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SUBJECT-MEDIA INTERACTIONS IN
LEARNING SPATIAL RELATIONS

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by

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ABSTRACT

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The study was designed to test the hypothesis that motion in visual media can be differentially effective in enhancing the learning of complex spatial relations as a function of the viewer's spatial aptitude.

84 subjects (42 males and 42 females) of high and low spatial aptitude (as measured by the Guilford-Zimmerman Test of Spatial Visualization) were taught the movement patterns of 5 chessmen with 1 of 3 instructional films:

- (1) A "Stills" condition which simulated a slide presentation .
- (2) A "Partial Motion" condition which was identical to the "Stills" condition except for the addition of an animated cueing arrow.

(3) A "Full Motion" condition which followed a standard motion picture format.

The experimental task called for subjects to solve problems by diagraming the correct movement patterns required to move a designated chesspiece from one point on the chessboard to another. Performance measures taken were number of problems correctly solved within the allowed time, and accuracy of movements (parsimony of moves in reaching a correct solution).

High aptitude subjects were expected to show no differences due to instructional mode because their superior ability would enable them to grasp the spatial concepts without motion. Low aptitude subjects were expected to perform better with the "Partial Motion" and "Full Motion" conditions, with the motion cues compensating for their lower aptitude. No differences were expected between the "Partial" or "Full" motion conditions because it was hypothesized that the simplest form of motion enhancement that furnishes the critical visual cues would be as effective as more elaborate forms.

The results supported the hypothesis on the number of correct responses criterion. No differences were observed on the accuracy or parsimony of movement measure.

Implications of these findings in terms of

cost effectiveness of instructional media and training are discussed, and potential extensions of the study suggested.

Introduction

Despite the increasing use of instructional films and film strips, few experimentally validated guidelines exist for their design and application. Past comparison studies have often used widely varying populations, subject matter, and assessment measures, making any generalization of results across studies difficult. The media selection manuals that are currently available (Brown, et al., 1973; Dale, 1968) offer only very general criteria for choosing between films and film strips. These guidelines are presumably based on what is known concerning the two media and various types of subject matter with little or no consideration of audience variables.

The principal functional difference between films and film strips is the former's employment of motion as a visual aid. Previous research has often failed to employ sufficient experimental controls while examining the motion variable (Hoban, 1950; Spangenburg, 1973).

Some studies have permitted discussions during the film strip presentations, casting doubt as to whether the results reflect media differences or the effects of participative learning (House, 1970). Other studies (Vernon, 1946; Van De Meer, 1954) have used film strips

which differed from the film versions in such features as use of camera angles, illumination levels, and viewing time. All of these factors represent potential sources of variance that are uncontrolled in the experimental design.

In other studies where statistically significant differences were found (Hoban, 1950; Travers, 1964), only small fractions of the material presented were retained by either the film strip or the film group, leaving the practical significance of the results open to question.

To assist in making practical choices between these two media, information is needed concerning their relative effectiveness in relation to types of subject matter and viewer characteristics. As a first step, it is important to examine under controlled conditions the principal dimension of difference: motion.

Motion

Motion is commonly used in visual information displays. Its principal uses are (1) as an attention-getting device to promote attendance to a display, (2) to focus attention on a critical portion of a visual display, (3) to aid in the discrimination of figure/ground relationship (Woodson & Conover, 1970).

The attention-getting feature has more application to operator displays than to instructional media, although there is some evidence that films have more "stimulation" value or interest value than film strips (Allen, 1967).

Such issues as viewer motivation and the "stimulation" levels of instructional media are complex and beyond the scope of the discussion here.

Assuming uniform attendance to both types of visual displays, a dynamic presentation could be said to have an advantage over a static presentation to the extent that it can draw attention to the critical portions of the display, and can enhance perception of the desired figure/ground relationships.

One way of estimating the potential benefit of using a motion display is to assess the difficulty of identifying "crucial" areas of the visual presentation, and the complexity of the figure/ground relationships (Attneave, 1959). Complexity can be operationally defined in several ways. The author believes it is perhaps best measured empirically by the difficulty observed in subjects in discriminating figure/ground relations on some task requiring this ability. Complexity then involves considerations of viewer capability as well as subject matter (Berliner, 1973).

If the material to be presented contains figure/ground relationships that are critical and potentially "complex", it can be inferred that a motion display may facilitate learning. The question then becomes what type of motion display will most effectively convey the desired material to the viewer.

Detail and Fidelity

One of the most important issues in audio visual selection is the degree of detail included in the visual presentation (Dwyer, 1973). There has been a trend toward the use of more realistic or detailed displays in audio visual media despite conflicting evidence of its effectiveness (Travers, 1964; Van DeMeer, 1954). Detail, as considered here, is operationally defined as anything that contributes to an increased physical resemblance between the visual display and the object it is depicting.

