Eye Movements of Elderly People While Riding Bicycles

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Abstract—**Many elderly people in Japan ride bicycles in their daily lives. But actually more than half of the people who died in accidents while riding bicycles are elderly. In order to clarify the background of the traffic accident involving elderly people, eye movements of ten elderly people (age: 65-76) while they were on bicycles were analyzed and compared with the data of ten younger people (age: 19-22) in an indoor simulation. The results showed that that the elderly often looked down at the road. It was also found that the elderly people concentrated their attention on one pedestrian when there were two upcoming pedestrians in the visual field.**

I. INTRODUCTION

Japan has become an aging society by rapid growth of senior citizen's population. The growth was so rapid that consideration on senior citizen in everyday life is still not enough. Due to aging process, various functions decline: sensory functions such as visual and auditory functions, cognitive functions, physiological functions, and motor functions. Such functional decline leads to various problems in daily life of older adults. Living environment should be designed regarding aging process in order to minimize the difficulties for elderly people.

Elderly people today are active and go outside frequently. For that, some elderly people prefer personal transportation. For instance, an Internet survey by DIMSDRIVE showed that 55.8% of men and 42.6% of women over 60 use bicycle more than a day in a week [1]. On the other hand, according to the statistics of the Metropolitan Police Department in 2006, 58.5% of lost lives in bicycle accidents were older than 65 years old [2]. These data show that many elderly people use bicycle and are correspondingly involved in traffic accidents frequently. The current traffic environment is not safe for the elderly.

For cycling, we control body movement. Declines in motor function may lead to a lack of balance on a bicycle and delay in a reaction. While cycling, the response time to a red signal and time required to stop cycling in older adults were longer than those in younger adults [3]. Such decline in cycling performance is probably one of the reasons for the high accident rate in elderly people.

The above mentioned body movement is controlled on the bases of perception or cognition from the traffic environment. As 95 % of information from outside is obtained by visual perception [4], analysis of visual information perception while cycling can help understanding the backgrounds of the traffic accidents involving elderly people. Unfortunately, there are not many researches that investigated how decline in visual functions of elderly people are related to the occurrence of the accident. Especially eye tracking study was not found on this topic, although eye tracking data is very informative. Eye movements of elderly during walking showed that the elderly depend on information from the lower part of the visual field more strongly than the younger people do, even though there were no differences in walking speed and cadences [5]. In addition, the sequential transitions of view point of the elderly shows that they require confirming their walking conditions by looking the lower part of the visual field. Similar analysis is required for the analysis of elderly people riding bicycles.

Therefore, an eye tracking study was conducted in order to clarify the factor of traffic accidents in which elderly people are involved. For that purpose, the data of elderly and younger people were compared.

II. EXPERIMENTAL METHOD

A. Subjects

Ten elderly persons between 65 and 76 years old (five males and five females) and ten younger persons between 19 and 22 years old (six males and four females) participated in this experiment. Of those, seven elderly people and ten younger people used a bicycle at least once a week.

B. Apparatus

An indoor simulation was conducted in this experiment for safety reasons. A bicycle was fixed in front of a white wall utilized as a large screen. Visual distance to the wall was 4 m. Movies of visual field of a cycling person which were recorded precede to the experiment were projected on the wall and subjects pedaled the fixed bicycle while looking at those movies (Fig.1).

Fig.1. Experimental setup.

Eye movements of subjects were recorded by the eye tracking system EMR-8B (Nac Image Technology, Inc.). The data sampling rate was 30 Hz and the spatial resolution was better than 0.1 degree visual angle. The eye

tracking video was recorded on a videotape, which showed the gaze point superimposed as a cursor on the image of visual field.

C. Procedure

After calibration of the eye tracking system, the following instruction was given to the subjects: "Please pedal the bicycle in the way you usually do, at your usual speed, and look the movies of the visual field of a cyclist which will be projected in front of you." As stimuli, four different movies were shown to the subjects. Only Situation A contained no pedestrian in the scene. Other three stimuli contained one or two pedestrian each. In Situation D, the cycling course included a corner to turn and there was a pedestrian behind the corner. The movie length was about 17 s in Situation A, B, and C. Only Situation D was about 7.5 s.

III. RESULTS

For each eye tracking video, areas of interests (AOIs) were defined and gazed AOI was identified frame by frame. Then gaze rate on each area was calculated based on gaze duration. Eye movement pattern was also analyzed.

A. Situation A

In Situation A, where the cyclist went straight about 50 m, three different eye movement patterns were observed for the elderly. In the first pattern, the subjects looked mainly straight forward and moved meanwhile their sight to the road near from them, right hand side, or left hand side shortly. The second pattern showed that the road near from the subjects was mainly looked and short glance ahead or to the right/left hand side was made meanwhile. The third pattern was similar to the second pattern, whereas the glance ahead or to the right/left hand side was longer than in the second pattern.

