Walking Environments for the Visually Handicapped: Recognition of Geometric Model Spaces in a Laboratory

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Abstract
In daily life it is not safe for visually handicapped people to walk alone as they can often fall victim to accidents or lose their way. In order to improve walking environments, it is important to show clearly how visually handicapped people recognize spaces and their position in spaces, and what the clues to recognition are.

In this study, in order to clarify the relation between spatial cognition and space form, and the characteristics of search behavior, experiments are carried out using model spaces based on specific geometric plan. The behavior is analyzed with the aid of a walking locus and observation; and the spatial cognition, by sketch map and interview.

Keywords: the visually handicapped; spatial cognition; walking environments; model spaces

1. Introduction
Recently in Japan, town planning, which takes into account citizens’ special needs, has progressed, so that elderly or handicapped people can now go out more easily. However, it is often hazardous for visually handicapped people to walk alone, as they can have accidents or lose their way. Improvements in the walking environment are needed so that visually handicapped people can reach their destination safely when walking alone. It is vital for such improvements to show clearly how visually handicapped people discern space(s). In this study, in order to clarify the relation between spatial cognition and space form, and the characteristics of search behavior, experiments are carried out in the following geometrical model spaces; square, rectangle and polygonal types as basic forms. However, such experiments are also needed in different spaces, such as irregular form spaces, curved wall spaces, etc. By accumulating and analyzing a large number of results, they can be used effectively for creating spaces which are adapted to visually handicapped people.

2. Theoretical Approach
The cognitive research on visually handicapped people has been studied since the 1980’s and there are a large number of findings. R.Passini1, 2) set up courses in building and carried out experiments. R.L.Hollyfield3) studied representation of quiet outside walking. J.F.Fletcher4) advocated theories of deficiency, inefficiency and difference. T.Yamamoto5) analyzed development process of spatial moving in children with or without visual experience. However, such studies have not fully clarified the relation between spatial cognition and space form. Since their experiments were also carried out in "public" space where much of the data was complicated, it was difficult to show the relation between the cognition and information clearly. Therefore, a strict theoretical approach is needed. Our team previously carried out a series of theoretical studies6, 7) on the visually handicapped under laboratory conditions. In these studies, characteristics of spatial cognition were clarified in square and corridor model spaces. From these results, we explored and recorded the "relation" between spatial cognition and basic space forms in order to show their fundamental abilities. This paper intends to highlight this relation and these abilities.

3. Outline of Experiments
3.1 Subjects
The subjects are seven visually handicapped people between 19 and 27 years old, and nine eye-masked people with ordinary vision who are aged between 21 and 23 years old. There is also a team of nine staff. They guide the visually handicapped people, take video footage, record experimental data, conduct interviews, and so on. Attribution of the subjects is shown in Tables 1. and 2.

3.2 Experimental spaces
Experimental spaces are created in a model laboratory situated at Kansai University (The lab measures 13m×18m, its CH= 3m, and the floor is carpeted. Illumination is fluorescent light). Individual experimental spaces are made of corrugated cardboard

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Table 1. Attribution of the Subjects (The Blind)

