25TH ITS WORLD CONGRESS
COPENHAGEN
17 – 21 SEPTEMBER 2018
Quality of life

TO MAKE AUTOMATED VEHICLES COMMUNICATIVE AND SOCIABLE ON ROADS

Satoshi Kitazaki, Ph.D.

Director, Automotive Human Factors Research Center,

National Institute of Advanced Industrial Science and Technology (AIST)

Tatsuru Daimon, Ph.D.

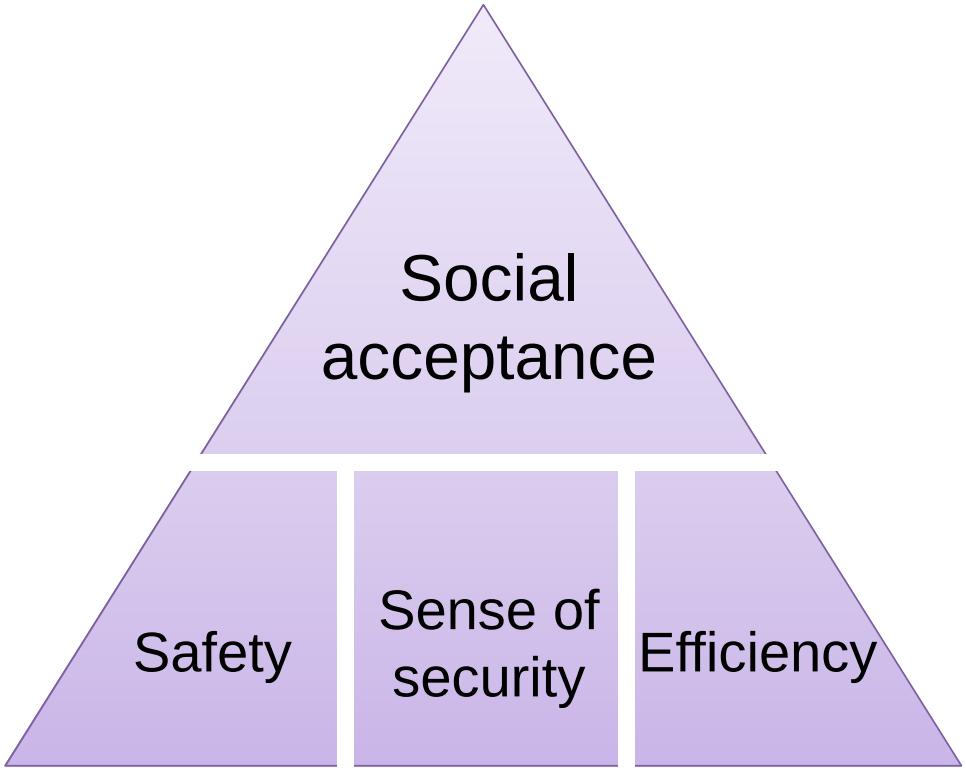
Professor, Faculty of Science and Technology, Keio University

SIP-adus Human Factors and HMI Research for Automated Driving, JAPAN

SOCIAL ASPECTS OF DRIVING

- Driving is essentially a social act of road users who share the public space.
- There are regulations but the regulations are not always effective in situations such as uncontrolled/unsignalized intersections or cross walks, transition of traffic signals, merging/changing lane, multi-lane roundabouts, and others.
- In such situations, road users non-verbally communicate each other in informal way to exchange intentions and arrive at safe joint actions.
- Communication-based safe joint actions sometimes overrule the traffic regulations for efficiency.
- Informal on-road communication is possibly influenced by social norms and also by attributes of road users.

