「Cross-ministerial Strategic Innovation Promotion Program (SIP)/
Automated Driving for Universal Services/
HMI and User Education」

FY 2020 Report

Keio University
AIST
University of Tsukuba
Tokyoto Business Services

March, 2021

Task A

Communication method between AV and traffic participants
Education, knowledge on such communication

Keio University

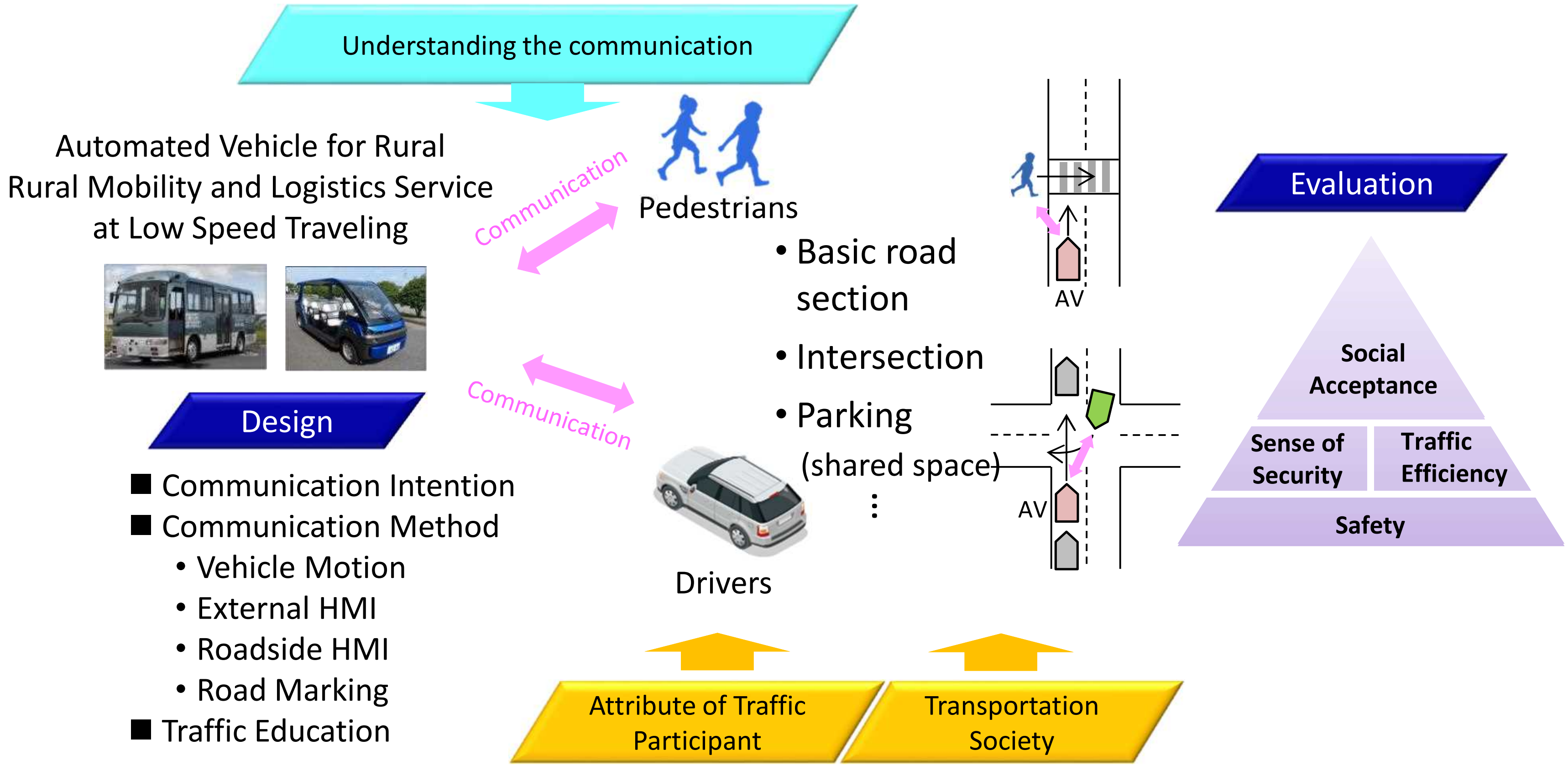
Overview

Task A

Communication method between AV and traffic participants

Education, knowledge on such communication

Safe, secure and efficient communication between AVs and traffic participants



Research Flow of Task A

1. Understanding current communication between AV and traffic participants

Rural mobility and logistic services at low speed traveling, effects of driverless car, road traffic conditions, etc.

Extracting Use-Case of communication between AV and surrounding traffic participant

2. Research on negative effect of communication between AV and traffic participants

Communication with one participant, multiple participants, effect of vehicle motion, eHMI, road traffic conditions,

Considering negative effect by using an eHMI

FY2019

Applying the important Use-Cases to VR/DS experiments

3. Research and proposal of communication method, knowledge necessary for communication

Vehicle motion, eHMI, roadside HMI, road marking, etc.
Knowledge necessary for AV, communication, limitation, etc.
(based on critical use-cases of communication)

FY2020

- VR/DS, Test-Track
- Questionnaire (Web, etc.)

4. Verification of communication method and education for communication between AV and traffic participant

(In field operational tests or field observations)

Critical use-cases of communication
Guidance of design factors on communication

Guidance of educational factors on communication

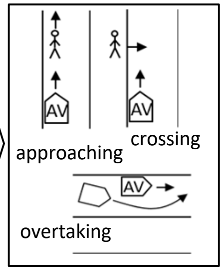
Safe, secure and efficient communication between AVs and traffic participants

Research activity of Task A in FY2020

1. Understanding current communication between AV and traffic participants

・Analysis of video data observed in FOTs

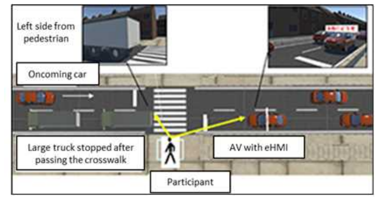
Interaction scene

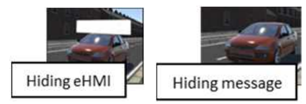


Extraction of use-case

Extraction of features of interaction / communication between AV and surrounding traffic participants

2. Research on negative effect of communication between AV and traffic participants





・VR/DS Experiments

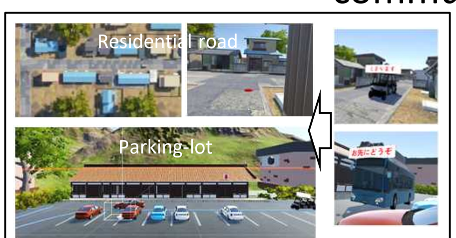
Road environment, traffic condition, vehicle motion, eHMI, …

・Traffic participant

・Use-cases of communication

・Mitigation for negative effect with eHMI

3. Communication design between low-speed AV and traffic participants, knowledge required for communication



VR experiment for use-case "crossing"

・VR/DS experiment

pedestrian, following driver

・Communication method

vehicle motion, eHMI, road marking, projection, …

VR experiment for use-case "approaching & avoiding"

Preparation for test-course experiment (Experimental vehicle and eHMI)

Experimental scene based on extracted use-cases:

crossing, approaching, avoiding

Same vehicle as FOTs promoted by MLIT

・driverless mode

・vehicle motion

・eHMI, road marking,

・knowledge, education

A-i Understanding current status of communication between AV for mobility/logistic service and traffic participants

- Investigation of unsafe and inefficient communication between low-speed Automated vehicles and road users

  Aims and Methods

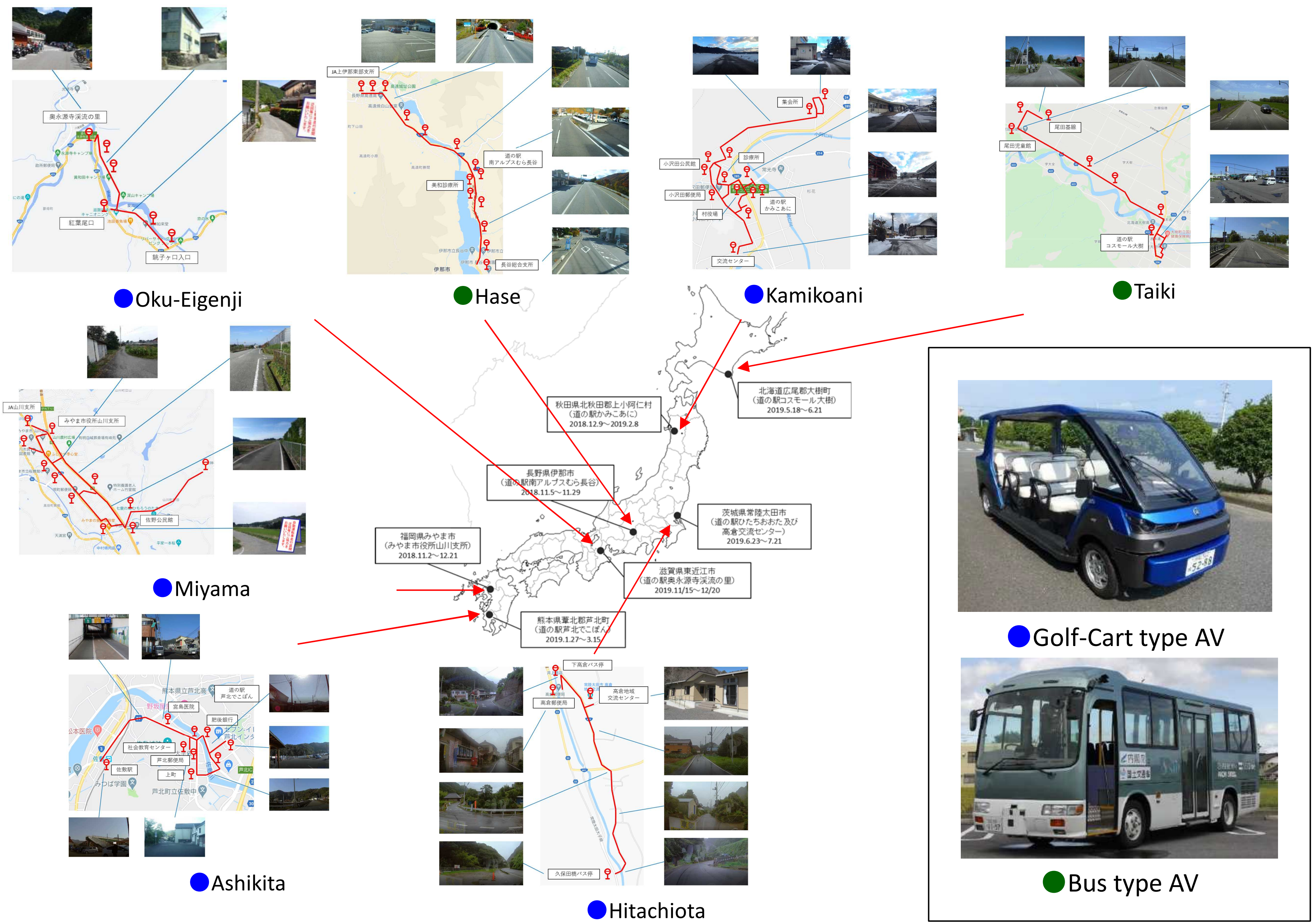
  - We aim to investigate frequency and factors of unsafe and inefficient communication (One recognizes other road users, and changes their behavior) between low-speed Automated vehicles and road users.

  - We calculate frequency of communication by each communication type (Passing (approaching, or avoiding), Crossing, and Overtaking), and road user (Pedestrian, bicycle, motorcycle, and vehicle).

  - We calculate frequency of failures in each communication.

  - We calculate frequency of failures, which is specific for AVs, in each communication, and discuss the factor.

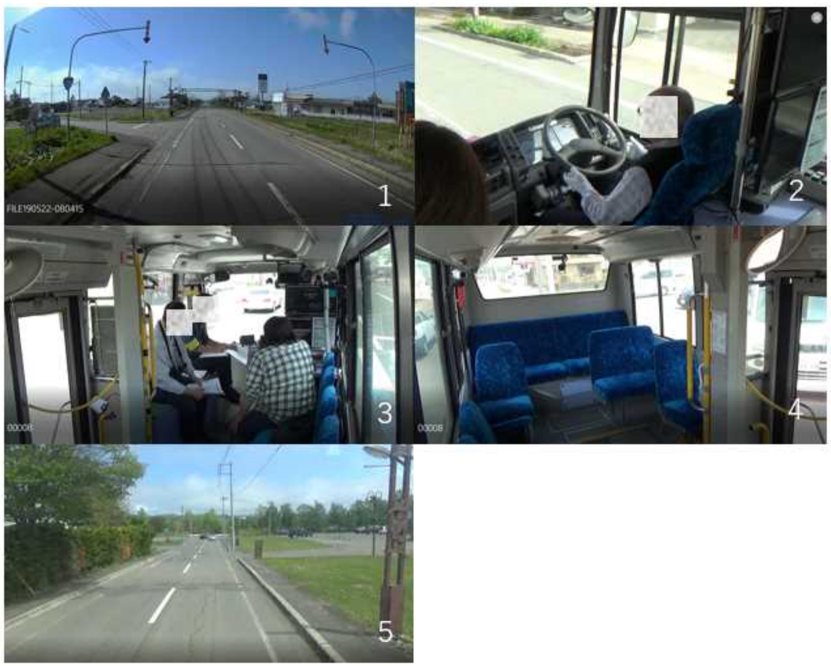
Target areas for automated vehicle FOT by MLIT, type of AV



Dashcam data of each AV

● Bus type AV

● Golf cart type AV



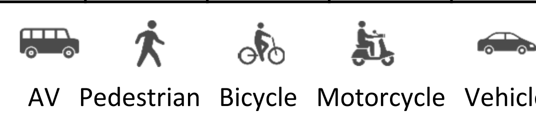
Examples for dashcam data measured in Taiki
1: Front-view 2: Driver
3: Passengers in front area 4: Passengers in rear area
5: Rear-view

Examples for dashcam data measured in Kamikoani
1: Front-view 2: Driver
3: Passenger 4:Rear-view

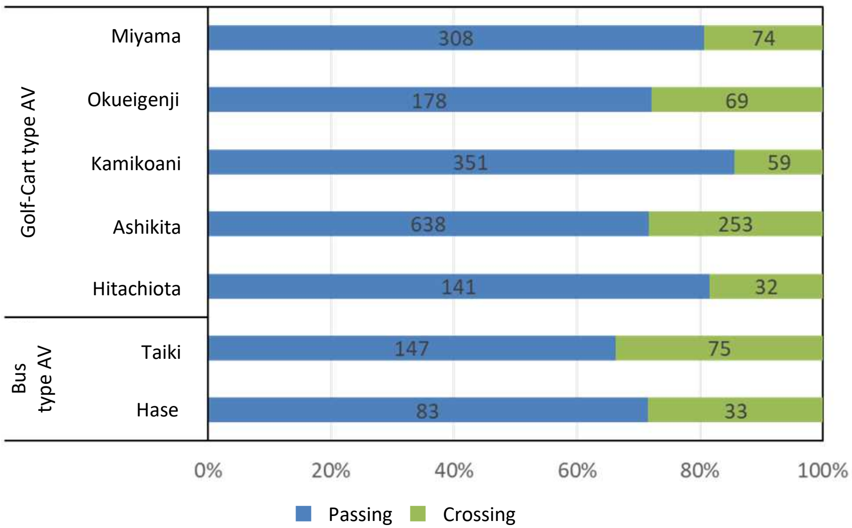
Types of communication between AVs and road users

Classification of communication scenes based on the components of traffic disturbance

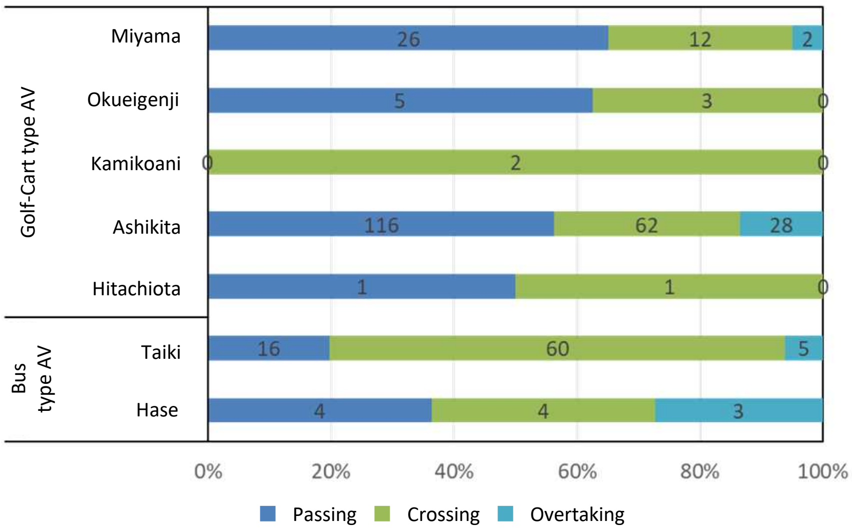
		Communication（Location and behavior of road user）											
Road type	AV's behavior	Passing				Crossing				Overtaking			
		Pedestrian	Bicycle	Motorcycle	Vehicle	Pedestrian	Bicycle	Motorcycle	Vehicle	Pedestrian	Bicycle	Motorcycle	Vehicle
Straight road	Active	AV cannot run our of rail.								AV cannot run our of rail.			
	Passive												
Intersection	Active	AV cannot run our of rail.								AV cannot run our of rail.			
	Passive												
Parking lot	Active	AV cannot run our of rail.								AV cannot run our of rail.			
	Passive												



