

# Effect of Tailored Alarm Timing for Forward Collision Warning Systems on Driver Behaviour and Trust in the Systems

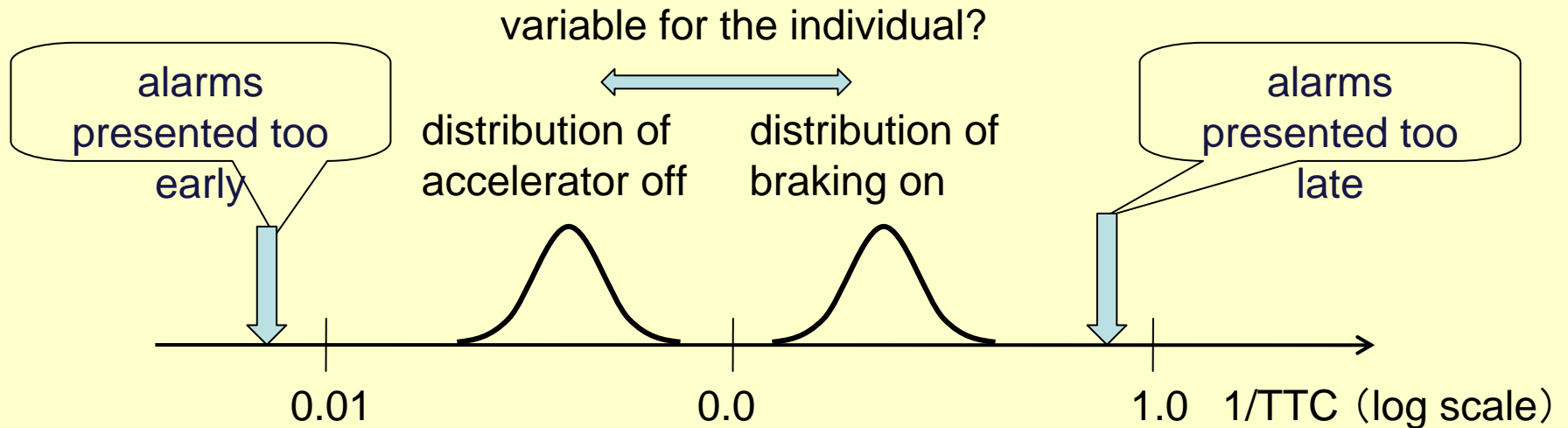
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# When should an alarm be presented for Forward Collision Warning Systems?

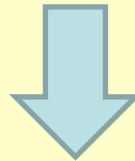


Drivers....

- reluctant to respond to alarms presented too early/late  
➡ distrust in alarms
- leave driver's tasks (recognition tasks) to alarm systems  
➡ over reliance on alarm systems

