ED 125 774 PS 008 681

AUTHOR Hardwick, Douglas A.; McIntyre, Curtis W.
TITLE The Mental Manipulation of Cognitive Maps in Children and Adults.
PUB DATE Apr 76
NOTE 17p.; Paper presented at the Biennial Southeastern Conference on Human Development (4th, Nashville, Tennessee, April 15-17, 1976)

EDRS PRICE MF-$0.83 HC-$1.67 Plus Postage.
DESCRIPTORS *Abstract Reasoning; Adults; *Age Differences; *Cognitive Development; Cognitive Measurement; College Students; Elementary Education; Elementary School Students; *Mental Development; *Research
IDENTIFIERS *Cognitive Maps

ABSTRACT

Two experiments compared the cognitive maps (mental representations of the spatial environment) of first graders, fifth graders and college students, and investigated developmental changes in the ability to manipulate cognitive maps mentally. In the first experiment, subjects were asked to move from stationpoint to stationpoint and at each, to align a sighting tube in the direction of three targets. Half the subjects in each age group performed this task while in direct visual contact with the room, half while enclosed by an opaque screen. The three age groups differed only in the obstructed viewing condition. First graders were less accurate than either fifth graders or college students, suggesting that the spatial memory underlying cognitive maps does not reach its adult-like status until sometime between first and fifth grade. In the second experiment, subjects performed two tasks which tested mental mainpulation. Subjects imagined walking to new stationpoints, making three sighting tube responses based on each imagined location. Then subjects imagined that the room had rotated, making sighting tube responses in terms of the mentally transformed spatial array. Again, half the subjects in each age group were assigned to an obstructed viewing condition. Results showed definite age differences and indicated that complete mental manipulation is a two-stage process. In the first stage a strategy of manipulation is applied to the general spatial relationships contained in the cognitive map. In the second stage more specific relationships between self and spatial layout are reconstructed. (Author/SB)

The Mental Manipulation of Cognitive Maps in Children and Adults

Douglas A. Hardwick

Department of Psychology
University of Virginia
Charlottesville, Virginia 22901

and

Curtis W. McIntyre

Department of Psychology
Southern Methodist University
Dallas, Texas 75275

Presented at:

The Fourth Biennial Southeastern Conference
On Human Development

Nashville, Tennessee

April, 1976

The Mental Manipulation of Cognitive Maps in Children and Adults

Today I want to talk to you about the development of cognitive maps. For those of you unfamiliar with the cognitive map construct, let me begin there.

The relevant literature tells us that a cognitive map is a mental representation of the spatial environment. It specifies the location of objects and places outside our immediate field of view. Like the more familiar cartographic map, a cognitive map functions primarily to facilitate our orientation and movement within the extended environment. As yet, little is known about how children acquire cognitive maps or how such maps change with age and intellectual development.

When we first began our study of this problem it seemed that at least two important aspects of a cognitive map should show significant developmental changes. The first we termed <u>content</u>. This refers simply to the information contained in a cognitive map. The second we termed <u>manipulation</u>. This refers to the mental processes which are involved in the utilization of a cognitive map's information. Both of these aspects of cognitive map development will be touched upon in the research presented today. However, before I give you the details of our research, I want to tell you about the basic methodology we developed in our study of cognitive maps.

The classic methodological problem associated with the study of cognitive maps always has centered around the question of how one externalizes the map so that it can be evaluated objectively. With an adult this problem is easily resolved. All you have to do is ask the adult to draw a map of some environmental unit or simply ask him to describe verbally that environmental unit. However, these techniques cannot be used with young children. Often times, a young child (e.g., a first grader) possesses neither the motor skills nor the verbal facility to convey adequately his knowledge of how a familiar unit of the environment is layed out spatially.

To overcome this difficulty, a triangulation task, similar to that used in navigation to locate a ship's position with respect to mapped landmarks, was developed. Our triangulation task requires subjects to align a sighting tube (which is mounted on a compass marked in one degree units) in the direction of four locations within a familiar room. When transfered to a scale map of the room, the intersection of the direction lines obtained from three separate locations within the room are used to define the location of the fourth, while the combination of all four plotted locations is used to generate a sketch of the subject's cognitive map.

A series of slides illustrates what I have been talking about.

Slide One

The first slide is simply a schematic of the elementary school library in which we carried out our research.

