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Abstract

Previous research has demonstrated that 3-year-olds are capable of retrieving a toy hidden in a room when presented with a photograph that shows the location of the toy. This research examined whether their performance is affected by the amount of information depicted in the photograph. There were three conditions: in the first condition, the children were shown four photographs that each depicted a single hiding location; in another condition, the children were shown a single wide-angle photograph that showed all hiding locations; and in the third condition, a scale model of the room was used. Children performed better with the photographs than with the scale model, but only the difference between the wide-angle photo condition and the scale model condition was significant. Because both representations convey the same amount of information, the difference in performance is likely due to the nature of the symbol itself. A picture-referent relation is easier to represent than a model–referent relation for children this age. Thus, more cognitive capacity is available to children in the picture tasks to map information between symbol and referent.

Young children's use of individual and wide-angle photographs in a symbolic task

Symbols are incorporated into almost every facet of our lives. For example, the words that you are reading right now are symbols, as are complex mathematical equations, stop signs, and baby pictures. It would be impossible to function in our society without a very fundamental understanding of these symbols. The use and understanding of symbols comes easily to most adults. An adult would probably never look at a picture of a dog in an ad for dog food and try to pet the animal, nor would she see an algebraic formula and mistake it for a sentence. When adults encounter a symbol, we immediately think of what it represents.

In contrast, symbols are not so easily understood or so obvious to young children. Children have to learn that one thing can represent or "stand for" something else. Acquiring symbolic competence is a major developmental challenge for these youngsters.

There have been many investigations into young children's learning of symbolic representations. However, because there are many different kinds of symbols, as well as many different ways in which we use them, research within one area will not lead to a complete understanding of the development of symbolic competence. The focus of the current research is on young children's very early understanding and use of artifactual symbols (i.e., symbols that have an enduring physical presence in the world) as a source of information about their referents.

In order to use a symbol as a source of information, a child must understand that the symbol (e.g., picture, map, calendar, clock, etc.) is a representation. That is, the child must recognize that the symbol stands for something other that itself. Further, one must derive information from the symbol to make an inference about its referent (or vice versa).

DeLoache and her colleagues have conducted one of the most systematic research programs on young children's use of symbols (DeLoache, 1987, 1989, 1991; DeLoache & Marzolf, 1992; DeLoache, Miller, Rosengren & Bryant, 1993; Marzolf & DeLoache, 1994). DeLoache used object retrieval tasks in which children are asked to use a picture, scale model or map as a source of information about the location of a hidden object. In these tasks, a child must use the symbol (i.e., a picture, model, or map of a room) to obtain information about its referent (i.e., the location of the hidden toy in that space).

The task used most often is the standard model task. In this task a child sees a small toy hidden in a specific location in a scale model of a room. The child is then asked to find another toy hidden in the corresponding location in the room (DeLoache, 1987, 1989, 1991; DeLoache et. al., 1991; Marzolf & DeLoache, 1994; Marzolf et. al., in press). After finding the toy in the room, the child is then asked to return to the model to retrieve the toy that he or she had originally seen hidden. This memory retrieval is intended to examine whether any inability to find the toy in the room is due to simple forgetting or symbolic incompetence. To succeed, the children must represent the higher-order relation between the model and the room and map information (i.e., the location of the toy) from one space to another (Marzolf, 1996).

The studies have consistently shown that most 3-year-olds succeed at the standard model task, while most 2.5-year-olds do not (DeLoache, 1987, 1989; Dow & Pick, 1992). Three-year-olds are able to enter the room and go directly to the hidden toy whereas most 2.5-year-olds have difficulty finding the toy in the room, despite the fact that they almost always remember where the original toy was hidden in the model.

One theory explaining the respective success and failure of 3-year-olds and 2.5-year-olds

focuses on the need for children to achieve dual representation in the model task. DeLoache and Marzolf define dual representation as a one's ability to think about a symbolic object "both as the object that it is and as a representation of something other than itself" (DeLoache & Marzolf, 1995). In other words, the child must look at the model, play with it, and appreciate it as an object in itself, and at the same time understand that it is a representation of the room. The 3-year-old child clearly has this ability, while the 2.5-year-old child does not (DeLoache, 1987, 1989, 1991; Marzolf, 1996).

As a test of the dual representation hypothesis, DeLoache & Burns (1994) substituted pictures for the scale model in their object retrieval task. Not only are most 2.5-year-old and 3-year-old children are very familiar with pictures, but pictures, unlike models, do not require dual representation (DeLoache & Marzolf, 1992). Pictures are not complex, attractive objects in themselves, but rather they function almost entirely to represent something else. Children think about pictures only as representations of something else and not as objects themselves. Thus, pictures do not require dual representation in the same way that models do. In support of the dual representation hypothesis, DeLoache & Burns (1994) found that 2.5-year-olds readily used the pictures as representations of the room.

The realization that a picture or model actually represents something other than itself is what DeLoache and her colleagues have called "representational insight"(DeLoache, 1987; DeLoache & Marzolf, 1992). If a child is able to successfully complete the standard model task, it can be inferred that she "understands something about the relation between the symbol and its referent, that is, that the child has representational insight" (DeLoache & Marzolf, 1992).

