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One- to twenty-four-year memory for a school campus: Recalled areas and objects

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We investigated the effect of retention intervals and environmental knowledge on memory for areas in natural environment: A campus of junior high school. In Experiment 1, areas for the school building, playground, and swimming pool were estimated from pencil sketches drawn by 158 alumni who had graduated from the school a month to 24 years before. The number of recalled objects in each area, the level of certainty, and subjects' everyday-after-school activities during their school days were also assessed. Subjects who had participated in outdoor sports during their school days (*outdoor subjects*) were assumed to have better knowledge on the playground than those who had not (*indoor subjects*). The main findings were that not only retention intervals but also the campus knowledge affected recalled area of the playground. Moreover, positive correlation was found between areas and the number of recalled objects, suggesting that memory for an area was reconstructed in relation to the number of objects recalled in the area. Experiment 2 showed that recalling objects within an area increased estimation of the area. The constructionist view of spatial memory was supported. Memory transformation associated with areas was also discussed.

Key words: memory for natural areas, environmental knowledge, retention intervals, constructionist view of spatial memory.

Revisiting a place where one once lived, one may find it much smaller than one remembered: Such an experience suggests that memory for area transforms over time. Although it has been shown that memory for location, direction, and distance reflect subjective organization of environmental information rather than the actual one (Bahrick, 1983; Merrill & Baird, 1987; Okabayashi & Glynn, 1984; Oshima & Okaichi, 1990; Sherman & Lim, 1991; Stevens & Coupe, 1978; Tversky, 1981; Tversky, 1992), little is known about memory for area. In the laboratory settings, it has been demonstrated that the magnitude of recalled area (Y) is related to the compressive power function to the magnitude of physical area (X), i.e., $Y = kX^n$ where n is Stevens' exponent and k is a constant (Algom, Wolf, & Bergman, 1985; Chew & Richardson, 1980; Kemp, 1988; Kerst & Howard, 1978; Moyer, Bradley, Sorensen, Whiting, & Mansfield, 1978), and Kemp (1988) showed that the exponent (n) monotonically decreased as time elapsed. Because an exponent indicates the extent to which areas are discriminated from each other[2], Kemp's results suggest that memory for area becomes less distinctive over time at least in the laboratory settings.

It is not clear, however, whether memory for natural area also follows the law found in the laboratory. In the laboratory experiments, areas are displayed explicitly as stimuli, subjects are instructed to learn them, and

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retention time is rather short, which should facilitate subjects' retention of perceived image for area. On the other hand, in a natural environment, one may not pay much attention to area nor make attempt to remember them, in which condition it would be difficult to retain the perceived image for area. Then when required to recall, one may try to remember the area by consulting more concrete information like buildings and objects in the area, and reconstruct the image as suggested by the constructive theory of cognitive map (Bahrick, 1983; McNamara, Altarriba, Bendele, Johnson, & Clayton, 1989; Merrill & Baird, 1987; Okabayashi & Glynn, 1984; Sherman & Lim, 1991; Stevens & Coupe, 1978; Tversky, 1981; Tversky, 1992).

A tentative study by Naka and Minami (1991) examined pencil sketches of the layout of junior high school campus drawn by current students and alumni who graduated from the school seven years before. In order to see the effect of campus knowledge, subjects were partitioned into *outdoor subjects* and *indoor subjects* depending on their everyday after school activities that were virtually mandatory for all students. Outdoor subjects were expected to have better knowledge on the campus. From the drawing, relative areas for individual facilities were calculated in ratios to a main school building. Results showed that, first, the outdoor alumni drew areas more distinctively compared with other subjects; second, the recalled areas did not necessarily become less distinctive over time; finally, outdoor alumni recalled more objects in the campus (e.g. trucks, soccer goals, tennis courts, etc.), the number of which positively correlated with the area. These findings were interpreted in terms of *the certainty hypothesis*, i.e., as one remembers more objects in the campus and thus feel more certain of one's memory, one overestimates the area (Kemp, 1988; Kerst & Howard, 1978). However, no direct test was carried out because no certainty ratings were collected in the study. Furthermore, there could be an alternative explanation for the results, namely that the more one recalls the objects, the larger one draws the area simply because one needs more space to fill those objects in regardless of the level of certainty (*the filling-in hypothesis*) (cf. Sadalla & Staplin, 1980; Thorndyke, 1981).

