POLITECNICO MILANO 1863

DriSMi

Driving Simulator

TOYOTA

Enhancing Driver Acceptance Of Adaptive Cruise Control In Dynamic Simulators

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Overview

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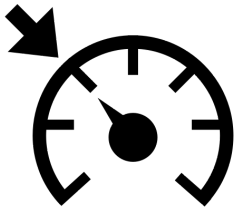
Overview – Research Ingredients

ACC System



Adaptive Cruise Control supplements conventional cruise control with an active vehicle-to-vehicle distance control feature. Designed for use on freeways and express ways, in **vehicle-to-vehicle distance control mode, your car automatically accelerates or decelerates** in order to maintain a preset following distance from the vehicle traveling directly ahead of you.

Toyota Owner's Manual

Driving Simulator

DriSMi, the dynamic driving simulator at Politecnico di Milano, is a a state-of-the-art tool in the automotive sector. It allows users to **virtually test** any type of vehicle even before building physical prototypes. By developing mathematical models of vehicle components or driver-assistance systems (ADAS), it's possible to **directly experience the impact of new features**.

www.drismi.polimi.it

Problem Statement

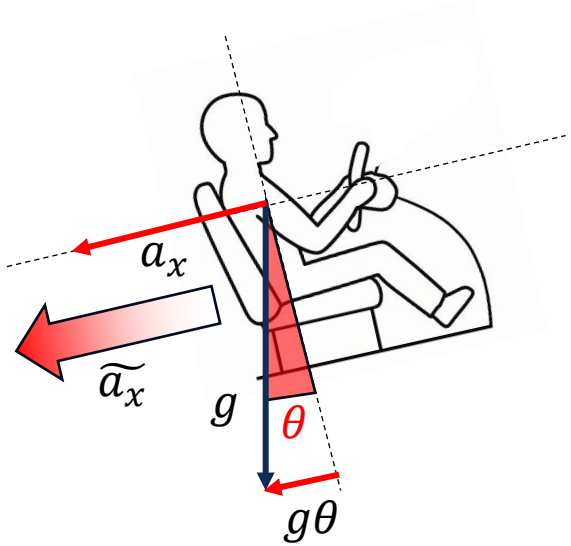
02

Tilt Coordination

Driving simulators have a **limited workspace → Motion Cueing Algorithms (MCA)** are implemented to maximise the driver perception. **For ACC, longitudinal motion is key.**

$$\widetilde{a_x} = a_x + g\,sin(\theta) \approx a_x + g\theta$$

θ Tilt Angle



A simulator pitch angle can improve the realism of **sustained longitudinal acceleration** feeling by introducing an additional longitudinal component force → **cue conflict risk in case of non-optimal tuning**