BENEFITS OF ON-ROAD COMMUNICATION



STRATEGY

25TH ITS WORLD CONGRESS COPENHAGEN 17 – 21 SEPTEMBER 2018 Quality of life

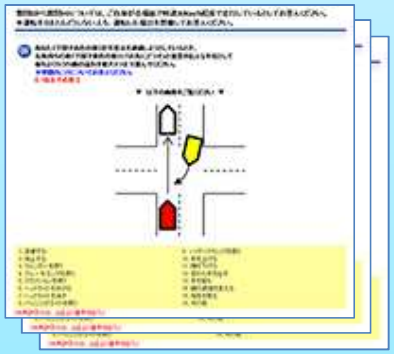
Understanding on-going on-road communication

■ Fixed-point observation

■ Closed track experiment

■ In-vehicle observation/measurement

■ Web survey



Design recommendations /requirements for on-road communication measures of AV

- AV vs VRU(s)
- AV vs Driver(s)

Effects of
- social norms
- attributes of road users

EXPERIMENTAL METHOD

25TH ITS WORLD CONGRESS COPENHAGEN 17 – 21 SEPTEMBER 2018 Quality of life

Simulated e-HMI

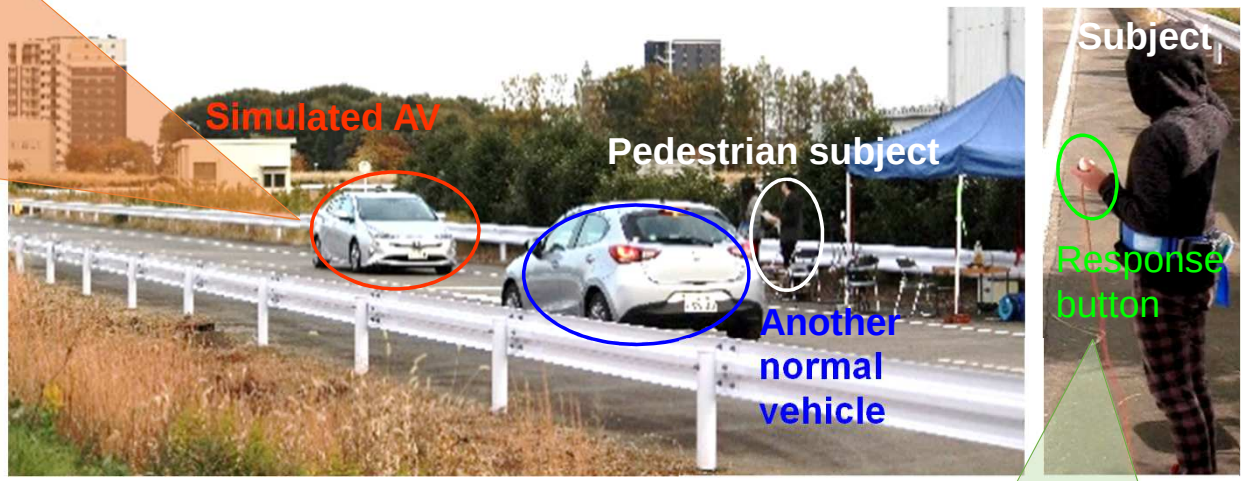
I am going to stop

After you

Automated driving

Text messages were used to eliminate ergonomic design factors of e-HMI.