Slide Two

The second slide is a further simplified drawing of the room shown in slide one. Notice that we selected four salient objects and then located in front of each a sighting tube stationpoint. From each stationpoint the subjects aligned the sighting tube in the direction of three target objects.

Slide Three

The third slide illustrates the nature of the maps produced by the triangulation technique. Notice that four intersection triangles are formed from the twelve lines of direction read from the sighting tube's compass. Each triangle corresponds to the subject's localization of a given target object.

Slide Four

The fourth slide in this series shows how a map can be analyzed. As slide four shows, the absolute accuracy of individual sighting tube responses can be measured by the error per angle setting. The consistency with which an object is localized in a given position in space can be measured by the area of its corresponding intersection triangle. Finally, the accuracy with which an object is localized from three different stationpoints can be measured by the deviation between the plotted midpoints of the target object and the corresponding intersection triangle.

The triangulation procedure was used in the present study to compare the cognitive maps of first graders, fifth graders and college students, and to investigate developmental changes in the ability to manipulate cognitive maps mentally.

Our first experiment was very simple. It was designed primarily to assess the accuracy of subjects' cognitive maps while demonstrating the developmental utility of the triangulation procedure.

In this experiment our subjects were asked to move from stationpoint to stationpoint and, at each stationpoint, to align the sighting tube in the direction of three target objects. Half the subjects in each age group performed this task while in direct visual contact with the room, i.e., they could see the objects they were asked to locate. The rest of the subjects performed the same task while enclosed by an opaque screen at each stationpoint.

The maps generated in this experiment were analyzed for locational accuracy and consistency, as well as, error per angle setting. In each case the pattern of results was the same. All of our subjects possessed relatively accurate, coherent cognitive maps and were able to maintain their spatial orientation within the room even when their view of the room was obstructed.

Of course, the subjects who could see the objects were more accurate than the subjects who could not see the objects. In addition, there clearly was an effect for age. However, this effect was not independent of the significant effect of viewing conditions. The three age groups differed only in the obstructed viewing condition. In the obstructed viewing condition the first graders were significantly less accurate than either the fifth graders or the college students in locating the target objects.

The results of this experiment indicate that cognitive maps, though not picture-perfect representations of spatial layout, can exist at a relatively high level of accuracy. Second, the spatial memory which underlies cognitive maps does not reach its adult-like status until sometime between first and fifth grades. Finally, the fact that there were no age differences within the unobstructed viewing condition suggests that the triangulation task was equivalent across the ages tested.

In our second experiment we were interested in the processes involved in the mental manipulation of a cognitive map. The assumption was that if a subject could manipulate his cognitive map of the library mentally, he would be able to imagine his movements within the room instead of actually carrying them out at a physical level. In terms of the technique introduced earlier, the subject would be able to make all 12 of his sighting tube responses from any one of our four stationpoints by imagining successive transformations of the relationship between self and spatial layout. Moreover, the 12 responses produced in this manner should be of sufficient accuracy to allow the construction of a coordinated physical map of the library.

Each subject performed two tasks which tested mental manipulation: perspective taking and mental rotation. In the perspective taking task the subject was told first to imagine that he had walked to a new stationpoint. He then was told to make three sighting tube responses based on that imagined location. This procedure was continued until the subject had imagined occupying three different locations within the room. In the mental rotation task the subject was told to imagine that the entire room had rotated about his location within the room. As in the perspective taking task, the subject than was told to make his sighting tube responses in terms of the mentally-transformed spatial array. Again, half the subjects in each age group were assigned to an obstructed viewing condition and the rest to an unobstructed viewing condition.

The results of this experiment were complex. Therefore, I will present only the highlights.

First, of all, the accuracy and completeness with which the subjects were able to transform their relationship to the room's spatial layout increased dramatically with age. An inspection of the physical maps generated in this experiment revealed that only the college students were able to approximate "in their heads" that which they had accomplished in our first experiment. In other words, only the college students produced coherent, coordinated physical maps of the type shown in slide three. The maps of the younger subjects were fragmented. They did not show the four intersection triangles that would be expected if they could transform mentally the relationship between self and spatial layout. The children, however, did perform better under the rotation instructions than under the perspective instructions. Indeed, under the rotation instructions the performance of the fifth graders approximated that of the college students.

Because the maps of the children were so fragmented, careful attention was given to the types of errors made. Several systematic error patterns were identified which reflected developmental changes in mental manipulation statêgies.

