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ABSTRACT

Visuals, like pictures, charts, diagrams, graphics, and the like, are widely used in education. However, there is little justification in the research literature for their use. The overall purpose of this exploratory study was to find out more about the processing of visuals or graphics in an educational task. Specifically, it was thought that prior knowledge of PERT (Critical Path Method) would facilitate the task of matching paragraphs to PERT networks. One group (prior knowledge) read a programed instruction (PI) text of PERT before going through a computer-assisted instruction (CAI) task. Another group (no prior knowledge) did the task before reading the text. Analysis of variance (ANOVA) did not show that knowledge of PERT helped performance. However, a group-by-sex ANOVA on proportion correct showed females performing better than males. Results were most valuable in pointing the way to further research dealing mainly with the meaningfulness of graphics or visuals. (JK)

CAI CENTER

TECH MEMO

LEARNING BY GRAPHICS:
TRANSLATING VERBAL INFORMATION INTO
GRAPHIC NETWORK FORMATS

Thomas G. Dunn and Duncan Hansen

Tech Memo No. 60
August 1, 1972
Tallahassee, Florida

Project NR 154-280
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Results were most valuable in pointing the way to further research dealing mainly with the meaningfulness of graphics or visuals.

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INTRODUCTION

The use of visual aids or visuals, that is, pictures, diagrams charts, graphs, etc., is widespread in education. However, there is little justification in the research literature for their use (Briggs, Campeau, Gagné, & May, 1967; Bourisseau, Davis, & Yamamoto, 1965).

Some theoretical statements about visuals images have been concerned predominately with how they serve as a substitute for verbal representations or personal experience. Gibson (1954) termed visuals as surrogates. Realistic surrogates, such as pictures, provide a substitute for first hand experience and teach concrete realities. The less specific surrogates stimulate the imagination and help to teach abstractions and general rules. Arnheim (1962) considered the picture as a statement about the object it represents. It does not present the object itself but a set of propositions about the object. Thus visuals appear to have characteristics similar to language.

A popular explanation for the value of visuals has been expressed by the saying "a picture is worth a thousand words." There are conflicting views in the literature concerning this statement. Arnheim (1962) attributed more generalized meanings to symbolic responses than direct responses. In studies using the word association techniques Otto (1962, 1963, 1964) concluded that visual stimuli evoke more sense impression associations than do verbally presented stimuli. However, in later studies (Otto and Britton, 1964; Bourisseau et al., 1965) reported that the verbal mode of presentation evoked significantly more sense-impression associations than did the pictorial mode. Bourisseau et al., (1965) concluded that visuals are more convergent than words in a person's information processing system. For example, a picture evokes specific associations that tend to be more integrated than verbal stimuli with their rich alternative array of responses.[2] Wimer and Lambert (1959) claimed that this converging effect causes visuals to have greater effectiveness as stimuli.

Perhaps a more promising approach in studying the value of visuals is that which investigates what meaning or meanings visuals communicate to the individual. Werner and Kaplan (1957) studied how Ss expressed themselves with schematic lines. Although their work was mostly exploratory they did find agreement in Ss choices of lines to express tense. Eisenman (1968) studied the semantic differential ratings of polygons. He found some significant results in the tendency of people to agree when rating some polygons on "beautiful-ugly," "fast-slow," and "strong-weak" dimensions.

A more relevant educational approach was that of Horn (1967). He gave the name "information maps" to the whole class of diagrams, maps, tables, charts, flowcharts, and graphs. Information maps are ways of arranging the material on a page (both words and illustrations) in such a way that the arrangement communicates something about the form, structure, and relationships present in the information.

Some examples are the "tree structure" which graphically sorts things into their kinds and the "cycle chart" which shows the flow of the process coming back to the starting place. Horn believes that information maps are useful in the analysis and communication of complex problems. The results of his research on information maps have not yet been reported.

Considering Horn's ideas on information maps, are there such maps which communicate concepts as specific as a grammar? Norman (1969, p. 42) in discussing grammar stated that we recognize patterns by rules and that these learned rules as well as other performance considerations (e.g., short-term memory limitations) impose severe restraints on the sequence of letters, words, and the way ideas are introduced on a page. Other investigators (Miller, 1962; Miller, & Isard, 1963) have expressed similar views. It is conceivable that visuals such as flow charts and specifically PERT networks, have features analogous to a grammar that they could impose similar restraints as do linguistic performance rules. That is, the rules governing the use of circles (bubbles), arrows, and dotted lines in a PERT network could suggest subject-verb-object forms present in the English language.

