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ACCIDENTS CAUSED BY DISTRACTED DRIVING IN JAPAN

HIROSHI MAKISHITA AND MIKI MUTOH
National Research Institute of Police Science, Japan

ABSTRACT

Distracted driving was the leading cause of injury-causing/fatal traffic accidents in Japan in 1995. The purpose of this study is to clarify the actual situation regarding this type of accident and distracted driving, in order to help determine the measures to decrease traffic accidents.

The distracted driving was classified into 3 groups by cause of distraction as follows: (1) a specific action unnecessary for driving (2) no specific action (3) a task needed for driving.

The accidents in Group 1 can be prevented if the driver avoids the specific action. A questionnaire survey was conducted on 230 drivers to find out the frequencies and subjective risk level of 15 items of specific actions. The result showed that many actions are not thought to be risky and are frequently done when driving.

The distraction in Group 2 and 3 can not be controlled by drivers. The only action they can take is to lower the velocity of vehicles, so the effect of lowering velocity to prevent the accidents was examined. The record of 51 accidents categorized into these groups was examined to find out the travel velocity of the vehicle and the distance from the obstacle, at the moment the driver realized that he must do something to avoid hitting it. Then the relationship was obtained between the travel velocity and the impact velocity.

This study showed how it would be effective to lower the travel velocity if drivers cannot concentrate on driving, and showed that the danger of distracted driving should be taught to drivers.

1. INTRODUCTION

Distracted driving represented 23% in 1995 and 21% in 1994 of the number of fatal traffic accidents caused by vehicle drivers[1)]. It was the leading cause of fatal traffic accidents in Japan in 1995 (2129 accidents) and was second only to speeding as a cause of fatal traffic accidents in 1994. Speeding is traffic violation most responsible for fatal accidents through the teens and the 20s, but in general decreases with age. The percentage of the accidents caused by distracted driving increases with age, and it becomes the highest percentage beginning in the 30s. Avoidance of distracted driving is thought to become more important for preventing traffic accidents, especially fatal accidents, as the percentage of older drivers increases. Distracted driving can easily be overlooked if it does not cause an accident. Most drivers are not aware that they commit the violation of distracted driving. Also, there are various behaviors of drivers which cause distracted driving. Therefore causes of distracted driving were examined, and they were classified into 3 main groups. Then each group was examined to find out what the drivers should do to prevent the accidents. In the first group, a specific action was the cause of distracted driving, so the frequency and the

each subjective risk of specific action was examined by a questionnaire. In the latter 2 groups, it was difficult to control the cause of distracted driving, so the effect of lowering velocity to prevent the accidents was examined. The examination was based on the accident reports by police officers.

2. CAUSES OF DISTRACTED DRIVING

Causes of distracted driving were classified into the following three groups:

Group 1. Specific action (it is hereafter referred to as "a secondary task") which caused the driver's distraction leading to accidents was found, such as talking on the telephone, watching television, or operating vehicle instruments. These actions are not necessary or are not directly necessary for driving.

Group 2. No clear causation of distracted driving was found, for example, drivers were careless, absent-minded, or just day-dreaming. In some cases, the other party involved was most responsible for the accident.

Group 3. Drivers' attention was distracted towards one object on the road to avoid hitting it, therefore causing them to hit other objects beyond their attention.

