イタルダインフォメーション ITARDA INFORMATION 交通事故分析レポート No.136

Special Accidents from collisions between four-wheel vehicles turning right and four-wheel vehicles going straight

~ Preventing a delay in noticing other vehicles is effective for avoiding accidents ~



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1 Introduction

The number of traffic accidents (casualty accidents) has been on a downward trajectory year by year. However, the fact still remains that the number of accidents that occur in a single year exceeds 380,000 accidents (2019), and many people still fall victim to such traffic accidents.

Given this state of affairs, in recent years fatal accidents due to pedal misapplication, fatal accidents involving pedestrians caused by collision accidents between a four-wheel vehicle turning right and a four-wheel vehicle going straight, and other such accidents have had enormous societal repercussions. There have even been some accidents that the media and others have chosen to spotlight, and which have received several days worth of ongoing coverage.

This issue will analyze collision accidents between a four-wheel vehicle turning right and a four-wheel vehicle going straight, as this is a type of accident in which there is enormous social interest, out of a desire to look at their characteristics and trends. Analytical results on collisions while turning right between a four-wheel vehicle and a motorcycle and accidents between four-wheel vehicles and bicycles / pedestrians were covered in ITARDA Information No. 91 and No. 95, and readers are encouraged to look at these as well.

Taking a look at the actual circumstances surrounding vehicle-vehicle accidents between four-wheel vehicles (Table 1) reveals that accidents between a vehicle turning right and a vehicle going straight are always the most highly ranked accident type in each category⁺², and thus represent a challenge. So then the question is: Why do collision accidents between a four-wheel vehicle turning right and a four-wheel vehicle going straight occur and what sorts of countermeasures are effective against them? By using Road Traffic Accident Statistics from 2009 - 2018 (hereinafter referred to as "macrodata") and in-depth case studies (hereinafter referred to as "microdata"⁻³), this issue will take a look at casualty accidents between a vehicle turning right and a vehicle going straight").

- *2) Number of casualty accidents = Total number of fatal, serious injury, and slight injury accidents; Number of fatal and serious injury accidents = Total number of fatal and serious injury accidents
- Share of fatal and serious injury accidents (%) = Number of fatal and serious injury accidents / Number of casualty accidents × 100 *3) With regards to the analytical results from the microdata, attention must be paid to the impact that the number of data points has on the accuracy.

Table 1. Number of accidents by type of accident between four-wheel vehicles and the share of fatal and serious injury accidents [macrodata (2009 - 2018)]

		Number of casualty accidents	Number of fatal and serious injury accidents	Share of fatal and serious injury accidents (%)
	Head-on collision	④ 95,988	2 19,224	1 20.0
	Rear-end collision	① 1,942,032	③ 19,217	1.0
	Crossing collision	 640,099 	1 29,167	3 4.6
Col	lision while turning left	22,031	446	2.0
Collision while turning right	Collision between a vehicle turning right / oncoming vehicle going straight	③ 123,680	④ 8,537	 6.9
	Other	38,490	859	2.2
Collision	while passing or overtaking	26,383	712	2.7
Collision while passing each other		30,838	1,099	④ 3.6
	Other	283,024	5.914	2.1

[The numbers in circles in Table 1 indicate their rank from the top-ranked entry for each category (excluding "Other")]

Causes of collision accidents between four-wheel vehicles turning right and four-wheel vehicles going straight

Table 2 shows the numbers for collision accidents between four-wheel vehicles turning right and four-wheel vehicles going straight by their causes by what factors are at play from the perspective of causes attributable to human factors, factors with the road environment, or vehicle factors. It also shows the share out of the total number of casualty accidents that these account for. This reveals that the majority of these were attributable to human factors, with only a small fraction of each attributable to road

environment-related factors or vehicle-related factors. Next, looking at the human factors involved in accidents between a vehicle turning right and a vehicle going straight from the graph on the front cover (composition rate by human factor of the primary party) shows that the most common factor behind collision accidents between a four-wheel vehicle turning right and a four-wheel vehicle going straight was a failure to confirm safety factors that led to a delay in noticing, which accounted for two-thirds of the whole. A common factor with head-on collisions and rear-end collisions is a failure to pay attention to what is up ahead, which stands in stark contrast with the fact that a failure to confirm safety factors is uncommon. In addition, with accidents between a vehicle turning right and a vehicle going straight, a failure to confirm safety factors and a failure to pay attention to what is up ahead combined account for nearly 80% of the total. This reveals that a delay in noticing oncoming vehicles as a result of these two factors serves as the primary cause of such accidents.

