

Deceleration Meter: A Management Tool for Reducing Over-reliance in Collision Warning when using Adaptive Cruise Control System

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ACC systems are widespread

- **Functionality**

- **Cruising**

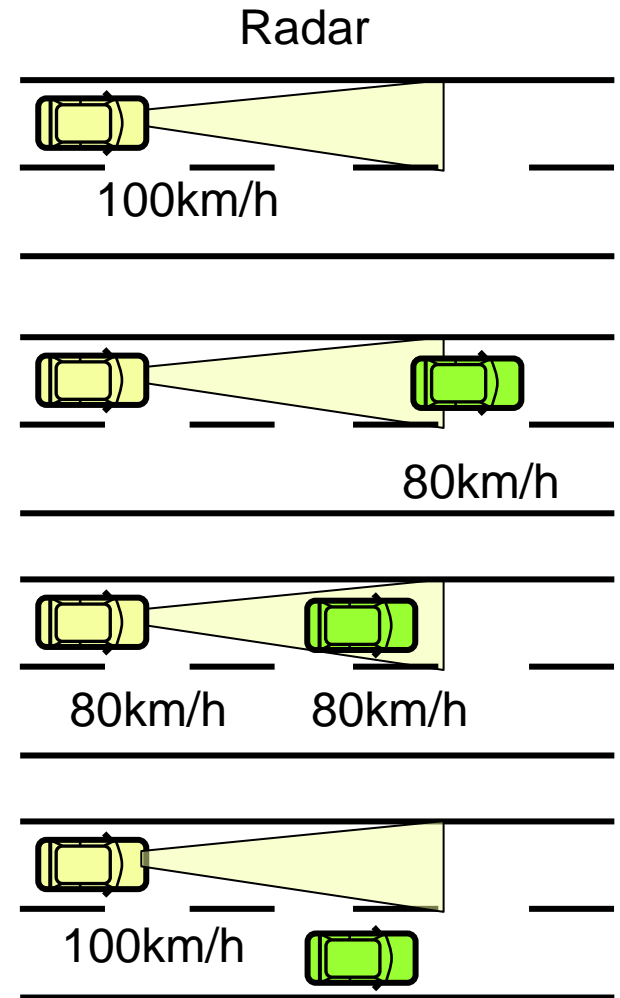
- Maintain the pre-set speed if there is no (slower) vehicle ahead