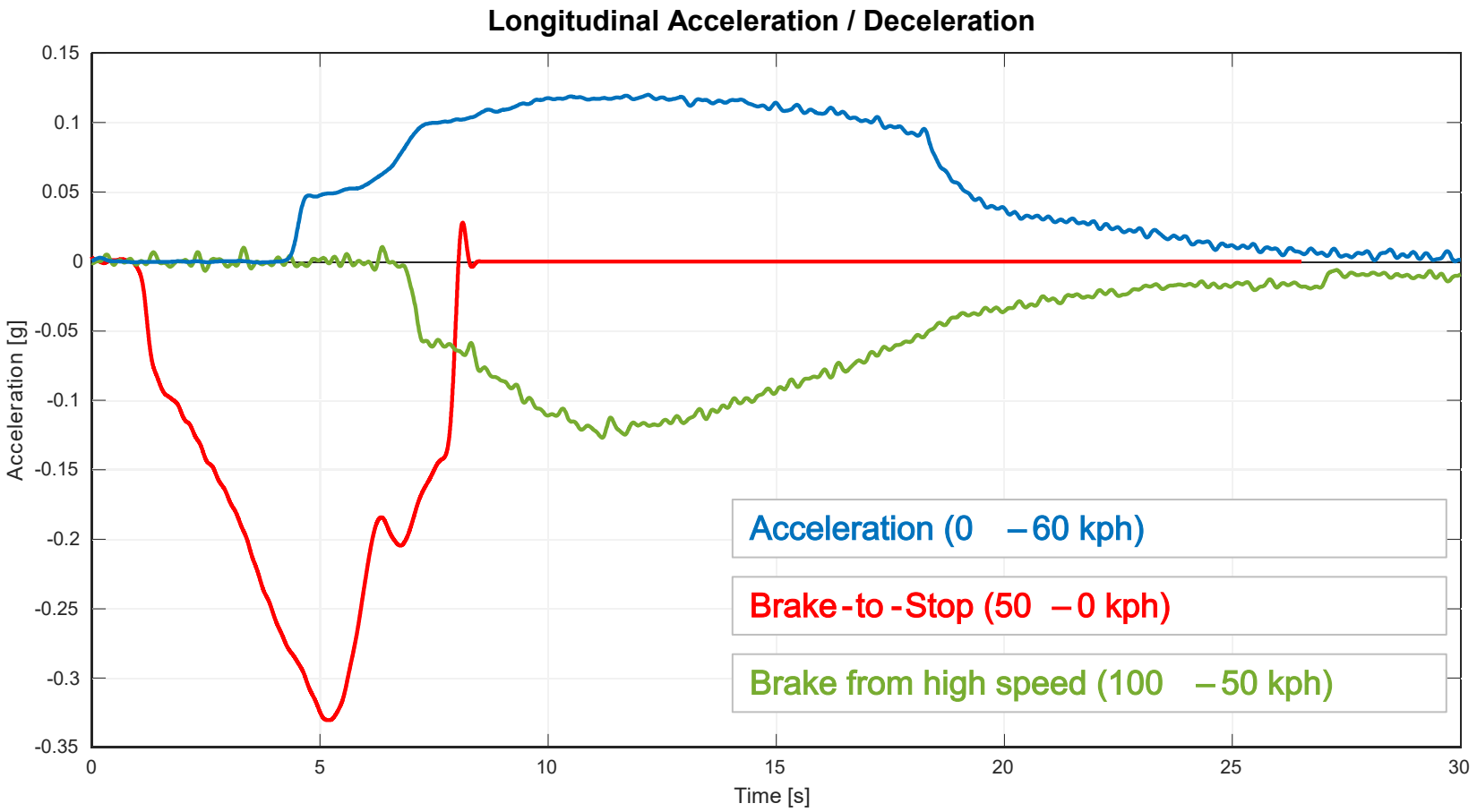
Research Question

To what extent tilt coordination influence the subjective evaluation of an ACC in Dynamic Driving Simulators?

Reference Manoeuvres

A test vehicle with ACC was tested on a proving ground in different acceleration/braking scenarios.

The **acquired longitudinal accelerations are used as reference signals** in the simulator experiments.



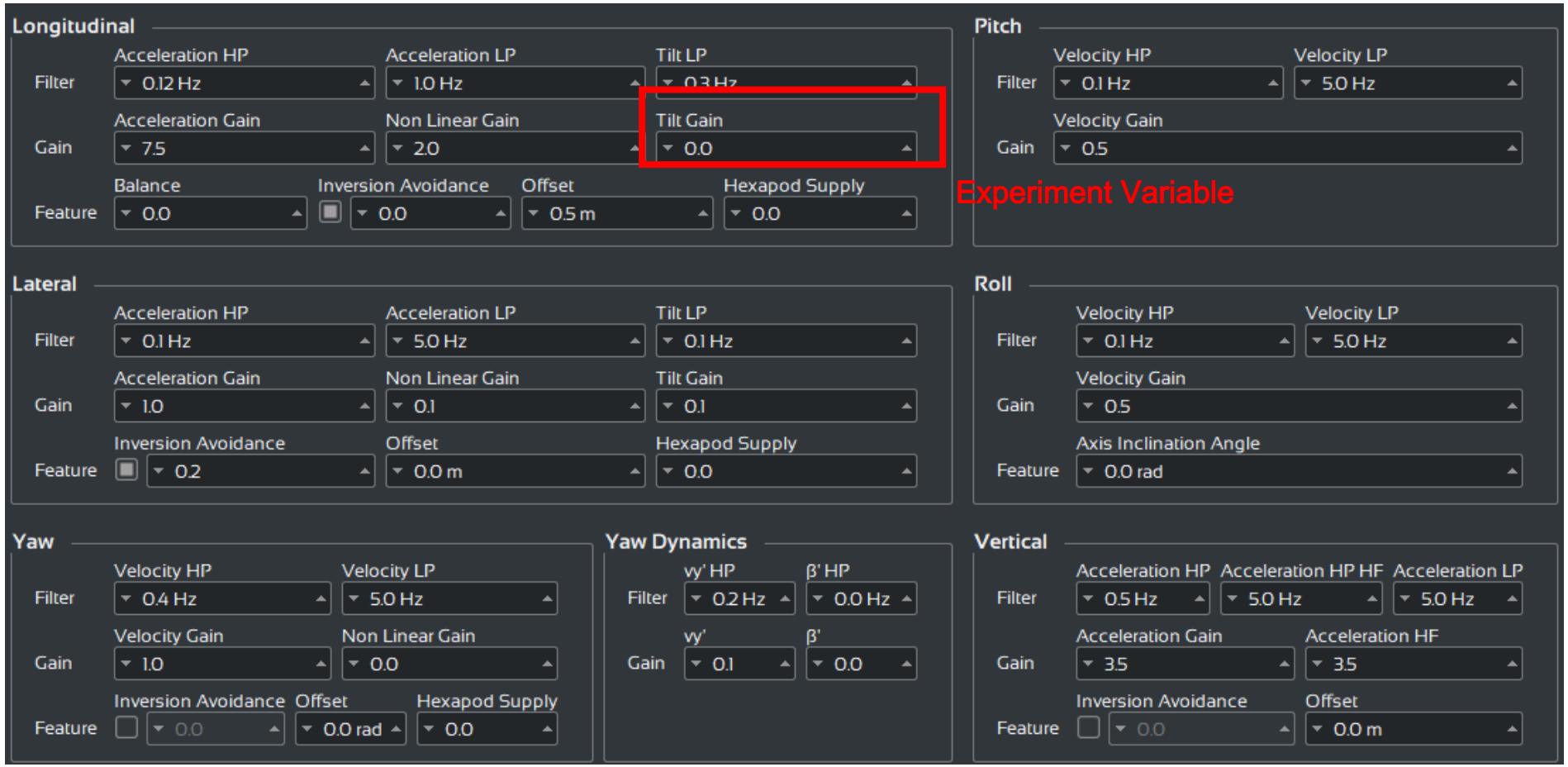
The manoeuvres were replicated in the driving simulator with 3 different tilt gains