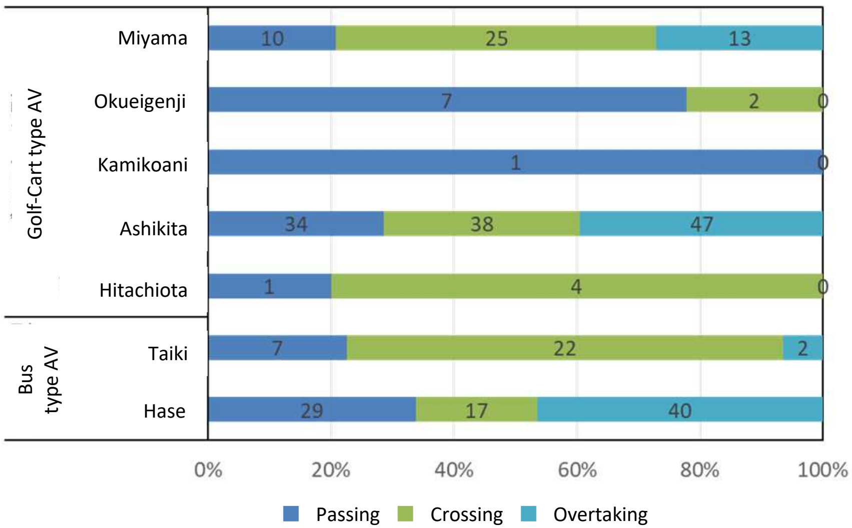
Frequency of each communication



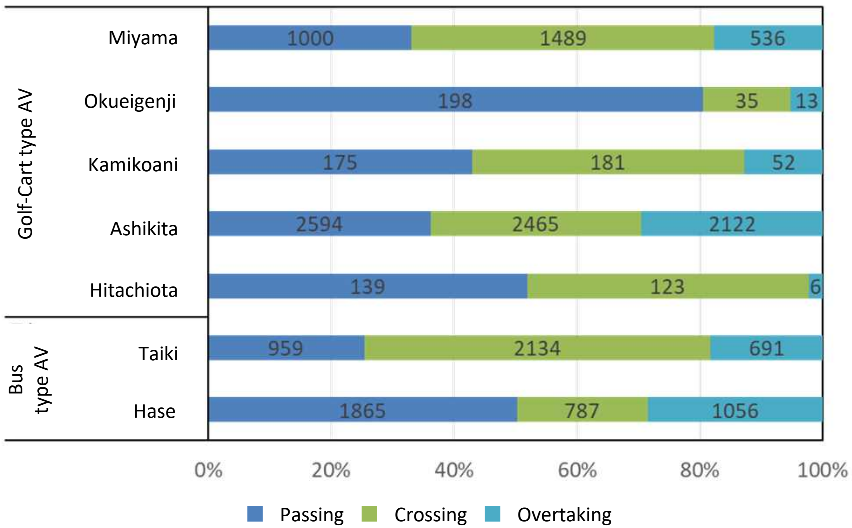
Frequency of communication between AV and pedestrian



Frequency of communication between AV and bicycle



Frequency of communication between AV and motorcycle



Frequency of communication between AV and vehicle

Cases of failure of communication between AV and road user

Pedestrian cross at intersection and road（5 times）

- Pedestrian group wanted to move to left side, however, could not understand AV's intention, and behavior. Pedestrian group stopped to wait AV's behavior.

AV approached to pedestrian from back（3 times）

- Pedestrian recognized AV from back. Pedestrian avoided to roadside, however, pedestrian remained in AV's lane. AV needed to stop to wait pedestrian's behavior.

AV approached to bicycle from back（3 times）

- Bicycle did not recognize AV from back. Bicycle remained in AV's lane, therefore, AV could not overtake bicycle.

AV pass vehicle at narrow road（38 times）

- AV and vehicle hesitated which should go first.

AV and vehicle face at parking and road（62 times）

- AV and vehicle hesitated which should go first.

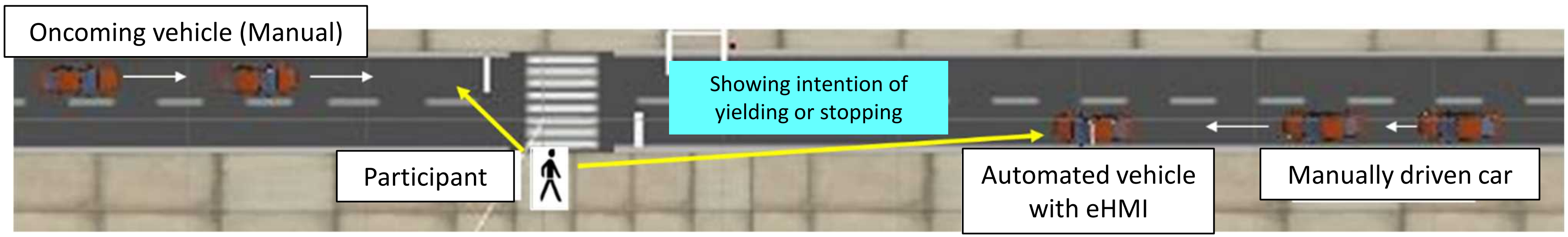
Vehicle overtakes AV at road（16 times）

- After vehicle overtook AV, vehicle was about to collide with oncoming vehicle.

A-ii Research on negative effect of communication between AV and traffic participants

- Mitigation for negative effect with eHMI
  - To examine impacts of two methods on mitigating negative effects by pedestrians' inappropriate reliance and trust towards eHMIs on low-speed automated vehicles

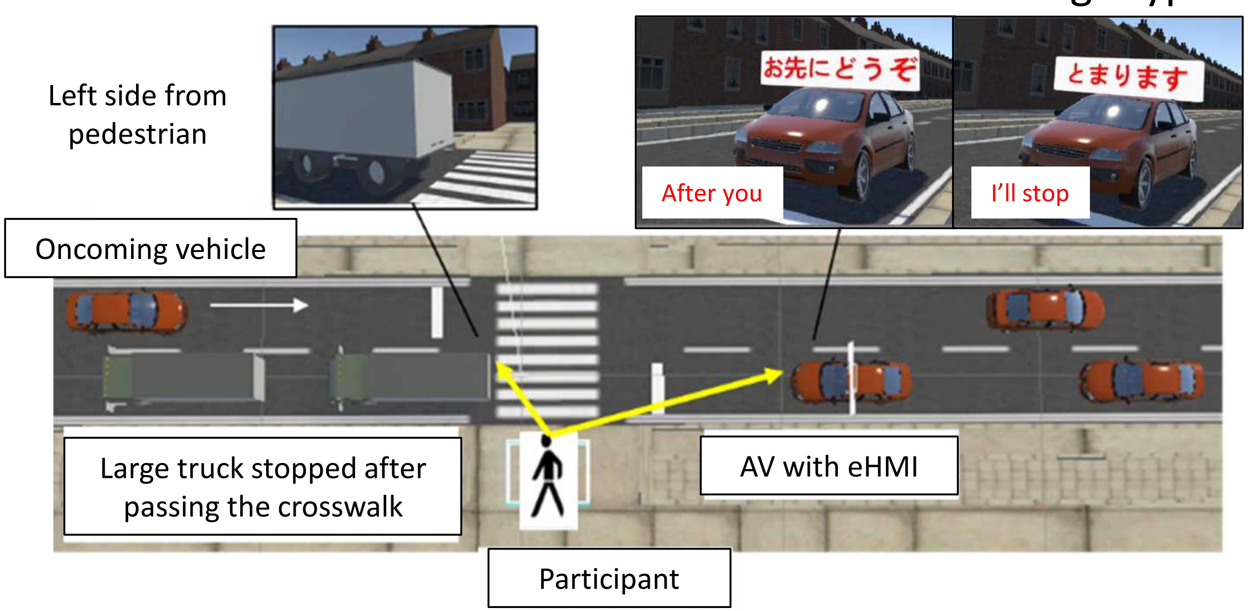
Traffic scenarios for the eHMI experience（1st~10th trial）

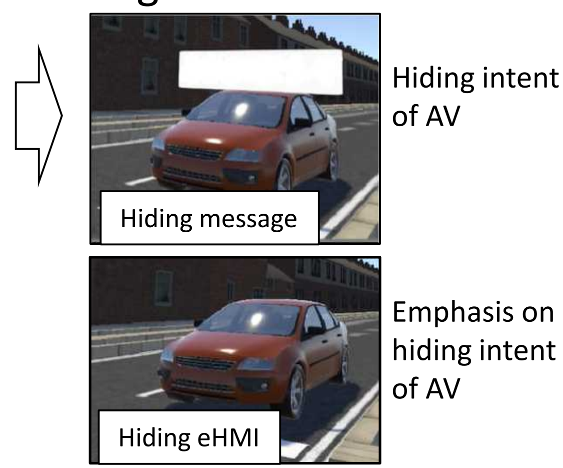


Scenario for negative effect（11th trial）

Message type

Mitigation method





Hiding intent of AV in traffic conditions that induce negative effect to pedestrians

Pedestrian behavior during pedestrian-AV communication via eHMIs

(Conducting in FY2020 - FY2021)

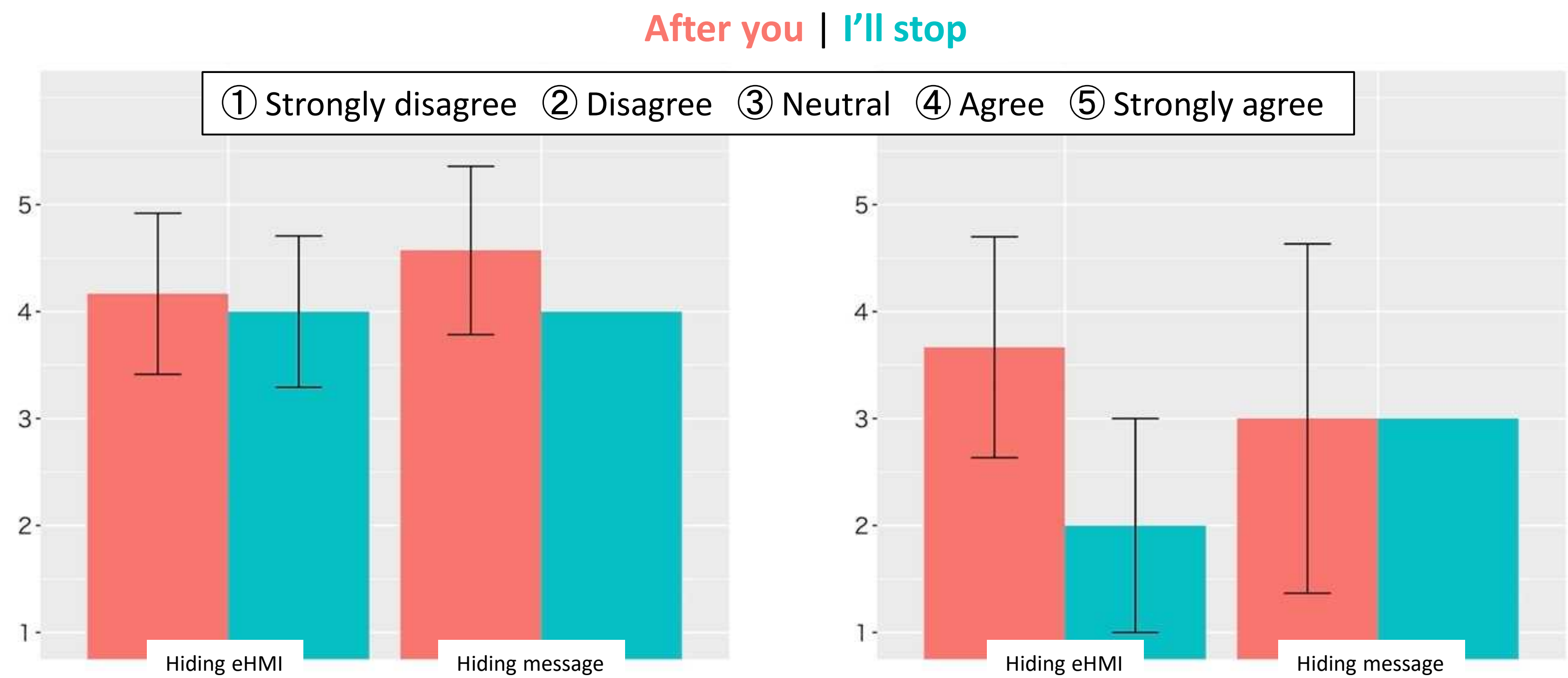
Results of participant behavior observed by VR experiment (Observed num. / Total num.)

Method	Message	N of participants	Looked left and right	Stopped	Occurrence of near-miss
Hiding message	After you	6	6 / 6	4 / 6	1 / 6
	I'll stop	1	1 / 1	1 / 1	0 / 1
Hiding eHMI	After you	7 1)	4 / 6	7 / 7	2 / 7
	I'll stop	5 2)	4 / 4	5 / 5	1 / 5

1)2) Recording error in experimental apparatus

- Pedestrians who did not look toward sides were observed in Hiding eHMI which conveyed "After you" more than other experimental conditions.
- When "After you" message was hided, 2 pedestrians kept crossing without stopping on the crosswalk while all pedestrians stopped during crossing in other 3 conditions.
- Pedestrians who experienced "After you" message had near-miss cases with the oncoming vehicle (Hiding eHMI = 2, Hiding message = 1 case).
- Still unclear impacts of both mitigation methods on solving the negative effect issue.
- "After you" message from eHMIs possibly leads pedestrians to be less careful of checking surrounded traffic environment

Pedestrian attitude towards AV: Cognition & sense of security

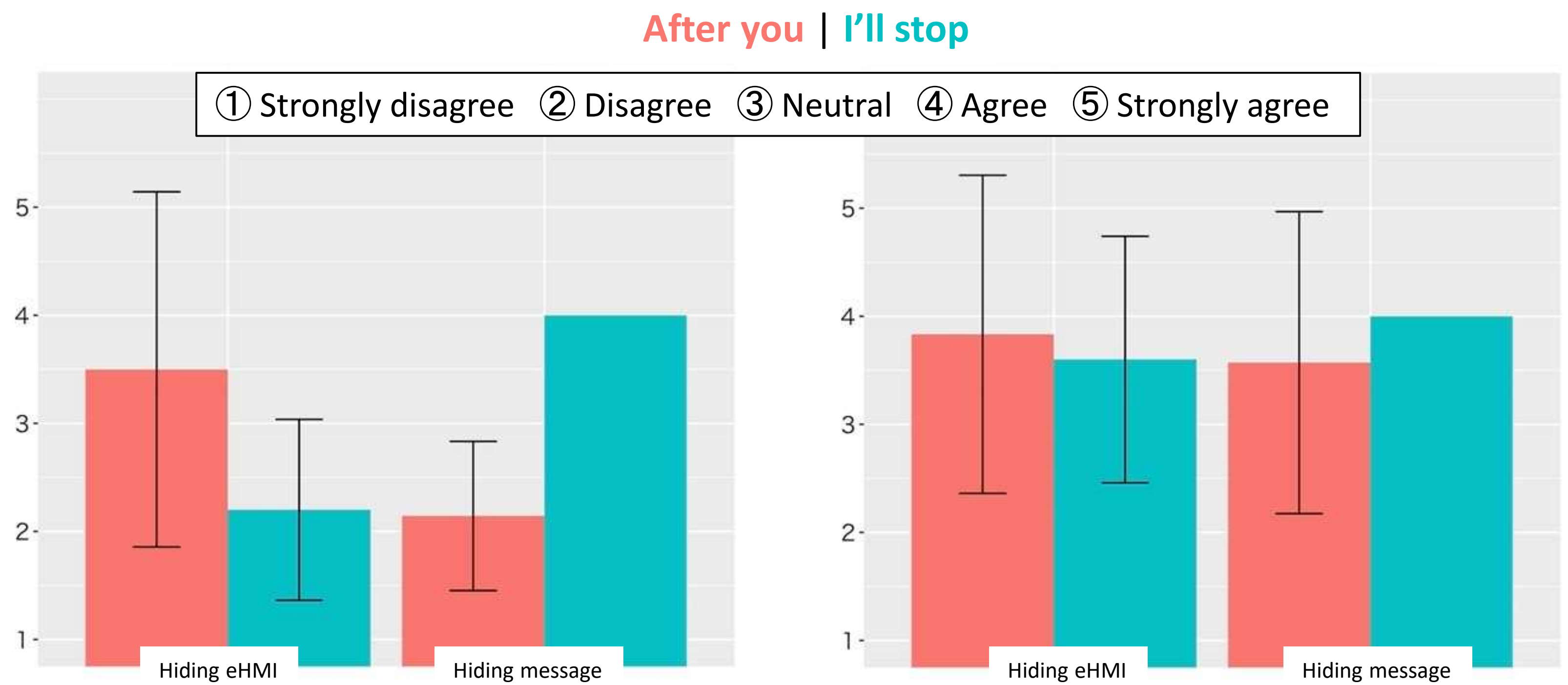


Q: The approaching car from the right side was yielding to you

Q: I could cross with sense of security before the approaching car from the right passed

- Both mitigation methods with "After you" message improved the level of pedestrian cognition of AV's intention compared to "I'll stop" message.
- Hiding message method may have impacts on negative effects rather than hiding eHMI method
- When the eHMI is totally hided, "After you" possibly lead higher sense of security than "I'll stop" message.