Cue summation theory (Hoban, 1950) suggests that learning will decrease as a function of the irrelevant cues that are presented simultaneously with the critical ones, possibly due to increased signal to noise ratio (Attneave, 1959). Thus whether visual "detail" enhances or degrades learning would seem to depend on whether it is critical to or aids in the perception of the desired material. The "desired" material refers to the learning

objectives of the presentation as defined by performance on some assessment measure. What is irrelevant detail in one presentation may be "critical" information in another depending on what material the display was designed to teach.

The operational fidelity of a visual presentation is measured by transfer of training. From this measure the degree to which the critical components are simulated effectively, and the irrelevant cues are deleted, is inferred. High transfer "assumes" high fidelity of simulation. Determining what components are critical is often very difficult. Roshal (1949) demonstrated knot tying with ropes with two different presentations: one showing a pair of hands manipulating the rope, and the other showed just the movement of the rope. Surprisingly, he found the presentation of hands did not increase learning. For this example, then, the hands can be considered irrelevant detail.

Because it is difficult to isolate critical elements from "irrelevant" cues, makers of instructional media often include a high level of detail, not knowing what may be unnecessary and what is critical. Whether additional irrelevant cues measurably degrade learning is in part a function of presentation time because the inclusion of irrelevant data (noise) increases the

informational load processing requirements (Mackworth, 1963).

Eye scan studies have found that humans will scan a visual display and then tend to fixate on the most informationally rich portions (Attneave, 1959).

Irrelevant cues could interfere with learning if (1) the additional time needed to scan before fixating on the relevant cues resulted in insufficient exposure time to the critical cues, or (2) the increased complexity prevented the identification of the critical cues.

Type of Motion

If motion is to be used to reduce the complexity of perceiving visual information, it follows that it should clarify critical information, and not add any irrelevant cues. The question of fidelity is as applicable to motion as it is to color, or any other means of adding detail. Evidence indicates (Clatsworthey & Frisby, 1974) that the perceptual mechanisms for real and apparent motion are equivalent, so the question of what actually moves or how the motion effect is achieved is basically a technical problem. The principal questions are how much motion is needed, and where should it be employed (i.e., what are the critical cues)?

Aptitude Treatment Interactions

The level of detail which conveys effectively the relevant cues, without any irrelevant cues, is likely to vary according to the amount of viewer knowledge of the material and aptitude for learning. Assuming that all potential viewers are naive to the subject matter, it may be that information that is needed for a clear understanding by a low aptitude viewer is superfluous for a high aptitude viewer. Thus the same presentation may be differentially effective for viewers as a function of aptitude level.

Recent research has shown evidence for specific treatment-ability interactions in a variety of areas (Tyler, 1972). Cronback (1957) has developed methods for formulating pay-off matrices to determine the practical value of matching aptitude level to specific instructional treatments. Although extensive investigation has been made in matching types of learning material to modes of audio visual instruction (Allen, 1967), few studies have been made of individual aptitudes in relation to audio visual media. Those studies which have been done in the area have largely used general intelligence or personality factors as subject variables rather than specific aptitude measures.

Bialek (et al., 1973) has outlined the concept

of optimizing learning by matching aptitude levels to specific instructional media. This work, like much of the research in this area, emphasized programmed instruction or self-paced modes in optimizing individual learning rather than comparisons of individual differences in relation to mass media presentations.

It is possible that one of the reasons experimenters have failed to demonstrate significant media differences consistently is the large internal variance caused by individual differences to modes of instruction. The search for the superior medium must involve the question, "Superior for whom?". Spatial aptitude is one area that may be relevant to a viewer's ability to learn from visual media.

Motion and Spatial Aptitude

The ability to conceptualize spatial relationships has been found to be a significant predictor of success in a variety of academic subjects including mathematics, art, mechanical science and handicrafts (Anderson, et al., 1954). Various types of spatial ability have been studied and identified, but all of them have been found to have a very low positive or negative correlation with tests of verbal ability (Smith, 1964). This represents a serious challenge to educational

institutions where students must take a varied curriculum.

For example, a student with above average verbal ability and low spatial ability may do well in liberal arts subjects, but have difficulty with such required subjects as geometry where spatial aptitude is used. Such a student may be limited in his future academic options unless he can perform to criteria in areas where he has little ability as well as in his areas of high potential. It would be useful then, to develop instructional methods of compensating for a lack of spatial aptitude.

The basic perceptual task in viewing visual displays is to organize the stimulus into the intended "figure-ground relationship". These two aspects of a visual perception were defined by Wolman (1973) as:

(A) The figure, which has good contour, unity, and is perceived as separate from the ground.

(B) The ground, which is relatively homogeneous and whose parts are not clearly shaped or patterned.

At any given time during a visual presentation, the "figure" should be the portion of the display containing the object or objects that the viewer was intended to "attend to" more closely. The "figure", then,

should be easily discriminable from the "ground" as possible.

In complex visual displays, the desired figure-ground relationship may be difficult to perceive, particularly if the viewer is unfamiliar with the stimulus and/or possesses little spatial aptitude. Any technique which aids in distinguishing the figure from the ground is potentially useful in enhancing viewer perception of the desired relationship. One method is to move the figure in relation to the ground or vice versa (Woodson, 1964). A complex stimulus is thus broken down into two portions, one which appears to move and one which remains static. Which portion is perceived as "figure" and which is "ground" is determined by the context of the display, viewer perceptual characteristics, etc. However, the initial step of organizing a complex stimulus into its two intended "perceptual" aspects is a necessary prerequisite before the desired figure/ground relation can be perceived.