- **Following**

- Maintain the headway distance if there is a (slower) vehicle ahead

- **Effectiveness**

- It contributes to reduce driver workload under peaceful traffic conditions

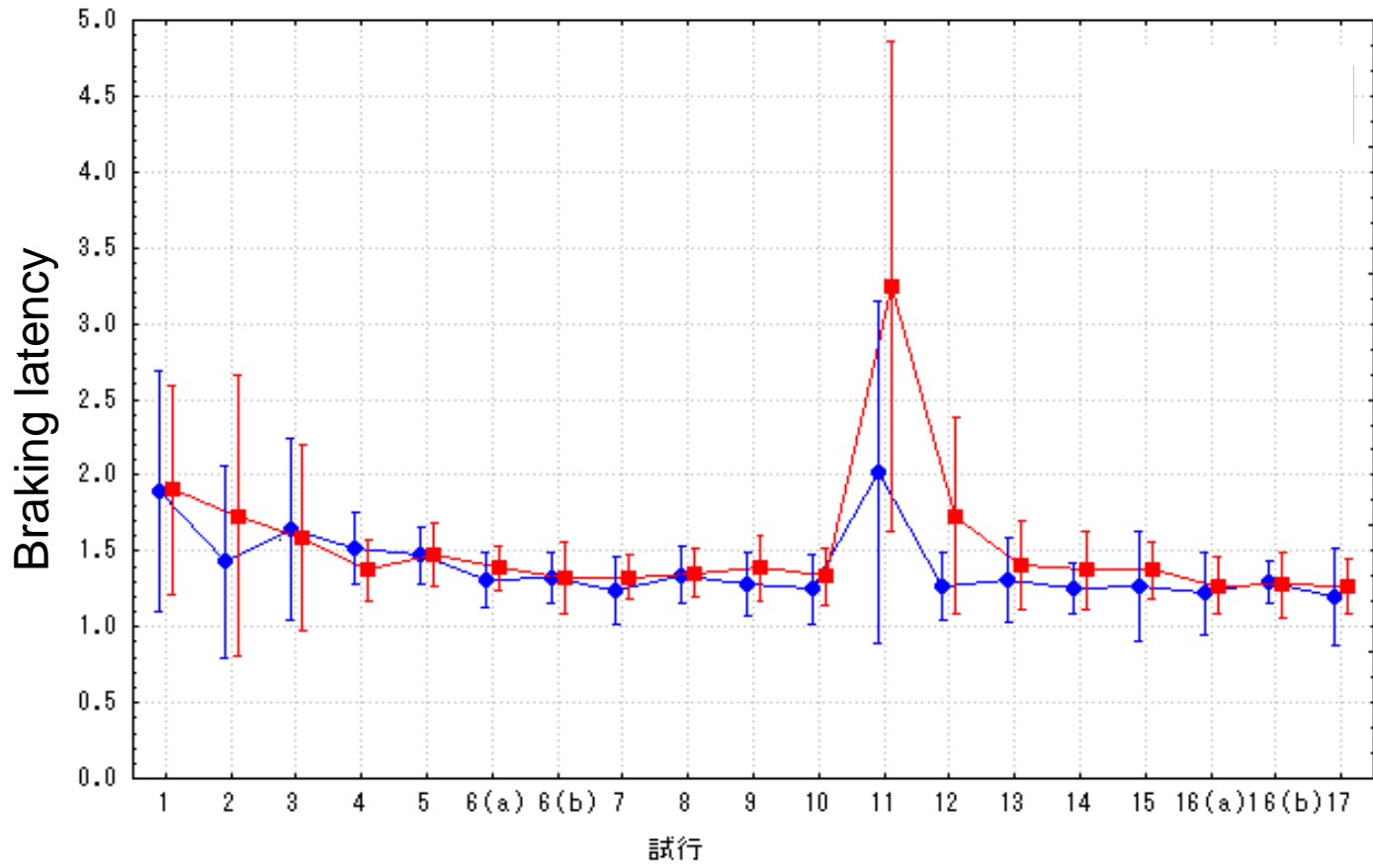


limit of an ACC system and driver's role

- ACC system is not aimed at “preventing” an accident.
 - Attaining safety is driver's responsibility.
 - The maximum deceleration rate by an ACC system is approximately **0.25 G** (2.5 m/s²).
- ACC's deceleration is not enough to prevent an accident if the deceleration of the preceding vehicle is very rapid.
 - The driver must intervene into control for avoiding the accident.
- Smooth taking over by the driver is necessary.
 - By issuing an auditory alert, the ACC system informs the driver when the accident is imminent.

Is it enough?

Drivers may be too much reliant on the alert system (Inagaki, et al., 2005)



