

Effectiveness of Warning Systems

Timing, Intensity, and False Alarms

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Background

Early warnings can support the driver by increasing alertness and conveying safety-relevant information.

However, warnings may also annoy, distract or startle the driver when poorly designed. False alarms may cause inappropriate responses.

Design

Driving Simulator (n=54)

Intensity (within)

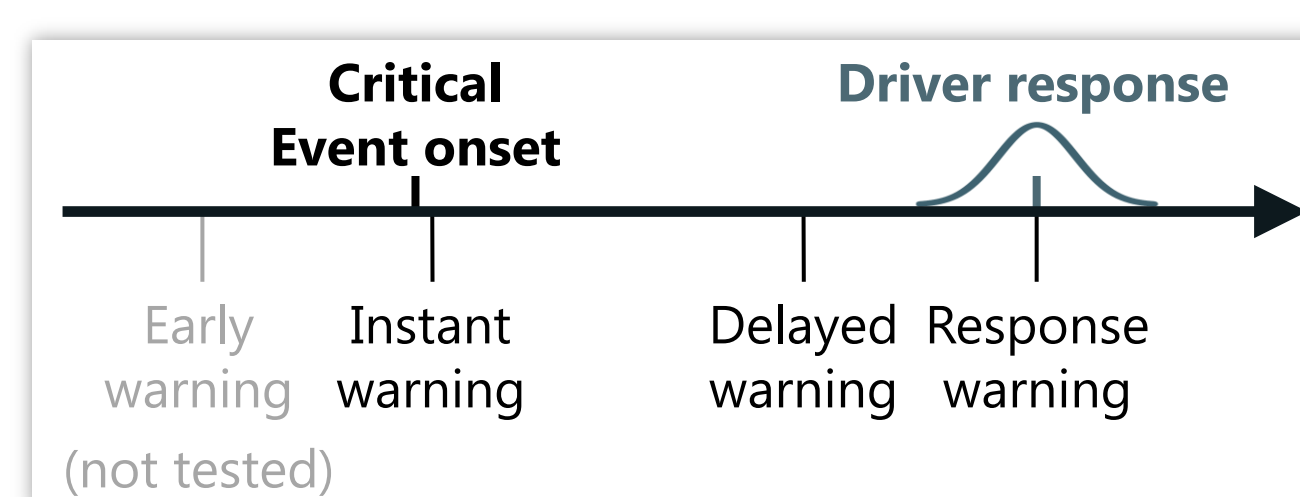
- High: 85 dB(A) fast onset
- Low: 77 dB(A) slow onset
- None: Control
- False alarm: 85 dB(A) fast onset

Timing (between)