With regard to younger subjects, individual differences were not observed. All the younger subjects concentrated on the central area of the visual field and shortly glanced also peripheral area.

In order to summarize gaze distribution of two age groups, five AOIs were defined as follows: looked straight ahead (LS), looked down (LD), right or left hand side (SI), sky (SK), and others (O) (Fig. 2). As shown in Fig. 3, elderly subjects looked less frequently straight ahead (LS) than younger subjects. Instead, elderly subjects looked down (LD) far more frequently than younger subjects.. With regard to right or left hand side (SI), no clear difference in the gaze rate was observed. Sky (SK) was hardly gazed by both elderly and younger persons.

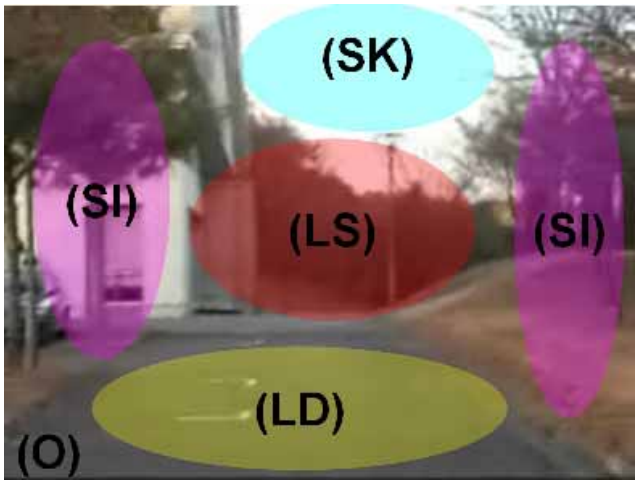

Fig.2. AOIs in Situation A

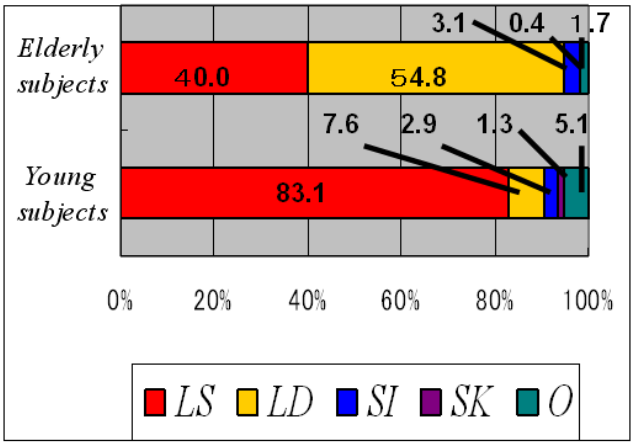

Fig.3. Gaze distribution in Situation A

B. Situation B

In Situation B, the cyclist overtook one pedestrian, who was initially 50 m ahead. At the beginning of the movie, this pedestrian was already visible, so that all the subjects looked him first of all. After that, the subjects concentrated on the pedestrian, and turned to the front several times on the way. When the distance with the pedestrian became closer, subjects looked straight ahead only.

After the cyclist took over the pedestrian from the left hand side, the observed eye movement patterns were similar to those of Situation A.

AOIs in Situation B were defined as shown in Fig. 4: looked straight ahead (LS), looked down (LD), pedestrian (P), right hand side (SI), and others (O). As shown in Fig. 5, a clear difference between two age groups was not confirmed and there was also no individual difference within each age group. Until the pedestrian was took over, the pedestrian was mainly looked, so that about half of the total gaze was on the AOI “Pedestrian” (P). After that, the subjects looked mainly straight ahead and it took about 30% of total gaze. Different from Situation A, the load (LD) was far less frequently gazed.