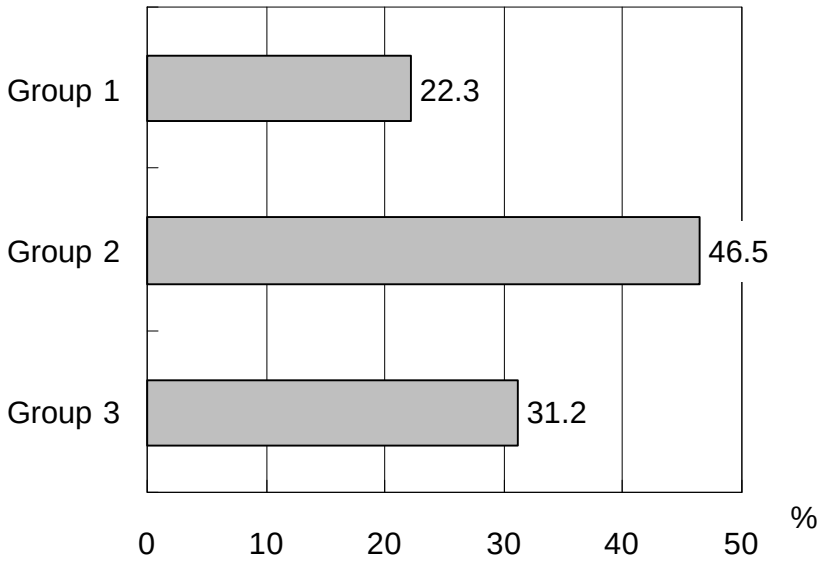

Figure 1 The percentage distribution of the causes of distracted driving
Group 1 A secondary task was the cause of distracted driving.
Group 2 No specific action was found as the cause of distracted driving.
Group 3 A task needed for driving was the cause of distracted driving.

The accidents categorized into Group 1 can be prevented if drivers avoid the secondary tasks, so drivers are expected to avoid secondary tasks to prevent accidents. On the other hand it is not clear what drivers should do to prevent accidents categorized into Group 2 and 3. Figure 1 shows the percentage of injury-causing/fatal accidents in 1995 in Japan, classified into each group.

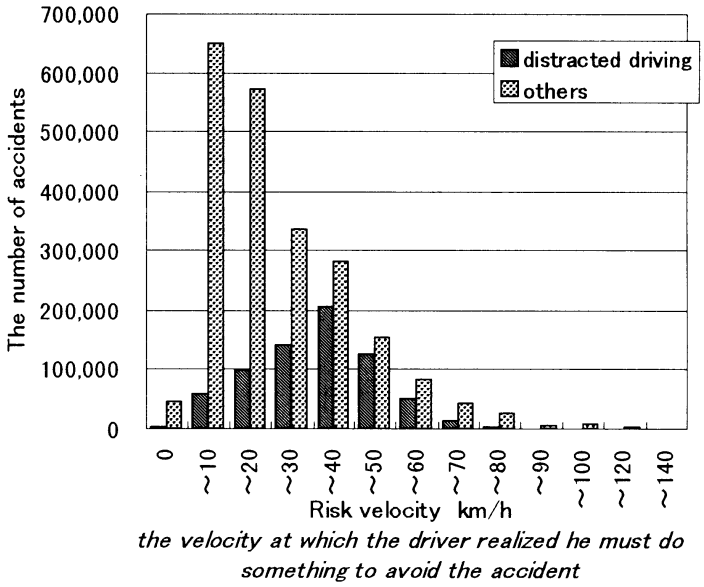

Figure 2 Distribution of the risk velocity

Figure 2 (aggregate from 1990 to 1994 in Japan) shows the distribution of velocity of vehicles at the time when the driver realized he must do something to avoid the accident. The velocity is called the risk velocity and it can be regarded as the stable travel velocity at which the vehicle was traveling prior to this moment. The distance from the obstacle, at the moment the driver realized that he must do something to avoid hitting it, is called the risk distance. Accidents caused by distracted driving can be avoided if the risk velocity is lower, the risk distance is longer, or the drivers' action is quicker.

In Group 1 as mentioned before, drivers can avoid secondary tasks if they want, and the risk distance is expected to be longer and also the drivers' action quicker. Drivers have to know what tasks are dangerous in each traffic condition in order that they can avoid those tasks properly. Subjective risk and frequencies of secondary tasks are examined in this study, based on a questionnaire survey.

In Groups 2 and 3, it is not clear what the drivers should do to avoid accidents. The effect of the advice is said to be doubtful, if it cannot show concretely how the drivers should change their usual behaviors[2]. Such advice as 'don't be careless, don't day-dream or don't be absent-minded' is useless and cannot make drivers avoid these situations classified into Group 2. Also the drivers cannot be made to avoid necessary tasks such as watching other vehicles, watching traffic signs, etc. which are classified into Group 3. In situations where the driver's mind is not clear or he cannot pay attention to many things he must do, the only action he can take is to lower the velocity to avoid an accident. The effects of lowering travel velocity on avoiding accidents are examined in this study based on the accident reports.