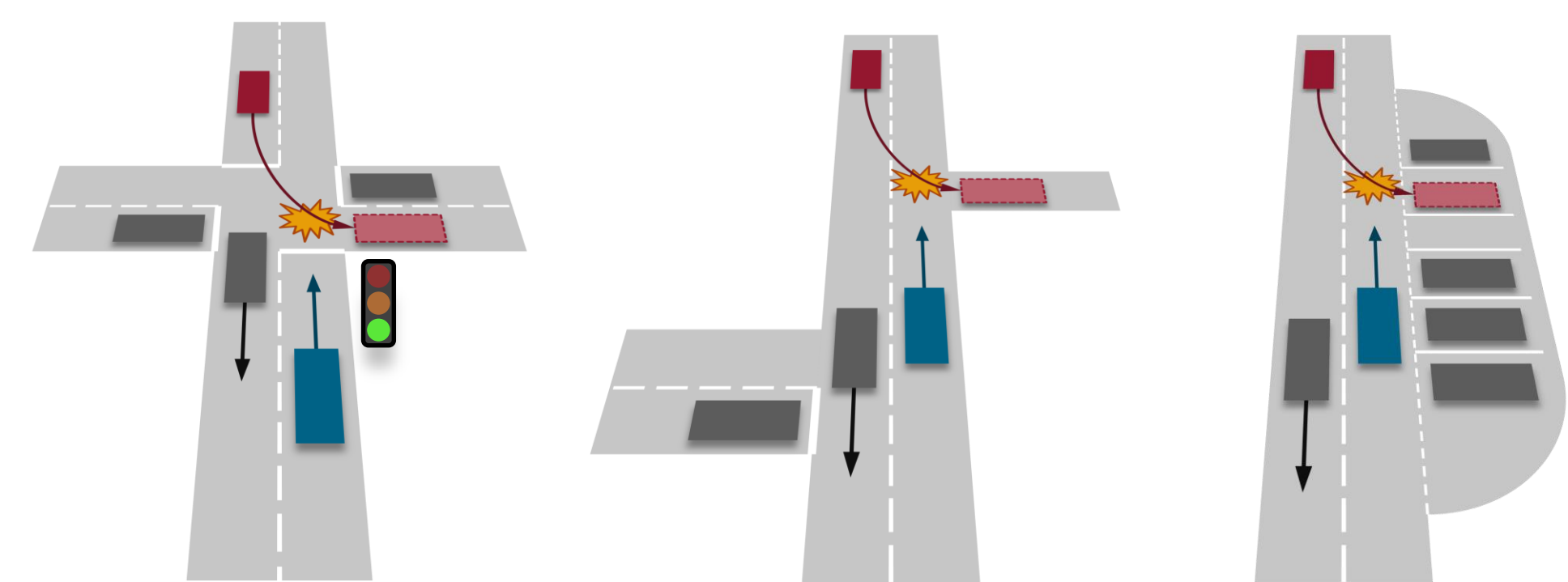
- Instant: 50 ms after event onset
- Delayed: 450 ms after event onset
- Response: At accelerator release

