Roles of Navigation System in Walking with Long Cane and Guide Dog

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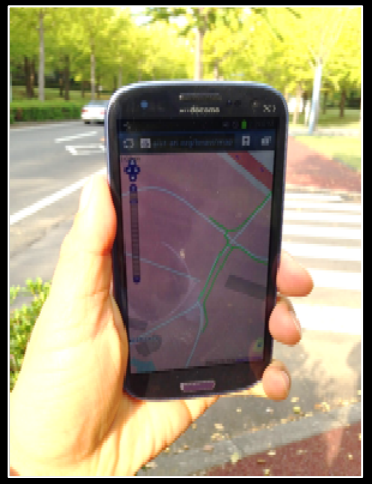
Introduction

- Owing to the popularity of smartphones, a variety of navigation applications for sighted pedestrians has been developed.
  - If such applications could be equipped with interfaces suitable for visually impaired pedestrians, it would become popular also among them.



Introduction

- ‘Walk’ comprises O & M (Orientation and Mobility).
  - Orientation: geographical navigation and the spatial recognition
  - Mobility: road-condition understanding, body control, obstacle avoidance, etc.

O & M

Walking with cane or with guide dog, using talking navigation

	Orientation Support	Mobility Support
Talking navigation	✓ High	Low
Cane	N/A	✓ High
Guide dog	Low	✓ High

*Route guidance
*POI notification
*Map search

*Detecting road conditions

*Orientation to some extent
*Mobility to greater extent

Motivation

Long Cane or Guide Dog
+
Navigation system

→ More practical and popular

↓ Sensor/Guidance Log

Quantitative evaluation on O&M skills for training

Walking with cane or with guide dog, using talking navigation

- Qualitative understanding of relationship between a navigation system and a cane or guide dog: OK
- What remains are
  - How and to what degree we can obtain sensor log by the navigation system and other wearable devices to evaluate O & M skills of trainees
  - How to provide trainees/trainers with feedback after walking

What this presentation is about

- Preliminary subjective experiment on how such combinations works
- Exploration of the applications of sensor log such as evaluation indices and intuitive ways of feedback

Walking experiment: Devices

- Talking GPS:
  - Trekker Breeze (made by HUMANWARE and localized in Japanese by EXTRA)
  - Audio assistance with regard to the distance and direction to the next stop,
    whether the destination
    is along the route or off it,
    and landmarks

Trekker Breeze

Walking experiment: Devices

In addition to the talking GPS, the subjects were also equipped with the following devices:

- EEG (Electroencephalogram, Brain Wave):
  - B3 Band made by B-Bridge
- Heart rate, GPS:
  - RS 800 CX N GPS made by POLAR
- PDR (Pedestrian Dead Reckoning, relative positioning):
  - GALAXY S II made by SAMSUNG

Walking experiment: Subjects

- Five subjects were completely blind and one has extremely low vision.
- Four subjects were walking with a cane and two subjects were walking with a guide dog.