Since motion displays can aid in focusing on relevant cues and clarifying figure/ground-relationships, it should require less spatial ability to perceive demonstrated spatial relations in a dynamic presentation mode than in a static presentation. Past research has indicated that motion may be useful in demonstrating

spatial concepts (Dwyer, 1973; Spankenburg, 1973; Gibson, 1954). However, motion should only enhance learning if it adds significantly to the viewer's perception of these relations. Therefore, viewers with the spatial aptitude to perceive the spatial relations presented without the use of motion should not show any improvement in learning. For them, motion cues are extraneous or irrelevant.

Statement of the Problem

This study will examine the effects of motion as a learning aid for high and low spatial aptitude subjects in learning spatial concepts. Two levels of motion "detail" will be used: A "simple" case with animated cueing arrows, and a standard motion picture format. The study is designed to look at two aspects of motion. Motion's effectiveness in focusing on and clarifying figure/ground relationships will be assessed by comparing the performance of groups taught with motion to those taught without it. The effect of more detailed motion beyond that necessary to illustrate the desired figure/ground relationships will be assessed by comparing the group which received "simple" motion instruction to the "full motion" or motion picture group. The addition of motion detail beyond that necessary or "critical" to learning is expected to have no positive effects.

Motion, then, should be effective when it enhances critical cues. Any motion beyond the amount needed becomes unnecessary detail, and will therefore have no effect, or will be detrimental to learning.

Sex/Aptitude Interaction

Female subjects are expected to score lower on the Guilford-Zimmerman Test of Spatial Visualization based on the normative data published in the test manual (Guilford, 1956), and the general findings in the literature (Knapp, 1964). For this reason, the performance of males and females will be analyzed separately.

Mental Ability

Published data indicates that there is no significant correlation between performance on the Guilford-Zimmerman Test of Spatial Visualization and mental ability as measured by the Otis Self-Administering Test of Mental Ability for either sex (Guilford, 1956). However, to assess any possible effects of general mental ability on the performance of subjects in this study, the Otis will be administered to all subjects, and an analysis for mental ability effects performed. General mental ability is expected to have no significant effect on

performance on the Guilford-Zimmerman test.

Aptitude/Motion Interaction

It is hypothesized that the high-ability subjects, as determined by scores on the Guilford-Zimmerman Test of Spatial Visualization (Guilford, 1956), will not vary greatly in their performance as a function of instructional mode because their superior aptitudes enable them to grasp "complex concepts". Conversely, low-aptitude subjects will increase performance levels as a function of added motion. It is further expected that the simplest type of motion that depicts the figure/ground relationship will function as effectively as the more elaborate form because the added motion will contribute no additional relevant information.

Method

Subjects

A total of 84 subjects comprised of 42 males and 42 females, ranging from 17 to 29 years of age were used, 14 in each of 6 experimental groups. Ss were recruited from undergraduate psychology courses at California State University at Northridge. Potential Ss were screened for any prior knowledge of chess, with only chess-naïve subjects being selected for the study. In order to obtain the 84 usable Ss, 224 potential Ss were screened. Only Ss reporting 20/20 corrected vision were included in the analysis.

Stimulus Materials

Ss were asked to view one of three films demonstrating (1) the movement patterns of five chess pieces and (2) examples of how to solve problems of moving a specified piece to a new position on the board. The three visual presentations varied only in the type and degree of motion used.

(1) In the "Stills" condition, a series of still pictures was photographed in sequence on film

(See Figure 1). Film was used in lieu of actual slides to standardize the presentation time for all Ss receiving this treatment. Two-second gaps were inserted between stills to prevent apparent motion effects. The reference time needed to counteract afterimage effects varies according to illumination factors, contrast levels and presentation time (King, 1971). Two seconds was found to be adequate for the experimental presentation conditions during informal pretesting with five viewers.

The format employed was to present a picture of a chessboard and describe verbally where the piece would move. After the two-second interval of dark screen, the next move would appear, showing the board after the described move had been made (See Figure 1). One still was used for each move that the chess piece had to make in order to reach the indicated square. A "move" was defined for each piece during the film. For some pieces a move was the distance it could travel without changing directions. Others were limited in the number of squares that they could travel over in one "move". Even though they weren't being taught to play chess, Ss were told to think of a "move" as what they could do in one "turn" if they were playing a game with another person.

The total number of stills in a series varied from four for simple demonstrations of movement patterns

Figure 1
Comparison of "Arrows" and "Stills" Condition

Stills

Still
Photo-
graph 1

Blank
Screen

Still
Photo-
graph 2

Arrows

Still
Photo-
graph 1
with
Cueing
Arrow

Blank
Screen

Still
Photo-
graph 2
with
Cueing
Arrow

to eight for some of the sample problems. Nine series of pictures were presented, five movement pattern demonstrations, one for each piece, and four problem-solving demonstrations. (There was no example using the king because of it's elementary movement pattern, and to keep the film presentations under ten minutes.)