Measurements

- Response times
- Reduced velocity
- Gaze direction
- Subjective rating

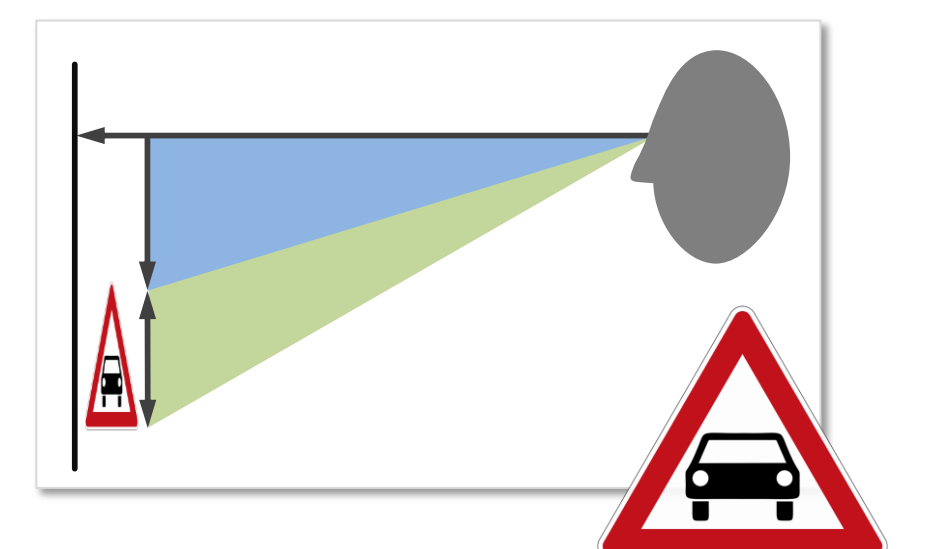
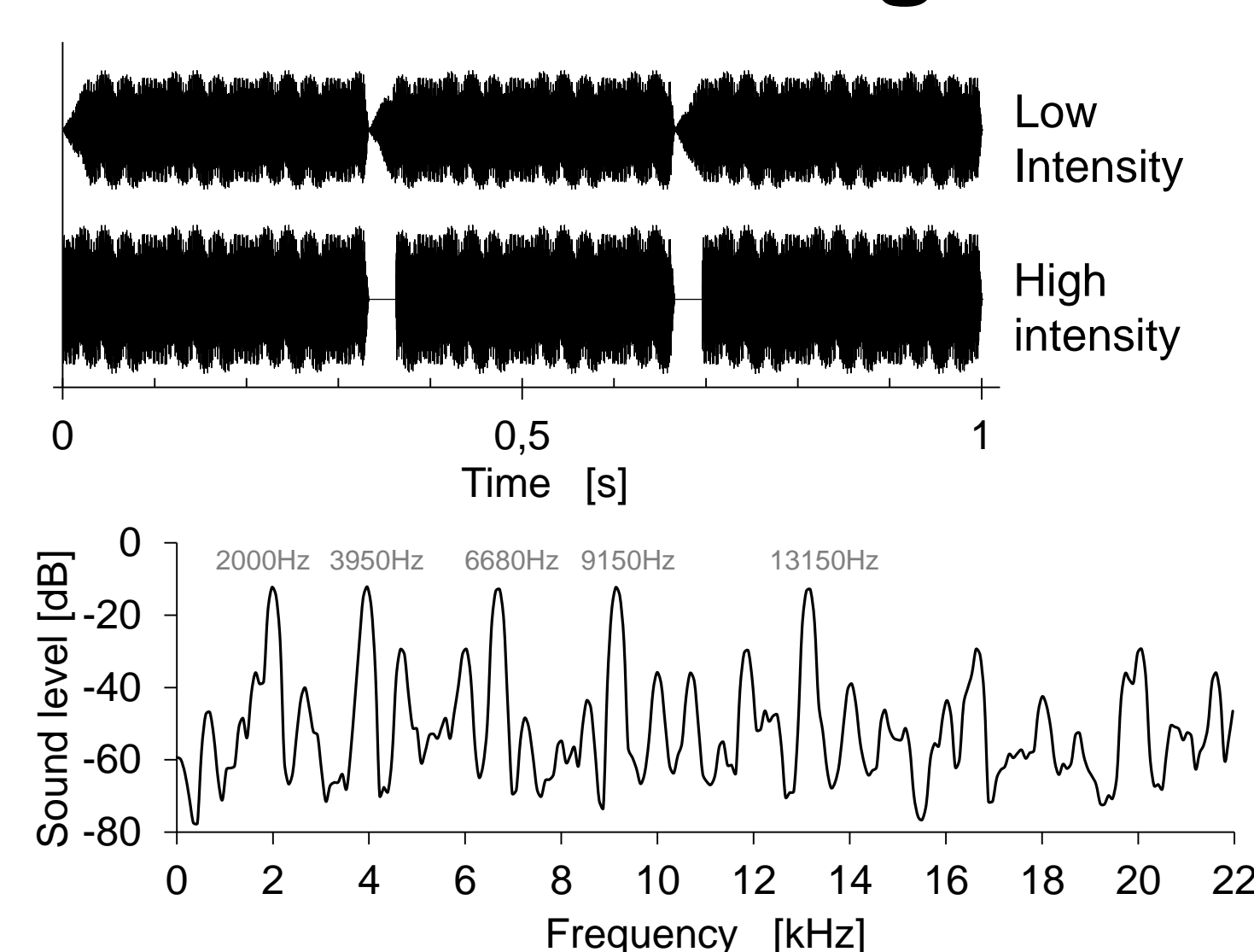