Base Cueing Setup

The base cueing is fixed, only the variation of the tilt gain is analysed

Maximum utilisation of the available platform workspace without considering the tilt gain contribution

Tilt LP set to replicate only sustained acceleration filtering high frequency

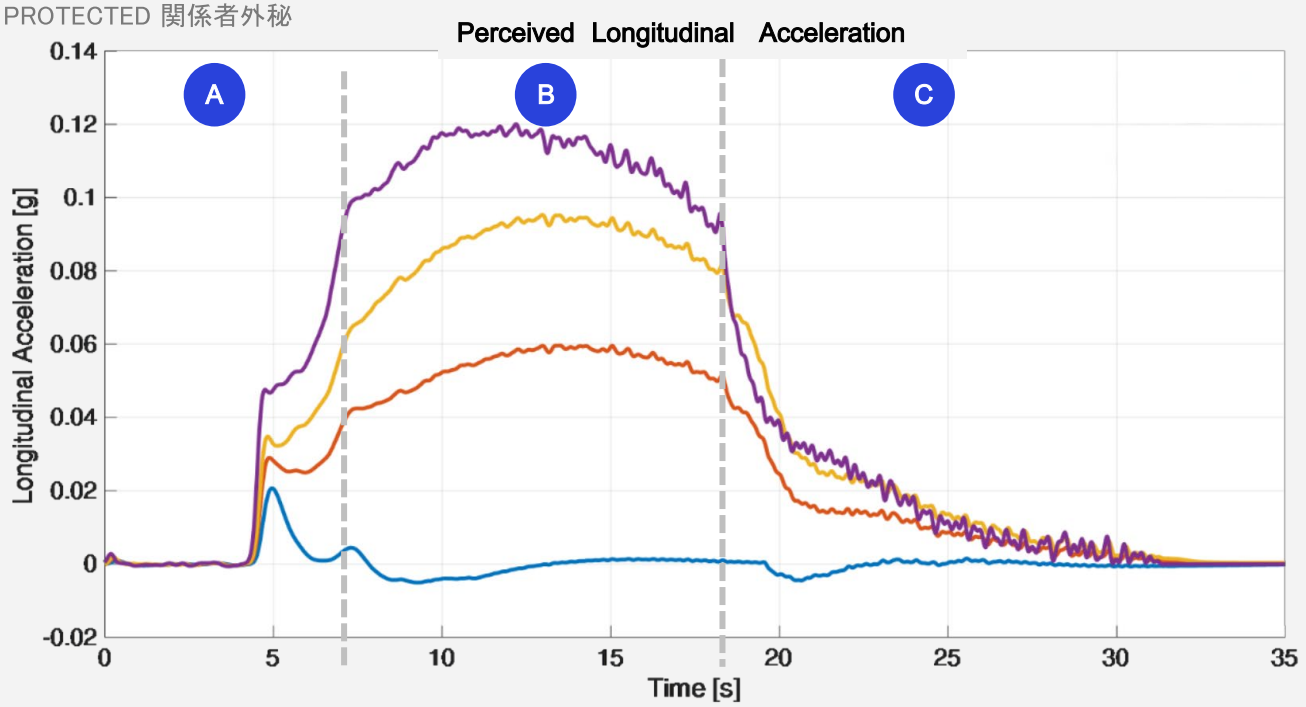


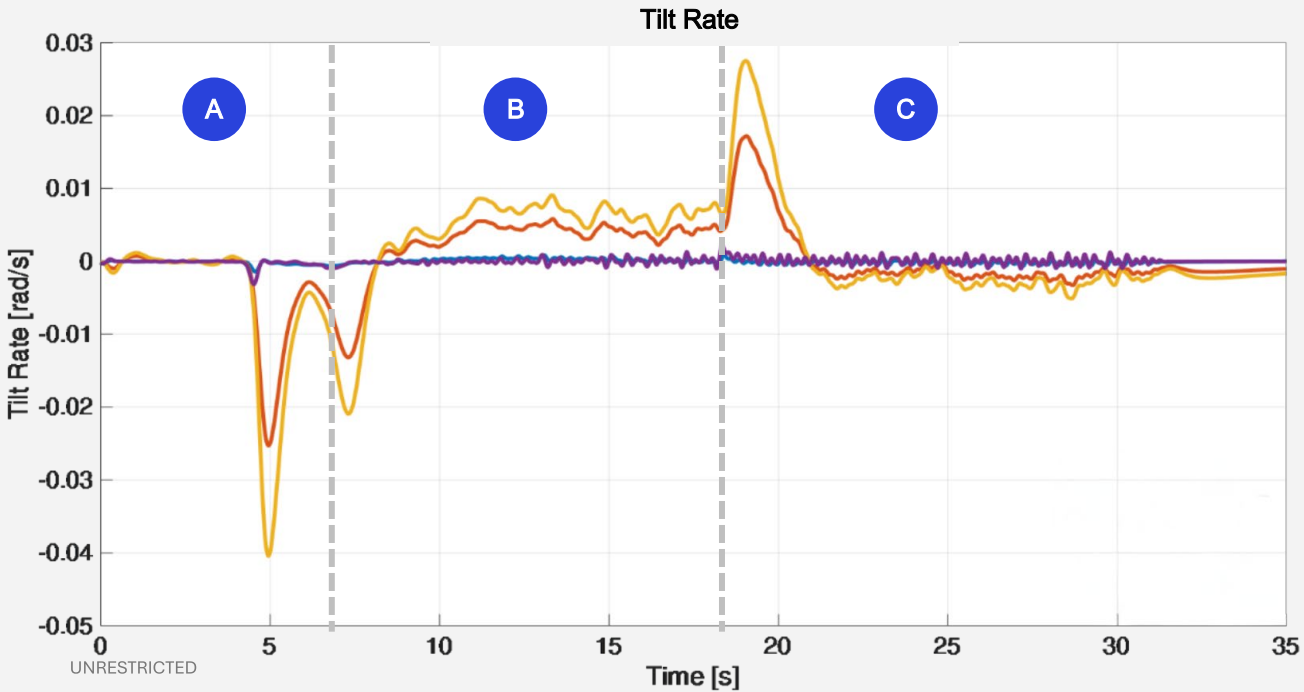
Objective and Subjective evaluation

03

Acceleration Scenario

- **Tilt Gain 0** : initial peak is catched, but lack in sustained acceleration part
- **Tilt Gain 5** : initial bite and sustained parts shapes are well preserved
- **Tilt Gain 8** : closer to the target (~ 80% of the amplitude) in the whole range





