Rijkswaterstaat
Ministry of Infrastructure and Water Management

Lab
Traffic and Transportation Safety

The Impact of a Dedicated Lane for Connected and Automated Vehicles on the Behaviour of Drivers of Manual Vehicles

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- Research objective
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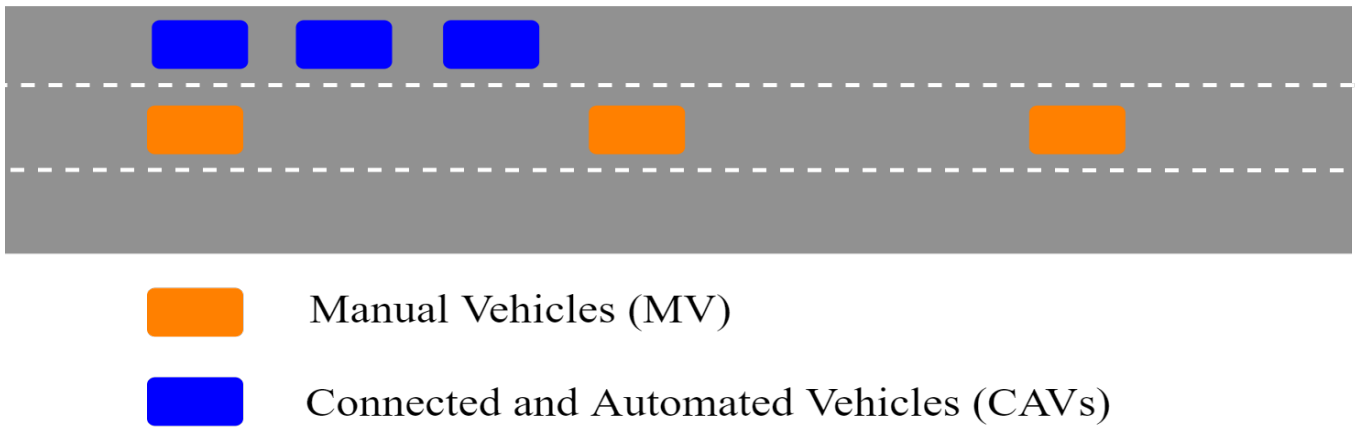
Background

- Connected and automated vehicles (CAVs) drive at shorter time headways (THWs)



- Manual vehicles (MVs) may adapt their behaviour in mixed situation

- By implementing dedicated lanes (DLs) more separation is created between MVs and CAVs

Main Research Objective

To investigate the behavioural adaptation of MV drivers in **car-following** and **lane changing** when driving **adjacent to the DL** and compare that to the behavioural adaptation when driving in a **mixed traffic flow** at a **low to moderate penetration rate**.

Research Expectations

1. In a mixed traffic situation and at low to moderate penetration rates of CAVs, the behavioural adaptation of MV drivers is negligible.

2. MV drivers adopt shorter time headways and merging gaps in car-following and lane changing respectively when driving next to DLs.

3. The behavioural adaptation is different for drivers with different demographics and driving styles.

Method

1. A driving simulator experiment (N=51; 22 F, 29 M)

2. Three scenarios (randomized order):

   Base: Only manual vehicles (THW: 2-4 s)

   Mix: Platoons of 2-3 CAVs (THW: 0.5 s; MPR = 43%)

   DL: Same traffic as Mix scenario with one DL

3. Questionnaires to retrieve demographics:

   (age, gender, education, familiarity with CAVs, driving style)