Pedestrian attitude towards AV: Consideration & Trust



Q: I hurried to cross the road minding the yielding car from the right

Q: I could trust the AV approaching from the right

- No clear tendencies of mitigation methods and message types were observed in pedestrians' consideration levels.
- Both mitigation methods help maintain levels of trust towards the AV.
- Overall, pedestrians' cognition and sense of security account for negative effects formed by continuous exposures to eHMIs compared to trust in the AV.

A-iii Preparation for test-course experiment (Experimental vehicle and eHMI)

Preparation for experimental vehicles and test tracks to study communication methods for extracted use cases

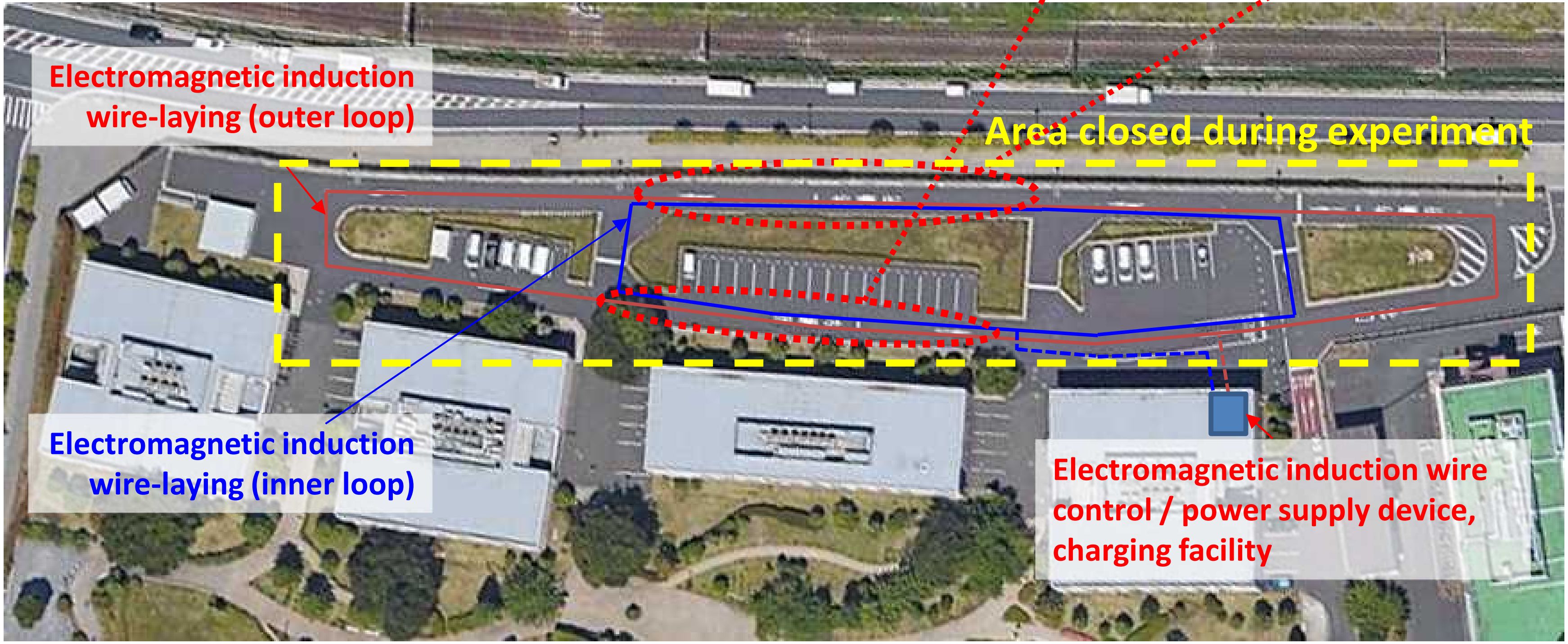
Experimental AV (Golf cart type)

External HMI

Various road environments for analysis and evaluation of communication between AV and traffic participants

Use-case for crossing

Use-case for approaching/avoiding



Keio University Shin-Kawasaki K^2 Town Campus Test Track

A-iv Examination and proposal of basic communication method between low-speed AV for mobility/logistics services and surrounding traffic participants in single roads and intersections

- Regarding unsafe and inefficient use cases in single road section, conducted VR experiments targeting the cases of "crossing" and "approaching/avoiding", and analyzed and examined the proposed communication methods

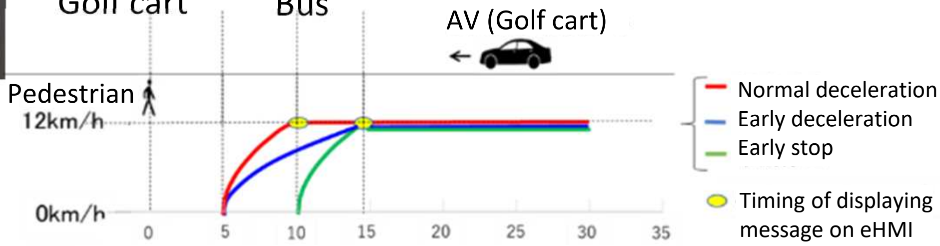
< Use case of “crossing” >

Analyzing pedestrians’ recognition and judgment on intention (yielding)of AV

Crossing – single road (residential road)

Golf cart　Bus

External HMI



Distance between AV and pedestrian (m)

< Use case of “approaching/avoiding” >

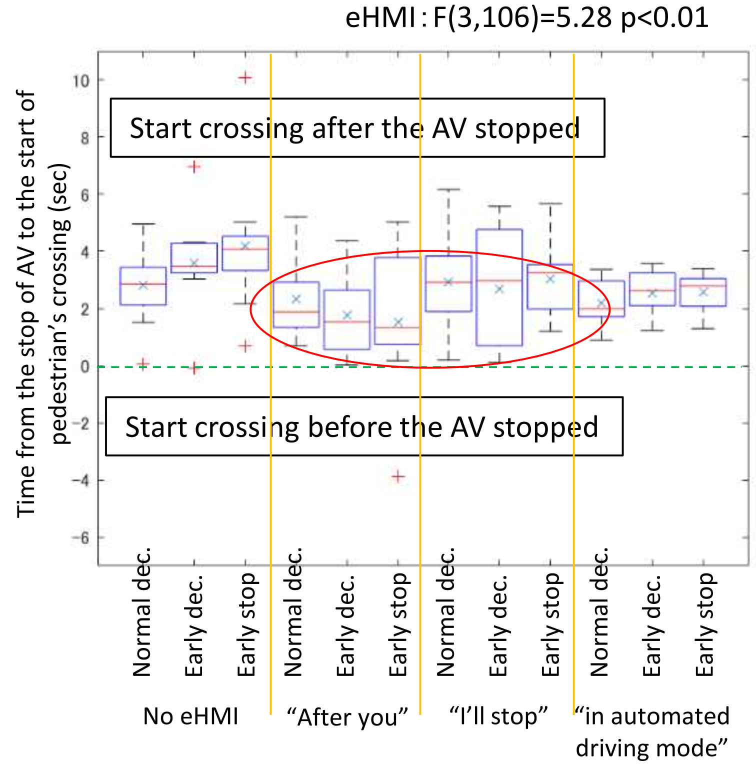
Analyzing pedestrians’ recognition and judgment on approaching/avoiding of AV

Approaching/avoiding – single road (peripheral road around road-station [mountainous area])

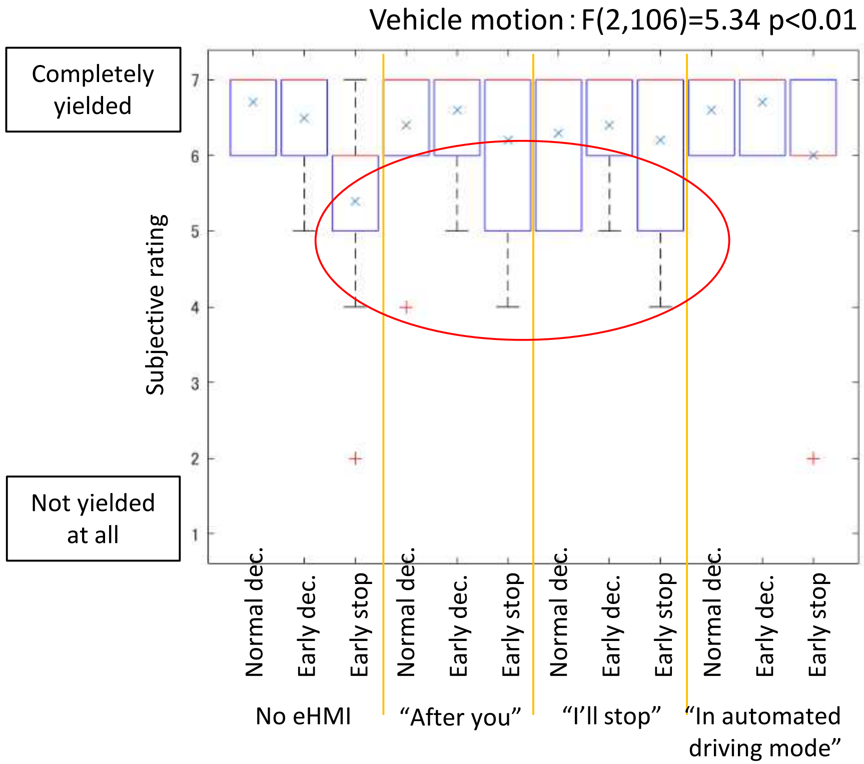
Golf cart　External HMI　Projection　Road marking

Example of VR experiment results in a single road section (crossing case)

- Communication from a low-speed AV (Golf cart) to a pedestrian
  - Normal deceleration has effect to shorten pedestrians' judgment whether they can cross early, comparing with the case of early deceleration and early stop..
  - External HMI reduces the difference in pedestrian's judgment timing based on vehicle motion, and provides them with early judgment and crossing.



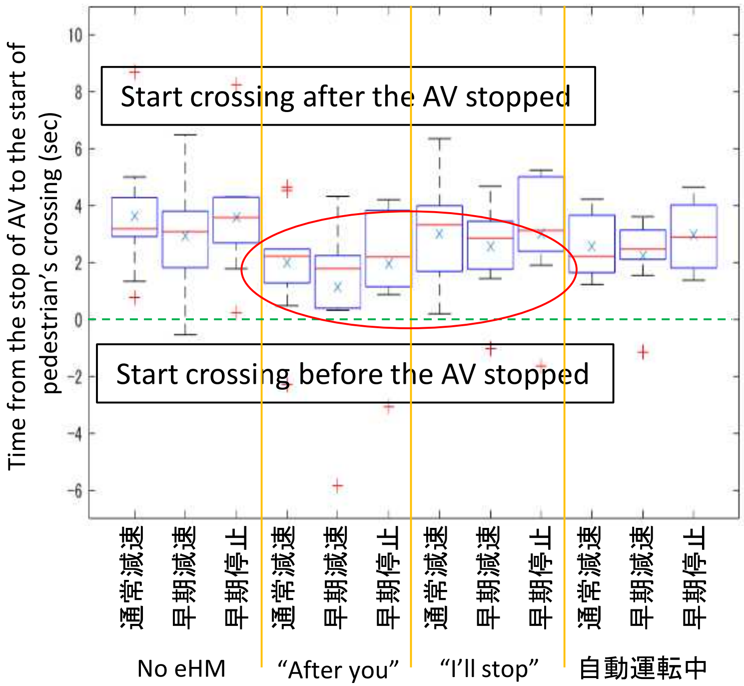
Time from the stop of AV to the start of pedestrian's crossing (Residential road (single road) – Golf cart)



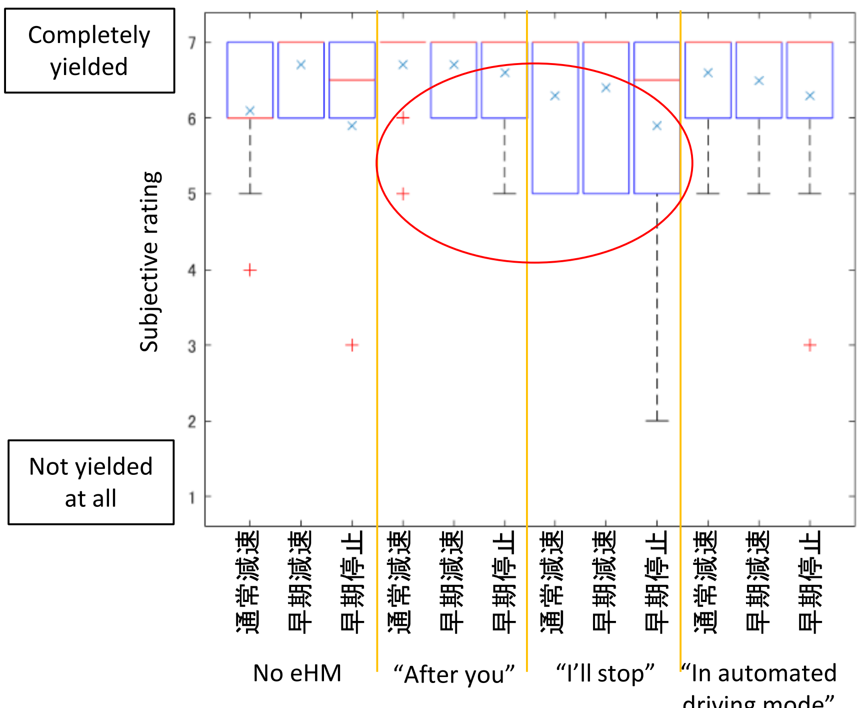
Pedestrians' recognition to AV's intent (yielding) (Residential road (single road) – Golf cart)

Example of VR experiment results in a single road section (crossing case)

- Communication from a low-speed AV (Bus) to a pedestrian
  - Unlike golf cart, early deceleration has effect to shorten pedestrians' judgment whether they can cross early, comparing with the case of normal deceleration and early stop..
  - Similar to golf cart, external HMI reduces the difference in pedestrian's judgment timing based on vehicle motion, and provides them with early judgment and crossing.



