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Analysis of Accidents in Right turn across path (for left-hand traffic) Between Cars and Motorcycles at Night

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1. Background

95% of casualties in motorcycle accidents (total of primary and secondary parties) occur due to vehicle-vehicle accidents (total from between 2015 and 2019; information shown below is for this time period). In 92% of these vehicle-vehicle accidents, the opposing vehicle is a car, meaning that most motorcycle accidents involve a motorcycle and car. Furthermore, crossing collisions are the most common type of accident, with accidents in right turn across path being the second most common type. The fact that accidents in right turn across path—uncommon in the case of accidents between cars—are so common in the case of motorcycle accidents is one of the main features of accidents in right turn across path (Fig. 1). In 91% of accidents in right turn across path involving a motorcycle and a car, the car is the right-turning vehicle and is the primary party (i.e., the driver involved in the accident with the most negligence; when negligence is the same, the driver that suffered the least amount of personal injury is the primary party), while the motorcycle is the straight-traveling vehicle and is the secondary party. In this research, we analyzed this type of accident in right turn across path. Also, when looking at which types of motorcycle accidents tend to occur in the daytime and which tend to occur at night, it can be seen that accidents in right turn across path are the most common type of accident that occurs at night. Although numbers of motorcycle rider casualties (total of primary and secondary parties) due to accidents in right turn across path that occur in the daytime and those that occur at night are roughly the same (Fig. 2), the risk of such accidents is higher at night as described above. In this research, we focused on accidents in right turn across path that occur at night and analyzed the features of accidents in right turn across path in an attempt to find ways to reduce such accidents.

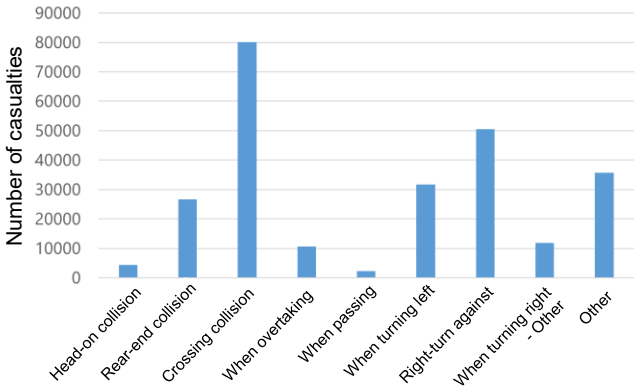

Fig. 1 - Number of motorcycle rider casualties by type of accident (total of primary and secondary parties)
(vehicle-vehicle accidents involving a car and a motorcycle)

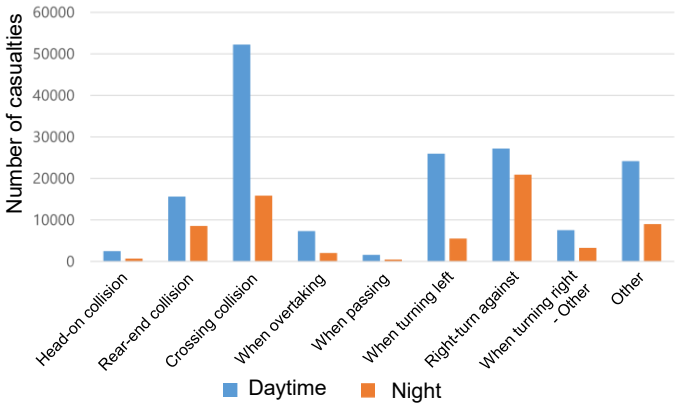

Fig. 2 - Number of motorcycle rider casualties by type of accident (total of primary and secondary parties)
(vehicle-vehicle accidents involving a car and a motorcycle)

Among the human factors cited in accidents in right turn across path in which the primary party was a right-turning car, “delay in noticing” made up 88%, while “misjudgment” made up the remaining 12%. Because these two causes are considered to be different, we analyzed "delay in noticing" and "misjudgment" separately.

