COGNITIVE MAPPING IN A COMPLEX BUILDING

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ABSTRACT: The Health Sciences Centre is a five-story hospital in which each floor is designed with a unique configuration. There are no main corridors in the hospital, nor any corridors that run the complete length of the hospital. Rooms are not rectangular and fail to follow any set pattern. Consequently it is easy to become disoriented in this building. The series of studies reported in this article examined the cognitive mapping systems of student nurses who had worked in the hospital for various periods of time. After inspecting several different measures, it was concluded that the student nurses had failed to form "survey"-type cognitive maps of the building even after traversing it for two years. A control experiment was tested, using naive subjects who were first asked to memorize floor plans of the building. These naive subjects performed significantly better on objective measures of cognitive mapping than did the nurses with two years' experience working at the hospital. It was concluded that mental representations of survey maps do not develop automatically in the complex spatial environment.

AUTHOR'S NOTE: *This research was supported by a grant from Social Sciences and Humanities Research Council of Canada. I wish to thank Jennie Haynes and Karen Morgan for helping to collect data for these experiments. I wish to give special thanks to Ms. L. D. Furlong, Supervisor of the General Hospital Nursing School and to the administration of the Health Sciences Complex for their cooperation in this study. Requests for reprints should be sent to Dr. Shannon D. Moeser, Department of Psychology, Memorial University of Newfoundland, St. John's, Newfoundland, Canada. A1B 3X9.*

ENVIRONMENT AND BEHAVIOR, Vol. 20 No. 1, January 1988 21-49

The term *cognitive map* is generally used to describe the mental representations that people form of their spatial environment. Although these representations are not isomorphic to the real world, they bear a close enough resemblance to the physical reality to enable the person to easily traverse his or her environment. Initial research in cognitive mapping abilities was begun by urban planners. As a result of studies by planners such as Appleyard (1970), de Jonge (1962), Gulick (1963), and Lynch (1960) we have a fairly comprehensive view of the way in which people represent the spatial layout of cities and towns. The results of these early studies suggested that most people first establish a mental representation of familiar path routes, then position landmarks, boundaries and districts in relation to these paths. Thus the urban planners stressed that path structures were the most critical features in the initial learning of the physical environment. Shemyakin (1962) studied the development of children's maps and likewise found that most of the early maps were drawn by following familiar routes, whereas maps drawn by initially positioning landmarks in the overall configuration appeared at a later development stage and remained rarer.

On the other hand, psychologists such as Evans et al. (1981), Hart and Moore (1973), Piaget, et al. (1960), and Siegel and White (1975) have argued that there are three stages in acquiring spatial knowledge of the environment. The first stage consists of structuring a cognitive representation of a few stable landmarks from the person's unique experiences. This is followed by a "route map" that connects these separate landmarks into a chain of paths and connected items. The final stage in cognitive map development is represented by a "survey map," which represents a configuration of routes and objects into a gestalt pattern and includes knowledge of distances that have never actually been traversed. The survey map is the closest mental representation to a cartographer's map, although even the cognitive survey map will contain systematic distortions.

In contrast to the vast number of studies concerned with macrospatial context such as cities and neighborhoods, there have been a relatively small number of studies concerned with the design and analysis of building interiors. Weisman (1981) found that the most serious disorientation problems occurred in buildings judged as being the most complex and difficult to describe. He found that floor-plan complexity was able to account for 56% of the variance in wayfinding difficulty, whereas experience with the buildings accounted for only 9% of the variance in disorientation reports.

Although maps and floor plans are designed to enhance geographic knowledge, few studies have been designed to assess their effectiveness. After Bronzaft et al. (1976) examined the implications of cognitive research for the design of subway maps, they found that the maps presently in use were often ineffective and confusing. Corlett et al. (1972) found that many disorientations occurred in an engineering building with the regular sign system, although most of these disorientations could be eliminated with a sign system designed to provide specific information at points where route choices had to be made. Similarly, Evans et al. (1980) found many errors in wayfinding behavior in a building in which the walls were painted in a monochromatic beige, but significantly fewer errors in the same building when various sections of the walls were painted in distinct colors.

There have also been a few studies designed to examine the various effects of building familiarity in conjunction with other variables. Garling et al. (1983) found that accuracy in locating building targets was positively correlated with familiarity and with free viewing access. Subjects with restricted visual access had difficulty in locating building targets, but the negative effect of restricted viewing was compensated for by presenting the restricted-viewing subjects with a floor plan before they were taken on tours of the building. Thorndyke and Hayes-Roth (1982) asked different groups of subjects to perform various tasks in building wayfinding. One of these tasks was an orientation test in which the subjects were taken to various locations in the building and asked to point out the direction of other unseen locations. Another task was a distance estimation test in which the subjects gave distance estimates between various sets of locations. Subjects with only one month's experience working in the building were better on the orientation task than the subjects who had memorized a map of the building. Furthermore, the longer the employees had worked in the building the better they were at making orientation judgments. Subjects who had memorized the map were better on the distance-estimate task than the one-month and six-month employees but poorer than the more experienced employees. Thus Thorndyke and Hayes-Roth noted that the more experienced the employee the more accurate he or she became at making judgments requiring a survey knowledge of the building.