Walking with a cane

Walking with a guide dog

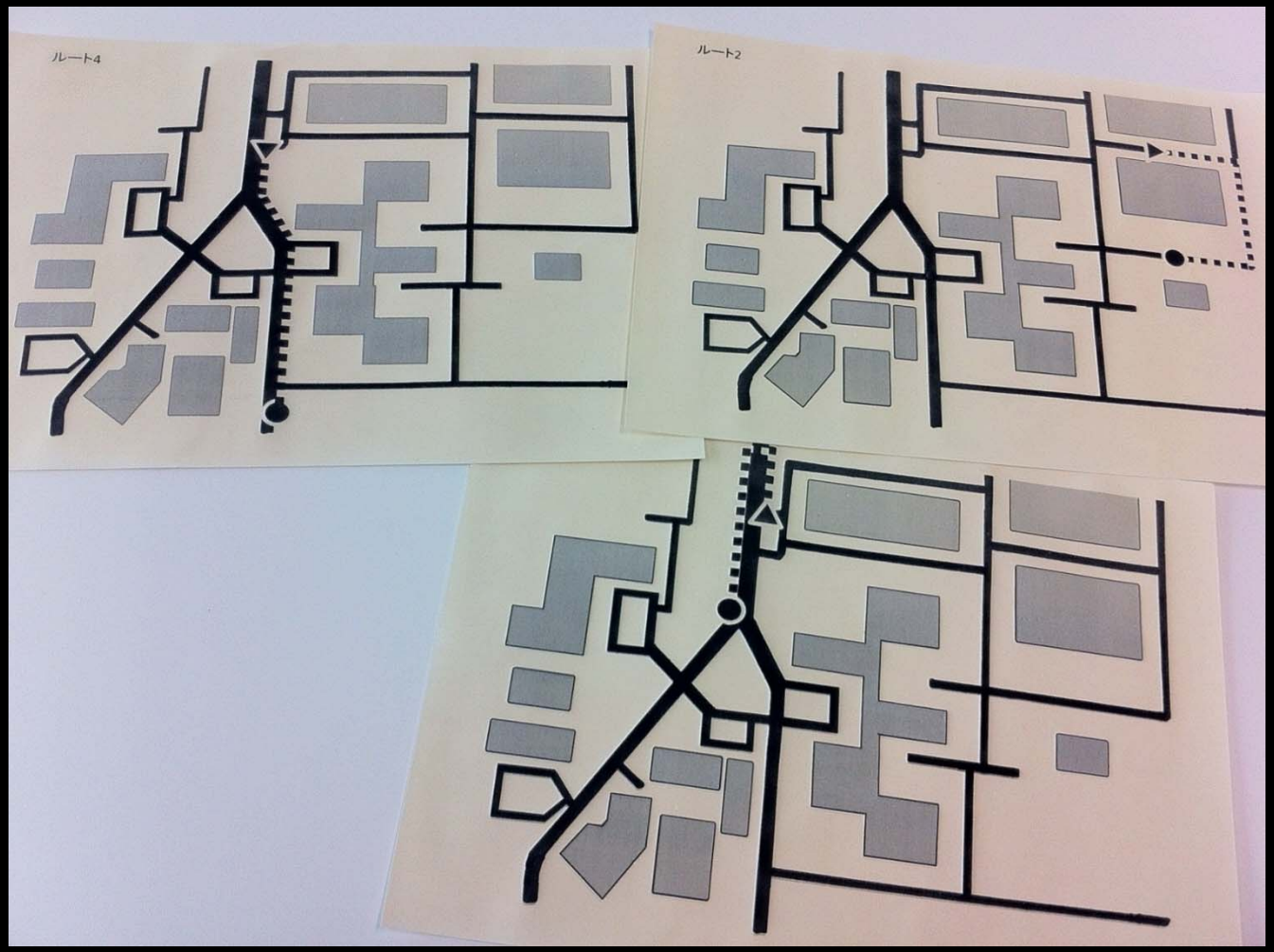
Walking experiment: Routes

- Multiple routes were established
  - Subjects would not remember a specific route
- The distance of each route was set at approximately 210 to 250m
  - To provide a uniform degree of exercise stress

Walking experiment: Procedures

- Aims of the experiment and what to do were explained to the subjects, and their consent was received.
- Operation of the talking GPS was practiced, and the wearable devices were attached.
- Trials were repeated 2–3 times for each subject.
  1. Prior understanding of the established routes using tactile maps with a supplementary oral explanation on the subject's questions
  2. Walking while using the talking GPS with a cane or with a guide dog
  3. Interview
- Tactile Trajectories were provided afterward.

