



Comparison of Driver In-Vehicle **Technology Engagement** for Hands-On and Hands-Free Partial Driving Automation

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| Tesla Model 3 and Cadillac CT6 are L2 capable vehicles with different concepts for operation, driver monitoring functions, and physical HMI designs



2020 Tesla Model 3

Hands-on L2 System (Autopilot)

Torque-based Driver Monitoring

Single, Center Touch Screen Display

Smartphone Connectivity with Voice Commands

Steering Wheel Controls



2018 Cadillac CT6

Hands-free L2 System (Super Cruise)

Camera-based Driver Monitoring

Center Stack with Touch Screen Display and Physical Controls

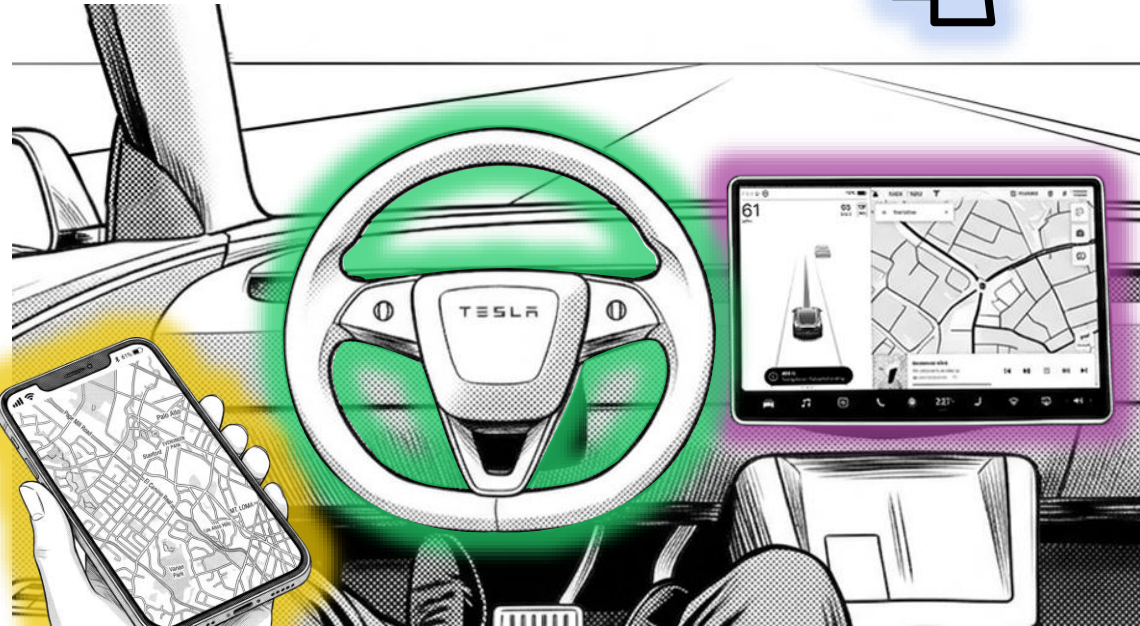
Smartphone Connectivity with Voice Commands

Steering Wheel Controls

| These vehicles are equipped with information-rich environments with infotainment, navigation, and communication interfaces