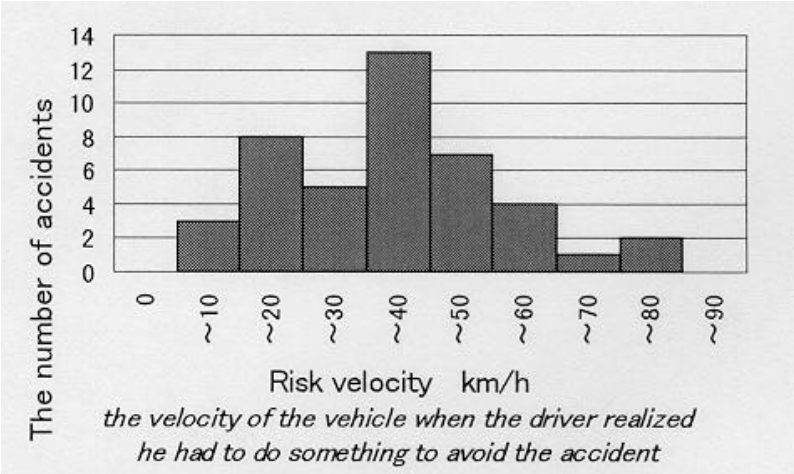

Figure 3 The distribution of the risk velocity

3. ACCIDENTS CAUSED BY DISTRACTED DRIVING ATTRIBUTABLE TO NO SPECIFIC ACTION IN CASE OF GROUP 2 AND 3

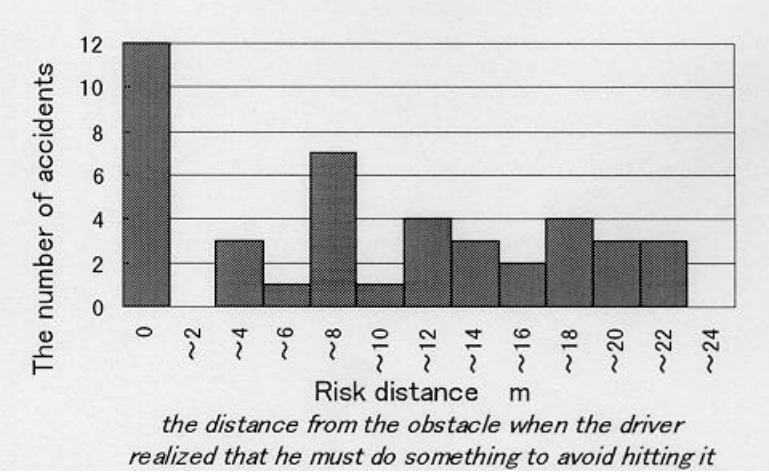

Figure 4 The distribution of the risk distance

3.1 Accidents Investigated in this Study

An investigation was made of the accidents classified into Groups 2 and 3, as mentioned before. It was based on the reports of accidents in Tokyo in 1995. Of the accidents in which persons were killed or injured severely, 361 were caused by distracted driving. The number of those accidents classified into Groups 2 and 3 were 285 or 79% of the total. The percentage was almost the same as in the whole of Japan as shown in Fig.1. Out of these 285 accidents, 51 cases are examined fully, where these 3 conditions are met:

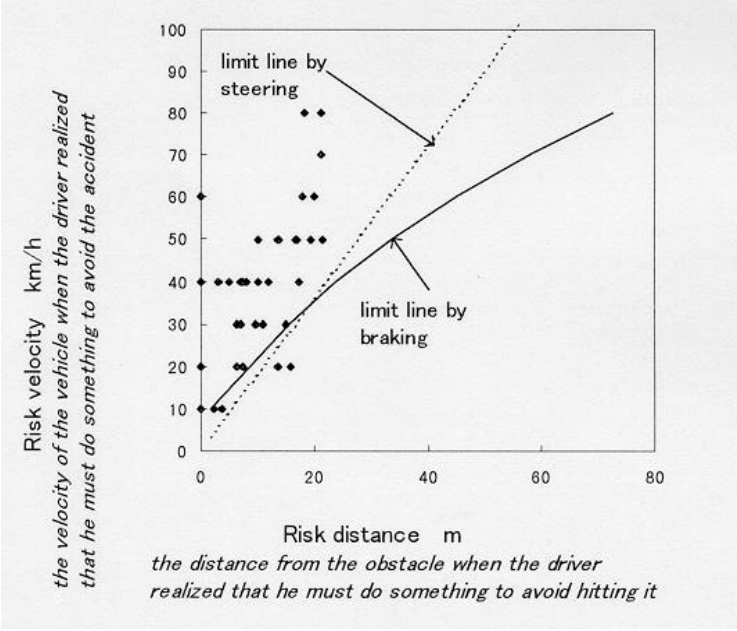

Figure 5 The relationship between the risk velocity and the risk distance

1) The accident point is not an intersection, 2) vehicles are going straight, 3) vehicle size is not so large.