Tactile maps for step 1



Buildings [polygons], Road [solid line], Established route [dotted line], Starting point [Solid triangle], Finish point [Solid circle]

Label: Walking mode

Three kinds of walking-mode labels were put to each period along timeline subjectively as follows:

(A) walk with confidence

(B) walk without confidence

(C) situation understanding

Label: Irregular movement

Five kinds of irregular-movement labels were put to each period along timeline subjectively as follows:

1. Stop walking rapidly
2. Change walking direction rapidly
3. Walk unsteadily
4. Decrease walking speed
5. Touch obstacles

Results: Accuracy & Efficiency

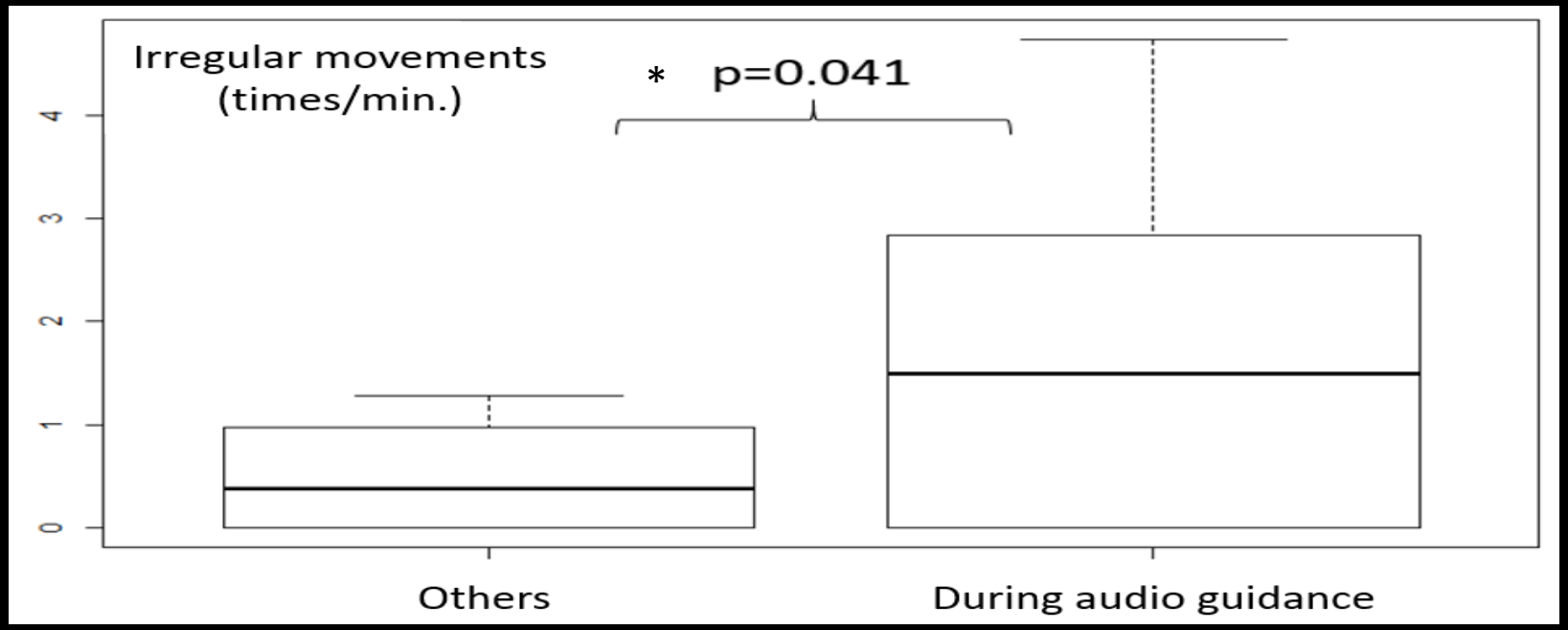
- Accuracy: the percentage of time period in which the subject stayed on the established route
  - (A) walk with confidence: 100%
  - (B) walk without confidence: 71%
- Efficiency: No critical problem
  - Walking speed with a cane: 3km/h
  - Walking speed with a guide dog: 4km/h

Results: Safety

Frequency of Irregular movements (times/min.)