| Subjects | Blind 1 | Blind 2 | Blind 3 | Blind 4 | Blind 5 | Blind 6 | Blind 7 |
|----------|---------|---------|---------|---------|---------|---------|---------|
| age/sex  | 22years/male | 20years/male | 24years/female | 26years/male | 19years/female | 22years/female | 26years/male |
| occupation | self-employed (hospice worker) | student | diabetic help | student | university student | technical college teacher | student |
| level of handicap | 1st class, acquired blindness | 1st class, acquired blindness | 1st class, acquired blindness | 1st class, acquired blindness | 1st class, acquired blindness | 1st class, acquired blindness | 1st class, acquired blindness |
| age became blind | 17 years | 0 years | 0 years | 16 years | 7 years | 2 years | 21 years |
| disease | strabismus, cataract | cataract | premature retinopathy | cataract | deuteranomaly | xanthisma | xanthisma |
| eyeight: right | light perception | 0 | 0 | light perception | 0 | 0 | 0.01 |
| view | nothing | nothing | angle of 30 degrees | peripheral vision | nothing | nothing | angle of 3 degrees |
| eyeight: left | light perception | 0 | 0 | light perception | 0 | 0 | 0.01 |
| bearing | normal | normal | normal | normal | normal | normal | normal |
| training: age | 17 years | 6-18 years | 6-15 years | 13 years | 8-15 years | 5-15 years | 19-20 years |
| contents | walking training | daily life training | braille training | braille training | braille training | daily life training | braille training |
| braille reading | all the time | all the time | all the time | all the time | all the time | all the time | all the time |
| walking cane | all the time | all the time | all the time | all the time | all the time | all the time | all the time |
| education: primary | general course | general course | general course | general course | general course | general course | general course |
| school | school for the blind for the blind school for the blind school for the blind school for the blind school for the blind school for the blind school for the blind |
| professional education | general course | general course | general course | general course | general course | general course | general course |
| destination | hospital, bank, customer | university, parent school | station, super market | university, Namba Oska, Kawanakaguchi | university, Osaka Umeda Osaka, Umeda Osaka | university, university, super market, station | Umeda Osaka, Yoshinawaki Osaka |
| frequency | 3 or 4 times/week | everyday | once/2 or 3 days | everyday | everyday | everyday | everyday |
| care giver | w/ a caregiver | w/ a caregiver | w/ a caregiver | w/ a caregiver | w/ a caregiver | w/ a caregiver | w/ a caregiver |
| transportation | train, bus, taxi | train, bus, taxi | train, bus, taxi | train, bus, taxi | train, bus, taxi | train, bus, taxi | train, bus, taxi |
| housing type | detached house | apartment house | detached house | apartment house | detached house | apartment house | apartment house |
| dwelling style | with family | without family | with family | without family | with family | without family | without family |
| health condition | good | good | good | good | good | good | good |

Table 2. Attribution of the Subjects (The Eye-Masked)

| Subjects | Eye-masked 1 | Eye-masked 2 | Eye-masked 3 | Eye-masked 4 | Eye-masked 5 | Eye-masked 6 | Eye-masked 7 | Eye-masked 8 | Eye-masked 9 |
|----------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
| age/sex  | 22years/male | 22years/male | 21years/male | 22years/male | 21years/male | 22years/male | 21years/male | 22years/male | 21years/male |
| occupation | student | university student | student | university student | student | university student | student | university student | student |
| eyeight: right | 1.5 | 0.2 | 1 | 0.5 | 1 | 1.2 | 1.5 | 1.2 | 1.5 |
| eyeight: left | 0.2 | 0.2 | 1 | 0.5 | 1 | 1.2 | 1.5 | 1.2 | 1.5 |
| bearing | normal | normal | normal | normal | normal | normal | normal | normal | normal |
| housing type | detached house | detached house | apartment house | detached house | apartment house | detached house | apartment house | detached house | apartment house |
| dwelling style | with family | with family | without family | with family | with family | with family | with family | with family | without family |
| health condition | good | good | good | good | good | good | good | good | good |

THE SQUARE TYPE

THE RECTANGULAR TYPE

THE POLYGONAL TYPE

Fig.1. Experimental Spaces
panels (1800×900, in vertical usage). Experimental spaces are shown in Fig.1.

There are four kinds of experimental space, based around square, rectangle and polygonal types.

3.3 Experimental period

The experimental period is from 5th to 7th December, 2003.

3.4 Experimental methods

First, the subjects receive directions from staff members at the starting point in each experimental space, and in order to recognize the form and size of these experimental spaces, they walk around them for 2 minutes (searching walk). If this walk ends within the time limit, the subject signals to the staff member; otherwise, when 2 minutes have elapsed, the staff member gives a signal to the subject.

Next, the subjects walk from the end point of the searching walk to the position that they think was the starting point (orientating walk). For this, there are no time limits. Their position after the orientating walk is recorded in relation to their initial starting point.

