AGE DIFFERENCES IN THE COGNITIVE PROCESS OF SIGN RECOGNITION IN ZOOS:

A CASE STUDY OF SAPPORO MURAYAMA ZOO

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ABSTRACT

The aim of this study was to obtain fundamental data to design zoo signs that are easy to understand by visitors of all ages by using Sapporo Maruyama Zoo as a case-study to identify age differences in the cognitive process of sign recognition. Subjects were divided into three groups, children, young adults and the elderly, and by using synthesized simulated images of signs and landscape photographs from inside the zoo, the time needed to complete tasks, error rate, subjective evaluation and changes in line of vision were evaluated. Results showed that age differences existed in sign seeking behavior and spatial cognition including where a subject was and where s/he wanted to go.

Keywords:
Universal Design, Sign Recognition, Eye-Tracking

INTRODUCTION

People from various age groups, from small children to the elderly, visit the zoo. Consequently, when designing signs for inside a zoo, it is essential that they can easily be understood by visitors of all ages, as well as blending in with the zoo's natural surroundings.

The aim of this study was to obtain fundamental data to design signs that realized the above mentioned criteria by using Sapporo Maruyama Zoo as a case-study to detect age differences in the cognitive process of sign recognition. Sapporo Maruyama Zoo is situated in Japan's most northern metropolis of Sapporo and is unique in that it is surrounded by an abundance of nature, the scenery of which changes dramatically during each of the four seasons. To begin with prototype signs were made and synthesized with actual photos of inside the zoo during the four different seasons: Spring, where leaves on the trees are bright; Summer, where leaves are darker green in color; Autumn, where red and yellow foliage can be seen and Winter, where everything is blanketed in white. Next, simulated images were created where the signs were artificially reconstructed and placed at various points inside the zoo. Finally, the simulated images were shown to the three subject groups; children, young adults and the elderly, and data were collected on the conspicuousness and induction properties of the sign, as well as subjective impressions, so that a comparative analysis could be carried out. Subjects were given the task of making their way to a designated animal house by following the sign on the simulated image. The time taken to complete the task as well as the error rate and subjective evaluation were recorded. By using equipment to trace the subjects' line of vision, subjects' eye movements and the time taken to stop and concentrate on certain points was recorded.

THE BASIC CONCEPT FOR THE SIGN PROTOTYPES

Based on the aforementioned study aim, the basic concept for the sign prototypes was as follows:

1. They should be easily understood by visitors of all ages- from children to the elderly.
2. They should blend in with features distinct to the zoo, such as the abundance of natural surroundings, including a primeval forest, as well as being highly conspicuous during all four seasons.
3. By using animal pictograms as the main design, they should not only be easy to

Figure 1. Prototypes for the 4 signs

understand but also fun to read.

4. There should be the following four types of signs:
   a. general guidance signs
   b. present location signs
   c. directional guidance signs
   d. signs for the names of each building.

EVALUATION OF THE EXPERIMENT USING THE SIMULATED SCREEN

PURPOSE OF THE EXPERIMENT.

The purpose of the simulated experiment is as follows:

1. To obtain data on the conspicuousness and induction properties of the signs from the three subject groups: children, young adults and the elderly, during the four distinct seasons at Sapporo Maruyama zoo, where dramatic changes in the scenery were artificially created, in order to perform a comparative analysis.
2. To analyze any difference found among the 3 subject groups, elucidate any considerations that had to be made when proposing signs for children and the elderly and to obtain guidelines for the final draft of the sign design.

OUTLINE OF THE SIMULATED EXPERIMENT

The prototype signs were artificially replicated inside the zoo by synthesizing photos and subjects were given a simulated task of finding a designated route. At the same time, their line of vision was traced and finally, a subjective evaluation of the signs was

Figure 2. A child (left) and elderly person (right) taking part in the experiment

obtained. Eye tracking took place using T60 Eye Tracker (Tobii Inc.). A computer with WindowsXP operating system was used to display the simulated screen and control eye tracing. With regards to the subjects, the distance between the Eye Tracker (including the simulated screen) and the subjects was set at 60cm. Furthermore, the Eye Tracker screen was adjusted so that it was at a right angle to the subjects' line of vision. Finally, when performing the tasks only the left click of the mouse could be used.

STRUCTURE OF THE SIMULATED SCREEN

In the simulated screen there were 12 routine tasks and 6 resting tasks

Routine Tasks

The routine tasks consisted of the following 4 processes:

1) Explanation of the task: "Try and find the route that leads to the 'rabbits'", would be an example of a task asking the subjects to reach a specific destination. Since the age range of the subjects varied considerably, animal names and place names that could be expressed in 'Katakana', a simple alphabet that can be read by children, were used. Subjects would first of all read the instructions and after understanding what they had to do, click on the 'start' button and then begin their task.