Time from the stop of AV to the start of pedestrian's crossing (Residential road (single road) – Bus)



Pedestrians' recognition to AV's intent (yielding) (Residential road (single road) – Bus)

A-v Examination and proposal of basic communication method between low-speed AV for mobility/logistics services and surrounding traffic participants at shared space (parking lot)

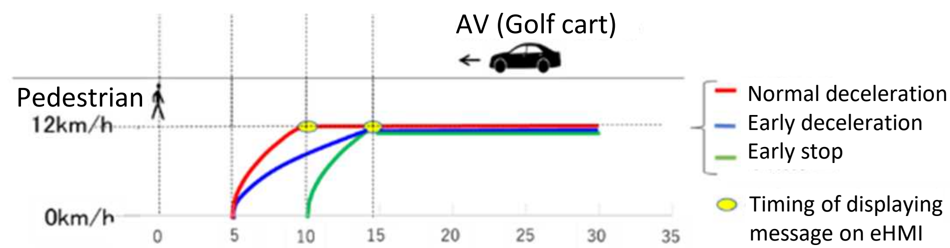
- Regarding unsafe and inefficient use cases in parking lots, conducted VR experiments targeting the cases of "crossing" and "approaching/avoiding", and analyzed and examined the proposed communication methods

< Use case of “crossing” >

Analyzing pedestrians’ recognition and judgment on intention (yielding)of AV

Crossing – parking lot (road station [mountainous area])

ゴルフカート　バス



Distance between AV and pedestrian (m)

< Use case of “approaching/avoiding” >

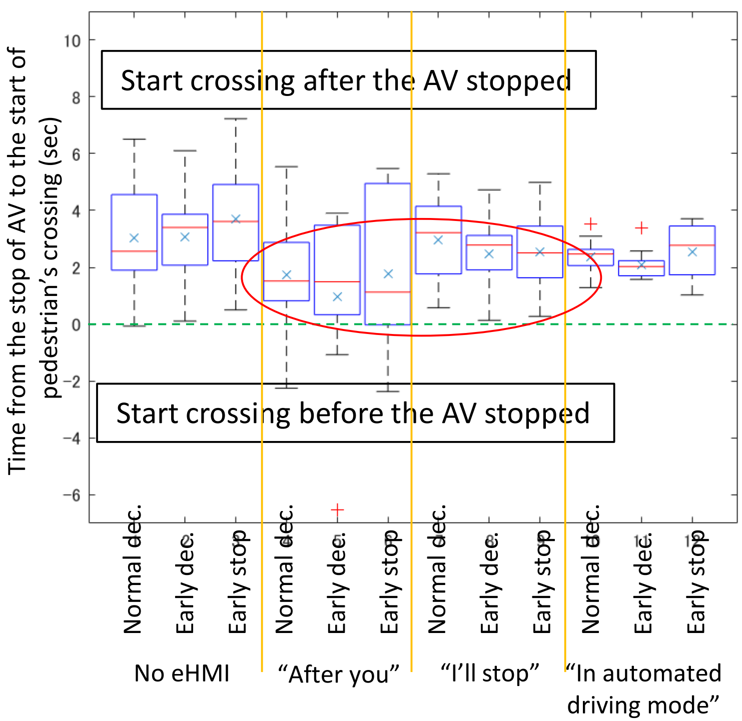
Analyzing pedestrians’ recognition and judgment on approaching/avoiding of AV

Approaching/avoiding – parking lot (road-station [mountainous area])

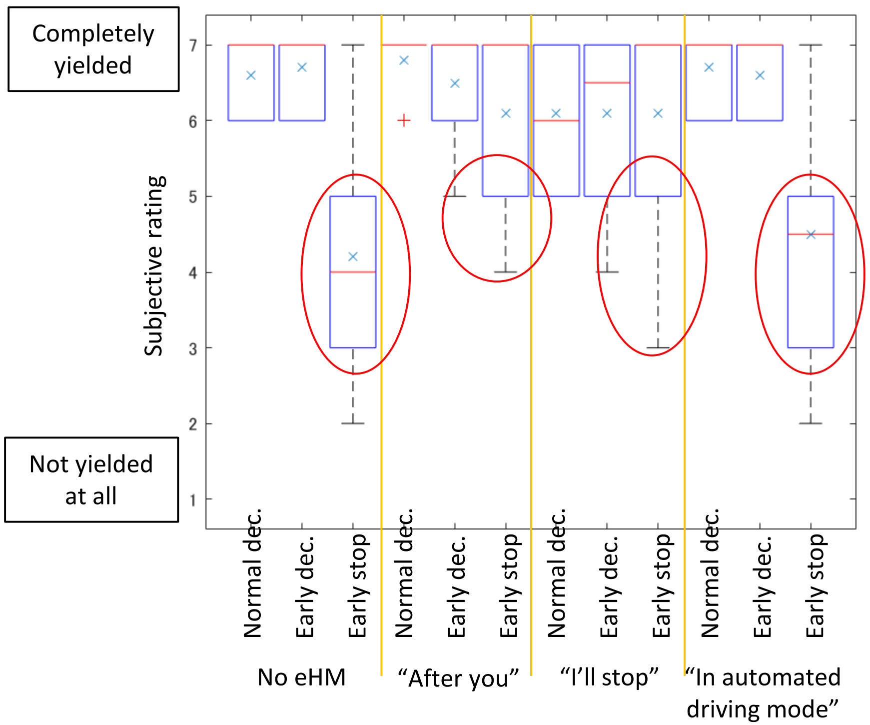
Golf cart　External HMI　Projection　Road making

Example of VR experiment results in a parking lot (crossing case)

- Communication from a low-speed AV (Golf cart) to a pedestrian
  - There is almost no difference in judgment whether pedestrians can cross and start between three types of vehicle motion, except for the case of eHMI with “After you”.
  - Tendency to shorten such pedestrians’ judgment by utilizing external HMI.
  - Early stop tends to provide that pedestrians feel not to be yielded by AV, compared to any other vehicle motion.



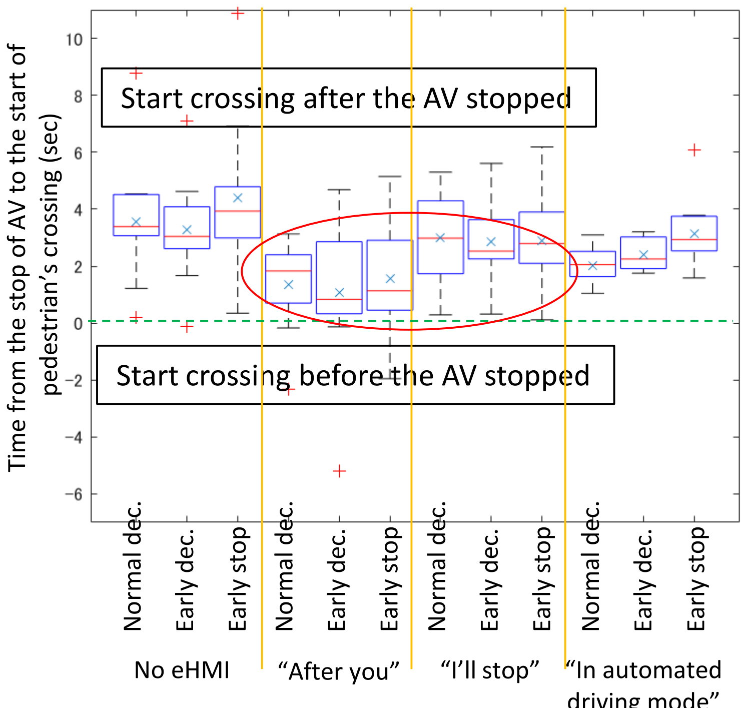
Time from the stop of AV to the start of pedestrian’s crossing (Road station (parking lots) – Golf cart)



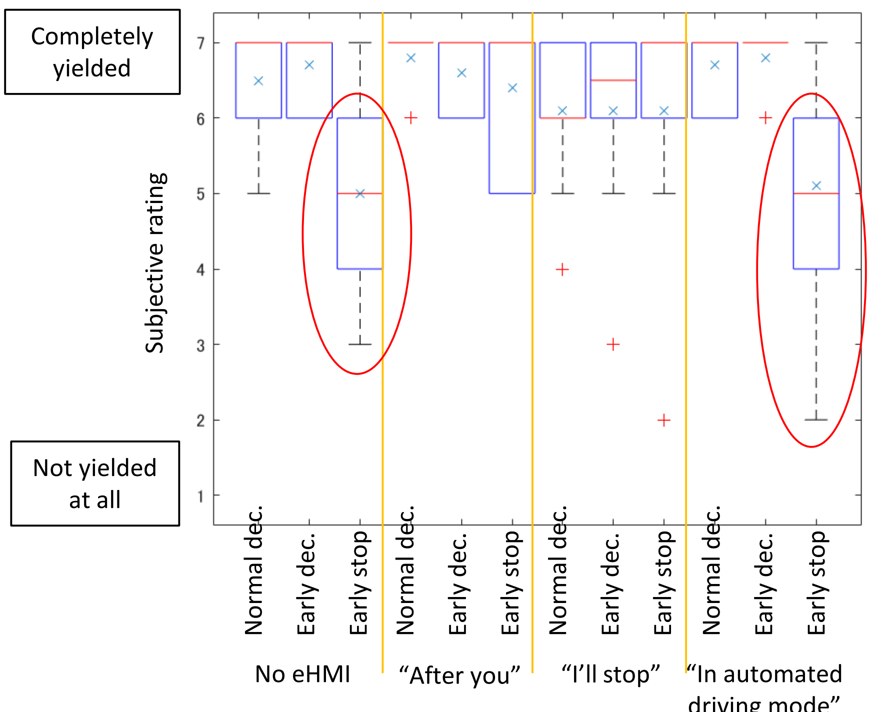
Pedestrians’ recognition to AV’s intent (yielding) (Road station (parking lots) – Golf cart)

Example of VR experiment results in a parking lot (crossing case)

- Communication from a low-speed AV (Bus) to a pedestrian
  - Similar to golf cart, there is almost no difference in judgment whether pedestrians can cross and start between three types of vehicle motion, except for the case of eHMI with "After you".
  - Tendency to shorten such pedestrians' judgment by utilizing external HMI.
  - In the case of no eHMI and eHMI with "In automated driving mode", early stop tends to provide that pedestrians feel not to be yielded by AV, compared to any other experimental conditions.



Time from the stop of AV to the start of pedestrian's crossing (Road station (parking lots) – Bus)



Pedestrians' recognition to AV's intent (yielding) (Road station (parking lots) – Bus)

Summarized results of Task A in FY2020（1）

i. Investigation of unsafe and inefficient communication between low-speed Automated vehicles and road users

- Inefficient cases were caused by without eye contact and gesture from AV, when AV faced to other road users at road and parking, because road user could not understand AV's intention and behavior.

- Inefficient cases were caused by low-speed and fixed acceleration/deceleration of AV, when AV faced to other road users at road and parking, because road user could not understand AV's intention and behavior.

- Unsafe and inefficient cases were caused by road user's limited knowledge about AV, such as road user did not know AV only could run on rail, when AV approached pedestrian from back, and could not communicate efficiently.

- Unsafe cases were caused by AV's low-speed and location (running left side of road). Vehicle tended to feel that AV made the vehicle overtake when the vehicle run back of AV, because of the low-speed and left side running. After overtaking AV, the vehicle often was about to collide with oncoming vehicle.

Summarized results of Task A in FY2020（2）

ii. Examination of methods to improve the negative effects to pedestrians caused by communication using eHMI of low-speed AV

- When there is a possibility to induce negative effect to pedestrians, proposed methods on mitigating such negative effect, “hiding message” and “hiding eHMI”, made a few improvements on pedestrians’ visual behavior and stopping on crosswalk to confirm surrounding safety. In order to make further improvements, it is necessary to provide knowledge or education on AV and eHMIs to traffic participants.

iii. Preparation for test-course experiment (Experimental vehicle and eHMI

- Two experimental vehicles equipped with automated driving function have been produced and introduced with road-taxed condition. They can travel on electromagnetic induction wires laid on the roads and parking areas of the Keio University Shin-Kawasaki (K2) Town Campus when activating the automated driving function.
- The use cases of “crossing” and “approaching/avoiding” can be reproduced in the test track environment and test track experiments are scheduled to be conducted in early FY2021.

Summarized results of Task A in FY2020（3）

iv. Examination and proposal of basic communication method between low-speed AV for mobility/logistics services and surrounding traffic participants in single roads and intersections

< Use case of “crossing” >

- Vehicle motion is the most effective cue to pedestrian-AV communication, and eHMIs equipped in AV may enable pedestrians to lead quick decision-making when they could not understand AV’s intention with only vehicle motion.
- External HMI conveying a message of “After you” is likely to enable pedestrians to make decision quickly, however it is important to consider other negative effects derived by eHMIs.
- Large vehicle type such as bus leads the high levels of pedestrians’ anxiety even though distance between pedestrian and AV is long. However, eHMI is expected to address this psychological issue to reduce the anxiety as well as to improve feeling of safety levels.

< Use case of “approaching/avoiding” >

- During communication between pedestrian and AV (golf cart) following pedestrians, pedestrians have difficulty in appropriate decision-making and cognition of AV’s intention by vehicle motion and eHMI with “I’ll stop”. For communication of approaching and avoiding AV, communication with road marking which indicates AV’s driving route possibly has effects on pedestrians’ cognition, decision, and attitude towards AV.

Summarized results of Task A in FY2020（4）

v. Examination and proposal of basic communication method between low-speed AV for mobility/logistics services and surrounding traffic participants at shared space (parking lot)

< Use case of “crossing” >

- Considering priority is ambiguous in parking areas unlike roads, AV’s stopping point affects the most communication between pedestrians and AV. Also, eHMIs equipped in AV may help pedestrians lead quick decision-making when they could not understand AV’s intention with only vehicle motion.
- During pedestrian-AV communication with both AV’s vehicle motion and eHMI, long distance between AV and pedestrian makes the communication difficult. More specifically, the long distance makes pedestrian ambiguous to interpret AV’s intention, resulting in increases of anxiety level during decision-making on crossing.
- Consistent with narrow roads, eHMI with of “After you” is likely to enable pedestrians to make decision quickly, however automation designers need to consider other negative effects derived by eHMIs.

< Use case of “approaching/avoiding” >

- During communication between pedestrian and AV (golf cart) following pedestrians, communication methods, such as “I’ll stop” message from eHMI and projecting driving direction from AV, may not ensure to yield appropriate decision-making and cognition considering encountering situations.

Task B

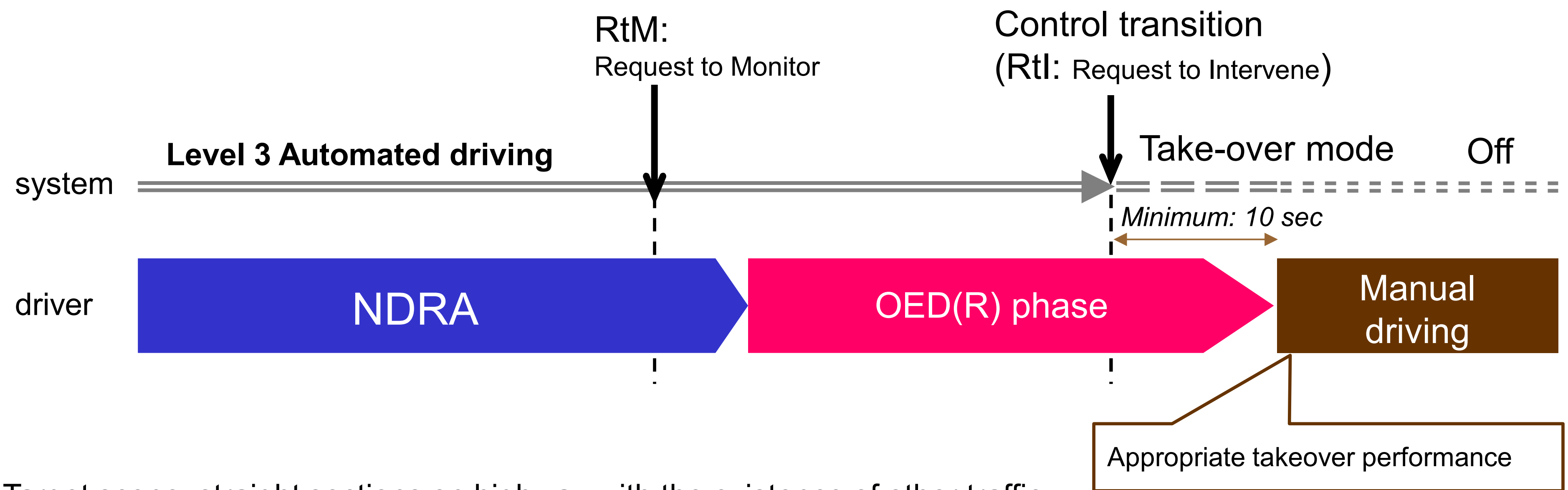
Development of evaluation methods of driver’s OEDR (Object and Event Detection and Response) and HMI for enhancing driver’ take-over in a transition from automated to manual driving

National Institute of Advanced Industrial Science and Technology (AIST)

The University of Tokyo

Outline of the effort on Task B (1/2)

