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An Experimental Study of Article-Finding Behaviors in a Shopping-Around Situation

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1 ABSTRACT

This paper reports, an experiment of 'article-finding behaviors (AFBs)' that are a typical shopping-around situation, under the following:

(1) incompleteness of mental-map, (2) loose time-constraints, (3) plural errands to be achieved, and (4) free walking in any remaining time.

Spatial behavior and cognition are measured by using an improved thinking-aloud-protocol method, GPS loggers, and video.

AFBs are often compared with 'way-finding behaviors' with a given goal point.

The findings are: (1) the layers of goal-subgoal of AFBs are fewer, (2) changes of the mental-map are observed, (3) walking speed is not different, and (4) walking routes are significantly different.

2 RESEARCH BACKGROUND AND OBJECTIVES

Modeling and simulation of downtown visitors' behavior is a great potential technique for supporting urban planning and design, thus one of the authors is recently tackling with research and development of a shop-around agent model. Recent research issues include agents' space cognition in their shopping-around situation.

A common factor of the typical shopping-around behavior observed in downtown is that (1) an actor's mental map of the district is incomplete, and the following can be observed: (2) under loose time-constraints; (3) they have plural tasks; and (4) they spend the remaining time strolling. It can be considered that complicated spatial cognition is involved in such spatial behavior; however, serious research has not been conducted yet.

Our research examines this kind of behavior as "article-finding behavior," and an experiment was conducted in the Osu district, Nagoya City; this research explores the characteristics of spatial cognition and behavior, through analyses employing the thinking-aloud-protocol method, and GPS loggers. In particular, this research clarifies the characteristics of article-finding behavior by comparing them to the experimental results of "way-finding behavior" with a focus on going to a given destination with an incomplete mental map.

3 EXISTING RESEARCHES AND FRAMEWORK OF THIS RESEARCH

This research focuses on shopping-around situations. As existing research on shopping-around behavior, questionnaire surveys by Takeuchi et al.(2011) and Oiwa et al.(2005) have been reported. In their research, to examine shopping-around behavior, in other words, typical behavior observed while shopping in a retail area, data for the shops visited or walking routes was collected by a questionnaire and analyzed; however, such research did not record or analyze the recognizing and thinking processes of a pedestrian while shopping, or the apparently insignificant behaviors that reveal these shopper's process. Therefore, this research defines general behavior while shopping, as the shopping-around situation, which includes not only walking-around behavior, but also cognitive behavior such as obtaining information by close observation or from studying a map. The methods described below are employed for analysis.

Section 4 describes the experiment, and Section 5.1 analyzes the spatial cognition that is seen when searching for articles, by employing the thinking-aloud-protocol method of Ericsson & Simon(1993). The section further conducts analysis by using the improved way-finding codes proposed by Hiiro et al.(1994) Then, by comparing the experimental results obtained this time with the results of the way-finding experiment previously conducted by Nakamura et al.(2011), the characteristics of article-finding behavior are clarified. Section 5.2 refers to the rough sketch maps to analyze spatial understanding used by Lynch (1960), and describes a map sketching exercise conducted to explore any relation between changes to the

before and after mental maps of each participant and their cognition level of the district (Funahashi, 1991a,1991b). In Section 6.1, with a focus on pedestrian insignificant behaviors, in a similar way to the analysis of finding behavior by Miura(2008), Mori & Oku(2002), and Suzuki et al.(2001), our research considers insignificant behaviors during the experiment, and examines the relation between spatial cognition and spatial behavior in article-finding behavior. Section 6.2 compares the walking route and walking distance of each participant, and from the viewpoint of route analysis, analyzes article-finding behavior in shopping-around situations.

4 ARTICLE-FINDING EXPERIMENT IN A SHOPPING-AROUND SITUATION

4.1 Classification of shopping-around behavior and selection of participants

In a large shopping street district, on a daily basis the structure and layout is daily changing its features; therefore, it is usual the visitor's memory, or their mental map would be incomplete. The experiment mainly focuses on the level of completeness of the visitors' mental map, in other words, the cognition level of the district (thereafter the cognition level). In the experiment, these levels were classified into three categories: High, Average, and Low.

