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

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_{3,140}=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.