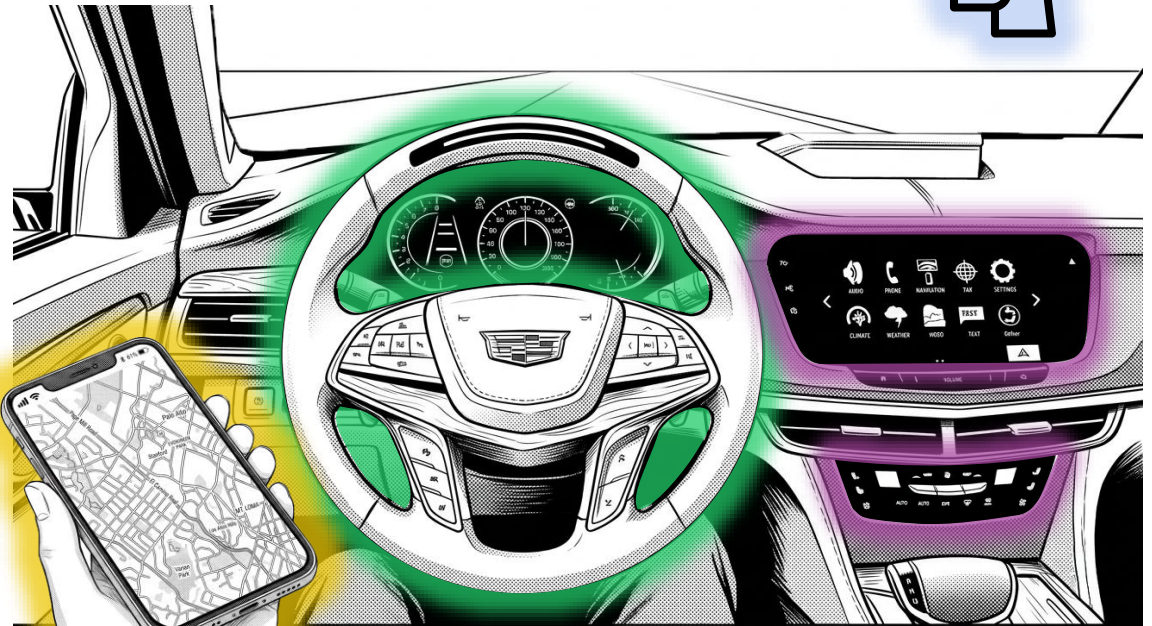
Center Screen/Stack

Cellphone



Steering Wheel Controls

