COMPUTER GRAPHICS : A TEACHING TOOL FOR MENTAL VISUALIZATION SKILLS

by

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ABSTRACT

Computer Graphics: A Teaching Tool for
Mental Visualization Skills (April 1985)
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Interactive computer graphics are shown to be an effective method for improving mental visualization skills. Computer-aided spatial skills improvment exercises (CASSIE) are developed at Texas A&M University to determine if they can be an effective tool for improving spatial skills. A pre-test post-test method is used to detect any improvment of the spatial skills of twenty-three architecture students. Results confirm a positve relationship between computer graphics used as a teaching tool and increases of spatial skills. Problems with CASSIE are discussed and continued research is highly encouraged.

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- Special thanks goes to Terry R. Larsen who went far beyond his responsibilites as an advisor. He made himself available night and day as CASSIE was being developed. I have learned over the past year that he is not only a dedicated professor but also a reliable friend.

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INTRODUCTION

Interactive computer graphics would appear an effective means of improving spatial skills given its potential for the visual simulation of spaces. This paper will analyse the effectivness of computer graphics as a teaching tool for these spatial skills. Computer-aided spatial skills improvment exercises (CASSIE) were developed at Texas A&M University to provide the training program that would be evaluated.

Spatial skills require the ability to picture an object in one's mind and to be able to manipulate that object by rotating or twisting it. (McGee 1979) These skills are used in everyday activities in a variety of ways. For example, when walking up to a glass door with a sign painted on the opposite side, you must either rotate the sign towards yourself or project yourself on the other side of the door to read and understand that sign.

For many years these skills have been used as an indication of technical ability. The Armed Forces place recruits into specific fields depending on their spatial abilities. Many schools of higher learning test for these abilities as a means of admission to the school. In addition, a high degree of spatial skills has been linked

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to success in many different fields such as engineering, architecture, and other sciences.

Much of the previous research in the field has dealt with spatial skill abilities dependent on sex, handedness, genetic background and other characteristics. This project deals with the improvment of mental visualization skills of a general group of architecture students at Texas A&M University. It can be expected that architecture students already have a high degree of these skills due to the training and experience they receive from their architecture program.

Review of the literature

Most research that is done in this field uses a pre-test post-test method for determining if spatial skills have improved after a training session has been administered. Different types of training techniques have been proven effective for a wide variety of subjects. These skills have been shown to improve for subjects that are male, female, left-handed, right-handed, young, and old.

Brinkman (1966) defined four necessary qualities that are needed for mental visualization skills: (1) differentiation or descrimination, (2) identification, (3) organization, and (4) orientation. In this study he used instruction of analytical geometry as a training tool for these skills. He found a positive relationship between improvment of spatial skills and the training method which was used. "It seems reasonable to assume that the functional skills of individuals in spatial visualization can be improved when appropriate training is provided." (Brinkman 1966 p.184)

One successful study (Blatter 1983), documented improvment in the skills of ninth graders after ten training sessions consisting of lectures on the problems given in the test. Dr. Mark McGee (1978) found significant increases in the skills of freshman psychology students at Texas A&M University. His training session also consisted of an hour lecture describing the problem task.

Increases of spatial skills were also recorded by Stericker and Levisconte (1982). The training methods that were used in their study included: repitition of problem, verbalization of problem, peer coaching, and visual aides.

Some of the difficulties found in the training of spatial skills seem to be related to the fact that people solve visual problems in several different ways (Kyllonen, Lowman and Snow 1984). Training techniques used to improve spatial skills will not be effective if the method taught to solve the problem is not similar to the method preferred by the subject. The difficulty then becomes trying to determine what is the preferred method of approach for each subject!

METHODS

Mental Visualization Tests

Three tests were chosen to evaluate the mental visualization skills of the subjects. These tests have been proven effective for many years in evaluating these skills. The three tests that are used were adapted from Thurstone's Primary Mental Abilities Battery. (1938)

The first test used is an adaptation of the Cubes Test. The subject is shown two figures that represent cubes. Each face of a cube has a different design on it. The subject is asked to determine if the figures can represent the same cube rotated into a different position. Several examples are provided to insure an understanding of the problem task. An example of this test is Figure 1 of the appendix.

The second test (Fold Test) shows a two-dimensional figure which can be folded along the designated lines to form a cube. Some of the faces have shaded squares on them. The subject is required to select the correct cube from a choice of four. Adequate instructions and examples are provided to insure an understanding of the problem. An example of this test is Figure 2 of the appendix.

