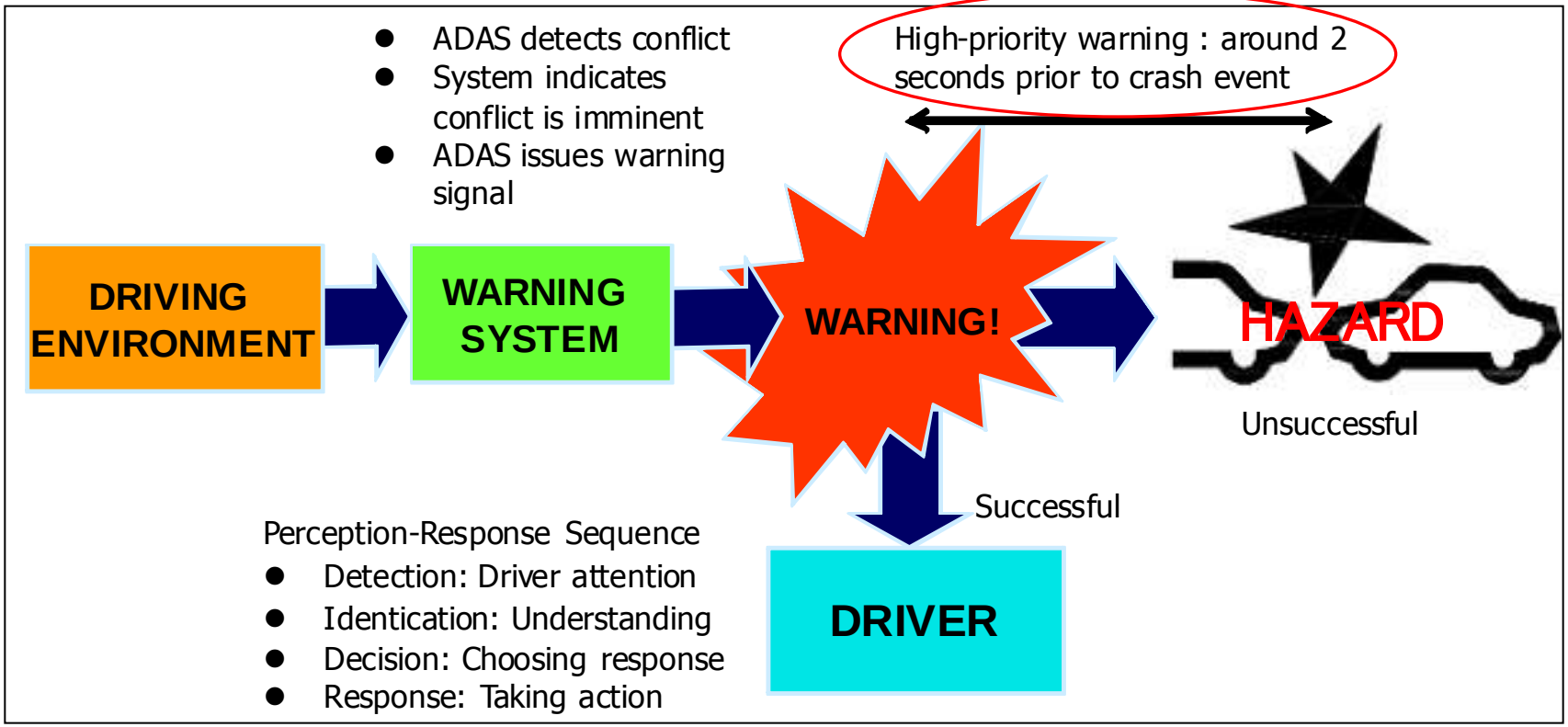
Warning Timing, Driver Distraction, and Driver Response to Imminent Rear-End Collisions

review of some research literature referred to in the ITS guidelines for high-priority warnings

ITS guidelines for high-priority warnings (WP.29-150.22)



ITS guidelines for high-priority warnings (WP.29-150.22)

3.5 High-priority warnings should elicit timely responses or decisions

High-priority warnings should allow drivers sufficient opportunity to perform an appropriate avoidance response.

In-vehicle high-priority warning systems increase a driver's opportunity to avoid threats. Timely responses are critical for collision avoidance. Earlier warnings, may in some situations, provide drivers with more time to respond appropriately to successfully avoid a situation; however, they may become a nuisance if they are frequent and unnecessary (Lee et al., 2002). This might cause drivers to deactivate the system. The timing of warnings should account for driver perception-response times, as well as the need to limit the occurrence of false alarms. The criteria for triggering a warning requires a balance between the goal of providing greater protection and the occurrence of false or nuisance alarms (Lerner et al., 1996).