- During audio guidance: 1.6
- Others (during no audio guidance): 0.5

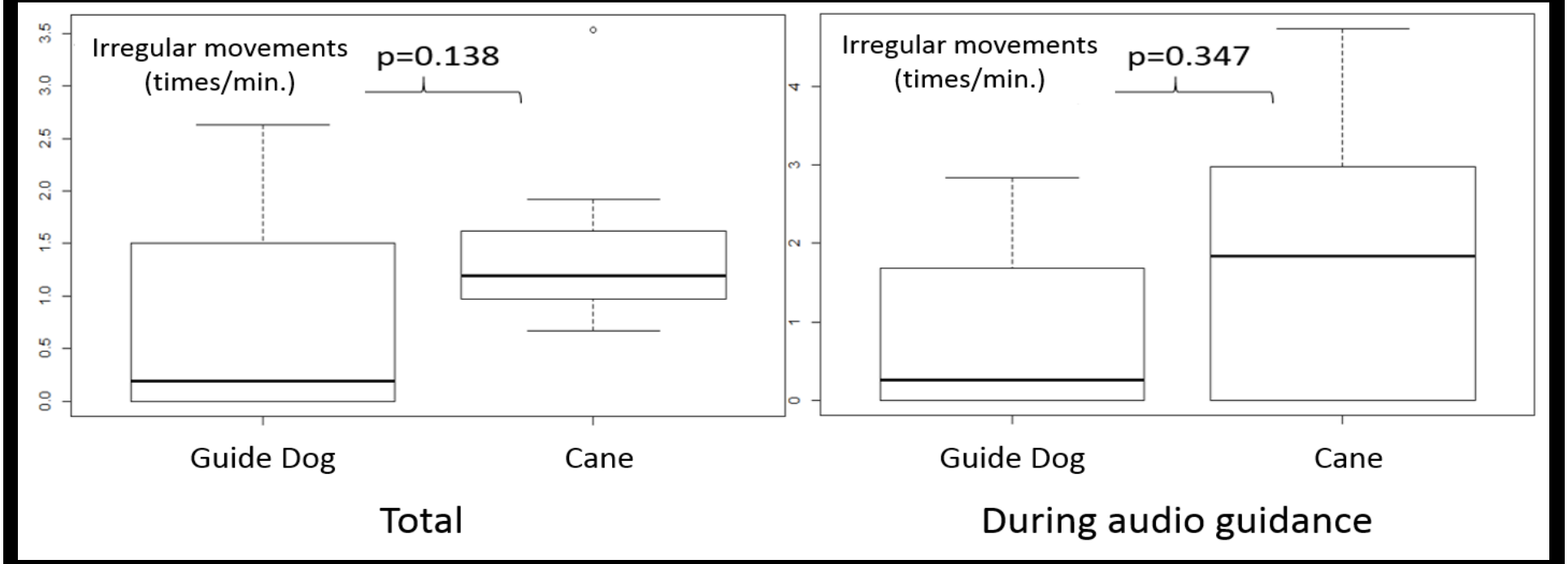
Note: In 40% of walking time, the audio guidance was provided.



Wilcoxon signed-rank test

Results: Safety

- No significant difference between walking with a cane and with a guide dog
- Some tendency of more irregular movements in walking with a cane