Voice Controls



Methodology

Dataset

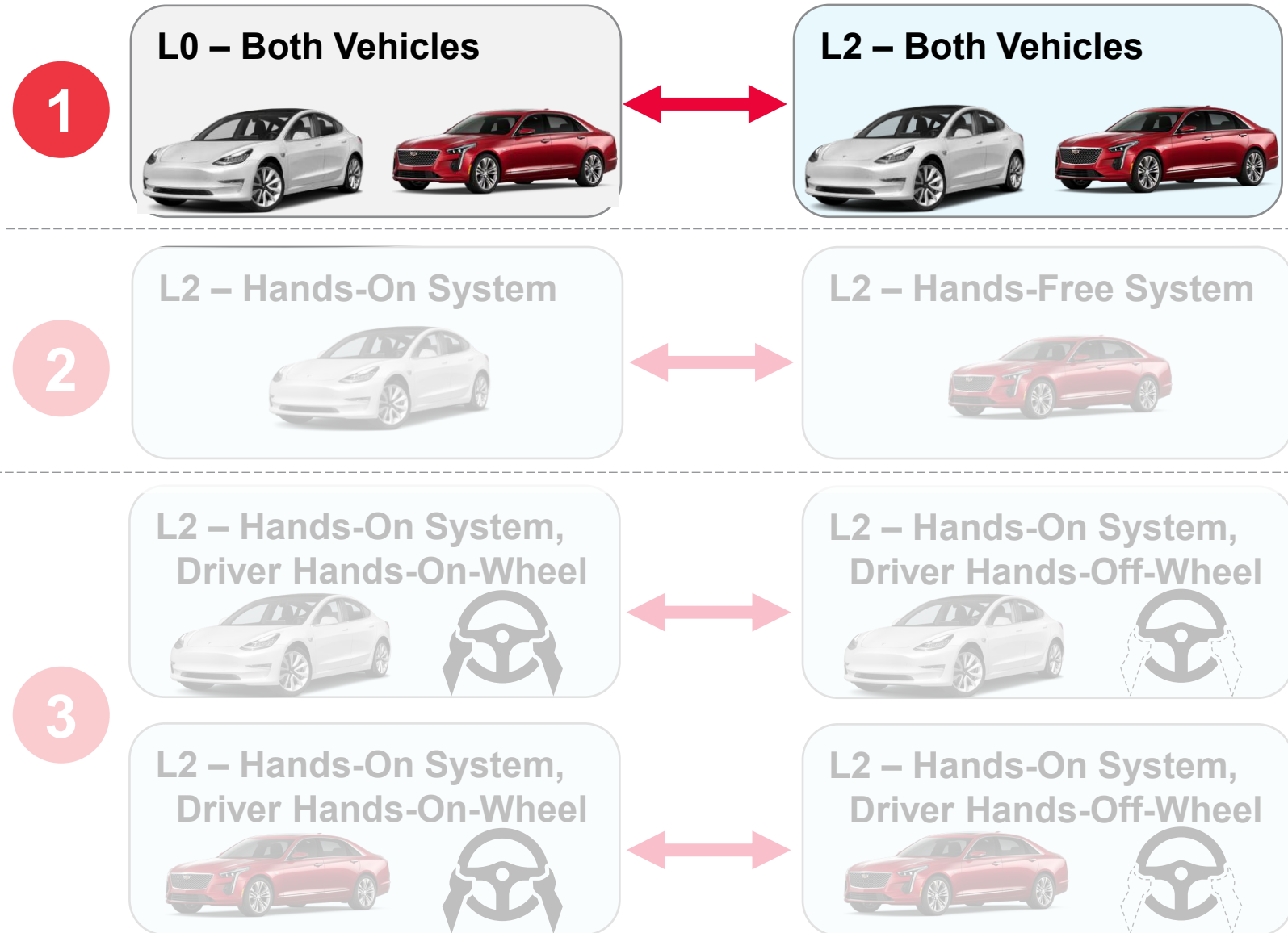
453 Trips (233 Tesla, 220 Cadillac)

