowhere.  It will probably be days",
 940  DATA   "before you are found.  You extricate",
 950  DATA   "yourself from the muddy plane and begin",
 960  DATA   "exploring your surroundings.  The rains",
 970  DATA   "have stopped as quickly as they began."
 980  DATA   "PAGE 4"
 990  DATA    " "
1000  DATA    " "
1010  DATA    " "
1020  DATA    "You are short of supplies. The copilot",
1030  DATA    "broke her arm and badly bruised her",
1040  DATA    "ankle.  You are pretty sore but without",
1050  DATA    "any serious injury.  Now to survive",
1060  DATA    "until help arrives."
```

```
]list 1070-1450

 1070  DATA   "PAGE 5"
 1080  DATA   "END OF THE COVER STORY"
 1100  REM   DETERMINATION OF CONDITION ASSIGNMENT
 1110 X =  INT (6 *  RND (1) + 1)
 1115 X = 1
 1120  HOME : VTAB (12): PRINT  TAB( 14);"CONDITION #";X
 1130  FOR Y = 1 TO 3000: NEXT Y
 1200  REM  CONTROL SEQUENCE FOR PRESENTING PARTS A AND B BY CONDITION
 1210  SPEED= 150
 1219  REM  CONDITION 1F
 1220  IF X = 1 THEN N = 1: GOSUB 1310: GOSUB 1350
 1229  REM  CONDITION 1B
 1230  IF X = 2 THEN N = 1: GOSUB 1350: GOSUB 1310
 1239  REM  CONDITION 3F
 1240  IF X = 3 THEN N = 3: GOSUB 1310: GOSUB 1350
 1249  REM  CONDITION 3B
 1250  IF X = 4 THEN N = 3: GOSUB 1350: GOSUB 1310
 1259  REM  CONDITION 5F
 1260  IF X = 5 THEN N = 5: GOSUB 1310: GOSUB 1350
 1269  REM  CONDITION 5B
 1270  IF X = 6 THEN N = 5: GOSUB 1350: GOSUB 1310
 1280  SPEED= 150
 1290  GOTO 1400
 1300  REM  PRESENTATION OF PARTS A AND B
 1310  FOR J = 1 TO N
 1320  GOSUB 2000
 1330  IF N > 1 THEN  GOSUB 19000
 1332  NEXT J
 1334  HOME
 1336  VTAB (12): PRINT  TAB( 14);"'LATER ON'"
 1338  FOR Y = 1 TO 2000: NEXT Y: HOME
 1340  RETURN
 1350  FOR J = 1 TO N
 1360  GOSUB 5000
 1370  IF N > 1 THEN  GOSUB 20000
 1372  NEXT J
 1374  HOME
 1376  VTAB (12): PRINT  TAB( 14);"'LATER ON'"
 1378  FOR Y = 1 TO 2000: NEXT Y: HOME
 1380  RETURN
 1400  REM  PRESENTATION OF PROBLEM SITUATION
 1410  SPEED= 150
 1411  VTAB (12): PRINT  TAB( 10);"'TROUBLE HITS'"
 1412  VTAB (12): PRINT  TAB( 11);"'TROUBLE HITS'"
 1413  VTAB (12): PRINT  TAB( 12);"'TROUBLE HITS'"
 1414  FOR Y = 1 TO 2000: NEXT Y: HOME
 1415 A = 1:B = 2:C = 3:D = 4
 1420  GOSUB 8000
 1430  PRINT "You begin feeling your way to the left": PRINT
 1450  GOTO 2080
```

```
]list 1460-4260

