WHAT IS THE PROFIT OF DRIVING FAST?  
-THE COMPARISON OF THE SPEEDY DRIVING AND SAFE DRIVING IN TERMS OF TRAVELING TIME- 

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Abstract: 
Almost all traffic accidents (collisions) occur when a vehicle's stopping distance is greater than the distance headway between it and other vehicles or obstacles. Stopping distance is sometimes lengthened unexpectedly by a drivers' sudden delay in cognition or sudden drops in braking power, while the distance headway can be shortened by a driver's impulse so as to shorten the time of the arrival. As a result, traffic accidents occur when the stopping distance becomes greater than the driver's distance headway. Therefore, it is important to maintain greater headways than suddenly lengthening stopping distances. In this study, the authors investigated driver's headway, time of the arrival and collision prone index (CPI) when drivers drove a vehicle with speed impulse. As a result, it was found that many drivers believed that their time of arrival would be shortened by speeding, however the difference in traveling time between driving fast and driving at normal speeds was almost always not meaningfully large. 

Keywords: Safe Driving, Hastening, Speedy Driving, Headway, Traveling Time, Collision Prone Index 

1. INTRODUCTION 
Almost all traffic accidents (collisions) occur when a vehicle's stopping distance is greater than the distance headway between it and other cars or obstacles. 

Stopping distance > Distance headway \hspace{1cm} (1)
Stopping distance (left side of the inequality of (1)) is sometimes lengthened unexpectedly by a driver's sudden delay in cognition, while the distance headway (right side of the inequality of (1)) can be shortened by a driver's impulse so as to shorten the time of the arrival. As a result, traffic accidents occur when the stopping distance becomes greater than the driver's distance headway [1]. Therefore, it is important to maintain greater distance headway rather than suddenly lengthening the stopping distance.

Nakajima et al. (1982) reported that the mode of time headway was around 1 second, while the mode of distance headway was around 25 meters, at the speed of around 90 km/h[2]. These gaps are not enough to avoid a collision with vehicles ahead. The main reasons why drivers do not maintain a sufficient distance headway are to shorten traveling time or get ahead of other drivers [1].

This behavior could be due to strong human instinct, a speed impulse[1]. At walking speed, speed impulse would be a very important characteristic for survival. As a result, we gain a lot of benefits by doing things at a fast pace. Therefore when we drive a car, it is natural that we want to drive fast. However, since the invention of the car, the impulse of speedy driving has been a dangerous factor because it makes drivers' distance headway shorter. As a result, traffic accidents occur when stopping distance becomes greater than the driver's distance headway. According to Maruyama's research (1982), roughly 54% of drivers hastened just before their accidents[3].

It is assumed that many drivers drive faster to shorten traveling time. However, it was reported that there were no meaningful differences in traveling time when driving fast and when driving at ordinary speeds. In addition, speeding promoted stress[4][5]. In general, many drivers do not understand the above fact clearly and insist on driving fast[5]. Therefore, we investigated driver's time of the arrival, headway, and collision prone index (CPI) when drivers drove a vehicle with speed impulse on a driving simulator.

2. THE NEW DRIVING SIMULATOR SYSTEM

2.1 Hardware

Figure 1 shows the construction of the driving simulator. It has three personal computers (PCs) and three displays for the center view, the left view and the right view. The center display gives drivers about 58° visual field horizontally. And the angle between the center
display and the side display is about 135°. As a result, the visual angle of the driver’s view is about 86° horizontally. A PC for the center view gets data from the steering wheel, accelerator pedal and braking pedal through an I/O interface. Three PCs are connected to each other with TCP/IP for sending and receiving the necessary data.

2.2 Software

The driving simulator works on Windows98 (Microsoft), and was developed by using DirectX7.0 (Microsoft). The model road in the simulator was a road in Fukuoka, Japan and is 3.1km in length. The positions, offset times, and cycles of traffic signals on the road were simulated. Figure 2 shows an animated image of the driving simulator. A room mirror was rendered at the top of the center view.
2.3 Time Efficiency on the Driving Simulator

We investigated time efficiency of driving by comparing traveling times on the driving simulator with those on the real road. We measured traveling times at three levels of maximum speeds (40km/h, 50km/h, 60km/h) on the driving simulator. Then, we compared the results with those at the same maximum speeds on the real road. Figure 3 shows traveling times at each maximum speed on the simulator and on the real road. The changes of traveling times, according to the increase of maximum speed on the driving simulator, were very similar to those on the real road. The results show that the driving simulator was able to simulate the time efficiency of driving on a real road.
3. COMPARISON OF THE SPEEDY DRIVING AND SAFE DRIVING

3.1 Purpose

We compared the speedy driving and safe driving in terms of traveling time and risk of a collision by using driving simulator.