The purpose of this study is firstly to investigate how retention intervals and campus knowledge affect memory for natural area. In particular, we are interested in whether memory for area is reconstructed in relation to the number of objects recalled in the area and/or the level of certainty. In Experiment 1, we assessed the recalled areas and the number of recalled objects from pencil sketches of a school campus drawn by junior high school alumni who had graduated a month to 24 years before. The level of certainty and subjects' activities during their school days were also assessed. According to the certainty hypothesis, positive correlation between area and the level of certainty is expected. On the other hand, the filling-in hypothesis predicts positive correlation between area and the number of recalled

[2] If the recalled area (Y) is plotted as a function of the actual area (X) on a log-log coordinates, then the relation between X and Y is expressed as $\log Y = n \log X + K$, where the exponent (n) represents the slope of a straight line. What the exponent, or the slope, represents is the extent to which areas are discriminated from each other. For example, consider two actual areas, A and B which recalled areas are A' and B', respectively. If the exponent is smaller than one, then the difference between the recalled areas on the coordinates is less than that of actual areas because $(\log A' - \log B') = n(\log A - \log B)$. If the exponent is zero, then the difference between the recalled areas is zero, namely $\log A'$ is no longer discriminated from $\log B'$. So, the monotonous decrement of exponent in laboratory studies suggests that areas become less discriminative as time elapses.

Table 1
Year of graduation and number of subjects in Experiment 1

Year group	Year of graduation	Total			No facilities		No boundary		School building				Swimming pool				Playground			
									Out		In		Out		In		Out		In	
		Total	Out	In	Out	In	Out	In	M	F	M	F	M	F	M	F	M	F	M	F
G1	1991	33	17	16	0	1	3	4	10	4	5	5	10	4	5	6	10	4	5	6
G2	1988	35	15	20	0	0	1	1	4	8	8	10	5	9	8	9	5	9	8	10
G3	1983	25	10	15	0	1	2	4	5	3	4	6	5	3	4	6	5	3	4	6
G4	1978	22	13	9	0	0	1	1	5	7	2	6	5	7	2	6	5	7	2	6
G5	1973	17	4	13	1	0	2	4	1	0	6	3	1	0	6	3	1	0	6	3
G6	1968	26	5	21	1	0	1	6	1	2	8	6	1	2	8	6	1	2	8	6

Note: Table represents from the left to right the total number of subjects, the number of subjects who did not draw facilities, the number of subjects who did not draw school boundary, and the number of male and female subjects who drew school building, swimming pool, and playground, respectively.

objects. Secondly, we would like to plow into memory transformation associated with area: The experience that a revisited place often appears smaller than remembered.

Throughout this study, we used pencil sketches instead of pairwise judgment or magnitude estimation that may be rather common methods for estimation of areas (Algom et al., 1985; Chew & Richardson, 1980; Kemp, 1988; Kerst & Howard, 1978; Moyer et al., 1978). As Evans (1980) pointed out, sketches might cause a problem of interdependency of estimation: If a part of campus is overestimated, then other part is necessarily underestimated because a total area is fixed. However, sketches and direct mapping have been used as well and found to be no less accurate than pairwise judgment (Baird, 1979; Baird, Merrill, & Tannenbaum, 1979; Kerst, Howard, & Gugerty, 1987; Merrill & Baird, 1979) and magnitude estimation (Oshima & Okaichi, 1990) at least for distance estimation. In fact, when drawing a sketch, subjects can use erasers and adjust the areas so that the map as a whole represents better image of the campus, as also suggested by Bahrick (1983) and Tversky (1981). Furthermore, the procedure is comparatively simple and according to Baird (1979), subjects prefers the direct mapping to pair comparisons, which seemed to be important when, like in the present research, collecting data by mailed questionnaires.

Experiment 1

Method

Subjects. Data were collected from alumni (G1 - G6) of a junior high school attached to Chiba University, Japan. Table 1 shows the year of graduation and the number of subjects in each year group. A letter and the task was sent to 480 members of alumni association, 139 of which responded in a month and 19 responded after a pressing letter was sent. Alumni's data reported here were collected within two months.