In the case of emergency braking responses, drivers that are fully expecting a hazard have an estimated median reaction time of 0.6 to 0.65 seconds. Drivers responding to unexpected but common hazards, such as brake lights, have an estimated median brake reaction of 1.15 seconds, while drivers responding to complete surprise events have an estimated median brake reaction time of 1.4 seconds. (Campbell et al., 2007).). Less information is available on the time to execute steering avoidance manoeuvres. Research suggests that greater time margins are needed to warn drivers for steering avoidance manoeuvres (e.g., > 1.2 seconds; Uno and Hiramatsu, 1997).

Effect of warning timing on collision avoidance

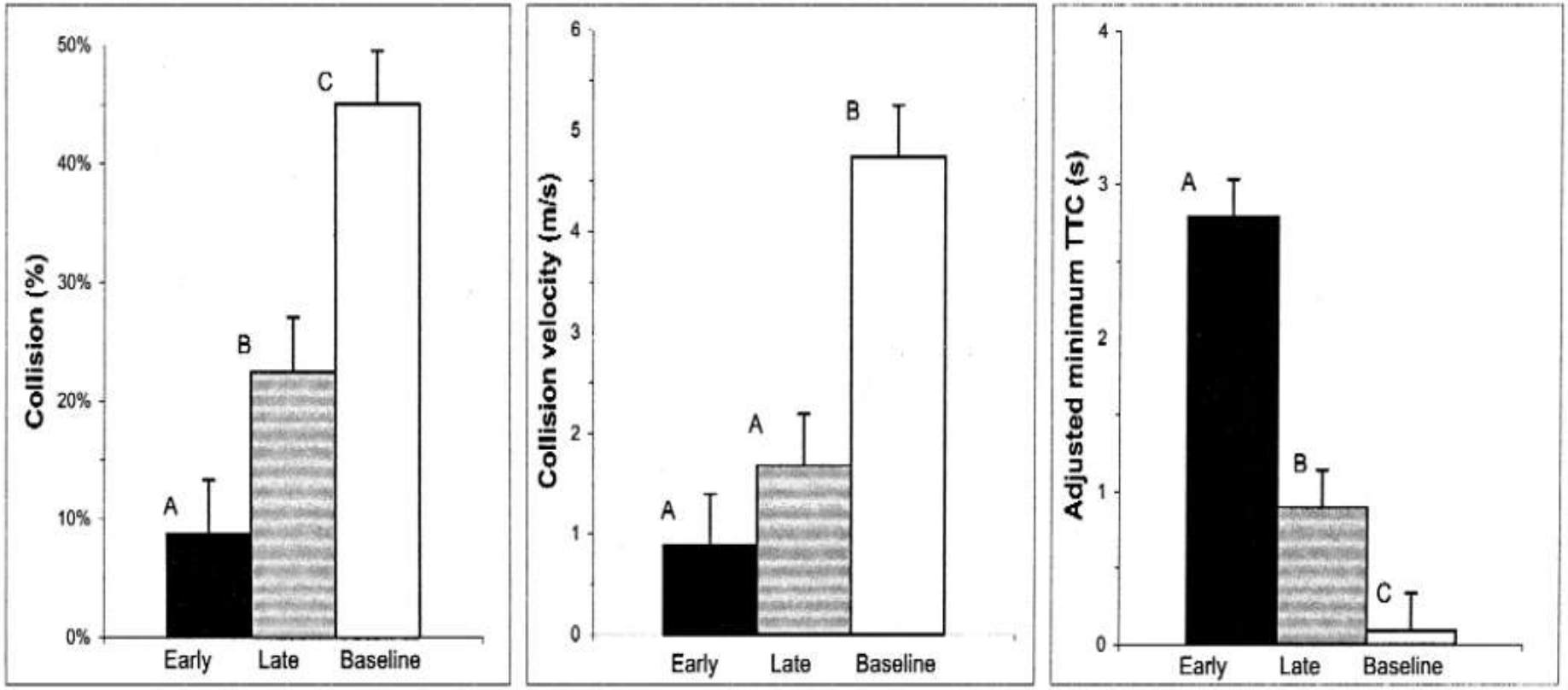


Figure 1. Safety benefit of early RECAS warning compared with late warning and baseline condition (no warning). Error bars represent one standard error.

