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HOW DO YOUNG ADULTS READ DIRECTIONS WITH AND WITHOUT PICTURES?(U)
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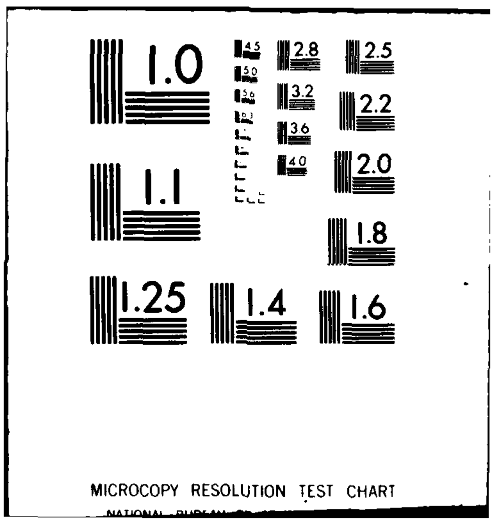
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DEPARTMENT OF EDUCATION

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How Do Young Adults Read Directions With and Without Pictures

David E. Stone
Marvin D. Glock

Technical Report No. 1

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This research is designed to explore the manner in which people read and use procedural information (directions) presented to them in text and illustrations. University undergraduates read directions for the assembly of a model loading cart, assembling the model as they read. The use of illustrations with text was found to produce significantly more accurate performance of the task. Results also suggest that specific types of information are presented more effectively in texts or in illustrations.

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20. Abstract

Several recent theories are considered for their implications regarding this issue.

Abstract

This research is designed to explore the manner in which people read and use procedural information (directions) presented to them in text and illustrations. University undergraduates read directions for the assembly of a model loading cart, assembling the model as they read. The use of illustrations with text was found to produce significantly more accurate performance of the task. Results also suggest that specific types of information are presented more effectively in texts or in illustrations. Several recent theories are considered for their implications regarding this issue.

How Do Young Adults Read Directions

With and Without Pictures?

The manner in which running text and illustrations complement each other to facilitate reading comprehension is a problem that has received increasing attention from those researching the reading process. This is not surprising given the fact that illustrations are to be found in virtually every form of printed discourse. In fact, the extensive use of illustrations with text suggests that the study of the reading process should properly include the study of comprehension of information extracted from illustrations as well as running text.

The studies reported in the literature dealing with this issue have used either children or adult subjects and narrative texts (reading materials selected from basal readers, news items or specifically prepared texts and illustrations). None has used procedural texts and illustrations (directions) although this form of reading material is in extensive use.

A selective review of related studies in the literature helps to clarify research questions pertaining to procedural texts with illustrations. Several studies have attempted to determine whether illustrations enhance the comprehension of stories in children's books. W. A. Miller (1938) reported that children's comprehension of stories was just as good without pictures as with them. Weintraub (1960) examined the effect of pictures on the comprehension of a second-grade basal reader and found that children who read the text without pictures had better comprehension scores than those who read the text with pictures. Vernon did two studies (1953, 1954) which found that an illustrated version of written text was neither remembered nor comprehended better than a non-illustrated version. Koenke (Note 1) found no difference in children's ability to state the main idea of a paragraph whether accompanied by a picture or not.

Peeck (1974) used cartoon pictures selected to convey information in an accompanying story. He varied the agreement between the information contained in the pictures and that contained in the text. When the information was presented in both picture and text, his fourth-grade subjects scored higher on questions assessing knowledge of information than children who read only text. Peeck found that for children reading illustrated text with points of conflict between picture and text there was no difference in retention between groups reading illustrated and non-illustrated versions of the text.

Lesgold, DeGood and Levin (1977) found that illustrations facilitated prose learning for first graders. One study done with adults, by Findahl (Note 2), attempted to determine whether pictures would improve memory for news items. Results indicated that the addition of pictures did produce improved recall of text.

Levin and Lesgold (1978) provide a comprehensive review of studies of learning in which the role of pictures is examined. In contrast to claims made to the contrary (Concannon, 1975; Samuels, 1970) they "conclude that there is solid evidence that pictures facilitate prose learning". The studies they review have five characteristics: 1. Prose passages are presented orally, 2. the subjects are children, 3. the passages read are fictional narratives, 4. the pictures overlap the story content, and 5. learning is demonstrated by factual recall.

The research reported in this paper: 1. assessed the effects of pictures on comprehension while subjects read a text selection, 2. used young adults (18-21 years old), 3. employed a procedural text (directions), 4. used line drawings that were comparable to the text in content and 5. used performance of an assembly task as the measure of comprehension. Thus, several aspects of reading heretofore unexamined were investigated here.

This research was designed in two phases. The first phase was an investigation of the effects of text on the comprehension of directions presented in line drawings. The two conditions were illustrations without text and illustrations with text. Phase two of the investigation involved collecting data for a text alone condition so that a comparison could be made among text alone, text with pictures and pictures alone conditions. The design of phase one was similar to that of most previous studies (at the outset) in that only two conditions were used. These studies all suffer from a methodological weakness in that they cannot isolate the effect of pictures, since they lack a picture alone condition. Phase one of this study suffered from the same defect in that there was no text alone condition. The addition of a text alone condition subsequent to phase one was designed to remedy this difficulty.

The research reported presently was designed, therefore, to assess whether text would enhance adults' comprehension of the concepts and relations among concepts as expressed in picture directions (in this case directions for the assembly of a model handtruck). Furthermore, the method used to assess readers' comprehension of this information was non-verbal, that is, their performance of the assembly task was recorded on videotape.

Method

Subjects

The sample was comprised of second- and third-year students who were undergraduates at Cornell University. Subjects were selected from a pool of volunteers within an introductory psychology course. Phase I of the experiment included 59 subjects who were randomly and independently assigned to two conditions of the experiment (illustration and illustration with text). Subsequently, a third condition (text alone) was added to the experiment and 31 additional subjects participated in this second phase of the study.

All subjects came from the same pool of Cornell University undergraduates even though they were drawn at different times. No significant differences were uncovered among the 3 groups based on the administration of a pretest of spatial ability, $F(2,87)=2.31$, $p>.05$. None of the subjects had prior experience with the task used in the study.