Critical events

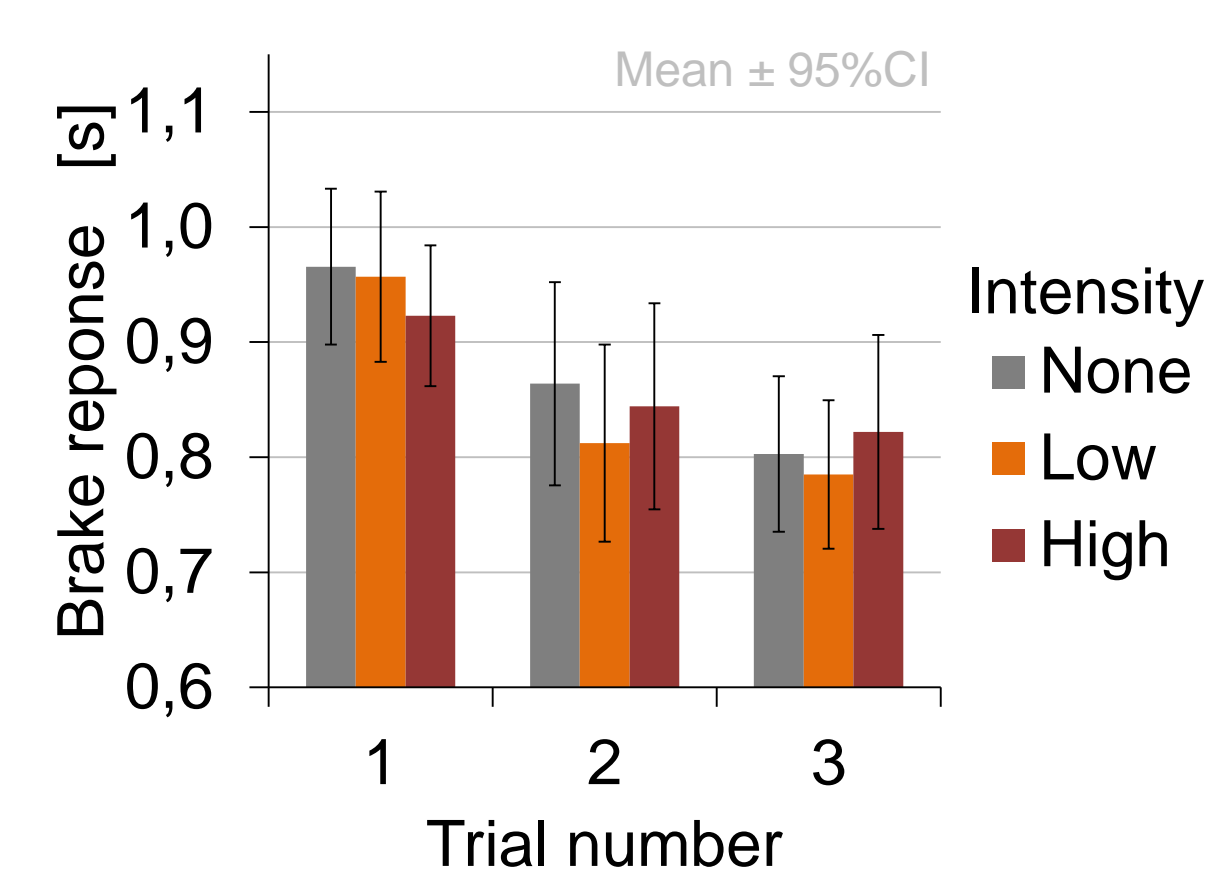


➤ 3 Events per driver + 1 false alarm

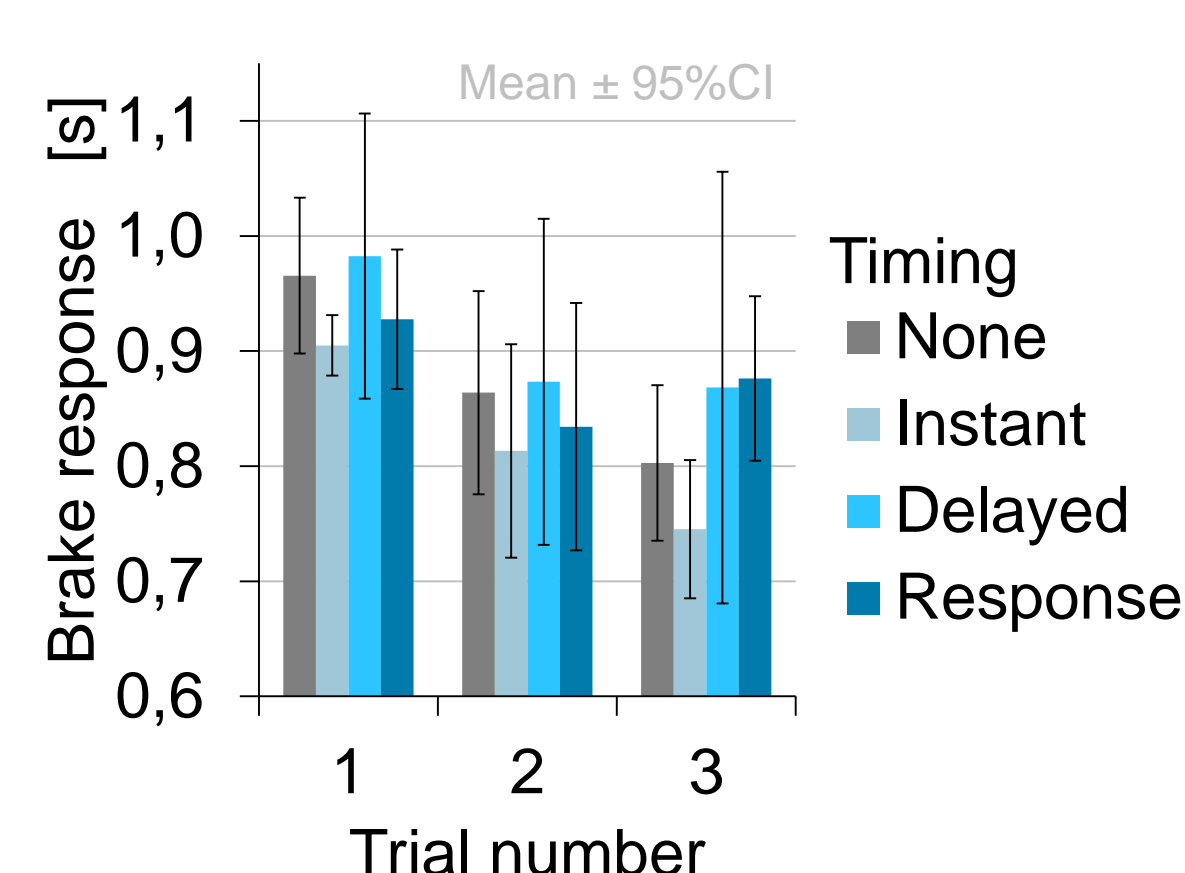
Bimodal warning



Driver response