# Driver-adaptive alarm timing

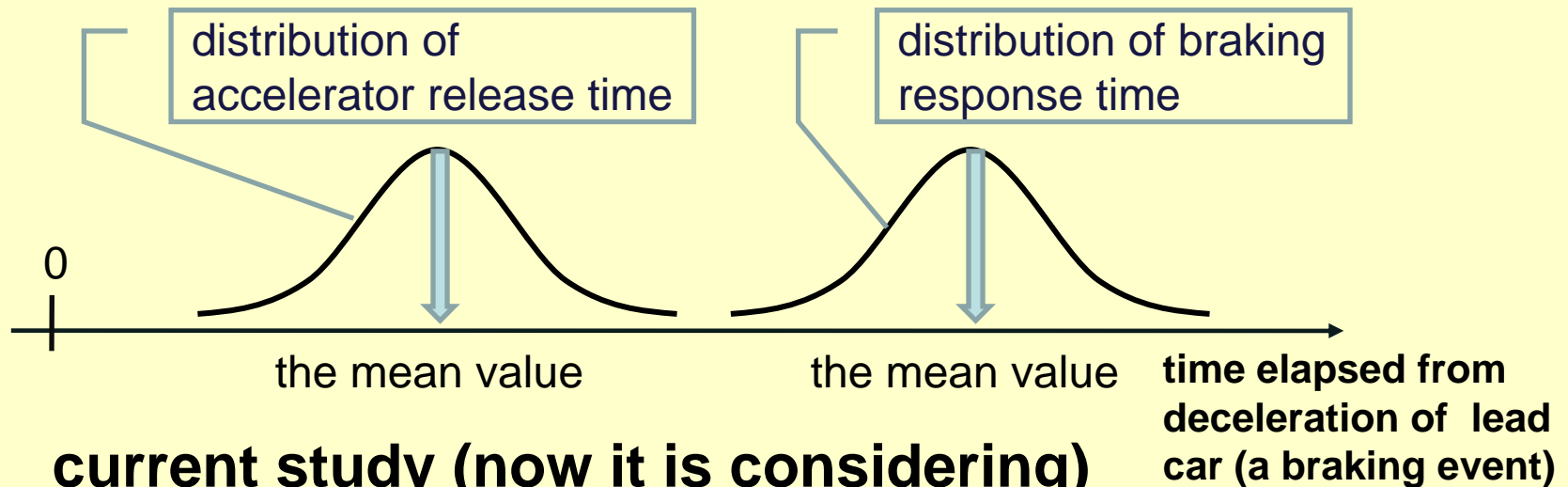
Driver-adaptive alarm timing is to tailor alarm timing to the individual based on an braking behaviour



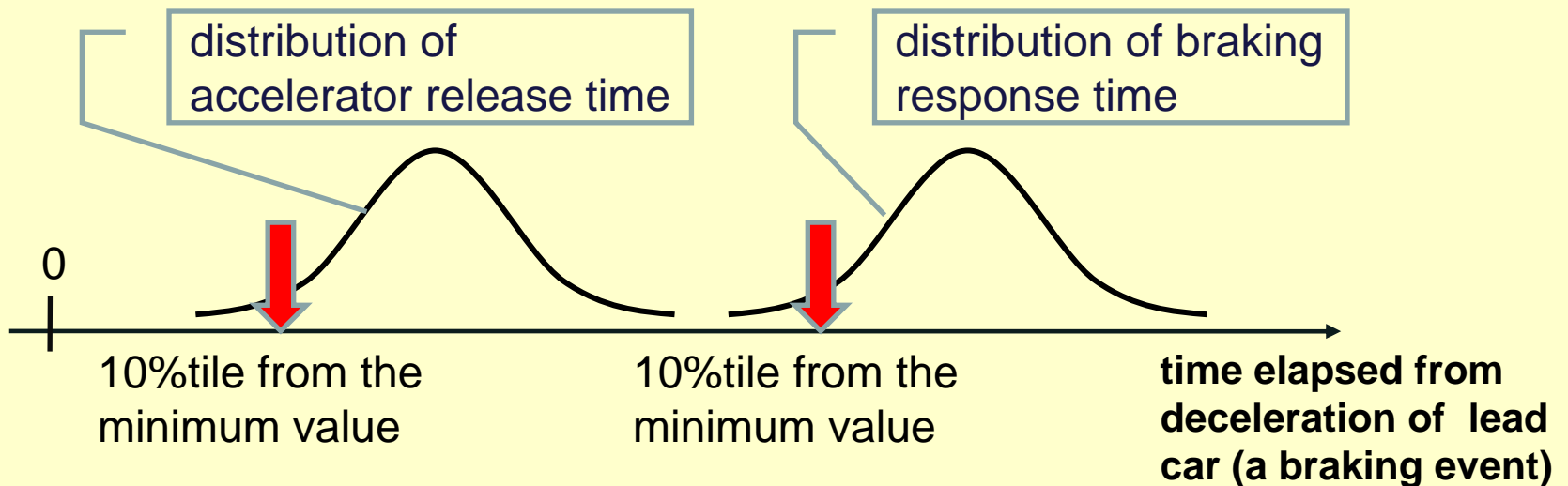
It is possible that driver-adaptive alarm timing may inhibit distrust in and over-reliance on alarms