Materials

The materials employed in this study consisted of: (1) text directions for assembly of a model loading cart (Table 1), (2) line drawings depicting the model at various stages of assembly (Figure 1), and (3) the parts of a Fishertechnik 100 model loading cart.

Insert Table 1 and Figure 1 about here

The text directions were derived from a group of students' written descriptions of the assembly task. Names for parts and features of parts were taken from these descriptions, as were subassemblies (i.e., handle, wheel, etc.) and names for subassemblies of the model. The order of assembly in the text was determined by ordering these subassemblies from simplest to most complex as reflected by the number of parts involved in each and by the number of operations to be performed with those parts. The resulting text directions were modified so as to delete unneeded content, add additional details and clarify ambiguities.

The line drawings used were based on the drawings of the model which are provided by the model's manufacturer. These line drawings were prepared for each part in the model, each subassembly, and the completed model. They, too were tested by asking students to perform the task using them as directions.

The text and line drawings, therefore, were designed to be comparable. Table 1 and Figure 1 contain the text and slides used in the study which are numbered to illustrate their comparability. Variations in subjects' comprehension of the directions in the three conditions of the study would consequently be indicative of the effects of media form on readers' comprehension and would not simply reflect differences in the information content in the directions.

The model itself was taken from a kit designed for children. The pieces snap or slide together with little difficulty. The assembled model is about 6 ½" tall, 2 ½" wide and 2 ½" deep.

This task was selected because the model parts may be assembled in a variety of sequences and orientations. (We are speaking here of orientations with respect to each other in space.) This flexibility is desirable since it permits subjects to express their understanding of the directions in a variety of ways, but also because it makes it possible to write a variety of types of directions for the task, each redefining the task in a different way. This task, therefore, may be useful for a variety of studies designed to examine both the design and comprehension of procedural texts prepared for assembly tasks.

Furthermore, there is apparently little information inherent in the configuration of the parts themselves to guide the subject in the assembly process.

This statement may appear to be counter-intuitive with respect to the wheel assemblies, for example. However, in a pilot study when ten subjects were asked to assemble the model in the absence of any directions, no two subjects sembled the parts in the same manner. In fact, each assembly was so different that no ready description can be provided of the assembled objects. No subject produced anything resembling a handtruck.

Equipment

The equipment used in this study included: (1) 2 Singer Caramate slide projectors, (2) 1 SONY videotape recorder, (3) 1 SONY (SEG-1) special effects generator, (4) 1 SONY Trinitron monitor, (5) 40 one-half hour, one-half inch SONY videotapes, (6) 2 slide carousels, (7) slides, and (8) 2 SONY television cameras.

Procedure

In Phase I of the study 59 subjects were randomly assigned to the two conditions of the experiment. Of these 59, 29 viewed illustrations without text and 30 viewed illustrations with text. In Phase II, 31 viewed text without illustrations.

Data were collected on the subjects one at a time. Each of them was seated at a listening station, facing the wall, in a corner of a library listening room. Parts for the model were laid out in front of each subject. A Caramate projector was located just left and another just to the right of the subject.

A television camera was positioned next to the Caramate projector on the left and was directed at the subject's head, the other was located to the left and rear of the subject and was directed at the workspace just in front of the subject. Only the model parts, Caramate projectors and one camera were visible to the subject, since all other apparatus was placed behind a partition.

Upon completion of the pretest subjects were instructed in the operation of the Caramate projectors and were shown which slides contained general instructions for the experiment. These instructions described the experiment as an attempt to learn more about how people read and follow directions. Subjects were then asked to look at a slide which showed line drawings of each of the ten kinds of parts used in the model. Each line drawing was labeled with its name, and features of these parts such as "tabs" (referred to later in the directions) were also labeled.

Each subject was asked to learn these names and was allowed a few minutes to do so. Subjects were then tested for their ability to name the drawings of the parts and their features, to identify the drawing of the parts and their features when given their names, and to perform both these tasks using the actual parts and not the drawings. Since these proved to be easy tasks, the criterion for them was 100% accuracy.

Once they could do this, subjects were shown the first slide of the directions for their condition of the experiment. Subjects viewing the slides would first look at one slide and then either look at the other slide (in the condition where text was presented with the illustrations) or look at the parts to be assembled.

They would then attempt to complete the subassembly of the model depicted in the directions. (Twelve subassemblies were depicted in the directions.) Upon completion of the subassembly, subjects would change the slide(s) and proceed to the next subassembly. This process would continue until the model was completed. Subjects were allowed to go back to earlier slides if necessary.

The videotape recorder was started immediately after the general instructions were presented. Videotape recordings were made using a special effects generator to provide a split-screen record of each camera's view. One camera, directed at the subject's hands provided information on the progress of the task. The second camera, directed at the subject's head provided information as to whether the subject was looking at the text, at the illustration, or at his/her hands. This camera also made it clear when a subject changed a slide.

The special effects generator produced a split-screen image on the monitor and on the videotape so that the experimenter could obtain precise information as to reading behavior (frequency, sequence and duration of looking) and reading comprehension (task performance). The videotape recordings were subsequently viewed and scored by the experimenter and an assistant. The second-by-second record of each subject's reading behavior and comprehension was then converted to a data structure for subsequent analysis.

Scoring

To score the videotapes the recordings of reading behavior and task performance were carefully examined. The method used to extract data from the tapes was to view each tape on a monitor and videotape recorder equipped with a pause button. The subject's reading behavior, in the form of looking for various periods of time at each of the two screens or at the model parts, was recorded by starting the tape and a stopwatch at the beginning of the task and stopping both at each change in reading behavior.

In this manner a record of reading behavior was produced which recorded the duration and sequence of the subject's looking at text, illustrations or task. Analysis of these data yielded information as to the frequency with which subjects looked at one source or the other. Slide change was also recorded so that the text and/or illustrations on view at any given moment could be determined.

The movement of the subjects' hands and eyes from one position to another was constantly recorded by each of the two television cameras. This movement was completely unambiguous, since the position of the two slide projectors and model parts were widely separated. This lack of ambiguity was confirmed by disinterested observers.