System-initiated (with RtI) transition from automated to manual driving



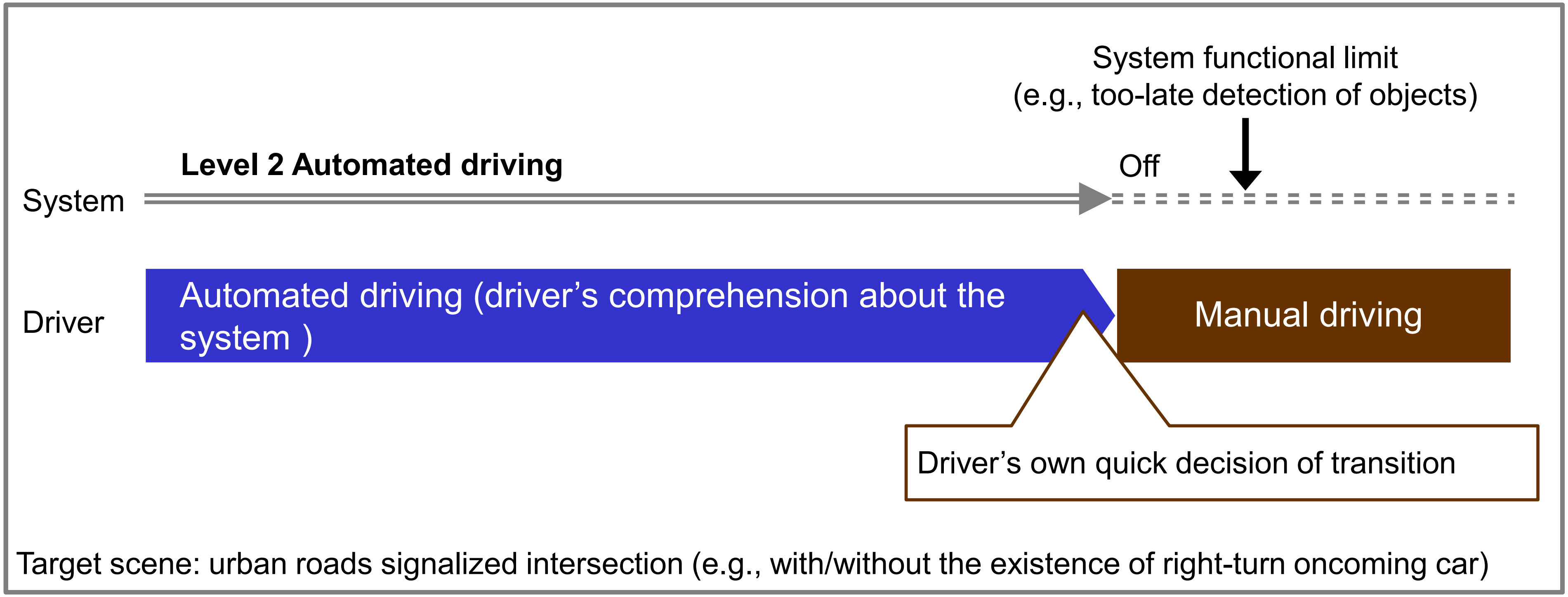
Target scene: straight sections on highway with the existence of other traffic
Basically, focus on pre-planned transitions
For unplanned transitions, consider a shorter period (10 sec or less) of OEDR condition

- **OED(R) status that direct to a good takeover performance**
- **Evaluation methods of OED(R) status**
- **Factors facilitating a good OED(R) status (methods to request OED(R), time for constructing a proper OED(R) status)**

NDRA: Non-Driving Related Activities
OED(R): Object and Event Detection(and Response)

Outline of the effort on Task B (2/2)

Driver-initiated transition from automated to manual driving



- **Evaluation methods of the driver’s comprehension about the system**
- **Factors facilitating a good comprehension about the system, prior knowledge**
- **ODDs that allow driver-initiated transition**

ODD: Operational Design Domain

Output of Task B

Evaluation methods of OED(R)

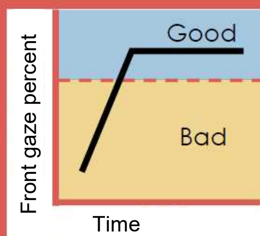
Establish methods that detect & analyze driver's OED(R), provide protocols and evidence of this

Metrics

- Gaze (high precision)
- Head orientation
- Others

Methods & standards

- Compare current condition to a good one extracted from Gaze behavior



Usage

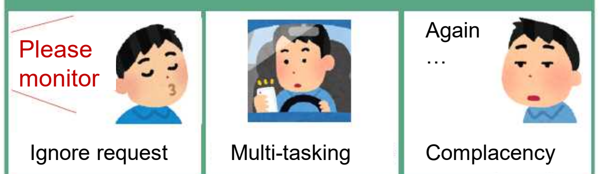
- Conduct practical test of the metrics in simulated R&D phase of actual HMI
- Publish the protocol, and make it available as manual

Basic knowledge about an effective request to monitor

Provide basic knowledge about drivers' reaction to system requests and how to deal with unwanted reactions

Question extraction

- Survey on driver's natural reaction to system requests
  - ➢ When and how often unwanted reactions occur ?



Provide basic knowledge

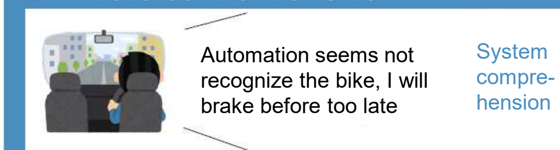
- Understand the reasons of unwanted reactions and provide essential knowledge
- Provide essential knowledge aiming at improve the unwanted reactions

Evaluating system comprehension

Establish methods that detect & analyze driver's system comprehension, provide protocols and evidence of this

Question extraction

- With proper system comprehension, drivers can detect danger and initiate control transition



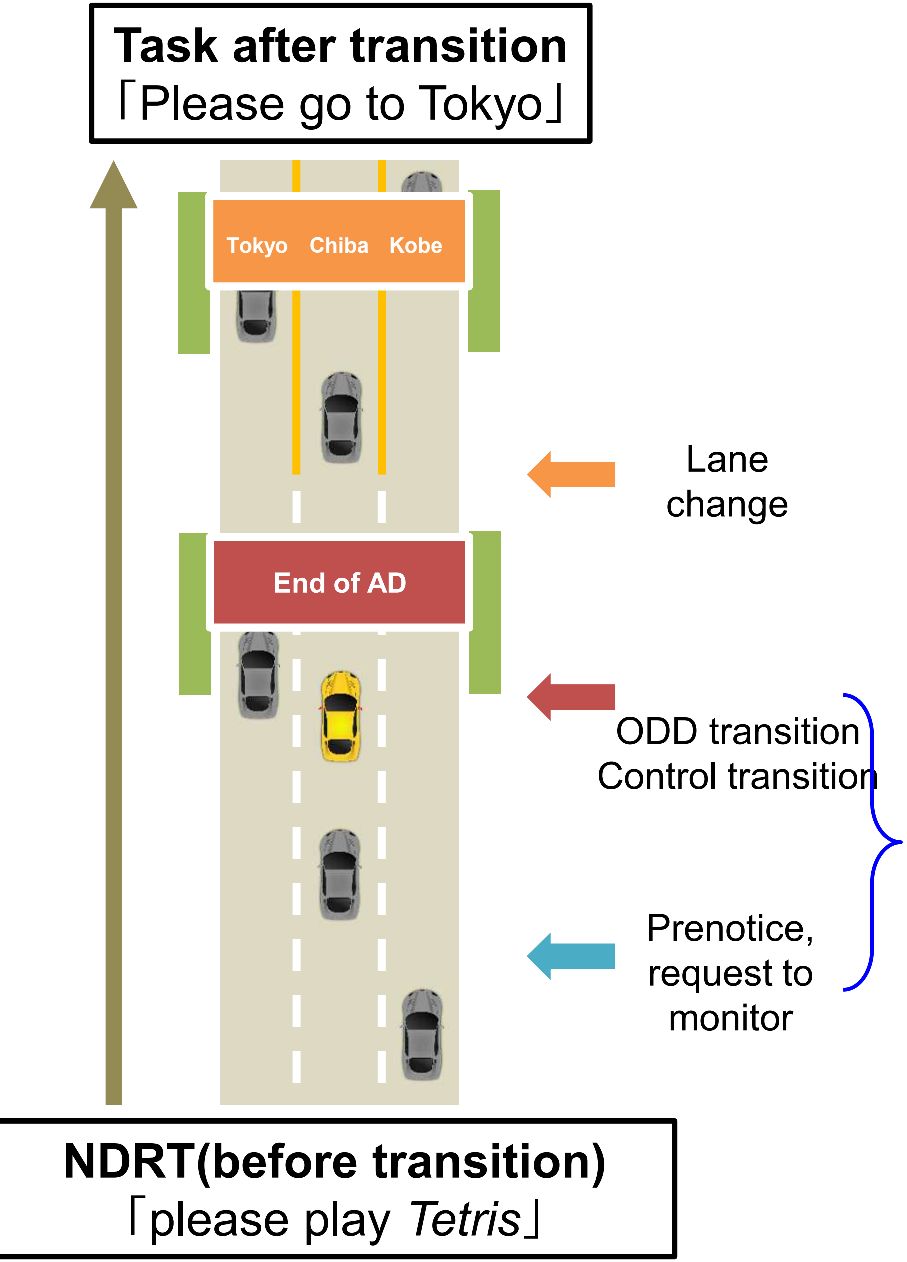
  - ➢ After a period of automated driving, how drivers predict the driving behavior of automation

Provide basic knowledge

- Explorative study on what & how to detect system comprehension
- Explore clues of system comprehension

OED(R): Object and Event Detection(and Response)

Study on evaluation methods of OED(R) —Methods –

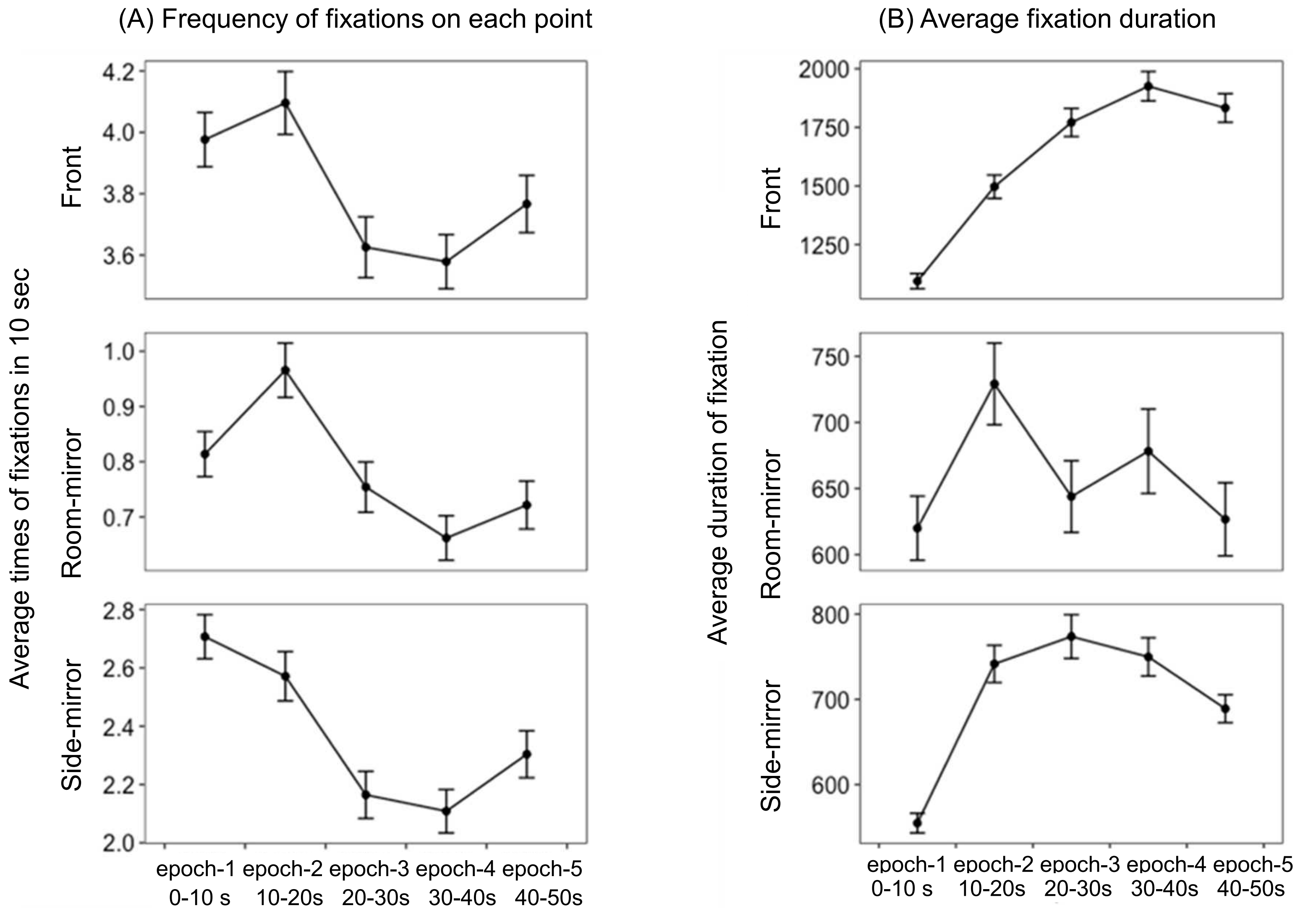


Object: analyze driver's gaze behavior, extract potential OED(R) metrics

- 10-sec segmentation of 50 sec (Prenotice of transition ~ before the transition)
- Extract gaze points (front, room-mirror, side-mirror) using view-tracker

AD: Automated driving

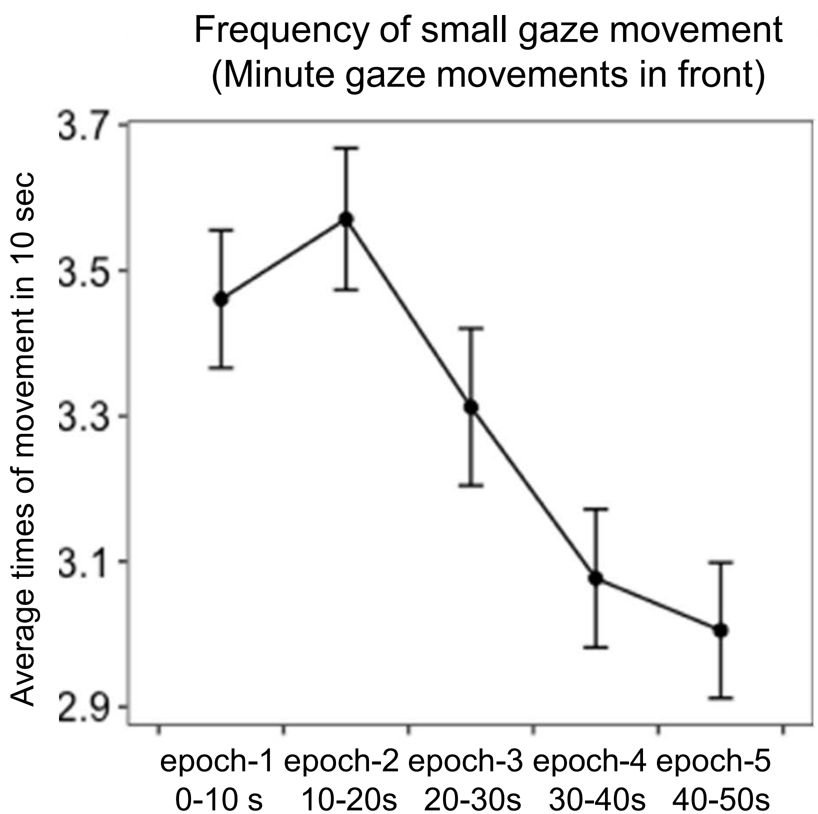
Study on evaluation methods of OED(R)
－Results: fixation frequency & duration－

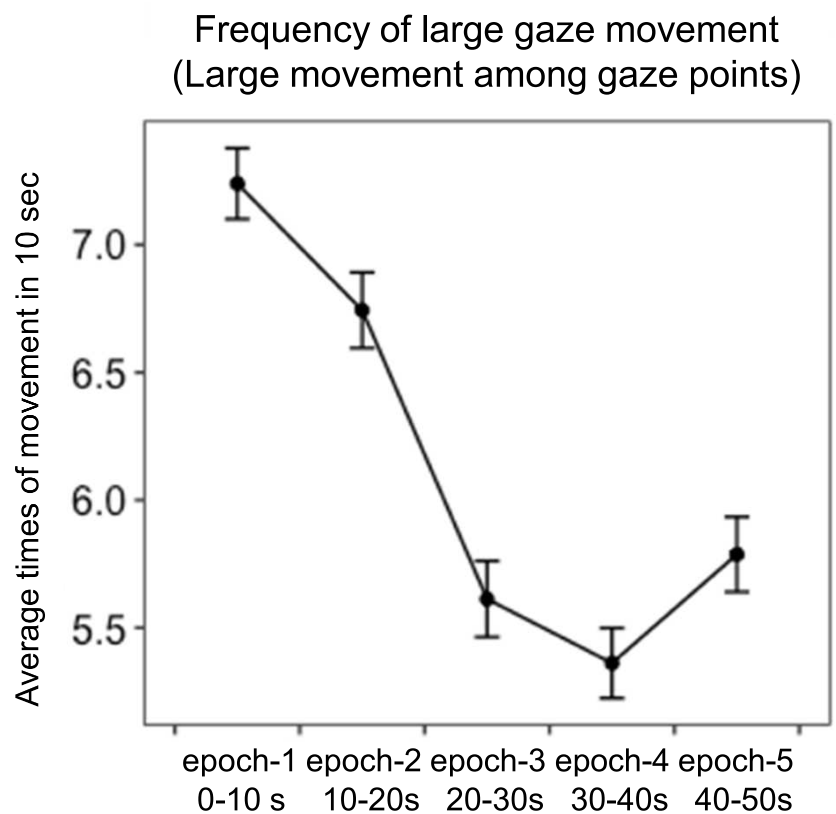


Regarding front fixations，more frequent but shorter fixations within 20s after initiation of monitoring，then less frequent but longer fixations

Study on evaluation methods of OED(R)
– Results: gaze movements –

Small gaze movement：attain the details of surrounding environment (e.g., right-front car to left-front car)
Large gaze movement： attain situations of wider environment (e.g., mirror to mirror)





Regarding gaze, regardless its size, frequent movements within the first 20 seconds period and then reduce drastically

Study on evaluation methods of OED(R)
– Summary –

Indices extracted last-year: fixation percentage，head orientation

Indices extracted this-year: fixation frequency, fixation duration, gaze movements frequency

<0 ~ 20s after initiation of monitoring>

Frequent longer fixations & gaze on mirrors
+ Frequent shorter fixation-on-front
➔understand the condition of back & side

<20s ~ before the transition>

Reduction of fixations & gaze on mirrors
＋long and continuous fixations on front
➔stable condition after understanding the peripheral environment

FY 2020 Report (The University of Tokyo)

Purpose of 2020:
An HMI will be proposed to improve drivers' understandings on level 2 automated driving systems, by comprehensively presenting a wide range of potential risks to drivers, and its effectiveness will be evaluated with driving simulator experiments.