System available

No alert

Correct alert

miss

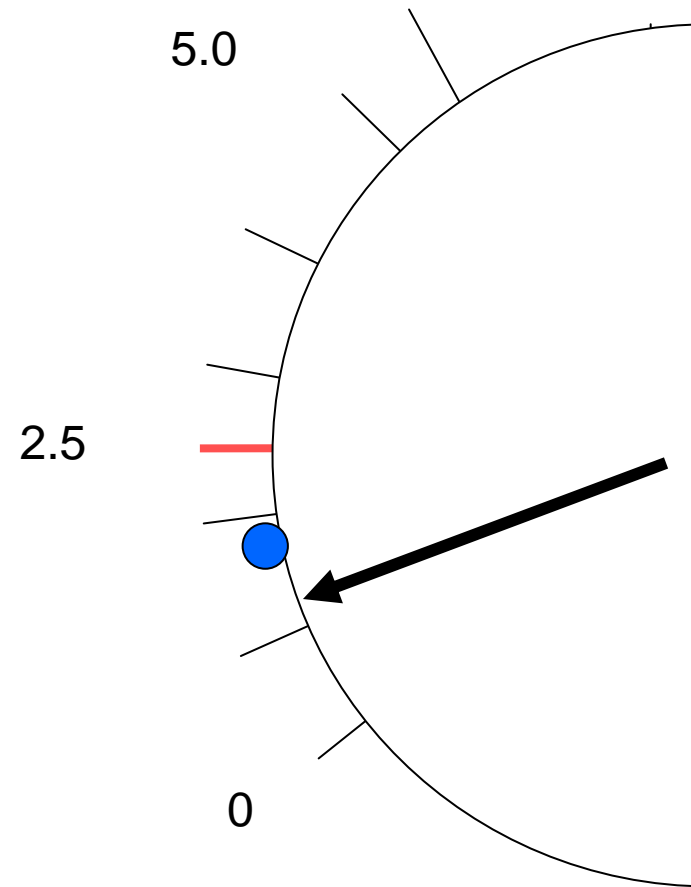
Correct alert

A: Correct alert

B: Miss

Deceleration meter: Showing “vestige” of ACC’s deceleration

- The display represents
 - the largest deceleration in the last 10 sec by putting the “bug”
 - the current deceleration rate of the host with the arrow.
 - the ACC’s maximum deceleration rate (2.5 m/s²) with the circle colored in red.
- A driver can
 - know how hard an ACC system made an effort AFTERWARD if the preceding vehicle had decelerated, and
 - thus may be able to understand the situations in which he or she should intervene into control.



Experiment

- Purpose
 - to investigate effectiveness of the deceleration meter
 - for preventing or reducing possibility of driver over-reliance on a warning system
- Task of drivers is
 - to drive on the cruising lane safely by using an ACC system as far as the traffic condition is suitable.
 - Neither passing a preceding vehicle nor changing lanes was allowed.

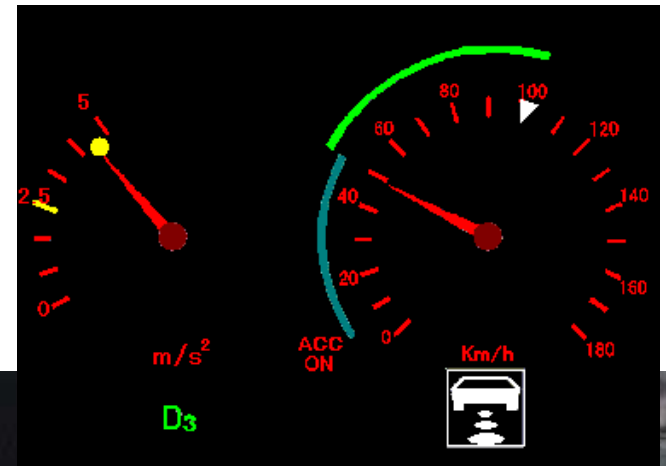
the ACC system is deactivated immediately when a driver hits the brake.

In that case, the driver needs to engage the ACC system again by pushing a button for the engagement.

It might be better for a driver to avoid unnecessary braking if a rear-end collision is not imminent.

Apparatus

- a fixed-base driving simulator
 - driving in a flat and nearly straight expressway.