In subsequent analysis, we will be using the term “accident risk”. An indicator which showing how many drivers have the opportunity to drive on how many roads is referred to as “induced exposure”.

However, because there is no statistical data that can be used directly, we will be using other types of data in its

stead. One such type of data is “number of secondary parties that did not commit a legal violation”. Past research(1) exists which has shown that the number of secondary parties who did not commit a legal violation is proportional to the “induced exposure”. With this in mind, in this research, we assessed the risk of an accident occurring by dividing the “number of driver casualties” by the "number of non-negligent secondary parties”.

In this research, we refer to this risk being the “accident risk”. It is necessary to keep in mind that the value for accident risk is a relative value that is helpful when making comparisons within the group being analyzed.

2. Accidents in right turn across path due to “delay in noticing”

Shown below is analysis performed when “delay in noticing” is the human factor responsible for an accident in right turn across path involving a right-turning car. From 2015 to 2019, the total number of motorcycle rider casualties was 22,889 in the daytime and 17,644 at night. Furthermore, the “number of secondary parties that did not commit a legal violation” among those riding a motorcycle totaled 74,854 in the daytime and 32,779 at night. Using these to calculate accident risk gives 0.31 in the daytime and 0.54 at night. This shows that the accident risk at night is 1.8 times that of in the daytime and means that the risk of an accident in right turn across path occurring at night is considerably higher than in the daytime.

We then analyzed what influence the speed of straight-traveling motorcycle had in accidents in right turn across path that occurred in both the daytime and at night. We found that the majority of motorcycle rider casualties occurred at around 30 km/h in both the daytime and at night. Furthermore, when looking at accident risk, we found that accident risk in both the daytime and at night increased as speed increased (Fig. 3). Here, accident risk is calculated by dividing “number of motorcycle rider casualties by straight-traveling motorcycle danger perception speed” by “number of secondary parties that did not commit a legal violation by danger perception speed” among those riding a motorcycle. Why do the drivers of right-turning cars experience a delay in noticing straight-traveling motorcycles moving at a high speed, the result of which is an increase in accident risk? We made the following observations regarding this question. In order to avoid an accident in right turn across path, the driver of the car waiting to turn right must notice the straight-traveling motorcycle driving when the motorcycle is at a distance that is proportional to its speed. In other words, if we assume that it takes 3 seconds for the driver of a car that has decided to turn right to make the right turn and proceed to the crash location, the driver of that car must notice any straight-traveling motorcycle moving at a

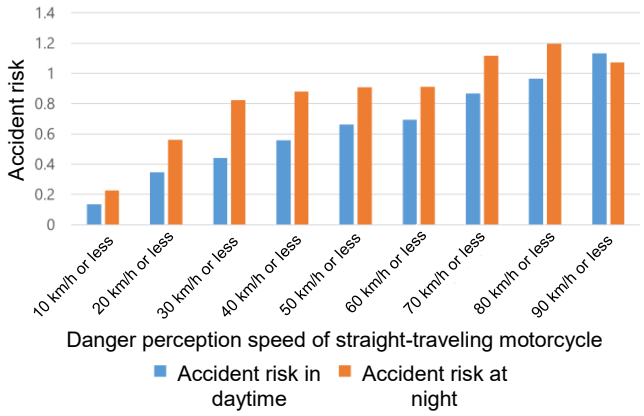

Fig. 3 - Accident risk by danger perception speed due to “delay in noticing”