Letters were sent in the beginning of May, 1991, at which time the youngest alumni (G1) had stayed out of school for a month, while the eldest (G6) stayed out of school for twenty-three years and a month.

Procedures. As for the drawing task, the instruction was "Draw a layout of your junior high school. It can be drawn from any direction, but draw it in detail. In addition, put down the names of facilities and objects in the drawing." Trying to induce natural drawing, no particular instruction was made. Subjects were provided with a blank space

(21.5 cm × 22.5 cm) to draw a sketch. They were then asked to rate the level of certainty by choosing one of following phrases: The drawing was (1) *all guessed*, (2) *mostly guessed*, (3) *partially guessed but basically accurate*, (4) *mostly accurate*, and (5) *quite accurate*.

Besides the task, subjects were asked to answer the questions regarding the revisit, the after-school activity, and the most impressive memory of school, the last of which we do not discuss here. As to the after-school activity, subjects were asked the name, main activities, and the place where the activities were held. As to the revisit, they were asked the number of revisit, the date of last revisit, and the impression of school at the revisit. They were asked to choose a phrase or more to describe the appearance of school : The school looked (1) *the same as before*, (2) *wider than before*, (3) *narrower than before*, (4) *lighter than before*, (5) *darker than before*, (6) *larger than before*, (7) *smaller than before*, and (8) *others*.

Results

As for the after-school activities, thirty-eight activities were identified, of which seven (soccer, softball, tennis, volley ball, athletics, baseball, and Japanese tennis) were defined as outdoor activities because the exercises were held in the playground. Subjects who participated in the outdoor activities were defined as *outdoor subjects* while others were defined as *indoor subjects*. Outdoor subjects were assumed to have better knowledge on the playground.

Figure 1 shows the actual layout of campus and an example of recalled layout. A typical sketch shows a square boundary representing a total school area, in which there were figures representing school facilities. We assessed the recalled area and the number of recalled objects for each of the school building, the swimming pool, and the playground. The playground was defined to be the area below the extension line of the school building facing to the playground. Table 1 presents the number of subjects who did not draw any facilities and those who did not draw the school boundary, which were excluded from further analyses. In the following, we present the results for the area, objects, and the level of certainty, and then the relationship between the area and the

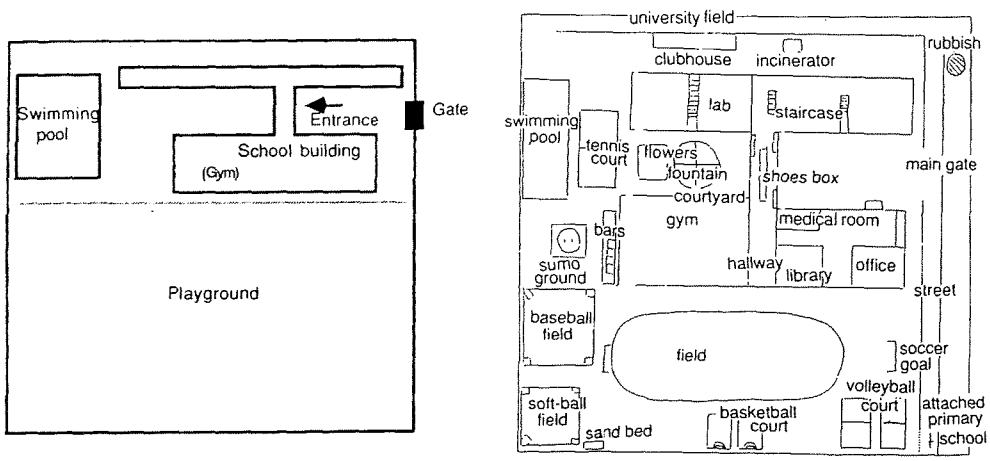

Figure 1. The actual layout of the junior high school (left) and an example of recalled layout drawn by a G5 indoor subject in Experiment 1 (right).