The third test is similar to Thurstone's Blocks Test. This block-counting exercise presents a stack of blocks that are of the same size and shape. Some of the blocks are labeled with a letter. The subject is asked to determine how many other labeled blocks are touching a specified block. Adequate instructions and examples are provided to insure a correct understanding of the task. This test can be found in Figure 3 of the appendix.

Development of CASSIE

The most dificult part of this research was the development of an interactive computer graphics package. CASSIE consists of a pre-test, a training session, and a post-test. The test which is used for both the pre-test and the post-test contains five questions from the Cubes Test, five questions from the Fold Test, and ten questions from the Blocks Test. A training session was developed for each test section after determining the activities required to solve the problem.

Interaction with CASSIE is accomplished with the use of a joystick. The subject is able to position crosshairs on the terminal screen and push a button to select a particular response. Several practice questions are given to insure the subject is comfortable with the input device before testing begins.

In the Cubes Test it was estimated that the subject would like to see one of the cubes rotate in order to see the other sides of the cube. This training session allows the subject to rotate cube B in six different directions at ninety degree increments. The cube can be rotated as many times as desired to determine if the two cubes are the same. A YES or NO response can then be selected. An important part of the training session is the fact that the subject is required to give the correct response before the next question will be given. This technique helps the subject to confirm if his/her answer is correct. The terminal display for this training session is represented in Figure 4 of the appendix.

The second test (Fold Test) involves visualization of a two-dimensional figure folding up to form a cube. The subject is given the option of selecting FOLD in which the figure will fold up to form a cube. This helps the subject actually "see" what would occur. The subject is then able to choose which of the four cubes is the best answer. This training session also requires the correct response before the next question will appear. The terminal display for this training session is represented in Figure 5 of the appendix.

The third test (Blocks Test) was not provided with a training session. This test served as the control to compare increases of skills due to the training sessions.

Subjects

Subjects were twenty-three students in the College of Architecture and Environmental Design at Texas A&M Universtiy. Sixteen freshman and seven seniors took part in the testing. The twenty-three volunteers were taken from regularly scheduled design studios.

Testing procedure

The volunteers were asked to take forty-five minutes of their time to work on CASSIE. The terminals were made available twenty-four hours a day for the convenience of the subjects. The subjects took part in the survey from March 20 to April 6. Directions were provided for logging on to the computer and initiating CASSIE. However, all remaining questions and prompts were handled by CASSIE.

RESULTS

The pre-test post-test results of the Cubes Test show a large increase in the spatial skills of the total population. (see Table 1) The total population increased from seventy-seven percent (3.83) to ninety-four percent (4.7). A large part of this increase was from the freshman group. Their scores increased from seventy percent (3.5) to ninety-four percent (4.68). The senior group recorded a modest increase of spatial skills.

Variable	Mean	St. Dev.	Variance	N
Total Population				
Post-test	3.826	.984	.9684	23
Post-test	4.695	.471	.2213	23
Freshman Population				
Pre_test	3.5	.894	.8	16
Post-test	4.68	.479	.229	16
Senior Popoulation				
Pre_test	4.57	.787	.619	7
Post_test	4.71	.488	.238	7

TABLE 1. Summary of Cubes Test data

The results of the Fold Test show a moderate increase of skills for all of the groups. (see Table 2) The amount of increase was limited to three percent because the post-test average score was one-hundred percent.

Variables	Mean	St. Dev.	Variance	N
Total Population				
Pre_test	4.87	.344	.1186	23
Post_test	5.0	0.0	0.0	23
Freshman Population				
Pre_test	4.87	.342	.1166	16
Post_test	5.0	0.0	0.0	16
Senior Population				
Pre_test	4.86	.378	.1428	7
Post_test	5.0	0.0	0.0	7

TABLE 2. Summary of Fold Test data

The Blocks Test also showed an increase of mental visualization skills for all groups. (see Table 3) The average increase for the overall population was five and one-half percent. It is interesting to note that this test did not have a training session.