Intensity: $F_{2,140}=0.4, p=.672$
Expectancy: $F_{2,140}=13.3, p<.001$

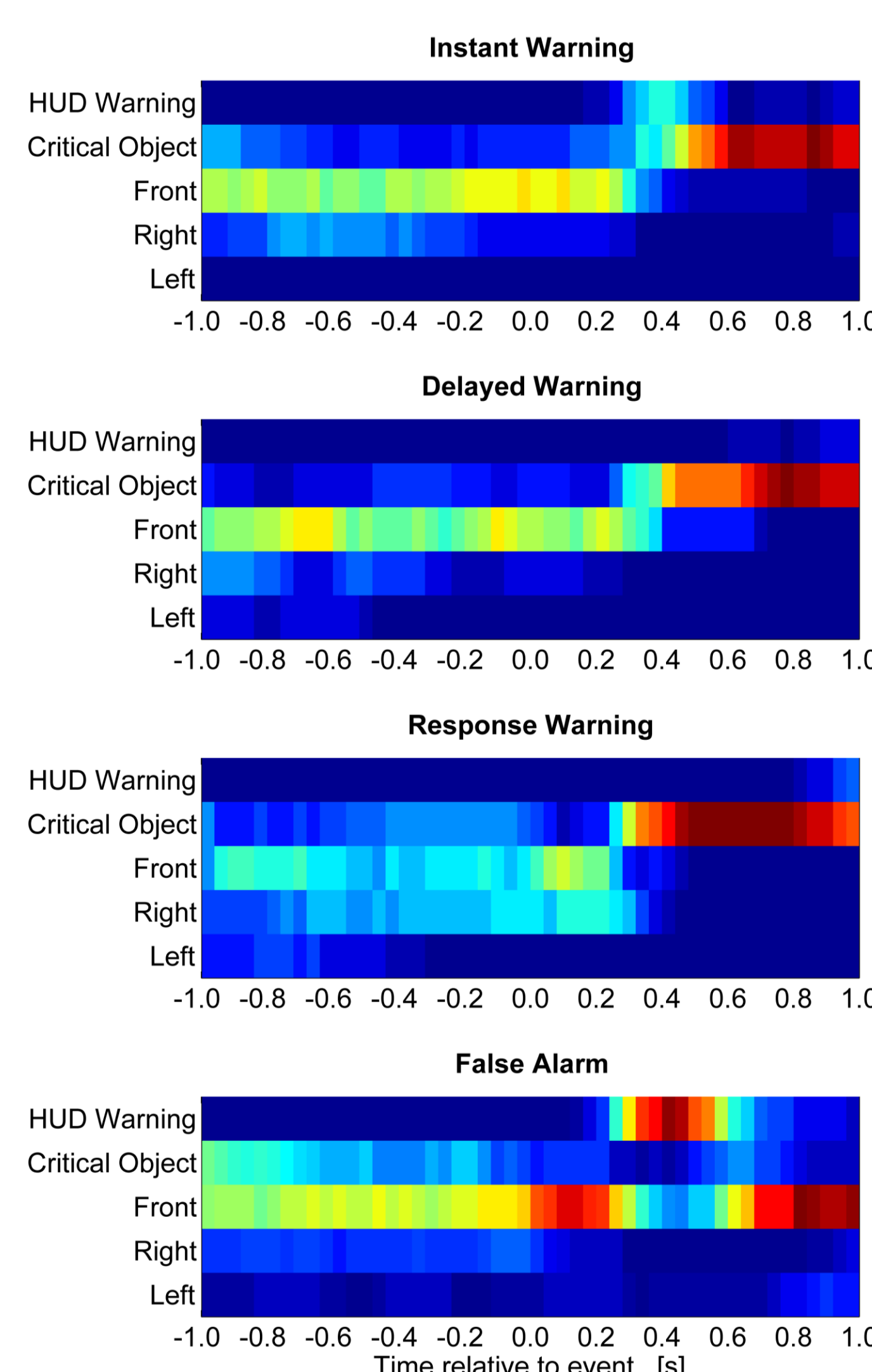


Timing: $F_{3,137}=2.3, p=.084$
Expectancy: $F_{2,137}=9.0, p<.001$