2) Finding the signs: After clicking on the 'start' button, a photograph of inside the zoo would appear on the screen as in Figure 3. (2. Finding the Sign). Subjects had to look for the sign within the photograph and when they found it, click on it directly. Actual photos of inside the zoo were used and the sign that was being evaluated was modeled using Shade 10.5 (e frontier, Inc.) to reconstruct images that represented different seasons and different positions of the sun in the sky. The photos were then synthesized using Photoshop CS3 (Adobe Inc.). The actual images used consisted of 12 different photographs: 2 photos of "Spring and Summer"(green leaves), season with leaves at full foliage; 2 photos of "Early Autumn" (leaves changing color), season with autumnal colors; 2 photos of "Late Autumn" (falling leaves), season with falling leaves; 2 photos of "Winter" (snow), season with snow lying on the ground; 2 photos of "Artificial Objects" which represent things that might interfere with the subjects ability to look for the signposts and directional signs inside the various building and 2 photos of "Crowds of people" that were used to reconstruct what the zoo might look like on weekends and public holidays.

3) Reading the Signs: After subjects found and clicked on the sign, as shown in Figure 3. (3.Reading the Sign) an enlarged version of the sign appears on the screen. Once the subjects had read and understood the sign, i.e. they understood where they were and where they have to go to, they clicked on the "X" on the top left hand corner of the sign.

4) Choosing the Route: After clicking on the "X", an image like that shown in Figure 3. (4.Choosing the Route) with the same scenery shown in (2. Finding the sign) appeared on the screen and the options for the route that the subjects could take were marked with numbers and arrows. By understanding where they were and where they had to go to, subjects then considered which sign was pointing in the right direction and clicked on the correct number from the 3-4 possible routes displayed on the screen.

Resting Tasks

Since some of the subjects were children, the 12 routine tasks were divided into 6 and after completing 2 routine tasks a resting task as shown in Figure 3. (5. Resting Task), appeared on the screen to refresh the subjects and stop them from becoming bored. To prevent any "order effect" the aforementioned 12 tasks appeared at random on the screen for each participant. Furthermore, to make it easy for the children to understand, simple adjectives were used and a page was created where subjects could directly enter their impressions of how they found the signs used in the experiment. A record of the operations the subjects performed (the time timing of the clicks and the buttons chosen) was automatically recorded during the experiment.

SUBJECTS

The experiment took place at Sapporo City University (Satellite campus, Geijutsu no Mori Campus) in May, 2010 and involved 28 subjects living in Sapporo city. The demographics of the subjects are as follows:

- The children's group: (aged 5-11 yrs; mean age 7.8 yrs, SD=1.7), (n=12; males 4, females 8).

Figure 3. Test Screen (Order of the Tasks)

- The young adult group: (aged 21-38 yrs; mean age 24.8 yrs, SD=6.5), (n=9; males 3, females 6)
- The elderly person's group: (aged 61-78 yrs; mean age 69.1 yrs, SD=6.6), (n=7; males 3, females 4)

Out of consideration for the children, it was requested that they be accompanied by a parent or guardian.

ANALYSIS OF SUBJECT GROUPS

After the experiment was over, a graph was created (see Figure 4.) with the subjects' age on the x axis and the time taken to complete the task on the y axis, to analyze the tendencies of each subject. According to the graph, a negative correlation (correlation coefficient= -0.669) was found in the children's group (age 5-11 yrs) and as the children got older they tended to complete the task quicker. In the young adult and elderly age groups, a positive correlation of 0.784 and 0.471, respectively, was found. Furthermore, children around the age of 10 yrs tended to be able to complete the task within 200 seconds, which was similar to the time taken by young adults, aged 21-24 yrs, in the young adult group (aged 21-28 yrs). From these results of the simulated image, we could deduce that for children aged 10 years or over, the level of difficulty or the subjective impressions of the experiment were similar to those of young adults, so they were excluded from the children's group. In addition, in