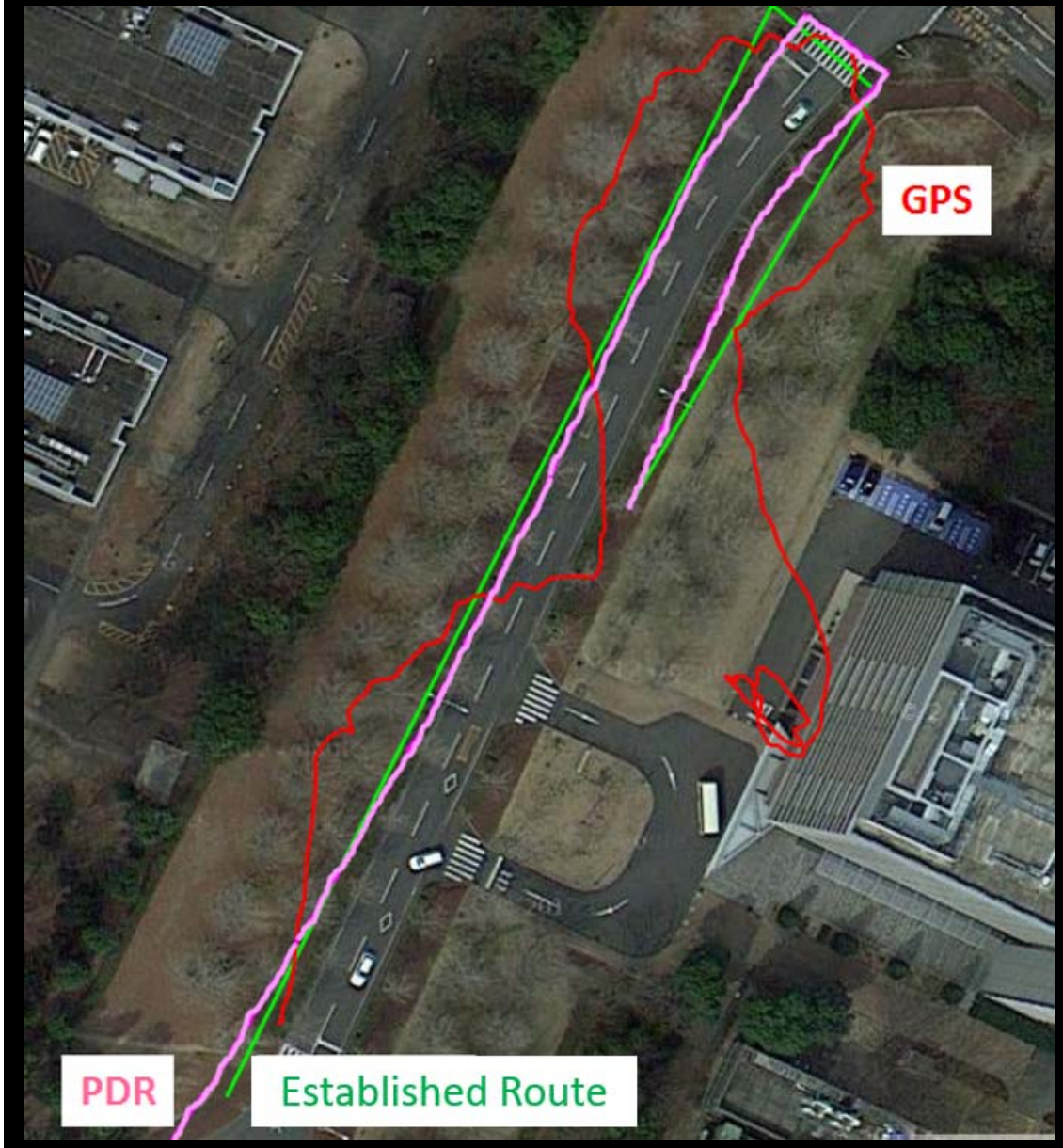
Mann-Whitney U test

Results: Brain wave & Heart rate

- Brain wave:
  - The concentration index: (B) > (A)
    - 100% (11/11 trials)
  - The relaxation index: (A) > (B)
    - 82% (9/11 trials)

  Notes: 11 trials included both modes of (A) walk with confidence and (B) walk without confidence.
- Heart rate: No particular results were obtained regarding the heart rate.

