An investigation on the optimal positioning of in-vehicle side-view displays

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1. Introduction

Major automobile manufacturers have been petitioning NHTSA to permit automakers to replace the traditional exterior side-view mirrors with micro-compact cameras (Alliance of Automobile Manufacturers, Inc and Tesla Motors, Inc, 2014). Employing wide angle lens, such cameras could completely eliminate blind spots. Also, instead of the traditional side-view mirror positions, real-time video images from the cameras can be presented at any positions inside the car via electronic displays. The use of such in-vehicle electronic side-view displays may improve driver's visual information processing, and, therefore, could benefit driving performance and safety.

Despite the potential, however, little ergonomics research has been conducted on the design of in-vehicle side-view displays and knowledge gaps currently exist regarding the optimal design. One such knowledge gap pertains to the optimal spatial arrangement of side-view displays.

2. Method

As an effort to address the problem of determining the optimal spatial arrangement of side-view displays, a driving simulator study was conducted to comparatively evaluate a baseline (the conventional side-view mirrors arrangement) and three side-view display design alternatives, as shown in Figure 1. The three design alternatives were derived considering the existing ergonomics display design principles (Bhise, 2011).

![Figure 1. The baseline and design alternatives evaluated: (A) conventional side-view mirrors arrangement, (B)~(D) three arrangements of side-view displays](image)

The four display systems shown in Figure 1 were evaluated in terms of driver performance in detecting hazardous elements in the environment, correctly assessing the situation and taking necessary actions to avoid critical accidents.

In this pilot study, one female and nine male subjects participated. Their average age and years of driving experience were 27.9 and 5.1 years, respectively.

Each participant performed a single experiment trial for each of the four display systems. The order of the presentation of the four display systems was randomized for each participant.
In each experiment trial, the participant’s vehicle was generated on the 2nd lane in a three-lane highway. The speed of the participant’s vehicle was fixed at 100km/h. While the participant was performing lane keeping, an obstacle appeared 100m ahead in the participant’s vehicle’s lane (the 2nd lane) at random times, and, simultaneously, two virtual vehicles were created behind the participant’s vehicle - one on the 1st lane and the other on 3rd lane. The distances from the subject’s vehicle to the two virtual vehicles at the moment they emerged differed: 5m and 15m. Both of the virtual vehicles moved forward at 105 km/h. To avoid the collision with the obstacle ahead as well as the virtual vehicles behind, the subjects were instructed to make a safe lane change by examining both of the side-view mirrors/displays and judging the distances from the virtual vehicles. In each trial, the obstacle and virtual vehicles appeared on the road five times.

Three dependent variables were employed (Savino, 2009): response time (the time duration from the appearance of the obstacle to the onset of lane changing), the number of collisions with the obstacle/virtual vehicle, participant preference rating on a ten point scale.

For the response time and the number of collisions, the mean values of the five data points in an experimental trial were computed and used for subsequent analyses.

3. Results and discussion

Table 1 shows the mean values of the three dependent variables for the four display systems.

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Response time (sec)</td>
<td>1.52</td>
<td>1.51</td>
<td>1.37</td>
<td>1.41</td>
</tr>
<tr>
<td>Number of collision</td>
<td>0.2</td>
<td>0.3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Preference</td>
<td>4.5</td>
<td>6</td>
<td>8.5</td>
<td>7.1</td>
</tr>
</tbody>
</table>

Alternative C showed the shortest response time, followed by Alternatives D, B, and A. No collisions occurred for Alternatives C and D; on the other hand, on average, 0.2 and 0.3 collisions occurred for Alternatives A and B, respectively. Lastly, subjects preferred Alternative C the most.

The results suggest that the closer the side-view displays to the driver’s forward field of view, the better the outcome in terms of the driver performance. Also, the participants were found to prefer the arrangements where the left and right side-view displays were close to each other. However, placing the two side-view displays too close to each other, as in D, may not be the optimal solution as Alternative C was found to be slightly better than Alternative D in response time and preference rating.

4. Conclusion

This study investigated the optimal positioning of in-vehicle side-view displays by comparing four alternative display arrangements. The study results indicated that Alternative C was the optimal spatial arrangement.

Additional data collection employing more subjects is currently underway for statistical analyses. Also, in addition to the spatial arrangement, the size and shape of the side-view displays need to be investigated in future studies.

References