A Initial phase

B Sustained acceleration

C Final phase

Tilt gain 0

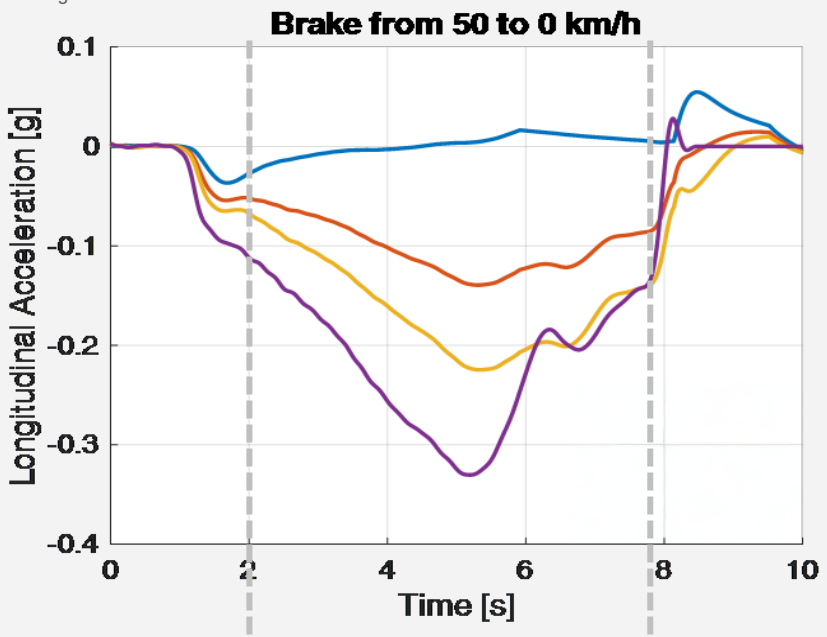
Tilt gain 5

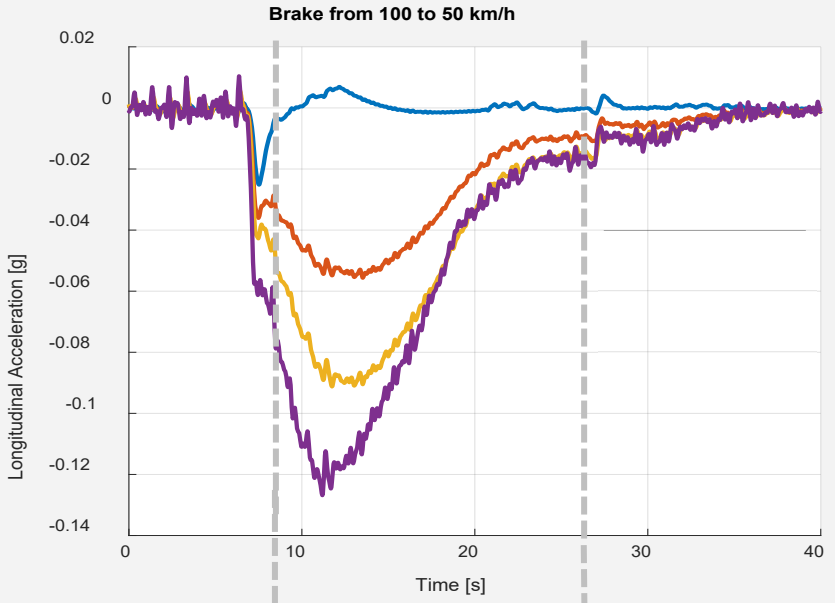
Tilt gain 8

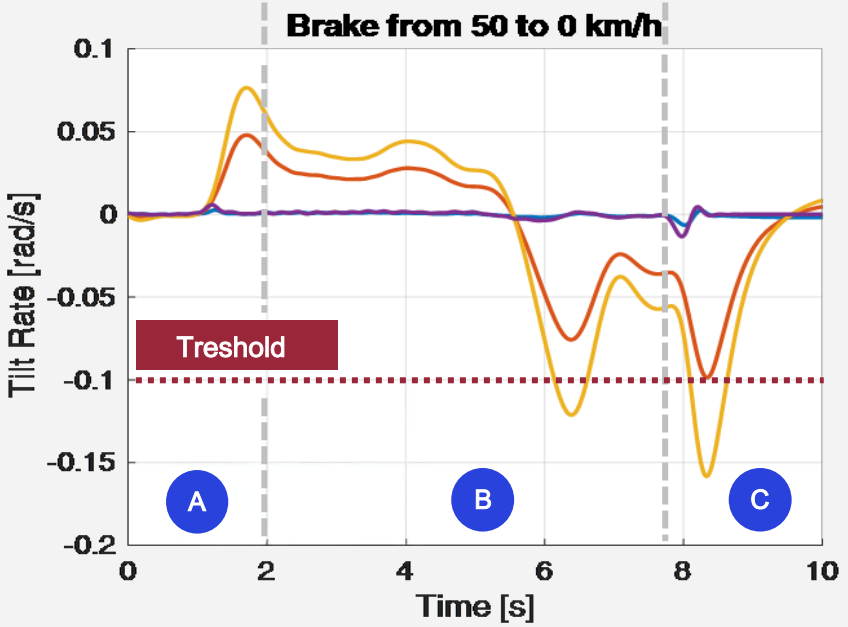
Reference

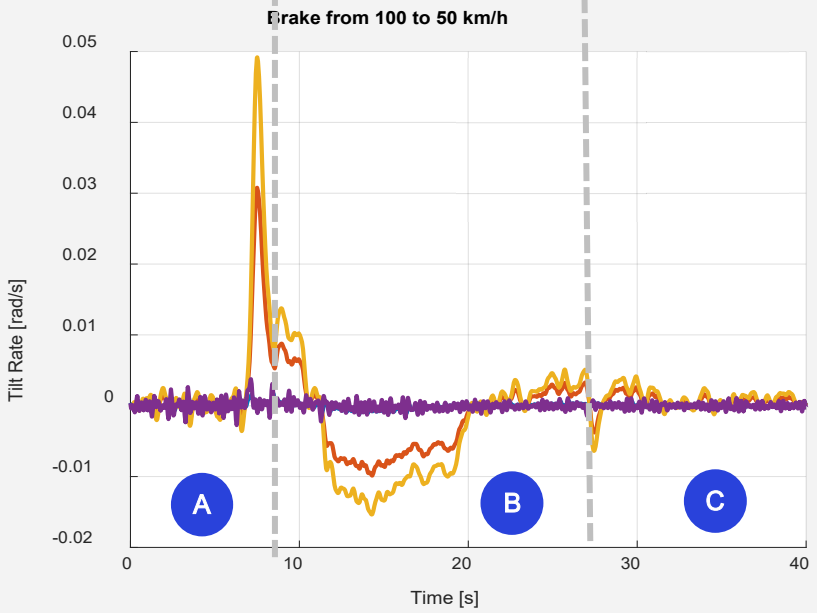
Braking Scenarios

- **Tilt Gain 0** : initial and final jerks are catched, lack in the sustained area
- **Tilt Gain 5** : initial bite and sustained parts shapes are well preserved
- **Tilt Gain 8:** shape overall closer to the reference signal → in the brake-to-stop the tilt rate exceeds the perception threshold