Variables	Mean	St. Dev.	Varience	N
Total Population				
Pre_test	9.3	1.145	1.312	23
Post_test	9.87	.344	.1185	23
Freshman Population				
Pre_test	9.13	1.258	1.58	16
Post_test	9.875	.341	.1166	16
Senior Population				
Pre_test	9.7	.756	.5714	7
Post_test	9.86	.378	.1428	7

TABLE 3. Summary of Blocks Test data

DISCUSSION

The increases of spatial skills demonstrated in all tests seem to indicate that interactive computer graphics is an effective means of improving mental visualization skills. The improvment of skills can be attributed to three causes. (1) Familiarity with the tests typically accounts for a slight increase of skills between the pre-test and the post-test. (2) The fact that the training sessions required a correct answer before continuing to the next question enabled the subjects to confirm that their answers were correct. (3) Perhaps the most effective means of improvment would be from the visual simulation the subject receives. Having control over the cubes and figures enables the subjects to actually "see" what they should be mentally visualizing .

The simplicity of the tests may have hindered the amount of improvment that was recorded. During the Fold Test, all of the subjects scored one-hundred percent on the post-test. This grouping of scores at the top end of the scale does not show the improvment that would have occurred with a more difficult test. A revised test may result in a wider range of scores and a more accurate appraisal of the improvment.

RECOMMENDATIONS

The results of this project have proven to be very impressive. However, two problem areas have been discovered that should be corrected before continuing the research. (1) The test should be made more difficult to more accurately determine the increase of skills by eliminating the tight grouping of scores. (2) A variety of subjects should be used in the future. Architecture students have been shown to already have a high degree of these skills and may be more responsive to training. If subjects are drawn from the non-science fields, perhaps a more accurate appraisal of the abilities of CASSIE to improve mental visualization skills will be seen.

CASSIE should continue to be developed. New and more effective training methods can be added to the training sessions. Further testing and research should confirm the effectivness of computer graphics as a teaching tool for mental visualization skills.

APPENDIX

TERMINAL DISPLAYS
(FIGURES 1 - 5)