31 Drivers (16 Tesla, 15 Cadillac)

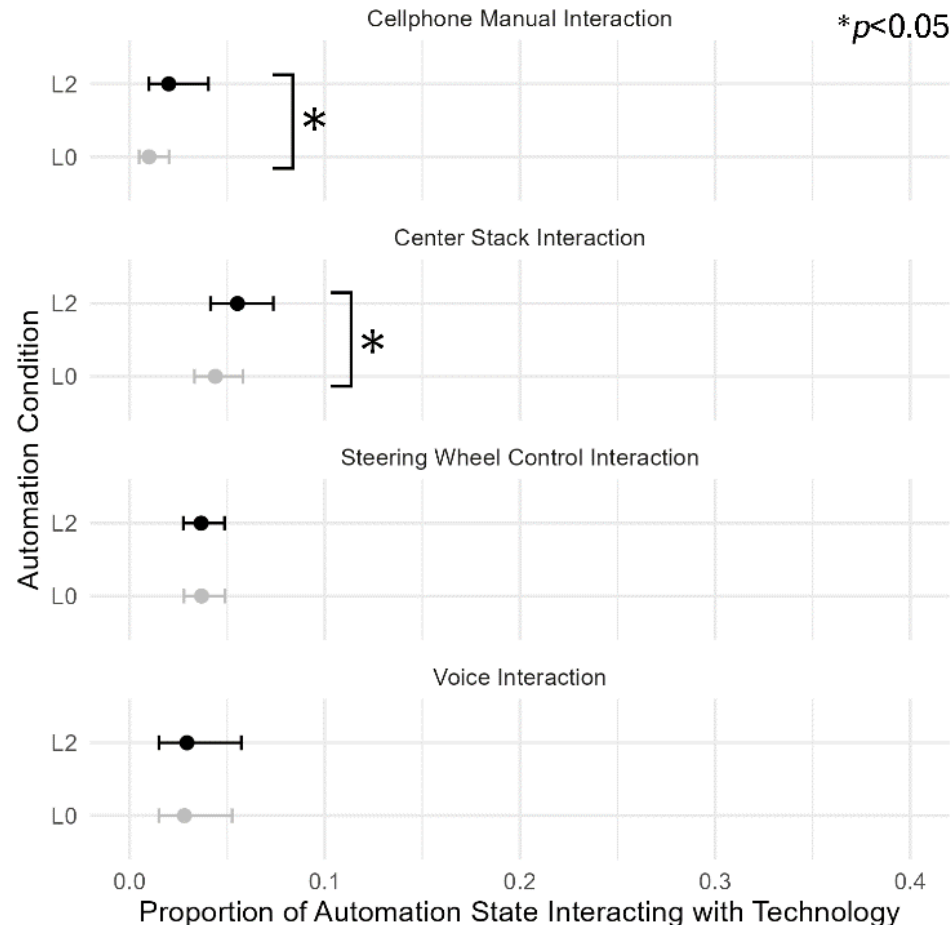
Motorway driving only

Analysis

- DVs → (1 & 2) Use prevalence, (3) Hands-on-wheel proportion
- IVs → (1) NDRT, (2) Vehicle, (3) NDRT & Vehicle
- Models → GLMM with a negative binomial link function