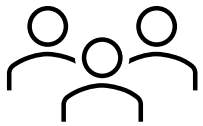






Tilt gain 0 | Tilt gain 5 | Tilt gain 8 | Reference

Subjective Evaluation – Questionnaire



12 Drivers

- Age from 25 to 57
- Driving experience from 7 to 39 years

Questions

01 How realistic was the **braking/acceleration feeling** compared to what you expected?

02 How realistic was the feeling of **sustained braking/acceleration** ?

03 How realistic was the feeling of **braking/acceleration in the initial phase** ?

04 How realistic was the feeling of **braking/acceleration in the final phase** ?

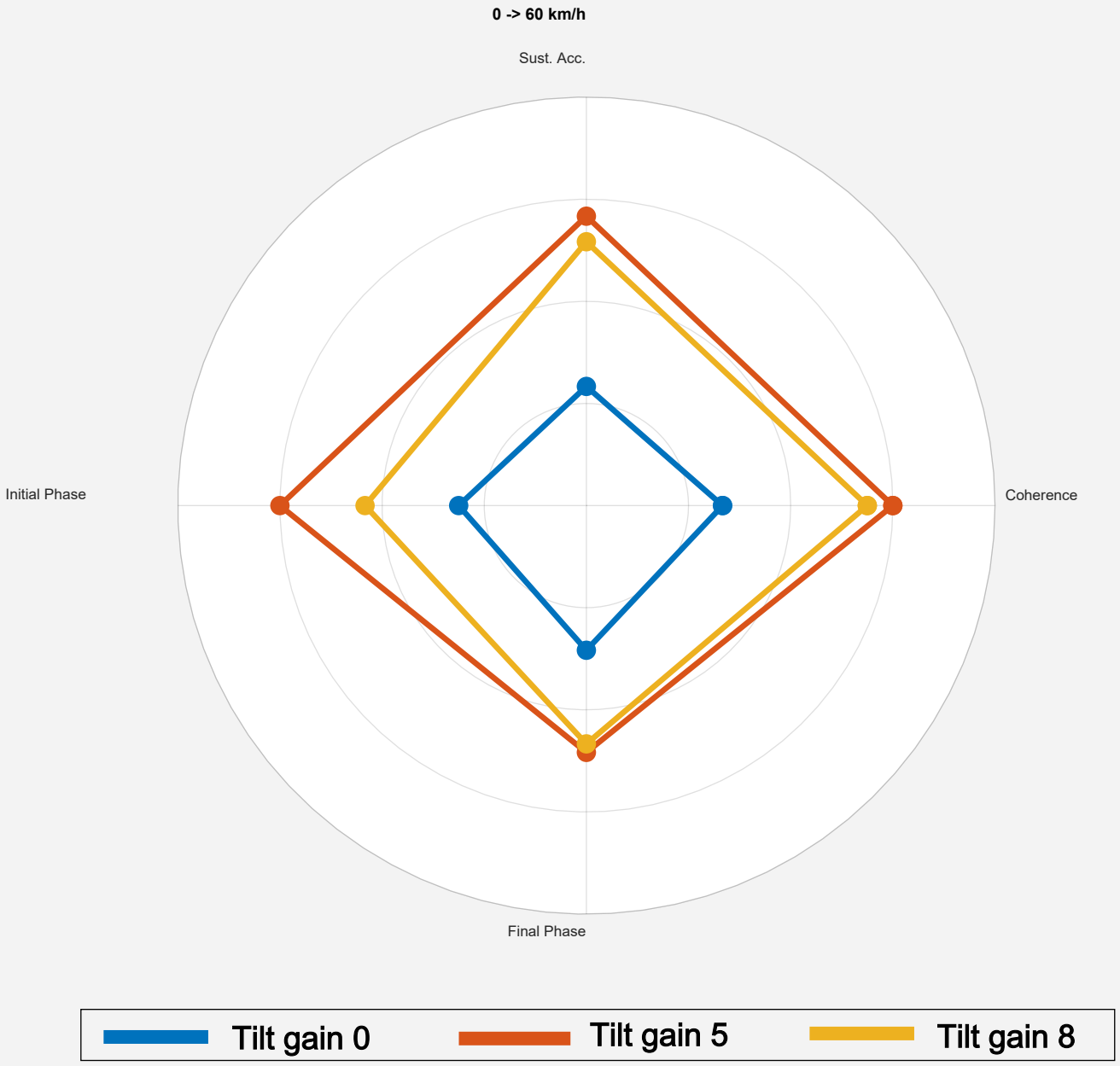
Results

04

Acceleration from 0 to 60 km/h

- Main preference points are the sustained acceleration and the initial phase
- Similar preference with Tilt Gain 8 in the final part
- Tilt Gain 0 worst overall