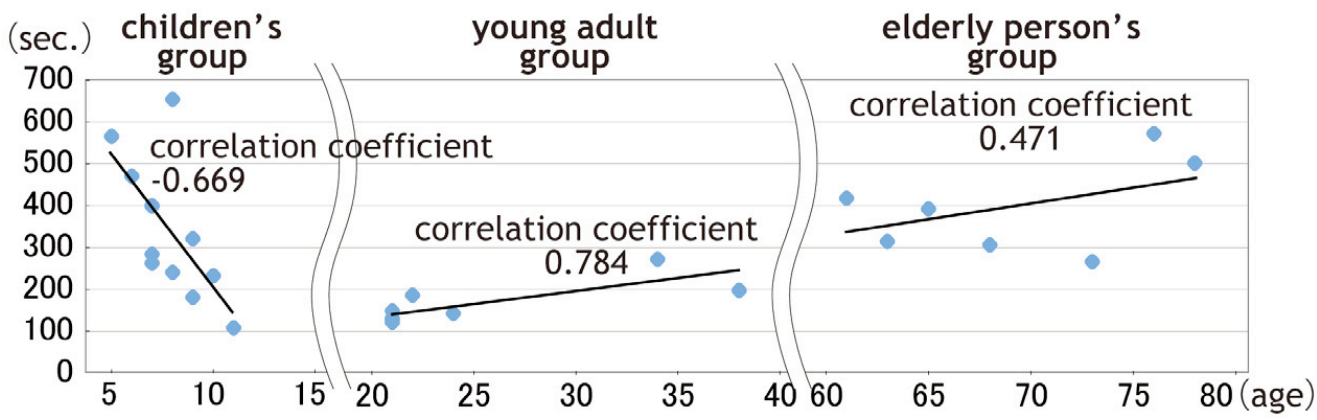


Figure 4. Correlation between age and time taken to complete tasks in all subjects

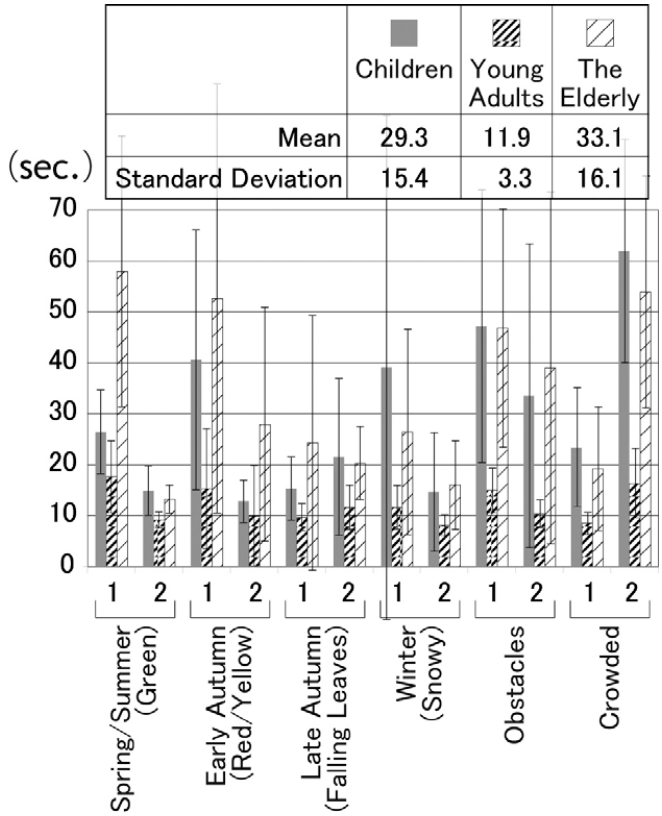


Figure 5. Comparison of each group and time taken to complete tasks

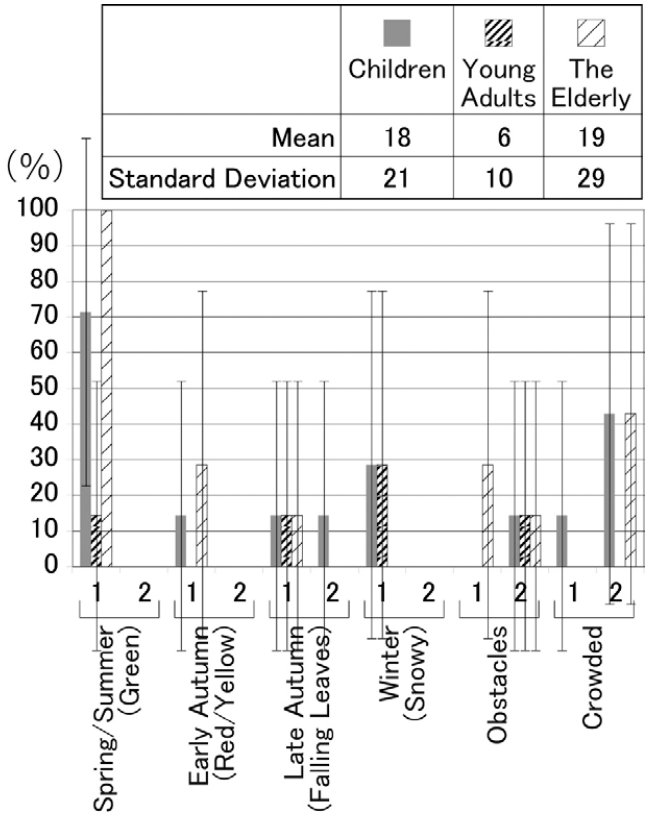


Figure 6. Comparison of each group and error rates

children aged 6 yrs or under, there were problems with language comprehension and mastering of the computer, so it was determined that the data obtained from this age group might not be accurate. No clear correlation was found between the number of visits to the zoo and the time it took to complete the tasks, (correlation coefficient= children -0.262, young adults 0.374, elderly persons 0.089).
After taking the aforementioned points into consideration, the subjects used in the final analysis were as follows:

- The children's group: (aged 7-9 yrs; mean age 7.9 yrs, SD=0.9), (n=7; males 3, females 4).
- The young adult group: (aged 21-24 yrs; mean age 21.6 yrs, SD=1.1), (n=7; males 3, females 4)
- The elderly person's group: (aged 61-78 yrs; mean age 69.1 yrs, SD=6.6), (n=7; males 3, females 4)

EXPERIMENT RESULTS AND DISCUSSION

ANALYSIS OF THE RECORD OF OPERATIONS PERFORMED BY SUBJECT

Figure 5 is a graph of the time taken to complete each of the 12 tasks in each subject group. While it took the young adult group an average of 11.9 sec to complete each task, it took the children and elderly group 29.3 sec and 33.1 sec, respectively. Similarly, while the standard deviation (SD) was 3.3 in the young person's group, it was large in the children and elderly groups at 15.4 and 16.1, respectively. Figure 6 is a graph of the error rate for each task in each of the subject groups. While it was 6% in the young adult group, it was 18% and 19%, in the children and elderly groups, respectively. Similarly, while the SD was 10 in the in the young adult group, it was high at 21 and 29, in the children and elderly groups, respectively. Furthermore, as stated in paragraph "STRUCTURE OF THE SIMULATED SCREEN", the tasks in the simulation were composed of (1.Explanation of Task), (2.Finding the Sign), (3.Reading the Sign) and (4.Choosing the Route). Out of these tasks, (2.Finding the Sign) tests "Conspicuousness", i.e. do the signs stand out enough within the scenery of the zoo, while (3.Reading the Sign) test the induction properties of the signs, i.e. is it easy to understand the way to a given destination from the a specific point just by looking at the sign. However, since (4.Choosing the Route) involved looking at the angle of the sign within its surroundings in the park and understanding in what direction to proceed, it was decided that

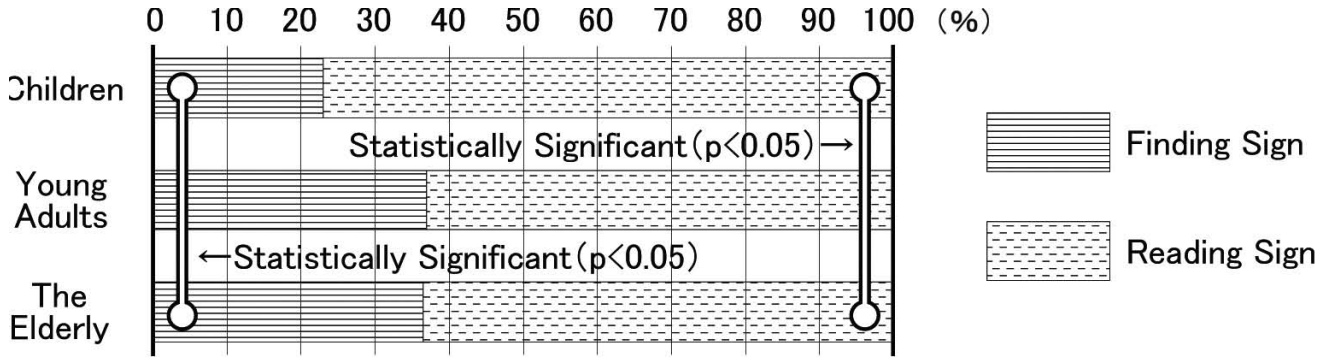


Figure 7. Allocation rate of the mean time needed to complete each task within each subject group

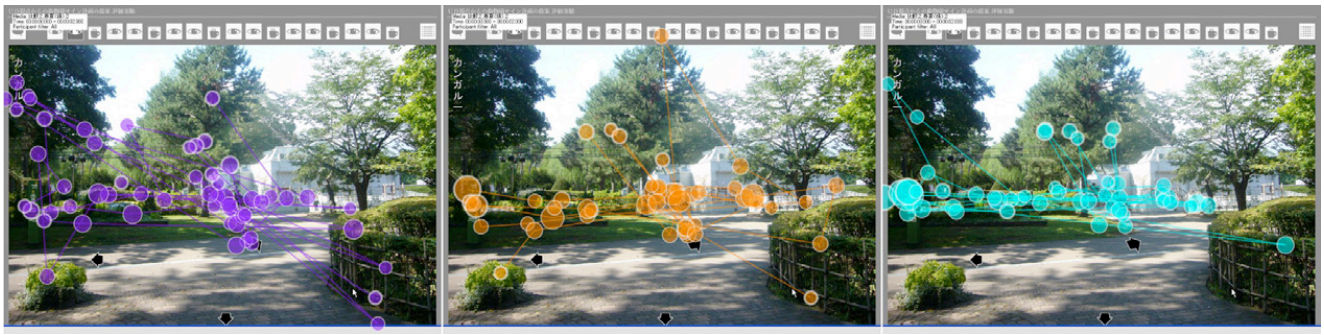
this involved the ability to understand spacial relationships and thus excluded from the analysis.