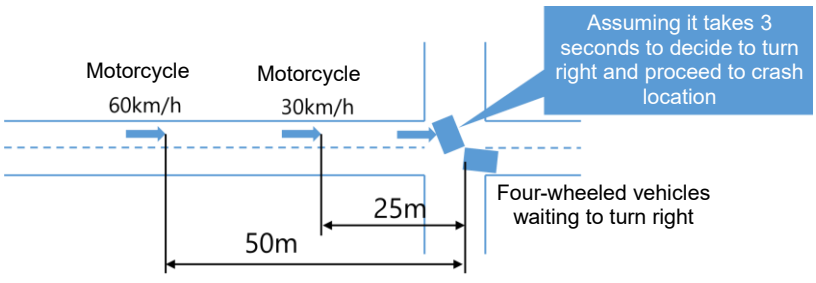

Fig. 4 - Relationship between straight-traveling motorcycle speed and distance

speed of 30 km/h when that motorcycle is 25 m or more ahead in order to avoid an accident in right turn across path. Similarly, when the speed is increased to 60 km/h, it is necessary for the motorcycle driving straight ahead to be noticed when it is 50 m or more ahead (Fig. 4). Noticing a motorcycle that is far away is more difficult than noticing a motorcycle that is nearby, which is understandable considering the view angle from which the motorcycle is seen by the driver of a right-turning car. The view angle of a motorcycle that is far away will be small, while that of a motorcycle that is nearby will be comparatively larger. Recognizing the existence of something with a small view angle is difficult, and delays in noticing such objects is a cognitive characteristic of human beings.

Next, by looking at the day-night ratio of accident risk, it can be seen that when the speed of a straight-traveling motorcycle is low, the day-night ratio (accident risk at night ÷ accident risk in the daytime) will be large, resulting in a higher accident risk at night than in the daytime. When the distance between a right-turning car and a straight-traveling motorcycle is short (at a slow speed), it appears to be significantly more difficult for the driver to notice a straight-traveling motorcycle at night than in the daytime. Conversely, when the distance is long (at a fast speed), it appears there is little difference in noticing whether it be at night or in the daytime (Fig. 5).

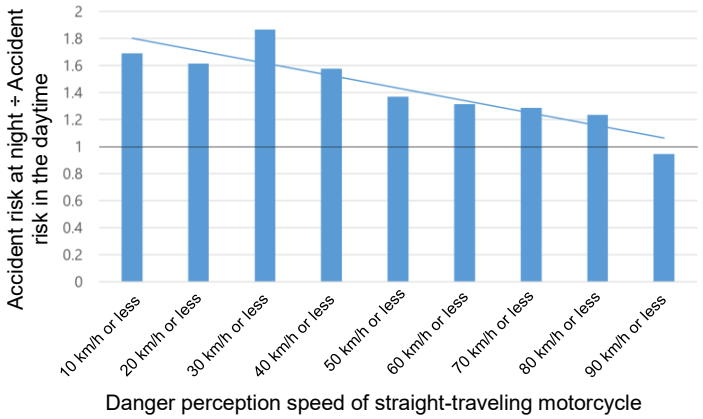

Fig 5. - Day-night ratio of accident risk by danger perception speed

When the distance is short, it is easier for drivers to notice motorcycles in the daytime because the motorcycle and its rider are more visible, while at night only the headlights are conspicuous, making noticing more difficult. Furthermore, when the distance is long, parts of the motorcycle other than the headlights are not as conspicuous even in the daytime, creating a situation that is almost the same as at night, leading us to assume that the difficulty drivers have in noticing motorcycles does not change significantly between day and night. Accordingly, it is necessary for extra attention to be paid at night, even when speeds are slow.

Finally, we analyzed what influence the age of the driver of the right-turning car had in accidents in right turn across path that occurred in both the daytime and at night. When looking at what influence age had in accident risk, we found that accident risk was higher at night than in the daytime regardless of age group. Furthermore, we found that accident risk was considerably higher for elderly groups than that of middle-age groups at both night and in the daytime. Here, accident risk is calculated by dividing "number of motorcycle rider casualties by right-turning car driver age group" by "number of secondary parties that did not commit a legal violation by age group" among those driving a car. In the daytime, the accident risk for people aged 75 and older is 3.3 times higher than the accident risk for people aged 35 to 44, and at night, this ratio increases to 5.2 times (Fig. 6). This means that a marked increase in accident risk due to age is seen at night when compared to in the daytime. It appears that the elderly may have a lower cognitive ability to notice motorcycles than middle-age groups, especially at night, meaning it is imperative that immediate action be taken for the elderly.