To discover differences in visitors' cognition and behavior according to the cognition level, a questionnaire survey1) was first conducted among 21 university students to establish the cognition level, and a total of 8 students were selected as participants (3 High, 2 Average and 3 Low).

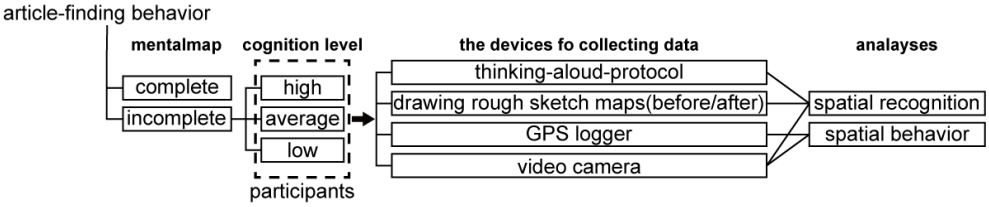

Fig. 1: Classification of article-finding behavior and its measurements

4.2 Experimental method of article-finding behavior

The experiment was conducted in the daytime on a non-rainy day in the Osu district, Nagoya City (Fig. 2). The Yabacho intersection was set as the starting point, and the following instructions were given to the participants: "Locate one example of each shop selling flowers, taiyaki pancake (fish-shaped pancakes filled with bean jam), or flashlights, (one shop per article). Return to the starting point within 60 minutes." Participants were given total freedom to decide the order of search for each article and how to allocate their time; they could also engage in free strolling at anytime. They were not allowed to carry a map of the district, but could refer to wall maps, signs, etc.

The thinking-aloud-protocol method was used to collect data. More specifically, participants were requested as much as possible to report out loud any thoughts that entered their minds; each participant was accompanied by an experimenter whose purpose was to encourage them to speak by asking appropriate questions. This spatial cognition process was collected as data by using a video camera to record speech and behaviors, and a GPS logger to track the actual walking route and speed. In addition, to explore any relation between their district cognition level and any changes of their mental map, before and after the experiment the participants drew a rough sketch map of the Osu district on a sheet of white paper.

4.3 Coding of thinking-aloud-protocols

The obtained thinking-aloud-protocols were segmentalized at each pause or at the end of a sentence, and then encoded as shown in Table 1. The codes employed were established by Nakamura et al.(2011), who added codes to the basic reference work of Hiiro et al.(1994), and moreover, in this research, to encode any remarks made by participants when they were unable to find their target store or article in a location where they had guessed they might find it, a new code "#: Awareness" was added.

