

Driver distraction at roadway event boundaries



A simulator investigation within an event segmentation framework

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Driver distraction and the driving context

Driver distraction is a leading contributor to traffic crashes, intensified by the proliferation of in-vehicle digital systems.

Existing distraction-detection systems predominantly rely on driver-specific metrics while overlooking the broader **driving context**.

This can lead to false positives, missed warnings, or delays, ultimately reducing system effectiveness.

Fasanmade, 2021; Michelaraki et al., 2023; Regan et al., 2008; Ayas et al., 2026; Sathyanarayana et al., 2011; Mohammed, 2019

Addressing driver distraction

Behavioral change through the “three Es” alongside technology adoption

Enactment

Enforcement

Education

Driver Monitoring Systems (DMS) provide real-time alerts to mitigate distraction-related incidents.

Qi et al., 2020; Scanlon et al., 2017; Masello et al., 2023

Addressing driver distraction

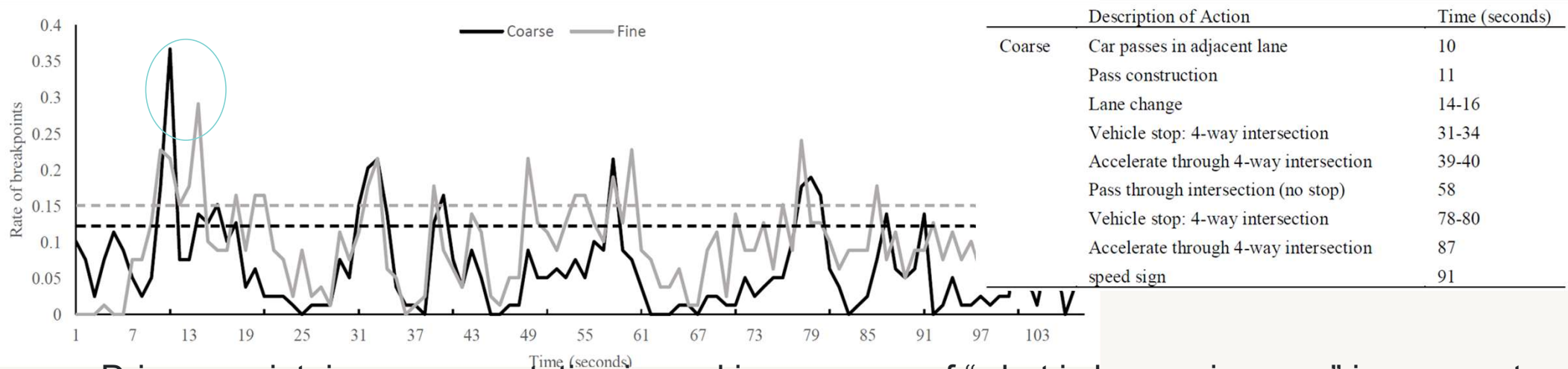
Guided by the EST framework, we investigated how pre-designed roadway characteristics influence drivers' engagement with smartphone-related secondary tasks on the tactical and control levels.

Aimed to inform intelligent DMSs combining driver mental state and roadway context for selective, context-sensitive alerts.

Postulated - greater smartphone interference near event boundaries, where replacing the “old” driving-setting model with an “new” one requires more attentional resources.