Distraction and False Alarm

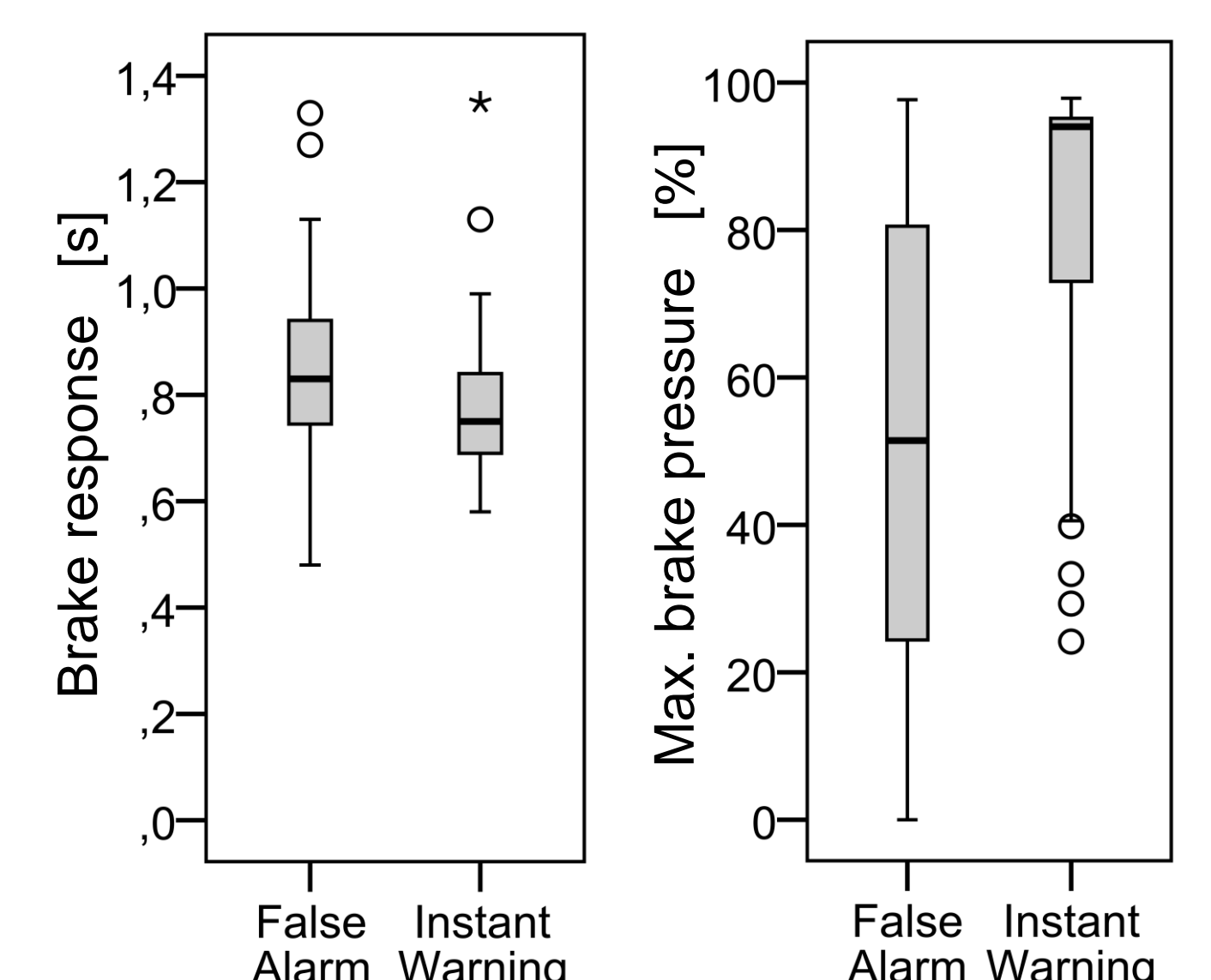
Instant warning: 40% of cases HUD was focused prior to critical object

➤ Resulted in 60 ms slower brakes and 2km/h less speed reduction



False Alarm:

- 5% looked at critical object
- 75% looked at HUD warning
- 75% show brake response partly similar to instant warning