3.2 Risk Velocity and Risk Distance

The risk velocity and risk distance were examined for the 51 cases mentioned before. The risk velocity and the risk distance were based on the reports that police officers made judging by material evidence: for example a mark on the road, deformation of the vehicle, the shape of the road, testimony of the driver, and

so on. Such data could be found for 43 cases. Figure 3 shows the distribution of the risk velocities and Fig.4 shows the distribution of the risk distances. The distribution of the risk velocity of those cases is similar to that of distracted driving in Japan overall shown in Figure 2. The relationship between the risk velocity and the risk distance is shown in Figure 5.

3.3 Limits of Risk Velocity and Risk Distance at Which Accidents Can Be Avoided

A line, forming a boundary, which shows whether the accidents are avoidable or not, can be drawn through the area showing the relationship between the risk velocity and the risk distance.

A solid line in Figure 5 shows the boundary which determine whether accidents are avoidable or not by braking. The line shows the stopping distance, i.e., the distance the vehicle goes before stopping, if the driver tries to avoid the accident by braking, for each risk velocity. The distance was calculated in the following way:

$$l = v_o^2 / 2\mu g$$

where l :braking distance (the distance that the vehicle goes while brake is operating)
v_o :risk velocity
μ :a constant of friction of the road
g :acceleration of gravity

$$s = v_o \cdot t_o + l$$

where s :stopping distance (the distance the vehicle goes before it stops)
t_o :the reaction time (the time from the instance the driver notice the risky condition to the instance the brake starts to act)

A constant of friction and a reaction time were needed to calculate the distance. Though a constant of friction varies according to the driving conditions, e.g. kinds of pavement, conditions of road surface (wet or dry), velocity of the vehicle [3)4)5)], the calculation made in this paper is based on the value 0.5, a relatively low value. Also reaction time varies according to the driving conditions [6)7)]. In one report reaction time ranged from 0.5 to 0.7 seconds, when a driver noticed the red light and tried to stop by braking[8)]. Another report stated that 1 second is assumed as reaction time in the USA for determining the stopping distance[9)]. The calculation here is based on the value 1 second as reaction time, a relatively high value.

A broken line in Figure 5 forms a boundary showing whether accidents are avoidable or not by steering. The limit line shows the distance that the vehicle goes for each risk velocity, before the vehicle starts to change direction. The driver can avoid the accident by steering if the following condition is true:

$$x > v_o \cdot t$$

x :risk distance
v_o :risk velocity
t :the time needed for the vehicle to change the direction

The distance calculated here is based on the assumption that the time needed for the vehicle to change direction is 2 seconds[10)].

Each plotted point in Figure 5 shows the risk velocity and the risk distance for each accident. The point shows how much lower the risk velocity had to be than the actual one for the accident to be avoided. For example, if a plotted point is below the limit line after it is moved by 10km/h along the vertical axis, the accident could have been avoided if the risk velocity had been 10 km/h lower than the actual one.

3.4 The Effect of Lowering the Travel Velocity and Noticing the Obstacle Earlier

The following analysis was made in order to find out not only the possibility of avoiding accidents but also the variation of the impact velocity. The impact velocity was calculated on the basis of the risk velocity and the risk distance, together with the aforementioned assumed values of a 0.5 constant of friction and a reaction-time delay of 1 second. Each curve and each plotted point on Fig.6 shows the results of the calculation. Each curve shows the relationship between risk distance and impact velocity for each risk velocity. Each plotted point shows the set of values for each variables in a given accident.

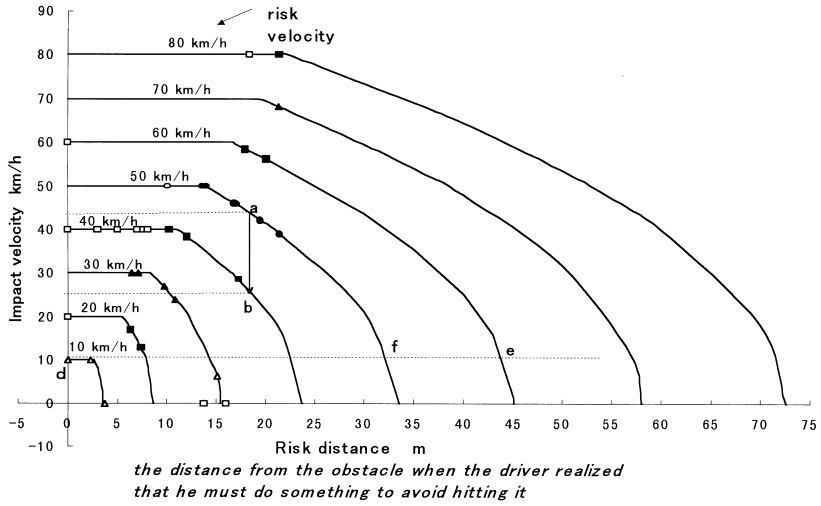

Figure 6 The relationship between risk distance and impact velocity for each risk velocity