Drivers have more manual cellphone use and center stack interaction when using the L2 system than when driving manually



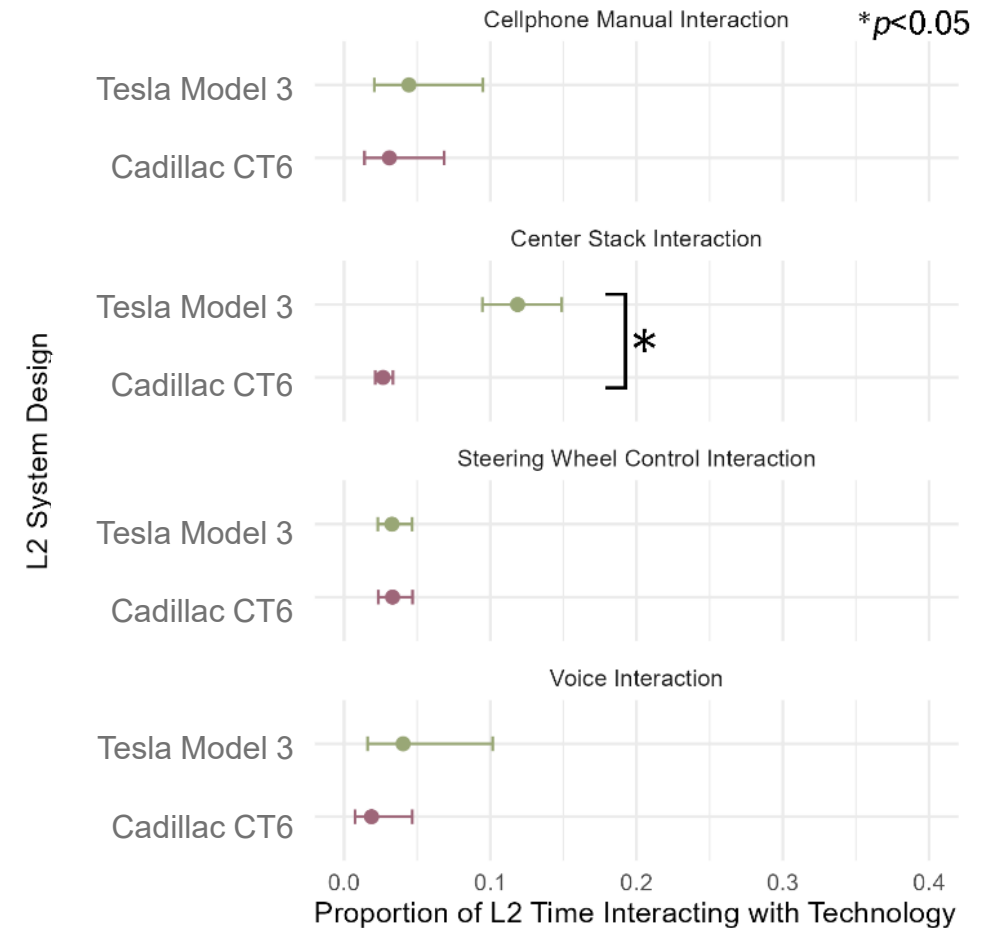
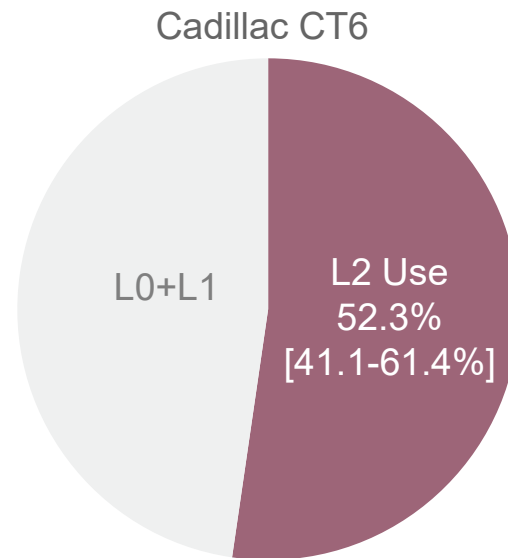
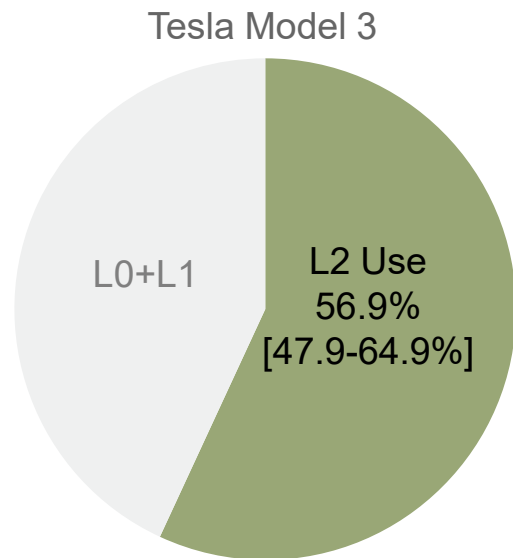
- Higher prevalence of **manual cellphone interaction** during automation use (OR = 2.01, CI_{95%} [1.11– 3.64])
- Higher prevalence of **center stack interaction** during automation use (OR = 1.26, CI_{95%}[1.01 – 1.57])
- Consistent with previous findings (Gershon et al., 2023; Noble et al., 2021)