An experiment in a closed track

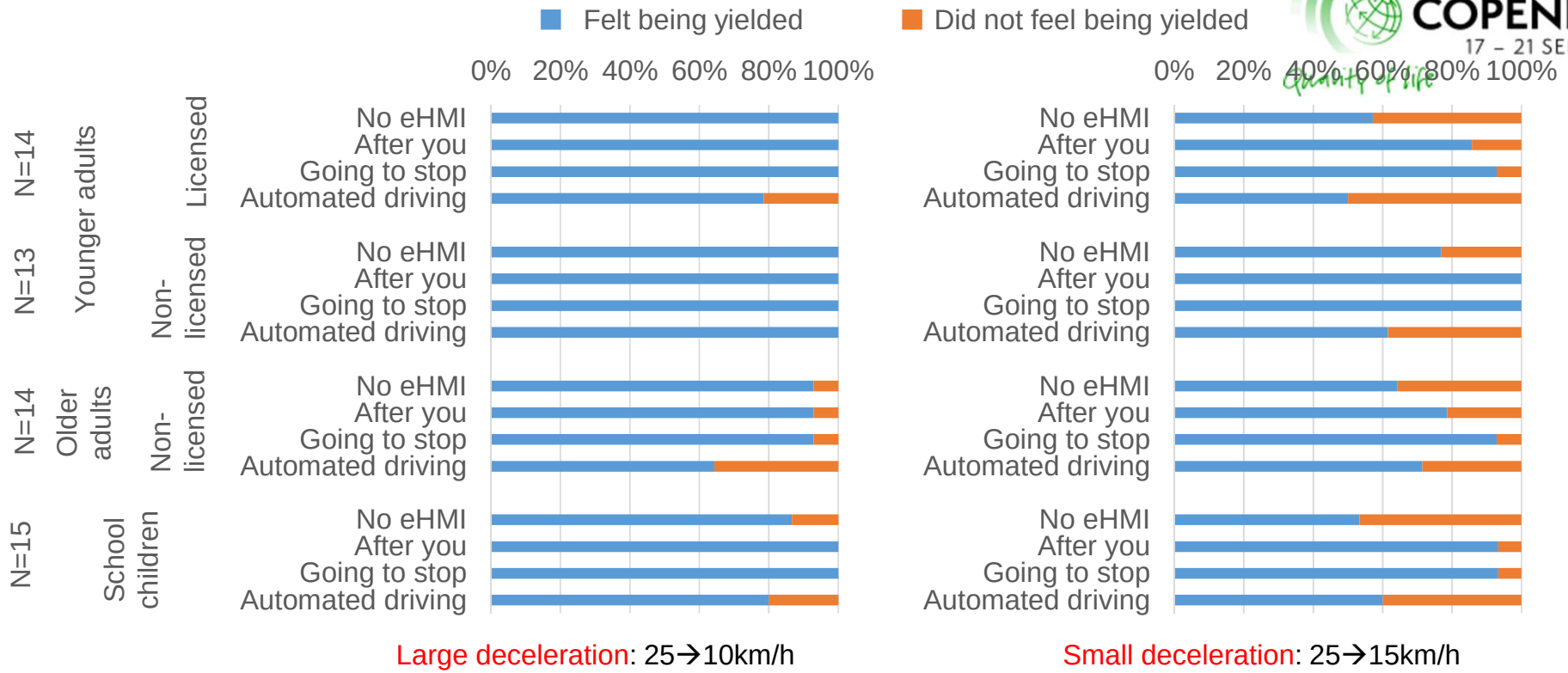


Instruction to the subjects

Press the button when;

- You feel being yielded.
- You make a decision to cross the road.

RESULTS FOR "EFFICIENCY"