(2) In the animated or "Arrow" condition, the film was identical to the still version except for the addition of a wooden arrow, which was photographed tracing the path through which the chess piece would move. When the next picture was presented with the changed board, the arrow would outline the path that the piece had just moved over to get to its new position (See Figure 1).

(3) In the motion picture or "Actual" motion condition, the chessmen actually moved over the described paths.

The running time for the "Actual" motion presentation was seven and one-half minutes, as contrasted with approximately eight minutes and twenty seconds for each of the other two presentations. The additional time was used for blank portions between "slides". Actual "demonstration" time is defined as the time that the chessboard was presented, and was identical within six seconds for all conditions.

To control against any limited knowledge of

chess, the movement patterns of the standard pieces were altered. The audio portion of each presentation described what was happening in the visual channel, but contained no non-redundant material, i.e., information not also presented visually. The only exception to this was the names of the chess pieces, which were not shown visually.

The "Still" and "Actual" presentation modes were selected for study as representative of filmstrips and motion pictures respectively. The "Arrow" or animated motion presentation was selected as an alternative method of demonstrating the desired motion effect. This technique can utilize the more economical filmstrip medium, or be incorporated in motion pictures to represent movement in cases where real-time motion is impossible or prohibitively expensive. Cueing techniques using motion have been found to be effective in some cases (Lumdaine, 1951).

The test used to assess learning from the film consisted of 32 diagrams of chessboards. There were varying numbers of chessmen spread randomly over each board. One of the chesspieces was outlined in red. Somewhere on each board was a red X marked over an unoccupied space. The task was to draw a line with pen or pencil from the outlined piece to the space marked with a red X, using the correct movement pattern of that piece. Ss were

required to draw an X at the end of each move or "turn" that the piece would use in getting there. Ss were further instructed to choose the path requiring the fewest number of moves. If two paths required the same number of moves, the path with the shortest distance was to be selected.

Items varied in complexity as a function of:

- (1) Number of moves required
- (2) Number of alternative paths using correct movements, equal number of turns but with differential distances required (i.e., number of squares passed through)
- (3) Complexity of a given chessman's movement pattern (e.g., Can it move more than one way? Can it change directions, etc.?)
- (4) Number of extraneous chessmen on the board

Without empirical testing and validation, the relative influence of each of these factors and their interaction is unknown. These 32 items were ranked into 4 groups which were roughly similar along the 4 dimensions just outlined (See Table 1). They were then randomly assigned to 1 of the 4 groups of 8 items (1/4 of the test). Although not each quarter of the test can be said to be equivalent in difficulty, it is believed that any potential disparity of consequence has been reduced.

Table 1

Description of Criterion Test Items

Item Number	Turns Required	Number of Alternative Correct Responses	Complexity of Chess Piece Used	Additional Chess Pieces on the Board
1	2	0	2	9
2	2	0	2	16
3	4	0	2	19
4	2	0	3	20
5	2	1	1	21
6	2	0	2	8
7	3	1	3	9
8	2	0	4	6
9	3	1	4	5
10	3	0	2	21
11	1	0	2	13
12	5	1	1	8
13	2	0	3	22
14	1	0	2	3
15	4	0	2	11
16	-	-	-	-
17	6	0	2	18
18	2	0	3	16
19	5	1	4	20
20	4	1	3	21
21	-	-	-	-
22	3	0	3	23
23	3	0	2	17
24	3	0	2	16
25	5	0	2	5
26	3	1	4	4
27	5	1	4	13
28	3	0	4	17
29	3	1	3	19
30	5	0	1	12
31	-	-	-	-
32	4	0	4	16

All Ss received the same sample sequence of problems

Experimental Design

The study utilized a 2x2x2x3 factorial design, using 2 levels each for mental ability, spatial aptitude and sex, and 3 levels of motion for the instructional modes. A representation of the design is given in Figure 2.

Experimental Hypothesis

A summary of the experimental hypothesis is given below:

Spatial Aptitude and Instructional Mode

1. $\bar{X}$ High SA $>$ $\bar{X}$ Low SA For Stills Condition
2. $\bar{X}$ High SA $=$ $\bar{X}$ Low SA For Arrows Condition
3. $\bar{X}$ High SA $\leq$ $\bar{X}$ Low SA For Full Motion Condition

Mental Ability

1. $\bar{X}$ High MA $\geq$ $\bar{X}$ Low MA For all Conditions

Sex

1. $\bar{X}$ Males $>$ $\bar{X}$ Females For all Conditions

Note: SA = Spatial Aptitude

MA = Mental Ability

Figure 2

Representation of Experimental Design

			Instructional Mode		
			Stills	Arrows	Full Motion
High Spatial Aptitude	High Mental Aptitude	Male			
		Female			
	Low Mental Aptitude	Male			
		Female			
Low Spatial Aptitude	High Mental Aptitude	Male			
		Female			
	Low Mental Aptitude	Male			
		Female			