Much of the previous research has examined factors that influence representational

insight. For example, DeLoache et. al. (1991) found that when the furniture within the two spaces did not look alike (e.g., the couches were different colors), even normally successful 3-year-olds failed the task. Marzolf, DeLoache, and Kolstad (1999) did a series of studies in which the furniture in the model and in the room was not arranged similarly, therefore decreasing spatial similarity. For example, the large blue chair was in the back right corner of the room, next to a table, but the miniature chair was in the front left corner of the model, next to a plant. The success of the 3-year-old children decreased quite dramatically, from 81% to 33% when the objects in the two spaces were arranged differently from each other. Thus, they did not achieve representational insight in the absence of spatial similarity. Previous experience with symbols, instructions, and similarity of scale have also been shown to influence representational insight (DeLoache, Kolstad, & Anderson, 1991; DeLoache & DeMendoza, in press; Marzolf & DeLoache, 1994).

Representational insight is not all that is necessary to use a symbol as a source of information about its referent. Mapping, that is, applying information that has been derived from the symbol to its referent, is also important. This may seem obvious, but even adults can have problems with mapping. For example, scientists have known for years that the Egyptian hieroglyphs have meaning and that they are some sort of ancient writing, but it is only recently that the hieroglyphs have begun to be decoded. A complex mathematical formula is another example. Many know that $E=mc^2$ represents something, but few know exactly to what it refers or how to effectively use it.

Mapping in the standard model task or picture task is relatively simple; it is basic object to object mapping. The child sees that the toy is hidden behind the chair in the model, and

simply has to look behind the chair in the room. But many symbol referent relations are not so simple; they require one to map relations, not just objects. A violinist reading musical notation cannot just view a note and know how to make that note on the instrument. He must see the note in the context of the staff, the other notes, the key of the piece and the tempo before he can accurately play that particular note. A line on a map does not independently correspond to a particular road. Rather, it is defined by its relations with other features on the map.

Even though many symbolic tasks do require mapping multiple relations, it has been only recently that research has begun examining young children's ability to map relations in simple model and picture tasks (Blades & Cooke, 1994; Bence & Presson, 1997; Marzolf, 1996). In Marzolf's studies, four identical white boxes were placed next to the different items of furniture in the room, and four identical miniature white boxes were placed in corresponding locations in the model. The child in the experiment saw the experimenter hide the small toy in one of the boxes in the model and was told that the larger toy was hidden in the "same place" in the room. The child was then asked to find the larger toy. A memory retrieval task for each trial was also included. In order to successfully complete the task, the child had to correctly represent three relations: The higher-order model-room relation; the toy-box relation; and the box-landmark relation. Further, they had to map the latter two of these relations from the model to the room. Marzolf found that 3-year-old children had difficulty successfully completing the task even though they did seem to represent the three relations. The problem seemed to stem from the mapping process. The children seemed to map only one relation, the toy-box relation, even though they represented the other two (Marzolf, 1996).

Marzolf explained his results by theorizing that representing each relation requires

cognitive effort, and that mapping requires an additional amount of effort. Representing each relation seems to be within the capacity of most 3-year-olds, but coordinating these relations to perform a mapping seems to move the task beyond their capacity. To test his hypothesis, Marzolf (1996) conducted a picture study that was analogous to the model task with identical boxes. The rationale behind this experiment was that the picture-referent relation is easier to represent than the model-referent relation is. That is, less cognitive effort is required in the picture task because there is no need for dual representation. Also, because children are very familiar with pictures as representations, representing a picture-referent relation might be more "automatic" and hence require less cognitive effort. If this is the case, then there may be enough cognitive capacity remaining to successfully perform the mapping in the picture task.

In the picture study, instead of using a model to communicate where the toy was hidden, Marzolf used five individual color photographs. Each photograph showed one landmark and its corresponding white box. After an extensive orientation in which the child was familiarized with the experimenter and the pictures, the child sat at a table and the pictures were arranged in front of her in a small semicircle.

On each of the four test trials, the experimenter pointed to the box in one of the four pictures and told the child that the toy would be hidden "right here." Neither the box nor the landmark was labeled. The child then searched for the toy in the room. Thus, to succeed in this task, the child had to represent and map the same relations as in the model task with the boxes. The only difference was that the task involved a picture-referent relation rather than a model-referent relation. After finding the toy, the child was asked to point to the picture that showed where the toy had been hidden. This is analogous to the memory retrieval in the model task.

Marzolf found that children in the study were very successful at remembering which picture they were told indicated the hiding place (97%), as well as finding the toy in the room (88%). This contrasts sharply with the performance of children in the model task, who performed well on the memory retrieval (88%), but not the symbolic retrieval (44%) (Marzolf, 1996). These findings confirm Marzolf's hypothesis-- because picture-referent relations are easier to represent than model-referent relations are, the demands of the task fell within 3-year-old children's limited cognitive capacity.

An alternative explanation exists for the 3-year-olds' successes at the picture task and poor performance in the model task. Perhaps the difference in performance is actually due to the fact that the picture task has less distracting information. In contrast to the model task, in which all possible hiding places are visible, each individual photograph in the picture task depicts only one possible hiding place. Although previous research has shown no effect of individual photographs vs. wide-angle photographs (DeLoache & Burns, 1994), this explanation has not been ruled out in this task.