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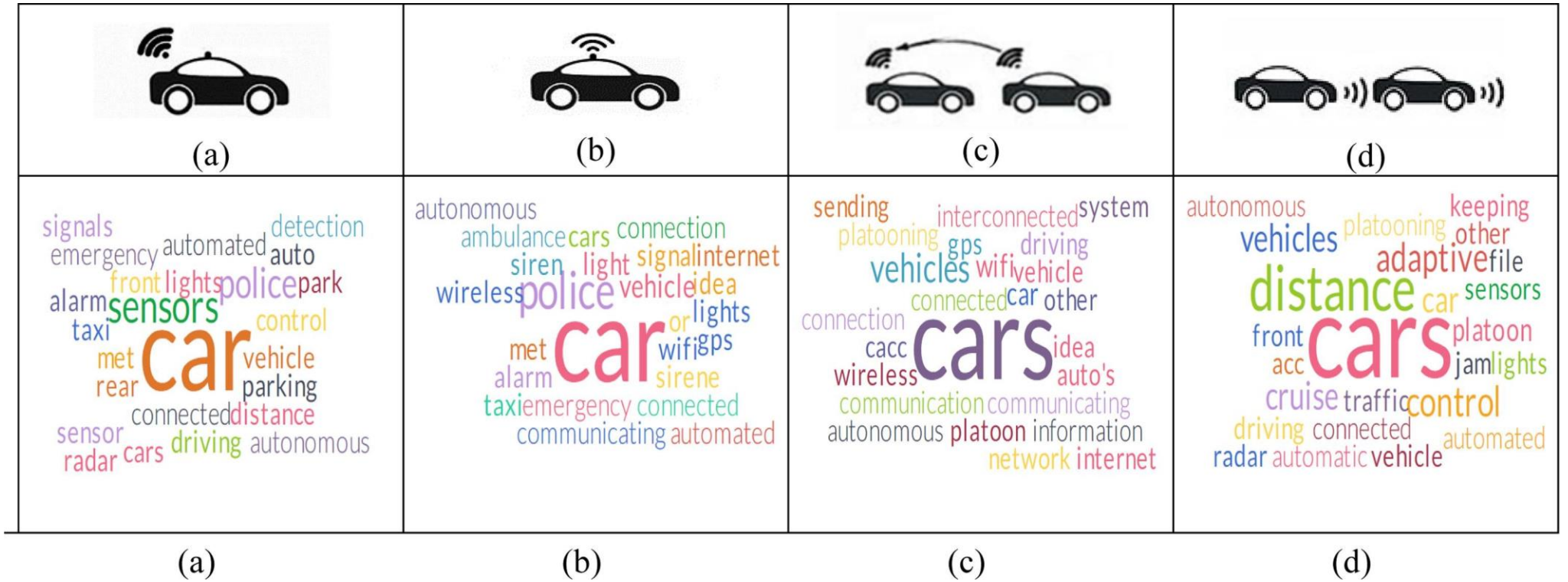
Method

- Platooning pictogram



(a) (b) (c) (d)

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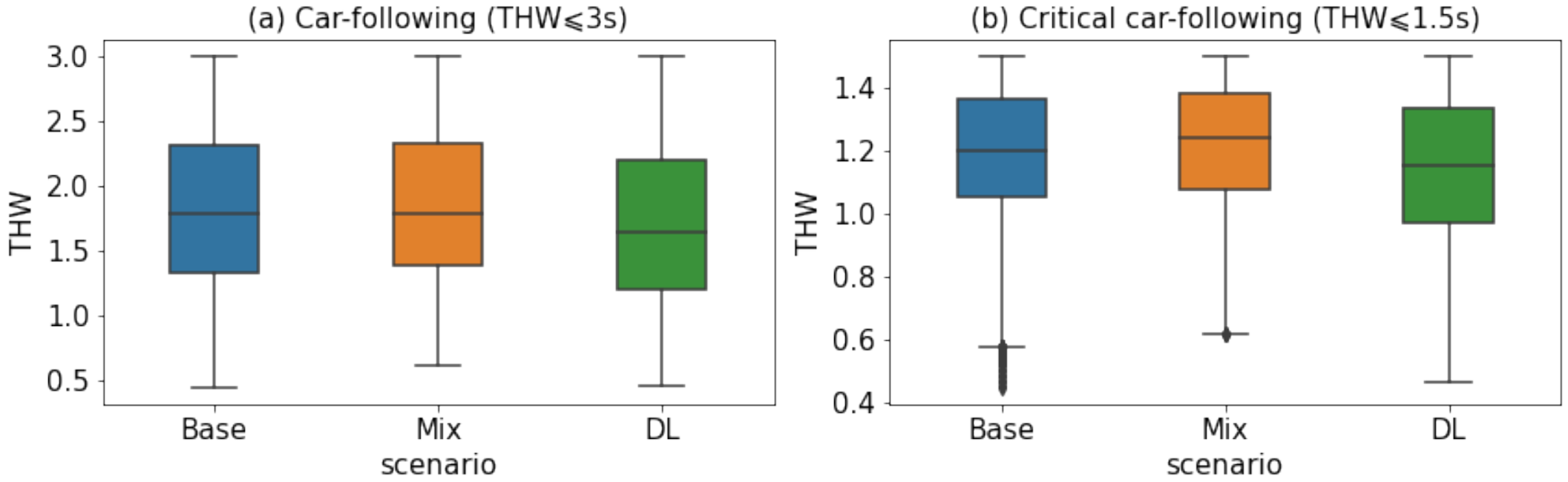
Analysis and results