Note: RECAS = Rear-End Collision Avoidance System

Lee, J. D., McGehee, D. V., Brown, T. L., & Reyes, M. L. (2002). Collision warning timing, driver distraction, and driver response to imminent rear end crashes in a high-fidelity driving simulator. Human Factors, 44(2), 314-334.

Effect of warning timing on collision avoidance

The data demonstrate that RECAS warnings provide a substantial benefit, particularly if the warning is given early.

Compared with no warning at all, an early RECAS warning reduces the number of collisions by 80.7%.

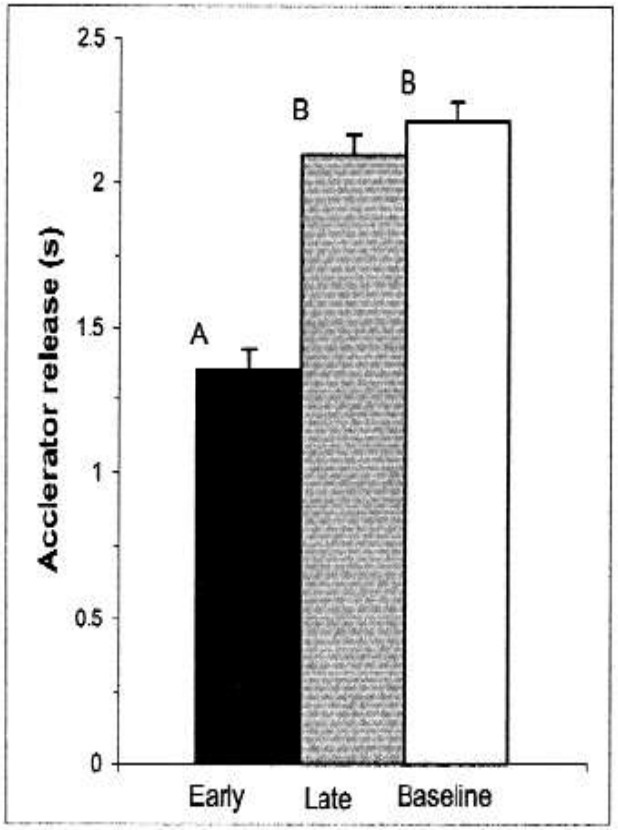
Assuming that collision severity is proportional to kinetic energy, the early warning reduces collision severity by 96.5%.

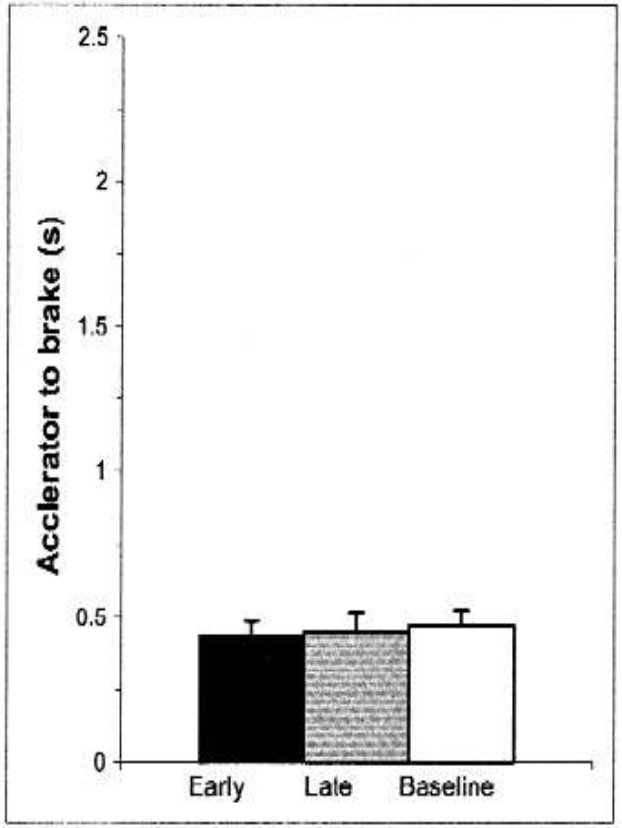
In contrast, the late warning reduces collisions by 50.0% and severity by 87.5%.