Procedure

Ss were tested for spatial aptitude, using the Guilford-Zimmerman Test of Spatial Visualization (Guilford, 1956). Ss scoring at or above the 68th percentile were assigned to the high ability group; Ss scoring at or below the 34th percentile were assigned to the low ability group. ← pen

Appropriate norms were used for male and female Ss (Guilford, 1956). (Raw scores: 20 & 13 "high"; 14 & 7 "low" for males and females.) Ss were then tested for general intelligence as measured by the Otis Self-Administering Test of Mental Ability (Otis, 1956). Ss scoring above the 50th percentile of the standardized norms for college students (Otis, 1956) were arbitrarily assigned to the "high" intelligence groups; Ss scoring below the 50th percentile were arbitrarily assigned to the "low" intelligence group. Sharper differentiation between intelligence groups was not feasible, given the restricted range of the university population.

Males and females were then divided separately into two sets of four groups: High Mental Ability-High Spatial Aptitude; Low Mental Ability-High Spatial Aptitude; High Mental Ability-Low Spatial Aptitude and Low Mental Ability-Low Spatial Aptitude. Each group was then ranked by Spatial Aptitude, and each subject was

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assigned to one of the experimental conditions, using a table of random numbers.

Ss then viewed one of the three films. They were instructed to watch the movement patterns of each piece carefully and to try to remember or "visualize" how each piece moved. Discussion or questions were not permitted once the film had begun.

At the film's conclusion, the criterion test was administered asking them to solve chess problems by drawing movement patterns on diagrams of chessboards (See Appendix "A"). Written instructions were provided, and were reviewed orally by the E, who also answered questions.

Ss were instructed to diagram the movement pattern that the indicated piece would use to get to a new position outlined on the board. They were told to choose the pattern requiring the fewest number of moves. If two alternate paths required an equal number of moves, they were instructed to choose the path which required moving through the fewest number of squares. They were instructed how to indicate the end of one "turn" as well as the total path taken. A more detailed description of the instructions given is found in Appendix "A".

Ss were told to go as fast as they could while being as accurate as possible, and that they would have

ten minutes to work. Ss were shown where to look in their test booklet to review factual information needed to perform the test, such as a key of piece names and symbols and a summary of movement patterns. Ss were reminded that this was a time-limited test and asked to refer to the information sheet only if they really felt they needed to do so. They were told to go in sequence and not skip problems unless they were completely stumped.

At the end of ten minutes, papers were collected, Ss were excused, and any questions they had answered.

Dependent Measures

For each S, three scores on the assessment test were recorded:

- (1) Number of problems correctly completed.

A correct movement is defined as a correct movement of a piece in the fewest number of "turns" possible. "Correct" movement means consistent with the movement patterns that each piece is allowed.

- (2) Number of incorrect problems where the wrong movement pattern was used.

- (3) Number of problems correctly completed

with the fewest number of turns and spaces traveled through.

There were a total of nine items that had more than one correct answer (i.e., more than one way to get to a square, using the same number of turns). In each case, one alternative required fewer spaces and therefore was the preferred path.

There were four problems which had no solution. One such item appeared in each quarter of the test.

Further details concerning the nature and distribution of test items is given in Table 1.

Items not attempted were not counted. If more than five items were skipped, the score was not used in the analysis because it was felt the items completed were no longer representative of the test.

Results

Correct Responses

An analysis of variance of correct responses yielded significant main effects for spatial aptitude, sex, and instructional mode, but not the Mental Ability factor (See Table 2). A significant interaction was obtained between spatial aptitude and instructional mode which supports the main hypothesis of differential effectiveness of instructional mode as a function of spatial aptitude. Mean responses for all experimental groups are presented in Table 3.

The spatial aptitude x instructional mode interaction is shown in Figure 3. A Duncan Multiple Range Test was employed to analyze specific differences of the means of the resulting six experimental groups. These are summarized in Table 4.

No significant differences were found between high aptitude subjects for different instructional modes. For lower aptitude subjects, the Stills condition was significantly poorer than both Arrows and Full Motion, but Arrows and Full Motion did not differ significantly. High aptitude subjects performed significantly better than their low aptitude counterparts in each instructional mode.

Table 2
Analysis of Variance for Correct Responses

Source	<u>SS</u>	<u>DF</u>	<u>MS</u>	<u>F</u>
Total	1895.56	83	-	-
Spatial Aptitude	530.02	1	530.02	52.17**
Sex	348.11	1	348.11	34.26**
MA	10.01	1	10.01	.99
Mode	216.87	2	108.44	10.67**
Spatial x Sex	33.43	1	33.43	3.29
Spatial x MA	.89	1	.89	.09
Spatial x Mode	74.06	2	37.03	3.64*
Sex x MA	.01	1	.01	.00
Sex x Mode	23.36	2	11.68	1.15
MA x Mode	19.06	2	9.53	.94
Spatial x Sex x MA	6.27	1	6.27	.62
Spatial x Sex x Mode	4.40	2	2.20	.22
Spatial x MA x Mode	17.15	2	8.58	.84
Sex x MA x Mode	2.54	2	1.27	.13
Spatial x Sex x MA x Mode	.22	2	.11	.01
Error	609.86	60	10.16	-