In addition, at the end of the orientating walk, the subjects are asked to turn and face in the direction that they thought they started from. This "direction angle" is the angle between the starting direction and the direction the subjects actually turn to face. The angle is shown in terms of a scale, -180 ~180 degrees.

All the subjects walk with the aid of a cane.

After this experiment, the subjects come out of the experimental space, sit down in a chair and draw a sketch map at a desk near the experimental space. The instruction for drawing the sketch map is "Please draw how you felt the space." The eye-masked subjects have to draw two sketch maps; the first with eye-mask, the second, without. There is no time limit for drawing a sketch map. After drawing is over, a member of staff asks the subject what form and size the space was, what criteria were used for deciding the direction of return to the starting point, and when they got there, which direction had they started out walking in, and what they noticed.

The experiment is repeated using the same procedure in each model space type.

4. Results and Considerations

4.1 Walking speed

Walking speed is analyzed by using the length of walking measured from the walking locus figure created after the end of experiments, and walking time. (The walking time also includes the time the subjects stop and think.)

4.1.1 In the searching walk

The walking speed in the searching walk is shown in Fig.2.

The walking speed of the blind is fast in the 10m square, and it is slow in the 4m rectangle. In the square type, the smaller the space is, the slower walking speed tends to be.

The walking speed of the eye-masked is fast in the equilateral triangle, and it is slow in the equilateral octagon. In the rectangular type, the smaller the space is, the slower walking speed.

In all the spaces, the walking speed of the blind is faster than that of the eye-masked.

4.1.2 In the orientating walk

The walking speed in the orientating walk is shown in Fig.3.

The walking speed of the blind is fast in the 10m square, and it is slow in the 4m rectangle. This is the same as the searching walk. In both the square and rectangular types, the smaller the space is, the slower the walking speed.

The walking speed of the eye-masked is fast in the 10m rectangle, and it is slow in the 8m rectangle.

In all the spaces except the 10m rectangle, the walking speed of the blind is faster than that of the eye-masked.

4.1.3 Comparing the searching walk with the orientating walk (Figs.2. and 3.)

In all the spaces except the equilateral hexagon, the walking speed of the blind in the searching walk is faster than that recorded in the orientating walk.
In all the spaces except the 10m rectangle and the equilateral octagon, the walking speed of the eye-masked in the searching walk is faster than that recorded in the orientating walk.

Thus, the speed of both the blind and the eye-masked in the searching walk tends to be faster than the orientating walk. This shows that it is more difficult for the subjects to recognize their "position" in the space than it is for them to discern the feature of the "space" itself. Because of this level of difficulty, the process takes longer and suggests that the subjects need to be more careful in recognizing their positions.

In both the searching walk and the orientating walk, the smaller the space of the square type models is, the slower the walking speed tends to be. Interestingly, the walking speed in the equilateral triangle (noted for its length of sides) is the fastest in the polygonal type. The longer the distance following a straight line of wall is, the faster the walking speed tends to be.

4.2 Distance from the starting point
"Distance from the starting point" is the length of straight line drawn from the starting point to the subject's position at the end of the orientating walk. The distance from the starting point is shown in Fig.4.

In the case of the blind subjects, distance from the starting point is long in the 10m square and 10m rectangle, and it is short in the 4m square. In such square spaces, distance from the starting point varies greatly, according to the size of the space. In both the square and rectangular spaces, the smaller the space is, the shorter the distance from the starting point tends to be. In the polygonal type, it is longer.

In the case of the eye-masked subjects, distance from the starting point is long in the equilateral pentagon and equilateral triangle, and it is short in the 8m, 6m and 4m rectangles.

Comparing the blind results with those of the eye-masked, differences are slight in rectangles of 8m, 6m and 4m, and ultimate distance from the starting point is short. Differences in these spaces are small.

With regard to the distance from the starting point, the results of the blind and the eye-masked are similar for the rectangular spaces. In the rectangular spaces, it is relatively easy to recognize one's position, but in the polygonal type, difficult.