A record of task performance was produced as a videotape was viewed. The completion of each subassembly was noted as it occurred. All errors of assembly were also noted as they occurred. However, only uncorrected errors were finally scored as errors. An analysis of this second-by-second record of task performance yielded information as to the completion time for each subassembly, the number and type of errors in the subassembly and the sequence in which the subassemblies were completed.

This scoring procedure has proven to be highly reliable. Crandell (Note 3), using the same scoring technique, employed an independent judge (blind to the treatment conditions) to provide experimenter-judge scoring correlations. He reports correlations between experimenter and judge on mean time looking at text of $r=.961$ mean time, looking at illustrations of $r=.991$ and mean errors in assembling the model of $r=.960$.

All of the above information on each subject was coded into an appropriate data structure for analysis. The data structure represented changes in eye position, completion of subassemblies, errors of assembly and slide changes as a string of numbers and symbols that were stored on a floppy disc for a PDP 11/40.

A sample of such a data structure follows: "1.0.14.8.1". In this case the subject looked at an illustration for one second(1), did not look at the text at all (0), looked at the model parts for fourteen seconds(14 and completed the subassembly called the "base" (it was labeled #8) with an error of type 1 (1). Periods denote changes in activity while slide changes (not shown in this example) are indicated by a "/".

Design and Analysis

There were 3 levels of Media Form (Text, Text with Illustrations, Illustrations) and one task requirement in this study. The independent variables were between-group variables. Accuracy scores for assembly of the model were the values of the dependent variable. The distribution of scores was non-normal; the Kruskal-Wallis test (based on an α of .05) followed by all pairwise Mann-Whitney comparisons (based on an α of .01) (Kirk, 1968) were computed to assess the effects of the 3 treatment conditions.

Results

Measures of Comprehension

Readers' comprehension of the reading materials was operationally defined as the accuracy with which they followed the directions in performing the task. Accuracy of assembly was determined by counting the number of errors made in following the directions. Data concerning the types of errors made were also examined.

Types of errors. A review of the errors made by subjects in all conditions of the study indicates that errors were of four types.

a. orientation of parts - parts of the model were attached at the proper place but not properly oriented in space (e.g., 90° out of alignment with the other parts).

b. location of parts - parts attached at the wront point on the model.

c. wrong parts used - subject selected and wrong part (one other than the one identified in the directions) but attached it to the model (e.g., "short rod" used instead of "long rod.")

d. parts omitted - model assembly but some parts "left-over," never used.

Number of errors. Sixty of the 90 subjects made errors in completing the assembly task. The mean number of errors made by subjects in each condition is shown in Table 2 below.

Insert Table 2 about here

The Kruskal-Wallis test results revealed a significant difference among the three groups in the number of errors in the assembly task ($p < .0005$). All-pairwise Mann-Whitney comparisons conducted at an α level of .01 (Kirk, 1968) indicate that subjects who viewed text with illustrations made significantly fewer errors in the assembly task than did subjects who viewed text alone ($p < .001$, two-tailed) or illustrations without text ($p < .001$, two-tailed). No significant differences (in the total number of errors made) were found between subjects who read text alone and those who viewed illustrations alone ($p > .05$).

Table 3 shows the mean number of errors of each type by condition in the study.

Insert Table 3 about here

The Kruskal-Wallis text (based on an α of .05) was performed on the error data by type. A significant difference among the three groups was found for errors of orientation of parts ($p<.0005$), but not for other type of errors (all ps $<$ .05).

All pair-wise Mann-Whitney comparisons were performed at an α level of .01 on the orientation data of the three groups. Results indicate that the addition of illustrations to text resulted in significantly fewer errors in orientation of parts during the assembly process ($p<.001$, two-tailed) when compared to the text alone condition. Significantly fewer errors of orientation were made by subjects in the illustration alone condition than in the text alone condition ($p<.005$). No significant differences were found in orientation errors between the illustration condition and the text with illustration condition.

Eye-track Data (Illustration Conditions) Eye-track data were collected during the study and are descriptive of the manner in which readers selectively combine information presented verbally and pictorially. Subjects typically spent the first second or two (on each picture-text display) viewing the illustration and they then proceeded to read the text. At various points in the text readers referred back to the illustration. (The equipment used did not provide information as to the precise location of these points.) The average reader who viewed text with illustrations referred to the illustration 36 times during the reading session. The mean duration of each of these glances at the illustrations was 1.84 seconds.

Overall, subjects spent more time looking at text in this condition than they spent looking at illustrations. The total mean time per subject spent in looking at text was 309 seconds and the mean time spent looking at illustrations was 66.24 seconds.

In the condition with illustrations and no text the mean time spent looking at illustrations was 160.33 seconds. (No eye-track data were collected in the text alone condition.)

Discussion

This study attempted to determine whether the addition of line drawings equivalent in information content to text directions would enhance adults' comprehension significantly more than that produced by either text or illustrations presented alone.

Since the information content of text and line drawings was designed to be completely redundant, the finding of optimal comprehension in the text and illustration conditions cannot be explained by the argument that additional information was present in that condition. A review of the types of errors made in each condition of the study suggests that the explanation lies in the differential effectiveness of illustrations and texts in communicating different types of information. For example, the finding that the addition of illustrations to text resulted in significantly fewer errors of orientation of parts seems to indicate that the illustrations convey spatial information more effectively than text. This is also supported by the finding that significantly fewer errors of this type were found in the illustration alone condition as compared to the text alone condition.

Several additional alternative explanations may also be considered. The first is that there are points of ambiguity in both text and illustrations and that at such points the presence of redundant information in another form provides the reader with an opportunity to seek clarification from that alternate source. An additional possibility may be that individuals differ in their ability to extract and use information presented verbally or pictorially and that providing alternate forms of the directions allowed these individuals the flexibility of selecting the optimal form for their needs.

Both these possibilities would seem consistent with Gibson and Levin's (1975) theoretical basis for understanding how people read pictures and text. They view the process of reading as one of extracting information from pictures and text, although the processes are undoubtedly different. They believe that "higher order structures" are basic to perceiving patterns of distinctive features in pictures and text. The structures are seen as rule systems that describe subordinate relationships among phonological, syntactic and semantic components involved in reading. The key processes involved in developing such rule systems include abstracting relationships, ignoring irrelevant information, locating potential information areas, using distinctive features, and obtaining intrinsic reinforcement through the discovery of structure and the reduction of uncertainty.