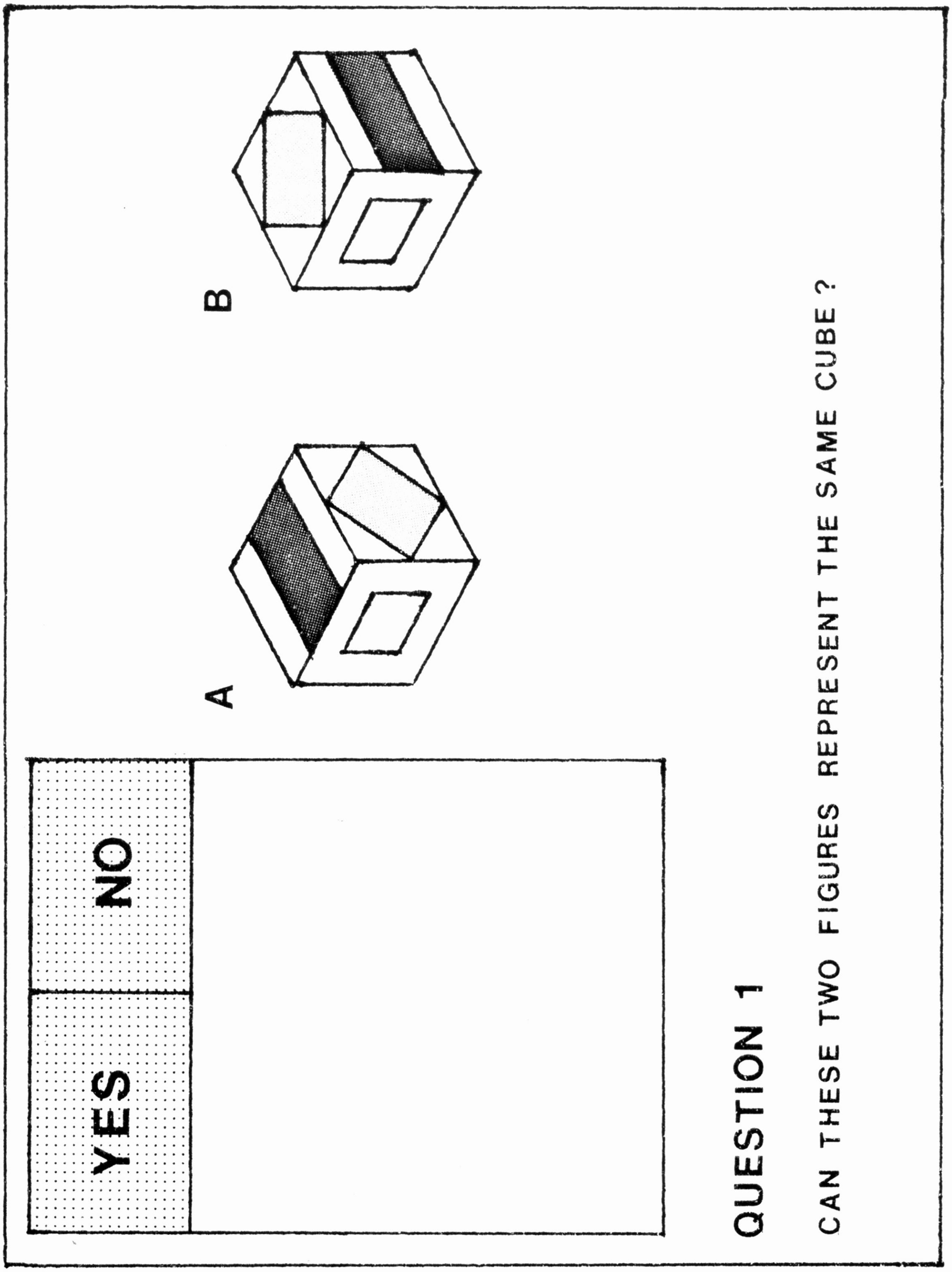

FIGURE 1. Terminal Display for Cubes Test

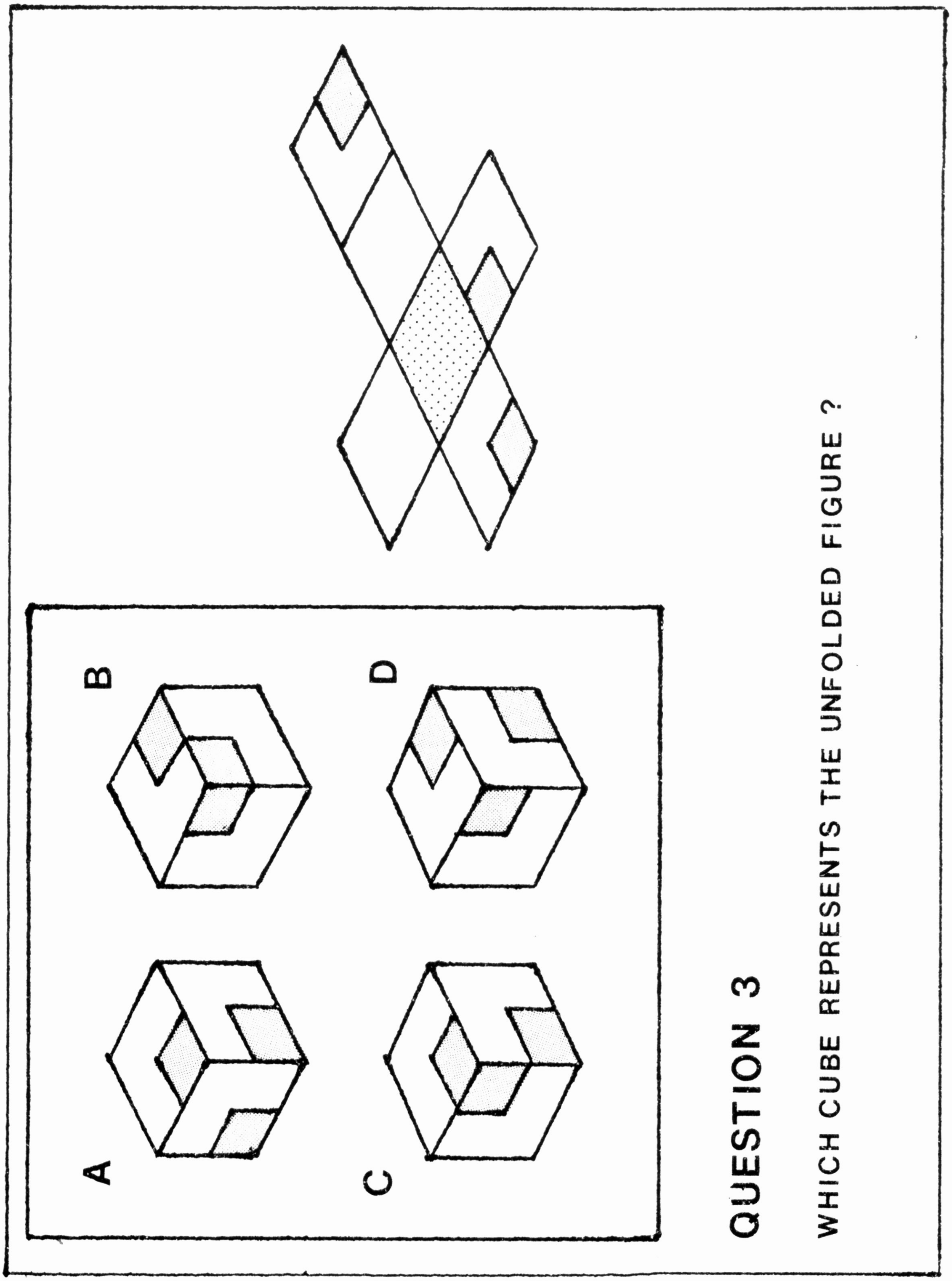