* $p < .05$

MA = Mental Ability

** $p < .01$

Table 3

Mean Number of Correct Responses for All Subject Groups

Group	Experimental Condition						$\bar{X}$
	$\bar{N}$	"Stills"	$\bar{N}$	"Arrows"	$\bar{N}$	"Full Motion"	
High Spatial Aptitude							
Males							
High MA factor	3	21.67	4	20.25	4	19.25	20.4
Low MA factor	4	18.75	3	21.33	3	20.67	20.3
Females							
High MA factor	3	14.00	4	15.75	4	16.21	15.3
Low MA factor	4	12.00	3	14.33	3	16.00	14.1
Low Spatial Aptitude							
Males							
High MA factor	4	11.75	3	15.50	3	15.67	14.3
Low MA factor	3	9.33	4	14.25	4	16.28	13.3
Females							
High MA factor	4	7.75	3	12.33	3	13.00	11.0
Low MA factor	3	6.67	4	10.50	4	15.25	10.8
$\bar{X}$		3.64		4.43		4.72	

NOTE: Maximum Score = 32

MA = Mental Ability

Figure 3

Mean Number of Correct Responses

Table 4

Summary of Duncan Multiple Range Comparisons
for the Spatial Aptitude/Instructional Mode
Interaction

High Spatial Aptitude	<u>Still Condition Arrows Full Motion</u>
Low Spatial Aptitude	Still Condition <u>Arrows Full Motion</u>
Condition	<div data-bbox="297 942 412 974">Stills</div> <div data-bbox="297 1005 412 1037">Arrows</div> <div data-bbox="297 1068 509 1100">Full Motion</div> <div data-bbox="566 942 1378 1100"> Low Spatial Aptitude High Spatial Aptitude Low Spatial Aptitude High Spatial Aptitude Low Spatial Aptitude High Spatial Aptitude </div>

Note: Groups joined by underlining are not significantly difference p .05. For example, for high spatial aptitude (first line of the table) all conditions are joined by underlining, indicating no difference. On line two, under low spatial aptitude, "Stills" is not underlined, indicating it differs significantly from the other two groups.

Shortest Possible Path

Mean values for all conditions are shown in Table 5. A second analysis of variance was performed for correct responses completed, using the shortest possible route (See Table 6). Only the nine items having alternative correct responses (i.e., there were at least two correct paths requiring the same number of turns but one alternative traveled through fewer spaces) were analyzed. A more detailed explanation is given in the Appendix.

Significant main effects were obtained for spatial aptitude and sex (For the high spatial aptitude group, $\bar{X} = 5.09$; for low spatial aptitude $\bar{X} = 2.54$; and sex, for males $\bar{X} = 4.65$; for females $\bar{X} = 3.04$). No other significant results were found. Thus, the "qualitative" performance as it was operationally defined failed to support either main hypothesis.

Incorrect Response Analysis

The number of items which were incorrect because of improper movement patterns (e.g., moving a bishop as if it were a rook) was determined for each experimental group (See Table 7). The purpose was to determine if the information needed to perform the experimental task was in fact being learned. For

Table 5

Mean Number of Correct Responses Completed with
Parsimony*lon Items with Alternative Correct Responses

Group	Experimental Condition						X
	N	"Stills"	N	"Arrows"	N	"Full Motion"	
High Spatial Aptitude							
Males							
High MA factor	3	5.33	4	6.75	4	6.00	6.1
Low MA factor	4	6.25	3	6.33	3	5.33	6.0
Females							
High MA factor	3	4.33	4	5.00	4	4.75	5.2
Low MA factor	4	4.00	3	4.67	3	5.00	4.5
Low Spatial Aptitude							
Males							
High MA factor	4	3.25	3	3.67	3	3.33	3.5
Low MA factor	3	3.00	4	3.00	4	2.75	2.9
Females							
High MA factor	4	2.00	3	3.00	3	2.33	2.4
Low MA factor	3	2.00	4	2.00	4	2.50	2.2
Mean for all Subjects	28	3.79	28	4.29	28	4.00	

Note: Maximum score = 9

MA = Mental Ability

*Parsimony is defined as traveling through the fewest possible number of spaces in giving a correct response.