One of the goals of this experiment was to replicate the previous finding that children perform better in the picture task that requires mapping multiple relations than in the scale model task (Marzolf, 1996). In the current study, then, one group of children received the model task in which the toy was hidden in one of four identical white boxes. A second group received a similar task, but one in which information about the location of the toy in the room was conveyed via four individual photographs that each showed a single hiding location. In accord with previous research (Marzolf, 1996), we expected that the children in the individual photograph condition would perform better than the children in the scale model task. The

second goal was to investigate the cause of this difference. Specifically, we examined whether the expected difference is due to the nature of the representation (photograph vs. scale model) or whether it is due to the amount of information conveyed in each representation. This was accomplished by presenting a third group of children with a similar task in which information about the location of the toy was conveyed via a single wide-angle photograph of the room. This photograph showed every item in the room, and thus conveyed the same amount of information as the scale model. Success on this task would support Marzolf's claim that children perform better with photographs because picture-referent relations are easier to represent than model-referent relations, and not because the photographs used in his previous task contained less distracting information than the scale model (Marzolf, 1996).

Method

Participants

Thirty-five children (17 boys and 18 girls) between the ages of 35 and 40 months participated in this experiment. The children were randomly assigned to one of three conditions: 6 boys and 6 girls were assigned to the wide-angle photograph condition (average age 37.2 months); 5 boys and 6 girls were assigned to the individual photograph condition (average age 37.0 months); and 6 boys and 6 girls were assigned to the model condition (average age 37.1 months). Parents were contacted through records of newspaper birth announcements. The sample was mostly white and middle class.

Materials

The room (8' 8" x 14' 7") used for this experiment was furnished with an end table, a sofa, a floor pillow, a coffee table, and a chair. This space has been used in numerous similar experiments (Meyers & Marzolf, 1999; Breuer & Marzolf, 1999). The space also contained four white boxes: one was placed on the end table; one was located next to the sofa; one was next to the chair; and one was on the floor pillow.

The model (17" x 24") was equipped with miniature versions of all of the items in the room. Each set of corresponding items was similar in every way, with the obvious exception of size. The miniature sofa in the model, for example, was upholstered with the same fabric as the sofa in the room. The furniture in the model was arranged in the same way as the objects in the room. The model was placed on a table outside of the room, such that the child could not see the interiors of the two spaces at the same time. The spaces were aligned (Fig. 1).

Two types of photographs were used in this experiment. A wide-angle photograph that

showed the majority of the room was used in the wide-angle photograph condition. Each item of furniture and all four boxes were clearly visible in the photograph (Fig. 2). Four photographs that showed each individual landmark and the boxes associated with these landmarks (e.g., one photograph showed the chair and the box next to the chair) were used in the individual photograph condition (Fig. 3). A fifth photograph showed the table that was used during the orientation to the task, but not during the test trials. During testing, the photos were located on a table outside of and aligned with the room. They were not arranged randomly, but were arranged roughly in the same manner of the room. For example, as the child enters the room, the chair is immediately to his or her left and the floor pillow is immediately to his or her right. Therefore, the pictures were arranged so that the picture of the chair was at the far left and the picture of the floor pillow at the far right (Fig. 4 & 5, respectively). A stuffed tiger served as the target object.

Procedure

Each child was tested individually, and the experiment consisted of three phases. The first phase was a "warm-up" period in which the experimenter and the child did a puzzle together. The goal of this phase was to familiarize the child with the experimenter and with the testing location. This phase took approximately five to ten minutes.

The second phase was the orientation to the task. The goal of this phase was to familiarize the child with the testing materials, as well as to emphasize the symbol-referent relation. In this phase, the primary experimenter showed the child the room (described as "tiger's room") and labeled each object, making sure to indicate the boxes as well. The experimenter then showed the child the picture(s) or model, saying "these are pictures (or this is

a picture or this is a model) of tiger's room." The experimenter then pointed out the correspondence between each depicted object and its referent in the room. The orientation phase also consisted of a placement trial in which the experimenter showed "where tiger wants to sit in his room," by pointing in the pictures or model, depending on the condition. The experimenter then asked the child to place the tiger in that location (on the coffee table) in the room. If the child was incorrect, the experimenter placed the toy in the correct location and again emphasized the relation between the photo (or model) and the room.

The testing phase was the third phase. This phase consisted of four test trials in which the toy was hidden in each of the boxes. The order of the test trials was randomly determined. On each trial, the experimenter pointed in the picture or model where the toy would be hidden in the room. In the wide-angle photograph condition, for example, the experimenter pointed to the appropriate box and said, "I'm going to hide the tiger right here." The experimenter did not label the box or its associated landmark. While the child waited by the photo, the experimenter hid the toy in the room. Upon returning, the experimenter re-indicated the correct location in the picture and asked the child to search for the toy in the room (Symbolic Retrieval). If the child did not find the toy on the first try, the experimenter gave a prompt, "Remember where I pointed in the picture? That is where the tiger is hiding here in the room." If the child still did not find the toy the experimenter gave the second prompt, "I pointed to the box on/next to the ---- in the picture. That is where tiger is hiding here in his room." If the child was still unsuccessful, the experimenter gave the third and final prompt, "I think that tiger is hiding over here (indicating the correct location.)" During the testing phase, a second experimenter recorded where the child searched and as well as the prompts that were given for each test trial.

After retrieving the tiger, the child and the experimenter returned to the photograph and the experimenter asked the child to indicate in the photograph where the experimenter had indicated that he or she was going to hide the toy (Memory Check). The purpose of this memory check was to ensure that a child's inability to find the toy in the room was not due to simply forgetting where the experimenter pointed in the picture. A new trial was administered after each Memory Check, with the obvious exception of the last trial.