Table 2. Number of collision accidents between four-wheel vehicles turning right and four-wheel vehicles going straight by factors attributable to the primary party and the share of the total number of casualty accidents these account for

	Number of accidents	Share (%) *4
Human factors at play	123,524	99.9
Road environment-related factors at play	2,526	2.0
Vehicle-related factors at play	108	0.1

[Macrodata (2009 - 2018)]

^{*4)} Share by cause (%) = Number of accidents by each cause / 123,680 (total number of casualty accidents out of accidents between a vehicle turning right and a vehicle going straight) × 100

In addition, when viewed in terms of trends by age group, the human factors by age group for those age 65 and older (elderly people) and those age 64 and younger exhibit largely identical composition rates (Fig. 1). This reveals that the causal factors behind the occurrence of accidents between a vehicle turning right and a vehicle going straight are commonly shared irrespective of the age group.



Fig. 1. Human factors on the part of the primary party by age group for collision accidents between a four-wheel vehicle turning right and a four-wheel vehicle going straight

[macrodata (2009 - 2018)]

Next, Fig. 2 shows collision accidents between a four-wheel vehicle turning right and a four-wheel vehicle going straight by the locations where they occurred. Intersections accounted for just under 90% of the total, with more than 70% of these occurring at signalized intersections.

At intersections, there are numerous other entities that get involved in accidents from collisions while turning right aside from oncoming vehicles, including crossing pedestrians, bicycles, and other vehicles beyond the right turn. In addition, it is believed that the fact that cases where there are a large number of lanes at signalized intersections and the large number of entities in and of themselves due to traffic congestion increases the share of accidents that occur there. It will presumably be important to enable drivers to quickly notice dangers from among the many entities found at intersections for the sake of avoiding accidents. But when it comes to accidents between a vehicle turning right and a vehicle going straight, what are the original causal factors that give rise to this delay in noticing oncoming vehicles, such as a failure to confirm safety factors?



Fig. 2. Locations where collision accidents between four-wheel vehicles turning right and four-wheel vehicles going straight occurred [macrodata (2009 - 2018)]

Why did a delay in noticing an oncoming vehicle going straight occur on the part of the vehicle turning right?

When did the driver notice the oncoming vehicle going straight?

From here on, we will take a look at the main causes behind the drivers' delay in noticing oncoming vehicles going straight by focusing on accidents caused by the drivers of vehicles turning right involved in accidents between a vehicle turning right and a vehicle going straight from the microdata between 2009 and 2018. First, it is the author's intention to begin by ascertaining the point where the driver first noticed the other vehicle. When did the driver of the vehicle turning right first notice the oncoming vehicle going straight and when did they collide with them?

Accidents from collisions between four-wheel vehicles turning right and four-wheel vehicles going straight feature ~ Preventing a delay in noticing other vehicles is effective for avoiding accidents ~



Fig. 3. Points of travel from when the vehicle turning right enters the intersection until the collision occurs (conceptual diagram)

In the microdata from 2009 - 2018, there were 46 accidents between a vehicle turning right and a vehicle going straight that were deemed to have been caused by a delay in noticing the oncoming vehicle going straight on the part of the driver of the vehicle turning right. Of these, there were 28 accidents where the traveling speed at the point where the driver noticed the oncoming vehicle going straight (④) and the distance between this point and the point where the collision occurred (④→⑤) could be ascertained. For these accidents, the vehicle's speed and these distances were plotted on Fig. 4. In addition, a solid black line was used to indicate the distance needed for a four-wheel vehicle to come to a stop based on calculations on this same graph. The distance needed to come to a stop was found by totaling the brake reaction distance calculated based on a reaction time'⁵ of 0.8 seconds (the solid gray line) and the braking distance calculated based on a deceleration from braking of 0.5G.