# What should be adapted for alarm timing?

## past study (it has been investigated)



## current study (now it is considering)



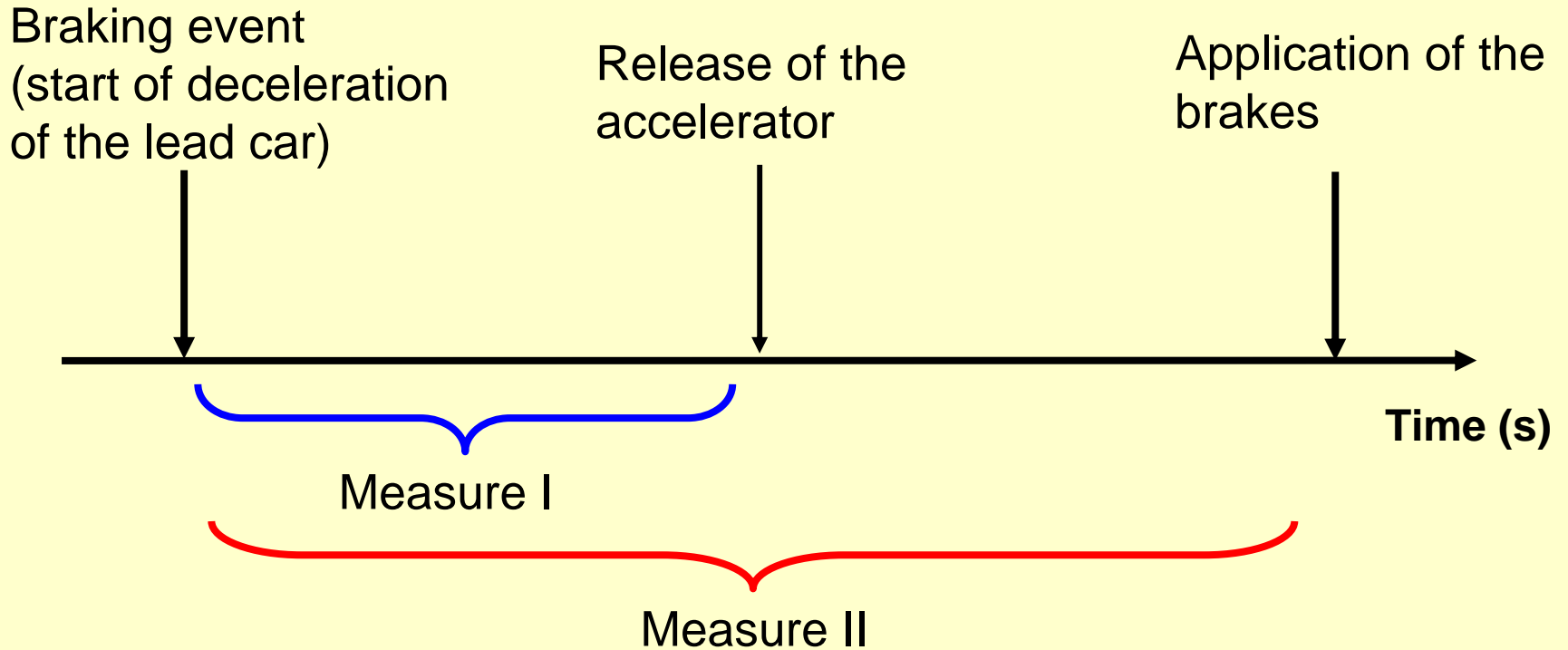
# Objective of the research

- Assessing effects of individual differences in braking behaviour (Experiment I)
- Investigating effects of driver-adaptive alarm timing on trust and driver behaviour (Experiment II)

# Experiment I

- **Apparatus:** a motion-based driving simulator
- **Participants:** 18 (mean=28.3, SD=9.0)
- **Experimental conditions:**
  - driving speed: 60km/h and 100km/h
  - lead time: 1.7s
  - deceleration of the lead car: 0.65G and 0.39G
  - 9 trials for each deceleration

