Effect of Cognitive Ability Deficits on Elderly Passengers' Mobility at Railway Stations – Focusing on Attention, Working Memory, and Planning

Muneo Kitajima[*], Takatsune Kumada[*],
Motoyuki Akamatsu[*], Hajime Ogi[*], and Hiroshi Yamazaki[**]

[*] *National Institute of Advanced Industrial Science and Technology*
1-1-1 Higashi, Tsukuba ,Ibaraki, 305-8566 JAPAN
kitajima@ni.aist.go.jp, t.kumada@aist.go.jp, akamatsu-m@aist.go.jp, h-ogi@aist.go.jp

[**]*Research and Development Center of JR East Group, East Japan Railway Company*
2-0, Nisshin-Cho, Kita-Ku, Saitama-Shi, Saitama, 331-8513, JAPAN
Hiroshi-Yamazaki@jreast.co.jp

The purpose of this research is to understand how a deficit in cognitive functions affects elderly passengers' behavior at railway stations. The cognitive functions we focus on include attention, working memory, and planning, which we have found to decrease independently with aging. We selected three railway stations (Akihabara, Sugamo, and Ohmiya) and assigned four participants at each station with different characteristics in terms of the above-mentioned cognitive functions; one had no problem in the three cognitive functions, whereas each of the other three had a different inferior cognitive function. At the railway stations, the participants were instructed to carry out a main mobility task, such as transferring from line A to line B, while performing two or three subtasks such as finding public telephone, restroom, or elevator. We recorded the participants' behavior using a wireless microphone and two video camera systems, a small wireless pinhole CMOS camera mounted on the participants' hats for recording their visual view and a CCD camera for recording the whole back view. After each task, the participants were conducted into a room and interviewed for their background knowledge, explanation of their behavior, etc. while reviewing the recorded videos. The results showed that three of the twelve participants with inferior planning function consistently had serious problems in performing the tasks. This indicates that special considerations are needed to support these people.

INTRODUCTION

Japan is currently experiencing not only the rapid advent of an aging society as its senior population (65 years and older) increases, but also a major shift in the composition of the total population with fewer young and working-age people (15 to 64 years old) as the result of a declining birthrate. In response to these societal changes, the Barrier-Free Transportation Law and a Pension System were established and emphasis is placed on the needs and the care of the elderly. Each of East Japan Railway (JR East) stations works to provide a barrier-free environment by modifying elevators and escalators to improve vertical access, providing well-arranged station guidance signs with easy-to-understand information, eliminating steps on platforms, encouraging safety measures on platforms by displaying guidance and warning signs, and so on.

However, it has been demonstrated that the usability of stations for the elderly is not improved at all even when guidance signs are designed according to the existing guidelines. This is probably because of the limited effectiveness of de-contextualized methods for improving the usability of stations derived from context-free guidelines for the elderly. Such methods would not be able to provide consistent solutions for people's problems in real setting. Sequences of people's actions in real settings would reflect the cognitive and behavioral demands defined by the specific task context at the time, and therefore the detailed description of each action may differ from the one observed in de-contextualized situations, which would have served as the basis for the guidelines. And thus, to provide a comprehensive guidance system that enables the elderly to navigate through the stations smoothly and utilize the facilities easily, it is necessary to implement station designs based on correct understandings of actions they may take in real settings to accomplish their goals from the perspective of cognition, behavior, and physical actions.

Navigating the station smoothly requires not only physical actions but also the cognitive and behavioral abilities necessary for performing the following activities: 1) determine a target appropriate to the purpose, 2) search for the target,

3) reach the target, and 4) achieve the purpose. In this study we conduct cognitive and behavioral surveys using the scenario, *navigating through a station that has never been visited*, in which we believe cognitive functions related to movement in the station would play a large role. We analyze the results to examine the influences of different performance levels of cognitive functions on behavior. We then clarify the relation between cognitive functions and the usability problem encountered.