 1460  PRINT "it appears to be the jewel chest!": PRINT
 1470  GOSUB 10000
 1480  PRINT "Taking a deep breath, you feel along": PRINT
 1490  GOTO 5270
 1500  SPEED= 255
 1510  GOSUB 17000
 1600  END
 2000  REM  PART A
 2010  GOSUB 10040
 2020  PRINT "In your wanderings you come across the": PRINT
 2030  PRINT "entrance to what appears to be a cave.": PRINT
 2040  PRINT "Its a few yards from the river bank,": PRINT
 2050  PRINT "just a couple of hundred yards from the": PRINT
 2060  PRINT "plane.  You part the foliage and walk on"
 2070  PRINT "inside.  Feeling your way to the left": PRINT
 2080  PRINT "you find a wall.  It has become very": PRINT
 2090  PRINT "dark just a few feet from the mouth of": PRINT
 2100  PRINT "the cave.  You strike a match."
 2110  GOSUB 10000
 2120  PRINT "You see that there is a corridor that": PRINT
 2130  PRINT "veers to the right and extends at least": PRINT
 2140  PRINT "several yards.  The match burns your": PRINT
 2150  PRINT "finger and you let it drop.  There": PRINT
 2160  PRINT "aren't enough matches to illuminate": PRINT
 2170  PRINT "your exploration.  Feeling along the": PRINT
 2180  PRINT "wall with your left hand, you move ": PRINT
 2190  PRINT "cautiously forward.": PRINT
 2200  GOSUB 10000
 2210  PRINT "Your out-stretched right hand comes": PRINT
 2220  PRINT "against what seems to be a wall.": PRINT
 2230  GOSUB 14000
 2240  GOSUB 10040
 2250  PRINT "You go on in the darkness, inching along"
 2260  PRINT "the wall.  Your out-stretched right hand"
 2270  PRINT "feels a moist wall in front of you.": PRINT
 2280  GOSUB 11000
 2290  GOSUB 10040
 2300  PRINT "Moving along again you come up against": PRINT
 2310  PRINT "another wall.": PRINT
 2320  GOSUB 11000
 2330  GOSUB 10040
 2340  PRINT "Keep on going slowly forward.  You bump": PRINT
 2350  PRINT "right into yet another wall.": PRINT
 2360  GOSUB 14000
 2370  GOSUB 10040
 4200  PRINT "Your right foot bumps into something on": PRINT
 4210  PRINT "the ground.  It makes a hollow wooden": PRINT
 4220  PRINT "noise.  There is a faint light from": PRINT
 4230  PRINT "above.  Its an opening in the cavern": PRINT
 4240  PRINT "ceiling.  Its too dim to see clearly": PRINT
 4260  PRINT "it appears to be a chest.  This certain-"
```

```
]list 4265-5340