In order to clarify further this issue it would be extremely useful to collect detailed eye-movement data while subjects read the text and view the illustrations. The videotaping procedure used in this study could not provide precise information concerning fixation points during the reading of text and examination of pictures. Existing eye-track systems could provide such information. This would make it possible to determine whether there are specific points in the text (and illustrations) at which most readers refer to the accompanying illustrations (or text). The existence of such points would be consistent with the view that ambiguities exist that are clarified by the alternate mode of presentation. Another approach might be to test for individual differences in cognitive styles and their optimal match with specific instructional formats. Work along these lines has recently been conducted by Crandell (Note 3), although he reports no significant effects for cognitive style variables.

Eye-track data. The eye-track data collected in this study seem consistent with Loftus and Bell's (1975) observations that readers who view an illustration spend the first few fixations extracting "gist" information. Gist information is defined as information that permits readers to say what the illustration represents in some general way (i.e., a picture of a horse vs. a picture of a lion). Readers then appear to refer to the text and read for several seconds.

They then periodically refer to the illustration. The mean number of discrete shifts from text to illustration (and vice versa) was 36.

Readers appear to be systematically comparing the semantic content of the pictures and text as demonstrated by their frequent looking from one to the other. Clark and Chase's (1972) theory of sentence-picture comparison may help us understand what is happening here. They base their theory on the assumption that, in order for people to compare pictures and sentences, they must first interpret the graphemic and pictorial properties of each into a common semantic format. Further, they assume that these interpretations are coded in terms of propositions. They report a series of experiments which are consistent with these assumptions and which support their view that there is a common "interpretive" system that underlies both language and perception and which is handled by a single set of cognitive principles.

An alternate explanation is suggested by Rumelhart's (1977) schema theory of reading comprehension. Rumelhart's model indicates that readers generate hypotheses at a variety of levels designed to account for the incoming information. Levels of hypotheses would include the letter-level, the lexical-level, syntactic-level and semantic-level. Hypotheses at an even higher level are proposed which account for entire stories. These hypotheses are called "schemata". Such schemata provide a context for incoming information, predicting (and inferring) the existence of lower level hypotheses. It may be that readers presented with illustrations and text redundant in terms of information content, rely on the illustrations to provide them with a context for the information which they extract from text.

It would be extremely useful to know exactly in what manner subjects selected and extracted information from each mode of presentation and how they combined such information. To the extent that precise eye-track information reflects cognitive events such data should be helpful in this regard.

Finally, it should be noted that these findings are of limited generalizability for a variety of reasons. First, the illustrations used here were simple perspective line drawings. No arrows, dotted lines, exploded views, or orthographic projections were used. It is possible that drawings employing these features might prove superior to text in communicating the directions for the task. In addition, the university population of highly verbal and academically homogeneous young adults used in this study may differ in their use of illustrations from other less verbal groups. Replications of these results with other populations would be desirable. Further, only one task was employed. Replications involving the construction of other objects would be desirable.

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Table 1

Text Directions

1. To form handle one: Insert a short rod through a clip so that the clip is in the middle of the rod.
2. To form handle two. Insert another short rod through another clip so that the clip is in the middle of the rod.
3. To form column one: Assemble one small block and three large blocks end to end.
4. To form column two: Assemble another small block and three other larger blocks end to end.
5. To form the back: Move the columns so that they are parallel with each other. They should be about the width of two blocks apart. (Be sure that the tabs at the end of each column point in the same direction.)
6. Connect the two columns by inserting four flat pieces between them. Slide each flat piece into place using the side grooves in the blocks. (All the flat pieces should have their smooth sides on the same side.) They must be flush with the ends of the columns without tabs.
7. To form the axle assembly: Insert the long rods through two angle blocks. The angle blocks should be oriented in the same way and should be about two blocks widths apart.
8. To attach the axle assembly to the back: Insert the tabs of the angle blocks in the end grooves of the columns. Be sure that the angle blocks are oriented in the same way and that one tab on each angle block faces the side of the back with smooth flat pieces.

9. To form the base: Fasten two large blocks end to end to form a short column. Attach a third large block to a flat piece by inserting the flared edge of the flat piece into a side-groove of the block. (Be sure that the ends of the flat piece are flush with the ends of the block.)

Attach another large block to the other flared edge of the flat piece in the same way. (Be sure that the tabs of the blocks point in the same direction.) Insert these two tabs into a side groove of the short column so that the side of the short column covers the ends of both large blocks and the end of the flat piece.

10. To attach the base to the axle assembly: Notice that the base has a column of two large blocks. One side of this column has a flat piece attached to it. Attach the opposite side of this column to the exposed tabs of the axle assembly. Be sure that the flat piece in the base has its smooth side up.

11. To form a wheel assembly: Place a washer over one end of the long rod so that it is flush with the angle block. Place a nut hub over the same end of the long rod so that its threads point away from the angle block.

Next place a tire over the same end of the rod. Next place a screw hub over the same end of the long rod with its threads toward the nut hub. Screw the nut hub and screw hub together with the tire between them. Finally, place a washer over the same end of the long rod so that it is flush with the screw hub.

11. To form another wheel assembly: Place a washer over one end of the long rod so that it is flush with the angle block. Place a nut hub over the same end of the long rod so that its threads point away from the angle block.

Next place a tire over the same end of the rod. Next place a screw hub over the same end of the long rod with its threads toward the nut hub. Screw the nut hub and screw hub together with the tire between them. Finally, place a washer over the same end of the long rod so that it is flush with the screw hub.

12. Next, the handles should be inserted in the end of the back with exposed tabs. Each handle should be inserted in the grooves at the front of the back so that the clips are resting against the ends of the blocks. The openings on one side of each clip should fit over the tabs at the ends of the columns. This completes the assembly of the loading cart.

Table 2

Mean Number of Errors in Assembly[a]

	$\bar{X}$	S.D.
Text (No Illustration) (N=31)	2.54	2.23
Text with Illustrations (N=30)	.60	.89
Illustrations (No Text) (N=29)	3.34	2.17

[a]Failure to complete an assembly was scored as an error.