*5) Time from after the driver notices the oncoming vehicle going straight until they begin decelerating by applying the brake

Fig. 4. Actual distance between the point where the driver noticed the oncoming vehicle going straight and the point where the collision occurred and the distance needed to stop based on calculations [microdata on 28 accidents (2009 - 2018)] Fig. 4 reveals that in more than 90% of the cases (27 of the 28 accidents), the distance between the point where the driver noticed the oncoming vehicle going straight and the point where the collision occurred was shorter than the distance needed to stop. This indicates that it was theoretically impossible to avoid the collision at the point in time where the driver noticed the oncoming vehicle going straight. In addition, just shy of 90% of the accidents (25 of the 28 accidents) were distributed within the brake reaction area. This reveals that these collisions occurred when the driver failed to notice the oncoming vehicle going straight (distance between the point the driver noticed the other vehicle and the point where the collision occurred = 0m) or when they noticed said vehicle right before the collision and just after they began to decelerate. So then why were they unable to notice the oncoming vehicle going straight until right before the collision was imminent?

What caused the delay in noticing the oncoming vehicle going straight on the part of the driver of the vehicle turning right?

The specific human factors behind 46 accidents deemed to have been caused by a delay in noticing an oncoming vehicle going straight inferred from testimony from the driver of the vehicle turning right as a party to the accident were organized and categorized into Table 3.

The results indicated that a failure to confirm safety factors due to the three factors of "Preoccupied by the area out beyond the right turn," "Did not realize an oncoming vehicle going straight was approaching," and "The vehicle ahead of the driver turned right and the driver thought their vehicle could make it as well (following the vehicle ahead of them)" accounted for approximately 80% of the total (36 out of 46 accidents). We will now take a look at each of these cases.

Table 3. Specific human factors behind accidents between a vehicle turning right and a vehicle going straight deemed to have been caused by a delay in noticing the oncoming vehicle going straight

Specific human factors		
Neglected to pay attention to what was ahead due to being distracted		
Neglected to pay attention to what was ahead due to being absentminded		
Insufficiently checked to ensure safety because the driver was preoccupied with the area out beyond the right turn	15	
Neglected to check to ensure it was safe due to a mistaken impression where the driver did not realize an oncoming vehicle going straight was approaching	15	
Neglected to check to ensure it was safe due to the mistaken impression in which, because the vehicle ahead turned right, the driver thought their vehicle could make it as well (following the vehicle ahead of them)	6	
Other	5	

[Microdata on 46 accidents (2009 - 2018)]

• Cases where the driver was preoccupied with the area out beyond the right turn (microdata on 15 accidents)

These are primarily cases in which it was found, based on the testimony of the parties to the accident, that the driver was not looking at the oncoming vehicle going straight, but was instead looking at the road conditions, vehicles, stores, crossing pedestrians, whether or not there were bicycles, and so forth in the area out beyond the right turn. Why then did this lead them to neglect to check in one direction?

Fig. 5 shows the results of arranging the angles needed to confirm it was safe in cases where the driver is only looking at the lane of oncoming vehicles going straight from the point where the vehicle began turning right and cases where they were looking at this lane and the area out beyond the right turn for the locations where the 15 accidents subject to review occurred. The angles needed to confirm it was safe were determined based on a combination of the width of the crossing road, the crossing angle, and the point where the vehicle began turning right.



[Angles needed to confirm it was safe from the point where the vehicle began turning right]

Fig. 5. Angles needed to confirm it was safe from the point where the vehicle began turning right in cases where the driver was preoccupied by the area out beyond the right turn

[microdata on 15 accidents (2009 - 2018)]

A person's central field of vision is said to be about 40° (20° in either direction). In cases where a driver is only looking at the lane of oncoming vehicles going straight, based on Fig. 5 we can see that they can only perceive things visually in roughly one direction, yet when they view both the aforementioned lane and the area out beyond the right turn this encompasses every angle, representing an area that is two to three times greater than their central field of vision. In other words, compared to a situation in which they are only looking at the lane of oncoming vehicles going straight, such as when they are going straight ahead, this increases the complexity in the sense that now they have to check to confirm that it is safe two to three times as frequently, which presumably could potentially lead to a failure to confirm safety factors with collisions while turning right.