The procedures for the individual photograph condition and the model condition were essentially the same. In the individual photograph condition, the experimenter pointed to the box in one of the four pictures arranged in front of the child. In the model task, the experimenter pointed to the miniature box that corresponded to the large box in which the toy was to be hidden. Although the typical procedure in the model tasks is to hide a miniature version of the toy in the model, previous research has shown that performance is essentially the same regardless of whether the experimenter hides a miniature toy or simply points in the model (DeLoache, 1991).

Results

There were two dependent variables. The first was the number of errorless retrievals in the room (Symbolic Retrieval). A child was credited with an errorless retrieval only if the child found the toy in the first place searched without receiving any prompts from the experimenter. Thus, the Symbolic Retrieval scores could range from 0 to 4. The second dependent variable was the number of correct Memory Checks. A child was credited with a correct memory check for each trial in which the child returned to the picture(s) or model and immediately indicated the correct location in the photograph(s) or model. Thus, the Memory Check scores could range from 0 to 4.

Figure 6 shows the group performance (% correct) for each condition. Children in the model condition were correct on 65% of the Symbolic Retrievals and 75% of the Memory Retrievals. Thus their performance was slightly better than expected (approximately 40% in Marzolf, 1996). Children in the individual photograph condition were correct on 80% of the Symbolic Retrievals and 84% of the Memory Checks. Finally, children in the wide-angle photograph conditiion were correct on 96% of the Symbolic Retrievals and 85 % of the Memory Checks.

The data were entered into a 3(condition) x 2(gender) x 2 (response: Symbolic Retrieval vs. Memory Check) repeated-measures ANOVA, with response as the within-subject variable. The only effect to reach statistical significance was the main effect of condition, $F(2, 29)=3.99$, $p<.05$. Planned contrasts indicated that the children in the wide-angle photo condition (96%) performed significantly better than the children in the model condition (65%) on the Symbolic Retrieval, $F(1, 29)=9.64$, $p<.01$. No other differences between groups reached significance.

The gender by retrieval interaction almost reached statistical significance, obtaining a p-value of .066. Girls and boys performed equivalently on the Symbolic Retrieval (81% vs. 83%, respectively), but girls performed quite a bit better than boys on the Memory Check (91% vs. 72%, respectively). Much of this difference was due to the surprisingly poor Memory Check performance of the boys in the scale model condition (58%).

Discussion

The goals of the current study were twofold. The first goal was to replicate the previous finding (Marzolf, 1996) that children perform better in the individual photograph task than in the scale model task. The current study did somewhat replicate the results of previous picture study: i.e., Children perform better in the picture task than in the model task, but this difference did not reach significance. Performance on the individual photograph task was nearly identical across studies (84% in the current study, and 88% in Marzolf, 1996). The absence of a significant difference from performance in the scale model task in the current study is due to the fact that the children in the model condition were more successful on the Symbolic Retrieval than in previous studies (65% in the current study, 40% in Marzolf, 1996). This finding may be due to the fact that in this study the experimenter pointed to the hiding place of the toy rather than actually hiding miniature version of the toy in the model. However, this hypothesis is unlikely given previous studies that demonstrated that performance in the model task is generally the same regardless of whether the experimenter hides a miniature toy in the model or simply points to the correct location (DeLoache, 1991). A more probable hypothesis is that the differences in performance are just due to individual differences between the samples. Indeed, four of the children in the model condition (all boys) performed only two or fewer correct Memory Checks. One might expect that their performance on the Symbolic Retrieval would have been even better had they been better at remembering the original location in the model. In past studies, poor memory performance has been justification for replacing children in the sample. Perhaps such a procedure should have been used in the current study.

The second goal was to examine whether the expected difference was due to the nature

of the representation (photograph vs. scale model) or whether it was due to the amount of information conveyed in each representation. On this point, the results are clear: Children in the wide-angle-photograph condition performed significantly better than the children in the model condition on the Symbolic Retrieval. Since the wide-angle-photograph and the model convey the same amount of information about the hiding locations, this finding demonstrates that the difference in performance is actually due to the nature of the representation and not due to the amount of information that is conveyed in each representation. Therefore, Marzolf's claim that children perform better with photographs because picture-referent relations are easier to represent than model-referent relations, and not because the photographs used in previous studies contained less distracting information than the scale model, is supported. The current findings, then, add a small but important element to our understanding of the complexity of young children's developing symbolic competence.

One result of the current study might warrant further consideration. The relatively successful performance of the children in the model condition was somewhat surprising, considering that this level of performance has never been achieved in numerous similar studies (Marzolf, 1996). In those studies, performance never reached 50%. This finding might warrant replication and further scrutiny as to the factors or differences in the current task that might have facilitated the children's performance.

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Figure Caption

Figure 1: Arrangement of experimental stimuli for the model condition.

Figure 2: Wide-angle-photograph used in current study.

Figure 3: Two of four individual photographs used in current study.

Figure 4: Arrangement of experimental stimuli for the wide-angle condition.

Figure 5: Arrangement of experimental stimuli for the individual photograph condition.

Figure 6: Percent correct as a function of condition and Symbolic Retrieval/ Memory Check.