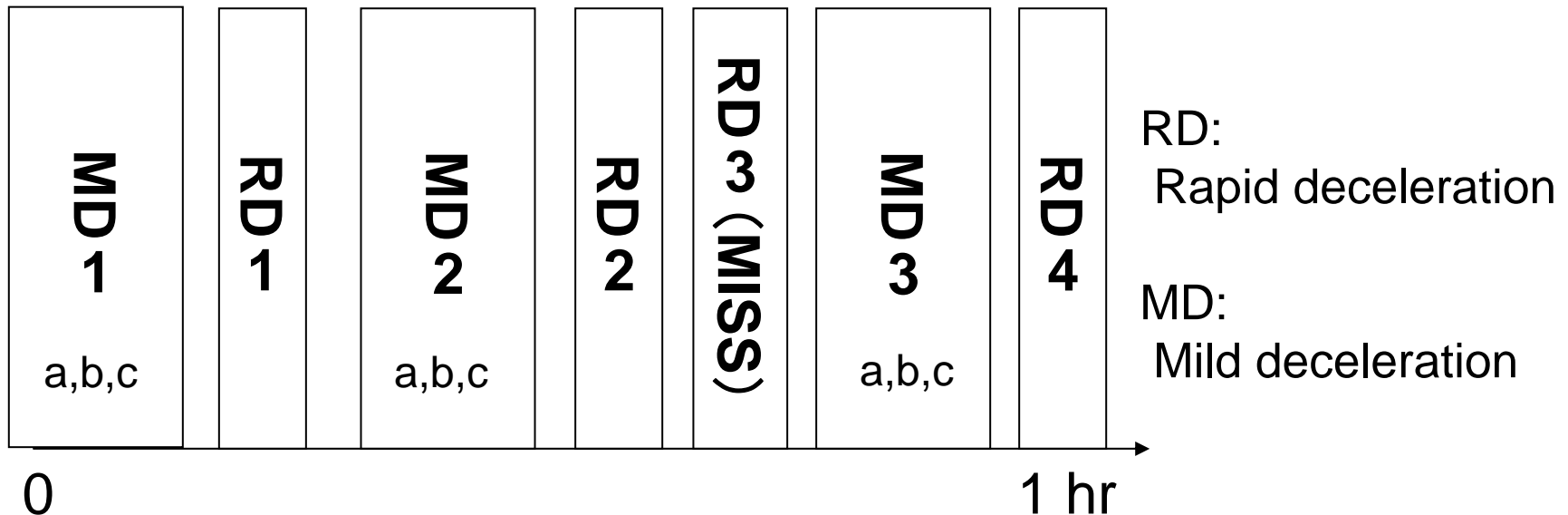


Participants and experimental design

- Participants
 - 18 graduate/undergraduate students
 - 21 – 24 years old; 6 females and 12 males
 - Paid 2,400 JPY for the total 2.5h trials and interview.
- Participants divided into two groups randomly.
 - Group A (A1 to A9):
 - given the deceleration meter and the auditory warning.
 - Group B (B1 to B9):
 - given only the auditory warning.

Procedure

1. 15 min run to acquire enough skill for driving
