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SIP-adus Workshop 2017
(Human Factors)

SIP Human Factors Research Project

Task C

Study of Communication between Automated Vehicle and Other Road Users

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Tatsuru Daimon
Faculty of Science and Technology, Keio University

Main topics of the 3-year studies in Task C

- Year 1 (FY2016) In-vehicle and fixed-point observations, in-field experiment
  - To study non-verbal communication between drivers and other road users

- Year 2 (FY2017) In-field (test truck) experiment
  - To investigate the effect of external HMIs (messages, lamp, etc.) and ID display (ex. in automated driving) on behavior of surrounding road users.

- Year 3 (FY2018) In-field (test truck) experiment
  - To identify fundamental requirements for external HMIs and ID display for sending messages to surrounding road users (prototyping included).

Communications in driving situation

- Communication between drivers (D2D), between drivers and pedestrian (D2P)

Yielding to other road users

Vehicle motion, lighting device

Hand gestures, eye contact

<u>Drivers take various types of communication method when yielding to other road users</u>

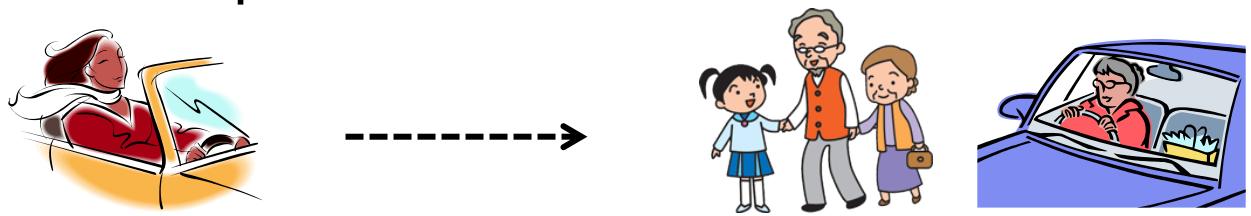
Safety and security, smooth traffic flow

Purpose of the study in FY2016

- Research question

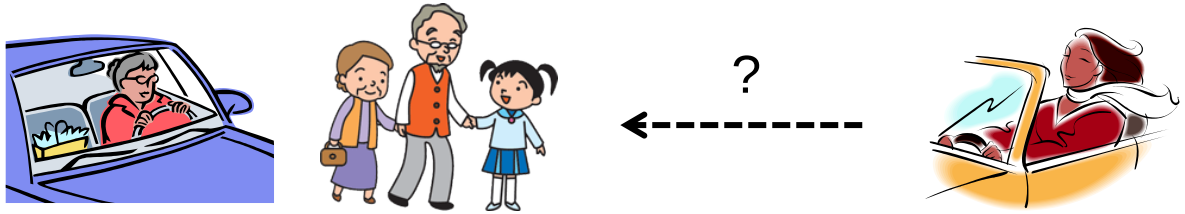
  How do drivers behave to yield to other road users (pedestrians, drivers)?

  – How do drivers behave for pedestrians or drivers?



Vehicle behavior, headlight operation,
(decelerating, stopping) (headlight flashing)
hand gesture, etc.

  – How do pedestrians or drivers judge such driver/vehicle behavior?



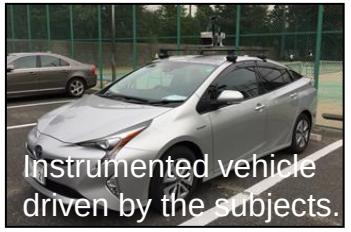
Experiment methods

Communication behaviors between driver and pedestrians (D2P) were observed at fixed-points and also in the car driven the participant.

❑ Fixed-point observation【Qualitative】


Local road; unsignalized crosswalk (D2P) etc.

❑ In-vehicle observation 【Quantitative】

Local road; unsignalized crosswalk (D2P) etc.

❑ Web survey 【Qualitative】

Cultural effects on communication
Effect of driving license on communication

❑ In-field experiments 【More quantitative】


Pedestrians' judgement on driver yielding behavior (D2P).

Experiment car

- Measuring equipment
  - Laser range finder
    Distance between surrounding road users
  - 360-degree camera
    Surrounding road users' behavior
  - In-vehicle cameras
    Driver behavior, etc.
  - CAN data
    Vehicle status, etc.
  - GPS data
    Vehicle position, velocity, etc.