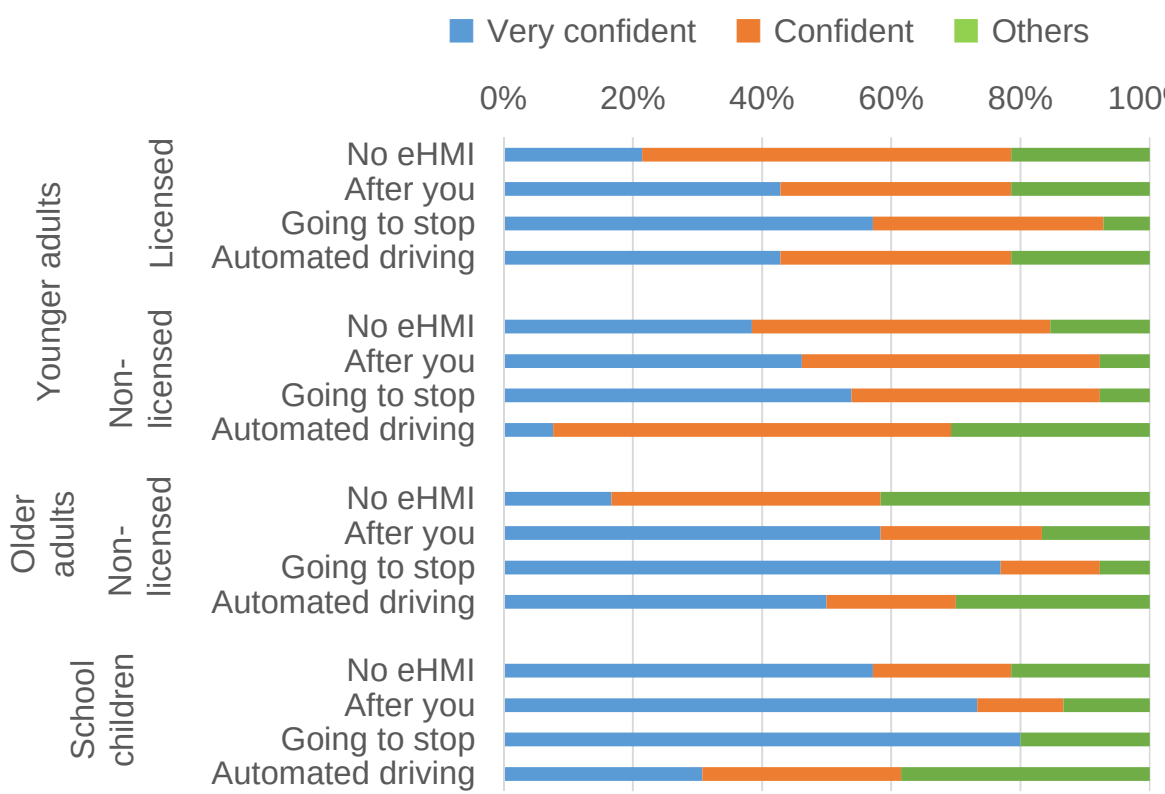


Large deceleration: 25→10km/h

Small deceleration: 25→15km/h

- Large deceleration of AV was a clear sign of "Yielding" for the pedestrians.
- Small deceleration of AV was not a clear sign of "Yielding" but external HMIs meaning "After you" and "I am going to stop" compensated it.
- The external HMI meaning "Automated driving" decreased or did not increase the rate of interpretation as "Yielding" by some types of pedestrians.

RESULTS FOR "SENSE OF SECURITY"



- External HMIs meaning "After you" and "I am going to stop" increased pedestrians confidence to cross the road in comparison to the situation with deceleration only.
- The positive effect of the external HMI meaning "Automated driving" was smaller than the effects of other meanings. It also showed negative effects for some types of pedestrians.

RESULTS FOR "SAFETY"

25TH ITS WORLD CONGRESS COPENHAGEN 17 – 21 SEPTEMBER 2018 Quality of life

- Behavior for checking other vehicles

★No check at all for the other direction

Sub No.	Age	Attributes	Gender	eHMI
15	10	School child	M	Automated driving
16	10	School child	M	Automated driving
37	8	School child	F	After you
				Going to stop
35	73	Older, non-licensed	F	Automated driving
25	46	Younger, Licensed	F	Automated driving
31	44	Younger, Licensed	F	Going to stop
46	29	Younger, Licensed	F	After you

★Reduced number of checking (only once for each direction)

Sub No.	Age	Attributes	Gender	eHMI
09	10	School child	M	After you
				Going to stop
23	77	Older, non-licensed	F	After you
24	68	Older, non-licensed	F	Automated driving
52	77	Older, non-licensed	F	Going to stop
45	21	Younger, non-licensed	F	After you
				Going to stop
20	31	Younger, Licensed	M	After you
54	35	Younger, Licensed	M	Automated driving

- External HMI negatively influenced pedestrians behavior to check other vehicles before crossing, resulting in fewer or no checking of the other direction.
- No correlations in message meanings and pedestrian types have been found so far.

CONCLUSIONS

- On road communication can be evaluated for efficiency, safety and sense of security.
- Vehicle behavior is the primary communication cue to surrounding pedestrians.
- External HMI can be an additional cue to clarify AV's intention to yield when vehicle behavior is not clear enough.
- Meaning for an external HMI signal needs to be selected carefully to magnify the positive effects.
- Different types of pedestrians responded to the external HMIs differently. The design of external HMI needs to be "Universal".

FUTURE WORK

- More data are needed to find criteria to maximize the positive benefits and minimize the negative effects of the external HMI.
- Effects of external HMI for multiple pedestrians needs to be studied, especially for the safety aspect.
- Effects of different social norms need to be studied.
- Limitations of one-way communication from AV to Pedestrian(s) need to be clarified in comparison to two-way communication.
- Ergonomic parameters for external HMI design need to be evaluated.