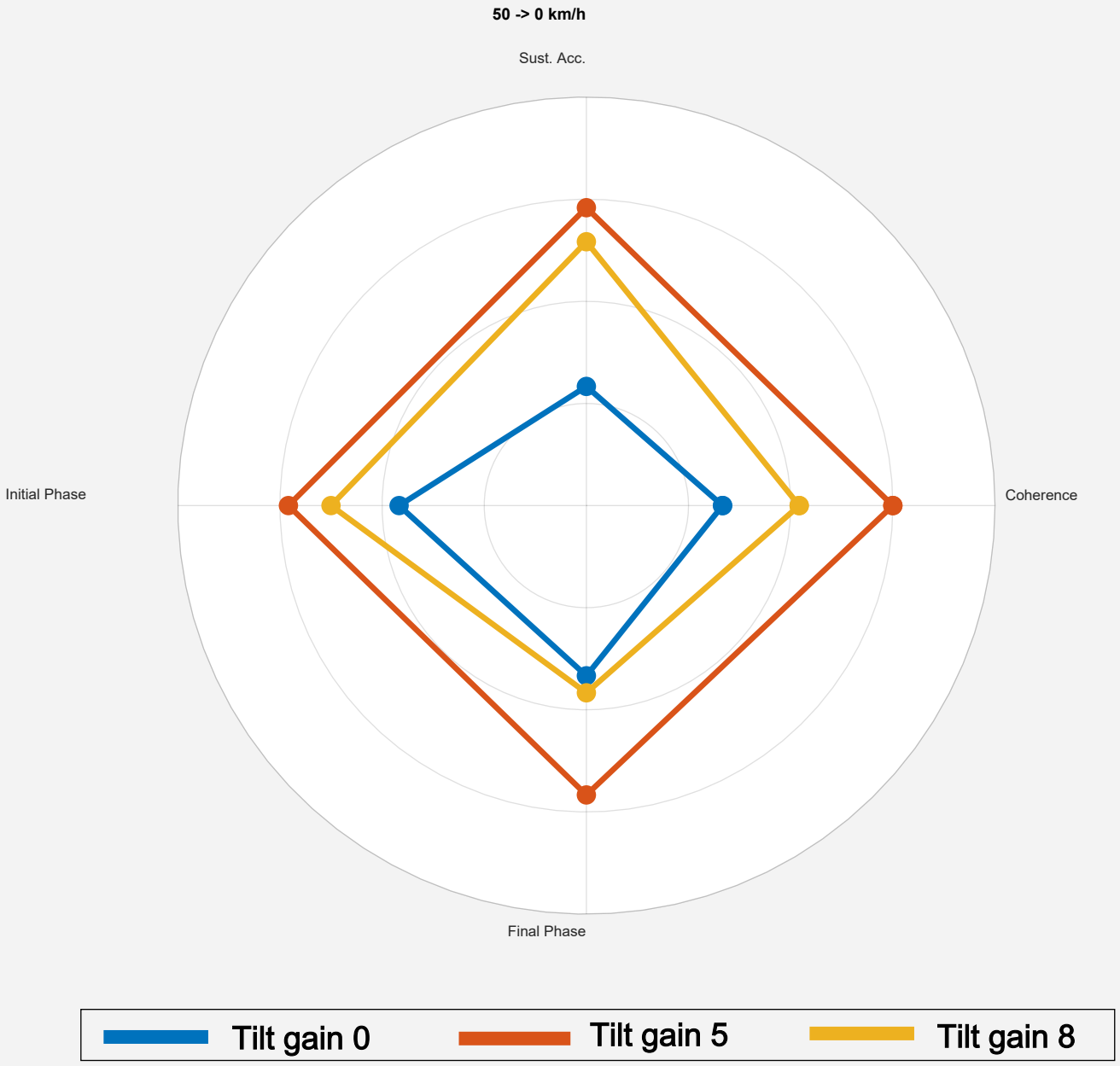
Tilt Gain 5 preferred



Braking from 50 to 0 km/h

- Main preference points are the sustained acceleration and the final phase
- Similar preference with Tilt Gain 8 in the initial part
- Tilt Gain 0 worst overall