How much the impact velocity changes, in relation to changes in the risk velocity, can be determined by moving a plotted point from one curve to another curve, parallel to the vertical axis. For example if the point "a" is moved to the point "b", which means that the risk velocity changes from 50 km/h to 40 km/h, the impact velocity lowers by 17 km/h from 43km/h to 26 km/h. Similarly as this, the drop in the impact velocity is larger than the drop in risk velocity (travel velocity) in 19 (points painted black in Fig.6) out of 43 cases. Also, if all plotted points are moved from one curve to the next one below, parallel to the vertical axis, thereby lowering the risk velocity by 10 km/h, the impact velocity changes to 0 km/h, (meaning accidents can be avoided), in 8 out of 43 cases.

On the other hand, the plotted points in Fig.6 show that the risk distance was very short in almost all accidents caused by distracted driving. Also in many cases (25 cases) drivers could not lower the velocity of the vehicle at all before the accidents happened, so in these cases the risk velocity equaled the impact velocity. Fig.7 shows the relationship between the additional time required by the driver to avoid the accident, and the impact velocity for each risk velocity. The time is hereafter referred to as "required time". If the driver in the accident plotted on the curve noticed the risky condition earlier than the required time that the plotted point shows, he could avoid the accident. For example if the driver is going 60 km/h and he notices the risky condition one second after the instance he needs to notice it in order to avoid the accident, he hits the obstacle at about 45 km/h. The required time in most cases of accidents were between 1 and 2 seconds (shown in Fig.8).

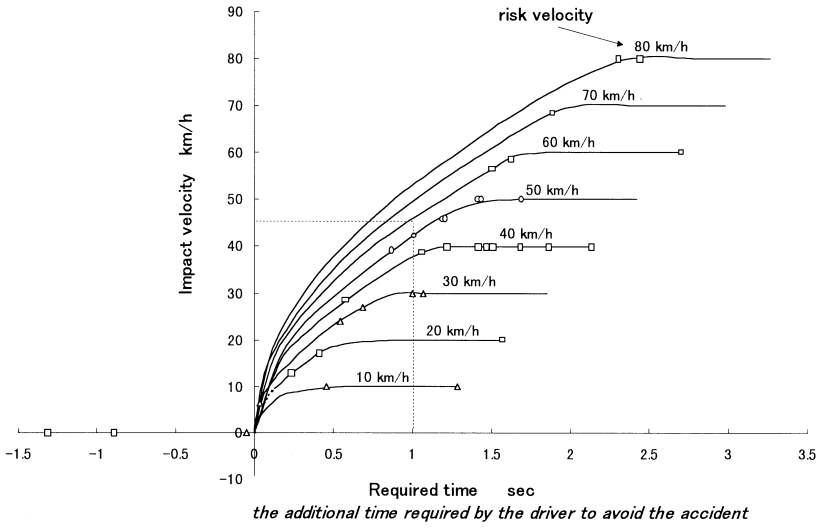

Figure 7 The relationship between the required time and the impact velocity for each risk velocity

The required time and impact velocity were calculated in the following way:

The variables are defined as follows:

- μ :a constant of friction of the road
- g :acceleration of gravity
- t :required time
- t_o :reaction time (the time from the instance the driver notice the risky condition to the instance the brake starts to operate)
- x :risk distance
- s :stopping distance (the distance the vehicle goes before it stops)
- v :impact velocity
- v_o :risk velocity
- x_o :the distance the vehicle goes through the reaction time

i) if $s<x$ (The vehicle can stop before it impact the obstacle.)

$t=(s-x)/v_o$

$v=O$

ii) if $v_o \bullet t_o<x<s$ (risk distance x is shorter than the stopping distance s, but it is longer than the distance the vehicle goes before brake operates.)