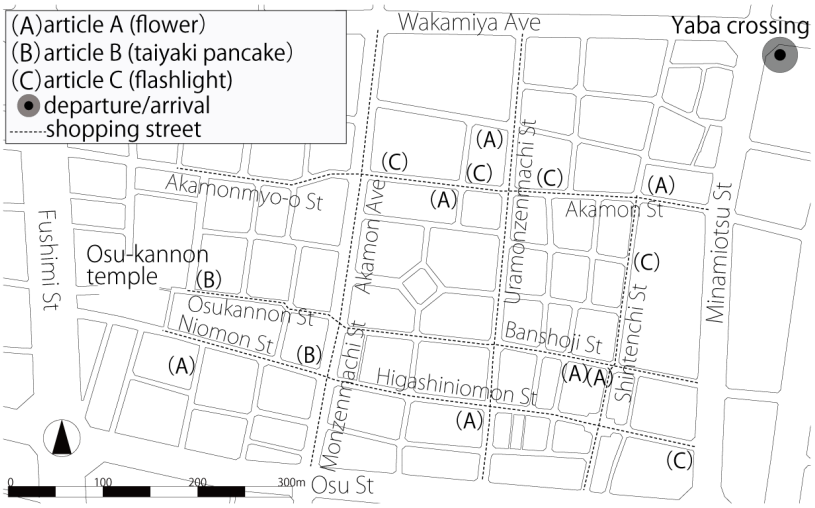

Fig. 2: Osu district map and Shop locations sell the articles

	code	name	example
directions-information	V	view	visual information
	S	sign	check information (map,traffic-sign)
	M	memory	remember the place of the store
plan	Ap	plan A	go to the specific area
	Bp	plan B	do something for the time being
	Cp	plan C	go with feeling
	Dp	plan D	return
expressing emotion	?	lostness	"let me see..." "umm..." "I' m lost."
	!	finding	"I know!" "I see."
	#	awareness	"There' s no it in the place which intended."
	code	**thinking-aloud-protocol about lostness**	
cause of lostness	α	failure of the movement to the destination	
	β	cannot grasp the current place	
resolution of lostness	α'	quick fix	
	β'	check information (map,traffic-sign)	

Table 1: Code system of thinking-aloud-protocols

5 ANALYSIS OF THE CHARACTERISTICS OF SPATIAL COGNITION IN THE ARTICLE-FINDING EXPERIMENT

5.1 Goal-subgoal analysis of article-finding behavior found by

A sub-goal refers to a partial goal condition that is formed to help fulfill a goal (fulfillment of goal conditions). Fig. 3 shows a typical case of analyzing the sub-goals and two goals of a participant, and Fig. 4 shows their walking route, and the spots where they made any remarks. As a method to organize the analysis, the process from each sub-goal formation through to fulfillment is represented by one box. Remarks that could be interpreted as being made during the process of achieving the sub-goal are given on the right side of the box. For example, the sub-goal of Remark No. 7, which was set to achieve the sub-goal set in Remark No. 6, is shown on the right side of the No. 6 box.

At Remark No. 2 in Fig. 3, the participant commented on a shop where they thought the article would be sold; however, they noticed that they were unable to find that particular shop (#), which indicates that the newly added code in this research enabled us to encode pedestrian behaviors more accurately. Moreover, in all district cognition levels, one particular result was observed: the participants found a shop which they thought was likely to sell a target article, but they were unable to find the article (#).

Next, the results of the article-finding experiment and the way-finding experiment were compared. The article-finding experiment gave "plural tasks" to examine "article-finding behavior," whereas the way-finding experiment gave "a single task" to examine "way-finding behavior."

Remarks No.		Participant : O.N The cognition level : High
1	(Ap)	First, Let's look for three articles.
2	Ap	First, I head to taiyaki pancake(article B) and go this street ahead.
3		M There will be taiyaki pancake shop in this street.
4		# There's no it in the place which intended.
5	Bp	For now I turn into the street, Banshoji St..
6	MAp	I go the street that used to visit.
7	Ap	to the left.
8	Ap	I walk the length of this street.
9		!V There's a wall map, so I verify the place for taiyaki pancake shop.
10	SAp	I go ahead on schedule.
11		!V I found taiyaki pancake shop.
12	Bp	First of all, I go ahead.
13	Ap	I go a far street.
14	VBp	I turn left because it is a main street.
15	VBp	If I keep going ahead, there seem to be nothing. So I turn into Akamon St..
16	!V	That store seem to be selling a flashlights(article C) so I go in.
17		!V I found it.
18	VBp	There seem to be no stores ahead so go right.
19	Bp	I try to go right.
20	Bp	I go left.
21	VBp	If I go right, I would come back the street that have walked through. So to the left.
22	Bp	to ahead.
23		!V I found flower shop(article A).
24		All tasks were finished.
25	(Ap)	I put in the time by strolling around.
26	Bp	to the left.
27	VBp	I stop at that book shop.
28	Bp	to the right.
29	Bp	to the right.
30	Ap	I keep returning to the starting point.