Experiment 1:
A driving simulator experiment was performed to identify the difference in driving behavior between level 2 automated driving and manual driving.

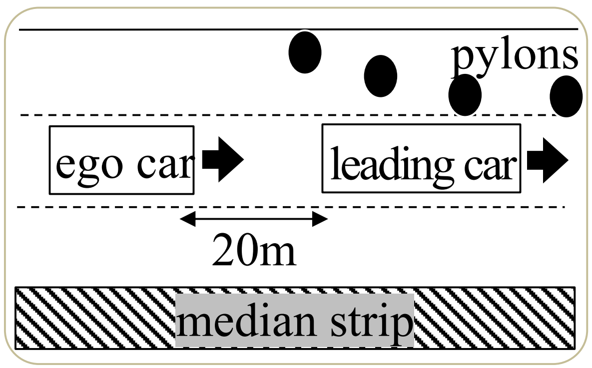
Experiment 2:
An HMI was proposed to present real time results of image recognition by the systems to drivers, and its effectiveness was evaluated with a driving simulator experiment.

Experiment 3:
Evaluation and comparison were performed for two types of HMIs: the HMI proposed in Experiment 2 and the windshield projection type (HUD) HMI.

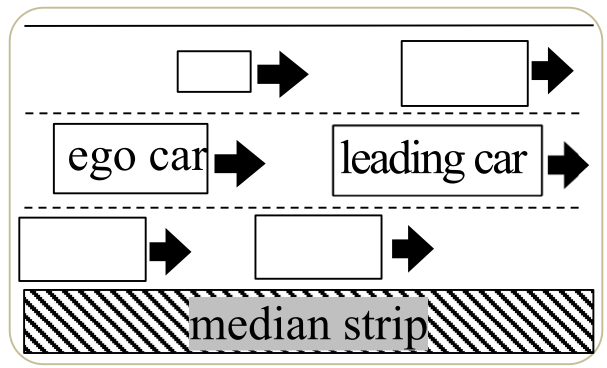
Experiment 1

Objective: Establish a measurement method to evaluate driver's system understanding status.
Method: Compare driving behaviors, including eye-gaze behaviors, during level 2 automated driving and manual driving.

In the experimental scenario, three potential risk scenes that require attention to the surroundings occurred multiple times.



①Pylon for lane regulation



②Overtaken by multiple motorcycles

③Fog

Surrogate Reference Task (SuRT)

	Operation	SuRT
1	Manual	Without
2	Level 2	Without
3	Manual	With
4	Level 2	With

The experiment was conducted with the approval of Ethics Review Board, the University of Tokyo.
Participants: 10 men aged 21-25.

Gaze time and p-value of t-test

(1) Without SuRT

	Manual(s)	Level 2(s)	p value
Front	**659**	**528**	**0.0010**
Right	15.3	23.8	0.21
Left	**16.6**	**49.2**	**0.017**
Speedometer	**41.8**	**14.8**	**0.039**
Right mirror	13.5	20.6	0.068
Left mirror	3.56	5.60	0.081

(2) With SuRT

	Manual(s)	Level 2(s)	p value
Front	**541**	**316**	**0.0035**
Right	7.38	12.1	0.063
Left	10.7	18.4	0.10
Speedometer	**29.9**	**11.7**	**0.046**
Right mirror	**15.1**	**28.7**	**0.0043**
Left mirror	2.19	3.65	0.20
SuRT	92.8	224	**0.0062**

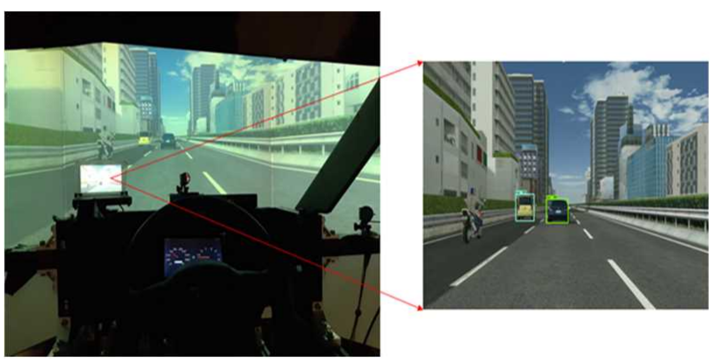
* Significance level: 5%
* Red: A significant increase in gaze time for level 2 ($p < 0.05$); Blue: A significant increase in gaze time for manual operation.

Significant differences in gaze time were observed in multiple areas. It was found that gaze time to the front and the speedometer were significant shorter during level 2 automated driving than during manual driving, for both without and with SuRT conditions. For other areas, there was a tendency that the gaze time became longer when level 2 automated driving was used.

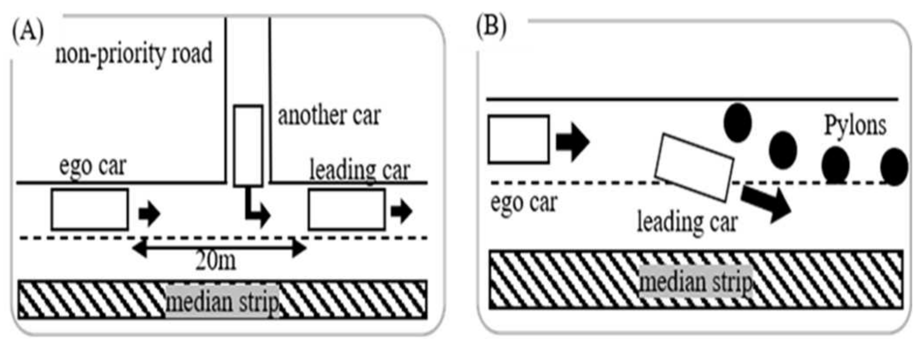
Experiment 2

Objective: Propose a new HMI to promote proper system understandings of Level 2 automated driving systems and to enable safe operation of Level 2 automated driving even in complex traffic environments.
Method: Propose an HMI that directly presents the real-time recognition result of the traffic situation ahead by the system to drivers and evaluate its effectiveness with a driving simulator experiment.

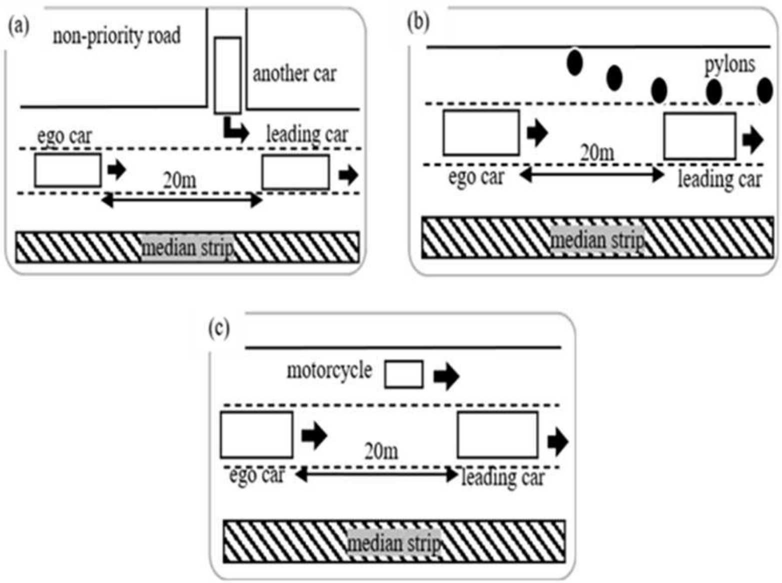
Two types of actual risk scenes (collision will occur without driver intervention) and three types of potential risk scenes (no accidents will occur) are prepared, and two types of scenarios (i) and (ii) that combine them were used.



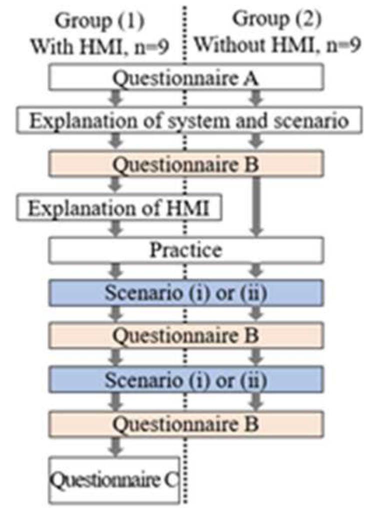
Proposed HMI



Actual risk scenes

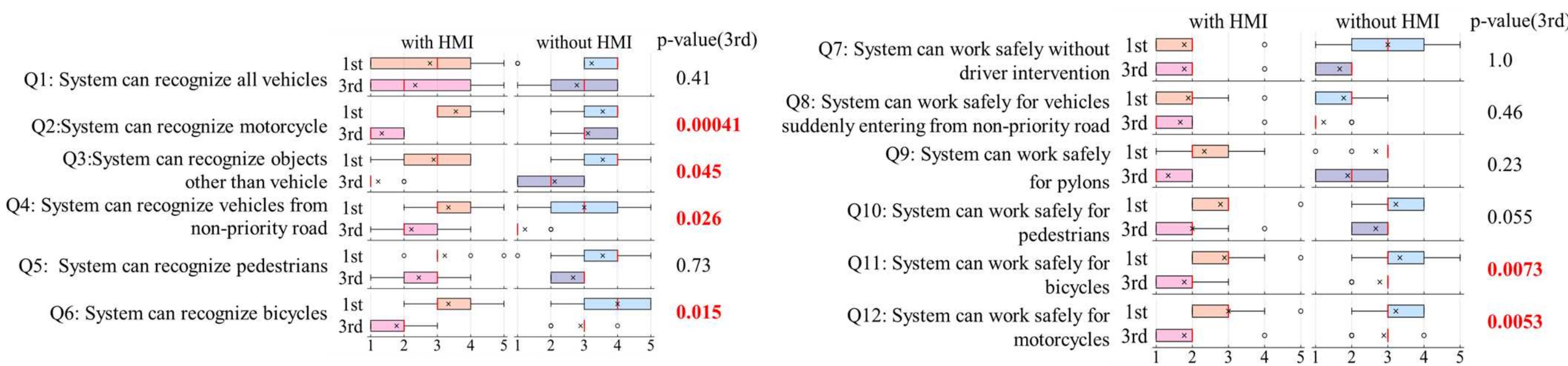


Potential risk scenes



Experimental procedure

The experiment was conducted for 18 participants with the approval of Ethics Review Board, the University of Tokyo.



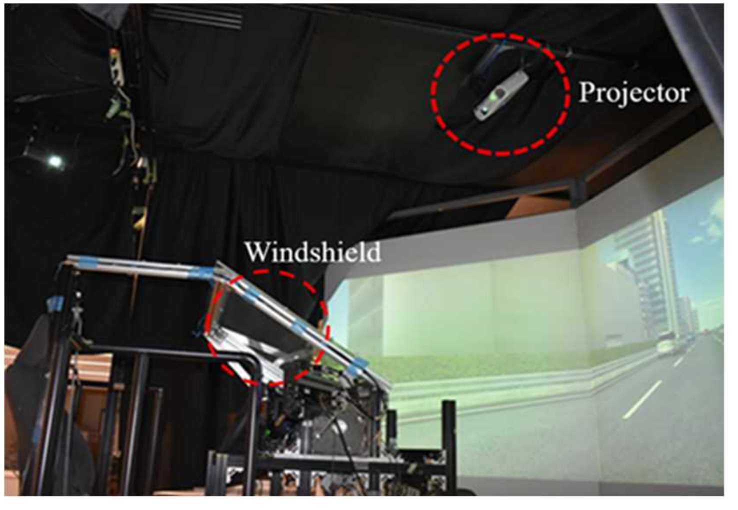
For the questionnaire, 1 means "Do not agree at all" and 5 means "Completely agree". X and ○ indicate average values and outliers, respectively.

Questionnaire results indicated that an improvement in system understanding could be achieved by presenting information with the proposed HMI.

Experiment 3

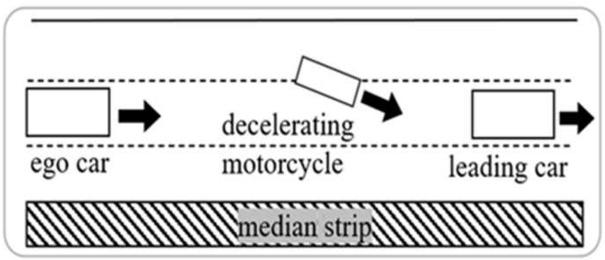
Purpose: To propose an HMI suitable for presenting information in consideration of driver's visual field characteristics.
Method: Evaluation and comparisons were performed for two types of HMIs, including the HMI proposed in Experiment 2 and the windshield projection type (HUD) HMI.

Two kinds of systems including a system (i) that can recognize car, van, truck, motorcycle, and pylon, and a system (ii) that can only recognize car, van, and truck, were applied. The experiment was conducted under a total of six conditions in combination with the two systems and three conditions of HMI (without HMI, HMI proposed in Experiment 2, and HUD HMI).

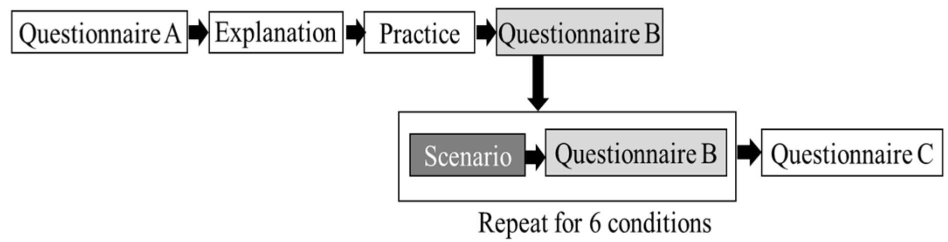


Windshield projection type (HUD) HMI

In the experimental scenario, three potential risk scenes as in Experiment 1 occurred multiple times, and an actual risk scene would finally occur in which the motorcycle slowed down and changed lanes in front of the ego vehicle. The experiment was conducted for 18 participants with the approval of Ethics Review Board, the University of Tokyo.



Actual risk scene



Experimental procedure

The windshield projection type (HUD) HMI was found to be effective in improving knowledge transfer, attention level, and speeding up of the intervention behavior, and therefore, was effective for fostering an appropriate system understanding. Although the HMI proposed in Experiment 2 did not show an improvement in rapid intervention, it was demonstrated to be more useful than the HUD HMI in terms of knowledge transfer.

Task C

Education and Training for Users

University of Tsukuba

Topic in FY2020

Purpose

Based on the achievement of SIP-adus (2016~19), FY20_Civ aims to verify different types of education contents of driving automation (DA), and tends to reveal the effects on learning effectiveness, driver attitude and driver performance.