The present study was initially designed to investigate the development of cognitive mapping abilities in a complex building. The building being used in this research is a five-story hospital, a setting wherein the ability to locate rooms quickly and accurately is of utmost importance. This building had been described by several people as one that was particularly difficult to traverse with ease. Consequently, it seemed that this building would provide an excellent example to study the developmental progress from simple landmark and route maps to more complex survey maps.

The first experiment was designed to investigate differences between cognitive maps formed by people who had worked in the building for only a few months and those who had worked there for two years or more. I hoped to discover how simple mapping representations became more detailed as experience progressed.

EXPERIMENT 1

METHOD

Setting: The Health Sciences Centre is a five-story hospital that appears to contain a more complex spatial layout than most public buildings. The first three floors each have a distinct external outline, and only the top two floors are identical in outline to each other, although they differ from the other three. The interior of the building consists of a maze of corridors and nonsymmetrical rooms. Within the building, visual access to other parts of the building are severely restricted by the fact that the corridors are constantly broken into short segments. Furthermore, there are often fire doors that divide the corridors into even shorter sections and further serve to restrict visual continuity. Once inside the building, visual access to the outside environment is very limited. Thus it is difficult to use exterior landmarks as orientation markers while in the building. Floor plans of the first two floors of the Health Sciences Centre are shown in Figures 1 and 2. Although the hospital contains five stories, only four are relevant to this study, as story three contains only maintenance equipment and is not part of the normal hospital setting.

Subjects: The first experiment was participated in by 10 first-year female student nurses and 10 third-year female student nurses. These students were enrolled in the General Hospital School of Nursing. Although their hospital training took place at the Health Sciences Centre, their academic classes and residence hall were located at the General Hospital, which was about three miles from the Health Sciences Centre. The first-year students used in this

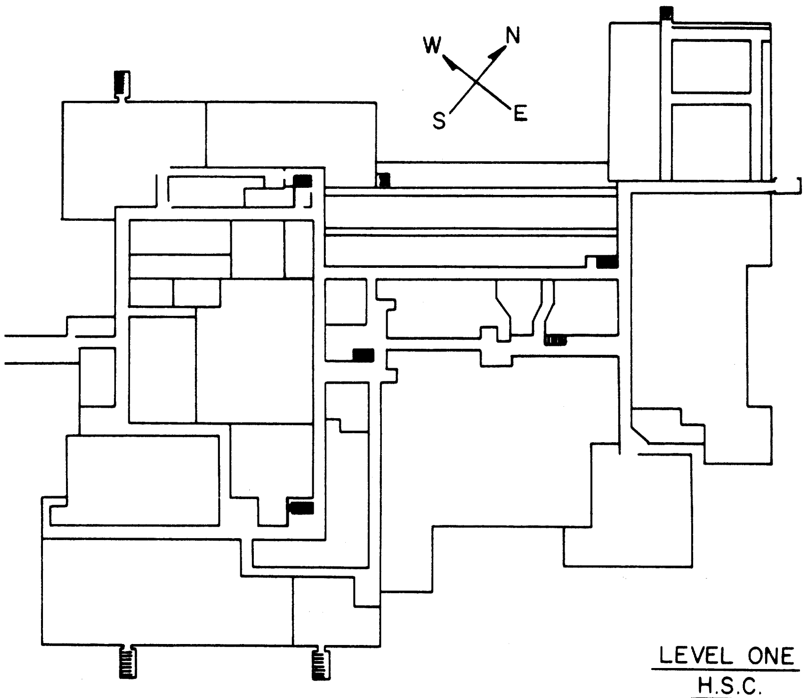

Figure 1: A Floor Plan Map of the First Floor of the Health Sciences Centre

experiment had approximately four months' work experience in the hospital; the third-year students had approximately 25 months' work experience in the hospital. The students were volunteers, and they were recruited from and tested in their residence at Southcott Hall in the General Hospital.

Materials: The materials consisted of four plain sheets of 8-inch-by-11-inch paper. Each sheet of paper was marked with a floor number (1, 2, 4, or 5), but no other information was written on the sheets. Pencils were also supplied.

In addition, a set of 8-inch-by-11-inch maps of the first, second, fourth, and fifth floors of the hospital was obtained from the hospital administration. These were used for