If in fact the rules governing PERT do act as such a restraint then it would be expected that subjects with a knowledge of PERT would be able to match paragraph selections to PERT Networks better than subjects not knowing PERT. This hypothesis was investigated in this study. Other questions investigated were: (1) the effect of prior knowledge of PERT on latency in such a task, and (2) the effect of prior knowledge of PERT on number of "branches" (branches meaning the number of times the individual chooses to see the material before responding). Research over the years has indicated that meaningful material is learned better and takes less time to learn than nonmeaningful material (DeCecco, 1968,

p. 336). Assuming that PERT Networks would be meaningful to Ss having prior knowledge of PERT, it was expected that the prior knowledge Ss would take less time and make less branches than those not knowing PERT.

It was hoped that answers to these questions would add to the information concerning the use of graphics and visuals in training and educational situations.

METHOD

Subjects

The subjects (Ss) used were 38 members of the Psychology 317 class (15 males and 23 females). These students were randomly assigned to either the prior knowledge (PK) group or the no prior knowledge (NPK) group.

Materials

The IBM 1500 Instructional System (IBM, 1967) was used to present a computer-assisted instruction (CAI) task. This system has terminals consisting of (1) cathode ray tube (CRT); (2) light pen; (3) typewriter keyboard.

The CAI material consisted of 16 sets of Program Evaluation and Review Technique (PERT) networks with accompanying paragraph selections. After Ss viewed a network, four paragraphs were presented one at a time. The subject matter in the paragraphs was simple and was assumed to be familiar to all Ss. The PERT networks varied in complexity, for example, the number of bubbles (circles) ranged from 7 to 18. Most of the bubbles in the networks were numbered. Correspondingly, some keywords in the paragraph selections were underlined and numbered. This was to serve as a cue for the Ss who were instructed to choose the paragraph which best matched the network. Figure 1 shows a sample PERT network with the four paragraph choices. The presentation here may be misleading in that the network and choices could only be seen one at a time during the CAI task. However, the programming logic did permit Ss to view the network and paragraph selections as many times as desired before making a choice of the correct alternative. A programmed text on PERT was also used in this study.

Procedure

The PK group read the PI text of PERT before going through the CAI task; the NPK group did not. Ss in the PK group read the PERT text one night and went through the CAI task the next night. The opposite procedure was followed for the NPK group. Table 1 shows the scheduled sessions for both PK and NPK groups.

TABLE 1

Schedule of Sessions for PI PERT Text and CAI Task for Both PK and NPK Groups

	Prior Knowledge Group (PK)			
	Monday	Tuesday	Wednesday	Thursday
7:00 P.M.	PI	PI	CAI	
9:00 P.M.		CAI		
	No Prior Knowledge (NPK)			
	Monday	Tuesday	Wednesday	Thursday
7:00 P.M.		CAI	PI	PI
9:00 P.M.			CAI	