One type of error, predominately observed in the first graders, was the classic egocentric response. The next slide illustrates egocentric responding in this experiment.

\- - - - - -

Slide Five

In slide five, the subject is standing at stationpoint A and is told to imagine that he is standing at stationpoint C. The dotted lines show how the subject should have responded given an imagined location at stationpoint C. The solid lines show how the subject actually responded. It is obvious that the subject failed to transform his relationship to the room's spatial layout. Instead, he responded solely in terms of his physically occupied stationpoint. [We should note that egocentric responses were much less prevalent in the mental rotation task than in the perspective taking task. Moreover, when the mental rotation instructions were given to subjects in the obstructed viewing condition, egocentric responding was wiped out as a source of errors.]

A second type of error, predominately observed in the fifth graders, is illustrated in the next slide.

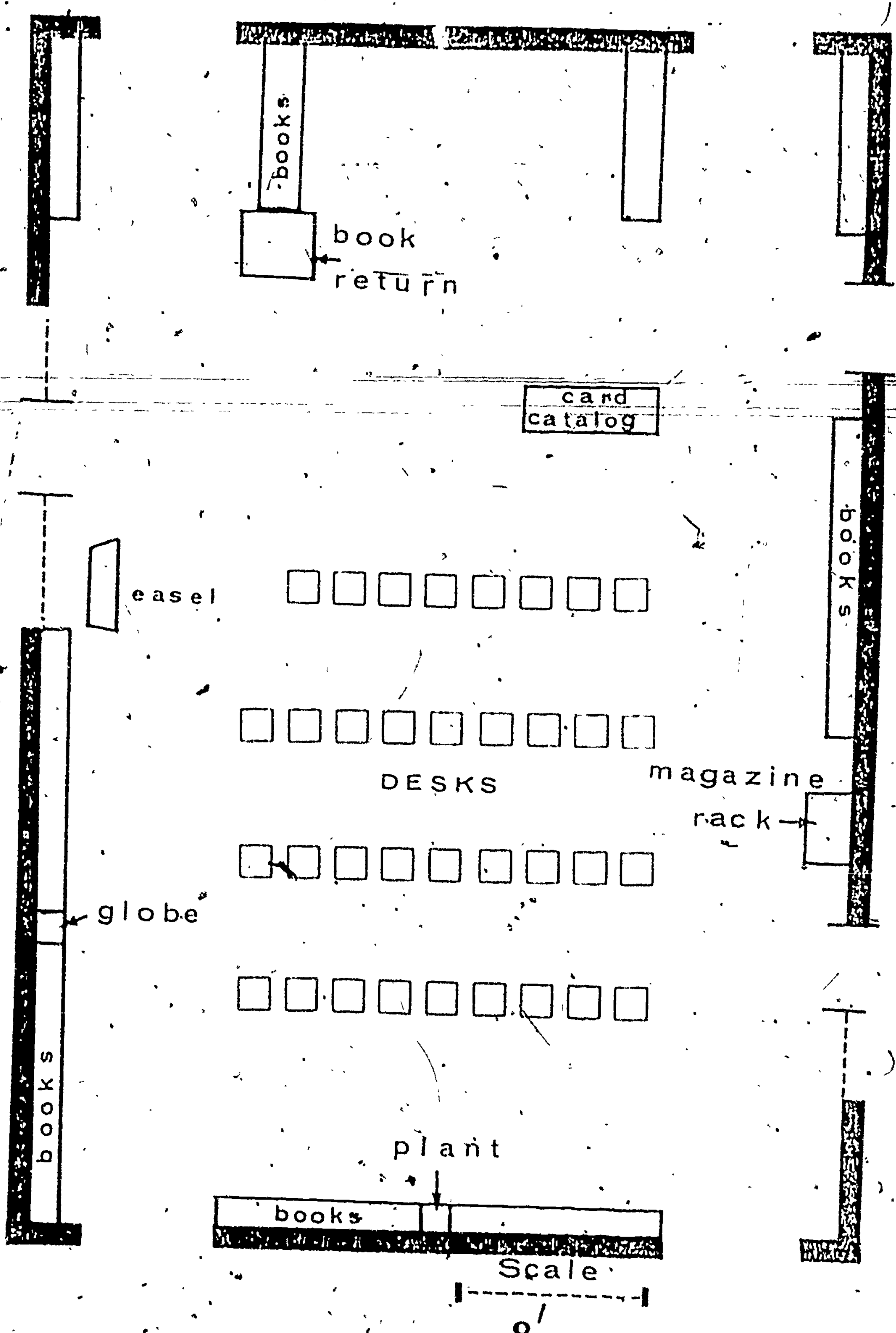
- - - - - -

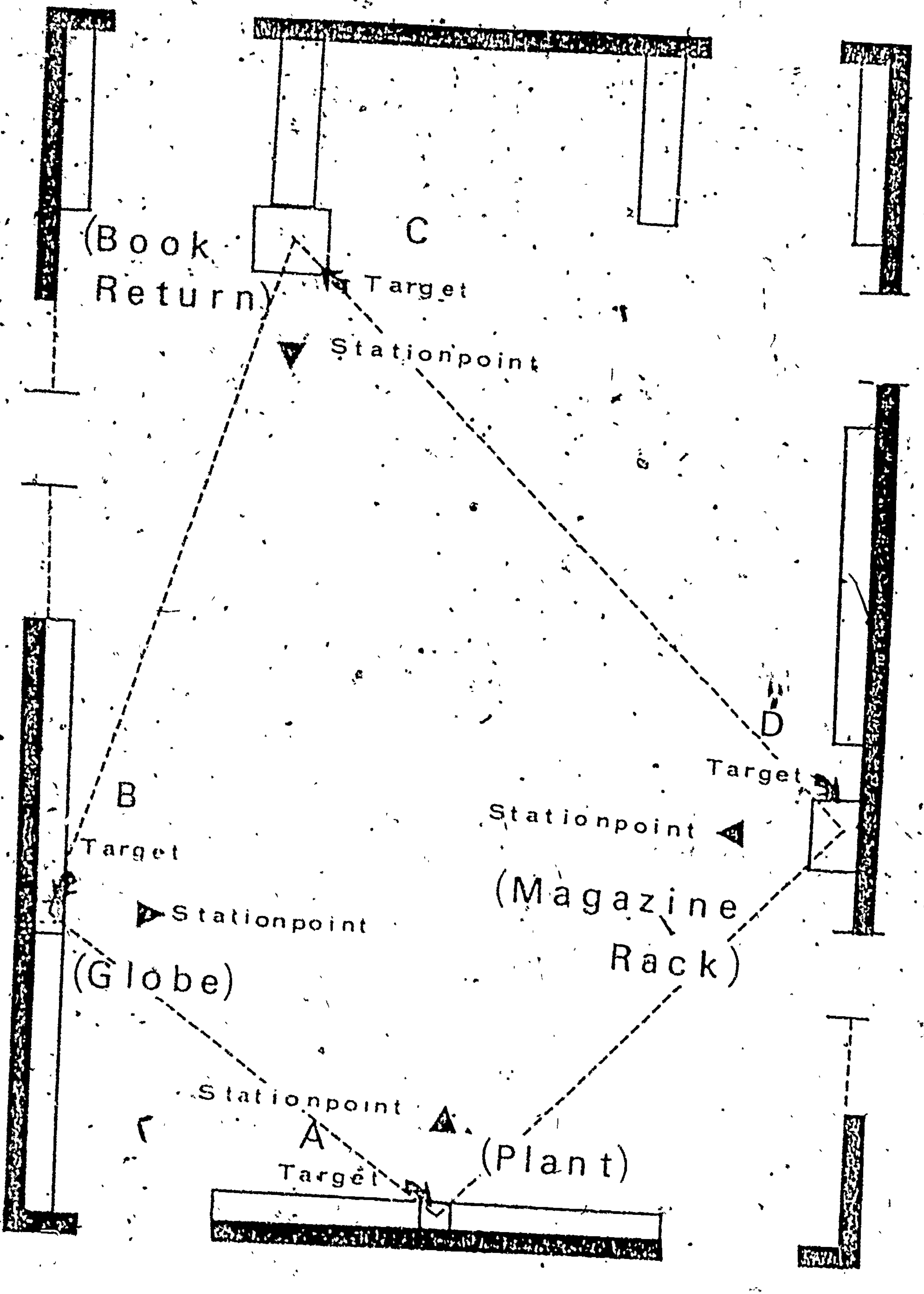
Slide Six

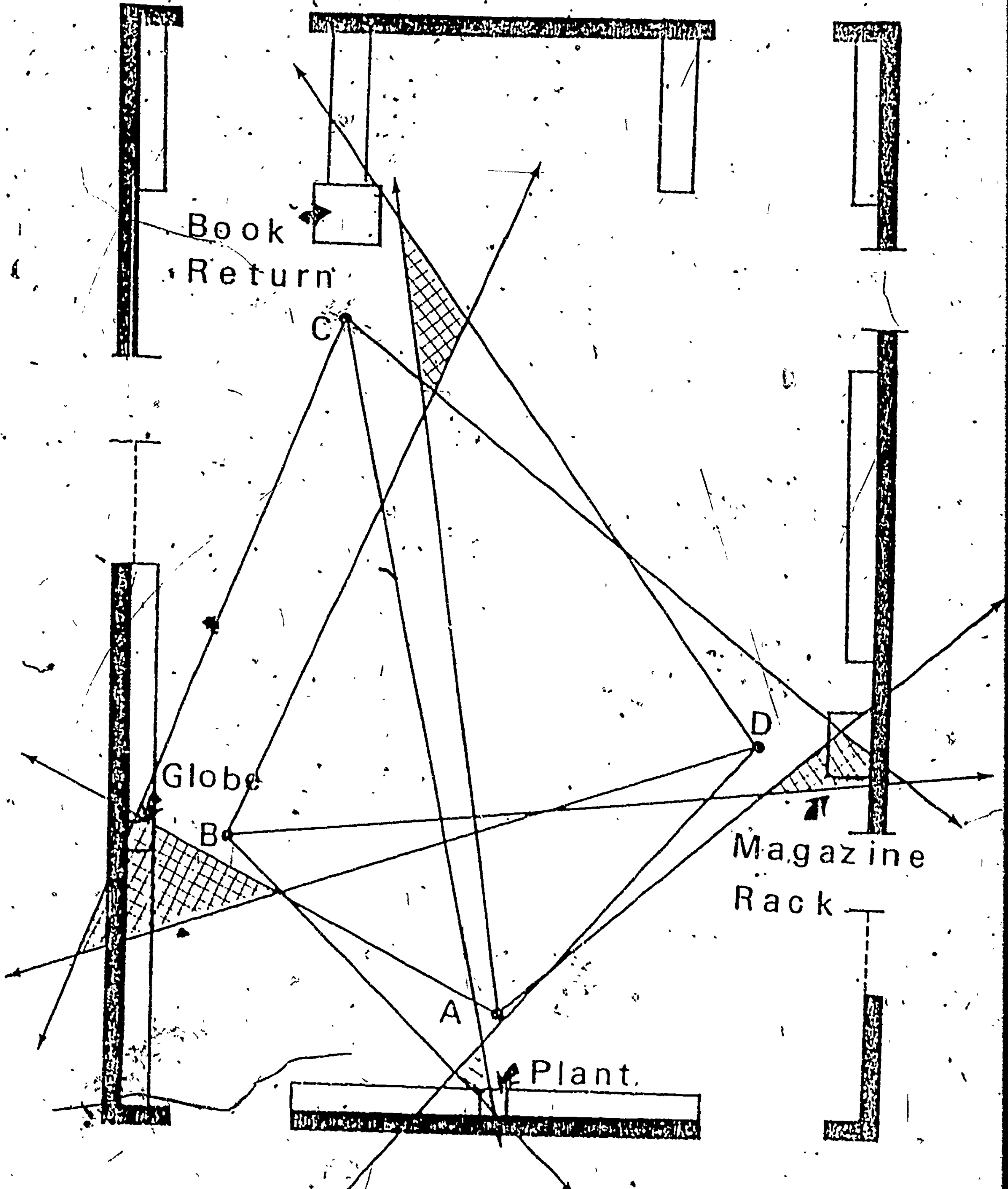
- - - - - -

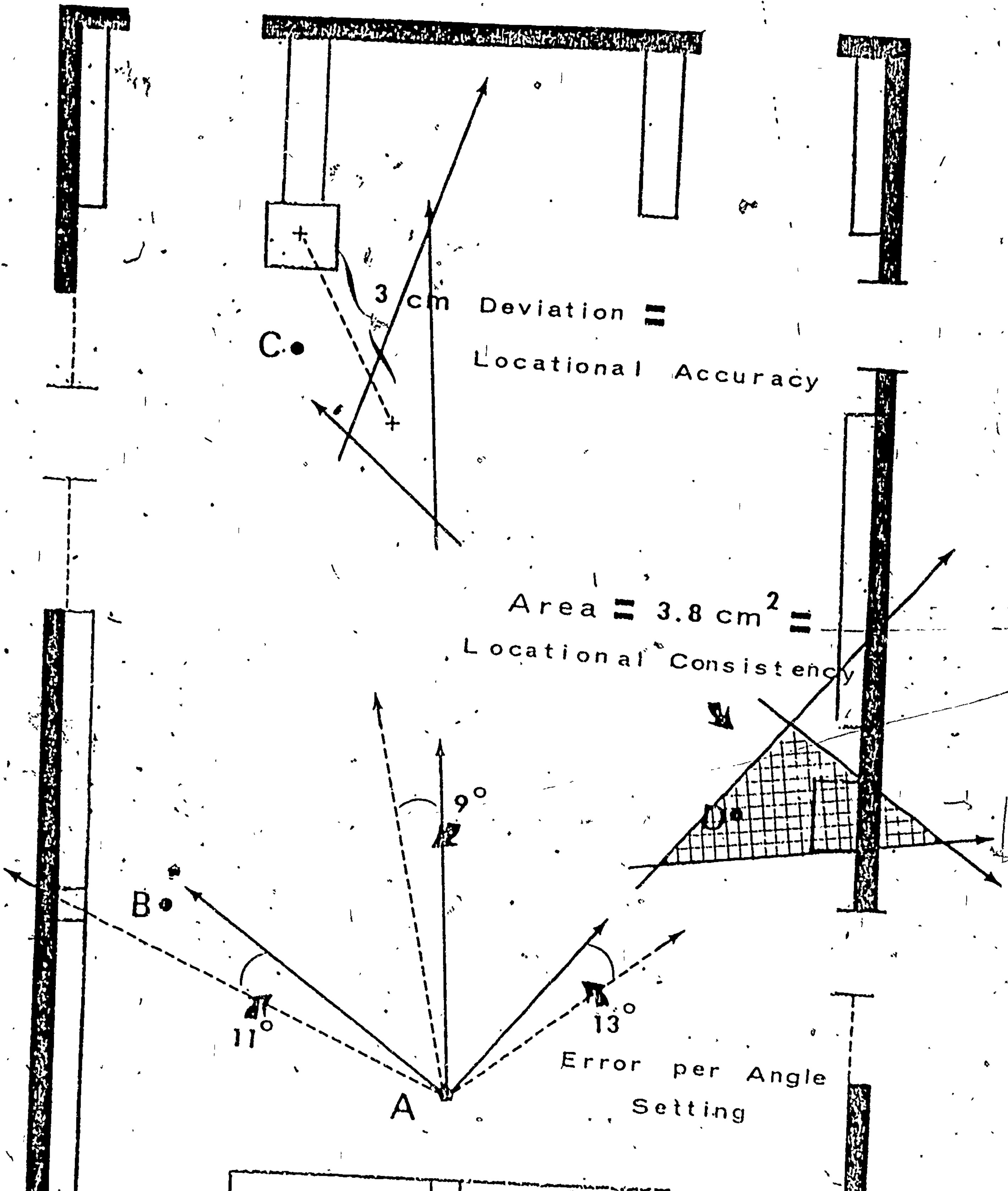
Again, the dotted lines show how the subject should have responded, while the solid lines show how the subject actually responded. In this case the subject's responses reflect a strategy of location substitution. The subject obviously transforms accurately the ordinal relationships which hold among the objects in the room. However, he fails to complete mental manipulation by taking into account the asymetrical layout of the target objects.