- **Car following behaviour**



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Car following behaviour (THW≤ 3s)

Linear Mixed Effect Models were estimated:

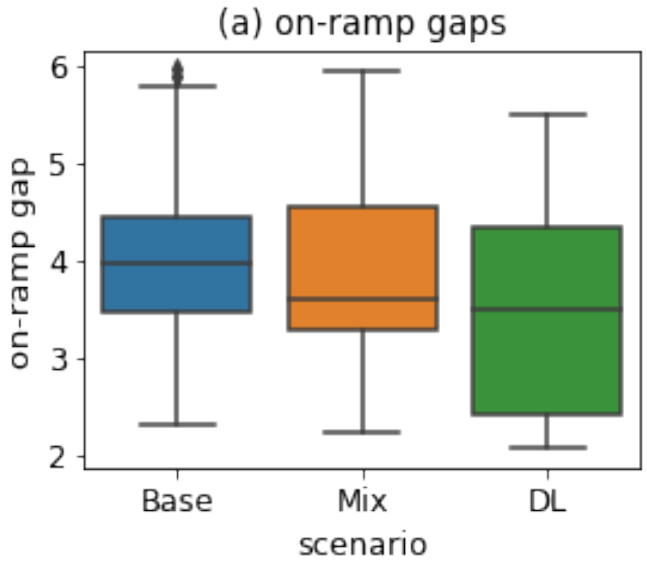
- THW reduction is significant in DL scenario specially on the lane next to the CAV platoons but not in the mix situation with moderate MPR.

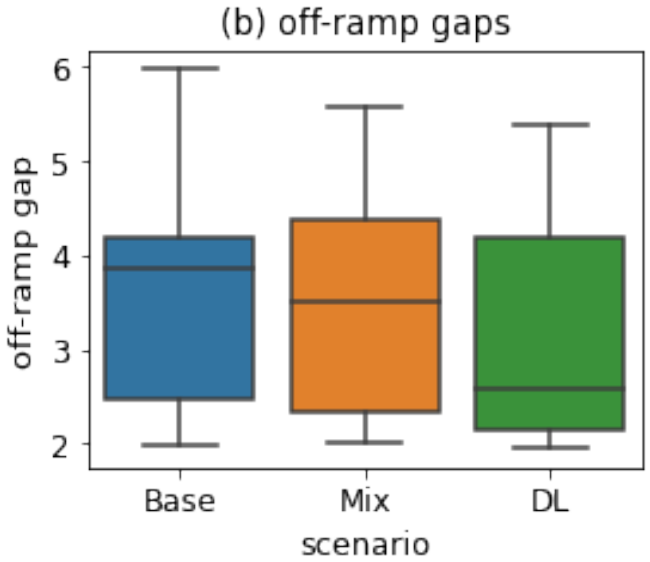
- The interaction between age and scenario showed that older drivers decrease their car following THW in DL scenario more than Mix scenario.