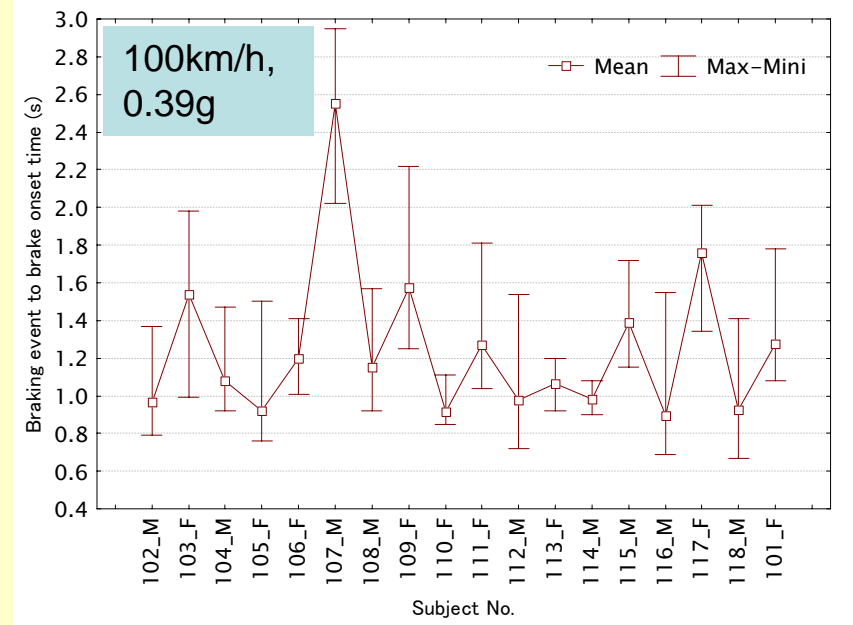
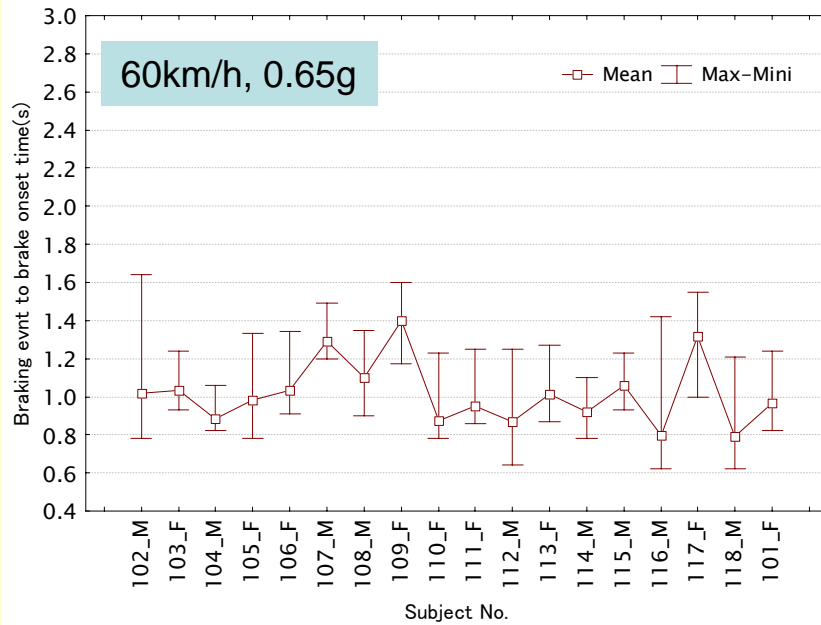
# Dependent variables



Measure I: Braking event to accelerator release time

Measure II: Braking event to brake onset time

# Results: Braking event to brake onset time



- There may be individual differences in the swiftness of braking response time.