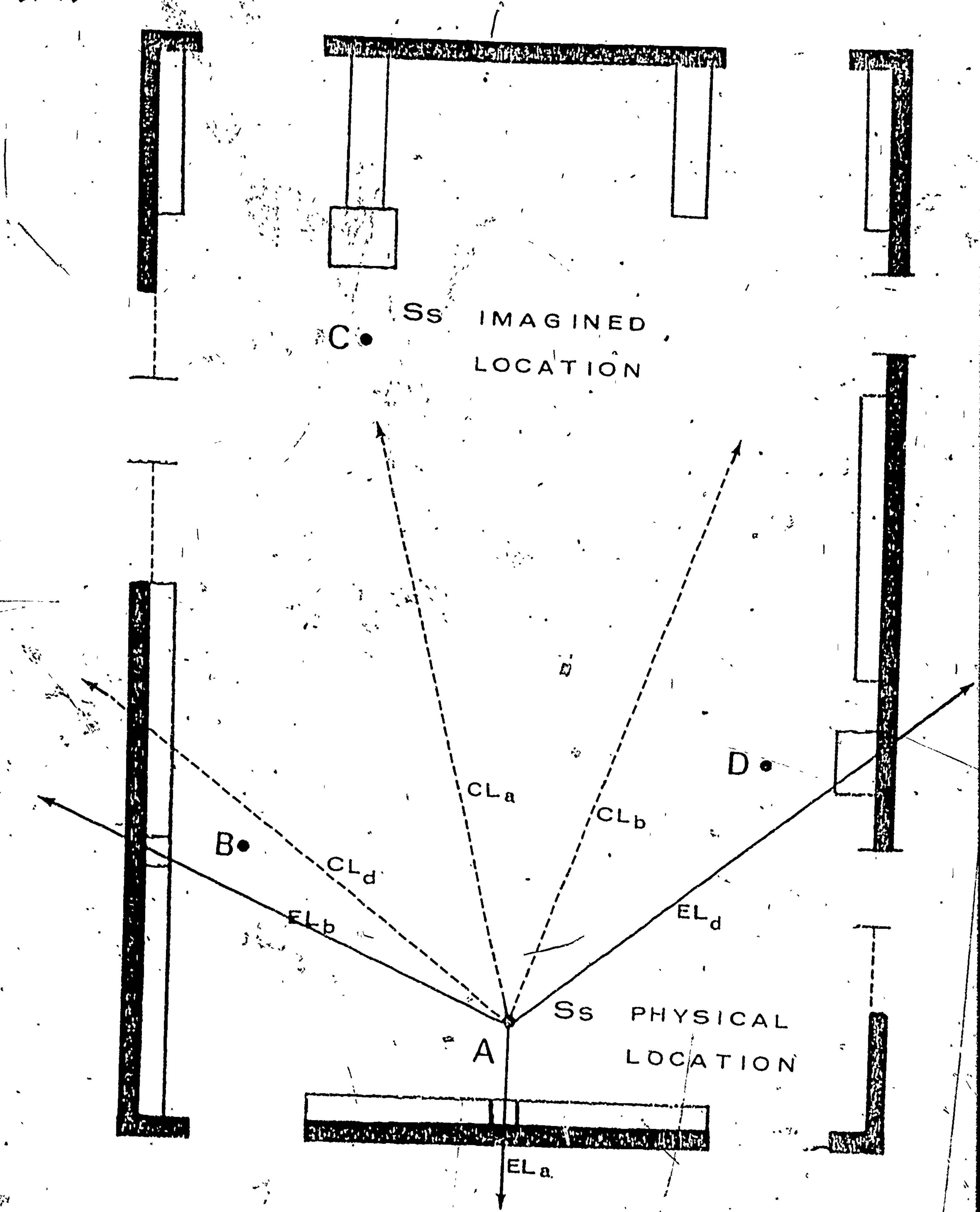
The above error types, and others, led to the conclusion that complete mental manipulation is a two stage process. In the first stage a strategy of manipulation, or transformation rule, is applied to the general spatial relationships contained in the cognitive map. In the second stage more specific relationships between self and spatial layout are reconstructed. The difficulty experienced by first graders in a mental manipulation tasks appears to be in the first stage of the process, i.e., they are unable to apply an appropriate transformation to the general relationships contained in their cognitive maps. Fifth graders are generally successful in applying an appropriate transformation but often fail to reconstruct the more specific relationships necessary for complete manipulation. In contrast, college students are able to complete both stages of the process.