 4265  IF A = 1 THEN  GOTO 1460
 4270  PRINT "ly is worth a match!  Striking the match"
 4280  PRINT "you see that indeed it is a chest."
 4290  GOSUB 10000
 4300  PRINT "It has lettering on the top.  It is in": PRINT
 4310  PRINT "German.  You kick open the lid.  Jewels!"
 4320  PRINT "Lots of jewels!  The match goes out.": PRINT
 4330  PRINT "You try to lift the box.  Too heavy.": PRINT
 4340  PRINT "You stuff your jacket pockets with as": PRINT
 4350  PRINT "many gems as possible.  You look again": PRINT
 4360  PRINT "at the light from the ceiling.": PRINT
 4370  PRINT "You better get back to your partner.": PRINT
 4380  PRINT "You can--and will--come back for more": PRINT
 4390  PRINT "of the treasure."
 4400  GOSUB 10000
 4410  RETURN
 5000  REM   PART B
 5010  GOSUB 10040
 5020  PRINT "In your wanderings you come across what": PRINT
 5030  PRINT "appears to be a hole in the densely": PRINT
 5040  PRINT "foliaged ground.  How curious!  You are": PRINT
 5050  PRINT "only a few hundred yards from the plane": PRINT
 5060  PRINT "and your partner.  Might as well do a": PRINT
 5070  PRINT "little exploring.  You tie some vines": PRINT
 5080  PRINT "together, making certain they are very": PRINT
 5090  PRINT "strong. You tie one end to a tree trunk."
 5100  PRINT "You drop the other end down the shaft.": PRINT
 5110  GOSUB 10000
 5120  PRINT "Gingerly, you crawl down.  When you": PRINT
 5130  PRINT "reach the floor you see the faint out-": PRINT
 5140  PRINT "line of a chest to the right.  There's": PRINT
 5150  PRINT "something slithering over it.  You'll": PRINT
 5160  PRINT "check that out later!  Quickly, you ": PRINT
 5170  PRINT "move to the left. It becomes very dark.": PRINT
 5180  PRINT "You strike a match.  You see that you": PRINT
 5190  PRINT "are in a cave.  The cavern extends on-": PRINT
 5200  PRINT "ward ahead at least several yards.": PRINT
 5210  GOSUB 10000
 5220  PRINT "The match burns your fingers.  You let": PRINT
 5230  PRINT "it drop to the ground.  There are not": PRINT
 5240  PRINT "enough matches to illuminate your ex-": PRINT
 5250  PRINT "ploration.  Driven by curiousity, you ": PRINT
 5260  PRINT "continue on in darkness.  Feeling along": PRINT
 5270  PRINT "the wall with your right hand you move": PRINT
 5280  PRINT "cautiously forward.  Your out-stretched": PRINT
 5290  PRINT "left hand comes against what seems to be"
 5300  PRINT "a wall.": PRINT
 5310  GOSUB 14000
 5320  GOSUB 10040
 5330  PRINT "You go forward in the darkness, very": PRINT
 5340  PRINT "carefully.  You run up against a wall.": PRINT
```

```
]list 5350-8220

 5350  GOSUB 11000
 5360  GOSUB 10040
 5370  PRINT "Carry on.  Moving slowly along, you": PRINT
 5380  PRINT "suddenly bump into  a wall in front": PRINT
 5390  PRINT "of you.": PRINT : PRINT
 5400  GOSUB 14000
 5410  GOSUB 10040
 7000  PRINT "Your right foot bumps into something on": PRINT
 7010  PRINT "the ground.  It makes a metallic noise.": PRINT
 7020  PRINT "This is certainly worth a match!  Strik-"
 7030  PRINT "ing the match you see that it is a steel"
 7040  PRINT "box.  It has lettering on the top and": PRINT
 7050  PRINT "sides.  They are in German.  Flipping": PRINT
 7060  PRINT "open the latches, you raise the lid.": PRINT
 7070  PRINT "Medical supplies and food rations!": PRINT
 7080  GOSUB 10000
 7090  IF B = 2 THEN  GOTO 1500
 7100  PRINT "You strike another match.  There is ": PRINT
 7110  PRINT "a decent assortment of army rations,": PRINT
 7120  PRINT "analgesics, bandages, insulin, epi-": PRINT
 7130  PRINT "nepherine, antibiotics, and other medi-": PRINT
 7140  PRINT "cines.  You stuff your pockets with some"
 7150  PRINT "analgesics and a bunch of food.  You": PRINT
 7160  PRINT "better get back to your partner.  You": PRINT
 7170  PRINT "can--and will--come back for more food.": PRINT
 7180  GOSUB 10000
 7190  RETURN
 8000  REM    TEST SITUATION
 8010  GOSUB 10040
 8020  PRINT "Your partner is beginning to act pretty": PRINT
 8030  PRINT "strange.  Her speech is periodically": PRINT
 8040  PRINT "nonsensical.  Her color is poor.  She": PRINT
 8050  PRINT "complains of feeling confused and dizzy."
 8060  PRINT "In a moment of lucidity, she reveals": PRINT
 8070  PRINT "that she is diabetic.  You didn't know!"
 8080  GOSUB 10000
 8090  PRINT "She becomes faint and then lapses into": PRINT
 8100  PRINT "unconsciousness.  You've got to find her"
 8110  PRINT "insulin.  She muttered something about": PRINT
 8120  PRINT "her flight bag.  Frantically rummaging": PRINT
 8130  PRINT "through the bag, you find three empty": PRINT
 8140  PRINT "vials of insulin.  She's exhausted her": PRINT
 8150  PRINT "supply!"
 8160  GOSUB 10000
 8170  PRINT "Suddenly you recall the medicine in the": PRINT
 8180  PRINT "steel box.  The quickest way to it would"
 8190  PRINT "be the shaft, however, its doubtful that"
 8200  PRINT "the vines would tolerate another climb-": PRINT
 8210  PRINT "ing.  No time to take chances.  You must"
 8220  PRINT "take the route from the mouth of the": PRINT
```

```
]list 8230-14036