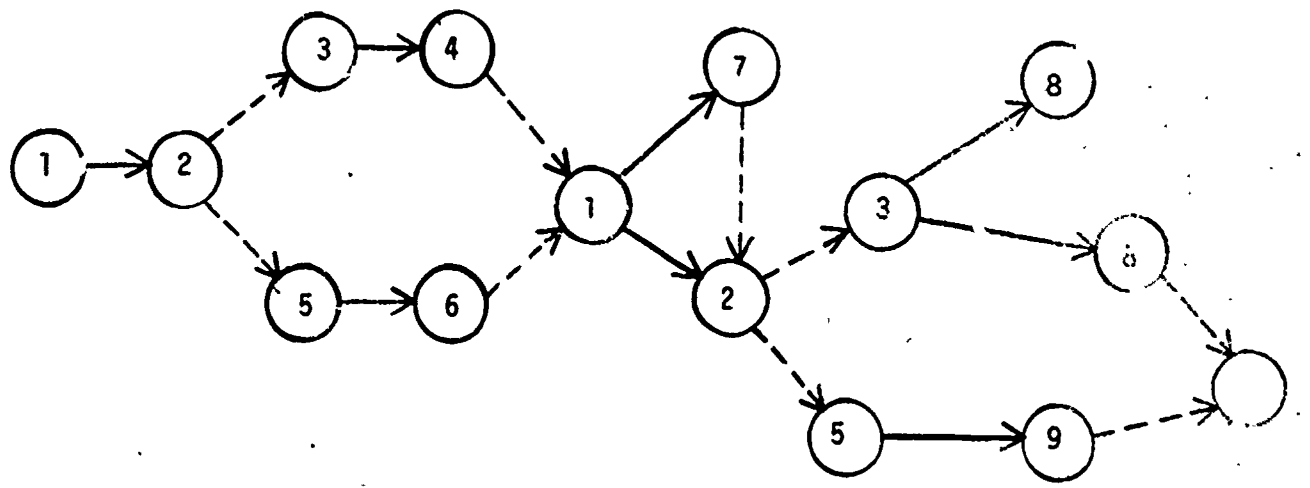

Fig 1--Sample PERT Network with Paragraph Choices

The dectectives(1) searched the building(2). One(3) found a gun(4). The other(5) found some shells(6). They(1) left the building(2) and then discussed their findings(7). The first detective(3) then saw a figure(8) leaving the alley and chased him(8). The other dectective(5) called the precint(9) for assistance.

The detectives(1) searched the building(2). One(3) found a gun(4). The other(5) found some shells(6). They(1) discussed their
* findings(7) and then left the building(2). The first(3) detective saw a figure(8) leaving the alley and he(3) chased him(8). The other(5) detective called the precint(9) for assistance.

The detectives(1) searched the building(2). One(3) found a gun(4). The other(5) found some shells(6). They(1) discussed their findings(7) and then left the building(2). The detectives (3 and 5) saw a figure(8) leaving the alley and they(3 and 5) chased him(8). Then one(5) of the detectives called the precint(9) for assistance.

The detectives(1) searched the building(2). They(3 and 5) found a gun(4) and some shells(6). They(1) discussed their findings(7) and then left the building(2). The first(3) detective saw a figure(8). The other detective(5) called the precent(9) for assistance.

* Correct Answer

Noteworthy in these analyses was the correlation between proportion correct and latency. Latency accounted for 56 percent of the variance in the NPK group and 24 percent of the variance in the PK group. Other correlational analyses dealt with the item variables of proportion correct, number of bubbles, latency and branches. The results are reported in Table 3. There were no significant correlations with proportion correct in either group. The significant correlations among number of bubbles, latency, and branches were expected since the amount of material to be read increased as the number of bubbles increased.

TABLE 3

Correlational Analyses of Item Variables: Proportional Correct, Number of Bubbles, Mean Latency, Mean Branches For PK & NPK Groups

	PK				NPK			
	1	2	3	4	1	2	3	4
1 Prop. CA	1.00	.06	.07	-.29	1.00	.09	.05	.03
2 No. of Bubbles		1.00	.47	.75**		1.00	.53*	.67**
3 Latency			1.00	.61**			1.00	.83**
4 Branches				1.00				1.00

*p < .05
**p < .01

The ANOVA's, with correct answers, latency and branches as dependent measures, considered items as a repeated measure. The Greenhouse and Geisser procedure of using conservative degrees of freedom (Winer, 1962, p. 306) was used since there was doubt as to the assumption of equal covariances in the variance-covariance matrix.

The groups by items ANOVA on correct answers with items as the repeated measure did not show any significant differences. These results are presented in Table 4.

TABLE 4

Groups by Items ANOVA on Correct Answers with Items as Repeated Measure Using Conservative Degrees of Freedom

Source	DF's	Mean Square	F Ratio
Group Effect (A)	1	.3701	.59
Error Between	36	.6270	
Item Effect (B)	1	5.7615	1.72
A x B	1	2.0247	.60
Error Within	36	3.3580	

The graphic relationship groups and items for the dependent variable of proportion correct is depicted in Figure 2.

The overall effect of prior knowledge on performance in this task was not significant. However, in studying this data it seemed that females did better than males. It was for this reason that some additional analyses included sex as a factor. It must be remembered that males and females were not randomly assigned to groups. This fact must be kept in mind when interpreting the results of any sex analyses.

A group by sex analysis of variance on proportion correct revealed both a sex effect where females did better than males ($p < .05$) and also a group by sex interaction ($p < .05$). These results are shown in Table 5.