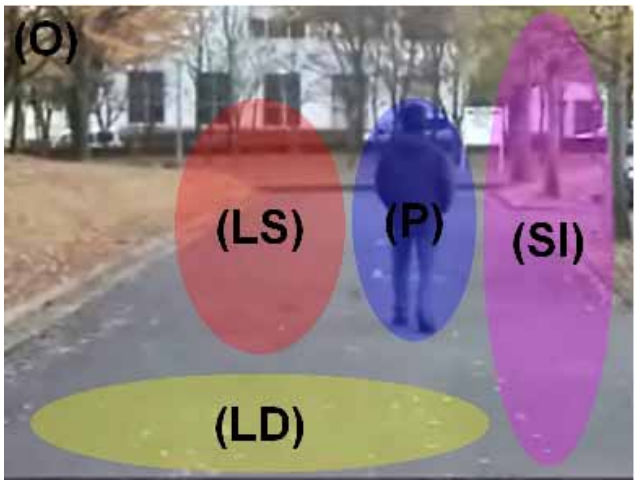

Fig.4. AOIs in Situation B

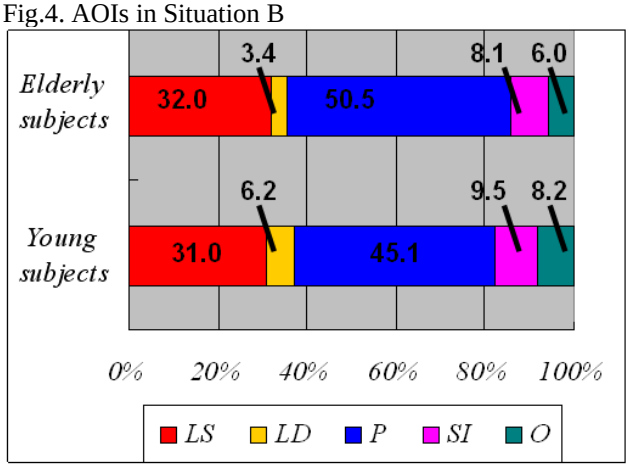

Fig.5. Gaze distribution in Situation B

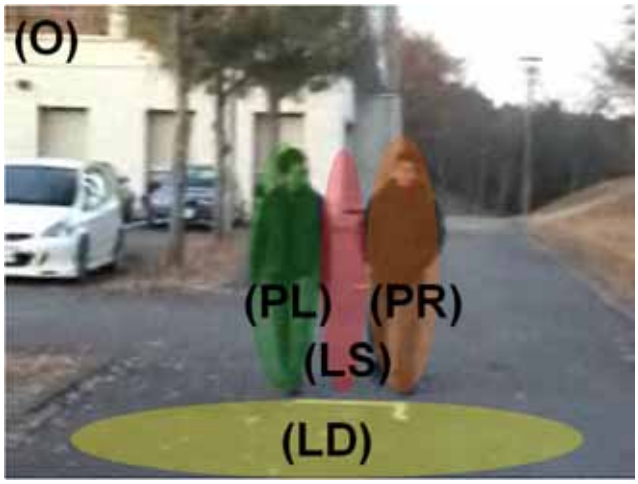

Fig.6. AOIs in Situation C

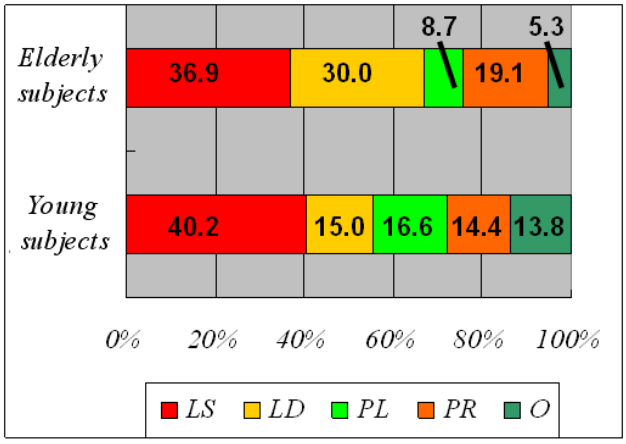

Fig.7.Gaze distribution in Situation C

C. Situation C

In Situation C, the cyclist went between oncoming two pedestrians from the distance of about 50 m. Similar to Situation B, these two pedestrians were visible at the beginning of the movie, so that all the subjects looked them first of all. After that, three elderly subjects and all the younger subjects looked two pedestrians one after other. The space between two pedestrians was also observed. Other seven elderly subjects looked the pedestrian on the right hand side and the space between two pedestrians one after other and regarded hardly the pedestrian on the left hand side.

The eye movement patterns after passing two pedestrians were similar to those observed in Situation A.

The visual field in Situation C consisted of the following five AOIs: looked straight ahead (LS), looked down (LD), pedestrian on the left (PL), pedestrian on the right (PR), and others (O) (Fig. 6). Although several eye movement patterns were observed, of total the elderly subjects tended to concentrate on the pedestrian on the right hand side (PR), whereas the younger subjects looked two pedestrian (PL and PR) equally. The difference in the gaze rate on AOI "looked down" (LD) was caused mainly by eye movements after passing two pedestrians.

D. Situation D

In Situation D, the cyclist went 20 m down hill, and then turned left and collided with a pedestrian.