3.2 Method

3.2.1 Subjects

Six men who have driver’s licenses participated in the experiment. The average age was 25.0 years old. All subjects didn’t know the purpose of this experiment and we did not allow them to have any knowledge regarding this study.

3.2.2 Procedure

The subjects drove a vehicle from start to goal on the driving simulator at four levels of maximum speeds (40km/h, 50km/h, 60km/h, 70km/h). We measured their time headway and traveling time at each maximum-speed condition. Also, they were directed to guess the traveling time before driving (pre-guessing time) and to report the traveling time after driving (post-guessing time) at each maximum-speed condition. After the experiment, we analyzed their time headway and velocity at each condition, and also calculated CPI (Collision Prone Index) by equation (2) and (3).

\begin{align*}
S_d & = R_t \cdot v + \frac{v^2}{2\mu g} \\
\text{CPI} & = \frac{S_d}{Dhw}
\end{align*}

(Sd: stopping distance[m], Rt: reaction time[sec], v: velocity[m/sec], \(\mu\): coefficient of friction, g: acceleration of gravity[m/sec^2], Dhw: distance headway)

We let \(R_t\), \(\mu\) and g equal constant values, 1.5, 0.65 and 9.8, respectively. Using the CPI value, it is possible to evaluate the relationship between the stopping distance and the distance headway. If the CPI value is greater than 1.0, a collision between a leading vehicle and a following vehicle will occur when the leading vehicle stops quickly. And, as the CPI value becomes greater, the possibility of collision gets higher. We compared the average of time headway and CPI at each maximum-speed condition.
3.2 Results and Discussion

3.2.1 Traveling time

Figure 4 shows the average of actual traveling time, pre-guessing time and post-guessing time at each maximum-speed condition. At each speed, there is no meaningful difference between the pre-guessing time and post-guessing time. The difference between the pre-guessing time at high speed and that at low speed were larger than the difference between the actual time at high speed and that at low speed. This result supports that subjects believe that the faster they drove, the shorter the traveling time became. It is considered that this is one of the main factor to promote speedy driving for many drivers.

3.2.2 Time headway and CPI

Figure 5 and Figure 6 shows the average of time headway and the average of CPI at each speed.
maximum-speed condition respectively. The maximum speed of other vehicle on the driving simulator was 61.2km/h. Therefore in the maximum-speed of 40km/h and 50km/h, subjects were practically not able to keep up with the other vehicle. As a result, in the maximum-speed of 60km/h and 70km/h, the time headway became smaller. Compared CPI values at each maximum-speed condition to evaluate how dangerous these situations were, CPI values in the maximum-speeds of 40km/h, 50km/h, 60km/h and 70km/h were 0.98, 1.12, 1.78 and 2.02 respectively. The CPI value in the maximum-speeds of 60km/h and 70km/h were much higher than those in the maximum-speeds of 40km/h and 50km/h.

Compared driving at the regal speed on this road, 50km/h with the driving at the maximum-speed of 70km/h, the rate of reduction of actual traveling time was 8.5%. However, the rate of change of CPI value was about 180%. These results show the inefficiency of speedy driving. And It is concluded that the driving fast with insufficient headway is no worth the risk of a collision.

4. CONCLUSION

We compared the speedy driving and safe driving in terms of traveling time & the possibility of a collision by using a driving simulator. As a result, subjects believe that the faster they drove, the shorter the traveling time became, and this factor seems to promote speedy driving for drivers. Also, we investigated the risk of a collision on the speedy driving through comparing the CPI values calculated based on the stopping distance and the distance headway. It was found that as the velocity of the vehicle becomes higher, the CPI value increases and the driving fast with insufficient headway is no worth the risk of a collision. These results
suggest that there is a necessity in discerning suitable headway and velocity based on a driver's CPI value.

REFERENCES