 8230  PRINT "cave.  No time for errors.  You run to": PRINT
 8240  PRINT "the cave enterance.": GOSUB 10000
 8250  PRINT "You're inside now, but what way to turn?"
 8260  GOSUB 10000
 8270  RETURN
 10000  VTAB (24): PRINT  TAB( 4);"(PRESS THE ";
 10010  FLASH : PRINT "SPACE BAR";
 10020  NORMAL : PRINT " TO CONTINUE)";
 10030  GET B$
 10040  HOME
 10050  PRINT : PRINT : PRINT
 10060  RETURN
 11000  PRINT "Which way do you turn?  Take a guess,": PRINT
 11010  INPUT "right or left (R/L)?";C$: PRINT
 11020  IF C$ <  > "L" THEN  GOTO 11035
 11030  IF C$ = "L" THEN  GOTO 11090
 11035  GOSUB 13000
 11036  IF C = 3 THEN  GOSUB 18000
 11040  INPUT "Please try again, right or left (R/L)?";D$: PRINT
 11050  IF D$ <  > "L" THEN  GOSUB 12000
 11060  IF D$ = "L" THEN  GOTO 11090
 11070  IF E$ <  > "L" THEN  GOTO 11040
 11080  IF E$ = "L" THEN  GOTO 11090
 11090  HOME : VTAB (12): PRINT  TAB( 10);"Let's continue on"
 11100  FOR F = 1 TO 1000
 11110  NEXT F
 11120  HOME
 11130  RETURN
 12000  HOME
 12010  VTAB (12): PRINT  TAB( 10);"PRESS THE 'L' KEY";E$
 12040  FOR G = 1 TO 1000
 12050  NEXT G
 12060  HOME
 12070  VTAB (12): PRINT " ";
 12080  RETURN
 13000 H$ =  CHR$ (7): SPEED= 75
 13010  FOR I = 1 TO 3
 13020  PRINT H$
 13030  NEXT I
 13040  SPEED= 150
 13050  HOME
 13060  VTAB (12): PRINT "Dead end!": PRINT
 13070  FOR Y = 1 TO 1000: NEXT Y
 13100  RETURN
 14000  PRINT "Which way do you turn?  Take a guess,": PRINT
 14010  INPUT "right or left (R/L)?";M$: PRINT
 14020  IF M$ <  > "R" THEN  GOTO 14035
 14030  IF M$ = "R" THEN  GOTO 14090
 14035  GOSUB 13000
 14036  IF C = 3 THEN  GOSUB 18000
```

```
]list 14040-

 14040  INPUT "Please try again, right or left (R/L)?";I$: PRINT
 14050  IF I$ <  > "R" THEN  GOSUB 15000
 14060  IF I$ = "R" THEN  GOTO 14090
 14070  IF J$ <  > "R" THEN  GOTO 14040
 14080  IF J$ = "R" THEN  GOTO 14090
 14090  HOME : VTAB (12): PRINT  TAB( 10);"Let's continue on"
 14100  FOR F = 1 TO 1000
 14110  NEXT F
 14120  HOME
 14130  RETURN
 15000  HOME
 15010  VTAB (12): PRINT  TAB( 10);"PRESS THE 'R' KEY";E$
 15040  FOR G = 1 TO 1000
 15050  NEXT G
 15060  HOME
 15070  VTAB (12): PRINT " ";
 15080  RETURN
 17000  HOME
 17010  VTAB (12): PRINT  TAB( 17);"THE END"
 17020  FOR Y = 1 TO 2000: NEXT Y
 17030  HOME : FOR Y = 1 TO 1000: NEXT Y
 17040  VTAB (10): PRINT "THE NUMBER OF ERRORS = ",E
 17080  PRINT : PRINT : PRINT "THE ELAPSED TIME = ",T
 17090  GET B$
 17100  HOME
 17110  VTAB (12): PRINT "   THANK YOU FOR YOUR PARTICIPATION"
 17120  FOR Y = 1 TO 2000: NEXT Y
 17130  HOME
 17140  RETURN
 18000 E = E + 1
 18010  RETURN
 19000  GOSUB 10040
 19010  PRINT "Your partner seems to be doing alright.": PRINT
 19020  PRINT "She seems most impressed with the gems.": PRINT
 19030  PRINT "After a brief rest you decide to ": PRINT
 19040  PRINT "return to the cave for more of those": PRINT
 19050  PRINT "jewels.  Telling your copilot that": PRINT
 19060  PRINT "you are going to make another quick": PRINT
 19070  PRINT "trip, you hurry off to the cave.": PRINT
 19080  GOSUB 10000
 19090  RETURN
 20000  GOSUB 10040
 20010  PRINT "Your partner seems to be doing alright.": PRINT
 20020  PRINT "She is most thankful for the food.": PRINT
 20030  PRINT "After a brief rest you decide to ": PRINT
 20040  PRINT "return to the cave for more of those": PRINT
 20050  PRINT "rations. Telling your copilot that": PRINT
 20060  PRINT "you are going to make another quick": PRINT
 20070  PRINT "trip, you hurry off to the cave.": PRINT
 20080  GOSUB 10000
 20090  RETURN
```

APPENDIX 3

TEXT OF THE NARRATIVE GAME

PLANE DOWN!