FIGURE 2. Terminal Display for Fold Test

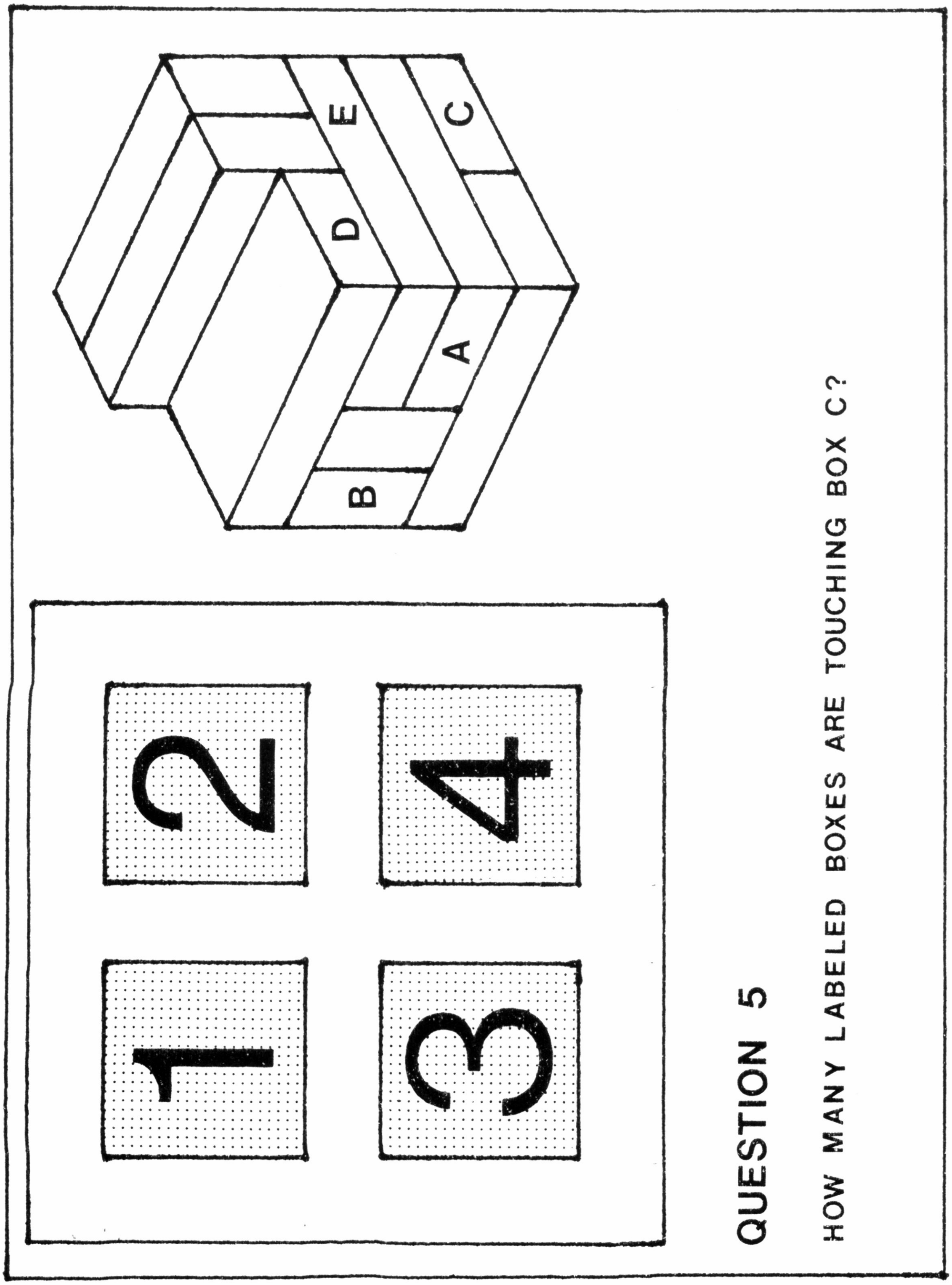

FIGURE 3. Terminal Display for Blocks Test