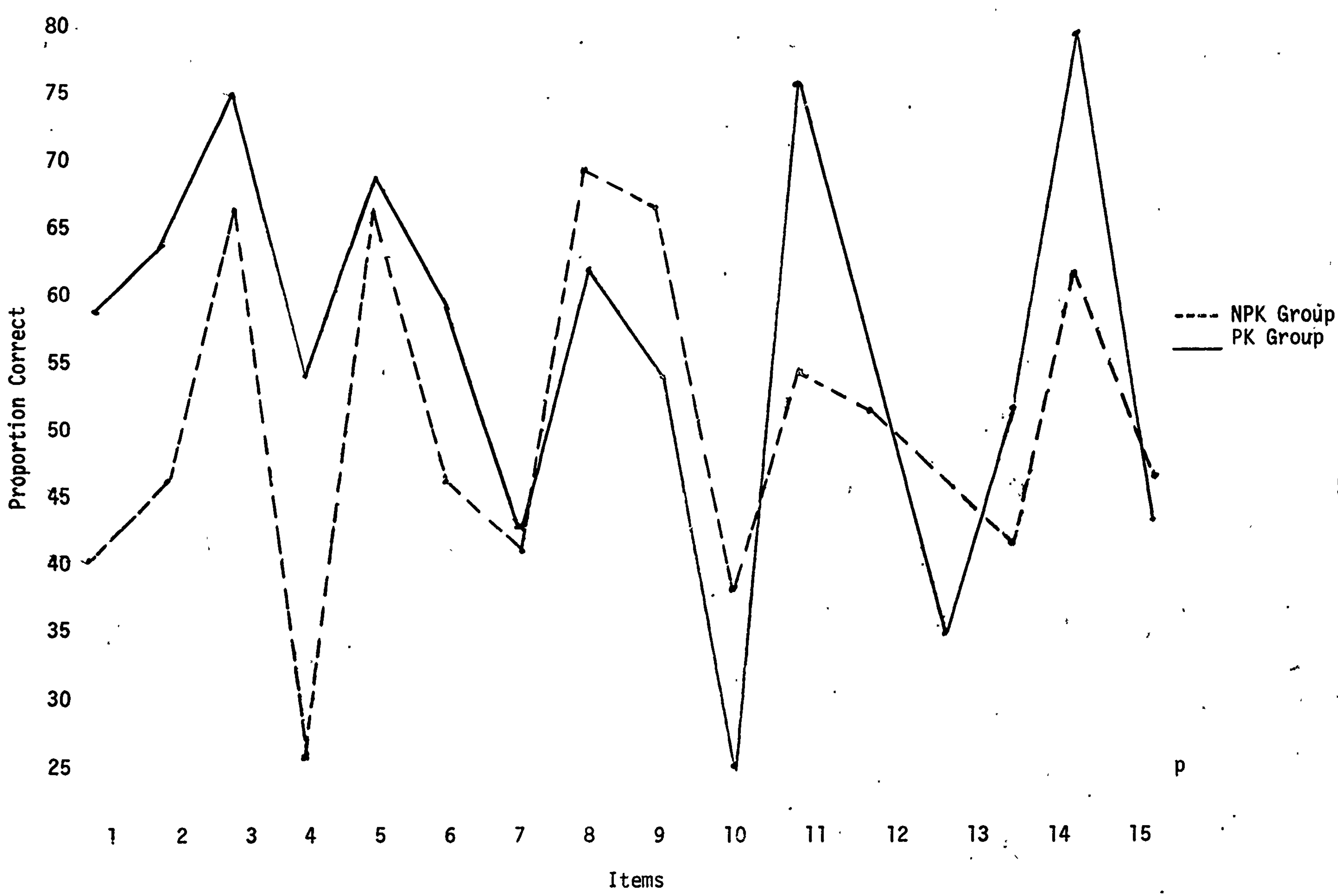

Fig. 2.--Proportion Correct Per Item for NPK and PK Groups

TABLE 5

ANALYSIS OF VARIANCE, GROUPS BY SEX**

ON PROPORTION CORRECT

Source	df	Mean Square	F Ratio
Group Effect (A)	1	.0054	.16
Sex Effect (B)	1	.1810	5.38*
A x B	1	.1678	4.99*
Error	34	.0336	

*p < .05

** A nonparametric factorial ANOVA could also have been used in order to avoid violating too many assumptions. The procedure is that of Kellogg V. Wilson's discussed in the Psych. Bulletin, 1956. Using this procedure the main effects were not significant, but there was a significant sex interaction, p < .05.

The overall sex effect has to be seen in terms of the interaction as depicted in Figure 3. This shows males and females performing the same with no prior knowledge and females performing better than males when both have prior knowledge.

The groups by items ANOVA on latency with items as the repeated measure revealed a significant group effect only, with the PK group having greater latencies than the NPK group (p < .05). Table 6 shows the source table for this analysis.