Experimental car

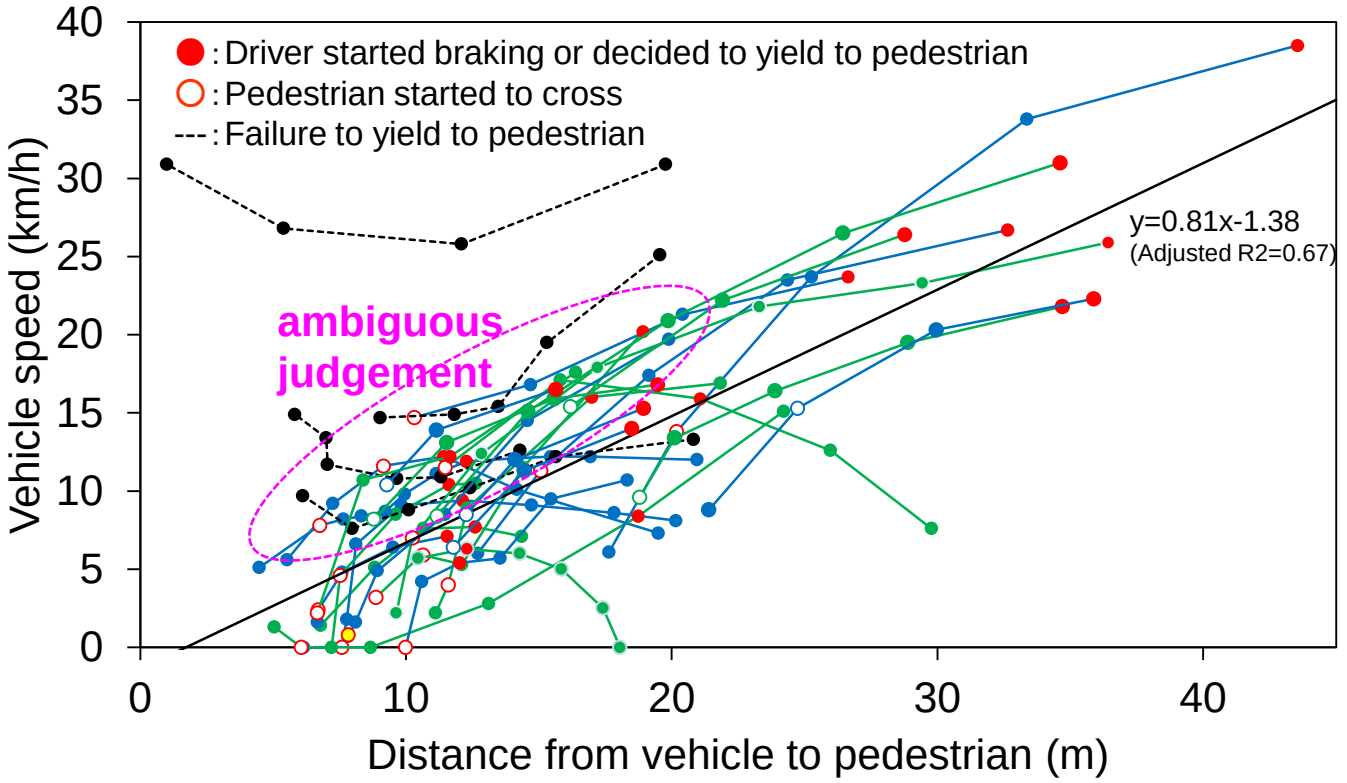
360-degree camera

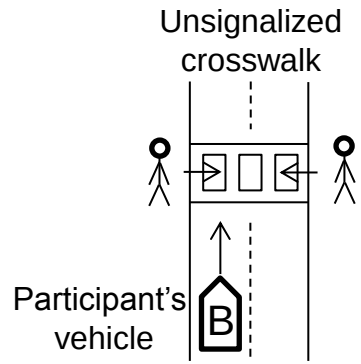
Laser range finder
（Total 360-degree）

Monitor for recording data

Center console

D2P on local roads (in-vehicle observation)