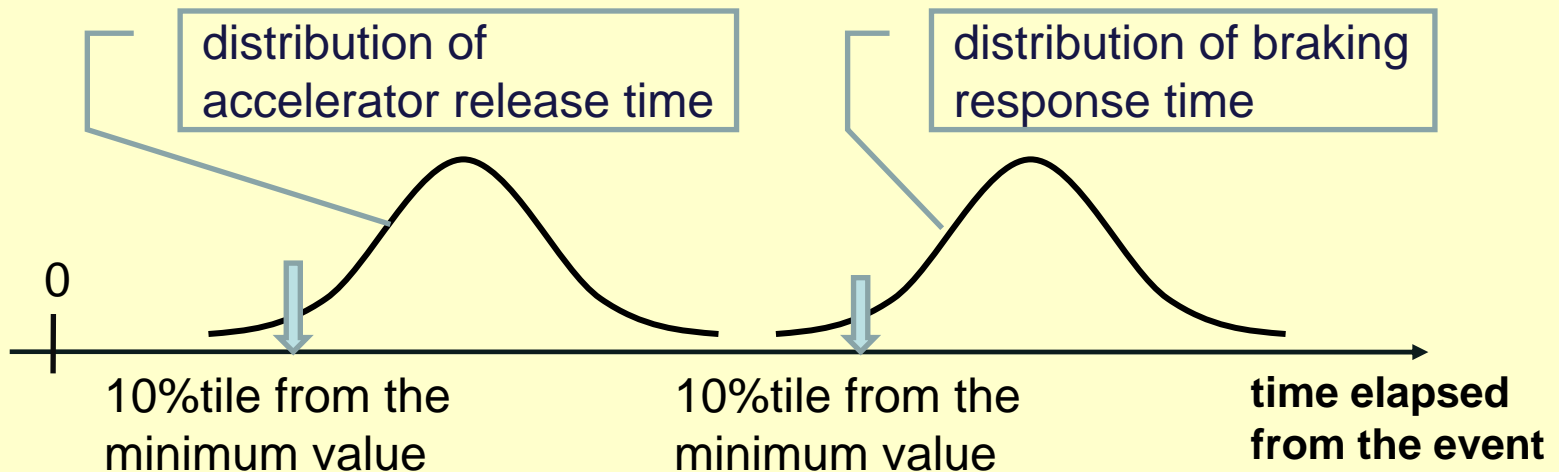
# Experiment II

- Objective: Investigating effects of driver-adaptive alarm timing on trust and driver behaviour
- Apparatus: the same as in experiment I
- Participants: the same as in experiment I
- Experimental conditions: the same as in experiment I
  - driving speed: 60km/h and 100km/h
  - lead time: 1.7s
  - deceleration of the lead car: 0.65G and 0.39G (between-subject)

# Alarm timings

- Alarm timing Accelerator\_Off = Braking event to accelerator release time -1.282  $\sigma$
- Alarm timing Braking\_On = Braking event to brake onset time-1.282  $\sigma$

$\sigma$  : standard deviation of distribution



Braking event to accelerator release time -1.282  $\sigma$

Braking event to brake onset time-1.282  $\sigma$

# Dependent variables

- Braking event to accelerator release time (the same as in Experiment I)
- Braking event to brake onset time (the same as in Experiment I)
- Perceived alarm timing (11-point rating scale: too late-appropriate-too early)
- Alarm effectiveness (11-point rating scale)
- Trust (11-point rating scale)

Question: How much do you trust the warning system?