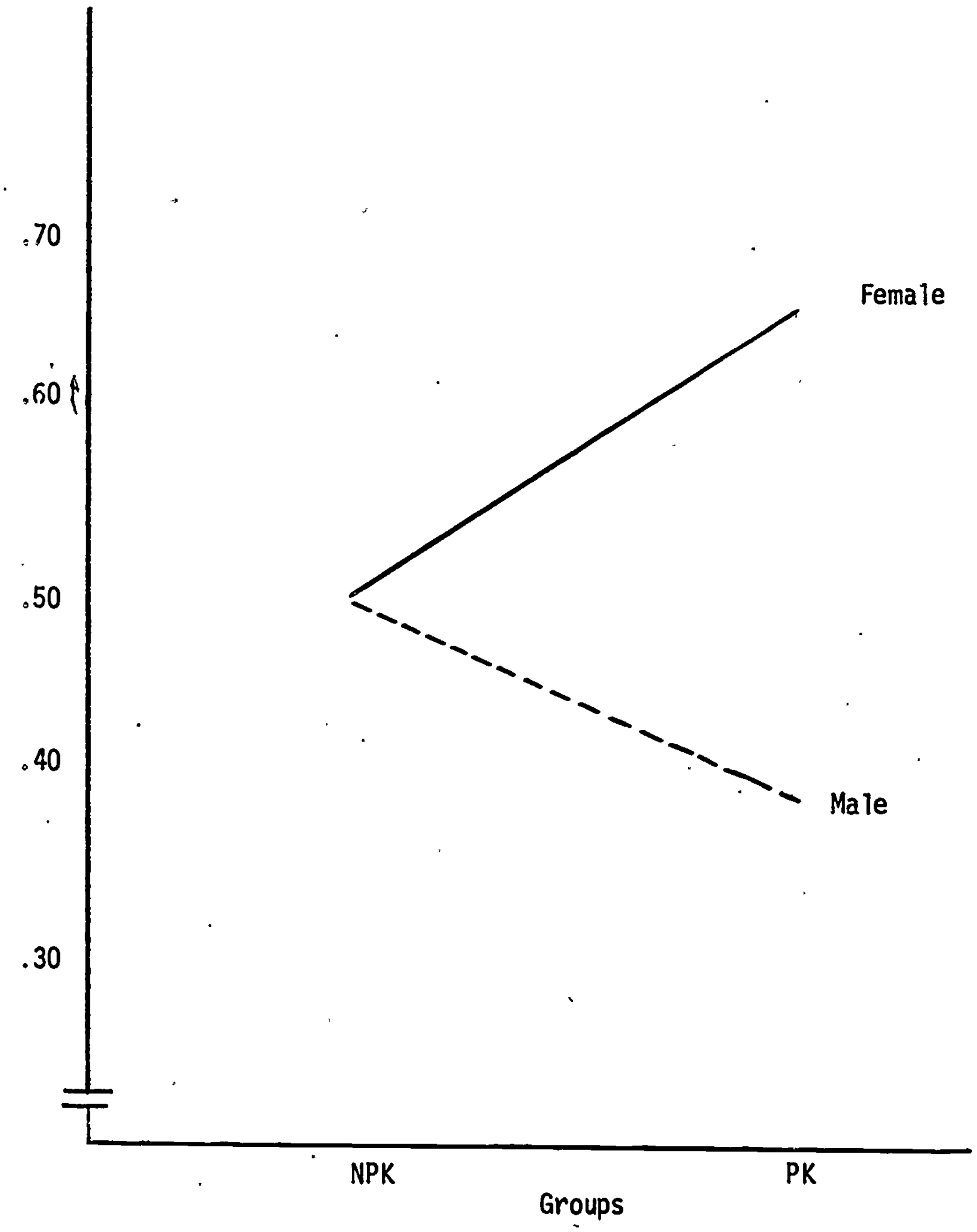

Figure 3.--Proportion Correct by Sex in PK and NPK Groups

TABLE 6

GROUPS BY ITEMS ANOVA ON LATENCY WITH ITEMS AS REPEATED MEASURE, USING CONSERVATIVE DEGREES OF FREEDOM

Source	df	Mean Square	F Ratio
Group Effect (A)	1	273403.70	4.13*
Error Between	36	66145.32	
Item Effect (B)	1	252108.59	3.68**
A x B	1	121507.43	1.78***
Error Within	36	68165.44	

*p <F .05
** The Item Effect (B) while not significant using conservative degrees of freedom was significant at the .01 level when liberal degrees of freedom were used.
*** The A x B interaction was not significant using conservative degrees of freedom, with liberal degrees of freedom it was significant at .05 level.