4.3 Angle of direction
Using the data of the angle of direction after the orientating walk, "Difference of the angle" and "Correct answer rate" are analyzed for each type of space. The difference of the angle is the absolute value of the angle of direction and the correct answer of the angle of direction is given in terms of a scale, -22.5 ~ 22.5 degrees.

4.3.1 Difference of the angle
The difference of the angle is shown in Fig.5.

Fig.5. Difference of the Angle

The difference of the angle of the blind is large in the equilateral octagon and equilateral pentagon, and it is 0° in the 10m and 6m squares, and the 10m and 8m rectangles. That of the eye-masked is large in the equilateral octagon, and it is 0° in the 10m, 8m and 6m rectangles. In the polygonal type, the fewer the number of corners there are, the smaller the difference in direction. The difference of the angle of both the blind and the eye-masked is small in the rectangular type, while in the polygonal type, large.

In all the square and polygonal type spaces, the difference of the blind is smaller than that of the eye-masked, and it can be said that the blind are superior to the eye-masked in their sense of direction.

4.3.2 Correct answer rate for the angle of direction
The correct answer rate for the angle of direction is shown in Fig.6. Correct answer rates of both the blind and the eye-masked are highest for the rectangular spaces, followed by the square and then the polygonal.

Differences between the blind and the eye-masked are large in both the square and polygonal types. In the polygonal type, the fewer the number of corners there are, the higher the rate of the eye-masked tends to be.

For all of the square and polygonal spaces, the correct answer rate of the blind is higher than that of the eye-masked. But in the rectangular spaces, the
difference is small and the rate is uniformly high.

This may be so because the short side of the rectangle is always 2m and there are both short and long sides. This difference in the length of the sides enables the subject to easily recognize both the space and distance. In the 4m rectangle, the rate of the blind and the eye-masked is low, because the difference between short side and long side is small.

For both the blind and the eye-masked, the variation of direction is large in the polygonal type, and the correct answer rate is low. It is difficult to recognize the direction in a space without a right-angle corner or in one that does not generally feature in daily life.

4.4 Direction that they turn first

"Direction that they turn to first" is the direction that the subjects turn to at the wall reached first in the searching walk. Using the walking locus figures created after the end of experiment, we have classified them into R (right turn), L (left turn), and B (back).

4.4.1 Direction that they turn to first

The direction that the blind and the eye-masked turn to first is shown in Figs.7. and 8.

(1) The blind

In the square type, the smaller the space is, the higher the ratio of R turns. In the rectangular type, the ratio of R and that of L are almost the same. In the polygonal type, with the exception of the equilateral pentagon, L turns feature more prominently.

(2) The eye-masked

Differences in the square type are small, and the ratio of R and that of L are almost the same. In all the spaces of the square type, there is a ratio of B and it is about 10% uniformly. This behavior signifies the subjects' search for a clue to recognition because there are few features in the space itself; it also indicates the subjects' attempts to 'make sure of' the space because the square type is comparatively easy to predict or imagine. In the rectangular type, the smaller the space there is, the lower the ratio of R, the higher that of L; there is no ratio for B.

(3) Comparing the blind with the eye-masked

In the case of the blind, the ratio of R and that of L are almost the same in the rectangular type, and the smaller the space of the square type is, the higher the ratio of R turns. On the other hand, in the case of the eye-masked, the ratio of R and that of L are almost the same in the square type, and the smaller the space of the rectangular type is, the higher the ratio of L turns.

With regard to the direction that they turn to first, the characteristics of the blind are different from those of the eye-masked.

4.4.2 Factor of the direction that they turn to first

The factors governing the direction that they turn to first are shown in Table 3. This is based on both interview and observations of their behavior.

Since the subjects use a walking cane in their right hand, the direction that they turn to is determined by whether they make sure of the wall with their free hand or with the cane; it was noted that they often shift the walking cane onto their left hand.