EST & Attention - in brief

Event boundaries definition: The bottom-up approach

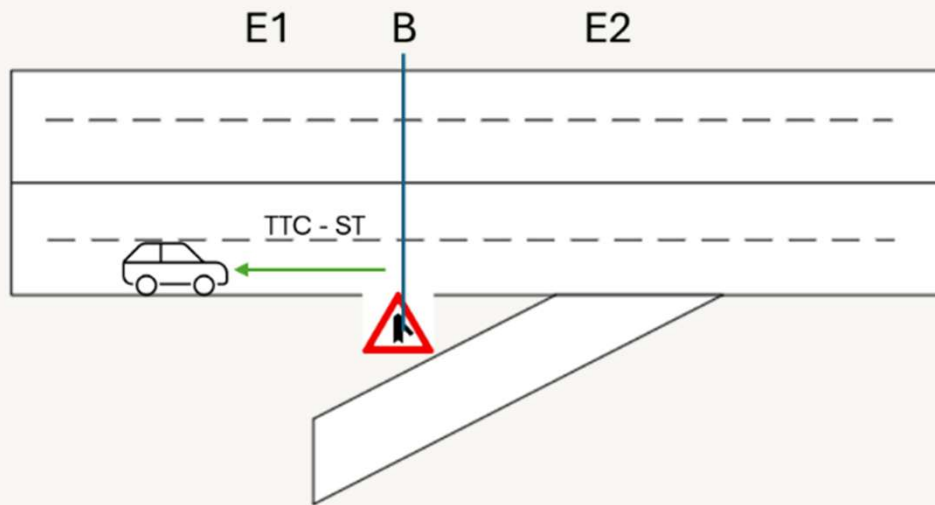


- Drivers maintain a representation in working memory of “what is happening now” in an event model, which facilitates predictions of the near future.
- When prediction errors spikes, the **old event model** is cleared from WM, a **new model** is generated and observers perceive an event boundary >> **where distraction is most harmful.**
- In this way, event segmentation regulates processing resources over time and can be thought of as a form of **attentional control**

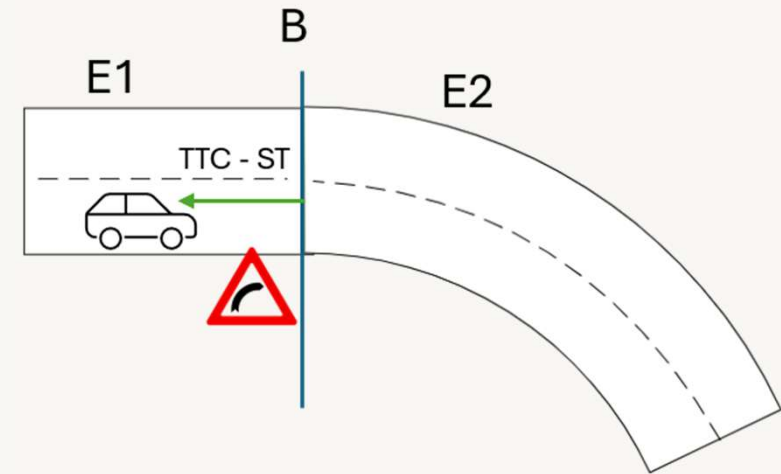
Sall, R. J., Wagner, R. B., & Feng, J. (2019, November). Drivers' Perceptions of Events: Implications for Theory and Practice. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* (Vol. 63, No. 1, pp. 1996-2000)

Smith, M. E., Hall, C. S., Membreno, R., Quintero, D., & Zacks, J. M. (2024). Attention to event segmentation improves memory in young adults: A lifespan study. *Psychology and aging*, 39(7), 750.

Event boundaries: The top-down approach (road geometry)



Right-merging road

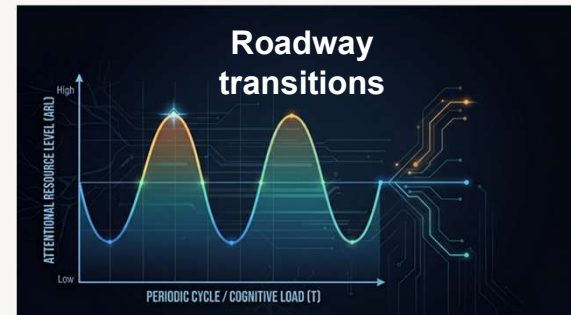


Sharp right curve

Predefined transitions provide a testable operationalization of roadway context

B = boundary; E1/E2 = events; TTC = time to collision; ST = secondary task

The proposed attentional mechanism



Roadway transition

Existing event-model should be replaced with a new model

Smartphone task

Visual-manual engagement

Concurrent attentional demands

Driving performance and task regulation

Study hypothesis: close timing may increase interference. Dashed links denote proposed mechanisms.