Method

Independent variable between subject: Education content

- Quiz-participatory video (QPV)
- Motivational-narrative video (MNV)
- Slideshow (SS)

Participant

Condition	Number		Average age		
	Male	Female	Male	Female	Total
PV	8	8	31.9	50.1	41.0
NV	8	9	38.9	48.4	43.9
SS	8	9	44.1	43.1	43.6

Dependent variables

- Learning effect: quiz about DA
- Driving safety: Rate of successful intervention
- Driver attitude

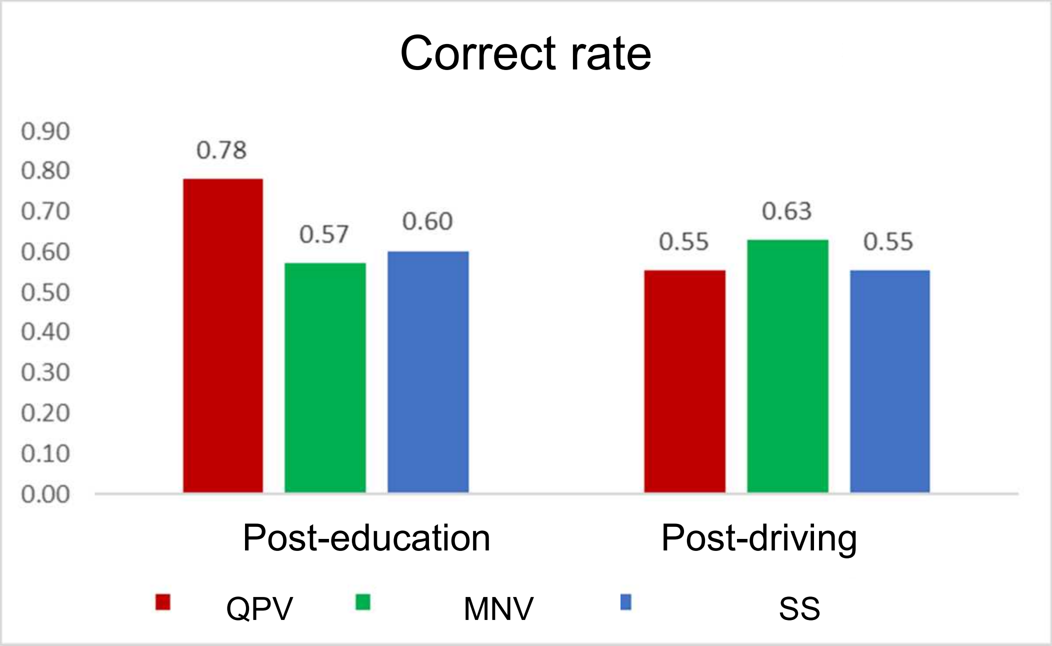
Method (cont.)

Procedure

<table>
<tr><th>Day</th><th colspan="3">Procedure</th></tr>
<tr><td rowspan="6">1st</td><td colspan="3">Explanation for 1st day</td></tr>
<tr><td colspan="3">Inform consent</td></tr>
<tr><td>QPV</td><td>MNV (takeaway text)</td><td>SS</td></tr>
<tr><td colspan="3">Quiz & questionnaire</td></tr>
<tr><td colspan="3">Instruction of specific DA for 2nd day</td></tr>
<tr><td colspan="3">Questionnaire</td></tr>
<tr><td rowspan="6">2nd</td><td colspan="3">Explanation for 2nd day</td></tr>
<tr><td colspan="3">Quiz & questionnaire</td></tr>
<tr><td colspan="3">Explanation and exercise of driving simulator (DS)</td></tr>
<tr><td colspan="3">Instruction of driving task and non-driving-related task</td></tr>
<tr><td colspan="3">Test trials</td></tr>
<tr><td colspan="3">Questionnaire</td></tr>
</table>

Results : Learning effect

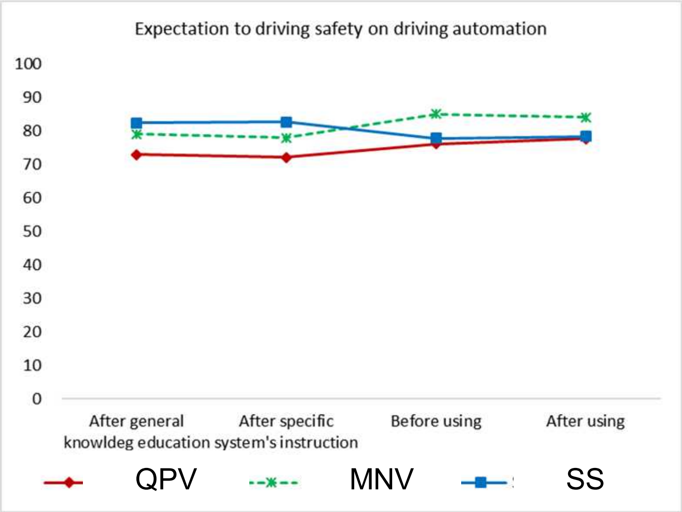
- Quiz

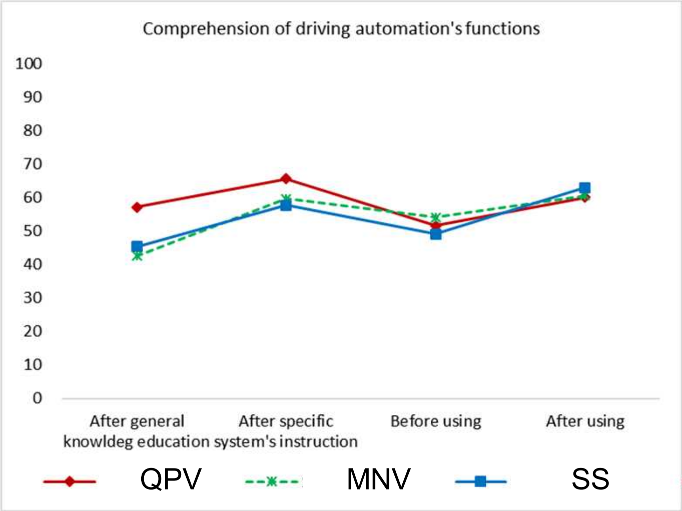


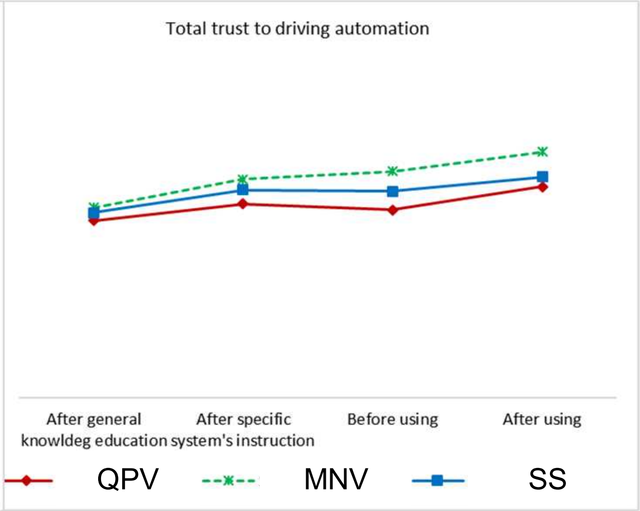
It is shown that the learning effect of participatory video (8min) was significantly higher than the others. However, the effect tended to be degraded over time. on the other hand, it is implied that the effect of short narrative video (2min) conducted a positive change after a long term.

Results : driver attitude

- Questionnaire



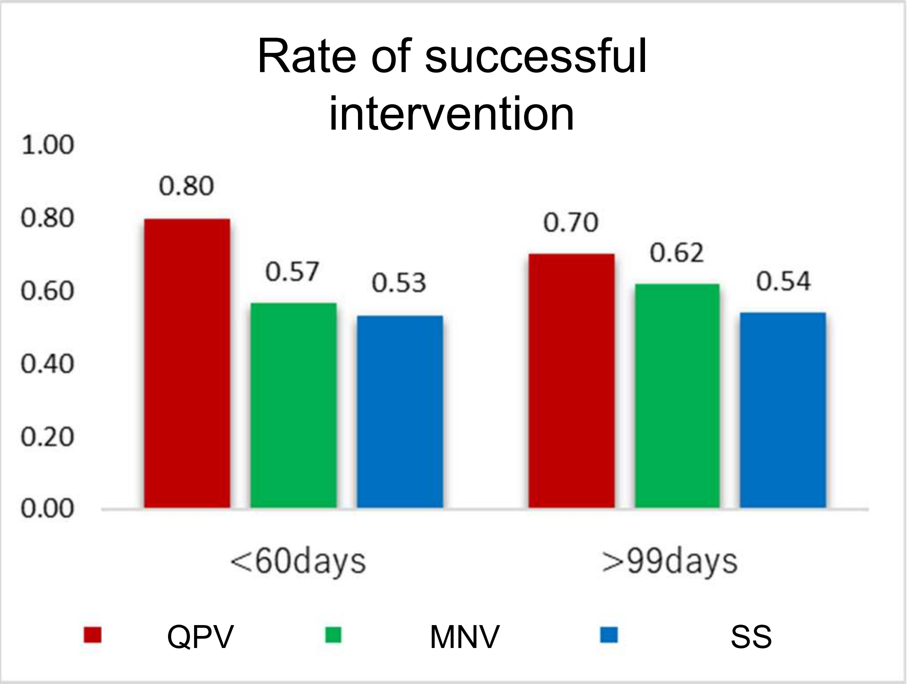




It is indicated that education contents influenced driver attitude to the DA for a long term, and motivational narrative video (2min) operated a relatively positive effect on the attitude's change.

Results：Driving safety

- Rate of successful intervention



Although no statistically significant learning effect was shown, quiz-participatory video (8min) was relatively effective to driver intervention for a long term.

Conclusion

This study investigated the effect of education content for general knowledge about DA, and the DS-experimental results revealed that:

- the learning effect of participatory video (8min) more effective on comprehending DA immediately after educating, however, the effect was degraded over time.
- Simply motivational video is helpful to influence driver attitude to DA toward a positive way.

A Study of what information that should be conveyed by rental cars company or/and dealers

Purpose

Drivers who purchase a new automated vehicle or rent one temporarily from a rental car company need to understand the features of the system's functions within a short period of time so that user can use the system safely, and the contents need to be clarified.

The purpose of this experiment is to investigate whether the transition pattern of mode change should be notified to users in advance before using automated vehicle.

Method

Mixed-2 factorial experiment design

Factor 1: Transition Method (Within-subject)

- Fixed Transition :When the mode(level 3 mode) is out of operational design domain , the system will request driver to interevent.
- Adaptive Transition : When the mode(level 3 mode) is out of operational design domain , the system will transition to a lower level of automation system mode (level 2 mode) within the operating conditions of the system.

Factor 2: the prior knowledge of mode transition pattern(Between-subject)

- Without be noticed: No explanation of the design of mode changing pattern
- Be noticed : Noticed to user about the design of mode (Fixed/Adaptive) changing pattern

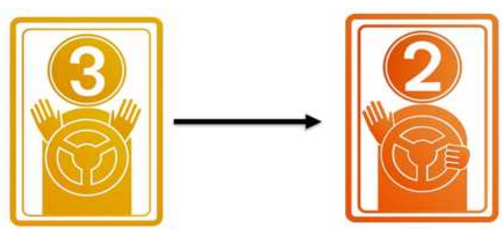
Evaluation

- The driver`s reaction to the mode changing
- The subjective evaluation of Comprehension of corresponding behavior of mode change (0-7)/acceptance of this mode change (0-7)

Method

Details

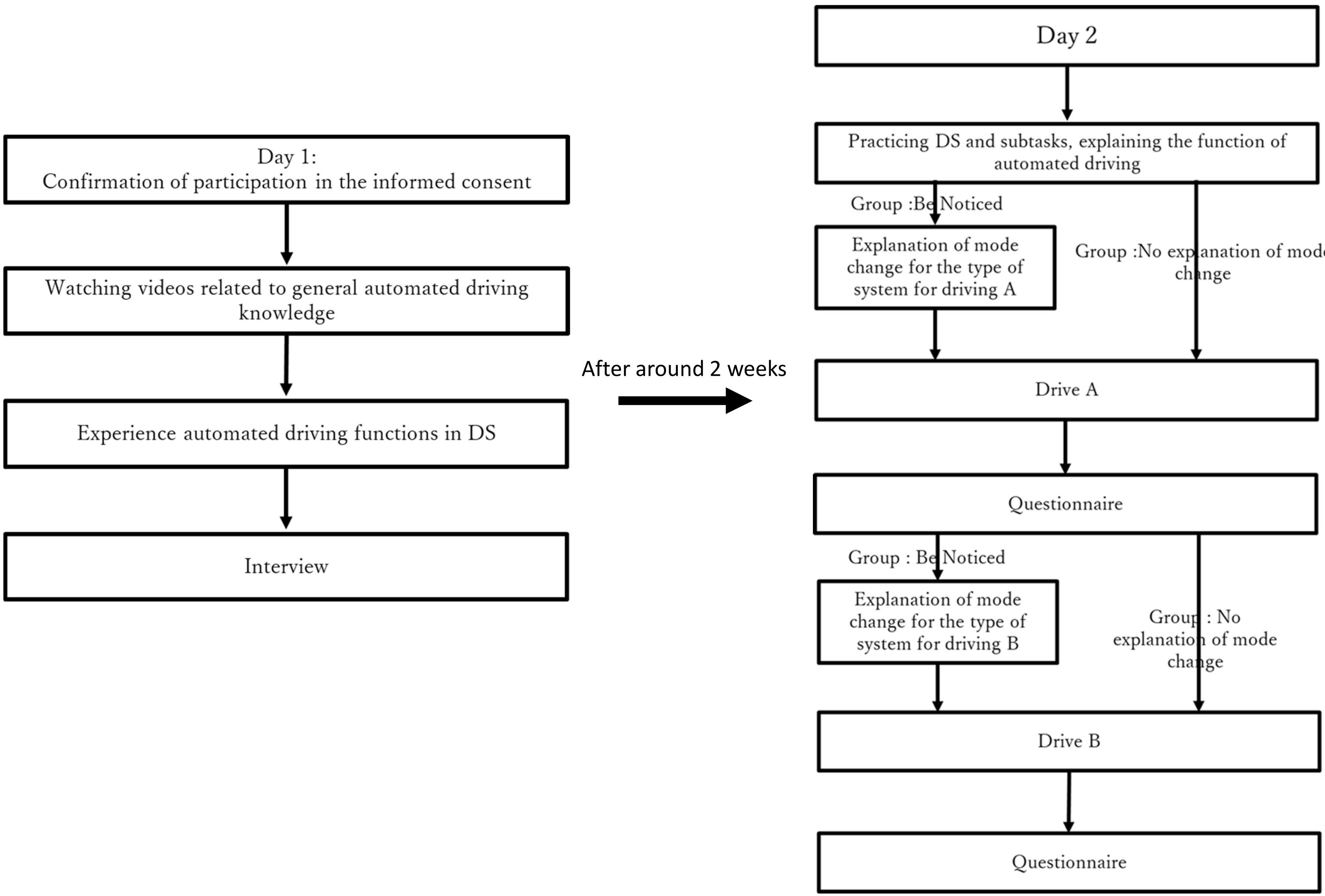
- Honda driving simulator
- Participant : 10 , from 21- to 67-year-old. (M=43.7 SD=14.4)
- Main Task : Keep using the automated driving function if possible and safely.
- Secondary task : A video game using tablet
- HMI: voice announcement to driver about mode change. Visual HMI show the current status of system of activating and deactivating functions of ACC and LKAS and who (system or driver) have the monitoring responsibility.
- Depending on their group of prior knowledge of mode transition pattern and the conditions, the information provide to participants before the experiment is different.



