How do Bicyclists Intercept Moving Gaps in a Virtual Environment?

Benjamin Chihak Sabarish Babu Timofey Grechkin Christine Ziemer James Cremer Joseph Kearney Jodie Plumert
Departments of Psychology and Computer Science, The University of Iowa

Coordinating one's actions with the movements of other objects in the environment is important for both interception and avoidance tasks. Recent experiments show that performance in some interception tasks is well explained by a motion control strategy based on adjusting speed to maintain a constant bearing angle (CBA) between an individual's direction of motion and the object to be intercepted [Lenoir et al. 2002]. When the object and observer travel on intersecting, linear trajectories and the object travels with constant speed, then an observer employing the CBA strategy will move with constant speed.

This study investigated how bicyclists adjust their speed to pass through a moving gap crossing their line of travel. Thirty five participants rode a bicycling simulator through a virtual town. On each cross street, a train of 14 blocks (each the size of typical sedan) was positioned approximately 150 meters to the left of the intersection in the near lane. The blocks were triggered to move as the bicyclist approached the intersection. Participants were instructed to time their arrival so that they would safely pass through a 3.5 second target gap in the train of blocks.

The movement of the cross traffic was timed such that if participants rode at constant speed they would either arrive at the intersection as the gap was about to close (Speed Up trials), just after the gap opened (Maintain trials), or just before the gap opened (Slow Down trials). To safely cross through the gap in Speed Up trials, bicyclists needed to accelerate before they reached the intersection; in Maintain trials, participants could safely pass through the gap by maintaining a constant speed; and in Slow Down trials, bicyclists needed to reduce their speed in order to safely cross through the gap.

Results

One important measure of gap crossing behavior is the Time-to-Spare (TTS) when the bicyclist clears a stream of traffic [Plumert et al. 2004]. The mean TTS was 2.46 s for the Slow Down condition, 2.17 s for the Maintain condition, and 1.69 s for the Speed Up condition. These differences were all significant at $p < 0.05$. Examination of the manner in which participants adjusted their speed to intercept the gaps reveals a consistent (and somewhat surprising) pattern of results. As shown in Figure 1, participants maintained a relatively steady speed of nearly 5 m/s until they were about 15 seconds from the intersection for all trial types. As expected, participants in the Speed Up conditions increased their speed to reach the gap before it closed. The reduction in speed in Maintain trials was unexpected and the amount of speed reduction in the Slow Down trials was higher than expected. In both cases, cyclists appear to have used a multi-staged strategy to put themselves in a position where they could accelerate into the gap in the last 4-7 seconds before they reached the intersection. Interestingly, the final acceleration was most dramatic in the Slow Down trials (for which riders initially had no need to accelerate in order to hit the gap). The impact of speed adjustments on the projected time of arrival at the intersection (i.e. the time of arrival if participants maintained constant speed) relative to the gap interval is shown in Figure 2. It shows an interesting convergence of the curves at about 5 seconds before reaching the intersection followed by a final period of acceleration as participants approached the gap. The multi-phased strategy participants appeared to be using does not fit predictions of the CBA strategy.

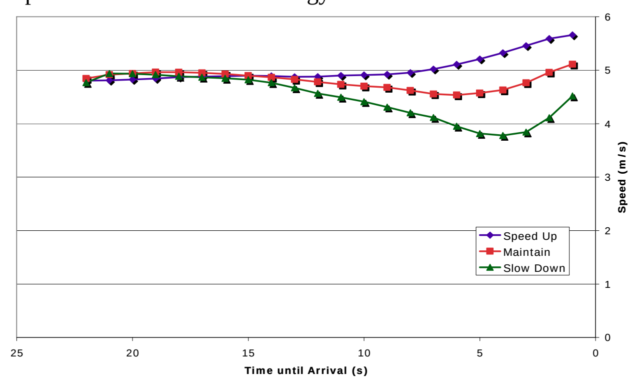

Figure 1. Average speed as a function of time to arrival at the intersection for each trial type.

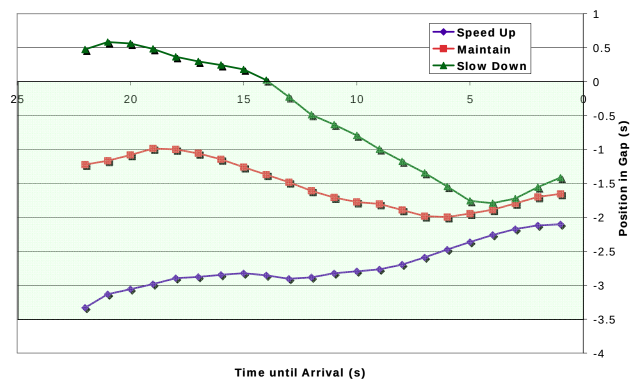

Figure 2. Mean projected time of arrival at the intersection relative to the target gap. The shaded area represents the gap.

References

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