Experimental manipulation of request timing

21 drivers

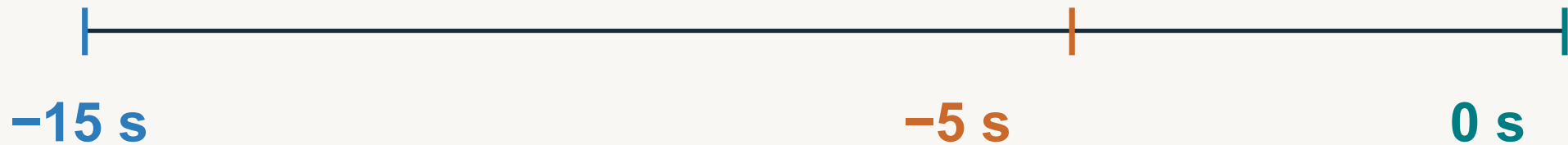
7 per condition

4 scenarios

Far request

Near request

Boundary



Control participants completed the 4 scenarios without a secondary task

Ages 25-29 years; driver's license held for at least five years; counterbalanced scenario order

RTI Driving Simulator at BGU



165° field of view and simultaneous driver-roadway video

Simulator vehicle, interior smartphone mount, and dual-camera (internal-external) position

Scenarios and smartphone-task presentation



Four road-related boundaries

- Straight to curve
- A merging road
- Narrowing lanes
- Rural to Commercial

4 Visual-manual tasks: 2 calling a number, 2 reading a short text in WhatsApp and replying with an icon.

Example task prompt and road merge from the right warning sign (cue of boundary) - presented on the simulator screen

Driving performance and secondary-task management measurements

Driving performance (based on dual camera video recordings)

Binary variables:

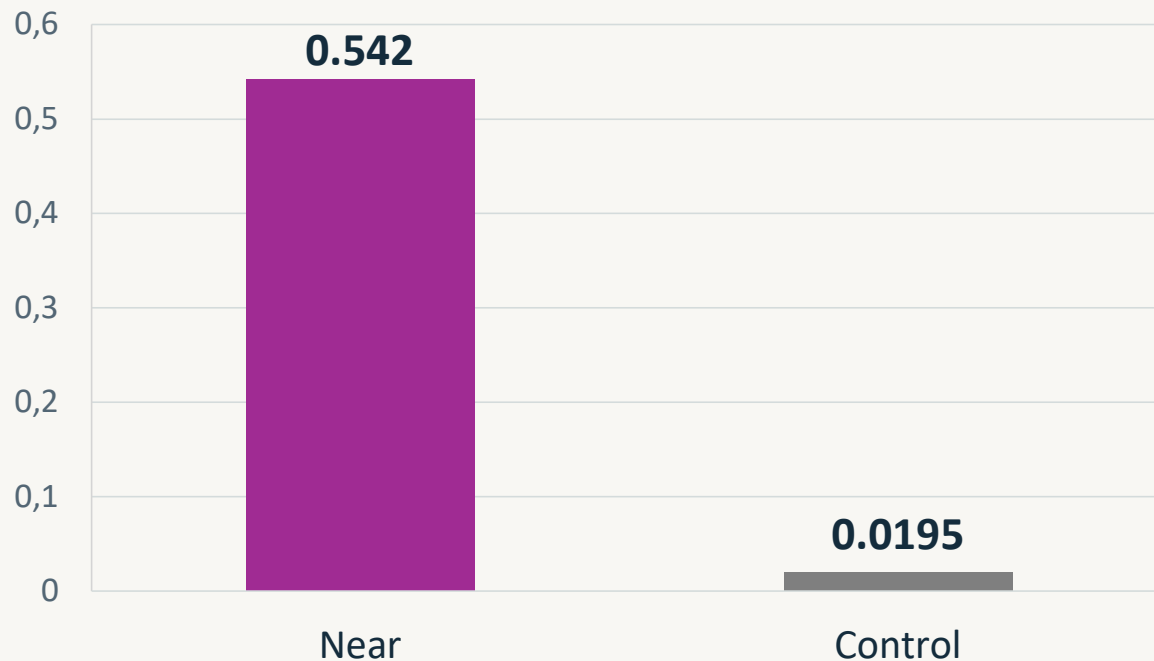
- Abrupt braking
- Lane departure
- Lane centering