Fig. 3: Goal-subgoal analysis of article-finding behavior, a typical case

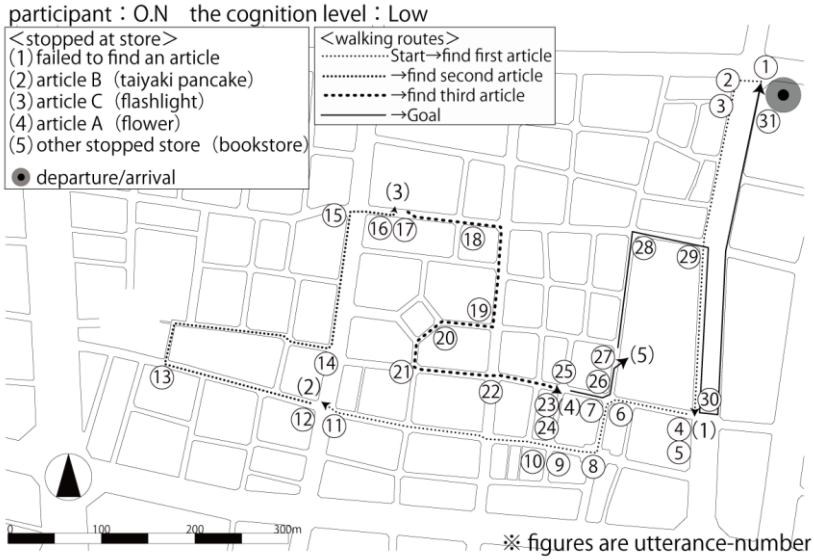

Fig. 4: Walking route and the spots where he made any remarks, example

Fig. 5 shows a distinct difference between these two approaches: in the article-finding experiment fragmentary subgoals were created and only a small amount of the stacking of subgoal layers was found; on the other hand, in the way-finding experiment, sub-goals tended to stack up in several layers. This can be attributed to the following: since the specific destination spots in the article-finding experiment were not given, participants needed to immediately decide whether to change or fix a (sub-)goal in response to the on-the-spot situation.

The second difference involved the creation of subgoals based on sign information. In the wayfinding experiment fewer and 'longer-term' sub-goals were created. In the article-finding experiment, when many tasks were still left to be fulfilled, relatively 'shorter-term' subgoals were created, and when only a few tasks remained, 'longer-term' subgoals were created. These results could be attributed to the following factors: when many tasks were left, acquisition and organization of information was complicated; however, as the number of tasks decreased, acquisition and organization of information became simpler. In addition, in the article-finding experiment sub-goal creation based on visual information was often observed. It would seem

that in response to the changing situation, participants needed to obtain visual information from their immediate surroundings.

"Free strolling" was observed for all participants after they fulfilled all their tasks. Many of the participants at that time drew up subgoals to return to the starting point more or less straightaway, but often by chance, as they found other activities that interested them, they tended to engage in alternative temporary behaviors, and subgoal creation decreased.

Goal-subgoal analysis allowed us to clarify the characteristics of spatial cognition recognized during "free strolling," "article-finding behavior," and "the fulfillment of plural tasks."