CLASSIFICATION OF THE ELDERLY ACCORDING TO COGNITIVE AGING CHARACTERISTICS

Attention, working memory, and planning

In this paper, we investigate how the elderly navigate through the station to accomplish their goals in terms of three cognitive abilities, *attention*, *working memory*, and *planning*, which are known to decrease independently with age. This phenomenon is called *cognitive aging*. We believe these cognitive abilities be indispensable for the passengers to navigate through the station and thus are useful concepts to understand people's behavior at stations.

We give brief descriptions for these cognitive abilities below.

Attention is the ability to distinguish information pertinent to the task at hand from extraneous noises. Although the ability to separate target information from external noises plays an important role in daily behavior, it is known that aging makes it difficult to ignore such unrelated information, resulting in a delay in discovering the target information. As the result, signs may be overlooked in one's daily life.

Working Memory refers to a psychological system that both stores information briefly and allows manipulation and use of the stored information. This function is the basis of the complex cognitive activities performed by a human being. However, working memory has a basic limitation: It can hold only a limited amount of information at one time. Due to this limitation, a person with an impaired working memory function is likely to lose the original goal for a given action and to fail to accomplish all the goals necessary to accomplish the task.

Planning is the prioritization and sequential implementation of the steps necessary to achieve a goal. It consists of repetitive cycles of appropriately setting a lower-level goal required to achieve the current goal, maintaining the lower-level goal until it is achieved, and when that goal has been achieved, then setting the next new lower-level goal.

Investigation of cognitive aging characteristics

To investigate the cognitive aging characteristics, we designed a cognitive function study using the AIST cognitive aging study[1)] as the base, modified the contents of the study according to the contents of our current survey, and then conducted a survey. This study is devised so that the participant's knowledge and/or general memory loss do not affect the study result. Table 1 shows the study items for examining characteristics of cognitive functions.

Table 1. Study Items for Cognitive Functions

Cognitive Function	*Study Item*
Attention	Search for target images Select correct shape/figure with designated feature
Working Memory	Write mirrored characters Write words in reverse
Planning	Recall and write a sequence of daily actions

Results

164 elderly people registered with the Silver Human Resource Center located in the Metropolitan Area participated in the survey. Table 2 shows the results.

Table 2. Results of the Cognitive Aging Survey

Ability in Cognitive Functions	*%*
Normal ability in all functions	15.5
Inferior in only one of the functions	31.7
Inferior attention (only)	*7.9*
Inferior working memory (only)	*12.2*
Inferior planning (only)	*11.6*

BEHAVIOR SURVEY AT RAILWAY STATIONS

Survey method

To identify the cognitive and behavioral processes of the elderly's movements through a railway station, we conducted surveys of actual behavior at JR East stations in the Metropolitan Area.

Railway stations and tasks

We selected three stations which have mutually different structures. This was done for the purpose of discovering factors affecting behavior that are independent of the structure of the station and are peculiar to the cognitive function characteristic of each participant. We describe briefly the features of the selected railway stations and the tasks we gave at the respective stations.

Akihabara Station:

- *Feature:* Platforms allocated on two stories cross each other.
- *Task:* 1) Change trains by moving from the No. 1 or No. 2 platform for the Yamanote/Keihin-Tohoku Line to the No. 5 platform for the Sobu Line for Shinjuku. 2) Use toilet and 3) use telephone during movement.

Sugamo Station:

- *Feature:* Simple structure with an island-type platform.
- *Task:* 1) Move from the platform for the Togenuki Jizo. 2) Use elevator and 3) use coin locker during movement. 4) Move from the arcade to the Sugamo Station and 5) take a train for Mejiro. 6) Use coin locker and 7) use toilet during movement. 8) Also, buy a ticket.

Ohmiya Station:

- *Feature:* Has four stories for the Shinkansen, concourse, and conventional lines accompanied by a wide space.
- *Task:* 1) Move from the east entrance to the platform for the Saikyo line and 2) take a train for Ikebuturo. 3) Use coin locker and 4) use toilet during movement. 5) Also, buy a ticket.

Participants

For the survey, we selected a total of 12 participants, three participants each from a total of four groups: one group of those with normal ability in all functions and three groups of those with inferior ability in one of the cognitive functions. Four participants with different cognitive aging characteristics performed the task in each of the three stations. Table 3 shows the design of the survey.