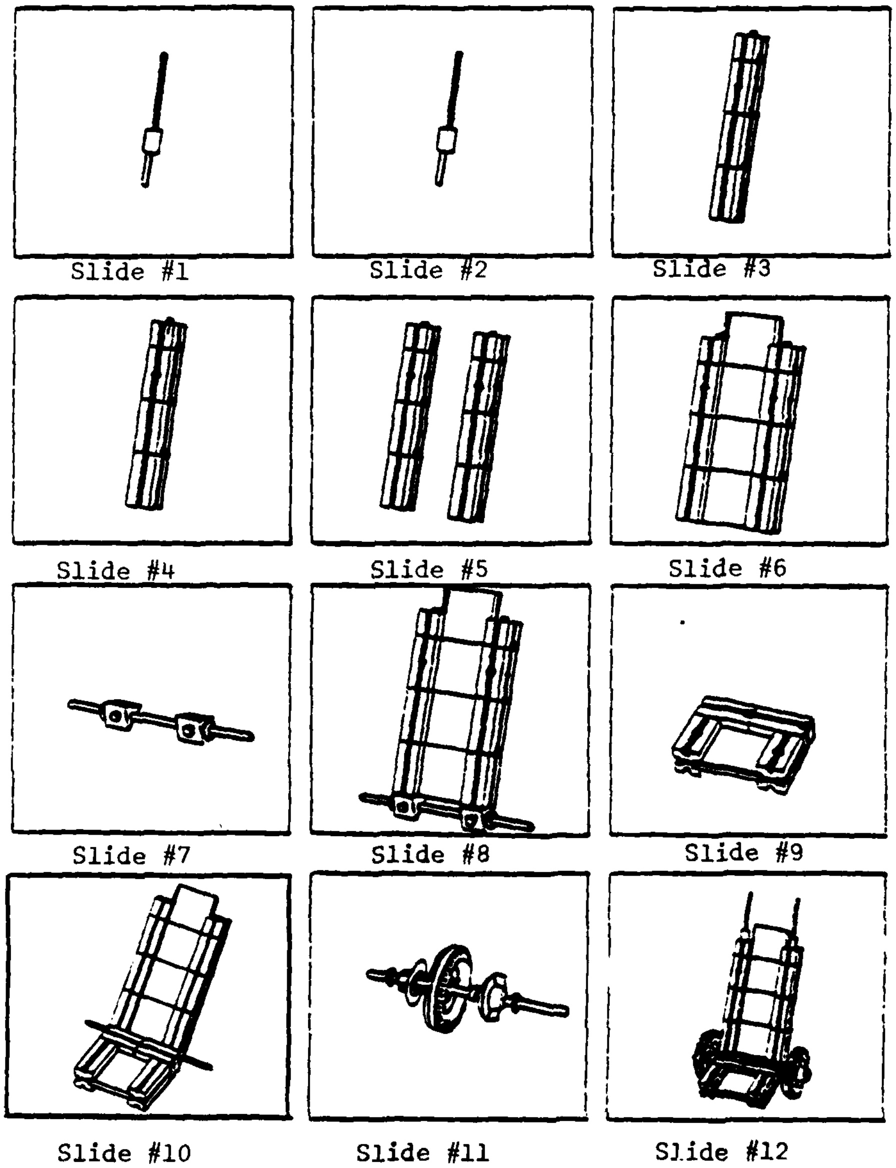
Table 3

Mean Number of Errors by Type and by Condition

	Orientation		Location		Wrong Parts		Missing Parts	
	$\overline{X}$	S.D.	$\overline{X}$	S.D.	$\overline{X}$	S.D.	$\overline{X}$	S.D.
Text (No Illustration) (N=31)	1.29	1.21	.90	1.13	.10	.39	.19	.47
Text with Illustration (N=30)	.07	.24	.47	.81	.00	.00	.07	.25
Illustrations (No Text) (N=29)	.38	.49	1.69	1.69	.31	.66	.97	1.37

Figure 1

SLIDES OF ILLUSTRATIONS
(Not shown in accurate scale)



Navy

1 Dr. Robert Breaux
Code N-711
NAVTRAEQUIPCEN
Orlando, FL 32813

1 Dr. Richard Elster
Department of Administrative Sciences
Naval Postgraduate School
Monterey, CA 93940

1 DR. PAT FEDERICO
NAVY PERSONNEL R&D CENTER
SAN DIEGO, CA 92152

1 Dr. John Ford
Navy Personnel R&D Center
San Diego, CA 92152

1 LT Steven D. Harris, MSC, USN
Code 6021
Naval Air Development Center
Warminster, Pennsylvania 18974

1 Dr. Patrick R. Harrison
Psychology Course Director
LEADERSHIP & LAW DEPT. (7b)
DIV. OF PROFESSIONAL DEVELOPMMENT
U.S. NAVAL ACADEMY
ANNAPOLIS, MD 21402

1 Dr. Norman J. Kerr
Chief of Naval Technical Training
Naval Air Station Memphis (75)
Millington, TN 38054

1 Dr. William L. Maloy
Principal Civilian Advisor for
Education and Training
Naval Training Command, Code 00A
Pensacola, FL 32508

1 Dr. Kneale Marshall
Scientific Advisor to DCNO(MPT)
OP01T
Washington DC 20370

Navy

1 CAPT Richard L. Martin, USN
Prospective Commanding Officer
USS Carl Vinson (CVN-70)
Newport News Shipbuilding and Drydock Co
Newport News, VA 23607