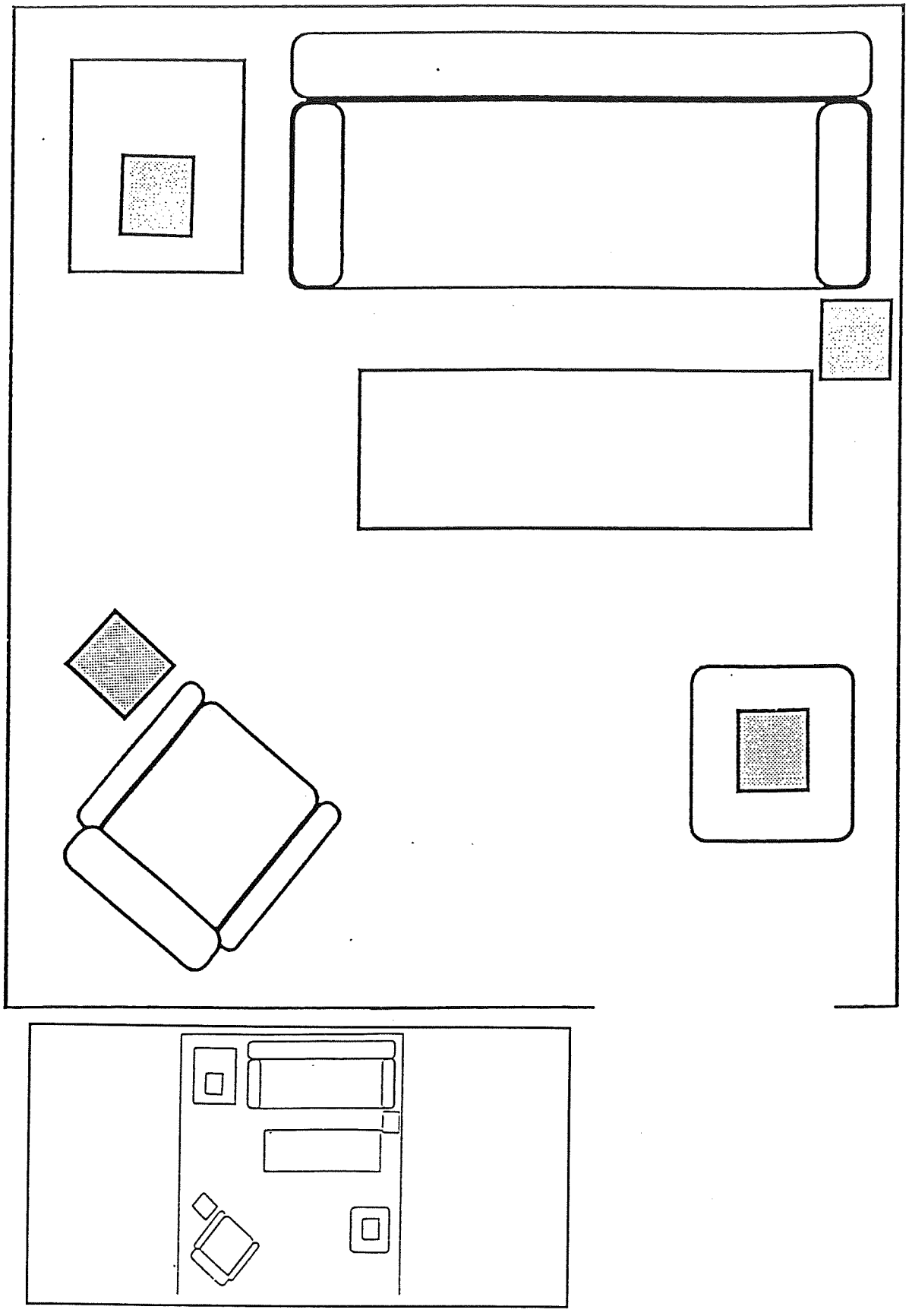

Figure 1.