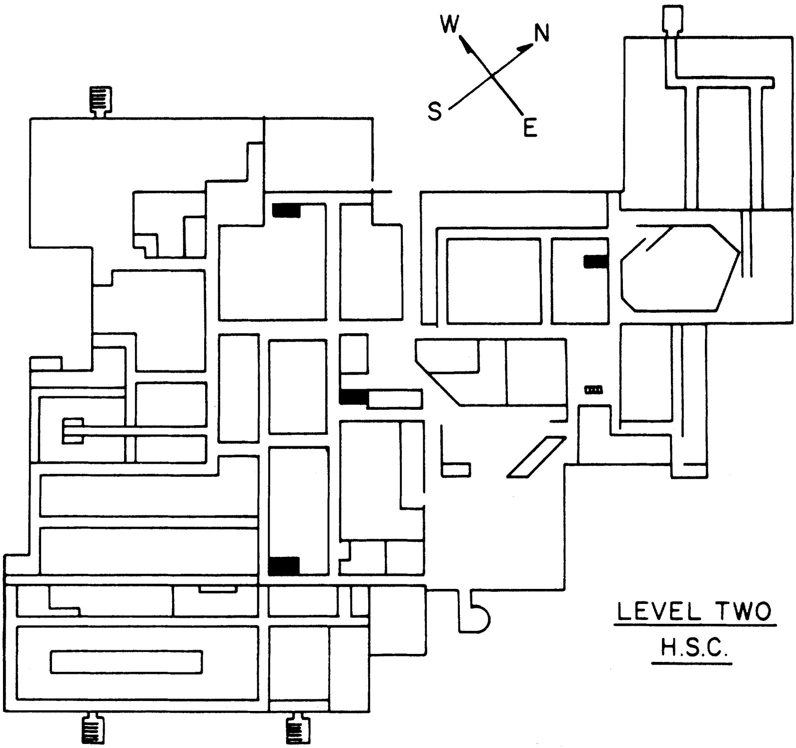

Figure 2: A Floor Plan Map of the Second Floor of the Health Sciences Centre

marking purposes. These maps contained an outline of each floor, plus outlines of all main rooms and corridors in the building. Each of the main rooms was labelled with its correct name. There were 22 room names on the first floor, 26 room names on the second floor, 6 room names on the fourth floor, and 8 room names on the fifth floor. In addition, entrances into the building were labelled and elevators were marked with Xs at the appropriate points. (There were three entrances on the first floor, four entrances on the second floor, and four elevators on each floor.) Thus there were a total of 85 items that could be placed on the four maps. The floor plans that were supplied by the hospital administration were copies of maps that appear regularly throughout the hospital. The plans that are illustrated throughout the hospital are all oriented with the NW wall appearing at the top of each map. The main hospital entrance is on the NW side of the building, but it is not the entrance typically used by the staff.

Procedure: Each student nurse was tested individually. They were told that this study was designed to investigate how easy it is to learn the spatial layout of the Health Sciences Centre, and that accordingly they would be asked to draw a map of each floor in the building to the best of their abilities. The students were each then given four blank sheets of paper and a pencil and asked to draw their maps. They were encouraged to include as many details as possible, including elevators and entrances. No time limit was placed on the task.

RESULTS

Map scoring: The students' maps were scored by comparing their drawings with the floor plans supplied by the hospital administration. None of the 20 maps produced by the students bore any resemblance to the administration floor plans (see Figure 3 for some typical examples produced by third-year students). Six first-year students and five third-year students drew what would be termed landmark maps, placing rooms in relationship to each other, without indicating corridors connecting these rooms. The other students drew what would be termed route maps, drawing a few corridors and indicating the rooms that were located along these routes. None of the subjects drew anything that could be labeled a survey map with a complex set of corridors. Only six of the maps were drawn with the NW direction at the top. Furthermore, as can be seen from Figure 3, all of the students drew maps that were very dissimilar from those drawn by the other students. There was no evidence of a single point of view among the students.