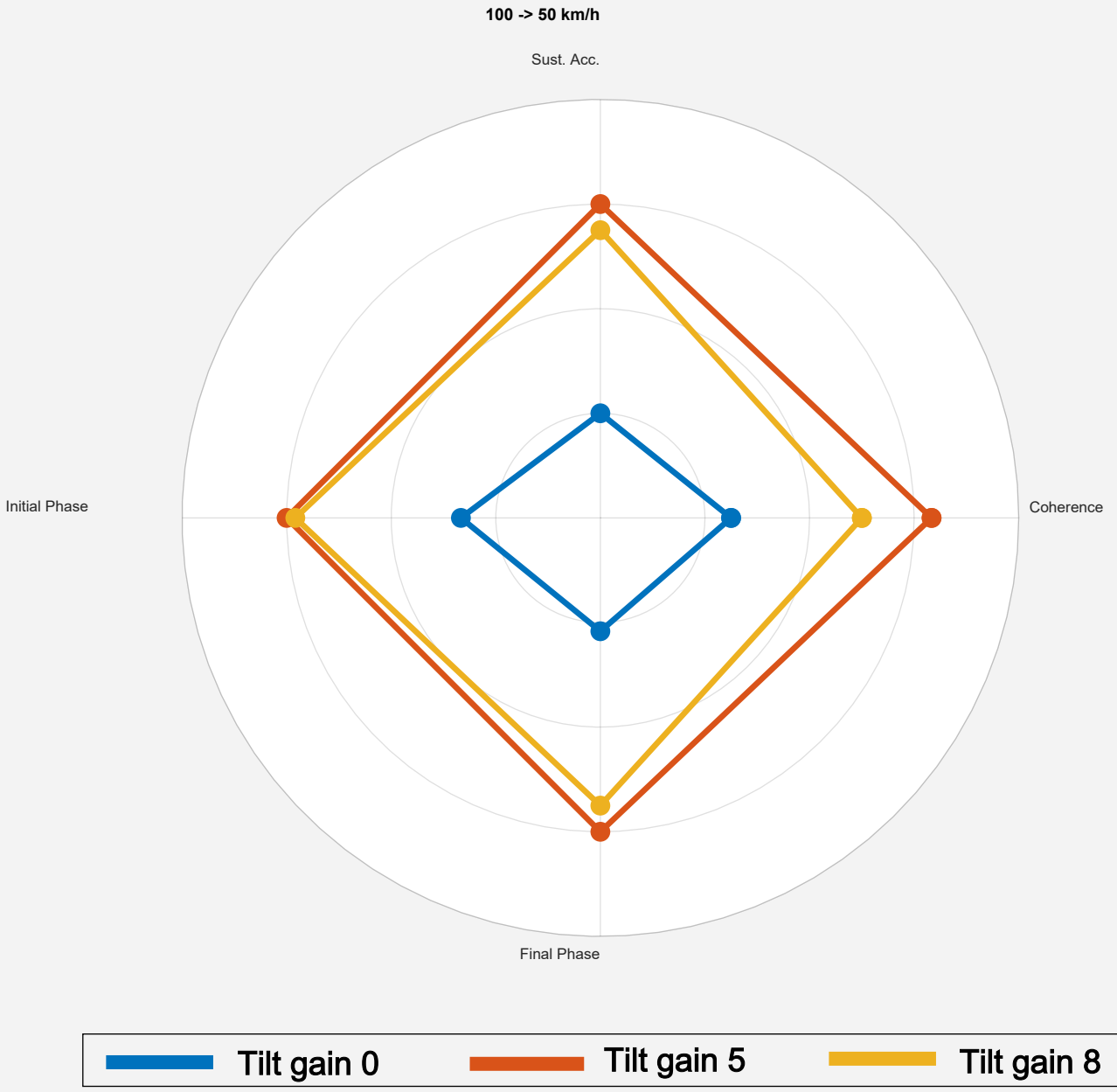
Tilt Gain 5 preferred



Braking from 100 to 50 km/h

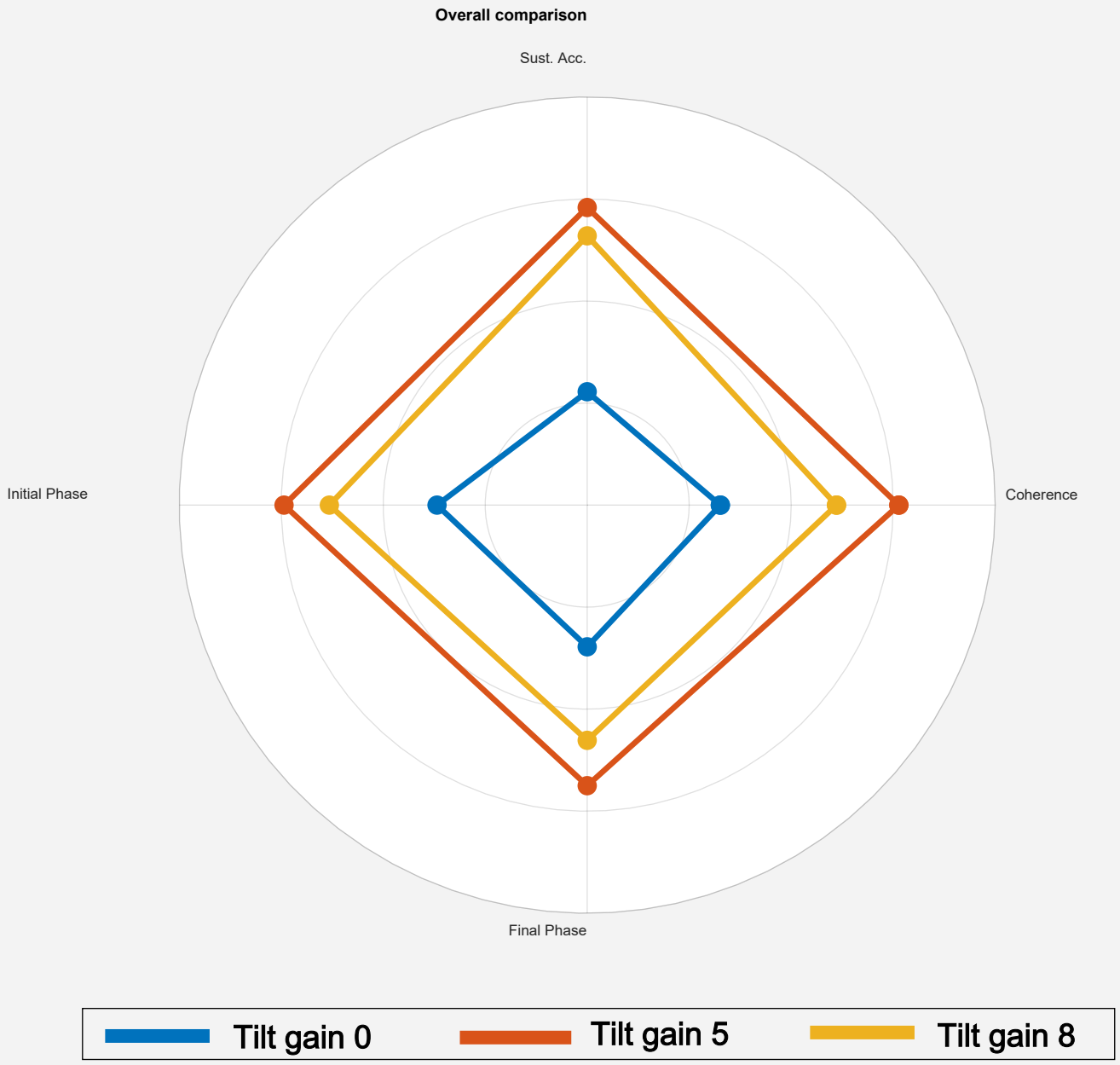
- Main preference points are the final phase and the general coherence
- Overall similar preferences for Tilt Gain 8
- Tilt Gain 0 worst overall

Tilt Gain 5 preferred



Global

Globally, the drivers preferred the **Tilt Gain 5** configuration, mostly because of the initial bite and the final phases of the maneouvres.



Conclusions

Tilt Gain 0

The feeling is a gentle acceleration/deceleration manoeuvre. Furthermore, the **initial bite is not perceived** .

Tilt Gain 5

The overall feeling is a **gentle manoeuvre** . The higher value of longitudinal gain makes the **initial bite closer to the target** with a better acceleration feeling onboard .

Tilt Gain 8

The drivers reported that with this configuration, the **sustained accleration feeling is enough** , but there is an **annoying sensation due to the high tilt rate in the transitions** .

Good Feelings

- Sustained longitudinal acceleration
- Initial bite of the maneouvre
- Final phase of the maneouvers

Bad Feelings

- A too high longitudinal tilt gain brings to an annoying sensation in the transitions → tilt rate thresholds to be carefully considered

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Thanks for your attention

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