In this narration game you play the part of a pilot flying to Rio to pick up several corporate executives. There is a tremendous cloud burst. The torrential rains are like nothing you've ever encountered. Suddenly you lose one engine due to water infiltration. Then the other prop sputters and dies. Looking over to your copilot you beg her to find a decent clearing in the jungle below. As you struggle with the controls the copilot points to a river. There are small expanses of river bank which may be just wide enough to put the craft down. The bank is so drenched that it will probably engulf the landing gear clear up to the fuselage, if not bury the entire plane. At least you will only need a couple of hundred feet of that sludge to stop. It beats the alternatives of ditching in the river or trees. The copilot frantically broadcasts MAYDAY. You are going down in the remote jungles of southeast Brazil!

The emergency locator sounds out its cry for help, but you are in the middle of nowhere. It will probably be days before you are found. You extricate yourself from the muddy plane and begin exploring your surroundings. The rains have stopped as quickly as they began. You are short of supplies. The copilot broke her arm and badly bruised her ankle. You are pretty sore but without any serious injury. Now to survive until help arrives.

PART A

In your wonderings you come across the enterance to what appears to be a cave. Its a few yards from the river bank, just a couple of hundred yards from the plane. You part the foliage and walk on inside. Feeling your way to the left you find a wall. It has become very dark just a few feet from the mouth of the cave. You strike a match. You see that there is a corridor that veers to the right and extends at least several yards . The match burns your finger and you drop it to the ground. There aren't enough matches to illuminate your exploration. Feeling along the wall your left hand you move cautiously forward. Your out-stretched right hand comes against what seems to be a wall. Which way do you turn? Take a guess, right or left?

(Several directions choices later...) Your right foot bumps into something on the ground. It makes a hollow wooden noise. There is a faint light from above. Its an opening in the cavern ceiling. Its too dim to see clearly what it is that your foot struck, but it appears to be a chest. This certainly is worth a match! Striking the match you see that indeed it is a chest. It has letterings on the

top. They are in German. You kick open the lid. Jewels! Lots of jewels! The match goes out. You try to lift the box. Too heavy. You stuff you jacket pockets with as many gems as possible. You look again at the light from the ceiling. You better get back to your partner. You can--and will-- come back for more of the treasure.

PART B

In your wonderings you come across what appears to be a hole in the densely foliaged ground. How curious! You are only a few hundred yards from the plane and your partner. Might as well do a little exploring. You tie some vines together, making cetain they are very strong. You tie one end to a tree trunk. You drop the other end down the shaft. Gingerly, you crawl down. When you reach the floor you see the faint outline of a chest to the right. There's something slithering over it. You'll check that out later! Quickly you move to the left. It becomes very dark. You strike a match. You see that you are in a cave. The cavern extends onward ahead at least several hundred yards. The match burns your fingers and you drop it to the ground. There aren't enough matches to illuminate your exploration. Feeling along the wall with your right hand you move cautiously forward. Your out-stretched left hand comes against what seems to be a wall. Which way do you turn? Take a guess, right or left?

(Several direction choices later...) Your right foot bumps into something on the ground. It makes a metallic noise. This certainly is worth a match! Striking the match you see that it is a steel box. It has lettering on the top and sides. They are in German. Flipping open the latches, you raise the lid. Medical supplies and food rations! You strike another match. There is a decent assortment of army rations, analgesics, bandages, insulin, epinepherine, antibiotics, and other medicines. You stuff your pockets with some analgesics and a bunch of food. You better get back to your partner. You can--and will--come back for more food.

TEST SITUATION

Your partner is beginning to act pretty strange. Her speech is periodically nonsensical, her color is poor, she complains of feeling confused and dizzy. In a moment of lucidity, she reveals that she is diabetic. You didn't know! She becomes faint and then lapses into unconsciousness.