When they make sure of the wall with their hand, they use both the hollow of the hand and the back of the hand. Some of the subjects show a body position in relation to the wall that is determined by risk aversion or by their habit in daily life. The direction that they turn to first is determined by whether they make sure of the wall with their free hand or with the cane; it was noted that they often shift the walking cane onto their left hand.

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turn to is also influenced by these two factors.

The relations between holding a cane and searching a wall are shown in Fig. 9. There are three types:
1. Holding a cane with their right hand and searching a wall with their left hand: in this case, they turn to the right.
2. Holding a cane with their left hand and searching a wall with their right hand: in this case, they turn to the left.
3. Holding a cane with their right hand and searching a wall with their right hand: in this case, they turn to the left.

* Holding a cane with their left hand and searching a wall with their left hand: in this case, it could not be seen.

4.5 Recognition of the space

"Recognition of the space" is limited to that of the form and size of the space plan, and the correct answer rate for this is derived from the result of the sketch map and interview.

The form of the space that they draw in the sketch map and the way they describe the form in interview are taken as their answer. With the size, 20% is the allowable margin of error. The correct answer rates for recognition of the space by both blind and eye-masked subjects are shown in Figs. 10 and 11. We have classified the correct answer into ‘both form and size’ (correct), ‘only form’ (correct) and ‘incorrect’.

(1) The blind

The correct answer rate for ‘both form and size’ is high in the 6m square and the 4m rectangle, and it is low in the 10m square, the 10m rectangle and equilateral triangle.

In the rectangular spaces, the rate for ‘incorrect’ is low, and it is high in the polygonal spaces. The rate for ‘incorrect’ is especially high in the case of the equilateral pentagon. In the rectangles, the smaller the space is, the higher the correct answer rate for ‘both form and size’ and the lower the rate for ‘only form’.

(2) The eye-masked

The correct answer rate for ‘both form and size’ is high in both the 4m square and rectangle, and low in the equilateral pentagon. In both the square and rectangular spaces, the smaller the space is, the higher the correct answer rate for ‘both form and size’. The rate for ‘incorrect’ is low in the rectangular spaces, and high in the polygonal type. Especially, it is high in the case of the pentagon. This also applies to the blind.

(3) Comparing the blind with the eye-masked

For the blind and the eye-masked, the smaller the space is, the lower the correct answer rate for ‘incorrect’ tends to be. But in the 4m square and the 4m rectangle, the rate tends to be high. It is thought that such spaces are too small for easy spatial recognition.
The rate for 'incorrect' is highest in the equilateral pentagon. It is thought that the pentagon is a difficult shape for spatial recognition. With rectangular spaces, the rate for 'incorrect' is low, especially for the 6m rectangle. For both the blind and the eye-masked, the rate for 'incorrect' is 0%. It is thought that in the form of a rectangle 2m×6m it is easy to recognize the space.

### 4.6 Search behavior and clues to recognition of space

Classification of walking, search behavior and clues to recognition of space are shown in tables 4 and 5. They are based on behavioral observation and the interviews.

In the experimental spaces, the subjects mostly search for clues on the surface of the wall because there are few clues in the space itself. Subjects try to make out the features of the wall itself, or of part of the wall or corners. In some space types, there are psychological changes in their behavior; they occasionally exhibit feelings of uneasiness, and they often appear disturbed, confused, and so on.

Most of the subjects walk along the wall using either a walking cane or their hands, while others walk straight across the space. It is thought that walking straight across the space is mainly to make sure of the nature of the space. It is important to note that the blind can walk not only along the wall but also across the space.

### 5. Conclusions

(1) For both the blind and the eye-masked, the smaller the space is, the slower the walking speed tends to be. The speed of the blind and the eye-masked in the searching walk tends to be faster than that recorded in the orientating walk. It is judged to be more difficult for them to recognize their "position" in the space than it is for them to discern the feature of the "space" itself. Because of this level of difficulty, the process takes longer and suggests that they need to be more careful in recognizing their positions.