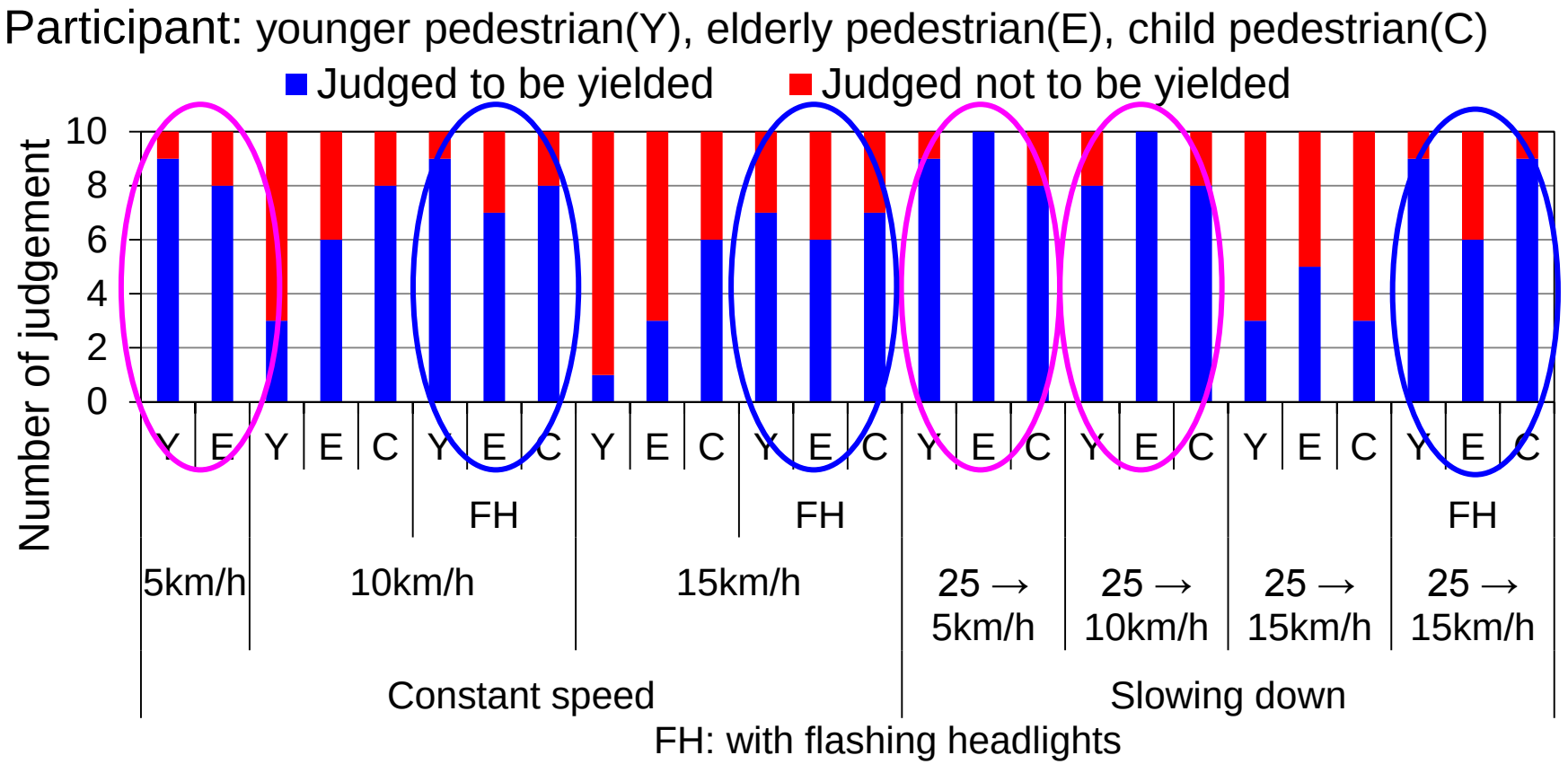




- Pedestrians started crossing when Car B slowed down to 0-15km/h with the distance 5-15m.
- Miscommunication occurred when Car B did not slow down enough for pedestrians to cross.