You've got to find her insulin. She muttered something about ger flight bag. Rumaging through the bag frantically you find three empty vials of insulin. She's exhausted her supply! Suddenly you recall the medicine in the steel box. The quickest way to it would be the shaft, however, its doubtful that the vines would tolerate another climbing. No time to take chances. You must take the route from the mouth of the cav. No time for errors. You run to the cave enterance.

You are inside now, but what way to turn?

APPENDIX 4

DEBRIEFING QUESTIONS FOR EXPERIMENT A1 (PILOT STUDY)

1.) How did you experience the game?

2.) How was the speed at which the words appeared for you?

3.) How did the fact that this was being timed affect you?

4.) How was the story's length--too long, too brief, or alright as is?

5.) What could be done to improve the story?

6.) Any other comments or questions?

APPENDIX 5

SUBJECT DATA FOR EXPERIMENT A2

SUBJECT #	CONDITION	ERRORS	TIME
1	F5	0	90
2	F3	2	144
3	F1	2	122
4	F5	0	98
5	B5	1	110
6	B3	0	130
7	F1	4	150
8	F1	2	195
9	B3	0	120
10	B5	0	96
11	F1	3	127
12	F3	2	171
13	F5	0	108
14	B3	2	151
15	F5	0	107
16	F5	0	115
17	F5	0	108
18	F3	3	150
19	F1	3	127
20	F3	0	134
21	F3	2	116
22	F1	2	104
23	F5	0	90
24	B3	0	92
25	B3	0	121
26	F5	0	101
27	B1	5	185
28	B5	2	192
29	B5	0	119
30	F3	2	133
31	B3	0	128
32	F3	5	165
33	B5	0	131
34	B1	2	156
35	B5	0	141
36	B3	0	130
37	F3	1	126
38	B1	4	145
39	F1	0	126
40	F5	0	89

SUBJECT #	CONDITION	ERRORS	TIME
41	F3	1	138
42	F1	1	131
43	B1	2	107
44	B1	5	123
45	B1	6	134
46	B5	0	100
47	F1	2	126
48	B1	4	118
49	B5	0	121
50	B1	2	137
51	B1	3	184
52	B3	2	135
53	F1	3	152
54	B1	3	175
55	F3	0	117
56	B3	2	113
57	B5	0	116
58	F5	0	101
59	B5	0	122
60	B3	0	114
TOTALS:			
N=60		85	7707
MEANS:			
		1	128

APPENDIX 6

DESCRIPTIVE STATISTICS FOR EXPERIMENT A2

ERRORS:

CONDITION

	F1	B1	F3	B3	F5	B5
MEAN	2.2	3.6	1.8	0.6	0.0	0.3
s.d.	1.14	1.43	1.48	0.97	0.0	0.67
var.	1.16	1.84	1.96	0.84	0.0	0.41

	1trial	3trials	5trials
MEAN	2.9	1.2	0.15
s.d.	1.45	1.36	0.49
var.	1.99	1.76	0.23

	FORWARD	BACKWARD
MEAN	1.33	1.50
s.d.	1.42	1.83
var.	1.96	3.25

TIME:

CONDITION

	F1	B1	F3	B3	F5	B5
MEAN	136.0	146.4	139.4	123.4	100.7	124.8
s.d.	24.81	27.82	18.52	15.65	8.97	27.11
var.	554.0	696.44	308.84	220.44	72.41	661.36

	1trial	3trials	5trials
MEAN	141.20	131.40	112.75
s.d.	26.20	18.60	23.22
var.	652.26	328.64	512.09

	FORWARD	BACKWARD
MEAN	125.37	131.53
s.d.	25.28	25.67
var.	617.90	636.92

APPENDIX 7

PARAMETRIC AND NONPARAMETRIC STATISTICS FOR EXPERIMENT A2

ANOVA:

	errors	time
order	0.36	0.96
trials	33.49***	7.07**
order x trials	7.41**	3.51*

Kruskal-Wallis ANOVA:

	errors	time
UncorrectedH =	33.319***	25.1420***
Corrected H =	37.8007***	25.1531***

Tests specific to the measured number of errors for Experiment A2:

t - tests:

F1 vs. B1	t = 2.39	(p>.05)
F3 vs. B3	t = 2.13	(p>.05)
F5 vs. B5	t = 1.42	(p >.1)
B1 vs. B3	t = 6.29	(p>.001)
F1 vs. F3	t = 0.67	(n.s.)