Table 2
Mean recalled areas in Experiment 1

Regions		Actual area	Year group G1	G2	G3	G4	G5-6	Total
School building		11.4						
Outdoor	*Mean*		19.9	15.3	20.6	22.7	22.2	19.7
	SD		7.8	7	5.3	8.7	3.8	7.5
	N		14	12	8	12	4	50
Indoor	*Mean*		16.2	19.1	21.6	21.6	24	20.9
	SD		7.5	6.7	5.9	3.5	7.7	7.2
	N		10	18	10	8	23	69
Total	*Mean*		18.4	17.8	21.1	22.2	23.4	20.4
	SD		7.7	6.9	5.5	7	7.3	7.3
	N		24	30	18	20	27	119
Swimming pool		4.9						
Outdoor	*Mean*		4.1	2.6	3.3	3.3	2.2	3.2
	SD		2.5	1.5	1.2	1.5	1.2	1.9
	N		13	12	5	10	4	44
Indoor	*Mean*		4	2.9	2.9	4	3	3.3
	SD		2.9	1.7	1.2	1.2	1.2	1.8
	N		11	16	9	8	16	60
Total	*Mean*		4.1	2.8	3	3.6	2.9	3.3
	SD		2.6	1.6	1.2	1.4	1.2	1.8
	N		24	28	14	18	20	104
Playground		61.3						
Outdoor	*Mean*		47.5	50.6	55.7	41.2	49.3	48.3
	SD		9.9	12.2	8.6	13.4	14.8	12.1
	N		14	14	8	12	4	52
Indoor	*Mean*		51	52.7	40.7	37.1	38.2	44.2
	SD		5.7	9.5	14.5	14.7	14.2	13.7
	N		11	18	10	8	23	70
Total	*Mean*		49.1	51.5	47.4	39.5	40.2	45.9
	SD		8.4	10.5	14.2	13.7	14.5	13
	N		25	32	18	20	27	122

number of objects, and the area and the level of certainty. As the number of subjects in G5 and 6 were small, data were pooled as G5-6 for the analyses of variance.

Areas. The area for each facility and total school area were measured. Then, the relative recalled area was calculated in ratio to the total school area using the following equation.

Relative recalled area = (*Measured area / Measured total school area*) × 100

For example, if a classroom building was drawn 4 000 mm² in a total school area of 10 000 mm², then the relative recalled area (recalled area hereafter) was 40.0. Using an actual map of the campus, the relative actual area (actual area hereafter) for each facility was calculated as well. Table 2 shows actual areas and mean recalled areas for each facility, year group, and activity group. Recalled and actual areas do not sum up to 100.0 because of uncounted residual areas.

A 5 (year) × 2 (activity) ANOVA was conducted on the recalled area of the school building, the swimming pool, and the playground separately. The main effect of year

was significant for the school building [$F(4, 109) = 2.73$, $MS_e = 50.16$, $p = .03$]. LSD tests showed that G4 and G5-6 drew the building larger than G1 and G2 [$p < .05$]: The area for school building increased over time.

The main effects of year and activity were significant for the playground [$F(4, 112) = 3.72$, $MS_e = 144.79$, $p = .006$; $F(1, 112) = 4.14$, $MS_e = 144.79$, $p = .04$]. LSD tests showed that G1, G2, and G3 drew the playground larger than G4 [$p < .05$], and G2 drew larger than G5-6 [$p < .01$]. As for the activity, outdoor subjects drew the playground larger than indoor subjects [$p < .02$]. There was marginal effect of interaction [$F(4, 112) = 2.31$, $MS_e = 144.79$, $p = .06$], suggesting that decrease in area over time was greater for indoor subjects than for outdoor subjects.

In order to see the sex difference, 5 (year) × 2 (sex) ANOVAs were conducted on each area separately. The main effect of sex and interaction was significant for the swimming pool [$F(1, 96) = 4.10$, $MS_e = 296.30$, $p = .04$; $F(4, 96) = 2.420$, $MS_e = 296.30$, $p = .05$], indicating that male subjects in G1 drew the swimming pool larger (5.1) than other subjects (2.5—3.4) except for the male subjects in G4 (4.0) [$p < .02$]. Because no other sex difference was found, we do not go further any more.

Objects. Some drew the objects detailedly (e.g., a tennis court with a net, poles and lines) and plurally (e.g. two identical tennis courts to indicate there were two) and others did not (e.g., a simple rectangle with a label of "tennis court"). In order to avoid overestimation, we counted objects regardless of detailedness and plurality. Table 3 shows the mean number of recalled objects for each facility, year group, and activity group.