Table 6

Analysis of Variance for Correct Responses Completed with Parsimony¹ on Items with Alternative Correct Responses

Source	<u>SS</u>	<u>DF</u>	<u>MS</u>	<u>F</u>
Total	504.95	83		
Spatial	144.05	1	144.05	29.04**
Sex	27.43	1	27.43	5.53*
MA*	3.05	1	3.05	.61
Mode	3.53	2	1.77	.36
Spatial x Sex	1.73	1	1.73	.35
Spatial x MA	1.58	1	1.58	.32
Spatial x Mode	.65	2	.33	.07
Sex x MA	.04	1	.04	.01
Sex x Mode	2.00	2	1.25	.25
MA x Mode	7.50	2	3.75	.76
Spatial x Sex x MA	.48	1	.48	.10
Spatial x Sex x Mode	4.65	2	2.33	.47
Spatial x MA x Mode	1.17	2	.59	.12
Sex x MA x Mode	1.15	2	.58	.12
Spatial x Sex x MA x Mode	8.11	2	4.06	.82
Error	297.85	60	4.96	

* $p < .05$

** $p < .01$

MA = Mental Ability

¹Parsimony is defined as traveling through the fewest possible spaces in giving a correct response

example, if Ss were confused about the names of pieces, or the symbols used to represent them, etc., then the instructional presentation would not adequately prepare Ss for the experimental task, which assumed this knowledge. Since only 8 out of 84 subjects made errors because of improper movement patterns, no further statistical analysis was performed on the data (See Table 8).

Table 8
Mean Correct Responses for Males and Females

Sex	Experimental Condition			$\bar{X}$
	"Stills"	"Arrows"	"Full Motion"	
Males	15.35	17.74	17.93	17.00
Females	10.07	13.21	16.06	13.11

Discussion

Aptitude - Media Interaction

Correct Responses

The data support the main hypothesis that motion demonstrations can be differentially effective in improving performance on a task involving spatial visualization as a function of the spatial aptitude of the subject. This effect was also found to be independent of general mental ability as measured by the Otis Test of Mental Ability.

The secondary hypothesis that a "simple" motion demonstration using animation techniques can be as effective in teaching spatial concepts as a full motion picture was also supported.

Despite the presence of some weaknesses in the experimental design to be described later, the author feels that the consistency of findings supports the hypothesis sufficiently to warrant further investigation.

The low incidence of errors due to incorrect application of factual information and their apparently random distribution (See Table 6) is interpreted as support for the assumption that the presentations adequately taught the necessary factual information, and

that the criterion test was measuring the ability to solve spatial problems and not simple differential retention rates of factual information.

Sex Differences

The findings were consistent with those reported by Guilford (1942) in that females scored generally lower than males on both the Guilford-Zimmerman Test and the experimental task as measured by total number of incorrect responses (See Table 7). Although this is useful information, more important is the issue of why? It is possible that spatial tests such as those used in the current study are not culture-free as regards sex (i.e., females may score lower for reasons other than their innate ability, such as practice, motivations, etc.). Assuming that the spatial tests were accurate reflections of the aptitude levels of males and females, the practical questions for educators remain, and can female performance be improved?

Methodological Problems

Test Reliability

Since the criterion test has not been

cross-validated, suspicion could reasonably be expressed about its interpretation and generalizability. For example, the failure of the high ability group to improve with increased motion could conceivably be due to a ceiling effect of the test within the allowed time limit. The assessment of motion performance differences between groups, therefore, may lack precision. However, the standard deviations for the high spatial aptitude groups do not differ significantly, indicating that the test ceiling was not a major factor (SD for Stills = 3.17, for Arrows = 3.51, and for Full Motion = 3.36).

Due to the restricted range of the population with respect to the MA factor, high and low MA groups were formed arbitrarily. The failure to find significance on the MA factor may be due to the lack of sufficient variability on this factor. Scores ranged for Low MA from the 32nd to 47th percentile; High MA ranged from the 54th to the 91st percentile (Otis, 1956).

Knowledge Assessment

Time constraints prevented the assessing of the fundamental factual knowledge (e.g., names of chess pieces) needed to perform the assessment test prior to its administration. Based on pretesting (See Appendix B),

the assumption was made that this criterion had been met. Summaries of this information were included with the test booklet to control for lapses of short term memory. Pretesting with 15 subjects demonstrated that the test could not be performed without viewing one of the filmed demonstrations (See Appendix B). Since only eight subjects made errors due to the incorrect application of factual knowledge, it can be inferred that the criterion task did measure more than mastery of the appropriate factual knowledge.

Measurement Dimensions

The assessment of "quality" of learning as measured by parsimony of movement on some of the items, yielded no defensible conclusions. One possible explanation is that none of the motion presentations were particularly effective in demonstrating how to select the shortest route, or that subjects were too preoccupied with the principal task of determining the fewest number of moves to consider the secondary goal of shortest distance. Another difficulty was that since not every item could be rated for parsimony, quality and quantity of performance were systematically linked (i.e., a low quantity score precludes a high quality score). For

example, a subject who only finished one-half of the items would only attempt five items which could be scored for parsimony, while a subject who finished all the items would attempt nine items. A subject who rushed through all of the items and scored several correct out of the nine possible items scored for parsimony would, from chance alone, receive the same score as a slower subject who attempted only a few of these items, but got them all correct. Since there were only nine items and the items could not be precisely weighted for difficulty, it was felt that a measure of percentage of items attempted correctly completed with parsimony would not be useful.

Scope of the Present Study

The implications of these findings in terms of their application to instructional modes, cost of educational materials, and potential enhancement of learning rates for population subgroups are, in the author's view, sufficiently rewarding to justify further studies in the area. A significant difference in learning produced by the independent variable of motion even in its "simplest" form lends credence to the application of the findings, where applicable, in work with low spatial aptitude groups, and possibly with the uneducated, the retarded, and in those cases where cultural/language

barriers reduce the effectiveness of written and auditory instructions.