ANOVA:

Source	SS	d.f.	MS	F	p
Total	156.58	59			
Order	0.41	1	0.42	0.36	n.s.
Trials	77.03	2	38.52	33.49	p<.001
Order x Trials	17.03	2	8.52	7.41	p<.01
Error	62.10	54	1.15		

Scheffe's test:

F(.05,2,54) = 3.23 ms errors = 1.15

Forward vs. Backward
F = 0.075

1 vs. 3 trials
F = 5.026*

B1 vs. F1
F = 1.71

3 vs. 5 trials
F = 1.92

F3 vs. B3
F = 1.25

1 vs. 5 trials
F = 13.15*

B5 vs. F5
F = 0.078

B1 vs. B3
F = 7.82*

F1 vs. F3
F = 0.139

B3 vs. B5
F = 0.078

F3 vs. F5
F = 2.82

B1 vs. B5
F = 9.47*

F1 vs. F5
F = 4.21*

K-W ANOVA:

UncorrectedH = 33.319 N = 60; k=6; d.f.=2
Corrected H = 37.8007 (p>.001)

Mann-Whitney U test:

U'(F1xB1) = 24 U'(F1xF3) = 37.5 U'(B1xB3) = 4.5*

U'(F3xB3) = 25 U'(F3xF5) = 10* U'(B3xB5) = 43.5

U'(F5xB5) = 40

*p<.02 (p<23 @.05)
(p<16 @.02)

("*" = p > .05)
("**" = p > .01)
("***" = p > .001)

Tests specific to the measured time to solution in seconds for Experiment A2:

t - tests:

F1 vs. B1	t = 0.877 (n.s.)
F3 vs. B3	t = 2.17 (p>.05)
F5 vs. B5	t = 2.65 (p>.05)
B1 vs. B3	t = 2.26 (p>.05)
F1 vs. F3	t = 0.35 (n.s.)

ANOVA:

Source	SS	d.f.	MS	F	p
Total	45000.85	59			
Order	570.42	1	570.42	0.96	n.s.
Trials	8355.10	2	4177.55	7.07	p<.01
Order x Trials	4154.33	2	2077.22	3.51	p<.05
Error	31920.90	54	591.13		

Scheffe's test:

F(.05,2,54) = 3.23 ms error = 591.1277

Forward vs. Backward
F = 0.193

1 vs. 3 trials
F = 0.325

3 vs. 5 trials
F = 1.177

1 vs. 5 trials
F = 2.739

B1 vs. B3
F = 0.895

B5 vs. B3
F = 0.003

B1 vs. B5
F = 0.789

B1 vs. F1
F = 0.183

F3 vs. B3
F = 0.433

B5 vs. F5
F = 0.983

F3 vs. F1
F = 0.020

F3 vs. F5
F = 2.534

F1 vs. F5
F = 2.10

K-W ANOVA:

UncorrectedH = 25.1420	N = 60; k=6; d.f.=2
Corrected H = 25.1531	(p>.001)

Mann-Whittney U test:

U'(F1xB1) = 39

U'(F3xB3) = 26

U'(F5xB5) = 14* (p<.02)

("*" = p > .05)
("**" = p > .01)
("***" = p > .001)

APPENDIX 8

DATA OF EXPERIMENT A1 (PILOT STUDY)

SUBJECT #	CONDITION	ERRORS	TIME
1	F1	2	168
2	F3	2	129
3	F1	4	144
4	B3	2	161
5	B5	0	131
6	F1	6	137
7	F2	3	135
8	B2	0	75
9	B3	0	122
10	B5	0	78
11	B1	5	175
12	B1	2	92
13	F5	0	102
14	F5	0	79
15	F2	3	270
16	B2	2	110
17	B3	1	82
18	F3	4	175
19	F1	3	126
20	B1	5	270
21	F3	3	148
22	F5	0	83
23	F2	2	73
24	B3	0	128
25	F5	0	112
26	B5	2	128
27	B1	4	133
28	F2	0	93
29	B2	2	96
30	B2	1	104
31	B5	1	123
32	F3	2	171
TOTALS:			