(2) If a space is smaller, it becomes easier to recognize one's position. And it can be said that the blind are generally superior to the eye-masked in their sense of direction, but in the rectangular spaces the eye-masked recognize as well as the blind do. Rectangular spaces are easier to recognize than square or polygonal ones. The lengths of the sides of a rectangle differ, and this difference becomes the clue to

#### Table 4. Classification of Walking

| walking along the wall | walk exactly around the space | The subjects find a base point and walk exactly around the space. |
|------------------------|-----------------------------|---------------------------------------------------------------|
|                        | walk less than all around the space | The subjects think that they walked all around the space. The subjects don't think that they will try to walk all around the space. |
|                        | walk more than all around the space | Although the subjects walk all around the space, they do more than exactly once around as a check. The subjects don't think that they will try to walk all around the space. |

| walking straight across the space | across the space from wall to wall | The subjects make sure of the feature of the form imagined in their mind. The subjects make sure whether the walls facing each other are parallel. The subjects make sure of the size of space. |
|----------------------------------|-----------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                  | across the space from wall to corner | The subjects make sure of the features of the form imagined in their mind. |
|                                  | across the space from corner to wall | The subjects make sure of the features of the form imagined in their mind. |
|                                  | across the space from corner to corner | The subjects make sure of the features of the form imagined in their mind. |
(3) The aberration in angle of direction is large in polygonal spaces, and the correct answer rate is also low. It is difficult to recognize direction in a space without a right-angle corner, and to recognize direction in a space that is not generally encountered in daily life. And the fewer the number of corners there are, the higher the number of correct answers of the eye-masked tends to be, but that of the blind shows almost no change. The number of corners does not influence the correct answer rate of the blind.

(4) It is thought that the direction that the subjects turn to first is based on their own habits, but right turn, left turn and turn back are not purely arbitrary: they do have a reason. Thus, these movements could be classified into groups. It is thought that such characteristics for the blind are different from those of the eye-masked in each space.

(5) The smaller the space is, the easier its recognition, but it is thought that if the space is too small, recognition becomes more difficult.

Certain types of spaces are easier or more difficult to recognize. Amongst the squares, the 10m square space is the most difficult to recognize; amongst the rectangles, the 6m space is easiest; and amongst the polygons, the equilateral pentagon is most difficult.

(6) Because there are few clues to direction or shape of space in an experimental space, the subjects’ behavior trying to get a clue from the wall could be seen. Search behavior and clues to recognition could be classified into eleven categories, and within each category there are several scenarios.

Looking for a base point on the wall or at the corner and walking round the space was often observed during the subjects’ searching walk. Some of the subjects walked straight across the space in order to ascertain whether it was the form predicted or imagined in their mind.

(7) There are two types of walking in this experiment; one is walking along the wall, another is walking straight across the space. “Walking along the wall” could be further classified into three types, and “walking straight across the space” could be further classified into four types. There is a rationale behind each one.

**References**

1) Passini, R. and Proulx, G. (1988) Wayfinding without vision; an experiment with congenitally totally blind. Environment and Behaviour, 20(2), pp.227-252.

2) Passini, R (1984) Wayfinding in Architecture. Van Nostrand Reinhold.

3) Hollyfield, R.L. and Foulke, E. (1983) The spatial cognition of blind pedestrians. Journal of Visual Impairment and Blindness, 77, pp.204-210.

4) Fletcher, J.F. (1981) Spatial Representations in Blind Children, 2: Effects of Task Variations. Journal of Visual Impairment and Blindness, 75, pp.1-3.

5) Yamamoto, T. (1993) Development of spatial cognition in visually handicapped people. Niheisha, (in Japanese).

6) Kametani, Y., Chibana, K. and Araki, H. (2005) Behavior and recognition of spaces in model laboratory: A study on walking environments for visually handicapped people part 2. Journal of Architecture and Planning, AIJ, 591, pp.79-86, (in Japanese).

7) Kametani, Y., Takei, T., Hayase, H., Chibana, K. and Araki, H. (2004) Recognition of spaces in model laboratory- A study on walking environments for visually handicapped people-. Journal of Architecture and Planning, AIJ, 582, pp.47-54, (in Japanese).