Gershon, P., Zuby, D., Reagan, I., Schmidt, S., Lenné, M., Fitch, G., & Hernandez, M. (2023). *How Technology Can Help Reduce Driver Distraction*. National Distracted Driving Coalition. USNDDC.org

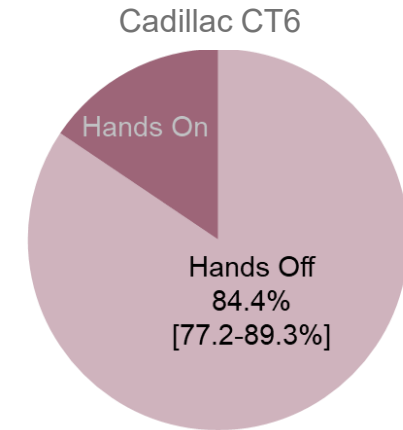
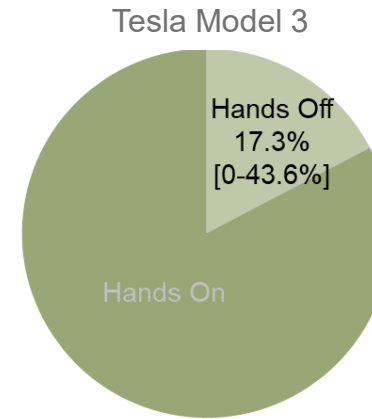
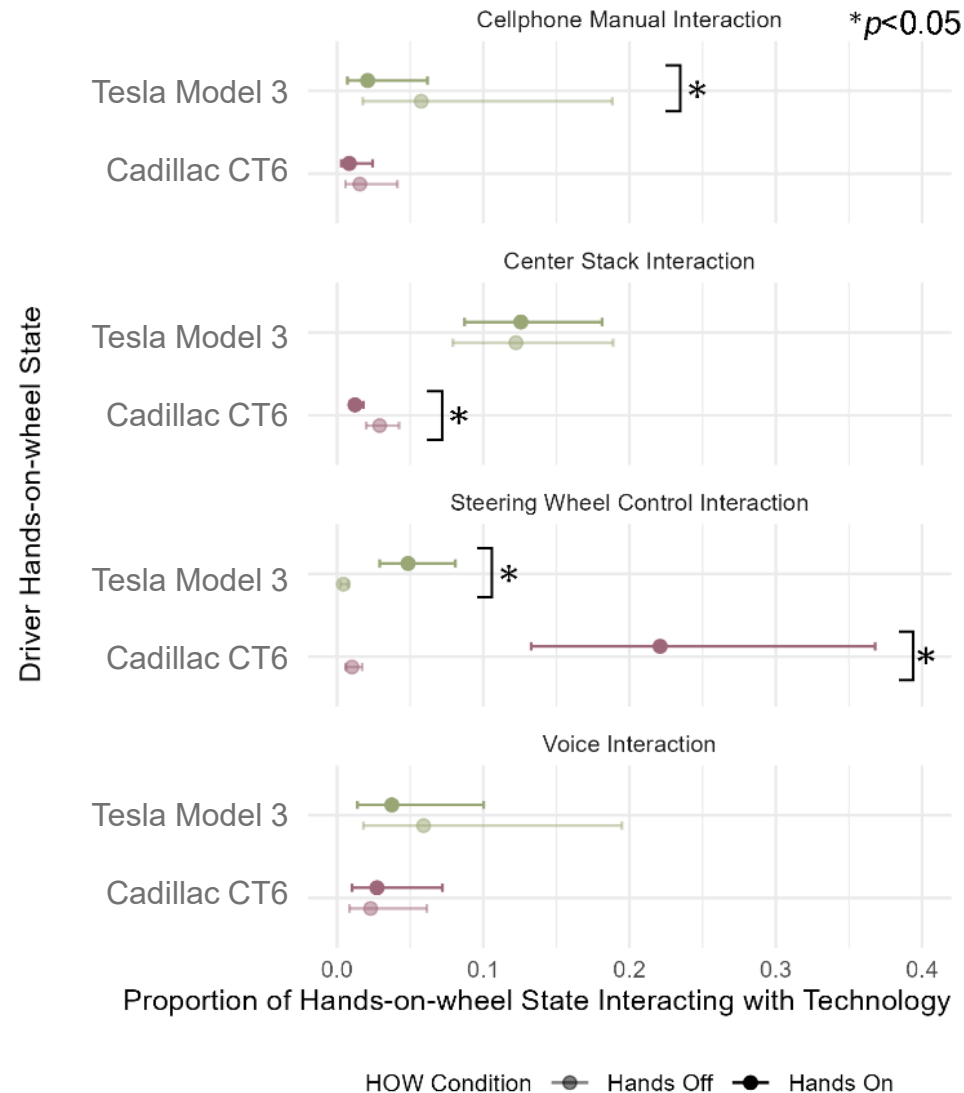
Noble, A. M., Miles, M., Perez, M. A., Guo, F., & Klauer, S. G. (2021). Evaluating driver eye glance behavior and secondary task engagement while using driving automation systems. *Accident Analysis & Prevention*, 151, 105959. <https://doi.org/10.1016/j.aap.2020.105959>

| Drivers using the Model 3 interacted with the center stack more than drivers using the CT6

- Autopilot was associated with a higher proportion of **center stack interaction** (OR = 4.45, CI_{95%}[3.30 – 6.01])
- Drivers of both vehicles used L2 automation in similar proportions