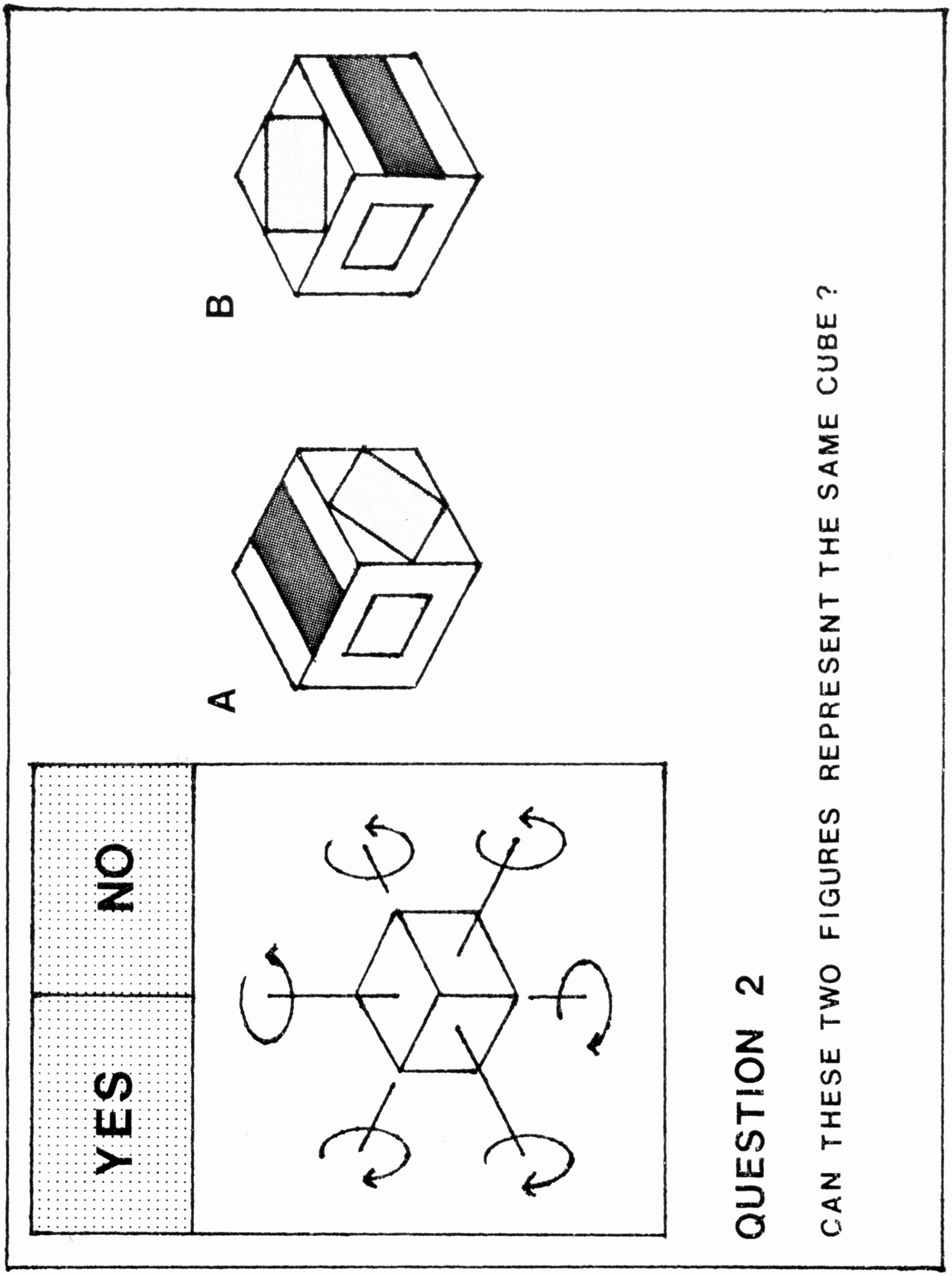

FIGURE 4. Terminal Display for Cubes Test (Training Session)