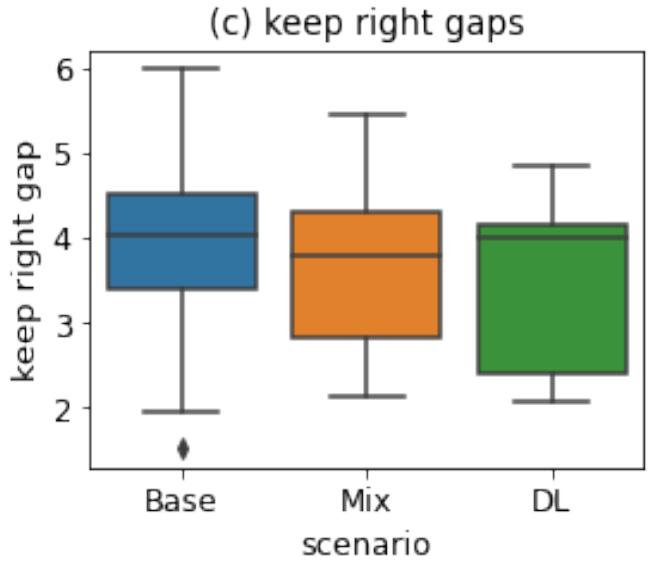
- Driving style has no significant impact on behavioural adaptation

Analysis and results (lane change behaviour)

- **Lane changing behaviour**







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Analysis and results (lane change behaviuor)

Linear Mixed Effect Models were estimated:

- Significantly shorter gaps in DL scenario at on-ramp, off-ramp, and in keep right manoeuvres

- Participants changed lane with 12% shorter gaps at on-ramps.

Conclusions

- The behavioural adaptation of MV drivers would be negligible in a mixed traffic at low to moderate MPRs.
- Concentrating CAVs on one lane increases the likelihood of behavioural adaptation due to higher conspicuity and exposure time.
- Factors like infrastructure, exposure time, and conspicuity of platoons are more influential in behavioural adaptation compared to driving style.

Limitations & Future Research

- Conduct field test instead of virtual reality
- Investigate long-term effects of behavioural adaptation
- Test more penetration rates

Questions?

How to find the full paper:

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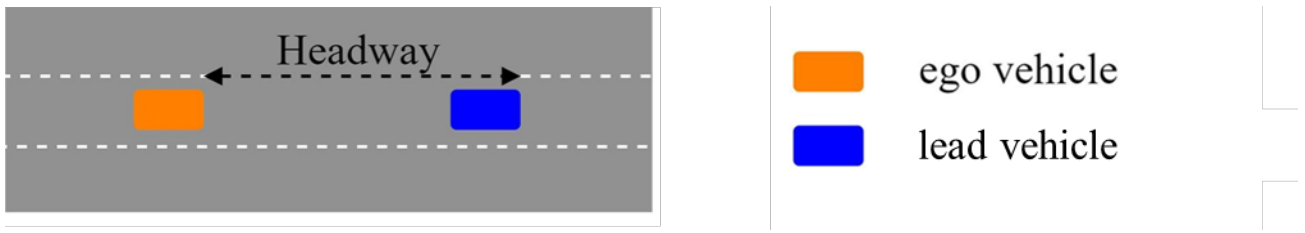
Data collection and processing

Car following THW Calculation

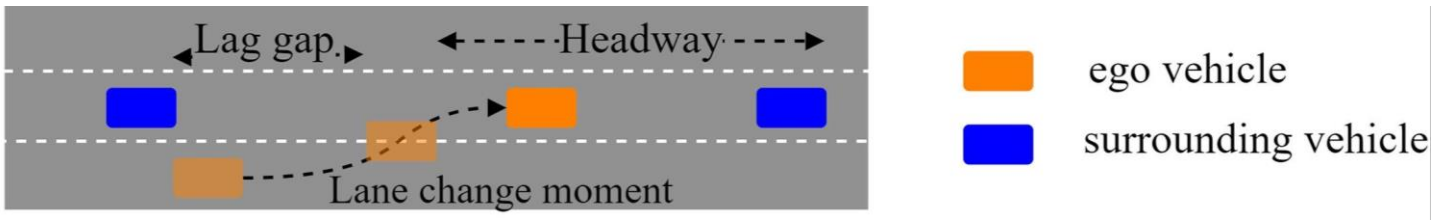
- Distance between ego and lead vehicle [m] divided by the speed of the ego vehicle [m/s].
- The car following event was defined **from five seconds after the moment when participant changed lane** until **five seconds before the next lane change**.



Data collection and processing

Lane change time gap Calculation

- sum of the **headway [m] divided by the speed of the ego vehicle** [m/s] and **lag gap [m] divided by the speed of the lag vehicle** [m/s].
- A lane change happens the moment when the **center of the ego vehicle passes the lane marking.**



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