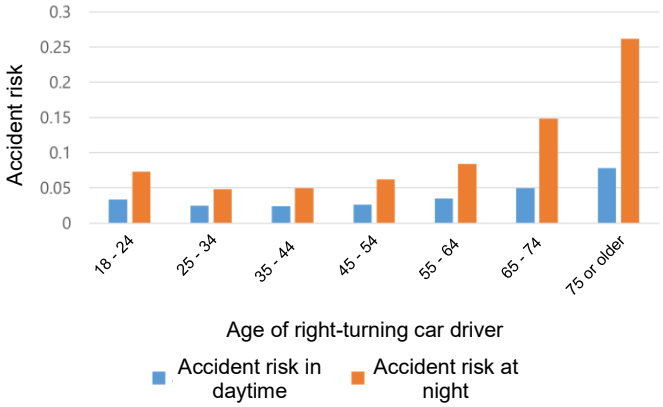

Fig. 6 - Accident risk by right-turning four-wheeled vehicle driver age group due to "delay in noticing"

3. Accidents in right turn across path due to "misjudgment"

Shown below is analysis performed when "misjudgment" is the human factor responsible for an accident in right turn across path involving a right-turning car. From 2015 to 2019, the total number of motorcycle rider casualties was 2,981 in the daytime and 2,474 at night. Furthermore, the "number of secondary parties that did not commit a legal violation" totaled 74,854 in the daytime and 32,779 at night. Using these to calculate accident risk resulted in 0.040 in the daytime and 0.075 at night. Accident risk at night is 1.9 times that in the daytime, and it can be seen that the risk of accidents in right turn across path at night is considerably higher than in the daytime in the same manner as "delay in noticing".

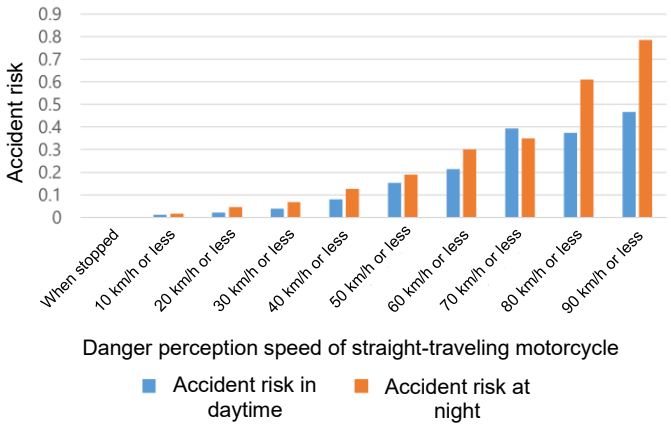

Fig. 7 - Accident risk by danger perception speed due to "misjudgment"

We then analyzed what influence the speed of straight-traveling motorcycle had in accidents in right turn across path that occurred in both the daytime and at night. When looking at accident risk in the daytime and at night, we found that accident risk increases as the speed increases in both the daytime and at night and in the same manner as "delay in noticing". However, compared to "delay in noticing", the influence of speed in the case of "misjudgment" was considerably stronger, with this influence being even stronger at night than in the daytime (Fig. 7). In the case of "delay in noticing", the accident risk at night at a speed of 80 km/h or less is 1.4 times that when 40 km/h or less.