$t=(s-x)/v_o$

$v_o^2-v^2=2mg\bullet(x-x_o)$

$x_o=v_o\bullet t_o$

t, v are obtained from the formulas before.

iii) if $x<v_o\bullet t_o$ (risk distance x is shorter than the distance the vehicle goes before brake operates.)

$t=(s-x)/v_o$

$v=v_o$

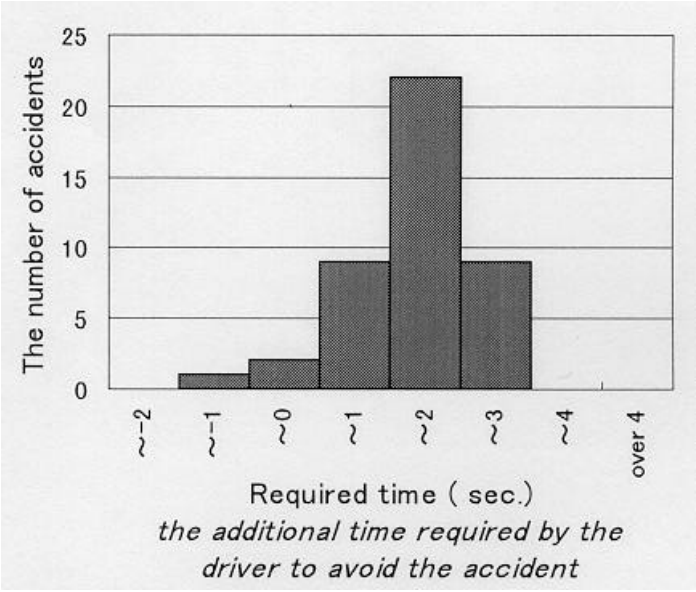

Fig. 8 The distribution of the required time

3.5 Discussion of the Effect of Lowering the Travel Velocity

When the risk velocity is high, drivers must notice the danger earlier than the other cases, but it is not the present situation. The required time in most cases of accidents were between 1 and 2 seconds (shown in Fig.8). If the required time is 2 seconds, drivers cannot lower the velocity of the vehicle before the impact in most cases (shown in Fig.7), so in these cases the risk velocity is equivalent to the impact velocity.

The plotted points in Fig.6 shows the risk distances in all accidents we investigated were within 25 meters regardless of vehicle velocity. If this condition hold true even in a larger sample of data, impact velocity in the accident caused by distracted driving is almost equivalent to risk velocity when the risk velocity is high,

especially more than 70 km/h. Therefore, the resulting change in impact velocity is almost equal to the change in risk velocity, when the risk velocity is high. On the other hand, when the risk velocity is relatively slow, the drop in the impact velocity is larger than the drop in risk velocity, as mentioned before.

The obstacle can appear at any place, when drivers are absent minded or day dreaming, though the risk distances were within 25 meters in our cases. If the risk velocity is high, the obstacle cannot be avoided by braking only even if the risk distance exceeds 25 meters (shown in Fig.6). The relative risk of accidents between different risk velocities can easily be estimated from Fig.6. Also the change in the probability of the accident, where the impact velocity is more than a certain value, corresponding to change in the risk velocity, can be obtained from Fig.6. For example, if the risk velocity is lowered from 60 km/h to 50 km/h, the change in the probability of the accident, where the impact velocity is more than 10 km/h, can be obtained as follows. If the vehicle is going 60 km/h, the obstacles which the vehicle might hit at more than 10 km/h are present between “d” and “e”. On the other hand, at 50 km/h, they are present only between “d” and “f ”. The vehicle , if it is going 50 km/h, can avoid hitting at more than 10 km/h obstacles which appear between “e” and “f ”. Then the probability of the accident where the impact velocity is more than 10 km/h decreases by 25% (ef/de), if the risk velocity decreases from 60 km/h to 50 km/h.

4. SECONDARY TASK LEADING TO DISTRACTED DRIVING IN CASE OF GROUP 1

The problem of a secondary task is that driver’s attention and eye may divert from the situation before him when he executes it. This means that it takes driver long time to perceive a risk. In this chapter, the situation of the secondary task and subjective risk of each task was shown on the results of questionnaire survey.

4.1 A Method of Questionnaire

This surveillance was based on a questionnaire answered by 372 drivers who visited the driver’s license office to renew their licenses in Oct, 1996.