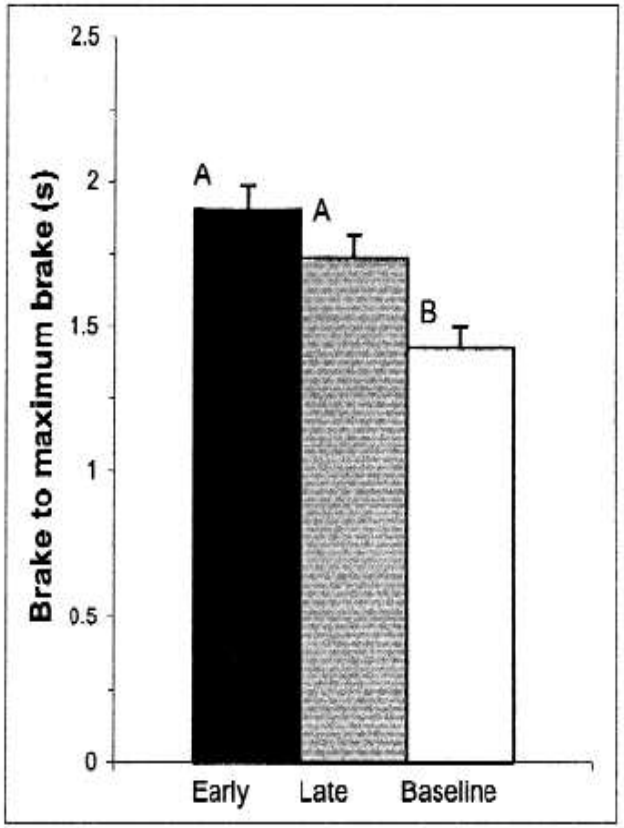
Note: RECAS = Rear-End Collision Avoidance System

Lee, J. D., McGehee, D. V., Brown, T. L., & Reyes, M. L. (2002). Collision warning timing, driver distraction, and driver response to imminent rear end crashes in a high-fidelity driving simulator. Human Factors, 44(2), 314-334.

Effect of warning timing on driver response







Lee, J. D., McGehee, D. V., Brown, T. L., & Reyes, M. L. (2002). Collision warning timing, driver distraction, and driver response to imminent rear end crashes in a high-fidelity driving simulator. Human Factors, 44(2), 314-334.

Effect of warning timing on driver response

The data identify how a warning affects the driver response.

RECAS aids drivers in avoiding collisions by speeding accelerator release, but it does not enhance any other aspect of the response. Drivers do not depress the brake more quickly or brake harder when they receive a warning.

In fact, because compliance with the RECAS warning generated a faster accelerator release, drivers were able to brake more gradually. The difference in mean deceleration suggests a potential indirect benefit of the warning: less abrupt deceleration may decrease the risk of being struck from the rear, a common occurrence when abrupt deceleration of one vehicle triggers a multiple-car crash.

Lee, J. D., McGehee, D. V., Brown, T. L., & Reyes, M. L. (2002). Collision warning timing, driver distraction, and driver response to imminent rear end crashes in a high-fidelity driving simulator. Human Factors, 44(2), 314-334.