DISCUSSION ON THE RECORD OF OPERATIONS PERFORMED BY SUBJECT

From Figure 5 it can be seen that the young adult group performed the tasks at a steady pace and the time they took can be considered as standard. However, in the children and elderly groups, the time taken to complete tasks, the error rate, average values and SD was high, indicating that problems existed in these groups compared to the young adult group. To be more precise, under the following 3 conditions: "Spring/Summer" (green leaves, photo 1), "Early Autumn" (leaves changing color, photo 1) and "Crowds of People" (photo 2) caused some difficulties for the children and elderly groups. On the other hand, as shown in Figure 7, the difficulty in task (2.Finding the Sign) was less pronounced in the children compared to subjects in the elderly group.

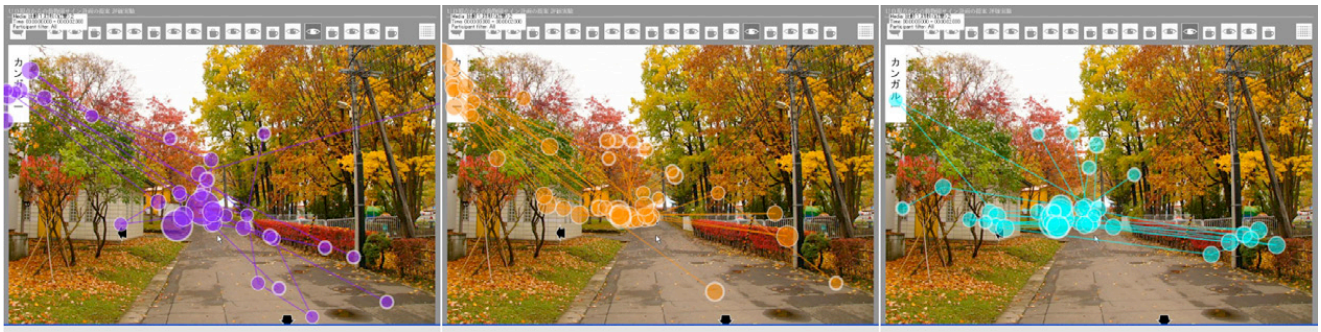
ANALYSIS AND DISCUSSION OF EYE-TRACKING DATA

Next eye-tracking data was analyzed and differences particular to each group were elucidated.



a. The Elderly *b. Children* *c. Young Adults*

Figure 8. Changes in line of vision for "Spring/Summer" (green) (Data of the first 2 seconds from the 7 subjects in each group superimposed on the image)



a. The Elderly *b. Children* *c. Young Adults*

Figure 9. Changes in line of vision for "Early Autumn" (leaves changing color) (Data of the first 2 seconds from the 7 subjects in each group superimposed on the image)

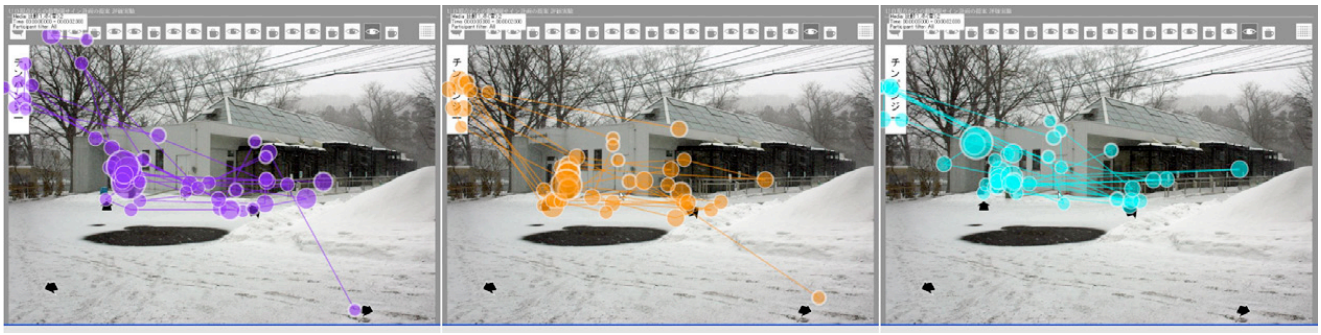
TIME TAKEN TO FIND SIGNS

Figures 8-12 are a plot of the points all subjects fixed their gaze on when looking at the above-mentioned 5 photos: “Spring/Summer” (green), “Early Autumn” (leaves changing color), “Winter” (snowy), “Crowds of people” and “Artificial Objects”. From left to right are the superimposed data for the first 2 seconds of changes in the line of vision in the children, young adults and the elderly (7 subjects in each group) when trying to find the sign. Furthermore, the bigger the size of the circle in the image, the longer the subject spent gazing at this point. The line of vision is said to be “fixed” when it stops for 100msec inside a circle on the screen with a radius of 35 pixels.