Figure 4 gives a graphic representation of this relationship. Note that only for one item (No. 12) did the NPK group have a longer latency than the PK group. This difference was not great enough to result in a significant interaction.

The groups by items ANOVA on branches with items as the repeated measure revealed only an item effect ($p < .01$). These results are shown in Table 7. This relationship between groups and items is presented graphically in Figure 5. The PK group averaged more branches than the NPK group on most items; however, the difference was not large enough to be significant.

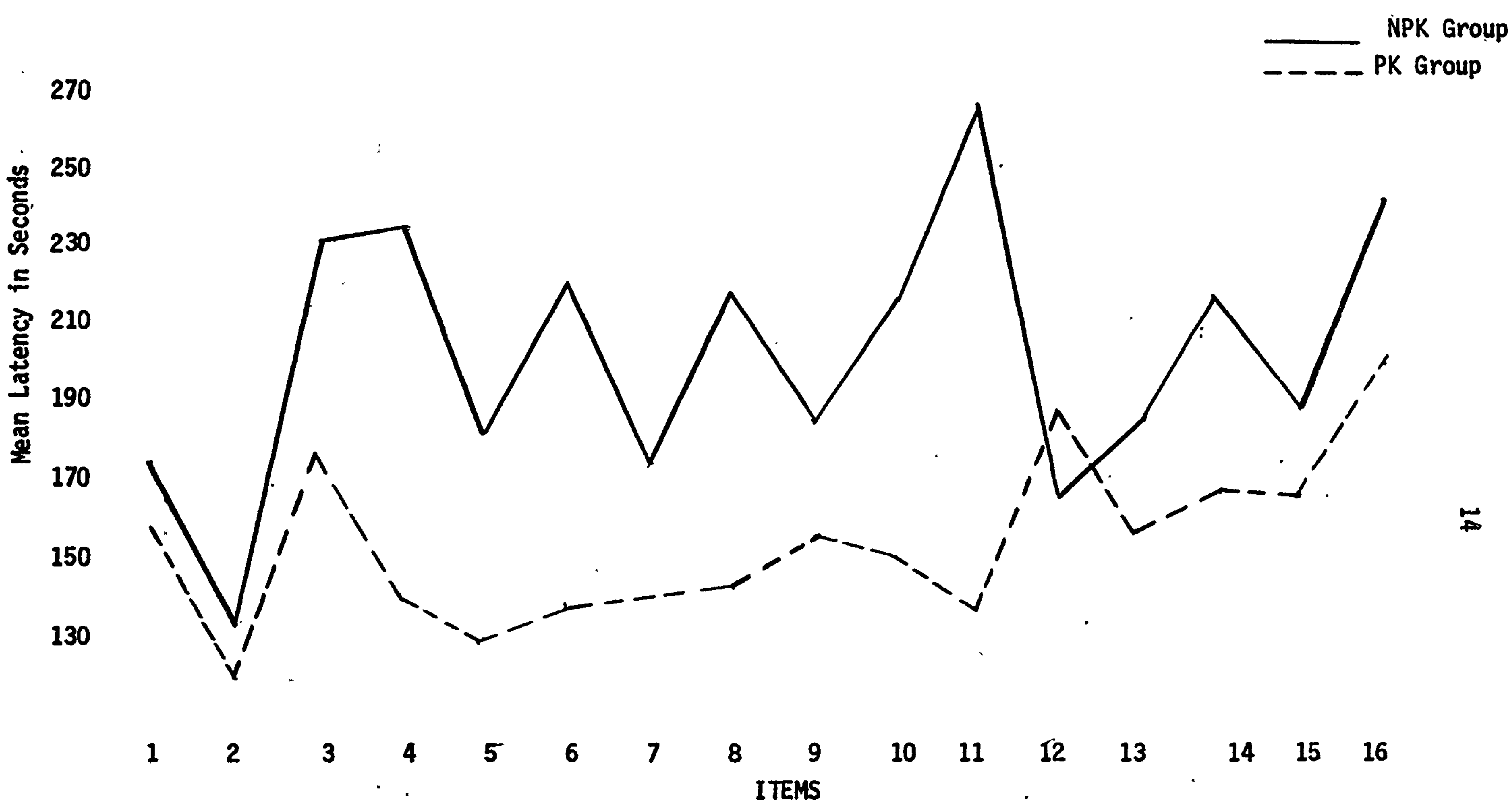

Figure 4.--Mean Latency in Seconds Per Item for both PK and NPK Groups

TABLE 7

ANALYSIS OF VARIANCE, GROUPS BY ITEMS ON BRANCHING, WITH ITEMS AS REPEATED MEASURE USING CONSERVATIVE DEGREES OF FREEDOM

Source	df	Mean Square	F Ratio
Group Effect (A)	1	731.73	2.97
Error Between	36	246.58	
Item Effect (B)	1	3746.01	8.39**
A x B	1	731.04	1.63
Error Within	36	448.32	

** $p < .01$ using conservative degrees of freedom

Groups by sex ANOVA's on both latency and branches revealed no significant differences. The results of these analyses are shown in Tables 8 and 9 respectively.