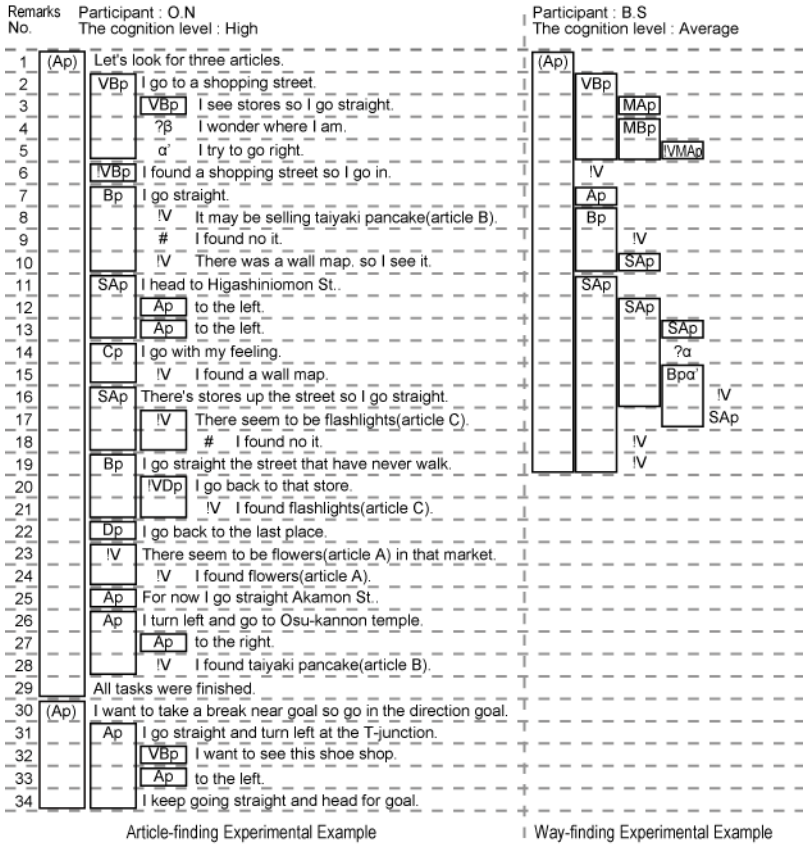

Fig. 5: Comparison between article-finding behavior and the way-finding behavior

5.2 Article-finding behavior found by mental map analysis

To analyze any change to their mental maps, each participant drew a rough sketch map of the Osu district and its environs on a sheet of white paper before and after the experiment (Table 2).

Generally speaking, pre-experiment sketch maps showed that participants with a High district cognition level did not demonstrate any error concerning the locations of shops and streets, although there were differences between individual participants. Post-experiment maps of all three participants showed high accuracy of the overall picture of Osu, and also shops other than those inolved in task fulfillment were added along with those side routes seen during the experiment, but not explored. These results could be attributed to the following factors: since the initially-held mental map was highly accurate, the amount of information to be newly obtained was less, allowing for easier organization. It can be said that the participants with a High cognition level made additions to and improved their mental maps.

Pre-experiment sketch maps of participants with an Average district cognition level showed an ambiguous positional relationship with low accuracy concerning the places that they had visited and the immediate neighborhood. In the post-experiment maps, they were able to draw the whole Osu district, and showed improved accuracy of the positional relationship among shops and streets. When compared to the participants with the High level, apart from those shops involved in task fulfillment, overall they drew fewer shops, and the streets drawn were mostly those that they had walked along during the experiment, and few side routes were shown. From these results it can be said that although they had a mental map, there were

mistakes in important parts, and therefore, they tended to correct mental-map errors by using information obtained in the course of their behaviors.

Pre-experiment, participants with a Low district cognition level were hardly able to draw a map. On the post-experiment map, they only partially depicted the task shops and the streets they had walked, and errors were found in the linkage of fragmentary information. This could be attributed to the following factors: the information obtained was all new, and they were unable to completely process it. From this finding, it can be said that the participants with a Low cognition level created a slightly better mental map.

As mentioned above, the participants were requested to draw a mental map as an actual map, and according to the different cognition levels, corresponding changes to the mental maps were observed. From the results of the experiment, it can be inferred that the accuracy of a mental map is improved through the following stages: creation > revision > addition, and in the early creation stage a larger workload is undertaken.