1 Dr William Montague
Navy Personnel R&D Center
San Diego, CA 92152

1 Commanding Officer
U.S. Naval Amphibious School
Coronado, CA 92155

1 Library
Naval Health Research Center
P. O. Box 85122
San Diego, CA 92138

1 Naval Medical R&D Command
Code 44
National Naval Medical Center
Bethesda, MD 20014

1 Ted M. I. Yellen
Technical Information Office, Code 201
NAVY PERSONNEL R&D CENTER
SAN DIEGO, CA 92152

1 Library, Code P201L
Navy Personnel R&D Center
San Diego, CA 92152

1 Technical Director
Navy Personnel R&D Center
San Diego, CA 92152

6 Commanding Officer
Naval Research Laboratory
Code 2627
Washington, DC 20390

1 Psychologist
ONR Branch Office
Bldg 114, Section D
666 Summer Street
Boston, MA 02210

Navy

1 Psychologist
ONR Branch Office
536 S. Clark Street
Chicago, IL 60605

1 Office of Naval Research
Code 437
800 N. Quincy SStreet
Arlington, VA 22217

5 Personnel & Training Research Programs
(Code 458)
Office of Naval Research
Arlington, VA 22217

1 Psychologist
ONR Branch Office
1030 East Green Street
Pasadena, CA 91101

1 Office of the Chief of Naval Operations
Research Development & Studies Branch
(OP-115)
Washington, DC 20350

1 Captain Donald F. Parker, USN
Commanding Officer
Navy Personnel R&D Center
San Diego, CA 92152

1 LT Frank C. Petho, MSC, USN (Ph.D)
Code L51
Naval Aerospace Medical Research Laborat
Pensacola, FL 32508

1 DR. RICHARD A. POLLAK
ACADEMIC COMPUTING CENTER
U.S. NAVAL ACADEMY
ANNAPOLIS, MD 21402

1 Dr. Gary Poock
Operations Research Department
Code 55PK
Naval Postgraduate School
Monterey, CA 93940

Navy

1 Roger W. Remington, Ph.D
Code L52
NAMRL
Pensacola, FL 32508

1 Dr. Bernard Rimland (03B)
Navy Personnel R&D Center
San Diego, CA 92152

1 Dr. Worth Scanland
Chief of Naval Education and Training
Code N-5
NAS, Pensacola, FL 32508

1 Dr. Robert G. Smith
Office of Chief of Naval Operations
OP-987H
Washington, DC 20350

1 Dr. Alfred F. Smode
Training Analysis & Evaluation Group
(TAEG)
Dept. of the Navy
Orlando, FL 32813

1 Dr. Richard Sorensen
Navy Personnel R&D Center
San Diego, CA 92152

1 Dr. Robert Wisher
Code 309
Navy Personnel R&D Center
San Diego, CA 92152

Army

1 Technical Director
U. S. Army Research Institute for the
Behavioral and Social Sciences
5001 Eisenhower Avenue
Alexandria, VA 22333

1 HQ USAREUE & 7th Army
ODCSOPS
USAAREUE Director of GED
APO New York 09403

1 Dr. Michael Kaplan
U.S. ARMY RESEARCH INSTITUTE
5001 EISENHOWER AVENUE
ALEXANDRIA, VA 22333

1 Dr. Milton S. Katz
Training Technical Area
U.S. Army Research Institute
5001 Eisenhower Avenue
Alexandria, VA 22333

1 Director
U.S. Army Human Engineering Labs
Attn: DRXHE-DB
Aberdeen Proving Ground, MD 21005

1 Dr. Harold F. O'Neil, Jr.
Attn: PERI-OK
Army Research Institute
5001 Eisenhower Avenue
Alexandria, VA 22333

1 Dr. Robert Sasmor
U. S. Army Research Institute for the
Behavioral and Social Sciences
5001 Eisenhower Avenue
Alexandria, VA 22333

1 Commandant
US Army Institute of Administration
Attn: Dr. Sherrill
FT Benjamin Harrison, IN 46256

1 Dr. Frederick Steinheiser
U. S. Army Reserch Institute
5001 Eisenhower Avenue
Alexandria, VA 22333

Army

1 Dr. Joseph Ward
U.S. Army Research Institute
5001 Eisenhower Avenue
Alexandria, VA 22333

Air Force

1 Air Force Human Resources Lab
AFHRL/MPD
Brooks AFB, TX 78235

1 Dr. Earl A. Alluisi
HQ, AFHRL (AFSC)
Brooks AFB, TX 78235

1 Dr. Genevieve Haddad
Program Manager
Life Sciences Directorate
AFOSR
Bolling AFB, DC 20332

1 Dr. Marty Rockway (AFHRL/TT)
Lowry AFB
Colorado 80230

1 Dr. Frank Schufletowski
U.S. Air Force
ATC/XPTD
Randolph AFB, TX 78148

2 3700 TCHTW/TTGH Stop 32
Sheppard AFB, TX 76311

1 Jack A. Thorpe, Maj., USAF
Naval War College
Providence, RI 02846

Marines

1 H. William Greenup
Education Advisor (E031)
Education Center, MCDEC
Quantico, VA 22134

1 Headquarters, U. S. Marine Corps
Code MPI-20
Washington, DC 20380

1 Special Assistant for Marine
Corps Matters
Code 100M
Office of Naval Research
800 N. Quincy St.
Arlington, VA 22217

1 DR. A.L. SLAFKOSKY
SCIENTIFIC ADVISOR (CODE RD-1)
HQ, U.S. MARINE CORPS
WASHINGTON, DC 20380

Coast Guard

1 Mr. Thomas A. Warm
U. S. Coast Guard Institute
P. O. Substation 18
Oklahoma City, OK 73169

Other DoD

12 Defense Technical Information Center
Cameron Station, Bldg 5
Alexandria, VA 22314
Attn: TC

1 Dr. Craig I. Fields
Advanced Research Projects Agency
1400 Wilson Blvd.
Arlington, VA 22209

1 Dr. Dexter Fletcher
ADVANCED RESEARCH PROJECTS AGENCY
1400 WILSON BLVD.
ARLINGTON, VA 22209

1 Military Assistant for Training and Personnel Technology
Office of the Under Secretary of Defense for Research & Engineering
Room 3D129, The Pentagon
Washington, DC 20301

1 HEAD, SECTION ON MEDICAL EDUCATION
UNIFORMED SERVICES UNIV. OF THE HEALTH SCIENCES
6917 ARLINGTON ROAD
BETHESDA, MD 20014