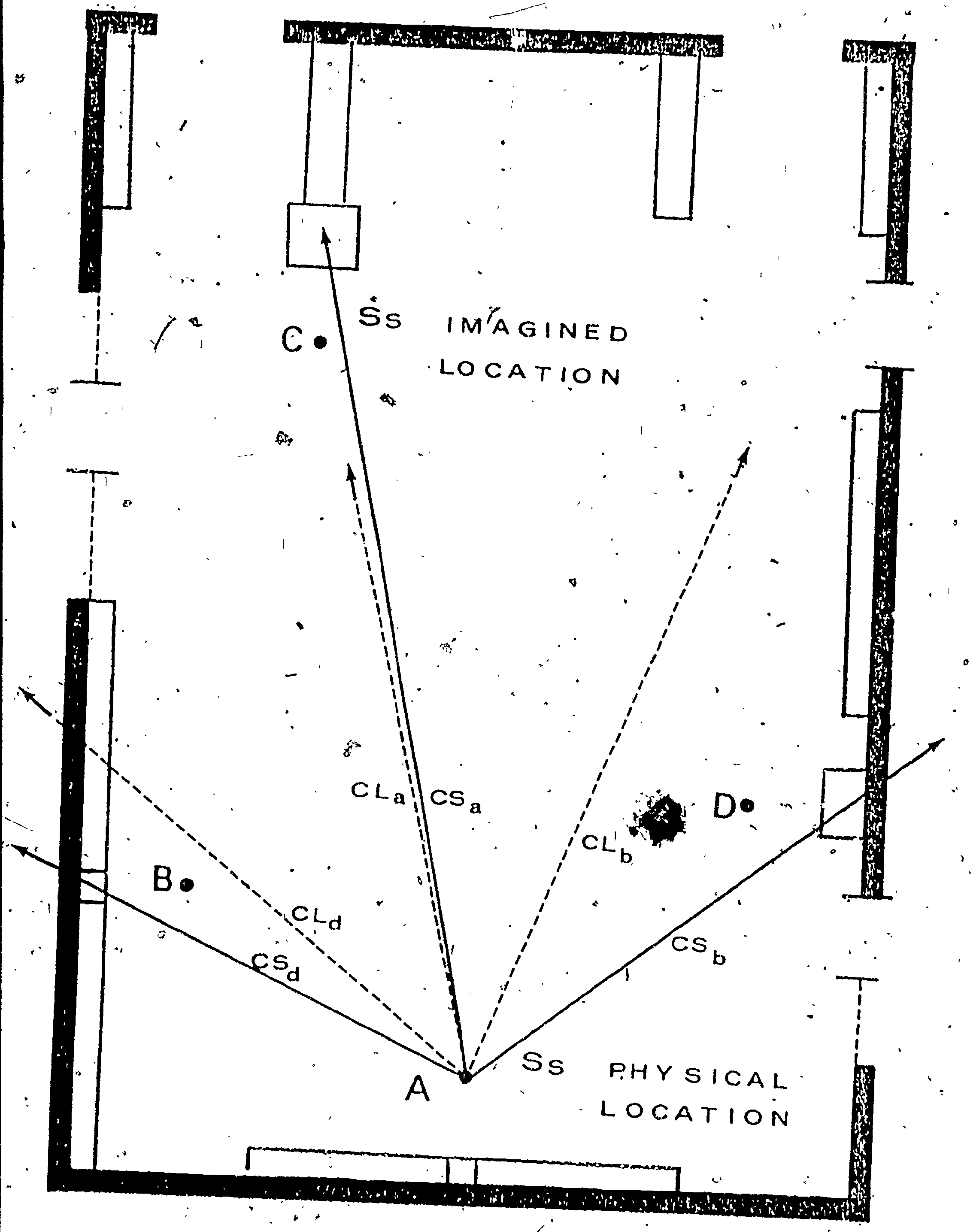

books
book return
card catalog
easel
books
DESKS
magazine rack
globe
books
plant
books
Scale
8'


C
(Book Return)
Target
Stationpoint
D
Target
Stationpoint
(Magazine Rack)
B
Target
Stationpoint
(Globe)
Stationpoint
A
Target
(Plant)


Book
Return
C
D
Globe
B
Magazine
Rack
A
Plant.


3 cm Deviation = Locational Accuracy
C
Area = 3.8 cm² = Locational Consistency
D
9°
B
11°
13°
A
Error per Angle Setting


Ss IMAGINED LOCATION
C
CLa
CLb
CLd
D
B
ELb
ELd
Ss PHYSICAL LOCATION
A
ELa


Ss IMAGINED LOCATION
C
CLa
CSa
D
CLb
B
CLd
CSd
CSb
A
Ss PHYSICAL LOCATION