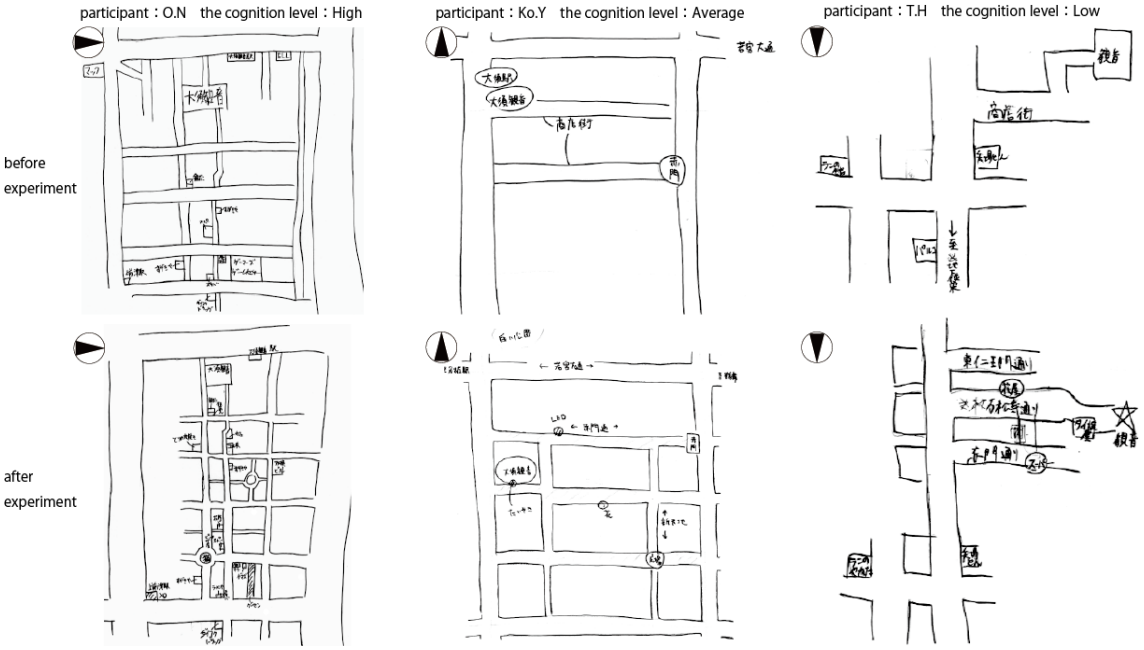

Table 2: Sketch maps before and after the experiment

6 ANALYSIS OF THE CHARACTERISTICS OF SPATIAL BEHAVIOR IN THE ARTICLE-FINDING EXPERIMENT

6.1 Article-finding behavior found by walking speed analysis

Table 3 shows the results of all participants. Their walking speeds were collected at 2-second intervals by GPS loggers to analyze the characteristics of spatial behavior in the article-finding behavior. Firstly, 343 spots, where the walking speed decreased by 1km/h or more, were extracted, and then by comparing with video images, 56 spots, where the drop in speed was caused by a positioning error of the GPS logger, were removed. Consequently 287 spots were selected as data.

The data was analyzed and the main causes for any walking speed decrease were classified into the following 4 categories: 1) Traffic, e.g. waiting for traffic lights to change or vehicles to pass; 2) Pedestrian congestion; 3) Acquisition and confirmation of visual information, e.g. checking shops; and 4) Consideration, e.g. checking a map.

The cognition level		High			Average		Low		
Participants		K.N	O.N	N.T	Ko.Y	Ku.Y	A.H	T.H	K.H
Times of retracing		0	0	1	1	3	3	2	2
Times of revisiting the intersection		0	0	0	1	2	4	3	3
Spots to stop in after article-finding		Restaurant,Temple	BookShop	Clothing Shop	none	Clothing Shop,SmokingArea,Toilet	none	ShoeShop	Shrine
Walking distances [m]	During finding	1113	1943	1338	2027	2010	2203	2040	2070
	After finding	905	875	812	1082	829	962	945	1419
	Total	2018	2818	2150	3109	2839	3165	2993	3489
Duplicated walking distance ratio [%]	During finding	0%	0%	4%	2%	14%	12%	12%	8%
	After finding	50%	20%	5%	39%	78%	83%	100%	72%
	Total	22%	6%	5%	15%	33%	33%	40%	34%
Having time to find an article [m:s]	1st	8:45	18:35	14:05	12:50	10:55	14:15	29:25	11:10
	2nd	12:25	35:25	28:10	24:05	22:40	34:30	31:55	20:20
	3rd	20:45	46:10	38:15	42:05	38:25	45:25	44:45	38:55
Times of walking speed decreas	Visual information	14	25	23	24	23	24	32	20
	Consideration	2	3	4	6	2	4	3	3
	Traffic	11	9	2	8	3	8	21	13