Results: Positioning



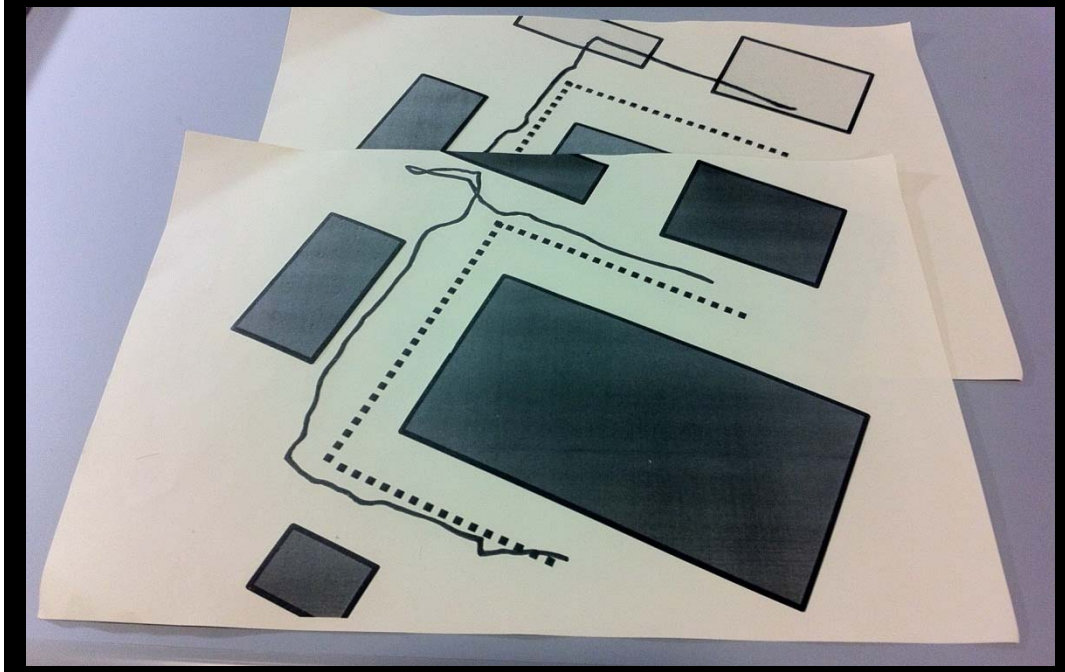
Evaluation of the accuracy of PDR.

- positioning error: 3 m
- Error of estimated walking speed: 20%

[Green] Established route
[Red] Walking path measured on the GPS
[Pink] Walking path measured on the PDR

Results: Tactile trajectory

- Subjects were shown “tactile trajectories”, which are tactile maps with his own trajectories.
- From the interview, we learned that the subject could instinctively confirm veering, and local and global deviation by using the tactile trajectory.



Tactile trajectory shows the buildings, the established route, and the walking trajectory, as measured by PDR or GPS.

Discussions: Evaluation indices

The following six indices potentially can be measured by what we used in the experiments.

(1a) Accuracy (Micro): Local veering

(1b) Accuracy (Macro): Deviation from the route in total

(2) Safety: Frequency of irregular movement especially during or shortly after audio guidance

(3a) Efficiency (Micro): Walking steps and walking speed

(3b) Efficiency (Macro): Time to finish walking along the established route

(4) Anxiety: Stress level during walking

Discussions:
Comparison between Cane and Guide dog

- The cognitive load for mobility seems to be relatively low for walking with a guide dog as compared to walking with a cane.
- Pedestrians with a guide dog have more spare cognitively to manage the talking navigation.
- There is a possibility that appropriate period to start using a talking navigation system is different between pedestrians with a cane and with a guide dog even if they have similar O&M performance.

Conclusions (E-mail: t.kurata@aist.go.jp)

	Orientation Support	Mobility Support	Cognitive Load when using talking navigation
Talking navigation	✓ High	Low (Negative Contribution)	
Cane	N/A	✓ High	Relatively High
Guide dog	Low	✓ High	✓ Relatively Low

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+
Navigation system

→ More practical and popular

↓ Sensor/Guidance Log

Evaluation Indices
Tactile Trajectories

→ Feedback to Trainees & Trainers

Thank You!!

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