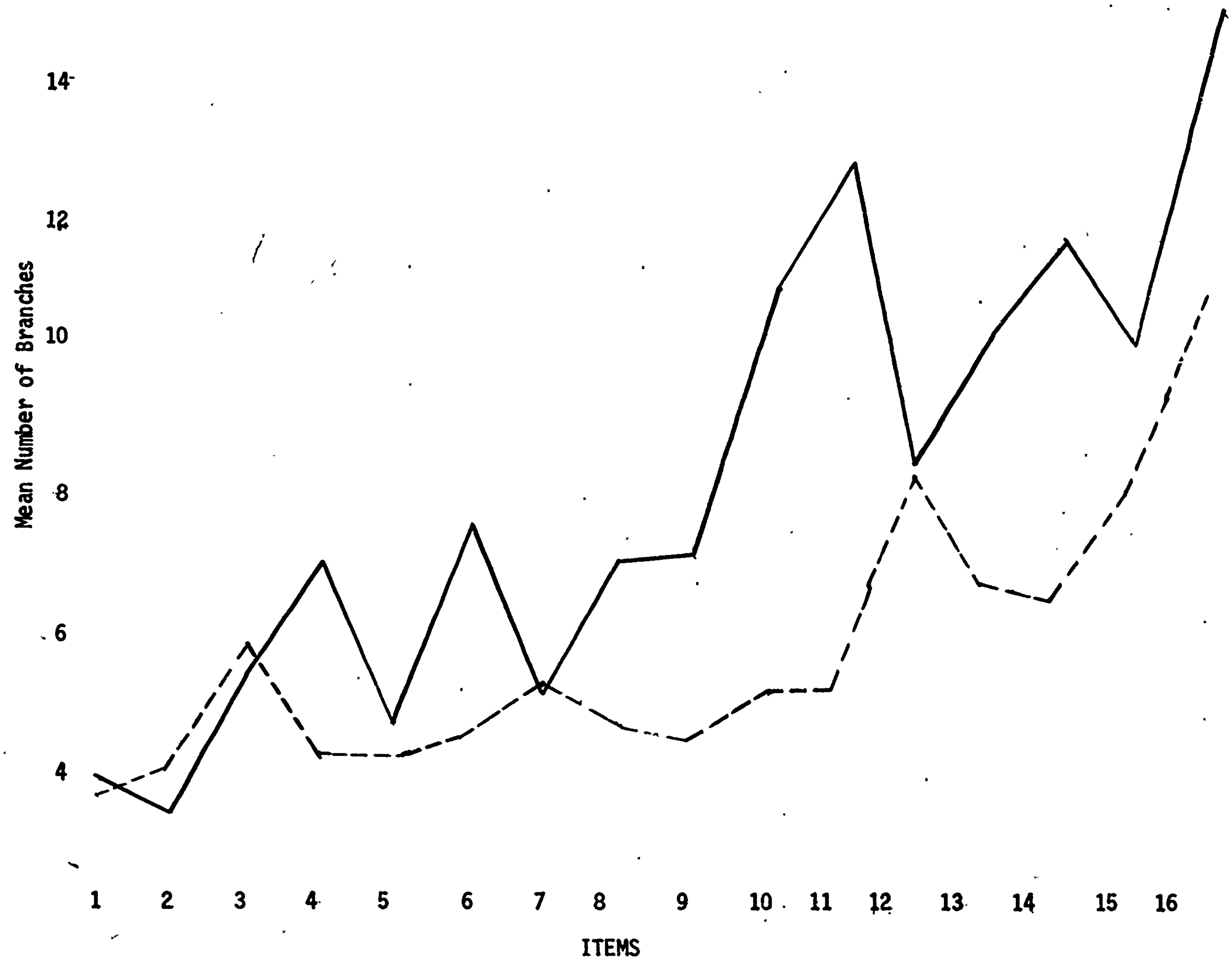

Figure 5.--Mean No. of Branches per Item for Both PK and MPK Groups.