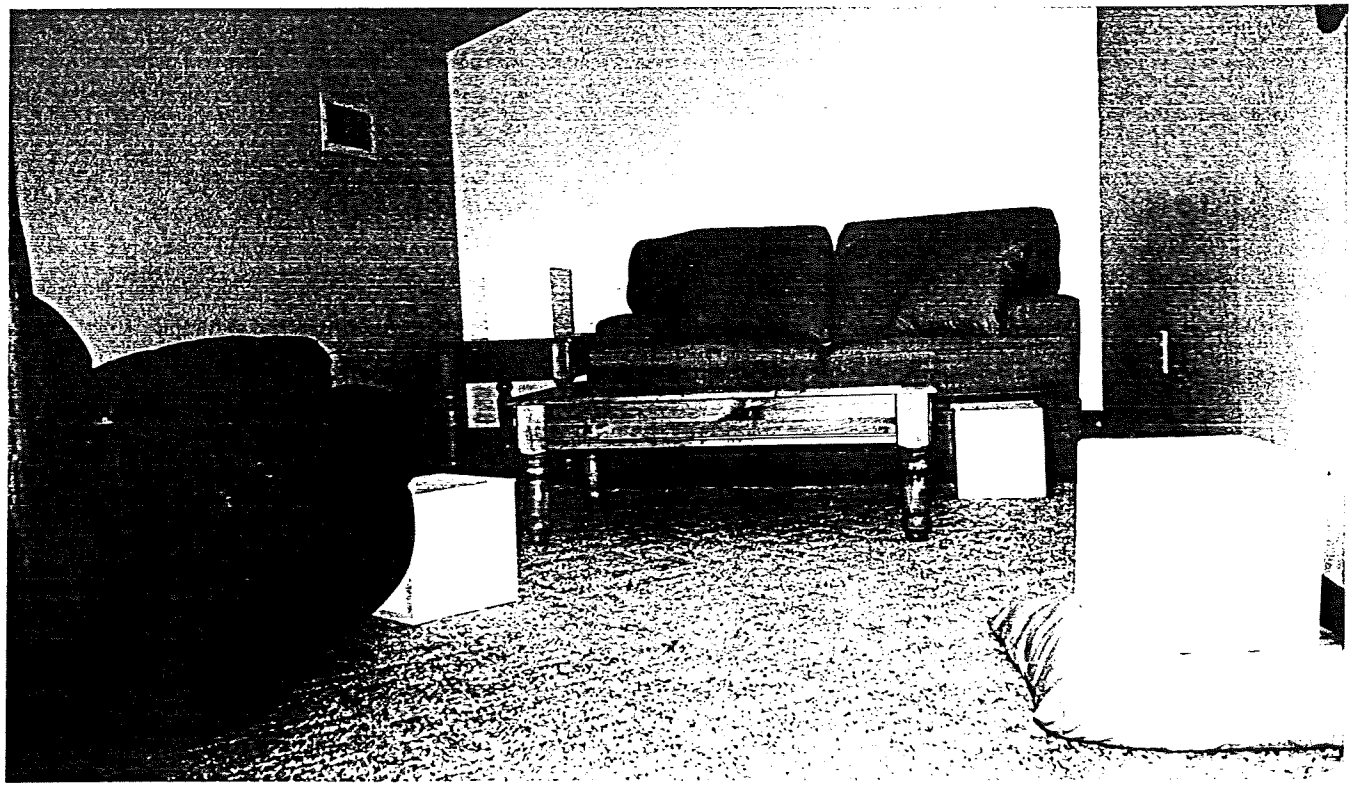

Figure 2.

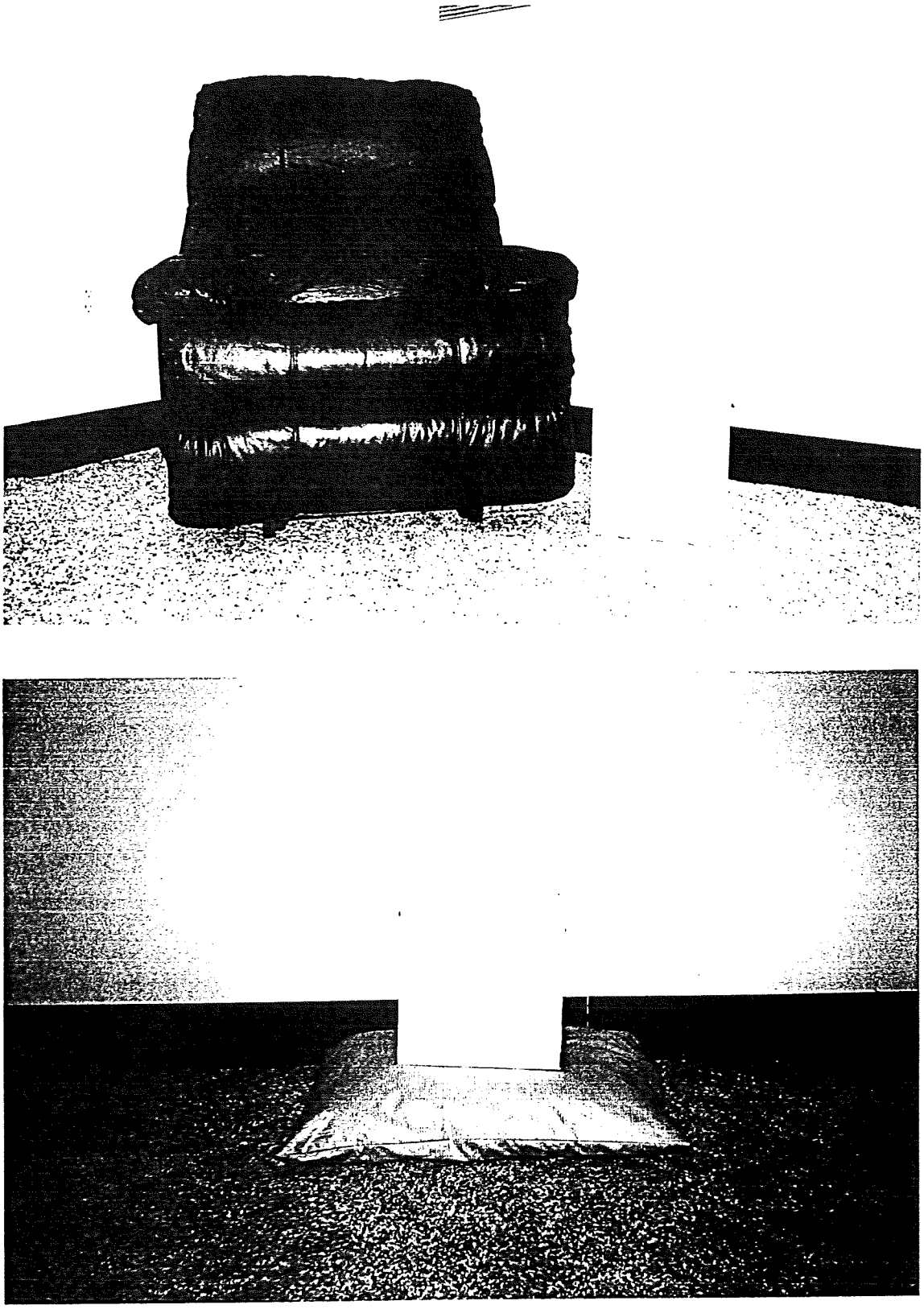

Figure 3.