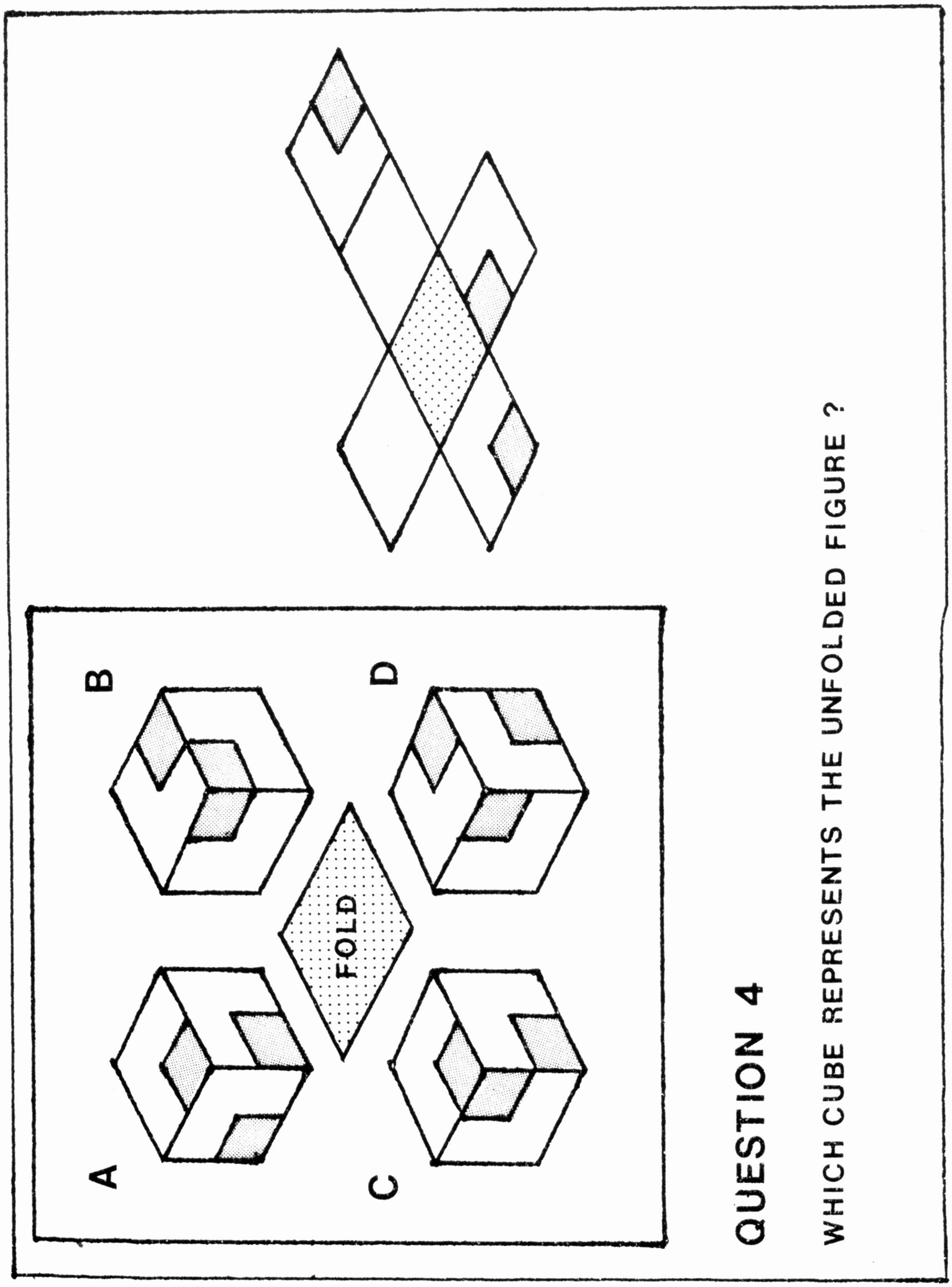

FIGURE 5. Terminal Display for Fold Test (Training Session)

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