Table 3: Result summary of the Experiment

Next, each point of time the walking speed decreased was recorded on a walking speed graph as shown in Fig. 6. In addition, the walking speed decrease spots of the participant and their route are shown in Fig. 7. As a result, once they entered into the shopping street, the frequency of "acquisition and confirmation of visual information" increased, along with a constant decrease in the speed of walking, compared to before the entering the shopping street. This could be attributed to the following factors: the participant, upon entering a shopping street, was bombarded by a large amount of information, and they maintained a slower walking pace while constantly obtaining and organizing this new information. It was also observed that they often stopped when they tried to obtain information actively.

After the fulfillment of all tasks, there was a drop in the frequency of walking speed decrease incidents due to "acquisition and confirmation of visual information" and "consideration." It can be inferred that since the participants had fulfilled their tasks, there was no need to actively obtain or search for information. In particular, those participants with a Low cognition level did not need to obtain information because they simply retraced their steps along their route (described in Section 6.2). Moreover, when the speed decreased due to "acquisition and confirmation of visual information," in most of these cases the participants had found something of interest to them.

These results did not show clear differences according to the district cognition levels. It can be inferred that this was true even of those participants with a High cognition level, who knew the street map well, but did not know exactly the kinds of shops and their locations, and thus they too needed to constantly obtain and organize information. From this finding, it can be said that walking speeds in article-finding behavior are not affected by the level of completeness of a mental map.