Civil Govt

1 Dr. Susan Chipman
Learning and Development
National Institute of Education
1200 19th Street NW
Washington, DC 20208

1 Dr. Joseph I. Lipson
SEDR W-638
National Science Foundation
Washington, DC 20550

1 William J. McLaurin
Rm. 301, Internal Revenue Service
2221 Jefferson Davis Highway
Arlington, VA 22202

1 Dr. Arthur Melmed
National Intitute of Education
1200 19th Street NW
Washington, DC 20208

1 Dr. Andrew R. Molnar
Science Education Dev.
and Research
National Science Foundation
Washington, DC 20550

1 Dr. H. Wallace Sinaiko
Program Director
Manpower Research and Advisory Services
Smithsonian Institution
801 North Pitt Street
Alexandria, VA 22314

1 Dr. Frank Withrow
U. S. Office of Education
400 Maryland Ave. SW
Washington, DC 20202

1 Dr. Joseph L. Young, Director
Memory & Cognitive Processes
National Science Foundation
Washington, DC 20550

Non Govt

1 Dr. John R. Anderson
Department of Psychology
Carnegie Mellon University
Pittsburgh, PA 15213

1 Anderson, Thomas H., Ph.D.
Center for the Study of Reading
174 Children's Research Center
51 Gerty Drive
Champiagn, IL 61820

1 Dr. John Annett
Department of Psychology
University of Warwick
Coventry CV4 7AL
ENGLAND

1 DR. MICHAEL ATWOOD
SCIENCE APPLICATIONS INSTITUTE
40 DENVER TECH. CENTER WEST
7935 E. PRENTICE AVENUE
ENGLEWOOD, CO 80110

1 1 psychological research unit
Dept. of Defense (Army Office)
Campbell Park Offices
Canberra ACT 2600, Australia

1 Dr. Alan Baddeley
Medical Research Council
Applied Psychology Unit
15 Chaucer Road
Cambridge CB2 2EF
ENGLAND

1 Dr. Patricia Baggett
Department of Psychology
University of Denver
University Park
Denver, CO 80208

1 Mr Avron Barr
Department of Computer Science
Stanford University
Stanford, CA 94305

Non Govt

1 Dr. Nicholas A. Bond
Dept. of Psychology
Sacramento State College
600 Jay Street
Sacramento, CA 95819

1 Dr. John S. Brown
XEROX Palo Alto Research Center
3333 Coyote Road
Palo Alto, CA 94304

1 Dr. Bruce Buchanan
Department of Computer Science
Stanford University
Stanford, CA 94305

1 DR. C. VICTOR BUNDERSON
WICAT INC.
UNIVERSITY PLAZA, SUITE 10
1160 SO. STATE ST.
OREM, UT 84057

1 Dr. John B. Carroll
Psychometric Lab
Univ. of No. Carolina
Davie Hall 013A
Chapel Hill, NC 27514

1 Charles Myers Library
Livingstone House
Livingstone Road
Stratford
London E15 2LJ
ENGLAND

1 Dr. William Chase
Department of Psychology
Carnegie Mellon University
Pittsburgh, PA 15213

1 Dr. Micheline Chi
Learning R & D Center
University of Pittsburgh
3939 O'Hara Street
Pittsburgh, PA 15213

Non Govt

1 Dr. William Clancey
Department of Computer Science
Stanford University
Stanford, CA 94305

1 Dr. Allan M. Collins
Bolt Beranek & Newman, Inc.
50 Moulton Street
Cambridge, Ma 02138

1 Dr. Lynn A. Cooper
Department of psychology
Uris Hall
Cornell University
Ithaca, NY 14850

1 Dr. Meredith P. Crawford
American Psychological Association
1200 17th Street, N.W.
Washington, DC 20036

1 Dr. Kenneth B. Cross
Anacapa Sciences, Inc.
P.O. Drawer Q
Santa Barbara, CA 93102

1 Dr. Hubert Dreyfus
Department of Philosophy
University of California
Berkely, CA 94720

1 LCOL J. C. Eggenberger
DIRECTORATE OF PERSONNEL APPLIED RESEARC
NATIONAL DEFENCE HQ
101 COLONEL BY DRIVE
OTTAWA, CANADA K1A 0K2