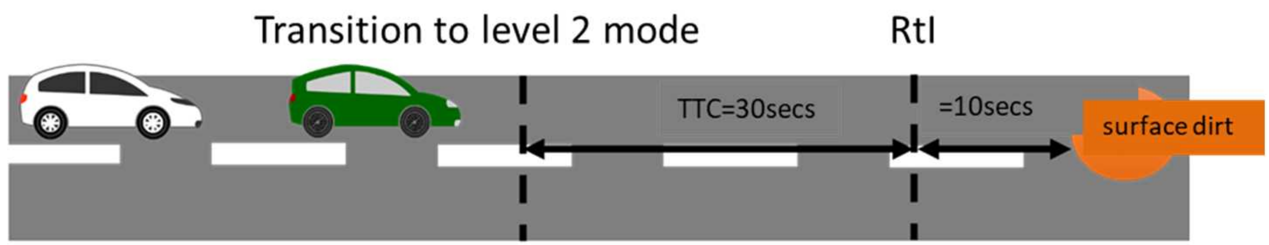
Depending on the situation, this mode change may announce by system

The ppt slide showed to "Noticed" group

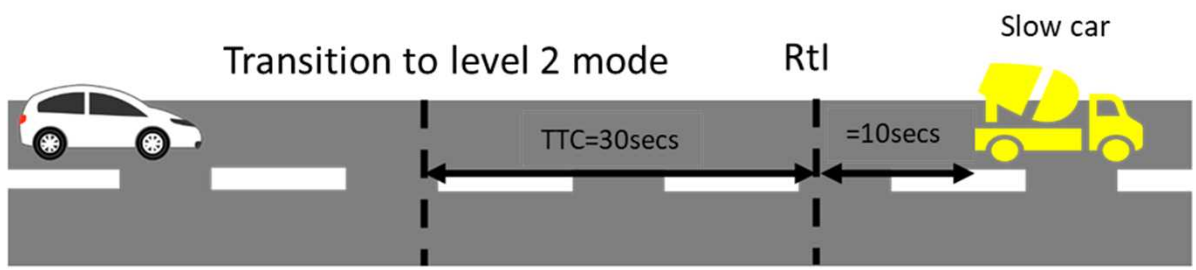
Method


Day 1:
Confirmation of participation in the informed consent
Watching videos related to general automated driving knowledge
Experience automated driving functions in DS
Interview
After around 2 weeks
Day 2
Practicing DS and subtasks, explaining the function of automated driving
Group :Be Noticed
Explanation of mode change for the type of system for driving A
Group :No explanation of mode change
Drive A
Questionnaire
Group : Be Noticed
Explanation of mode change for the type of system for driving B
Group : No explanation of mode change
Drive B
Questionnaire

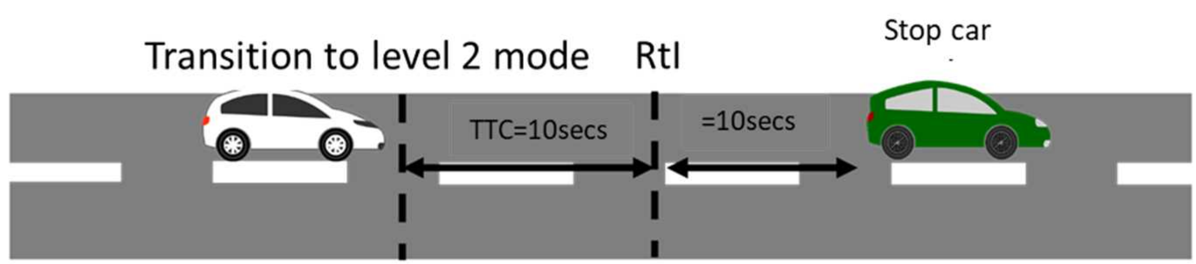
Scenario



Scene 1: Surface dirt



Scene 2: Slow construction vehicle



Scene 3: Stop vehicle required to lane change

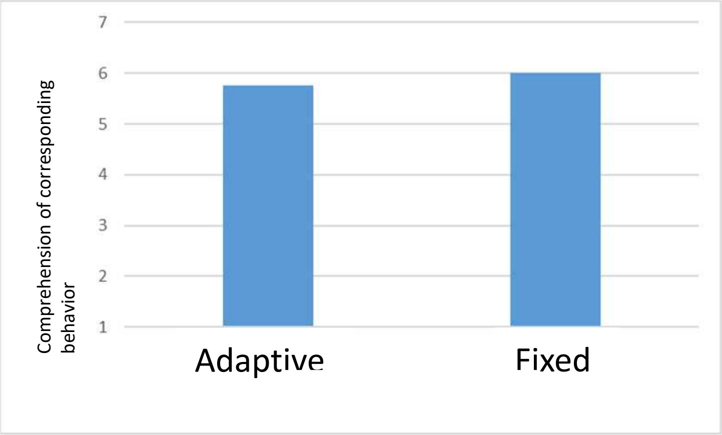
Result

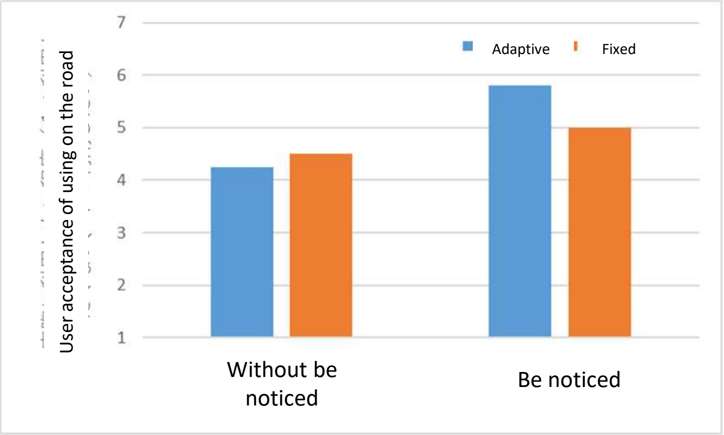
Effect of prior knowledge: driver behavior when transitioning from level 3 to level 2 mode

	Without be noticed	**Be noticed**
Scene 1: Surface dirt	Monitor the environment：3/5 Play Tetris after temporary monitoring ：1/5 Take over 1/5	Monitor the environment：5/5
Scene 2: Slow construction vehicle	Monitor the environment：4/5 Take over：1/5	Monitor the environment：5/5
Scene 3: Stop vehicle required to lane change	Monitor the environment：4/5 Take over：1/5	Monitor the environment：5/5

Some participants who did not receive a prior explanation of the pattern of mode change also moved to monitoring behavior, while there is some cases in the group(without be noticed) that 1 participant took the action of returning to the game after temporary monitoring. 1 participant only takeover the driving after the mode change announcement in all 3 scene.

Result





Comprehension of corresponding behavior of mode change (0-7)

User Acceptance of using on the real road (0-7)

The results suggest that by understanding the prior knowledge, the participants can prepare themselves for the actions to be taken during a mode change and can feel easier to understand the feature of the system.

Conclusion

This DS experiment was focus on whether the pattern of mode change is important information should be provided by dealer or rent car company staff for the temporary user to understand before using the system.

The results of driving reaction and subjective evaluation of comprehension of mode change suggest that when users receive an explanation of the system’s mode change patterns, they are better prepared for the actions they should take when ADAS(level 2 mode) is still available after a mode change.

Feasibility Study of a Remote DS Experiment

Purpose

To investigate the feasibility of conducting a remote experiment as a countermeasure against the spread of a COVID-19. This experiment using the Unity and WebGL program for replicating the past On-site driving experiment to evaluate whether the possibility of achieving the same experiment goal and getting the similar result as the On-site experiment.

1. Local: The experimenter sends the participant an experiment kit containing laptop /questionnaire/manual for the experiment. The participant follow the guidance and finish the experiment using the DS program on the laptop, and then returns it to the experimenter (Fig. 1).
2. Browser : The experimenter sends the participants an experiment kit containing the manual of experiment, website URL note, and questionnaire paper. The participants accesses the website on their own PC, finish the experiment, and returns the kit to the experimenter (Fig. 2).

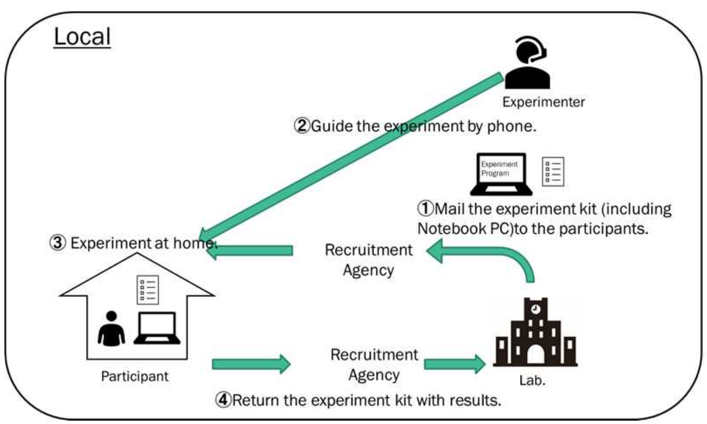


Fig.1 The procedure of mailing remote experiment N=20

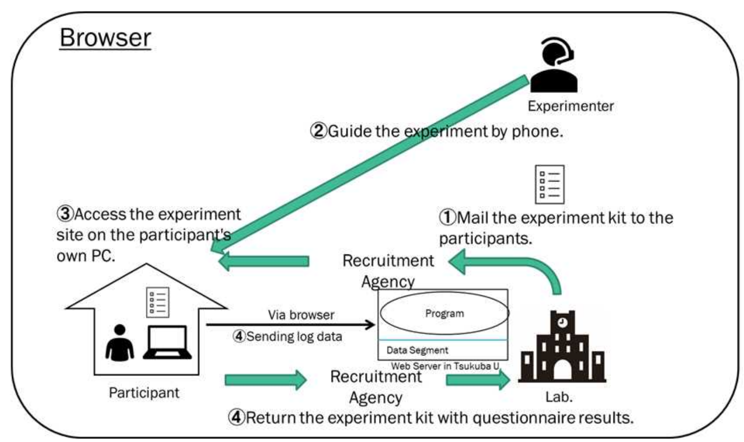


Fig.2 The procedure of browser remote experiment N=40

Experiment design and method

Two-factor between-subjects experiment

Factor1 : remote experiment method（3 levels）

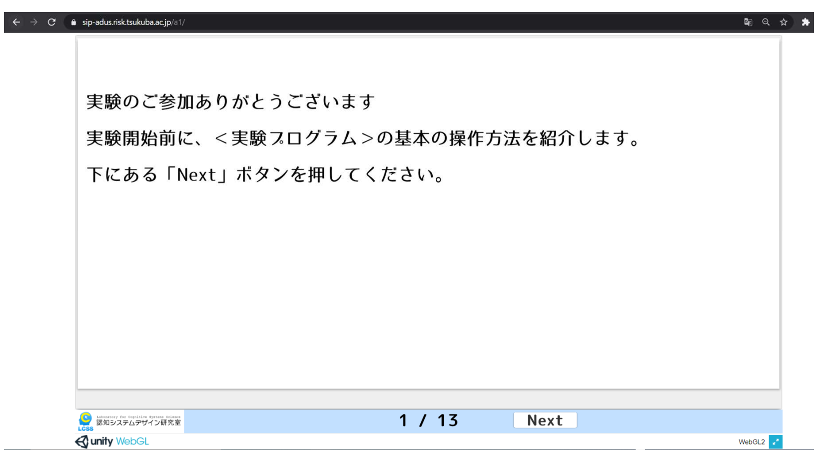
- Local — Data logging inside the note PC
- Browser
  - A : one-time data logging (after every test drive)
  - B : Real-time data logging

Factor 2 : Prior knowledge related to RtI scene（2 levels）

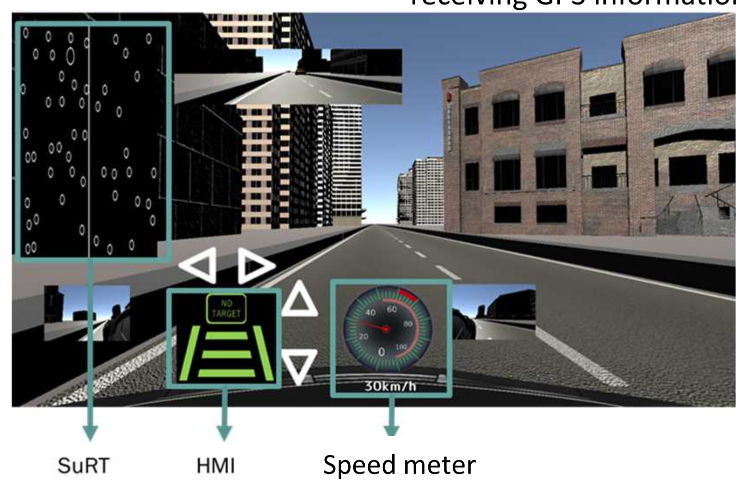
PkA : Without specific RtI scene description for user knowledge

PkB : With specific RtI scene description for user knowledge

Scene: RtI due to system limitation on difficulty of receiving GPS information



Program screen



Driver simulation screen

Result

The completion rate of the remote experiment is 90% (54/60).

Number of participants who took over the driving of the scene in this experiment

Scene	PkA	PkB
RtI due to system limitation on difficulty of receiving GPS information (SL-GPS RtI scene)	12/25(48%)	21/24(88%)
Details	PkA	PkB
Number of participants who intervened 10 seconds after RtI	2 participants	0 participant
Details	PkA	PkB
Number of participant exclusions due to prior intervention reason	1 participant	2 participants
Participant Internet Problem of sending data in this scene.	1 participant	1 participant

Number of participants who took over the driving (SIP phase 1 A-5-1 experiment)

Scene	PkA	PkB
SL-GPS RtI scene 1	2/16（13%）	15/16（94%）
SL-GPS RtI scene 2	4/16（25%）	15/16（94%）

Number of participants who took over the driving (SIP phase 1 A-5-2 experiment)

SL-GPS RtI scene 1	3/12（25%）	10/12（83%）
SL-GPS RtI scene 2	5/12（42%）	11/12（92%）

The result showed that the content of the prior knowledge taught affected the response to RtI. This result is similar to the result of replicated SIP phase 1 past experiment.

Result

The participant feeling of acceptance of remote experiment method

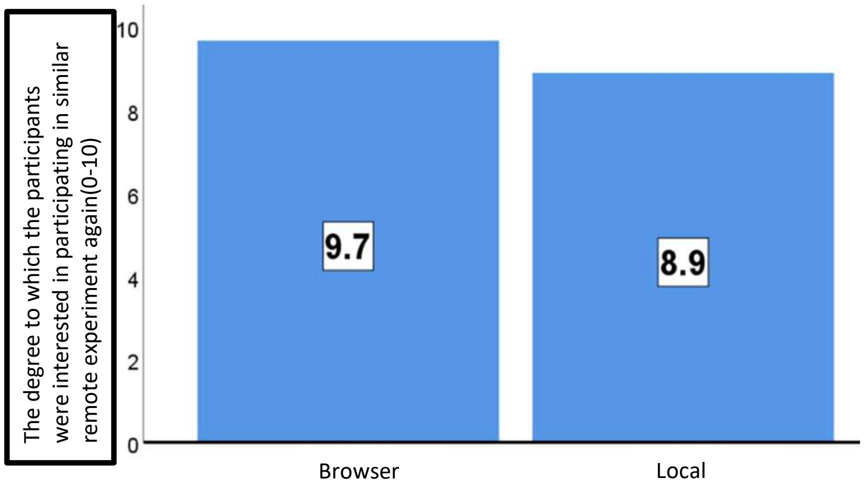


Fig 3. The degree to which the participants were interested in participating in similar remote experiment again(0-10)

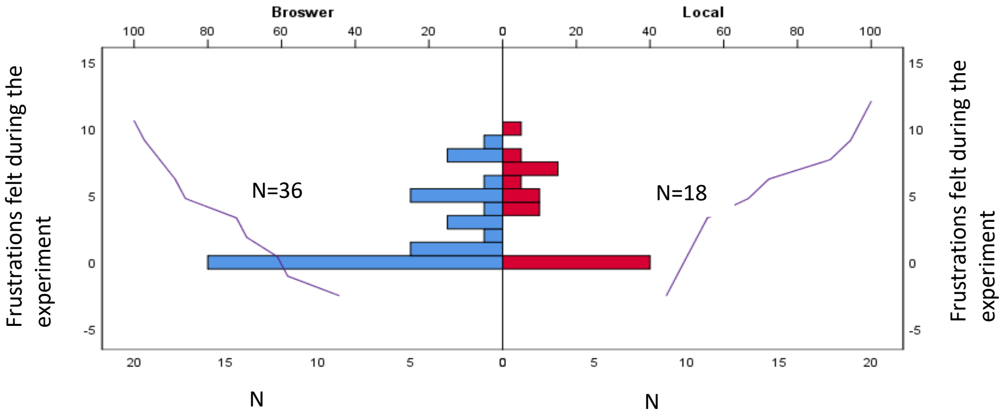


Fig 4. Frustrations felt during the experiment(0-10)

A number of participants would like to participate in the same type of remote experiment again.

Some participants were frustrated with the remote experiment. They were frustrated with the phone guidance, including the lack of information about the experiment and the lack of smooth access to the experiment website.

In conclusion, remote experiments have a high probability of achieving the same experiment goal and getting similar result as On-site experiment. Also, the participants were highly acceptive to participate in the remote driving simulation experiment. Furthermore, from the standpoint of countermeasures against the spread of Covid-19, the motivation of remote experiment should be highly considering.