A 5 (year) × 2 (activity) ANOVA was conducted on the number of recalled objects in each area separately. There was a marginal effect of year for the school building [$F(4, 109) = 2.16$, $MS_e = 142.85$, $p = .07$]. The number of recalled objects was greater for G2, G4, and G5-6 than for G1.

The main effect of year was significant for the playground [$F(4, 112) = 8.66$, $MS_e = 9.02$, $p < .0001$]. G1 and G2 recalled more objects than G3, G4, and G5-6 [$p < .06$], and G3 recalled more objects than G5-6 [$p < .001$]. On the contrary to the number of recalled objects for the school building, the number of recalled objects for the playground decreased over time. Outdoor subjects recalled more objects than indoor objects (5.4 vs. 4.2), but the difference was not significant.

The level of certainty. The level of certainty was scored as *one* for the least certain level and *five* for the most certain level so that the score ranged from one to five. Table 4 shows the mean level of certainty for each year and activity group. A year (5) × activity (2) ANOVA resulted in the main effect of year [$F(4, 105) = 3.26$, $MS_e = 0.60$, $p < .01$]. G1 and G2 rated higher than G4 and G5-6 [$p < .01$], and G3 rated higher than G5-6 [$p < .04$]. The level of certainty decreased over time.

Relationship between area and the number of objects, and relationship between area and the level of certainty. The filling-in hypothesis predicts the positive correlation between area and the number of objects. It was significant for the playground [$r = 0.42$, $p < .001$] and swimming pool [$r = 0.31$, $p < .001$]. The correlation for the school building was in the same direction [$r = 0.11$] but was not significant. On the other hand, the certainty hypothesis predicts the positive correlation between area and the level of certainty. Although the area for playground positively correlated with the level of certainty [$r = 0.20$, $p < .02$], other results were inconsistent: There was no relation between the swimming pool and the level of certainty [$r(101) =$

Table 3
Mean number of recalled objects in Experiment 1

Regions		Year group					
		G1	G2	G3	G4	G5-6	Total
School building							
Outdoor	*Mean*	7.8	16.7	8.7	13.2	18.2	12.2
	SD	13.3	14.7	10.9	11.1	14.6	13
	N	14	12	8	12	4	50
Indoor	*Mean*	5.6	14.3	13.2	15.8	11.2	12
	SD	7.6	14.8	14.7	9.7	7.1	11.3
	N	10	18	10	8	23	69
Total	*Mean*	6.9	15.4	11.2	14.3	11.8	12.1
	SD	11.1	14.3	13	10.4	8.7	11.9
	N	24	30	18	20	27	119
Swimming pool							
Outdoor	*Mean*	0.6	0.6	0.2	0.2	0	0.4
	SD	1.1	1.2	0.4	0.4	0	0.9
	N	13	12	5	10	4	44
Indoor	*Mean*	1	1.1	0.2	0.6	0.5	0.7
	SD	1.1	2.4	0.4	1.7	0.9	1.5
	N	11	16	9	8	16	60
Total	*Mean*	0.8	0.9	0.2	0.3	0.3	0.6
	SD	1.1	1.9	0.4	1.1	0.8	1.3
	N	24	28	14	18	20	104
Playground							
Outdoor	*Mean*	6.5	6.3	5.3	4.3	1.2	5.4
	SD	3.7	2.7	2	2.1	0.5	3
	N	14	14	8	12	4	52
Indoor	*Mean*	6.2	6.4	4	2.2	2.2	4.2
	SD	4.5	3	2.5	2.6	2.7	3.6
	N	11	18	10	8	23	70
Total	*Mean*	6.4	6.4	4.6	3.5	2.1	4.7
	SD	4	2.8	2.3	2.5	2.5	3.4
	N	25	32	18	20	27	122