Secondary Task management

- Completion duration
- Postponement of initiation

GLMM framework; Tukey pairwise comparisons

Abrupt braking: near requests versus control



0.542 (0.105)
Near condition

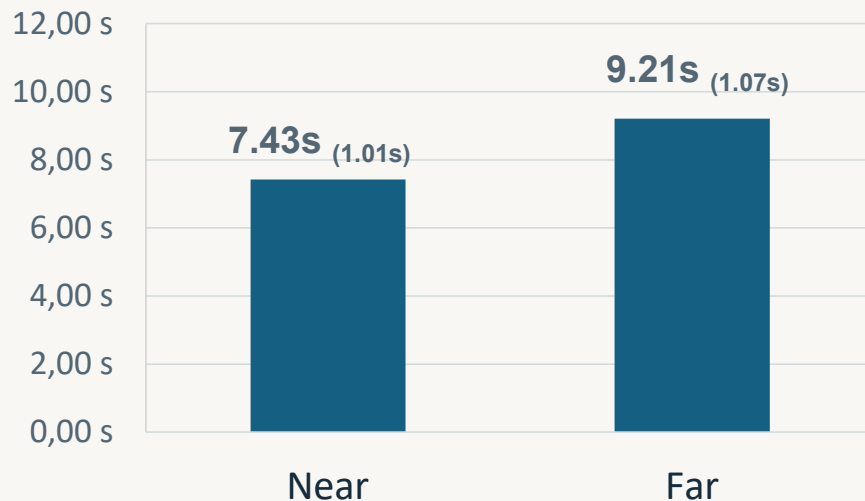
0.0195 (0.002)
Control condition

No statistically significant near-far difference was reported

Model-estimated probabilities of a sudden brake. GLMM framework; Tukey pairwise comparisons

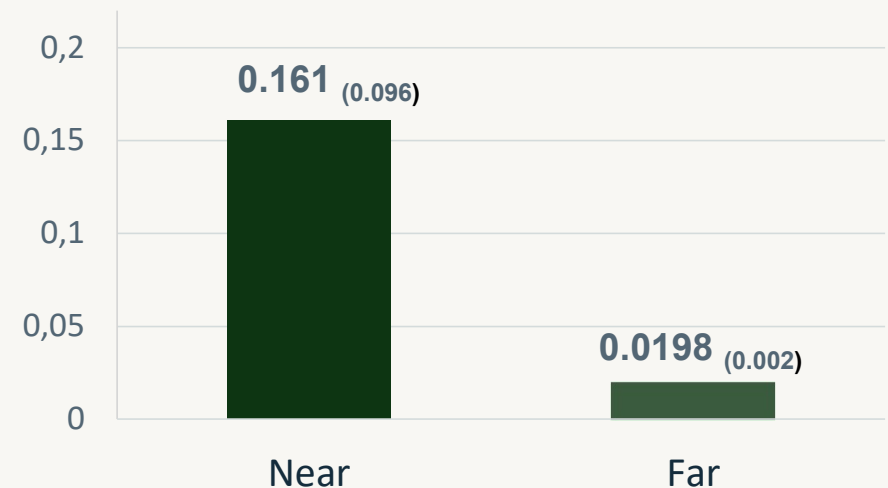
Estimated patterns in secondary-task management