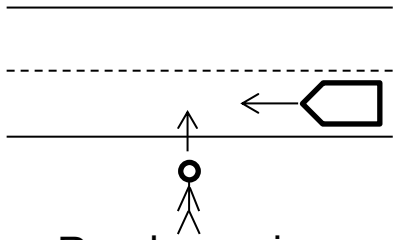
⇨ Cues for communication to pedestrians

D2P in local roads (In-field experiment)



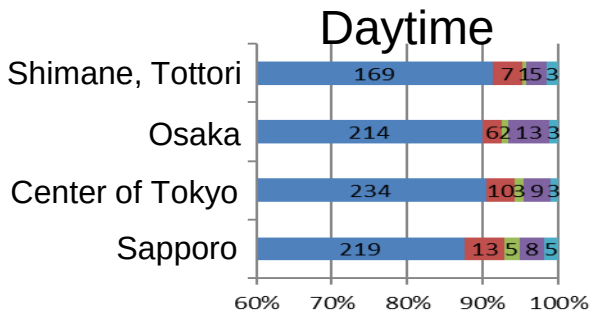
- Pedestrians judged the approaching vehicle yielded to them when the vehicle approached at very low speed (5km/h) and large deceleration.
- Flashing headlights gave an additional signal to yield, resulting in more judgement, both for the constant speed and slowing down conditions.

D2P in local roads (Web survey)

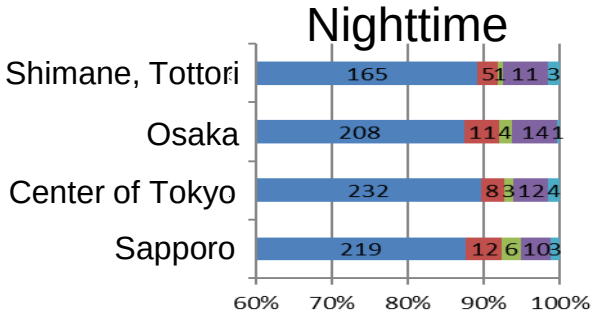


Road crossing
(No crosswalk)

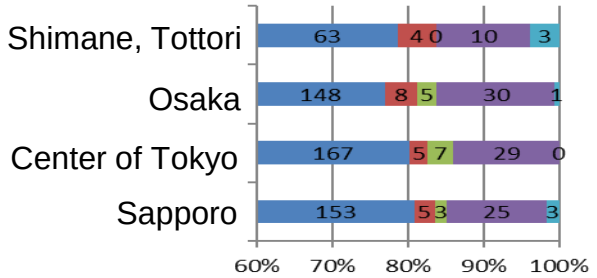
Vehicle behavior
Usage of lights
Horn
Driver's behavior
Others



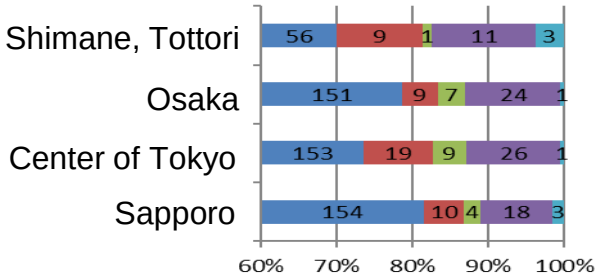
Licensed pedestrians



Licensed pedestrians



Non-licensed pedestrians



Non-licenses pedestrians

- The effects of type of pedestrian (licensed or non-licensed) were larger than the effects of location (culture) in Japan.
- Non-licensed pedestrians relied less on vehicle behavior and more on driver's behavior in comparison to licensed pedestrians.
- The effects of time of day were larger among the non-licensed pedestrians with more reliance on usage of lights in nighttime.

Summary and future works

- Summary
  - Vehicle motion/behavior was found to be the primary communication signal when yielding to pedestrians.
  - Flashing headlights gave an additional signal to yield, resulting in more judgement to be yielded for pedestrians.
  - Some profiles of vehicle behavior caused miscommunications. An external HMI for automated vehicles is expected to reduce occurrence of such miscommunications.
  - Communication signals for pedestrians to judge that approaching car yields to them were different between licensed and non-licensed pedestrians.
- Future works
  - The effect of external HMIs (messages, lamp, etc.) and ID display on recognition and behavior of surrounding road users.

Thank you for your attention.