On the road at the corner, "Stop" sign was indicated. All the elderly subjects looked that sign first of all, whereas younger subjects hardly regarded that sign. Instead, the younger subjects looked straight forward. The eye movement patterns of until approaching the corner were similar to those in Stimulus A. Then all the subjects looked first ahead to the corner, then at the suddenly appeared pedestrian.,

For Situation D five AOIs were defined: looked straight ahead (LS), looked down (LD), pedestrian (P), looked ahead of the curve (LC), and others (O) (Fig. 8). A clear difference was observed in the gaze rate of AOI "looked down" (LD): the elderly subjects looked this area more frequently than the younger subjects. Instead, the younger subjects looked more frequently AOI "looked ahead of the curve" (LC) than the elderly subjects. With regard to other AOIs, there was no clear difference between two age groups.

Fig.8. AOIs in Situation D

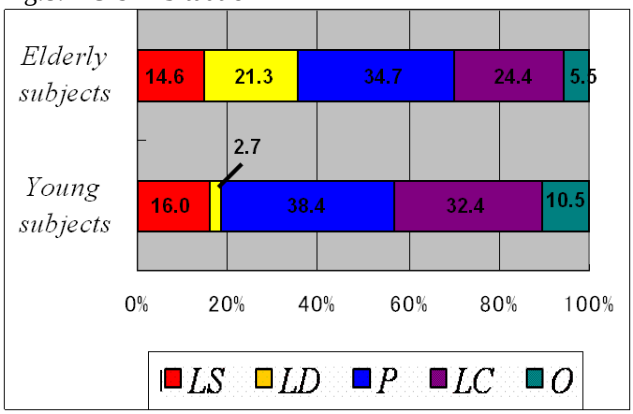

Fig.9. Gaze distribution in Situation D

IV. DISCUSSION

A. *Gaze down on the road*

Among four situations, the result of Situation A showed a clear difference in distribution of gaze points between elderly people and younger people. If there was no pedestrian, the elderly people looked more frequently down at the road than in the traveling direction, whereas the younger people looked mostly straight ahead and the road was hardly looked at,. This result is similar to the eye movements of the elderly while walking [5]. The concentration of gaze points on the down side is supposed to be related with the posture of the elderly. Frequently elderly persons are in a forward-bent posture so that they tend to look downwards. The other the reason is probably the narrow range of peripheral vision compared with younger people. For the safe cycling, attention to the road surface should be paid. If the cyclist is afraid of losing his/her balance on the bicycle due to uneven road surface or some obstacles, attention to the road surface is strongly required. It is supposed that the elderly subjects looked down the road from these reasons.

It was expected that the stop line on the road in Situation D attracted the attention of elderly subjects, because elderly subjects tended to look downwards and the stop line appeared conspicuously in the direction of their sight. As expected, the stop line was gazed more frequently by the elderly subjects than by the younger subjects.

On the other hand, the elderly subjects did not pay much attention toward the traveling direction. Consequently, it is inferred that the lack of information perceived from the traveling direction leads to traffic accidents.

B. *Gaze at pedestrian*

Different from Situation A, Situation B, C, and D included some pedestrians. These pedestrians distracted attention of subjects drastically. LS and LD, which should be looked in order to get information for moving forward, were gazed 90% of the total duration in Situation A. However, the total gaze rate on them in Situation B, C, and D was far lower than in Situation A. In order to avoid a collision with pedestrians, subjects focused their attention on those pedestrians. In such cases, the difference between two age groups was not large as a whole: gaze rate on pedestrians was slightly higher for elderly people than that for younger people. This tendency was also confirmed in the total gaze rate on two pedestrians in Situation C. However, gaze rate on individual pedestrians showed a difference: the younger people looked at the pedestrian on the right hand side and the pedestrian on the left hand side evenly, whereas the elderly people looked the pedestrian on the right hand side more frequently. In this situation, three subjects swerved to the right to avoid pedestrians when they passed between two pedestrians. It is supposed to be one of the reasons that people's sights are biased to the right.

V. CONCLUSION

This study was aimed to clarify the background of the traffic accident involving elderly people by analyzing eye movements during simulated cycling. The results showed that the elderly often looked down at the road. It was also found that the elderly people concentrated their attention on one pedestrian when there were two upcoming pedestrians in the visual field. From this result, it is supposed that elderly people have difficulties in paying attention to two or more pedestrians or other objects.

Actually cyclists are allowed to go on sidewalks in Japan, so they need to be very careful of pedestrians. However, this study showed clearly that the elderly tended to look downwards so that attention to pedestrians may delay. A preferable solution is an introduction of bicycle lanes, but they are hardly introduced in the urban area of Japan due to narrow width of roads. The first step to secure the safety of elderly cyclists is maybe to instruct elderly people to pay more attention to surroundings.

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