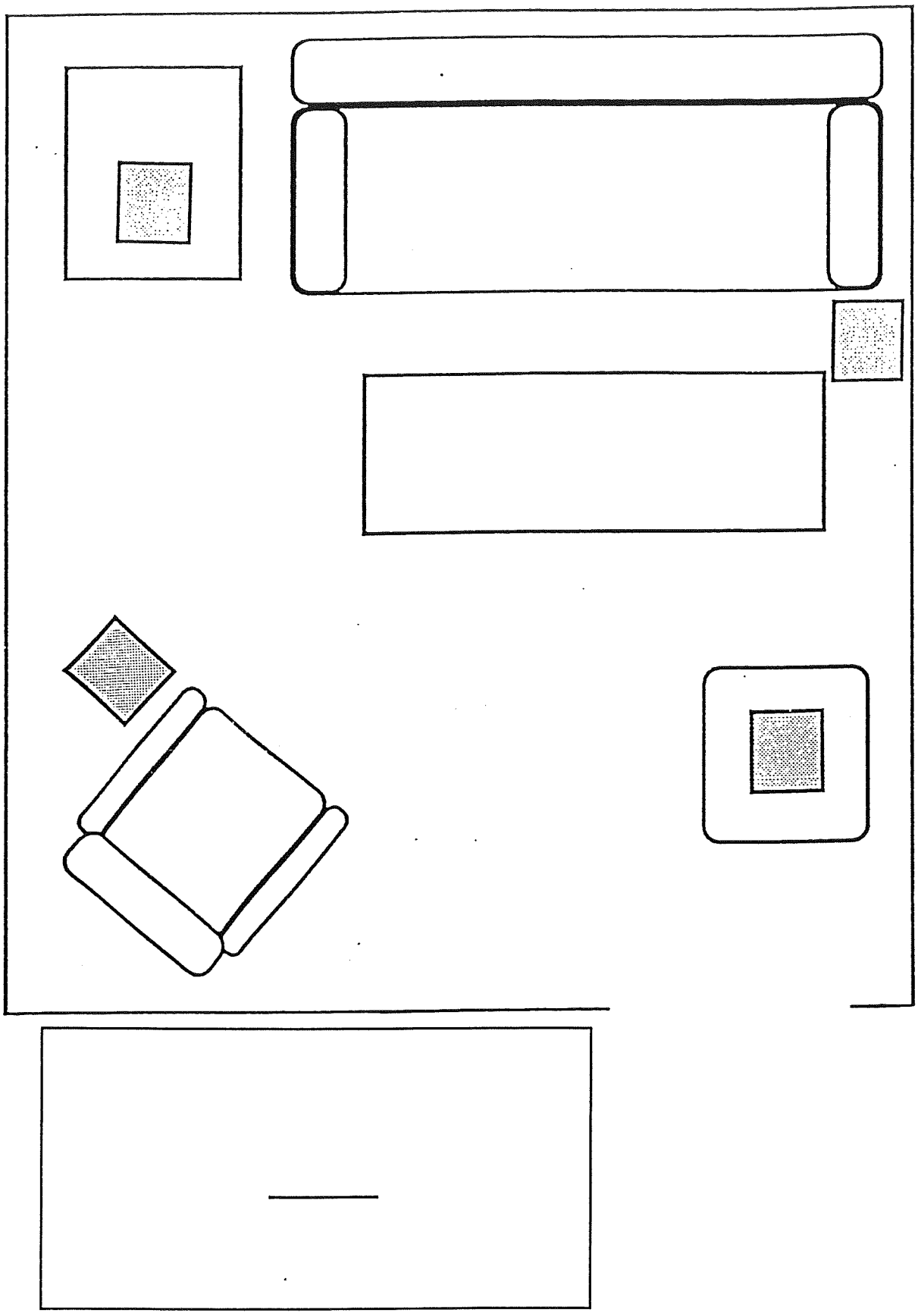

Figure 4.