The questionnaire consisted of three parts. They were ① driver’s traits and frequency of driving, ② use of cellular phones while driving and ③ secondary tasks while driving. As for using the cellular phone, drivers were asked whether or not they have a cellular phone, how often and how they use it while driving. They were also asked about secondary tasks (for example looking a map, eating something, using car navigation systems and so on) to estimate the frequency and the subjective risk of each secondary task while driving. The estimation was based on scale values from 1 to 4 (from “never” to “always” as for frequency, “ not dangerous” to “ dangerous” as for subjective risk).

4.2 Frequency and Subjective Risk of Secondary Task

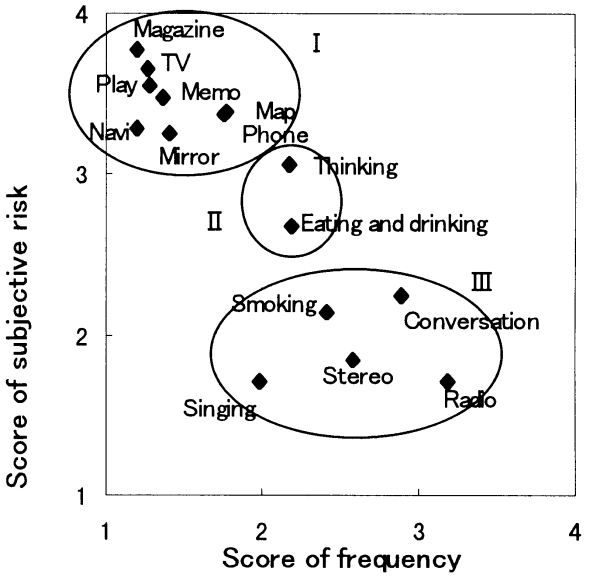

Figure 9 The relationship between frequency and subjective risk

For evaluating the results of the questionnaire, drivers were selected under the condition that they drive more than 2 or 3 days a week, in order to exclude “paper-drivers” who have a driving license but seldom drive a car.

1) The relation between the frequency and the subjective risk of each secondary task

The relation between scores of frequency and subjective risk of secondary task is shown in Figure 9. As shown by the row of plotted points, these two scores have a significantly negative correlation

(r = 0.85 : Correlation coefficient,
p< .001 : Significance level).

Table 1 Difference of the frequency and the subjective risk of secondary tasks

	Frequency				Subjective risk			
	Violator		Non-Violator		Violator		Non-Violator	
Listening to the radio	3.27(0.84)	>	3.00(0.93)	*	1.63(0.65)	<	1.85(0.66)	*
Operating a navigation	1.21(0.66)		1.13(0.44)		3.25(0.68)		3.41(0.64)	
Listening to the stereo	2.68(1.13)	>	2.37(1.01)	*	1.76(0.71)	<	1.99(0.65)	*
Watching TV	1.32(0.77)	>	1.12(0.36)	**	3.65(0.51)		3.77(0.51)	
Talking with passengers	2.96(0.89)		2.79(0.81)		2.15(0.77)	<	2.42(0.68)	*
Eating and drinking	2.37(0.82)	>	1.94(0.83)	***	2.56(0.75)	<	2.93(0.67)	***
Looking in a mirror	1.52(0.70)	>	1.23(0.45)	***	3.20(0.74)	<	3.43(0.72)	*
Consulting a map	1.87(0.77)	>	1.63(0.61)	*	3.40(0.63)		3.41(0.62)	
Making a note	1.47(0.72)	>	1.22(0.45)	*	3.49(0.66)		3.53(0.67)	
Use of a cellular phone	1.92(1.00)	>	1.44(0.68)	***	3.27(0.70)	<	3.62(0.57)	***
Reading a magazine	1.28(0.67)	>	1.08(0.27)	**	3.81(0.41)		3.81(0.52)	
Singing	2.05(0.95)		1.88(0.81)		1.66(0.71)		1.80(0.76)	
Smoking	2.57(1.34)	>	2.05(1.28)	**	2.04(0.78)	<	2.36(0.77)	**
Playing with passengers	1.34(0.55)		1.21(0.49)		3.52(0.63)	<	3.69(0.52)	*
Thinking about something	2.29(0.80)	>	1.97(0.79)	**	2.98(0.77)		3.19(0.73)	

Mean (SD) *p<.05 **P<.01 ***p<.001

As a result of a cluster analysis, 15 secondary tasks were classified into 3 groups. Some tasks, which make drivers look aside, are regarded as dangerous and are seldom executed by drivers. These include operations of in-vehicle equipment such as navigation systems (shown as “Navi” in Fig.9) and cellular phones (“Phone”), and were included in group I. On the other hand, the secondary tasks such as conversation with passengers (“Conversation”) and listening to the stereo (“Stereo”) do not physically interfere with the driving performance. They were estimated at a low risk and included in group III, so drivers do these actions frequently.