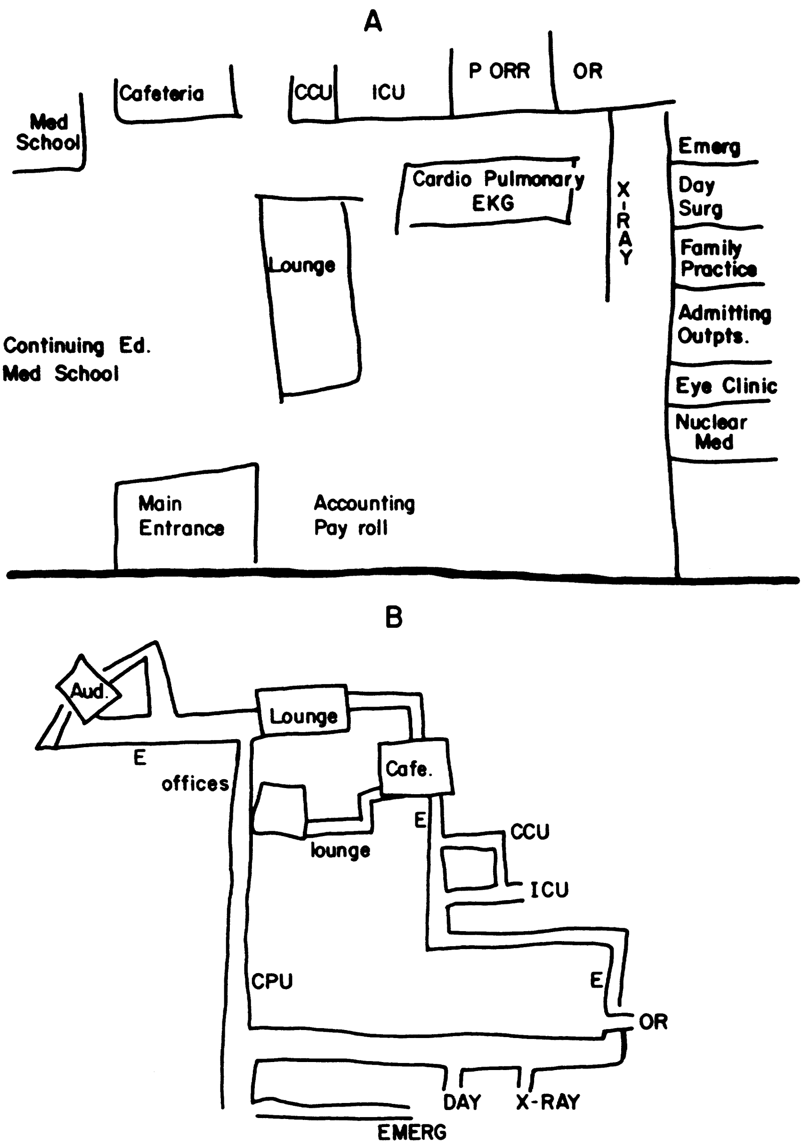

Figure 3: Figures of the Second Floor of the Health Sciences Centre Drawn by Two Third-Year Students in Experiment 1.

Because of the discrepancy between the administration maps and the students' drawings, the drawings were scored simply by counting the number of labels supplied in each drawing. One correct point was given for each label that was not placed inappropriately in relation to the other labels. Placing a label inappropriately in relation to the other labels but still in the correct general area was considered a minor error. Placing a label in the wrong area of the hospital or on the wrong floor was considered a major error.

The maps were scored independently by two assistants, and when the scoring was completed their marks correlated at the .91 level. On points of discrepancy between the two assistant's marking systems, this author made the final decision.

The mean number of correct mapping placements and mean number of errors made by the two groups of students is shown in Table 1. Analyses of variance found significant differences in correct mapping placements between the first- and third-year students, $F(1, 18) = 6.74$, $p < .05$, and among the number of correct placements on each floor, $F(3, 54) = 19.94$, $p < .01$. Newman-Keuls tests were used to compare the students on each of the four different floors. These Neuman-Keuls tests showed that the two groups were significantly different on the second, fourth, and fifth floors ($p < .05$ in all cases). The groups were not significantly different on the first floor. These results are not surprising, as most of the students' training takes place on the second, fourth, and fifth floors. What is surprising is that during the two-year period when the nurses frequently ran errands to the first floor, they did not appear to acquire much more knowledge about this part of the building than student nurses who had just begun their training program.

An analysis of variance was also done on the errors made by the two groups of nurses. This analysis found a significant difference between the first- and third-year students, $F(1, 18) = 9.49$, $p < .01$. Neuman-Keuls tests comparing the

TABLE 1
Mean Number of Correct Mapping Placements and Mean Number of Errors Made by the First- and Third-Year Nursing Students Tested in Experiment 1

Map Placements	Nursing Students	
	First year	Third year
Mean correct placements		
First floor	6.5	8.5
Second floor	6.2	11.0
Fourth floor	2.7	5.0
Fifth floor	0.2	3.6
Mean errors		
Minor errors	1.0	4.3
Major errors	1.1	1.6

students on the different types of errors showed that the two groups were significantly different only on the minor errors, $p < .05$.

Thus overall the third-year nurses were significantly better than the first-year nurses in correctly locating rooms in the hospital, although individual comparisons showed that this difference was only significant on floors two, four, and five. The third-year nurses also made a significantly higher number of minor errors than the first-year nurses.

DISCUSSION

As might be expected, the third-year nursing students placed significantly more names on their floor-plan maps than the first-year nursing students. This difference in performance should suggest that the third-year students had formed more complex cognitive maps. However, the maps drawn by the third-year students bore no resemblance to survey maps. Half of these students drew landmark maps, while the other half drew route maps. Furthermore, of the total number of places (rooms, elevators, and entrances) that could be drawn on these maps, the third-year students only correctly placed 29% of the first-floor items, 33% of the second-floor items, 50% of the fourth-floor items, and 30% of the fifth-floor items. In addition, all 10 of these third-year students made minor errors (places drawn in the correct general area but out of relationship with the other places drawn on the maps), and 7 of the 10 students made major errors (places drawn in the wrong area or on the wrong floor). Thus even those nursing students who had spent 25 months working in the hospital appeared to have a poor cognitive mapping system of this building.

As mentioned earlier, floor plans are strategically placed around the hospital to aid building orientation. At the end of the map-drawing session, the student nurses were asked if they ever made use of these floor plans. All students stated that they never used the floor plans because they provided no assistance in helping them to orient themselves within the building. Several nurses volunteered that the floor plans only served to confuse them. The main assumption behind floor plans is that they convey information about the layout of a building that cannot be mentally represented until the building is repeatedly traversed. In the words of Garling et al. (1983): "If floor plans are satisfactory in their primary function, they should facilitate improvement of orientation in a building. They should furthermore do so when it is more needed, that is, when the visual access to the building layout is poor."