Task duration



Longer estimated duration
in the far condition

Task postponement



Higher estimated probability to
postpone the engagement
in the near condition

GLMM framework; Tukey pairwise comparisons

Descriptive braking profiles in the merging scenario

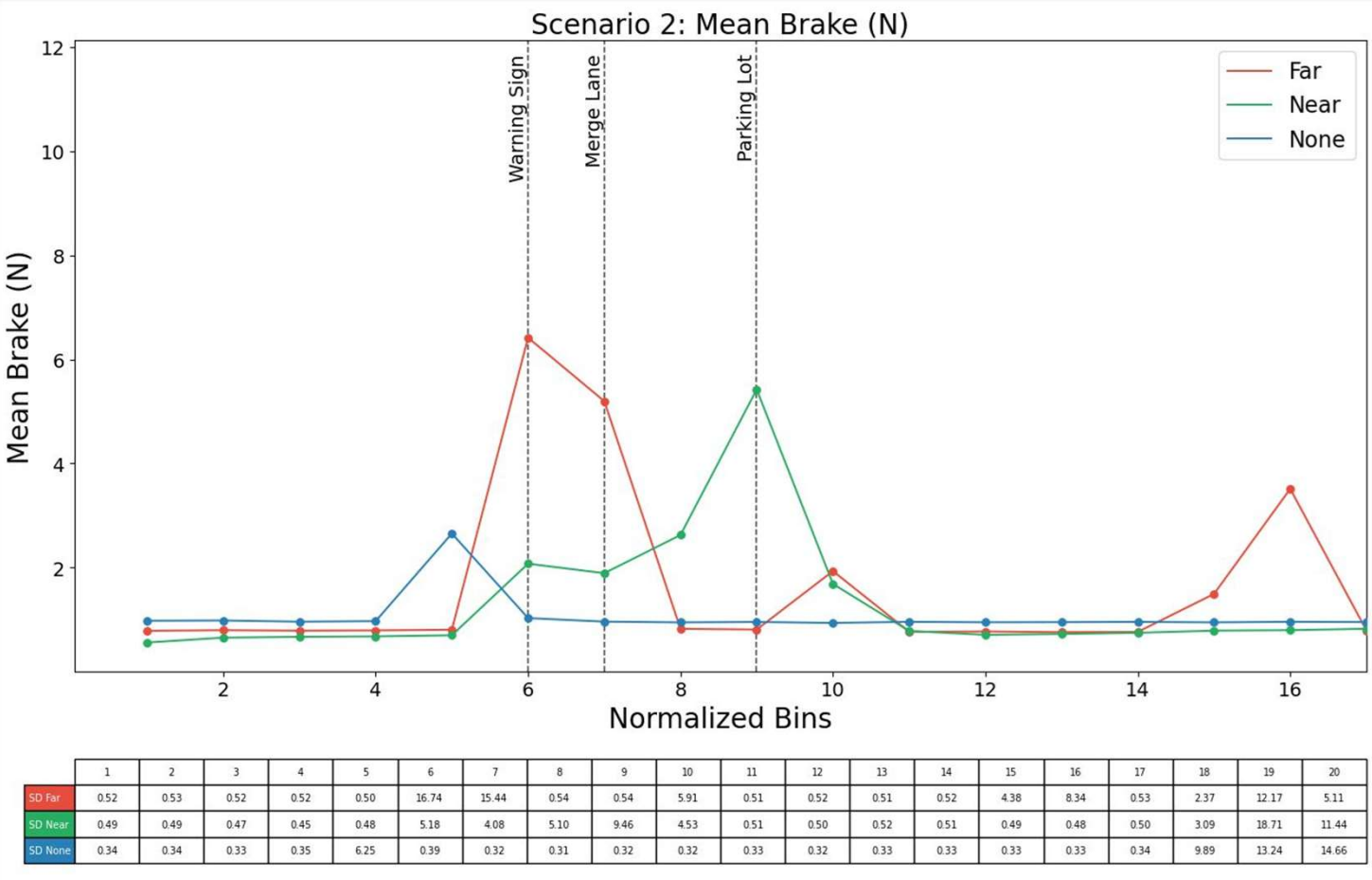


Figure 4. Illustration of the braking behavior analysis in the right-merging road scenario

Discussion

- This study used the EST framework to examine the effects of the timing of distraction on drivers' performance
- Our assumption was that when distractions are near the boundary, where attentional demands momentarily increase, a greater interference to driving performance will occur
- The findings show that drivers who were asked to engage with a secondary task **closer** to the boundary, tended to postpone their engagement to after the boundary. This strategy is consistent with Schömig & Metz (2013) model's tactical level.
- For those who decided to engage close to the boundary it resulted in a higher probability of initiating an abrupt break. (control leve, Schömig & Metz, 2013)
- Participants in the **far** condition, had enough time before the boundary to engage with the secondary task, but the total duration of engagement was longer than the near condition, assumingly because these drivers had to handle the boundary while engaging with the secondary task.

Limitations and scope of inference

Sample and setting

Only 7 students per experimental condition

Only 4 driving scenarios

Limited types of secondary tasks

Theoretical measurement

Top-down candidate boundaries

No direct prediction-error measure

No validated attentional mechanism

Scenario-specific tasks constrain separation of secondary task and context effects

Driver monitoring accuracy, false alarms, trust, and crash outcomes were not tested

Future research: testing the theoretical mechanism

Candidate road transitions

Validate where drivers perceive event boundaries (bottom-up)

Proposed attentional mechanism

Assess how drivers update their understanding of the driving situation while dividing attention

Then evaluate whether roadway context improves driver-monitoring alert timing

Larger and more diverse samples; explicit boundary validation; direct evaluation of proposed applications

Conclusions

A theory-guided approach to roadway context and distraction

Roadway context warrants consideration in the study of secondary-task engagement.

EST informed the selection of candidate road transitions.

Context-sensitive driver monitoring requires direct evaluation.

Incorporating context-aware information is a critical step toward advancing intelligent, adaptive driver support systems for robust distraction detection.

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