Although the improvement as a function of motion was somewhat stronger for females, they were consistent for all experimental groups. Females scored lower on both the Guilford-Zimmerman Test of Spatial Visualization and the experimental task, and at this writing the casual element underlying this phenomena is unknown. Of interest is whether the observed differences are innate or are attributable to cultural factors. The current study provides no means of assessing this aspect of the performance.

In summary, it is hoped the results of this study can serve as a basis for more extensive research in the area of aptitude/treatment interactions as they apply to instructional mass media.

References

- Allen, W. Media stimuli and types of learning. Audio-Visual Instruction, 1967, 12(1), 29-39.
- Anderson, G. & Fruchter, B. Survey of research on spatial factors. USAF: Personnel Research Laboratory, Lackland AFB, Texas, Contract AF 33 (038) - 18046, 1956.
- Attneave, F. Application of Information Theory to Psychology. New York: Holt & Company, 1959.
- Berliner, D. C. & Cahen, L. S. Trait - treatment interaction. In F. N. Kerlinger (Ed.), Review of research in education. Itasca, Illinois: F. E. Peacock, 1973.
- Bialek, H. M., Taylor, J. E. & Hauke, R. N. Instructional strategies for training men of high and low aptitude. Alexandria, Va: Human Resources Research Organization, (HumRRO Tech. Rep. 73-10) March, 1973.
- Brown, J. W., Lewis, R. B. & Harclerod, F. Audio-visual instruction: technology, media, and methods. New York: McGraw-Hill, 1973.
- Clatsworthy, J. L. & Frisby, J. P. Real and apparent movement: evidence for a unitary mechanism. Perception, 1973, 2 (2), 161-164.
- Cronbach, J. J. The two disciplines of scientific psychology. American Psychologist, 1957, 12, 671-684.

- Dale, E. Audiovisual methods in teaching (3rd Ed.)
New York: Holt, Rinehart, and Winston, Inc., 1972.
- Dwyer, F. M. The instructional effect of motion in
varied visual illustrations. Journal of Psychology,
1969, 73, 167-172.
- Gibson, J. J. A theory of pictorial perception.
Audiovisual Communication Review, 1954, 2, 3-23.
- Guilford, J. P. & Zimmerman, W. S. A manual of
instructions and interpretations. In Guilford-
Zimmerman aptitude survey. Beverly Hills:
Sheridan Supply, 1956.
- Hoban, C. F. Instructional film research from 1918-1950.
New York: Arno Press & N. Y. Times, 1970.
- House, R. L. Learning a motion and a non-motion concept
by motion pictures vs. a slide presentation.
Audiovisual Communication Review, 1970, 18, 425-436.
- King, L. A. Experimental Psychology (3rd Ed.). New York:
Holt, Rinehart, and Winston, Inc., 1971.
- Lumsdaine, A. A. The influence of a simple animation
technique on the value of a training film. USAF:
Human Factors Research Lab. Report No. 24, 1951.
- Mackworth, N. H., Kaplan, I. T. & Metlay, W. Eye
movements during vigilance. Perceptual-Motor Skills,
1964, 18, 397-402.

- McBeath, R. J. A comparative study of the effectiveness of film strips and filmgraphs for teaching facts and concepts. U. S. Dept. of HEW: Office of Education, No. 7-04-102-00, 1961.
- Otis, A. S. Manual of directions and keys. In Otis self-administering test of mental ability. New York: Harcourt Brace Jovanovich, 1956.
- Roshall, S. M. The effect of learner representation in film mediated perception. USN: SDC TR 269-7-5, 1949.
- Smith, M. Spatial Ability. San Diego, California: Robert R. Knapp, 1964.
- Spangenberg, R. W. The motion variable in procedural learning. Audiovisual Communication Review, 1973, 21 (4), 419-436.
- Travers, R. Audiovisual research related to information transmission. New York: University of Utah Press, 1964.
- Tyler, L. Human abilities. In Mussen, P. H. & Rosenzweig, M. R. (Eds.) Annual Review of Psychology, 1972, 23, 177-206.
- Van De Meer, M. A. Color versus black and white in instructional films. Audiovisual Communication Review, 1954, 2, 121-134.

Vernon, P. E. Experiments on the value of films and film strips in instructing adults. British Journal of Psychology, 1946, 16, 49-169.

Woodson, W. E. & Conover, P. W. Human engineering guide for equipment designers. Berkeley: University of California Press, 1970 (Second Edition).

Appendix B
Pilot Study

<u>Subject Ranking</u>	<u>Sex</u>	<u>Number of Correct Responses</u>
(High Spatial Aptitude)		
1	M	0
2	M	0
3	M	1
4	M	0
5	F	0
6	M	0
7	F	0
8	F	1
9	M	0
(Low Spatial Aptitude)		
10	M	0
11	F	1
12	F	0
13	M	0
14	F	0
15	M	0