EXPERIMENT 2

The maps drawn by the third-year nursing students suggest that these nurses have a poor general knowledge of the spatial layout of the Health Sciences Centre. However, questions have been raised as to the validity of using sketch maps as an accurate representation of cognitive maps. Golledge (1976) and Blaut and Stea (1974) have argued that sketch maps data underrepresent a person's knowledge because of limitations in drawing ability. Goodnow (1977) has suggested that initially drawn elements may have substantial effects on the relative size and/or position of subsequent elements. Furthermore, there are several examples in the cognitive-mapping literature of apparent discrepancies between the outcomes of different types of tests. Lynch (1960), for example, noted that Boston natives often failed to include the John Hancock building on their sketch maps of downtown Boston, even though they could easily locate it when directly asked to do so. Thus a clearer assessment of the nursing students' general knowledge of the building might be gained by providing the students with floor plan maps and asking the students to label these maps.

Experiment 2 was designed to test the knowledge of the student nurses using the labelling procedure. The subjects in this study were given copies of printed floor plans and an alphabetical list of all items that were to be placed on these floor plans. Because of the time at which this experiment was performed, the subjects used in this experiment had slightly different periods of working in the building than those used in Experiment 1. The first-year nursing students had not yet begun their practical training, so second-year students were used in their place. The third-year nursing students used in this experiment had about three months' less working experience than the third-year students used in Experiment 1.

METHOD

Subjects: Participating in the experiment were 22 second-year female student nurses and 22 third-year female student nurses attending the General Hospital School of

Nursing participated. The second-year students had approximately 7 months' work experience in the hospital, whereas the third-year students had approximately 21 months' work experience in the hospital. These students were tested at the beginning of one of their regularly scheduled classes. They were required to participate in the assignment, although they were told by their nursing instructor that their performance on this task would have no influence whatsoever on their academic standing.

Materials: The materials consisted of 8-inch-by-11-inch maps of the first, second, fourth, and fifth floors of the hospital. The respective floor numbers were labelled on each map, and in the left hand corner of each map was a directional compass showing north, east, south, and west. The maps were replications of plans presently in use by the hospital, and in addition to the outline of each floor they showed outlines of all main rooms and all hallways in the hospital.

Accompanying the maps was an alphabetical list of rooms in the hospital that had been compiled from information supplied by the hospital administration. This information was identical to that described for Experiment 1. Thus there were a total of 85 items that could be placed on the four maps.

Procedure: The second-year students were tested together in one classroom and the third-year students were tested together in another classroom. The students were given the maps and the alphabetical list, and were asked to mark the numbers corresponding to the rooms on the list in the correct places on the maps. They were asked to do as well as they could, but not to guess. The students were required to work on the task individually and not allowed to confer with other students. No time limit was set on the task. When a student completed the task, she handed her papers to the examiner and left the classroom.

RESULTS

The total number of correct placements was calculated for each subject by each floor. Also calculated for each subject was the total number of errors. Errors were defined as labels placed on rooms that were at least 30 feet away from their correct location.

Table 2 shows the mean number of correct placements and mean number of errors for each level of the Health Sciences Centre for the two groups of subjects. A two-way analysis of variance was performed on the correct placements, comparing the two groups of nurses by the four floors. This analysis found no significant differences between the student groups, between the different floors, nor any significant interactions. A comparison between the groups on number of errors also yielded nonsignificant results.

DISCUSSION

Although the third-year nursing students had 14 months' additional experience working in the Health Sciences Centre, they were no better on the labeling task than the second-year student nurses. This suggests that the experiences occurring during this 14-month period had little or no effect on the cognitive mapping systems being developed by these students. Overall performance on the task was poor in both groups, with an average of only 9% correct on the first floor, 13% correct on the second floor, 33% correct on the fourth floor, and 24% correct on the fifth floor. Thus these student nurses performed no better on the map-labelling task than did the third-year students on the drawing task given in Experiment 1.

TABLE 2
Mean Number of Correct Mapping Placements and Mean Number of Errors Made by the Second- and Third-Year Nursing Students Tested in Experiment 2

Map Placements	Nursing Students	
	Second year	Third year
Mean correct placements		
First floor	2.59	2.59
Second floor	4.45	3.86
Fourth floor	2.32	3.55
Fifth floor	1.86	3.36
Mean number errors	4.45	3.14

EXPERIMENT 3

Although map placement scores in Experiment 2 were very low, several subjects marked on their papers that they could not understand the floor-plan maps, but they did know where the rooms were in the hospital. As was mentioned in the discussion of Experiment 1, many nursing students stated that they could not understand the maps posted on the walls of the building. Thus it may be that these students had a cognitive mapping system that did not correspond to the types of floor plans used by the administration. On the other hand, these students may have thought they had a good knowledge of the hospital when all they were doing was following a few well-traversed routes and the sign system that directed them to particular points.

Therefore, Experiment 2 was designed to see if the experienced nursing students actually had a good relational knowledge of areas in the building, albeit one that might not map directly onto the floor plans used by the administration. To investigate the students' relational knowledge, two standard cognitive-mapping tests were used. The first was a direction-pointing task. The student was taken to one place in the building and asked to point out (on a compass) the direction of another place in the building. The second test was a distance-estimation task. The student was asked to mentally traverse the route from a given point to another point and estimate the distance it would take to traverse that route.