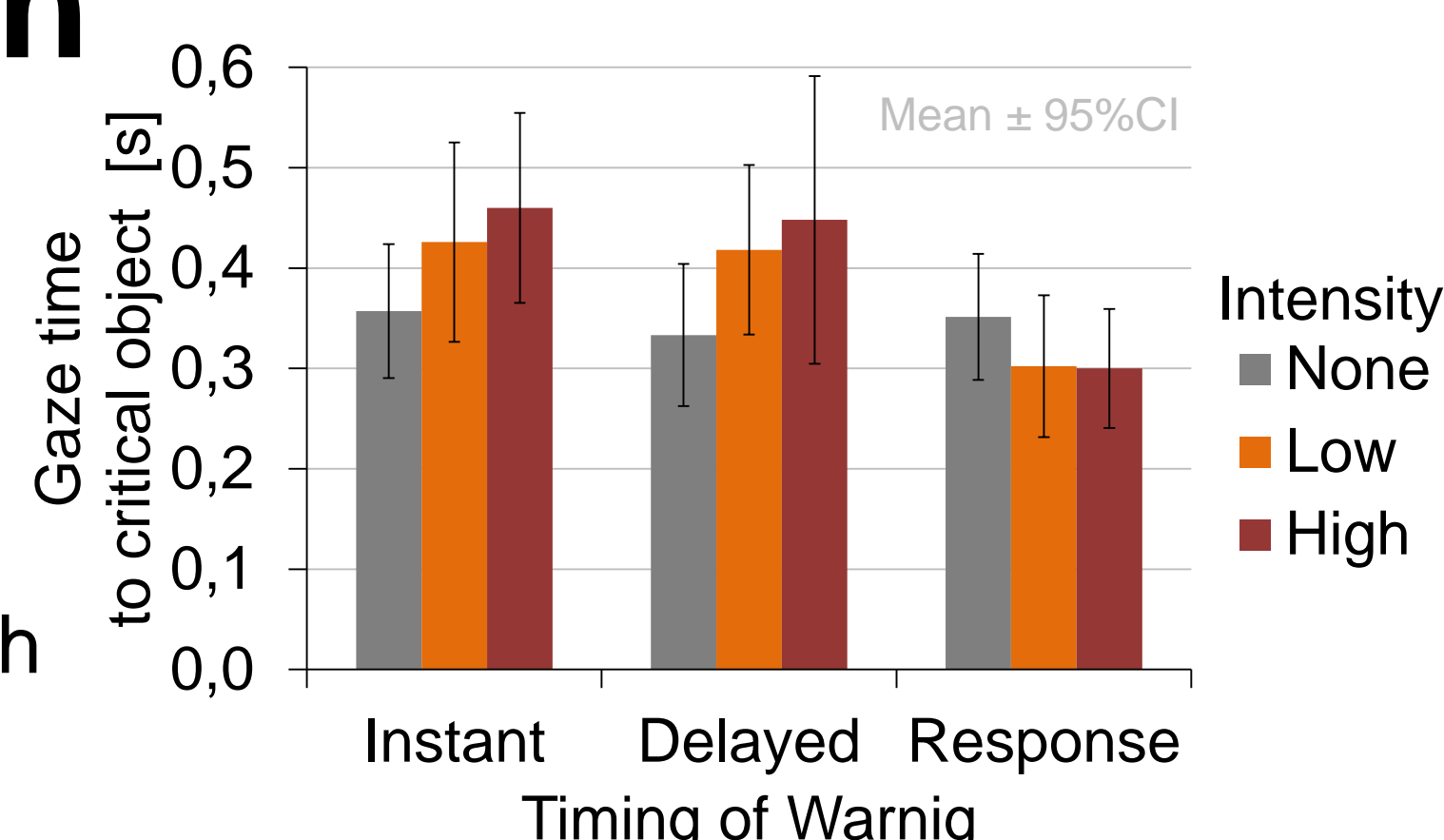


Object detection

No expectancy effect

Timing: $F_{3,104}=5.7, p=.001$

No main effect of intensity
post-hoc: None faster than High



Summary

- Instant warning induced only small improvements compared to control. Later warnings showed no improvement.
- Instant and delayed warning induced slower gaze times to the critical object compared to control. With instant warning in 40% of the cases the HUD was focused before the actual hazard.

- 75% of the drivers respond to false alarms without looking at the actual hazard.
- Until technology improves (sensor range, Car2X) warnings should be considered only in slowly evolving situations where an early warning (>1 second) is realizable.