The characteristics of changes in line of vision on each image as well as comments about it are discussed below:

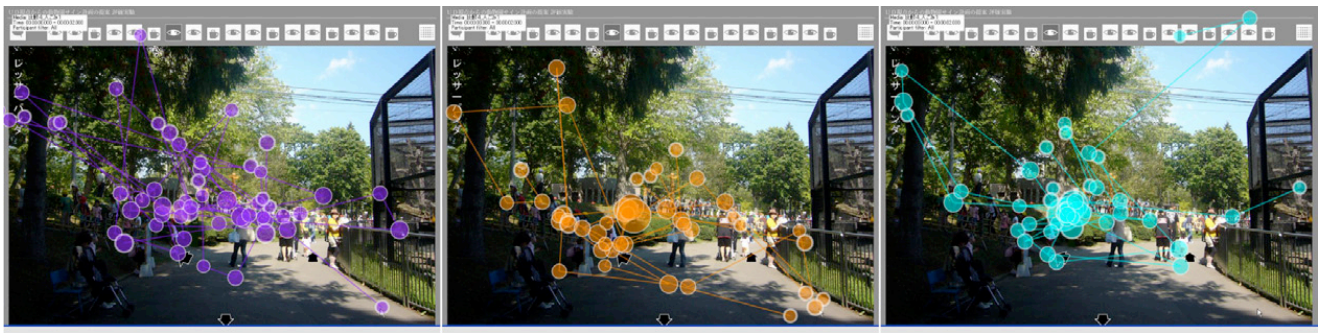
1) Spring/Summer (see Figure 8.)

Compared to autumn and winter little difference in the line of vision was found between each age group, however, subjects in the elderly group failed to locate the intended sign. This may have been due to



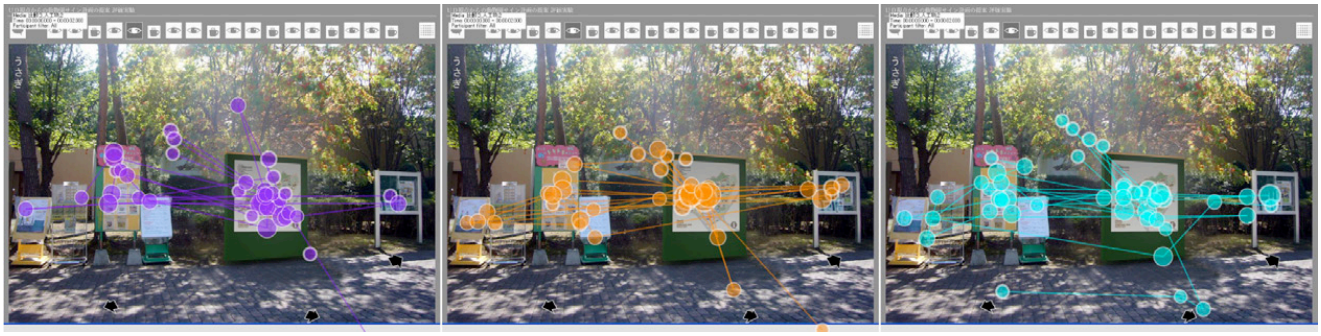
a. The Elderly *b. Children* *c. Young Adults*

Figure 10. Changes in line of vision for “Winter” (snowy) (Data of the first 2 seconds from the 7 subjects in each group superimposed on the image)



a. The Elderly *b. Children* *c. Young Adults*

Figure 11. Changes in line of vision for “Crowds of people” (Data of the first 2 seconds from the 7 subjects in each group superimposed on the image)



a. The Elderly *b. Children* *c. Young Adults*

Figure 12. Changes in line of vision for “Artificial Objects” (Data of the first 2 seconds from the 7 subjects in each group superimposed on the image)

the fact that color of the ground (dark-green) blended in with the dark green of the trees and was difficult to discern. In this study, we didn't specifically ask whether subjects suffered from cataracts. However since 70-80% of Japanese aged between 60 and 70 years suffer from cataracts; it may also be possible that the vision of subjects in this age group had declined due to cataracts. Regarding the children, in the "Spring and Summer" pictures a group of children was shown. This, along with picture 4 "Crowds of People", which shall be discussed later, seemed to grab the children's attention, resulting in their taking longer to complete the tasks.