Effect of warning timing and driver distraction on collision avoidance

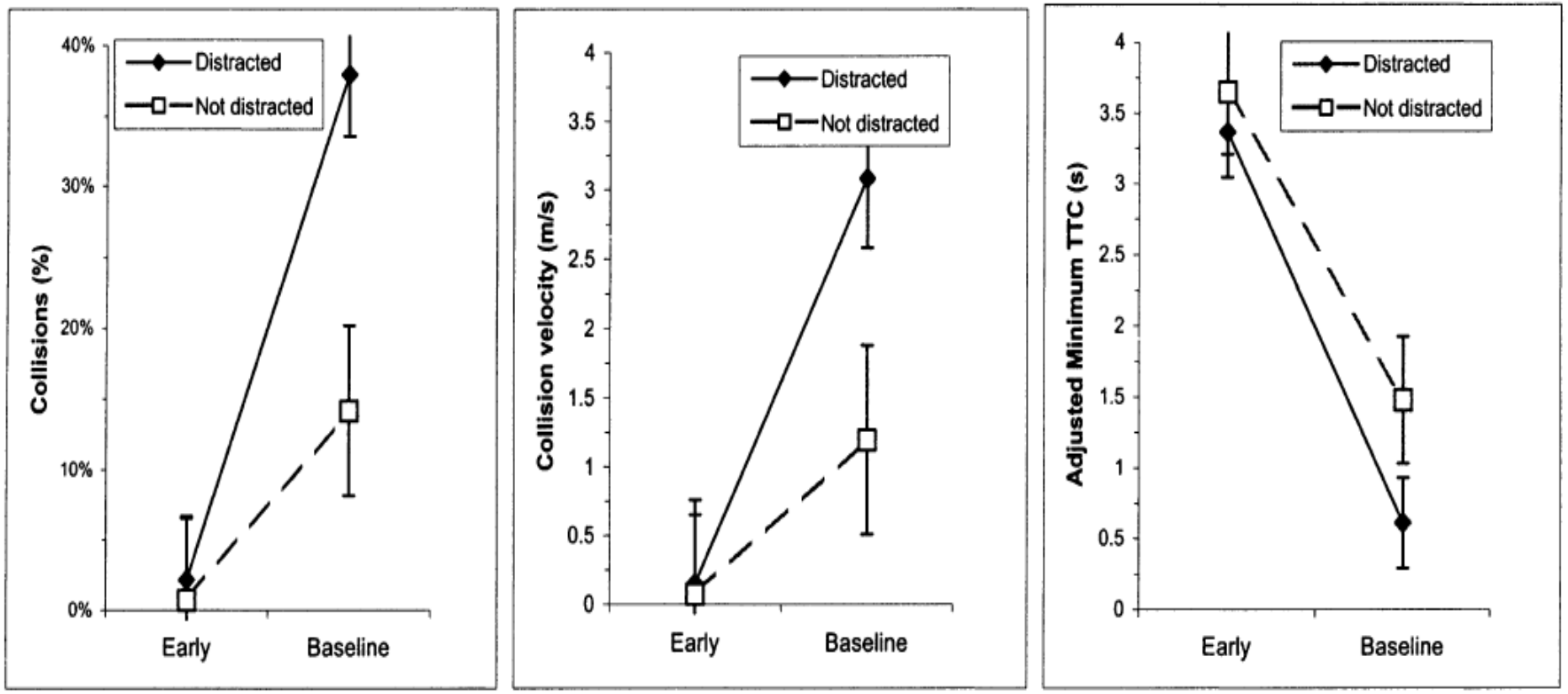


Figure 5. Effect of RECAS warning and distraction on safety.

Lee, J. D., McGehee, D. V., Brown, T. L., & Reyes, M. L. (2002). Collision warning timing, driver distraction, and driver response to imminent rear end crashes in a high-fidelity driving simulator. Human Factors, 44(2), 314-334.

Effect of warning timing and driver distraction on collision avoidance

Collisions occurred for undistracted drivers 14.2% of the time without a warning and 0.7% of the time when a warning was given. In comparison, collisions occurred for distracted drivers 37.9% of the time without the warning and 2.1% when a warning was given.

The warning also reduced collision velocity: without a warning, drivers collided at 2.1 m/s, compared with 0.1 m/s for drivers who received a warning.

The warning also increased the minimum adjusted TTC: without a warning, drivers had a minimum adjusted TTC of 1.0 s, compared with 3.5 s for drivers who received a warning.

The data provide no evidence to suggest that providing undistracted drivers with a collision warning could degrade driving safety.

Lee, J. D., McGehee, D. V., Brown, T. L., & Reyes, M. L. (2002). Collision warning timing, driver distraction, and driver response to imminent rear end crashes in a high-fidelity driving simulator. Human Factors, 44(2), 314-334.