Table 3. Design of the Behavior Survey

Station	Day-1 AM	Day-1 PM	Day-2 AM	Day-2 PM
Akihabara	Inferior Attention	Inferior Planning	Inferior Working Memory	Normal
Sugamo	Normal	Inferior Planning	Inferior Working Memory	Inferior Attention
Ohmiya	Inferior Planning	Inferior Working Memory	Normal	Inferior Attention

Survey method

The task was imposed on each participant, and his/her behavior was recorded using a small wireless pinhole CMOS camera attached to his/her hat, a wireless microphone, and a whole-back-view CCD camera (Figure 1, top). After each task, the participants were introduced into a room and interviewed for their background knowledge, explanation for their behavior, etc. while reviewing the recorded videos (Figure 1, bottom).

Behavioral data analysis

The tasks participants were instructed to accomplish are cognitive and behavioral tasks mainly consisting of searching actions to find the

Fig. 1. top –Participant performing a task at the Sugamo Station; bottom – interview after task

place to perform the task. Therefore, by comprehensively considering the video records and the results of the interviews, we divided a series of actions into segments each consisting of a searching action and further described them in details using five items to extract the characteristics of cognitive and behavioral processes in the station. The five items are:

1) goal
2) movement and behavior observed
3) motivation and the object of searching
4) guide boards and signs referred to
5) attributes of referral, i.e., collection of information or confirmation

The result was then examined from the viewpoint of the cognitive characteristics of each participant, and we attempted to relate it to the characteristics of behavior.

Results

During the survey, behavioral characteristics related to the inferior cognitive functions were observed. The inferior-attention and the inferior-planning groups, in particular, exhibited problems collecting and using information.

Analysis results as classified by the level of cognitive functions are summarized below.

Normal group

- The target was set flexibly according to the circumstance.
- The collection and confirmation of information necessary to accomplish the task were implemented with no problem.
- Exhibited quite a complete cognitive and behavioral pattern in the areas of retaining information that might be necessary in the future and predicting the time required to accomplish the task.

Inferior working memory group

- Showed almost the same behavioral pattern as the normal group.
- With a higher tendency to be encumbered by past experiences and preconceived ideas than the participants of the normal group.
- Sometimes forgot part of the task or were unable to change the target of action flexibly according to the circumstance.

Inferior attention group

- Adopted a strategy of directly searching for the object and never attempted to obtain or confirm information from hanging/overhead guidance signs.
- Frequently attempted to obtain and confirm information with difficulties in obtaining two or more items of information in parallel.

Inferior planning group

- Besides displaying a narrow range of methods to obtain information, performed many actions based on a mistaken idea without attempting an appropriate confirmation or correction.
- Seldom used guide boards.
- Although they sometimes looked at guide boards, this group was unable to obtain concrete information due to unclear purpose.
- Even if the purpose was clear, they were unable to obtain concrete information because they did not select an appropriate information source.
- This group was unable to utilize symbolic images or past experience concerning the structure of the station or routes.

The above results can be summarized as follows.

- Participants with inferior cognitive functions exhibited different behavioral characteristics.
- Signs are not helpful for the elderly with inferior cognitive functions. More specifically, we found that 1) inferior-attention group did not try to look at signs, and 2) inferior-planning group were unable to obtain information by looking at signs.

Although the conventional guideline for the elderly is based on the presumption that the elderly will look at signs, the current survey results suggest that such a supposition is not always true. We believe this gives us an important clue to solving usability problems at railway stations. For the inferior-attention group, for example, it will be useful to provide appropriate symbolic images. For the inferior-planning group, on the other hand, individual guides will be necessary.

CONCLUSION

In this paper, we demonstrated that when attempting to alleviate usability problems in navigating railway stations, which is a common predicament for many elderly users, identifying the root of problems by considering cognitive aging characteristics is an effective way to obtain clues for solving these problems. We also believe that this method would be effective for an even wider range of conditions. We will apply this method to other conditions in the future and verify its relevance.

REFERENCES

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