Left or Right: Auditory Collision Warnings for Driving Assistance Systems

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Assistance driving systems aim to facilitate human behavior and increase safety on the road. These systems comprise common systems such as forward collision warning systems, lane deviation warning systems, and even park assistance systems. Warning systems can communicate with the driver through various modalities, but auditory warnings have the advantage of not further tasking visual resources that are primarily used for driving. Auditory warnings can also be presented from a certain location within the cab environment to be used by the driver as a cue. Beattie, Baillie, Halvey, and McCall (2014) assessed presenting warnings in stereo configuration, coming from one source, and bilateral configuration, panned fully from left or right, and found that drivers felt more in control with lateral warnings than stereo warnings when the car was in self-driving mode. Straughn, Gray, and Tan (2009) examined laterally presented auditory warnings to signal potential collisions. They found that the ideal presentation of warnings in either the avoidance direction, in which the driver should direct the car to avoid a collision, or the collision direction, in which the potential collision is located, was dependent on time to collision. Wang, Proctor, and Pick (2003) applied the stimulus-response compatibility principle to auditory warning design by using a steering wheel in a non-driving scenario and found that a tone presented monaurally in the avoidance-direction led to the fastest steering response. However, the reverse finding occurred when similar experiments utilized a driving simulator in a driving scenario (Straughn et al., 2009; Wang, Pick, Proctor, & Ye, 2007).

The present study further investigated how to design spatially presented auditory collision warnings to facilitate drivers' response to potential collisions. Specifically, tones indicating a pedestrian walking across the road were presented either in the avoidance direction or in the collision direction. The experimental task consisted of monitoring the road for potential collisions and turning the wheel in the appropriate direction to respond. Additionally, time to collision was manipulated to investigate the impact of the timing of the warning and increasing time pressure on the steering response. Time to collision was manipulated by half second intervals from two to four seconds resulting in five different time-to-collision scenarios. Lastly, the effect of individual differences in decision-making styles were also considered by using two decision-making style questionnaires. Results from the experiment showed that the presentation of a collision warning in the collision direction led to faster responses when compared to the warning in the avoidance direction. This result may be due to the collision warning directing the attention of the participant to the location of the threat so that they can more quickly make a response decision. Further, the advantage of avoidance-direction warnings over collision-direction warnings was greater with greater time to collision. Results showed that participant responses to varying time to collision influenced their reaction time. The participants appeared to have not relied solely on the auditory tones, but rather they utilized the warning tones in conjunction with visual information in the environment. These results from this study have implications for improving collision avoidance systems: Presentation of a collision warning in the direction of the collision may be more intuitive to drivers, regardless of time to collision.

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References

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