• Cases where the driver did not realize an oncoming vehicle going straight was approaching (microdata on 15 accidents) These are primarily cases in which it was found, based on the testimony of the parties to the accident, that an oncoming vehicle turning right obstructed the driver's field of vision and they failed to realize that an oncoming vehicle going straight was approaching, or there was a situation in which one or two oncoming vehicles in the lane closest to the driver going straight made it through the intersection but they failed to realize another vehicle going straight was approaching from another lane further away from them.

Fig. 6 shows a breakdown of the 15 accidents subject to review in terms of the share of accidents that occurred by whether or not there was a blind spot and the number of lanes of oncoming traffic (including right-turn lanes). Accidents that were impacted by oncoming vehicles turning right, oncoming vehicles going straight that were stopped in traffic congestion, and so forth accounted for two-thirds of all of these cases. In addition, cases where there were a larger number of lanes of oncoming traffic at three or four accounted for just shy of 80% of the total nursing of cases.

The presence of blind spots and a greater number of oncoming lanes of traffic mean that these are inherently locations and spaces where confirmation must be made. Yet despite this, it is presumably conceivable that these drivers neglected to check to confirm it was safe out of the mistaken impression that there were not any oncoming vehicles going straight.



Fig. 6. Share of accidents between a vehicle turning right and a vehicle going straight by whether or not there was a blind spot / number of lanes in cases where the driver did not realize an oncoming vehicle going straight was approaching [microdata on 15 accidents (2009 - 2018)]

• Cases where the vehicle ahead turned right and the driver thought their vehicle could make it as well (following the vehicle ahead of them) [microdata on 6 accidents]

These are primarily cases in which it was found, based on the testimony of the parties to the accident, that since the previous vehicle turned right the driver thought that no oncoming vehicles were approaching, or thought it was safe since the vehicle ahead of them made a right turn. These accidents seem to have occurred because the driver was under the mistaken impression that since the previous vehicle turned right, this

effectively served as a priori confirmation that it was safe.

Fig. 7 shows a breakdown of driving behavior at intersections. The share of cases where the driver proceeded ahead without stopping accounted for more than 80% (five out of six accidents) of cases where the driver followed the vehicle ahead of them, which represents a significant difference in that this is just over 50% for all 46 accidents on the whole (24 out of 46 accidents). It is believed that a sentiment of wanting to rush through the right turn without attempting to act prudently, such as by coming to a temporary stop, could potentially give rise to mistaken impressions like this on the part of drivers.



Fig. 7. Comparison of driving behavior at an intersection

[microdata on 46 accidents (2009 - 2018)]

feature

Countermeasures against the delay in noticing oncoming vehicles going straight and their expected results

It has become apparent that having the driver preoccupied with the area out beyond the right turn, the presence of blind spots, a large number of lanes, and mistaken impressions caused by the movement of the vehicle up ahead have led drivers to neglect to check for oncoming vehicles going straight and thus to a delay in noticing other vehicles. On such occasions, it is important to adopt an attitude of placing the highest priority on checking for oncoming vehicles going straight and not rushing into making a right turn. Specifically, the driver must repeatedly go back and forth between checking the lane of oncoming vehicles going straight again. They must then thoroughly ensure that they proceed into the intersection without rushing the right turn, such as by coming to a temporary stop or moving at very low speeds.

In this sense, it will be necessary to provide support for making right turns, as such actions place a significant burden on the driver, from the perspective of the road environment and vehicle technology. From a road environment perspective, the hope is that in the future progress will continue to be made on alleviating the burden placed on drivers who have to check the lane of oncoming vehicles going straight. This can be done by shifting the right turn lane closer to the oncoming vehicle lane to make it easier to see, and increasing the number of traffic signals equipped with right turn-only signs (right arrows) primarily for intersections with a large number of lanes. Furthermore, from a vehicle technology perspective the hope is that efforts such as providing drivers with advance warning of the approach of oncoming vehicles going straight can lead to them properly noticing these other vehicles, determining the danger posed, and acting to avoid it. This can be achieved through cutting-edge safety technologies such as warnings through detection by automatic sensors, damage mitigation brakes suited to handling collision accidents while turning right, and signals between vehicles and between the road and vehicles.