2. Training run(s) to understand how an auditory alert is given.
3. 45 min peaceful drive with utilizing the ACC system.
4. 1 hour data collection run
 - MD: three mild decelerations (a, b, and c) occur.
 - RD: a rapid deceleration occurs once.



Performance measures

1. Braking latency

Elapsed time from the initiation of the preceding vehicle's "rapid" deceleration to hitting the brake

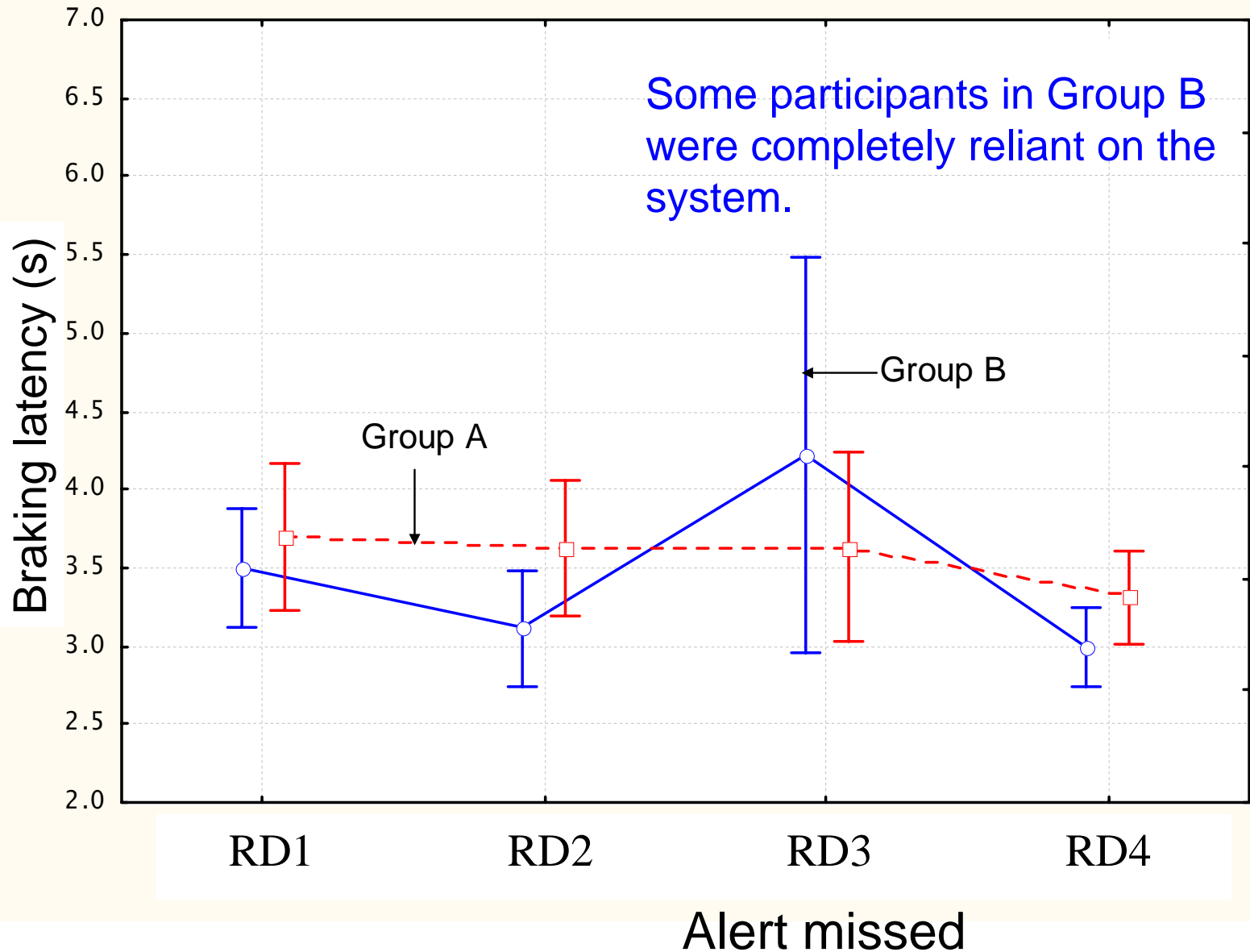
- The braking may be delayed if the driver is too much reliant on the alert system