Experiment 3 was also designed to see whether familiarizing naive subjects with floor plans of the building would help them develop a better building orientation. Accordingly, 20 subjects naive to the building were asked to memorize a set of the administration floor plans and then taken on a short tour of the building. Two days after their tour they were given the same tests as the experienced nursing students.

This latter comparison is somewhat similar to the study by Thorndyke and Hayes-Roth (1982). In their study one group of subjects consisted of naive individuals who were asked to memorize a floor plan of a building complex, one group consisted of employees who had worked in the building for a month, one group consisted of employees who had worked in the building for 6 months, and one group consisted of employees who had worked in the building between 12 and 24 months. All subjects were given a direction-orientation task and a distance-estimation task. Thorndyke and Hayes-Roth found that subjects with only one month's experience were better on the orientation task than subjects who had memorized the map. Subjects who had memorized the map were better on the distance estimation task than the one-month and six-month employees but poorer than the more experienced employees.

METHOD

Subjects: The nursing students who served as the control subjects were volunteers from the third-year class at the General Hospital School of Nursing. There were 20 control subjects, and none of the nurses who participated in this experiment had participated in either of the two earlier experiments. All of the nursing students were females who had between 22 and 26 months' experience working in the Health Sciences Centre. Their training program had been designed so that each had spent several months working in several different parts of the hospital. When volunteers were requested, they were told that they would be tested on their ability to find their way around the hospital. They were also told that their scores on these tests would not affect their standing in the nursing program and that no feedback on individual performances would be given to their nursing supervisors. The student volunteers were paid for participating in the experiment.

The experimental subjects were 20 female students recruited from a second-year psychology course at Memorial University of Newfoundland. They were paid for participating in the experiment. None of the student subjects had ever worked at the Health Sciences Centre or had ever had any extensive contact with the building.

Experimental training procedure: The experimental subjects were taken individually to an office in the university and asked to memorize the maps of the four floors of the Health Sciences Centre. These maps were identical to those used in Experiment 2 except that each of the main rooms was labelled with its appropriate name. After studying these maps for half an hour, the subjects were tested on the knowledge they had acquired during this study period. The test consisted of four maps identical to those used during the study period except that the rooms were not labelled. As per Experiment 2, a list of room names in alphabetical order was given to the subject, who was asked to place these names in their appropriate places on the maps. The subjects were also asked to indicate all entrances with an arrow, and to indicate all elevators by marking an X at the appropriate point. After completing the labelling task, the subject waited until the test was marked. If a perfect score was not obtained, the subject was asked to study the labelled maps for another half hour, then take the labelling test again. This learning and testing procedure was repeated until the subject received a perfect score on the labeling test. This training procedure took between one and three hours to complete, with most subjects requiring approximately two hours to achieve a perfect score.

Two days after the memorization task was completed, the subject was given an individually guided tour of the Health Sciences Centre. Each of the four floors was toured while the guide pointed out the rooms and areas that had been memorized on the floor plans. The student had a labeled map to follow while the tour was taking place and was asked to correlate the map with the physical tour. After all four floors had been toured, the map was taken from the student, who was asked to lead the guide to various points in the building. The tour and location test took approximately two hours to complete.

Testing procedure: The nursing students and the experimental subjects were tested individually using an identical procedure. The experimental subjects were tested two days following their tour of the building; the nursing students were tested at a time convenient to them. From each group ten subjects were led to an area near the center of the first floor of the building, and ten subjects in each group were led to an area near the center of the second floor of the building. Both areas were located such that they restricted the subjects' views of other parts of the building. Subjects tested on the first floor of the building were given tests pertaining to first floor locations; subjects tested on the second floor of the building were given tests pertaining to second-floor locations. Subjects from both the experimental and control groups were tested in intervening order.

The first test given a subject was a direction-pointing test. A large cardboard compass was placed on the floor with the main entrance of the building at zero degrees. Subjects were told that zero represented the direction of the main entrance. Then they were given a list of six locations and asked to indicate on the compass the direction of each of these locations. On the first floor, the locations were (1) the entrance to the radiotherapy clinic, (2) the entrance to the psychiatric clinic, (3) the entrance to the pharmacy, (4) the entrance to the animal cure labs, (5) the entrance to the experimental surgery labs, and (6) the entrance to the Memorial University School of Nursing. On the second floor, the locations were (1) the X-Ray information desk, (2) the outpatients' information desk, (3) the nuclear medicine information desk, (4) the entrance to the operating rooms, (5) the entrance to the auditorium, and (6) the entrance to the C.C.U. If the subjects were unable to place a location, they were asked to guess by pointing in some direction.

The second test given to a subject was a distance-estimation test. The subject was asked to verbally trace the route from the position at which she was now located to each of the six locations listed above. After she had described a given route as accurately as possible, the subject was asked to estimate the distance in feet that it would take to reach that location. Again the subjects were asked to guess if they were not able to place that location.