2) Early Autumn (see Figure 9.)
Subjects in both the children and elderly subject groups frequently checked the destination name displayed on the screen. While the young adults effectively looked for the destination by concentrating their line of vision on buildings or along fences, the line of vision of subjects in the elderly group went all over the place, even on roads or on treetops; places where signs would not normally be placed. This may have been due to the fact the elderly did not adequately understand the visual scene presented on the screen. Furthermore, since they frequently checked the destination name on the screen, deterioration in short-term memory can also be implied. While these tendencies in the elderly were also found by the authors during completion of other tasks, they are also tendencies that are often found in the elderly in general.

3) Winter (see Figure 10.)
As with early autumn, both the children and elderly subject group frequently checked the destination name displayed on the screen. Apart from this, each age group focused their line of vision on close to buildings. This may be due to the fact that the ground was uniformly covered in snow and in the background all the leaves had fallen from the trees, so there were fewer distractions in this season compared to the other seasons.

4) Crowds of people (see Figure 11.)
While the children and young people in the subject groups focused their line of vision on the target area or its surroundings, the line of vision in the elderly fluctuated greatly. As in early autumn, their line of vision often went to the tops of tress implying inadequate understanding of the visual scene presented to them. In particular, the children tended to focus their gaze on pictures of groups of children their own age and it was obvious that for children, other groups of children cause distraction. We believe the above factors may have influenced the time it took elderly subjects and children to complete the tasks.

5) Artificial Objects (see Figure 12.)
Other sign posts were found to be equally distracting in all age groups. We believe the above factors may have influenced the time it took elderly subjects and children to complete the tasks.

READING THE SIGNS
In Figure 13 the task given is to find the route to the "rabbits" from the general guidance sign on the screen. The line of vision of the 3 groups head 2 seconds is shown. The data of all 7 subjects in each age group is superimposed on the image. From this it

a. The Elderly *b. Children* *c. Young Adults*

Figure 13. Changes in the line of vision on the screen for finding the sign (Data of the first 2 seconds from the 7 subjects in each group superimposed on the image)

Table 1. Impressions of the direction signs (Subjective Evaluation)

	Spring/Summer (green)	Early Autumn (red/yellow)	Late Autum (Falling Leaves)	Winter (Snowy)	Obstacles	Crowded	Building Names			Directional Guidance Signs			General Guidance Sign		
	1:Easy to find～5:Hard to find	1:Easy to find～5:Hard to find	1:Easy to find ～ 5:Hard to find	1:Easy to find ～ 5:Hard to find	1:Easy to find ～ 5:Hard to find	1:Easy to find ～ 5:Hard to find	1:Clear ～ 5:Messy	1:Easy to understand ～ 5:Difficult to understand	1:Fun ～ 5:Boring	1:Clear ～ 5:Messy	1:Easy to understand ～ 5:Difficult to understand	1:Fun ～ 5:Boring	1:Clear ～ 5:Messy	1:Easy to understand ～ 5:Difficult to understand	1:Fun ～ 5:Boring
Children(Mean)	3.3	1.9	1.9	1.7	2.4	3.1	4.6	2.4	1.6	3.7	2.3	2.3	3.9	2.1	2.1
Children(Distribution)	2.2	0.5	0.8	0.9	1.3	1.1	0.6	2.6	1.0	1.2	1.2	1.2	2.1	1.1	0.8
Young Adults(Mean)	4.4	2.7	2.1	1.0	3.4	3.7	5.0	2.0	2.7	3.4	2.7	3.9	2.9	3.6	2.9
Young Adults(Distribution)	0.3	1.6	2.1	0.0	1.3	1.6	0.0	1.3	1.9	2.0	1.9	1.1	0.8	1.6	1.5
The Elderly(Mean)	4.7	1.7	2.3	1.7	3.7	3.7	4.9	1.7	1.7	3.1	2.6	3.3	2.7	2.7	1.1
The Elderly(Distribution)	0.2	2.2	1.9	2.2	1.6	1.9	0.1	1.6	1.6	2.1	2.3	1.6	1.6	1.9	0.5

can be seen that both the children and young adult group soon found the rabbit among the pictograms and their line of vision concentrated on the area around the histogram of the rabbit. On the other hand, subjects in the elderly group tended to depend on letters more than pictograms and consequently their line of vision tended to be all over the place as they looked at various areas for letters. Furthermore, while children moved their line of vision to the red mark that represented their present location, young adults also moved their line of vision to the present location mark as well as a similar red mark that represented the entrance to the east gate. In both of these groups, subjects try to determine the relationship between their present position and the direction of the place they want to go to. In the elderly, however, since they are unable to find location of the place they have to do to, it is suggested that they don't have enough time to also look for their present location.