2) The effect of age based on driver's record

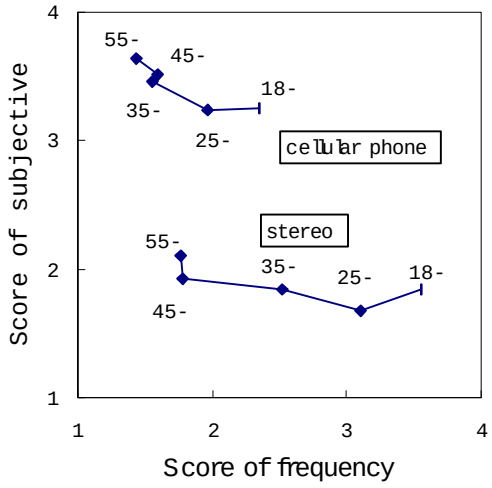

Figure 10 The relationship between frequency and subjective risk for each age group

Drivers were classified into 5 age groups (18-24,25-34,35-44,45-54,55-). The scores of frequency and subjective risk of each action were compared for each age group. The differences among age groups were statistically significant in frequency for 10 actions. The younger drivers are, the higher is the frequency of doing secondary tasks while driving. As for the subjective risk, younger drivers estimated 5 actions (① conversation with passengers, ② use of cellular phone, ③ watching TV, ④ eating and drinking, ⑤ thinking something) lower than other age groups. Figure 10 shows the result of "use of cellular phones" and "listening to the stereo". Both frequency and subjective risk are significantly different among these age groups for "use of cellular phone"; for " listening to the stereo", only frequency varies greatly.

3) The effect of experience of past violations

Drivers were classified into 2 groups according to whether or not they have a record of traffic violation during the last 3 years (They are referred to as "violators"). The result of a comparison between these groups was that violators executed 11 actions more frequently than non-violators and the subjective risk of violators was significantly lower than that of non-violators for 8 actions (Table 1).

4.3 Discussion of the Use of Cellular Phones and Other Secondary Tasks

Cellular phone use while driving has recently become a subject of discussion in Japan. Though cellular phone use is regarded as dangerous, it is not the only cause of distracted driving. Many drivers actually take other actions more often than use a cellular phone, and many accidents are caused by those actions. Then we should consider the risk of other actions while driving, similarly cellular phone use.

In the questionnaire survey, negative correlation was found between the frequency and the subjective risk of secondary task. This means that it is effective to let drivers understand the risk of doing something while driving in lowering the frequency of doing them. We also found in the questionnaire that risk of certain actions, which do not physically interfere with driving performance, are regarded to be small. These actions are, however, causing many accidents actually.

As for the driver's type, young drivers and violators frequently execute secondary tasks and these drivers tend to underestimate the risk of these actions. This result suggests that it is important to inform young drivers and violators the risk of these actions.

5. SUMMARY AND CONCLUSIONS

The research was made to help determine measures for preventing accidents caused by distracted driving. The distracted driving was classified into 3 groups by cause of distraction as follows: (1) a secondary task (2) no specific action (3) a task needed for driving

In the first group, drivers can avoid secondary tasks in order not to cause accidents in the dangerous situation. They have to know the risk of each secondary task. A questionnaire was made to find out frequency and subjective risk of each secondary task. This study showed that some tasks are not thought to be risky, though they causes many accidents. Also young drivers frequently do some secondary tasks, even though they think these tasks to be risky. These facts need to be understood by drivers.

In the latter 2 groups, it is not clear what drivers should do to prevent accidents. They can only lower the velocity of vehicles if they think they are easily distracted. A case study and an analysis was made to find the effect of lowering velocity. The relationship was shown between the risk velocity, risk distance, required time and impact velocity. The results also showed the change in the probability of an accident corresponding to change in the risk velocity.

The import of this study is the message to drivers as follows:

If you intend to do a secondary task, though you may not think it to be risky, please remember that many accidents are caused by it.

If you think that you are easily distracted when driving, please lower the velocity for you can thereby easily decrease the probability of an accident.

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