The subjects were allowed as much time as they wished to answer the test questions. After the distance test was completed, the experimental subjects were dismissed from the experiment. The nursing students, however, were asked to complete a map labeling test identical to that used in Experiment 2 before they were dismissed from the experiment.

RESULTS

Direction pointing: The direction-pointing task was scored in terms of the amount of deviation from the correct direction. If the subject pointed within five degrees of the correct direction, a score of zero was given. Incorrect deviations were calculated in degrees from this zero point.

If, for example, the correct direction was +100 degrees and the subject pointed to the +120 mark on the compass, a deviation score of 20 was given. All subjects were required to respond to this task even if they stated that they did not know where a place was located, and consequently had to guess at the direction. Mean error rates were calculated for each subject. The lower the score the better a subject was at direction pointing. Table 3 shows the mean number of degrees deviating from the correct direction for the 12 locations. In mean scores, the nursing students were poorer than the experimental subjects on 11 of the 12 locations.

Distance estimation: The distance estimation task was scored in terms of the number of feet deviating from the correct distance. If the subject estimated within five feet of the correct distance, a score of zero was given. Overestimations were subtracted from the correct distance and underestimations were added to the correct distance. All subjects were required to respond to this task even if they stated that they did not know where a place was located and consequently had to guess at the distance. Mean error rates were calculated for each subject. The lower the score the better a subject was at distance estimation. Table 4 shows the mean number of feet deviating from the correct distance for the 12 locations. In mean scores, the nursing students were poorer than the experimental subjects on 10 of the 12 locations.

An overall multivariate analysis of variance was done comparing the experimental and control groups on both direction pointing and distance estimation. This analysis was significant to the .05 level. Univariate analyses found a significant difference between the groups on the direction pointing task, $F(1, 38) = 7.46$, $p < .01$ and on the distance estimation task, $F(1, 38) = 4.10$, $p < .05$. Thus the experimental subjects who were naive to the building until they were given the training procedure were signficantly better

TABLE 3
Mean Number of Errors (in degrees) in Direction Pointing by Student Subjects and Third-Year Nurses in Experiment 3

	First Floor Areas	
Place	Nurses	Subjects
Radiotherapy	28.00	9.50
Psychiatry	34.50	15.50
Pharmacy	26.00	16.50
Animal care	92.00	27.50
Experimental surgery	80.00	45.00
MUN School of Nursing	41.50	15.00
Mean errors	50.33	21.50
	Second Floor Areas	
Place	Nurses	Subjects
X-Ray	35.00	32.00
Outpatients	45.00	20.50
Nuclear medicine	80.50	21.50
Operating rooms	31.50	35.00
Auditorium	26.00	12.50
C.C.U.	22.00	9.00
Mean errors	40.00	21.75

on both cognitive mapping tests than the nursing students who had worked in the building for more than two years.

Map locations: Table 5 shows the average scores obtained by the nursing students on the map-location task

TABLE 4
Mean Number of Errors (in feet) in Distance Estimation by Student Subjects and Third-Year Nurses in Experiment 3

First Floor Areas

Place	Nurses	Subjects
Radiotherapy	135	122
Psychiatry	218	154
Pharmacy	135	159
Animal care	337	81
Experimental surgery	283	205
MUN School of Nursing	162	48
Mean errors	212	128

Second Floor Areas

Place	Nurses	Students
X-Ray	300	226
Outpatients	261	242
Nuclear medicine	373	155
Operating rooms	245	264
Auditorium	125	33
C.C.U.	210	120
Mean errors	252	173

given at the end of testing session. These volunteers scored much higher than the nonvolunteers tested on the same task in Experiment 2.

TABLE 5
Mean Number of Correct Mapping Placements and Mean Number of Errors Made by the Third-Year Nursing Student Volunteers Tested in Experiment 3

Map Placements	Nursing Students
Mean correct placements	
First floor	15.10
Second floor	15.50
Fourth floor	4.60
Fifth floor	4.15
Mean number errors	6.16

DISCUSSION

Many of the student nurses in Experiment 2 had written on their papers that they knew where the rooms in the hospital were located even though they could not place them on the floor-plan maps. However, the third-year student nurses were also poor on the objective measures provided by the direction-pointing and distance-estimation tasks. These students often did not appear to know in what part of the building a particular room was located. Furthermore, they did not seem able to estimate distances by imagining walking along the corridors from one point to another. Thus the poor results obtained in the earlier experiments cannot be explained simply by postulating a disparity between the cognitive maps formed by the student nurses and the floor plan maps used by the administration. It is more likely that the student nurses actually possessed very positive cognitive maps of the building, and that these mental maps were probably similar to those that were initially drawn in Experiment 1. The drawn maps showed that these student nurses had some knowledge about relations among landmarks and some knowledge about the major corridors connecting these landmarks. But each nurse seemed to possess an individually distinct type of cognitive map. And there was no evidence from any of the three experiments that even after working in the building for two years these student nurses had developed survey cognitive maps.