2. Defensive preparation

Whether or not a driver hit the brake (or at least prepared to do) when the deceleration was mild

- The driver may hit (or prepared to do) the brake unnecessarily if he or she does not understand the limit of the ACC precisely

Results (1): Braking latency



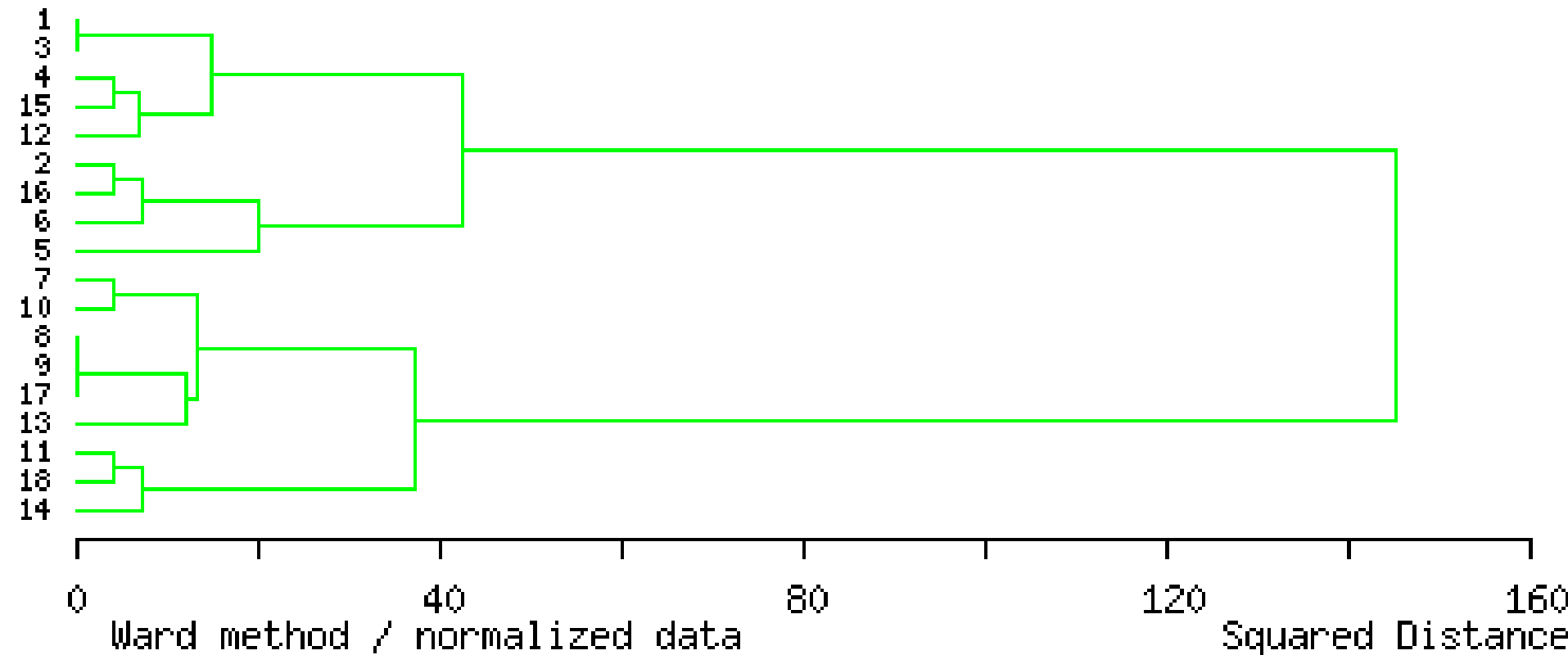
Result (2):
Defensive
preparation

It seems that there
are individual
differences.

However, is there
no tendency in
each group?

Participant		MD1			MD2			MD3		
ID	Name	a	b	c	a	b	c	a	b	c
1	A1	1	1	0	1	0	0	0	0	0
2	A2	0	0	0	0	0	0	0	0	0
3	A3	1	1	0	1	0	0	0	0	0
4	A4	1	0	0	1	0	0	0	0	0
5	A5	0	0	1	0	0	1	0	0	1
6	A6	1	0	0	0	0	0	0	0	0
7	A7	0	1	1	1	1	1	0	1	1
8	A8	1	1	1	1	1	1	1	1	1
9	A9	1	1	1	1	1	1	1	1	1
10	B1	0	1	1	1	1	1	1	1	1
11	B2	1	1	0	1	1	0	1	1	1
12	B3	1	0	1	1	0	0	1	0	0
13	B4	1	1	0	1	1	1	0	1	1
14	B5	0	0	0	1	1	0	1	1	1
15	B6	1	0	0	1	0	0	1	0	0
16	B7	0	0	0	0	0	0	1	0	0
17	B8	1	1	1	1	1	1	1	1	1
18	B9	1	0	0	1	1	0	1	1	1

Cluster analysis (Ward's method)



Participant		MD1			MD2			MD3		
ID	Name	a	b	c	a	b	c	a	b	c
1	A1	1	1	0	1	0	0	0	0	0
3	A3	1	1	0	1	0	0	0	0	0
4	A4	1	0	0	1	0	0	0	0	0
15	B6	1	0	0	1	0	0	1	0	0
12	B3	1	0	1	1	0	0	1	0	0
16	B7	0	0	0	0	0	0	1	0	0
2	A2	0	0	0	0	0	0	0	0	0
5	A5	0	0	1	0	0	1	0	0	1
6	A6	1	0	0	0	0	0	0	0	0
7	A7	0	1	1	1	1	1	0	1	1
10	B1	0	1	1	1	1	1	1	1	1
8	A8	1	1	1	1	1	1	1	1	1
9	A9	1	1	1	1	1	1	1	1	1
17	B8	1	1	1	1	1	1	1	1	1
13	B4	1	1	0	1	1	1	0	1	1
11	B2	1	1	0	1	1	0	1	1	1
18	B9	1	0	0	1	1	0	1	1	1
14	B5	0	0	0	1	1	0	1	1	1

These participants did not “prepare” braking when the ACC system can manage.

The meter may be useful to understand the limit of ACC.

These participants had been or became “prepared” to brake even when the ACC system can manage.

Concluding remarks

- This paper proposed the deceleration meter
 - for preventing or reducing possibility of driver's too-much reliance on a warning system in an ACC system.
- The experimental results showed its effectiveness
 - to understand the functional limit of the ACC's deceleration.
 - to reduce drivers' too much reliance on the alert system

Further studies

- To investigate what happens if the frequency of the rapid deceleration is small.
 - In this experiment, rapid deceleration of the preceding vehicle occurred very frequently.