TABLE 8

GROUPS BY SEX ANOVA ON LATENCY

Source	df	Mean Square	F Ratio
Group Effect (A)	1	14473.04	3.54
Sex Effect (B)	1	9534.88	2.33
A x B	1	104.96	.03
Error	34	4094.20	

TABLE 9

GROUPS BY SEX ANOVA ON BRANCHES

Source	df	Mean Square	F Ratio
Group Effect (A)	1	37.33	2.32
Sex Effect (B)	1	5.89	.37
A x B	1	3.27	.20
Error	34	16.08	

DISCUSSION

The overall purpose of this study was of an exploratory nature, that is, to find out more about the processing of visuals or graphics in an educational task. More specifically it was thought that prior knowledge of PERT would facilitate the task of matching paragraphs to PERT networks.

The results do not show that knowledge of PERT helped performance. However, closer inpsection of the data and the experimental design yield some possible explanations. First of all, the PERT programmed text may not have taught the subject matter well enough to have made a difference. Second, whatever advantage the PK group had, might have been nullified after the 7th item. Note that in Figure 2, the PK group did better than the NPK group on the first seven items and after that point differential performance trends were undetectable. It is possible that the NPK group learned enough during the first seven items to be able to perform as well as the PK group on the remaining items. Since PERT diagrams are not very complicated (at least not in the form used here) and only a very limited number of grammatical concepts could be expressed in the networks, the NPK group could have developed the necessary strategies without having prior knowledge of PERT. A third factor to consider was the possible sex effect. Definite conclusions will not be made concerning the sex analyses because of the experimental design. However, there is some support in educational literature for the apparent better performance of females, especially for tasks of a verbal nature, involved memory and quick preception of detail. Research indicates that females tend to perform better in these areas than males (Tyler, 1965, chap. 10). Continued research of this type should either include sex as a main effect or consider one sex only.

It had been expected that varying the complexity of networks would affect performance. For example, a negative correlation would be expected between proportion correct and number of bubbles. As can be seen in Table 3 there was no significant relationship between these variables for either the PK or NPK groups. Perhaps the text material rather than the network itself was the causative factor. Several subjects remarked that they enjoyed doing some items because the subject matter was interesting. It is not known how this might have affected the results but it is suggested that more interest and/or performance scaling be done on the paragraphs.

That the PK group had longer latencies than the NPK group was unexpected. It had been thought that due to their familiarity with PERT and PERT networks that the PK group would take less time. It is possible that the PK tried harder or followed more false leads before answering since they had more idea of what was being presented. However it would seem that this extra time was not constructive for two reasons: (1) overall difference in proportion correct was not significant and (2) the relationship (Table 2) between latency and proportion correct was greater in the NPK group (.75) than in the PK group (.49).

The analysis on branching was included for much the same reason as the latency analysis. That is, it was thought that since the PK group had some previous knowledge of PERT they would not need to see the material as many times as the NPK group. However, it was difficult to interpret the branching data since there was no control of the time spent looking at the choices. Therefore one S might look at a network for 10 minutes straight while another S might choose to see the same network 10 different times for a minute each time.

Since this research was exploratory in nature few definite conclusions can be stated. Perhaps its greatest value is in suggesting other avenues of research. Some questions which could possibly be answered are:

1) Can graphics or visuals be made more specific in meaning?

2) Can flow charting be made more specific in meaning and thus more useful?

3) Can presentation of textual information with such structured graphics increase the retention of this information? Related to this question, several days after going through the CAI program 3 of the Ss could remember entire paragraphs by looking at the networks alone.

4) Why does prior knowledge cause Ss to take longer on visual task than a group without prior knowledge?

5) Is there a sex difference on tasks of this nature? If so, what are the cognitive operations required in this task? Why did the sex difference occur in the PK group and not in the NPK group?

SUMMARY

This research attempted to gain more information about how visuals are processed given the effect of prior knowledge of PERT on matching written paragraphs to PERT networks. The dependent variables of proportion correct, latency and branching were studied with groups (PK & NPK) and items (repeated measure) as independent variables. ANOVA on proportion correct revealed no significant differences. However a group

by sex ANOVA on proportion correct showed females performing better than males ($p<.05$) and a significant interaction ($p<.05$). ANOVA on latency resulted in a significant group effect with the PK group having greater latencies than the NPK group ($p<.05$). The ANOVA on branches showed only a significant item effect ($p<.01$). Correlations were reported for subject performance and also on item variables.

Results were most valuable in pointing the way to further research dealing mainly with the meaningfulness of graphics or visuals.

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