For the 28 accidents from Fig. 4, back-of-the-envelope estimates of the number of accidents that could have potentially been stopped before the collision^{•6} were made for different cases, with the results shown in Fig. 8 and Fig. 9, respectively. These cases are: 1) An alarm notifies the driver of the oncoming vehicle going straight at the point where the vehicle began turning right (Fig. 3 (3)), and the driver applies the brakes (or damage mitigation brakes activate). 2) An advance notification^{•7} from signals between vehicles or between the road and the vehicle notifies the driver at the stage right before they begin making the right turn (point where the vehicle entered the intersection (Fig. 3 (1)) or the point where the vehicle came to a temporary stop (Fig. 3 (2))) and the driver applies the brakes. The reaction time (0.8 seconds), deceleration (0.5G), and traveling speed when the driver noticed the oncoming vehicle going straight were assumed to be the same as in Fig. 4.



Distance from the point where the vehicle began turning right to right before the collision (m) Fig. 8. Whether or not a collision occurred in cases where the driver noticed the other vehicle and braked at the point where the vehicle began turning right [microdata on 28 accidents (2009 - 2018)]



Distance from the point where the vehicle entered the intersection / point where the vehicle came to a temporary stop to right before the collision (m)

Fig. 9. Whether or not a collision occurred in cases where the driver noticed the other vehicle and braked at the stage prior to starting to turn right [microdata on 28 accidents (2009 - 2018)]

*6) The point right before where the vehicle turning right entered the line of motion of the oncoming vehicle going straight

*7) Assistance systems to prevent collisions while turning right through the use of signals considered in sources like the Plan for Promotion of the Development of Advanced Safety Vehicles (ASV) by the Ministry of Land, Infrastructure, Transport and Tourism

Based on the results of these back-of-the-envelope estimates, in the case of 1) collisions could have been avoided 50% of the time (14 out of 28 accidents) (Fig. 8). In the case of 2), collisions could have been avoided in more than 70% of the time (20 out of 28 accidents) (Fig. 9). As the above indicates, combining improvements in driver awareness and behavior with assistance from the road environment and vehicle technology could presumably give rise to greater effects in terms of reducing accidents.

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5 Conclusion ••••••

This issue took a look at why accidents between a vehicle turning right and a vehicle going straight occur and the sorts of countermeasures that are effective for combating them. The majority of these types of accidents occur due to a delay in noticing the oncoming vehicle going straight by the driver of the vehicle turning right. The three factors below serve as the main causes giving rise to this delay in noticing the other vehicle, and it is important that we once again recognize the difficulty inherent in making right turns.

- The increased complexity of making confirmation due to the wide angle needed to confirm it was safe at the intersection made it difficult to sufficiently confirm that it was safe
- The presence of blind spots and a large number of lanes engendered a mistaken impression in the driver that there were no oncoming vehicles going straight approaching and they neglected to confirm that it was safe
- A sentiment of rushing through the right turn so as to follow after the vehicle before them engendered in the driver the mistaken impression that the previous vehicle had already provided a priori confirmation that it was safe and they neglected to confirm that it was safe

Countermeasures include:

- Improve the awareness / behavior of the driver of the vehicle turning right: They must repeatedly go back and forth between checking the lane of oncoming vehicles going straight, the area beyond the right turn, and then the lane of oncoming vehicles going straight again. They must then thoroughly ensure that they proceed into the intersection without rushing the right turn, such as by coming to a temporary stop or moving at very low speeds.
- · Assistance from the road environment: Shift right-turn lanes closer to the oncoming vehicle lane and adopt traffic signals equipped with right turn-only signs (right arrows) primarily for intersections with a large number of lanes.
- · Assistance from vehicle technology: Practically implement and adopt cutting-edge safety technologies such as warnings via sensor detection, damage mitigation brakes suited to handling collision accidents while turning right, and advance warnings through the use of signals between vehicles and the between road and vehicles.

Combining and disseminating the countermeasures listed above in an effective manner can be expected to prevent a delay in noticing other vehicles on the part of drivers, and could help to further reduce accidents between vehicles turning right and vehicles going straight.

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