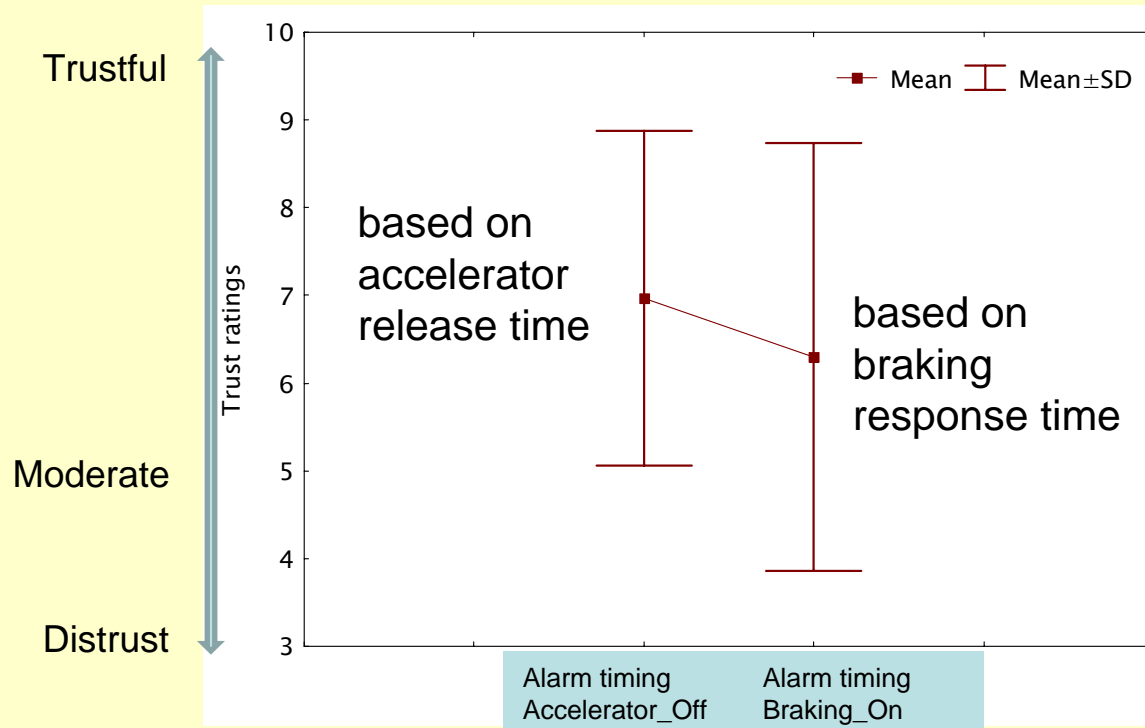
Answer:

Not at all

Completely

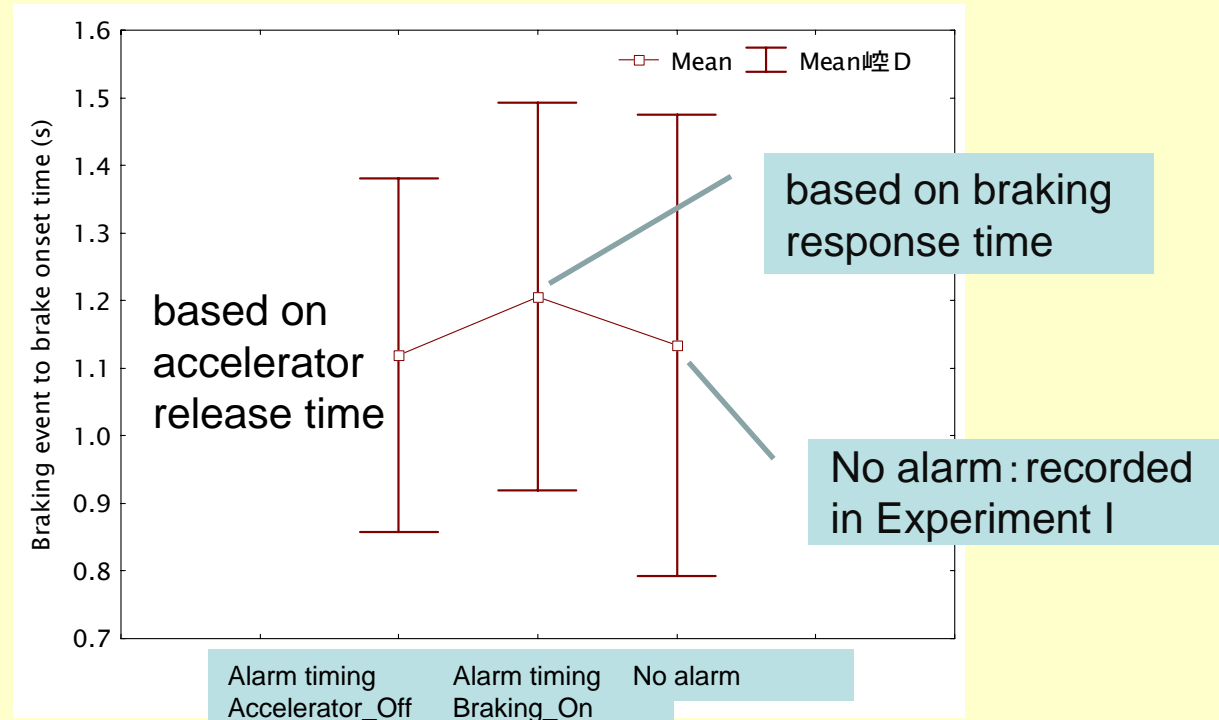


# Results: Trust



- Alarm timing Accelerator\_Off induces higher ratings of trust.  
 $F(1,140)=26.965, p<0.01$
- However, the value for alarm timing Braking\_On is also not so low.

# Results: braking event to brake onset time



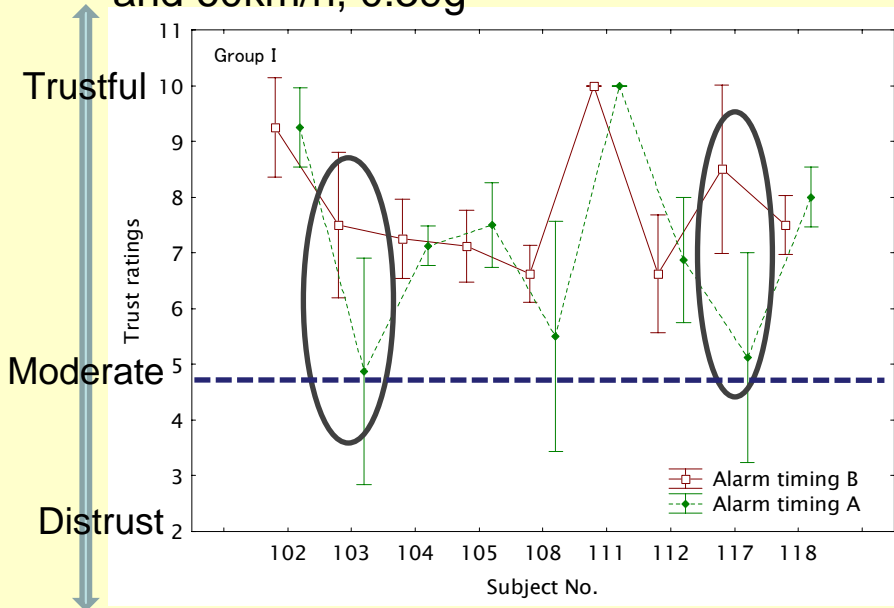
- Alarms that are presented based on braking response time induce a longer braking response time.

$F(2,280)=7.583, p<0.01$

- However, there is not a great difference in the value for the each condition

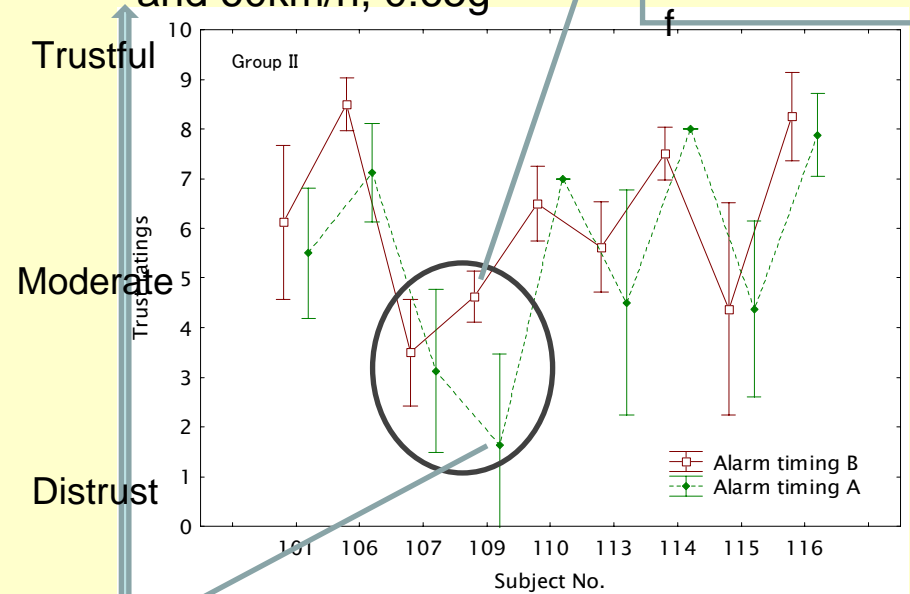
# Results: individual differences in trust ratings