1 Dr. Ed Feigenbaum
Department of Computer Science
Stanford University
Stanford, CA 94305

1 Dr. Edwin A. Fleishman
Advanced Research Resources Organ.
Suite 900
4330 East West Highway
Washington, DC 20014

Non Govt

1 DR. JOHN D. FOLLEY JR.
APPLIED SCIENCES ASSOCIATES INC
VALENCIA, PA 16059

1 Dr. John R. Frederiksen
Bolt Beranek & Newman
50 Moulton Street
Cambridge, MA 02138

1 Dr. Alinda Friedman
Department of Psychology
University of Alberta
Edmonton, Alberta
CANADA T6G 2E9

1 Dr. R. Edward Geiselman
Department of Psychology
University of California
Los Angeles, CA 90024

1 DR. ROBERT GLASER
LRDC
UNIVERSITY OF PITTSBURGH
3939 O'HARA STREET
PITTSBURGH, PA 15213

1 Dr. Marvin D. Glock
217 Stone Hall
Cornell University
Ithaca, NY 14853

1 Dr. Daniel Gopher
Industrial & Management Engineering
Technion-Israel Institute of Technology
Haifa
ISRAEL

1 DR. JAMES G. GREENO
LRDC
UNIVERSITY OF PITTSBURGH
3939 O'HARA STREET
PITTSBURGH, PA 15213

1 Dr. Ron Hambleton
School of Education
University of Massechusetts
Amherst, MA 01002

Non Govt

1 Dr. Harold Hawkins
Department of Psychology
University of Oregon
Eugene OR 97403

1 Dr. Barbara Hayes-Roth
The Rand Corporation
1700 Main Street
Santa Monica, CA 90406

1 Dr. Frederick Hayes-Roth
The Rand Corporation
1700 Main Street
Santa Monica, CA 90406

1 Mr. Richards J. Heuer, Jr.
27585 Via Sereno
Carmel, CA 92923

1 Dr. James R. Hoffman
Department of Psychology
University of Delaware
Newark, DE 19711

1 Glenda Greenwald, Ed.
"Human Intelligence Newsletter"
P. O. Box 1163
Birmingham, MI 48012

1 Library
HumRRO/Western Division
27857 Berwick Drive
Carmel, CA 93921

1 Dr. Earl Hunt
Dept. of Psychology
University of Washington
Seattle, WA 98105

1 Dr. Steven W. Keele
Dept. of Psychology
University of Oregon
Eugene, OR 97403

1 Dr. David Kieras
Department of Psychology
University of Arizona
Tuscon, AZ 85721

Non Govt

1 Dr. Stephen Kosslyn
Harvard University
Department of Psychology
33 Kirkland Street
Cambridge, MA 02138

1 Dr. Jill Larkin
Department of Psychology
Carnegie Mellon University
Pittsburgh, PA 15213

1 Dr. Alan Lesgold
Learning R&D Center
University of Pittsburgh
Pittsburgh, PA 15260

1 Dr. Michael Levine
Department of Educational Psychology
210 Education Bldg.
University of Illinois
Champaign, IL 61801

1 Dr. Charles Lewis
Faculteit Sociale Wetenschappen
Rijksuniversiteit Groningen
Oude Boteringestraat
Groningen
NETHERLANDS

1 Dr. Mark Miller
Computer Science Laboratory
Texas Instruments, Inc.
Mail Station 371, P.O. Box 225936
Dallas, TX 75265

1 Dr. Allen Munro
Behavioral Technology Laboratories
1845 Elena Ave., Fourth Floor
Redondo Beach, CA 90277

1 Dr. Donald A Norman
Dept. of Psychology C-009
Univ. of California, San Diego
La Jolla, CA 92093

Non Govt

1 Dr. Seymour A. Papert
Massachusetts Institute of Technology
Artificial Intelligence Lab
545 Technology Square
Cambridge, MA 02139

1 Dr. James A. Paulson
Portland State University
P.O. Box 751
Portland, OR 97207

1 MR. LUIGI PETRULLO
2431 N. EDGEWOOD STREET
ARLINGTON, VA 22207

1 DR. PETER POLSON
DEPT. OF PSYCHOLOGY
UNIVERSITY OF COLORADO
BOULDER, CO 80309

1 DR. DIANE M. RAMSEY-KLEE
R-K RESEARCH & SYSTEM DESIGN
3947 RIDGEMONT DRIVE
MALIBU, CA 90265

1 Dr. Fred Reif
SESAME
c/o Physics Department
University of California
Berkely, CA 94720

1 Dr. Andrew M. Rose
American Institutes for Research
1055 Thomas Jefferson St. NW
Washington, DC 20007

1 Dr. Ernst Z. Rothkopf
Bell Laboratories
600 Mountain Avenue
Murray Hill, NJ 07974

1 DR. WALTER SCHNEIDER
DEPT. OF PSYCHOLOGY
UNIVERSITY OF ILLINOIS
CHAMPAIGN, IL 61820

Non Govt

1 Dr. Alan Schoenfeld
Department of Mathematics
Hamilton College
Clinton, NY 13323

1 Committee on Cognitive Research
% Dr. Lonnie R. Sherrod
Social Science Research Council
605 Third Avenue
New York, NY 10016

1 Robert S. Siegler
Associate Professor
Carnegie-Mellon University
Department of Psychology
Schenley Park
Pittsburgh, PA 15213

1 Dr. Robert Smith
Department of Computer Science
Rutgers University
New Brunswick, NJ 08903

1 Dr. Richard Snow
School of Education
Stanford University
Stanford, CA 94305

1 Dr. Kathryn T. Spoehr
Department of Psychology
Brown University
Providence, RI 02912

1 Dr. Robert Sternberg
Dept. of Psychology
Yale University
Box 11A, Yale Station
New Haven, CT 06520

1 DR. ALBERT STEVENS
BOLT BERANEK & NEWMAN, INC.
50 MOULTON STREET
CAMBRIDGE, MA 02138

1 Dr. David Stone
Educational Systems Group
Hazeltine Corporation
7680 Old Springhouse Rd.
McLean, VA 22102

Non Govt

1 DR. PATRICK SUPPES
INSTITUTE FOR MATHEMATICAL STUDIES IN THE SOCIAL SCIENCES
STANFORD UNIVERSITY
STANFORD, CA 94305

1 Dr. Kikumi Tatsuoka
Computer Based Education Research Laboratory
252 Engineering Research Laboratory
University of Illinois
Urbana, IL 61801

1 Dr. John Thomas
IBM Thomas J. Watson Research Center
P.O. Box 218
Yorktown Heights, NY 10598

1 DR. PERRY THORNDYKE
THE RAND CORPORATION
1700 MAIN STREET
SANTA MONICA, CA 90406

1 Dr. Douglas Towne
Univ. of So. California
Behavioral Technology Labs
1845 S. Elena Ave.
Redondo Beach, CA 90277

1 Dr. J. Uhlaner
Perceptronics, Inc.
6271 Variel Avenue
Woodland Hills, CA 91364

1 Dr. Benton J. Underwood
Dept. of Psychology
Northwestern University
Evanston, IL 60201

1 DR. THOMAS WALLSTEN
PSYCHOMETRIC LABORATORY
DAVIE HALL 013A
UNIVERSITY OF NORTH CAROL
CHAPEL HILL, NC 27514

Non Govt

1 Dr. Phyllis Weaver
Graduate School of Education
Harvard University
200 Larsen Hall, Appian Way
Cambridge, MA 02138

1 Dr. David J. Weiss
N560 Elliott Hall
University of Minnesota
75 E. River Road
Minneapolis, MN 55455

1 DR. GERSHON WELTMAN
PERCEPTRONICS INC.
6271 VARIEL AVE.
WOODLAND HILLS, CA 91367

1 Dr. Keith T. Wescourt
Information Sciences Dept.
The Rand Corporation
1700 Main St.
Santa Monica, CA 90406

1 DR. SUSAN E. WHITELY
PSYCHOLOGY DEPARTMENT
UNIVERSITY OF KANSAS
LAWRENCE, KANSAS 66044

1 Dr. Christopher Wickens
Department of Psychology
University of Illinois

1 Dr. Thomas Crandell
Student Developmental Center
Broome Community College
Binghamton, NY 13903