N=32		61	4153
MEANS:			
		1.90	129.78

APPENDIX 9

DESCRIPTIVE STATISTICS FOR EXPERIMENT A1 (PILOT STUDY)

ERRORS:

CONDITION

	F1	B1	F2	B2	F3	B3	F5	B5
MEAN	3.75	4.0	2.0	1.25	2.75	0.75	0.0	0.75
s.d.	1.71	1.41	1.41	0.96	0.96	0.96	0.0	0.96
var.	2.19	1.5	1.5	0.69	0.69	0.69	0.0	0.69

	1trial	2trials	3trials	5trials
MEAN	3.88	1.63	1.75	0.38
s.d.	1.46	1.19	1.39	0.74
var.	1.86	1.23	1.69	0.48

	FORWARD	BACKWARD
MEAN	2.13	1.69
s.d.	1.78	1.70
var.	2.98	2.71

TIME:

CONDITION

	F1	B1	F2	B2	F3	B3	F5	B5
MEAN	143.75	167.5	142.75	96.25	155.75	123.25	94.0	115.0
s.d.	17.78	76.27	88.68	15.28	21.44	32.41	15.64	24.89
var.	237.19	4363.3	5898.2	175.19	344.69	787.69	183.5	464.5

	1trial	2trials	3trials	5trials
MEAN	155.63	119.5	139.5	104.5
s.d.	52.82	63.94	30.8	22.28
var.	2441.23	3577.25	830.25	434.25

	FORWARD	BACKWARD
MEAN	134.06	125.5
s.d.	48.74	47.68
var.	2227.06	2131.38

APPENDIX 10

PARAMETRIC AND NONPARAMETRIC STATISTICS FOR EXPERIMENT A1

ANOVA:

	errors	time
order	1.25	0.31
trials	13.81***	2.1
order x trials	2.41*	1.37

Kruskal-Wallis ANOVA:

	errors	time
UncorrectedH =	19.614***	13.105**
Corrected H =	20.771***	13.112**

t - tests:

Condition	errors	time
F1 vs. B1	0.226	1.494
F2 vs. B2	0.938	1.632
F3 vs. B3	2.946*	0.565
F5 vs. B5	1.562	0.629
B1 vs. B2	3.284*	1.568
B1 vs. B3	3.812**	1.059
B1 vs. B5	3.812**	1.281
F1 vs. F2	1.579	1.568
F1 vs. F3	1.020	0.263
F1 vs. F5	4.387**	0.181
B2 vs. B3	0.528	0.956
B2 vs. B5	0.528	0.658
F2 vs. F3	1.105	1.474
F2 vs. F5	2.946*	1.622
B3 vs. B5	0.000	0.368
F3 vs. F5	4.050**	0.437

Mann-Whitney U test:

Condition	errors	time
F1/B1	7	7
F2/B2	4.5	7
F3/B3	1	2
F5/B5	4	4
F1/F3	4	4
F3/F5	2	0
B1/B3	0	4
B3/B5	6.5	7.5

Scheffe's test:

Condition	errors	time
Forward/Backward	0.44	8.56
1trial/2trials	2.25	36.13
1trial/3trials	2.13	16.13
1trial/5trials	3.5 *	51.13
2trials/3trials	0.12	20.0
2trials/5trials	1.25	15.0
3trials/5trials	1.37	35.0
B1/F1	0.25	23.75
B2/F2	0.75	46.5
F3/B3	2.0	32.533
B5/F5	0.75	21.0
B1/B2	2.75	71.25
B1/B3	2.75	44.25
B1/B5	3.25	52.5
B2/B3	0.5	27.0
B2/B5	0.5	18.75
B3/B5	0.0	8.25
F1/F2	1.75	1.0
F1/F3	1.0	-----
F1/F5	3.75*	49.75
F2/F3	0.75	13.0
F2/F5	2.0	48.75
F3/F1	----	12.0
F3/F5	2.75	61.75

F(.05,2,24) = 3.40

C. diff. for error = 3.27
C. diff. for time = 129.73

("*" = p > .05)
("**" = p > .01)
("***" = p > .001)