Group I: 100km/h, 0.65g  
and 60km/h, 0.39g



$F(8, 63)=7.63, p<0.01$

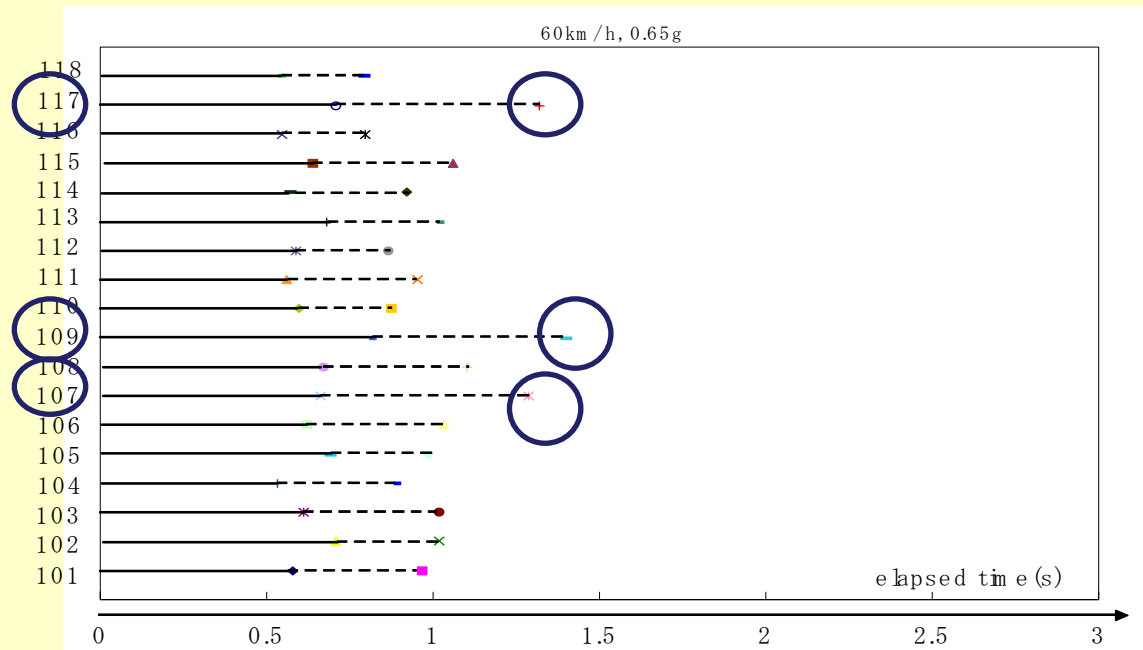
Group II: 100km/h, 0.39g,  
and 60km/h, 0.65g



$F(8, 63)=4.03, p<0.01$

- There is a great difference in the values between the alarm timings (103, 117, **109**).
- Trust ratings for the both alarm timings are relatively low (**107**).

# Ordinary braking behaviour and its relation to driver trust in alarms



Drivers who exhibited decreased trust in alarms have long time elapsed.



It could be necessary for drivers who exhibited particular driving characteristic to implement another alarm setting.

# Conclusions

- Alarms that are triggered at earlier timings of accelerator release time and braking response time for the individual do not impair driver trust in alarms and driver behaviour.
- For drivers who exhibit particular driving characteristics i.e., the timings of ordinary accelerator releasing or braking response are slow compared to average drivers, subjective ratings of trust in alarms may be low.



**Thank you for listening!**

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