The second part of the experiment was designed to test whether providing naive subjects with floor plans of the building would help them to develop the cognitive mapping skills needed to find their way around the building. Thorndyke and Hayes-Roth (1982) had found that subjects asked to memorize a floor plan map of a building complex were poorer on direction pointing and distance estimation than subjects who had at least one year's experience working in the building. On the other hand, Garling et al. (1983) found that they could compensate for the negative effect of restricted sight by presenting their restricted-viewing subjects with a floor plan before the subjects were taken on tours of the building. In Experiment 3 the naive subjects who were first asked to memorize the floor plans were significantly better on the direction-pointing and distance-estimation tasks than the nursing students who had two years' experience working in the building. Thus it would appear that on some spatial tasks at least, an overall survey knowledge of a building provides better spatial skills than several months' experience traversing that building.

As a final note it might be mentioned that it was very difficult to obtain volunteers from the third-year nursing class to participate in this experiment, even though we had full cooperation from the School of Nursing staff members, and even though these volunteers were paid for their participation. When volunteers were requested, the students were told that the tests would measure their knowledge of where places were located in the building. Although the students were assured that their individual scores on these tests would not be given to the school administration, they nonetheless seemed to feel that in some way a poor score would be a black mark on their nursing skills. Consequently, the volunteers who did participate in this experiment were likely to have been those who were most confident about their knowledge of the building. At the end of the testing session, the nursing students were asked to fill out floor-plan maps identical to the procedure used in Experiment 2. As can be seen by comparing Tables 2 and 5, the volunteer nursing students used in Experiment 3 seemed to have a greater level of cognitive mapping knowledge than the average third-year nursing students. Consequently, it is likely that had we been able to obtain a more random sample of nursing students for Experiment 3, the scores obtained on the direction pointing and distance estimation tasks might have been even lower than those that were obtained.

GENERAL DISCUSSION

Throughout the cognitive mapping literature there is the assumption that a person's mapping system of the environment automatically develops into a more complex representation as that person gains experience traversing that environment. Generally it is assumed that the person initially forms simple landmark and/or route maps but as he or she continues to traverse the physical space these mental representations develop into more complex survey maps. What has been demonstrated in the present series of studies is that this developmental progression does not occur automatically or without conscious effort in all environmental situations. The nursing students who had experienced traversing the Health Sciences Centre for two years showed no evidence of developing survey mapping systems. Initially, as shown in Experiment 1, the students did acquire additional knowledge of the building as they acquired more experience, but this additional knowledge of the building took the form of adding more places to the landmark or route maps that were initially formed, rather than changing the structure of the mental representations. Furthermore, after having formed their initial cognitive maps on the basis of their experiences in the building, these students found the maps placed on the walls by the administration to be confusing and consequently ignored this information. Contrast the nursing students' experience with that of our experimental subjects who were taught to memorize the maps before they had formed their own idiosyncratic cognitive representations. These subjects did not find the administration maps confusing. Finally, it should be noted that the cognitive maps formed by the nursing students did not seem to be easily transformed into more complex schema maps. As demonstrated in Experiment 2, little additional knowledge seemed to be added to the nursing students' cognitive maps between the seven months' working period and the 21 months' working period.

The question that needs to be asked is why these nursing students failed to develop survey mapping systems when so many studies have shown that most people do develop such survey systems. The answer must lie in the design of the building. The building design was so complex that it would require an intentional or effortful learning program, such as was initiated with the experimental subjects, for the average person to acquire a survey mapping system. This suggests that architects need to consider not only the functional needs of the building but also the mental restrictions placed on the average person's cognitive system.

In spite of their imperfect mapping systems, the nursing students were able to locate the places they needed to find. It is likely that their mapping systems did not become increasingly more complex because they found that they were able to find their way around the building by using a few well-traversed routes and by following the directional signs posted throughout the hospital. This method required less effort than attempting to form representational survey maps. But expending less effort extracted a price. The use of route maps and sign systems is not as efficient a method to traverse a spatial environment as is the use of survey cognitive maps. To go from one point to another the person might often have to follow a longer route than if he or she could visualize the various routes connecting the points. Furthermore, as Weisman (1981) has pointed out, individuals can become disoriented or lost if they accidentally alter their route. Finally, Moeser and Reardon (1986) have recently discovered that wayfinding difficulties can produce high levels of anxiety—anxiety that could interfere with the performance of these nursing students. There was some evidence of the anxiety produced by the wayfinding problems experienced by the nursing students in Experiment 3. The difficulties encountered in obtaining volunteers for this experiment suggested that these students lacked confidence about their knowledge of the spatial layout of the building.

To solve the problems encountered by the complexity of the building design, several approaches might be attempted. First, the results of Experiment 3 suggest that it might be more efficient to utilize a standardized training program to assist the student nurses in acquiring a survey map before they actually traverse the building. The students may then be able to combine the information they acquire from the initial memorization task with the knowledge they acquire as they experience the spatial environment to form a survey mapping system. Another approach might be to use a color-coding system, such as explored by Evans et al. (1980) to see if the students would automatically form a more distinctive representation of the continuities within the building structure. Whatever approach is finally chosen as the most productive, it would seem that something must be done to improve the mental representations of the building that are formed by the people who work in the Health Sciences Centre.

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