Table 4
Mean level of certainty in Experiment 1

Regions		Year group					
		G1	G2	G3	G4	G5-6	Total
Outdoor	*Mean*	4	3.7	3.5	3.8	3.2	3.7
	SD	0.6	0.6	0.7	0.7	0.5	0.6
	N	13	12	8	10	4	47
Indoor	*Mean*	3.9	4	3.9	3	3.1	3.5
	SD	0.7	0.8	0.8	1.1	0.7	0.9
	N	10	17	10	8	23	68
Total	*Mean*	4	3.9	3.7	3.4	3.2	3.6
	SD	0.6	0.7	0.8	1	0.7	0.8
	N	23	29	18	18	27	115

Table 5
Appearance of facilities at a revisit in Experiment I: percent of subjects who chose each phrase

	Year group					Activity		
	G1	G2	G3	G4	G5-6	Out	In	Total
Narrower/Smaller	13	31	12	61	32	21	34	27
Others	87	69	88	39	68	79	66	73
N	32	35	25	18	38	75	73	148

0.07], and the correlation was in opposite direction for the area of school building [$r(116) = -0.16$]. Increase and decrease of area seems to be better accounted for by the filling-in hypothesis.

The appearance of school at a revisit. Out of 158 alumni, 148 made at least a revisit to the school. The number of revisit ranged from 1 to 30+, and the last revisit ranged from less than a month before to 16 years before. Although the number of revisit as well as time of the last revisit could influence the memory for area, data were pooled together so that impression at the revisit could be analyzed. Otherwise, the number of data for each condition would be very small.

No one chose opposite adjectives (e.g., *narrower* and *wider*) at the same time. Table 5 shows the number of subjects who chose narrower or smaller. Although a half of subjects answered that the appearance did not change, if any change occurred, it tended to be *narrower* or *smaller* than *wider* or *larger* [$\chi^2(1) = 38.09$, $p < .001$]. It is notable that even at a month after graduation (G1), thirteen percent of subjects found the school narrower or smaller. As to the activity, 34% of indoor subjects found the school *narrower* or *smaller* while 21% of outdoor subjects did so, although the difference was marginal [$\chi^2(1) = 3.07$, $p < .10$]

Is there any difference between the area drawn by subjects who found the school *smaller* or *narrower* and the area drawn by subjects who found it otherwise? Recalled area for the school building and playground were greater for those who chose narrower or smaller, but the difference was significant for only the school building [22.15 vs. 19.45, $t = 2.04$, $p(168) < .025$]. The greater image of area, which presumably causes the gap between the remembered area and the actual one, may explain the experience that one finds a revisited place smaller.

Discussion

Not only retention intervals but also campus knowledge affected recalled area of the playground: The area drawn by outdoor subjects was significantly larger than that of indoor subjects, and it tended to remain unchanged while that of indoor subjects decreased over time. Moreover, there was positive correlation between recalled area and the number of recalled objects, supporting the filling-in hypothesis. It is noteworthy that subjects did not necessarily draw a realistic picture of object but in many cases only put down the label of object. Hence it seems not the physical size of objects drawn in the map but the imaged size of objects that affected the size of recalled area.

It is intriguing that the number of recalled objects was greater for elder alumni than younger ones. A feasible explanation is that elder alumni recalled objects using general knowledge of school building or building schema and thus could remember well even after long intervals, while younger alumni tried to recall objects from their memory which resulted in less number of recalled objects. In fact, of 2 236 objects recalled in the school building, 60% were the rooms that could be inferred from school subjects (e.g., a

math. room, a science lab., a language room, a music room, an art room), and 20% were the parts of buildings (e.g., an entrance, staircases, a hallway, bathrooms) that could be inferred from a building schema.

Turning to the correlation between area and the number of objects, it is possible, however, that it reflected only general accessibility of campus memory but there is no causal relationship between each other. In Experiment 2, we examined whether or not recalling objects affected the size of recalled area. We asked undergraduates to draw a layout of their junior high school, and then to remember objects in a particular place, either the school building or the playground. Subjects did not have to draw a picture in the layout but only put down the name of object on the side of map. Then we asked them to draw a layout once again. Of main interest was the change of area for the school building and playground between the first and second drawing. The filling-in hypothesis predicts that the subjects who recalled objects in school building would draw the building area larger in the second layout, whereas the subjects who recalled objects in the playground would draw the playground area larger in the second layout. Nevertheless, it is expected from the results of Experiment 1 that the change will be more drastic for the playground condition than for the building condition: In the latter, subjects may recall/infer many objects in the first drawing so recalling objects may not adds up much.