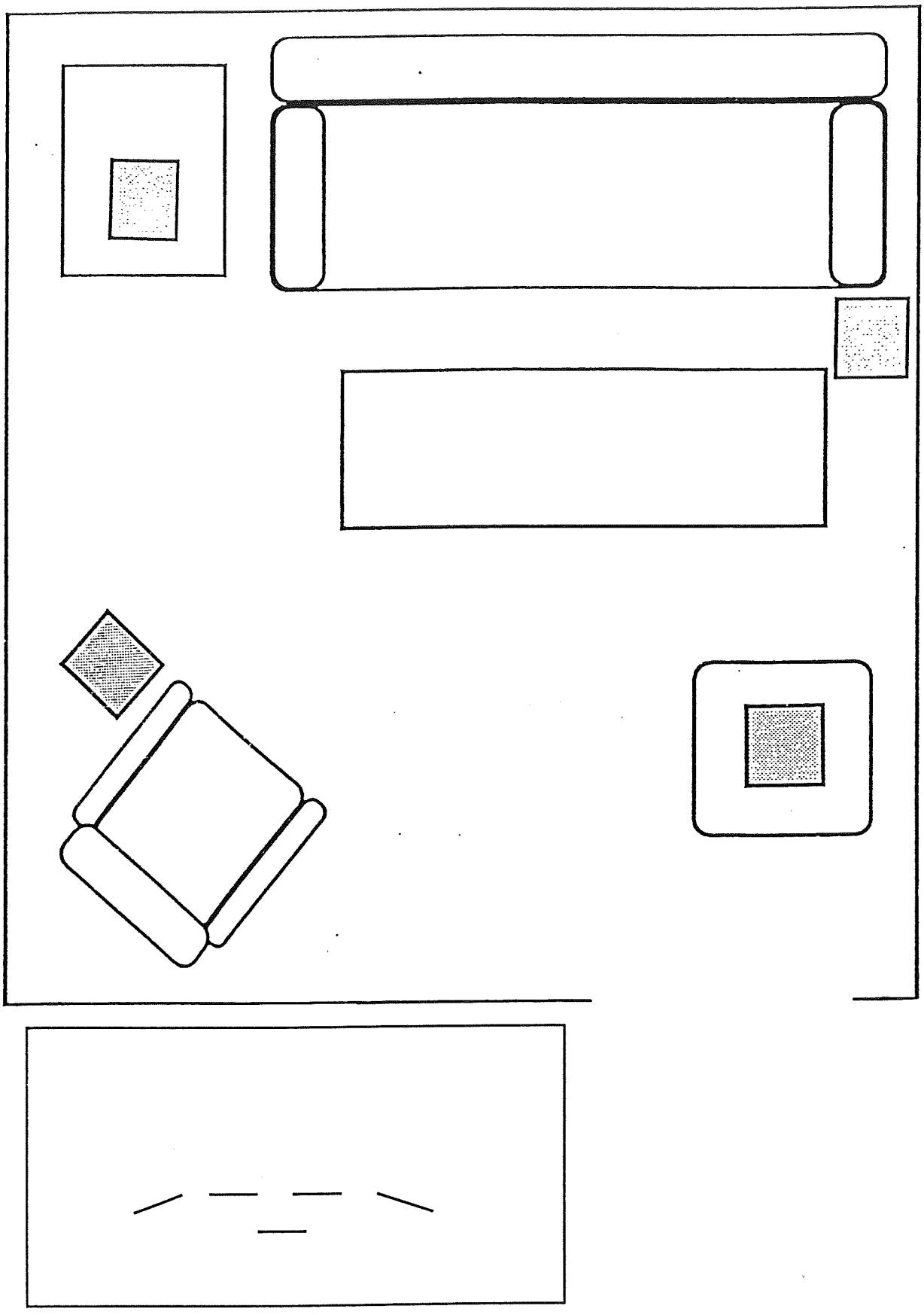

Figure 5.

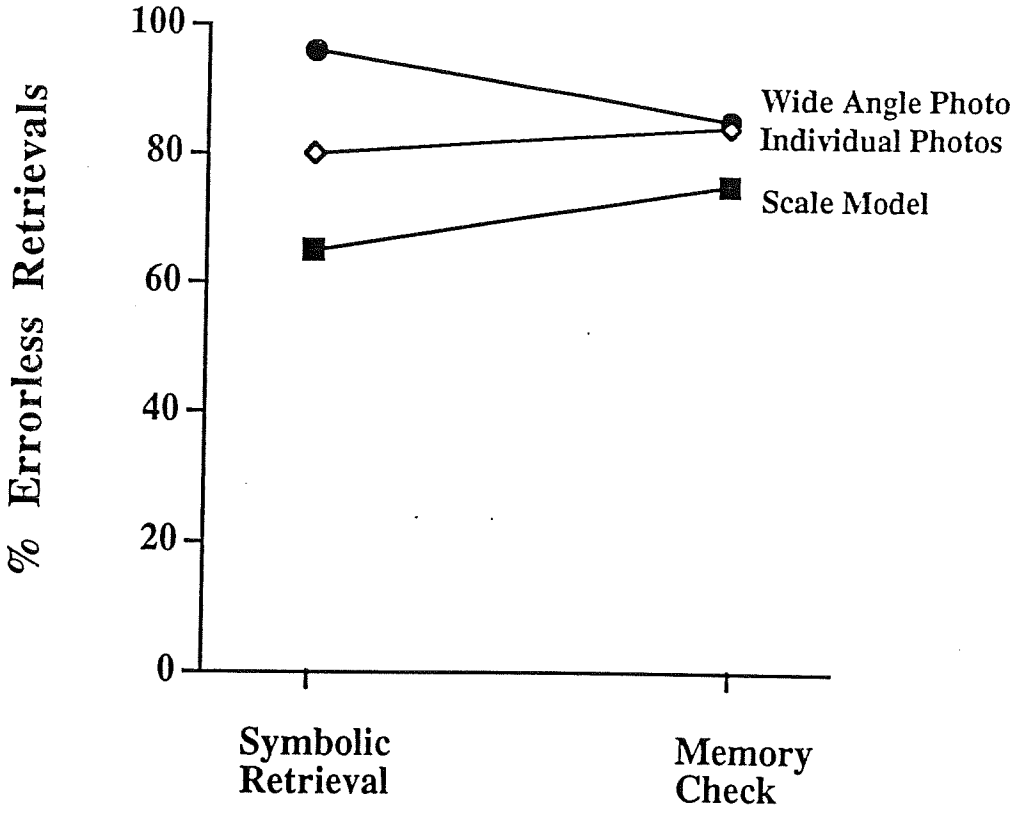
% Errorless Retrievals
100
80
60
40
20
0
Wide Angle Photo
Individual Photos
Scale Model
Symbolic Retrieval
Memory Check

Figure 6.