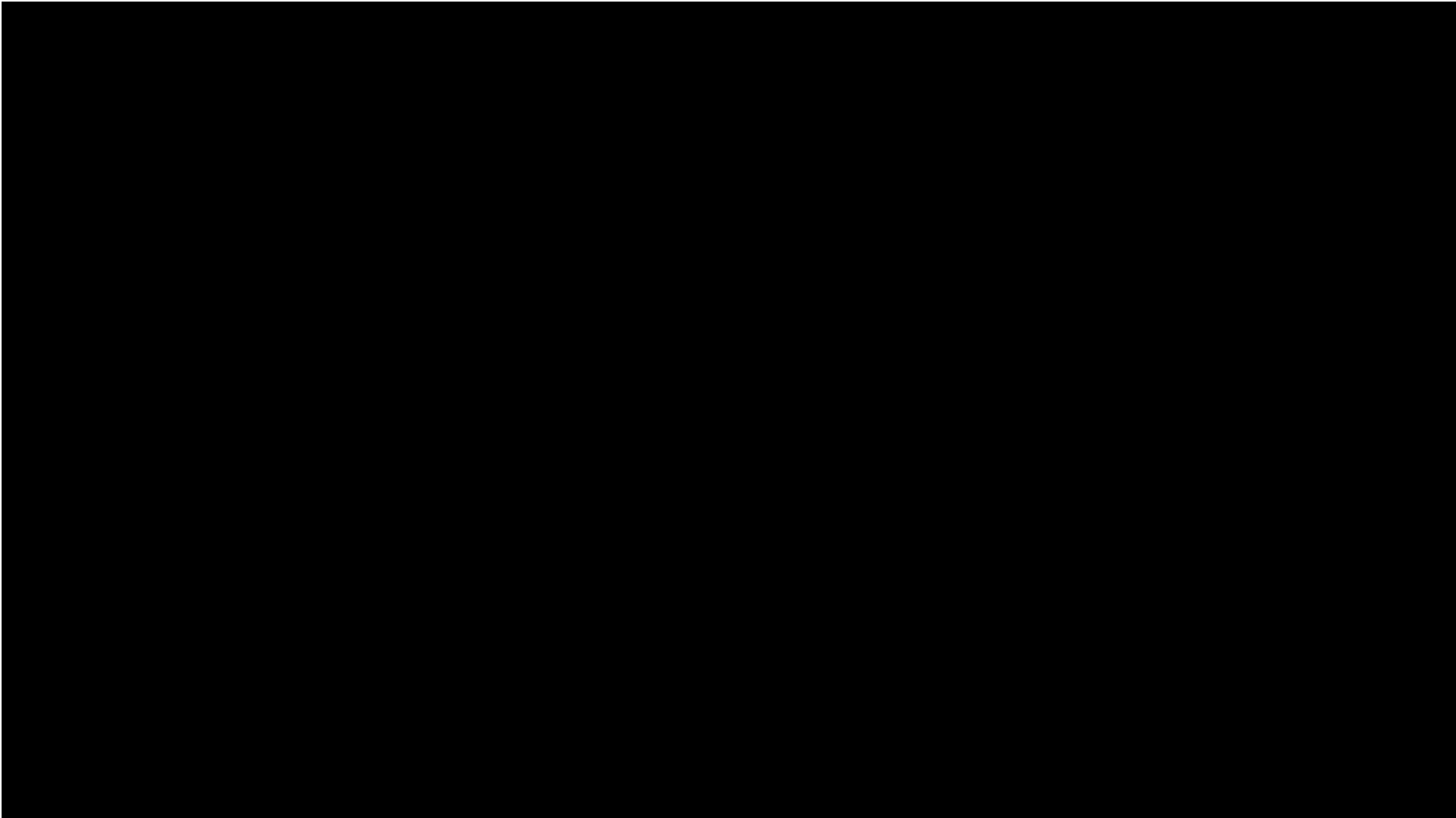


Drivers of each vehicle differentiate technology use by hands-on-wheel state



- Cadillac L2 system drivers had their hands off **84% of the time** while Tesla L2 system drivers had their hands off **17% of the time**
- **Manual cellphone interactions** were 2.75 times more prevalent for **Tesla** L2 drivers with their hands off ($CI_{95\%}$ [1.08–7.05], $p < 0.05$)
- **Center stack interactions** were 2.38 times more frequent while driving hands off with the **Cadillac** L2 system ($CI_{95\%}$ [1.53 – 3.72], $p < 0.001$)
- For both systems, **steering wheel control interactions** were more prevalent when drivers had hand(s) on the wheel (11.25 $CI_{95\%}$ [7.30 – 17.34], $p < 0.001$, and 21.70 $CI_{95\%}$ [15.55 – 30.27], $p < 0.001$)

- | Hands-on behavior is often associated with driving tasks unrelated to direct operation, or non-driving related tasks



| Conclusions

- L2 concept of operations (design), driver monitoring functions, and **in-cabin physical design** interact to shape driver hands behavior and technology use
 - Tesla Model 3 system had more interaction with the center screen compared to the Cadillac CT6 system
 - Tesla Model 3 drivers interacted more with the center stack and less with steering wheel controls
 - Tesla Model 3 manual cellphone use was more prevalent when drivers had no hands on the wheel
 - Cadillac CT6 had no difference between hands-on behavior
- Manual cellphone and center stack results are **consistent with previous findings** (Gershon et al., 2023; Noble et al., 2021)



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