As for the appearance of school, the school building was suggested to be the place where the change occurred. In Experiment 2, the appearance is assessed for each facility separately.

Experiment 2

Method

Subjects. Subjects were 186 freshmen and sophomores of Chiba University who were taking educational or developmental psychology course. They received a course credit by participating in this experiment. Subjects were randomly assigned to one of three recall conditions: The building condition (N = 66), the playground condition (N = 65), and the control (N = 55). Because the students were from all over Japan, no one was expected to graduate from the same junior high school. As in Experiment 1, subjects were partitioned into two groups: *Outdoor subjects* and *indoor subjects*.

Materials and procedures. The task and questions were given in a written form. First, subjects were asked to draw a layout of junior high school from which they graduated. A space of 13.6 cm × 13.7 cm was provided. The instruction was the same as in Experiment 1 except that they did not have to draw the layout in detail as long as it showed the shape and location of school buildings. They were then asked to rate the level of certainty. Next, they were instructed to recall as many objects as they could in (1) the school building (the building condition), (2) the playground (the playground condition), or (3) the vicinity of campus (the control). The instruction for the building condition was "Recall as many objects in *the school building / the playground / the vicinity* as possible. Write them down in the following underlined blanks." Twenty underlined blanks were provided. The subjects were then asked to draw a layout once again in a space of the same size on a different page, and to rate the level of certainty. An instruction was added saying that the second drawing did not have to be the same as the first one. Finally, as in Experiment 1, they were asked to choose a phrase to describe the appearance of facilities. They chose a phrase for the entrance of school building, the school building, the gym, and the playground separately. The phrases were (1) *the same as before*, (2)

Table 6
Mean recalled areas in Experiment 2

	Building		Playground	
Conditions	First	Second	First	Second
Building	14.2	14.5	41.0	39.7
$N = 58$	(7.8)	(10.6)	(14.6)	(13.7)
Playground	13.6	12.8	39.6	43.5
$N = 63$	(6.3)	(7.3)	(15.8)	(18.5)
Control	12.2	11.3	39.0	39.5
$N = 54$	(6.9)	(6.2)	(17.4)	(14.3)

Note: Parentheses indicate *SD*s.

smaller than before, (3) *larger than before*, and (4) *others*.

Design. A 3 (recall conditions: building condition / playground condition / control) × 2 (activities: outdoor / indoor) × 2 (drawings: first / second) mixed design was used. The former two factors were between-subjects.

Results and Discussion

The area. The relative recalled area was calculated for the school building and playground in the same way as in Experiment 1. Eleven drawings were discarded because the playground was not drawn or the campus was drawn in perspective. Table 6 presents the mean relative recalled area in each condition. Figure 4 shows the interaction of recall condition and drawing.

A 3 (recall conditions) × 2 (activities) × 2 (drawings) ANOVA was conducted for the school building and the playground separately. As for the school building, the main effect of activity was significant [$F(1,169) = 5.29$, $MS_e = 88.97$, $p = .02$]. Indoor subjects drew the school building larger than outdoor subjects [$p = .02$][3]. The change between the first and second drawing was in the predicted direction, i.e., the area increased from the first drawing to the second for the building condition, while it decreased for the playground and control conditions. However, the difference was not significant.

As for the playground, the interaction of recall condition and drawing was significant [$F(2,169) = 3.83$, $MS_e = 65.47$, $p = .02$]. The second drawing was larger than the first one for the playground condition [$p = .004$] while no difference was observed for the building condition and the control. Again, the filling-in hypothesis was supported.

The level of certainty. Eighteen subjects changed their ratings between the first and second drawings. Nine became more certain and nine became less certain. The level of certainty does not seem to be associated with recalling area.

The appearance of facilities at a revisit. One hundred and twenty-six subjects made at least a revisit. Table 5 presents the results. Although 21 to 56% of subjects judged the area to be *the same*, if any change occurred, it was apt to be *smaller* than to be *larger*. Four facilities altogether, *smaller* was chosen more often than *larger* [$\chi^2(1) = 42.10$, $p < .001$].