Effect of warning timing and driver distraction on response time

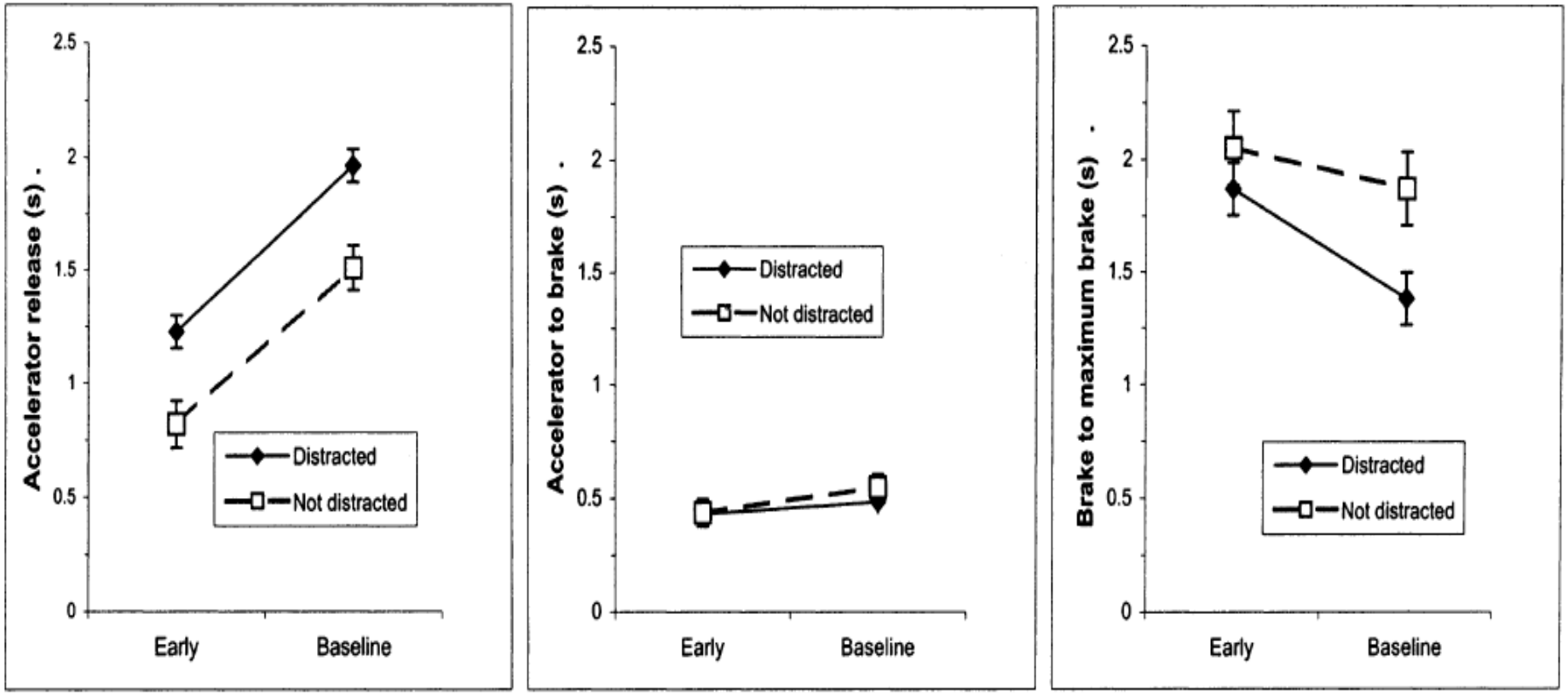


Figure 6. Effect of distraction and RECAS warnings on the response process.

Lee, J. D., McGehee, D. V., Brown, T. L., & Reyes, M. L. (2002). Collision warning timing, driver distraction, and driver response to imminent rear end crashes in a high-fidelity driving simulator. Human Factors, 44(2), 314-334.

Effect of warning timing and driver distraction on response time

Neither warning nor distraction affected the transition time from accelerator to brake.

The warning did increase the time between initial brake press and maximum deceleration, however.

Given a warning, drivers moved from initial brake application to maximum brake application in 1.96 s, compared with 1.62 s for no warning. In contrast, distracted drivers depressed the brake faster than did undistracted drivers.

Both distracted drivers and undistracted drivers responded faster with the warning and maintained a greater safety margin.

The data do not indicate that a warning might undermine safety for an undistracted driver.

Lee, J. D., McGehee, D. V., Brown, T. L., & Reyes, M. L. (2002). Collision warning timing, driver distraction, and driver response to imminent rear end crashes in a high-fidelity driving simulator. Human Factors, 44(2), 314-334.

Conclusions

An **early warning is of greater benefit than a late warning**.

Drivers respond to the collision warning as automation that redirects attention, not as automation that triggers a braking response. The data show that an **enhanced accelerator release response is the only warning effect**.

Consequently, the **benefits of early warnings in providing drivers with additional time to interpret and respond to the situation** probably outweigh the costs associated with inappropriate braking responses to nuisance alarms.

Both distracted and undistracted drivers benefited from the warning. Beyond the direct benefit of avoiding collisions with the lead vehicle, **drivers who received the warning decelerated more gradually, which may decrease the risk of being struck from the rear**.

Lee, J. D., McGehee, D. V., Brown, T. L., & Reyes, M. L. (2002). Collision warning timing, driver distraction, and driver response to imminent rear end crashes in a high-fidelity driving simulator. Human Factors, 44(2), 314-334.