REINFORCEMENT OF DATA ON OPERATIONS PERFORMED BY SUBJECTS AND EYE-TRACKING USING DATA FROM SUBJECTIVE EVALUATION

Table 1 represents the subjective evaluation of subjects obtained once they had completed the experiment. Regarding the question on whether the direction signs stood out enough in the picture of the zoo during the summer where the foliage was thick and dark green, both the young adult and elderly groups answered "no", while the children answered "no preference". This may explain why it took the children less time to find the sign compared to the other 2 groups. Furthermore, while both the children and elderly people's groups found the pictograms "fun", the children did not tend to rate them as "easy to read". Thus apart from the pictograms some other type of representation needs to be used that is both "fun" and "easy to read" for children.

CONCLUSION AND FURTHER STUDIES

This study began with the aim of obtaining fundamental data to design signs for inside a zoo that were both easy to understand by visitors of all ages, as well as blending in well with the zoo's natural surroundings. Above all, by focusing on age differences in the cognitive process of sign recognition, from the results of this experimental study, the following conclusion could be obtained. Regarding the relationship between age and time taken to complete tasks, while a positive correlation was found in both the young adult and elderly age groups, a negative correlation was found in the children's group. With regards to the average time it took to complete the tasks, while it was similar in the children's and elderly group, young adults were able to complete the task 3 times quicker. Similar results were found for error rates which were lower in the latter. A breakdown of the time taken to complete the task in children and the elderly showed that while children spent only 23% of their time to find the sign, they needed the remaining 77% of their time to read the sign. In the elderly, however, 36% of the time was spent finding the sign and 64% of their time on reading the sign. So, compared to the children, it was clear that the elderly spent more time trying to find the sign.

Additionally, results of eye-tracking data showed that in the task that involved finding the sign among the scenery, while children and young adults effectively searched for the signs by focusing their line of vision on buildings and areas near the road in all seasons, the elderly tended to look all over the place including places where signs would not be placed, such as in treetops and on the road. When we come across an image that stimulates our senses, the broad impression we perceive in this instance is known as the “gist” of something (Reference 2). For example, in the instance we are shown a picture of a forest, we recognize this as a forest. However, compared to children and young adults, the elderly need more time to understand the “gist” of the situation and this may be one of the reasons it took them longer to find the target, in this case, the signs. In 1975 Palmer displayed a visual scene for 2 seconds, and then showed several objects. He then carried out an experiment to see if subjects could answer what these objects were. Results showed that the correct answer rate was higher for objects related to the visual scene first shown (background context) than for objects not related and it is considered that understanding the visual scene (background context) influences the amount of time needed to reach the target.

Furthermore, during Spring and Summer when the leaves on the trees are thick and lush, the elderly group tended to need significantly more time to find the signs than the children and young adults. This may be because the base color of the signs was dark green and similar to the color of the leaves on the trees in the background making it difficult to distinguish them. The reason this occurred may be due to the effect of cataracts on their vision as mentioned in section TIME TAKEN TO FIND SIGNS.

Next, in the task to choose the correct direction by looking at the general guidance sign, the results of the eye-tracking data showed that both children and young adults were quick to pick out the histogram and recognize where to go, but the elderly subjects on the other hand relied more on letters than on pictograms and consequently their line of vision tended to be all over the place as they looked at various areas for letters, which resulted in their tending to need more time to complete the task. However, the children, too, took significantly more time to complete the task than the young adults. It is assumed that the reason for this is because, while children could find the pictograms quickly, they needed more time for the final confirmation which involved reading Chinese characters that are too difficult for many of the children to read compared with the young adults.

Looking at the experiment overall, subjects in the elderly group tended to frequently refer back to the task on the screen to confirm what they had to do (or the name of the place they had to go to). This may be due to a deterioration of short term memory in this age group. While these tendencies in the elderly were also found by the authors during completion of other tasks, they are also tendencies that are often found in the elderly in general.

From these results in can be surmised that to design signs that are easy to understand by visitors of all ages, it is necessary –if it doesn’t go too far against the prerequisite of having signs that blend in naturally with the zoos surroundings- to have stronger accent colors on the signs to make them more conspicuous against the background scenery and put them in a more easily recognizable place without any surrounding noise and with distinct features so that elderly visitors to the zoo can find them more easily. For children, on the other hand, instead of using complicated Chinese characters on signs, more efforts should be made to have pictograms or use a simpler alphabet such as katakana which children can understand and read more easily.

In this study data from a wide age group, children to the elderly were analyzed. However, recently more foreign tourists have been visiting Sapporo, especially those from East Asia, and it will be necessary to investigate in future studies how easy the signs are for such a group of visitors to understand.

Figure 14. The general guidance sign in Sapporo Maruyama Zoo

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