A 3 (description: *same / larger / smaller / other*) × 4 (facility: the entrance / the school

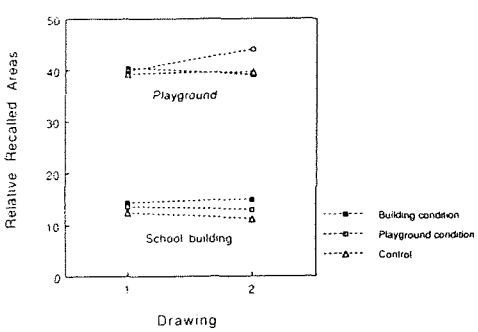

Figure 2. The relative recalled area (unweighted means) in the first and second drawing in Experiment 2.

[3] It is not clear, however, whether the difference is due to activity itself or incidental: Indoor subjects could happen to be those who graduated from schools where school buildings were large. Since there was no interaction of drawing and activity, we do not further discuss the main effect of activity.

Table 7
Appearance of facilities at a revisit in Experiment 2: percent of subjects who chose each phrase

	Facility				Activity		
	Entrance	School bldg.	Gym	Playground	Out	In	Total
Same	56	41	37	21	39	32	37
Larger	06	06	13	05	06	09	07
Smaller	17	29	25	21	23	23	23
Others	20	24	26	52	30	29	30
N	125	123	126	126	313	187	500

building / the gym / the playground) χ^2-test was conducted. The result was significant [$\chi^2(9) = 56.14$, $p < .01$]. The entrance was judged to be *the same* most often [$t_d = 4.71$, $p < .01$], and the gym was judged to be *larger* relatively often [$t_d = 2.80$, $p < .01$]. The school building was judged to be smaller compared with other facilities, although it was marginal [$t_d = 1.71$, $p < .10$]. The result is in accordance with that from Experiment 1, where the school building seemed to be the place where subjects found smaller.

General Discussion

The purpose of this study was to investigate the effect of retention intervals and campus knowledge on memory for natural area. In particular, we were interested in whether the recalled area changed in relation to the number of recalled objects and/or the level of certainty. Experiment 1 showed that campus knowledge as well as retention intervals affected the area for playground. Also, area positively correlated with the number of objects but not consistently with the level of certainty, supporting the filling-in hypothesis rather than the certainty hypothesis. In Experiment 2, we showed that area was drawn larger after recalling objects within the area. All in all, the filling-in hypothesis, which assumes that long term memory for area is reconstructed from other source in the environment, seems to be sustained. Although it should be fortified by further research, the basic findings can be incorporated with the currently developed theories that emphasize the constructive aspects of cognitive map (Bahrick, 1983; McNamara et al., 1989; Merrill & Baird, 1987; Okabayashi & Glynn, 1984; Sherman & Lim, 1991; Stevens & Coupe, 1978; Tversky, 1981; Tversky, 1992).

The second aim of this study was to assess the subjective impression of revisited area. Results showed that impression tended to be *smaller* or *narrower* than to be *larger* or *wider*. Because those who found the school *smaller* or *narrower* drew the area larger (Experiment 1), the phenomenon may be accounted for by the gap between the memory representation of area and the actual area. An area for familiar place like a school building may be overestimated because it contains many familiar objects. Thus, when revisited, it may appear to be smaller. Although an alternative could be the change in subjects' height, i.e., the taller one grows, the smaller one may see the area, it must not be the only reason because 13% of one-month alumni already reported that the school looked *smaller*. One would not grow so tall in a month.

Finally, the methodology needs to be reconsidered. Besides the interdependency of estimation that was already discussed, there may be another problem of purposeful drawing. Although the accuracy was stressed indirectly by the attached question on the level of certainty, and no emphasis was made

on any particular facilities, one might purposefully draw an important facility larger so that it stood out. It is indeed difficult to distinguish purposeful drawing from reflection of a naive cognitive map. After all, what the diagrams showed might be the subjective importance of areas: The facility of more importance was drawn larger than that of less importance as seen in Tversky (1992). Even if so, however, it is exactly what the constructionist view predicts, and therefore it does not jeopardize the conclusion drawn from this study. Nevertheless, further studies are necessary to determine whether or not the results are free from methodology.

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