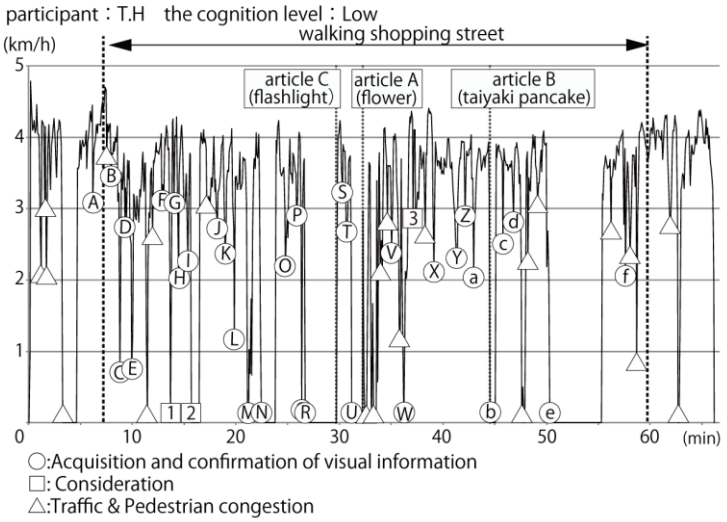

Fig. 6: Walking speed analysis on article-finding behavior, example

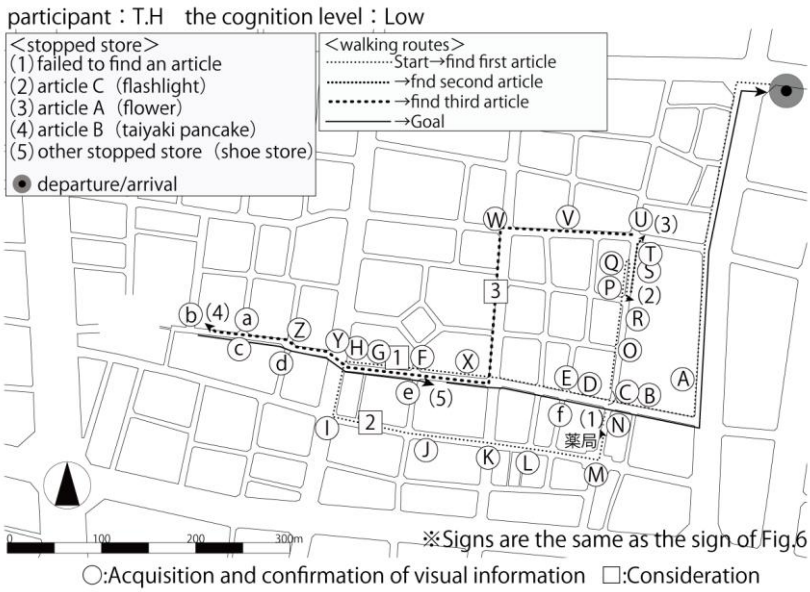

Fig. 7: Walking speed decrease spots of the participant and his route, example

6.2 Article-finding behavior found by route analysis

Table 3 shows the number of times the participants retraced their steps, which is a return behavior during article-finding, and the number of times they revisited any intersection. In both cases, the participants with a Low district cognition level tended to demonstrate higher scores. The main cause of retracing was that the shop or article was not found at a supposed location (8 out of 12 cases). The main reason for this can be considered as follows: being unable to find their target shop or article, and not knowing the way ahead, they started feeling uncertain, and turned back. Those participants with a High cognition level in the same situation were able to rely upon their mental map and move ahead, which resulted in a difference in the number of times of retracing.

Revisiting the same intersection due to retracing was observed in 7 out of 13 cases, and revisiting the same intersection from a different street was observed in the other 6 cases. It can be inferred that the participants with a Low level did not know how streets were connected, and thus retraced their steps.

Table 3 also shows analysis of walking routes and walking distances. The duplicated walking distance is the total of all the instances when participants walked along the same route, and the duplicated walking distance ratio indicates to what extent they walked the same street during searching and after searching.

On the whole the results indicate that the participants with a High cognition level showed a low value for the duplicated walking distance ratio during searching, whereas all participants with a Low cognition level showed a value around 10 %; this is caused by the retracing of the participants with a Low level. In addition, regarding the duplicated walking distance ratio after searching, the participants with a High level showed a low value, whereas the participants with a Low level showed high values with 72 % to 100 %. It can be said the participants with a Low level had a tendency to retrace their steps towards the final goal point without deviating. This could be attributed to the following factors: they held back from active strolling behavior so as to comply with the given final goal and time restriction.

7 CONCLUSION

The results obtained by this experiment are summarized as follows:

- From the goal-subgoal analysis employing the thinking-aloud-protocol method with the additional Awareness code, the cognition process that is characteristic of article-finding behavior was examined. When compared with way-finding behavior, it is characterized by a higher number of small sub-goals, and a lower number of planning layers.
- The experiment enabled the observation of the characteristics of mental maps and any changes. It can be considered that mental maps change through the stages of creation > revision > addition.

- In article-finding behavior, it is unlikely that walking speeds are affected by the level of completeness of the mental map.
- In terms of walking routes, differences among the district cognition levels were found in retracing and duplicated walking distances.

As shown by the above results, this article-finding experiment enabled the clarification of the characteristics of spatial cognition and spatial behavior in article-finding behavior.

Since the experiment was conducted under time constraints and the participants had limited time for exhibiting free strolling behavior, we were unable to conduct deeper analysis. Therefore, in the future, using several different kinds of analysis, there is a need to conduct an experiment focused on exploring the characteristics of free strolling behavior.

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9 NOTES

To select participants, a questionnaire survey was conducted to establish the frequency of visits to the target district, and to ascertain the respondent's knowledge concerning 11 facilities in the district. Respondents chose one of five levels of answer, which ranged from: "I can give directions to this facility (1 point)" through to "I do not know the way to this facility (5 points)." In addition to the knowledge score of facilities in the district, the frequency of visits was also taken into account when the district cognition level of the respondents was classified into the following three levels: High: less than 30 points, and one or more visits per month; Average: less than 40 points, and one or more visits per year, but less than one visit per month; Low: respondents who did not qualify as High or Average.