However, in the case of “misjudgment”, the accident risk at night at a speed of 80 km/h or less is 4.9 times that when 40 km/h or less. In this way, the influence of speed on accident risk at night due to "misjudgment" is strong, and it appears that it in order to reduce accidents, it is more important to reduce the speed of straight-traveling motorcycles than in the case of “delay in noticing”. One factor of “misjudgment” is “misjudgment of speed and/or distance”. Although it is necessary for drivers to make accurate judgments regarding the speed and distance of a distant, fast-moving motorcycle in order to avoid an accident, it has been observed that human cognitive characteristics can make such judgments difficult, meaning this is a possible cause for the strong influence speed has on accident risk due to “misjudgment”.

We then analyzed what influence the age of the driver of the right-turning car had in accidents in right turn across path that occurred in both the daytime and at night. When looking at what influence age had in accident risk, we found that accident risk was higher at night than in the daytime regardless of age group. Furthermore, we found that accident risk was considerably higher for elderly groups than that of middle-age groups at both night and in the daytime. When compared with “delay in noticing”, it was found that accident risk in the daytime increased the older the driver. In the daytime, the accident risk for people aged 75 and older is 5.3 times higher than the accident risk for people aged 35 to 44, and at night, this ratio increases to 5.7 times (Fig. 8). Furthermore, in the case of “delay in noticing”, the ratio of accident risk in the daytime is also 3.1 times higher, with this ratio increasing to 4.9 times at night.

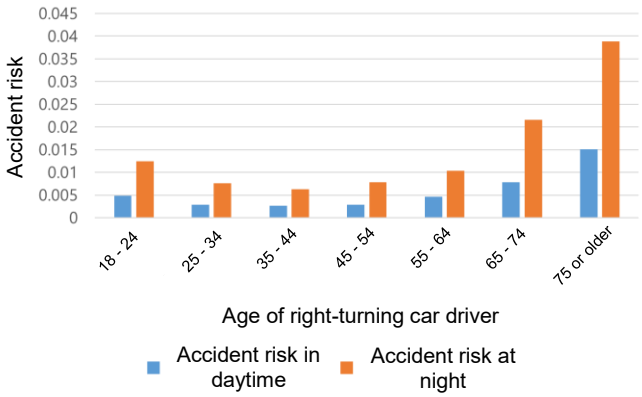

Fig. 8 - Accident right by right-turning car driver age group due to “misjudgment”

4. Direction of accident reduction measures of accidents in right turn across path

Accidents in right turn across path are the most common type of accident at night and accident risk at night is approximately double that of in the daytime. Accident risk increases in proportion to straight-traveling motorcycle speed and we observed that the influence of straight-traveling motorcycle speed was even stronger in accidents where the human factor of “misjudgment” was to blame. In the case of “delay in noticing”, accident risk is higher at night than in the daytime even at low speeds (30 to 40 km/h). Furthermore, the accident risk faced by elderly drivers of right-turning cars was higher than that faced by other age groups. This is especially true at night, with it being observed that accident risk is 5 times higher for later-stage elderly drivers (75 or older) at night than for drivers aged 35 to 44. Although accidents in right turn across path have been a significant portion of all car accidents for years, few concrete measures to address such accidents have been implemented. Based on the features of accidents in right turn across path clarified by this study, we would like to propose the following aims for measures designed to reduce accidents in right turn across path between cars and motorcycles.

<Motorcycles>

Soft measure: Motorcycle riders should be advised to reduce their speed when they encounter a car that is waiting to turn right, particularly at night.

Hard measure: A system that enables drivers to more quickly notice straight-traveling motorcycles even from far away should be urgently developed. Such a system could include the use of lights that improve the conspicuity of motorcycles (e.g. yellow-colored headlights/high-intensity lights/light arrangements that make the motorcycle seem larger in appearance).

<Cars>

Soft measure: Drivers of cars should be educated regarding the fact that it is easy to miss the presence of a straight-traveling motorcycle, especially at night, and that a sufficient amount of time is necessary to perform a safety check to confirm that there are no straight-traveling opposing vehicles.

Hard measure: Because elderly drivers face a higher accident risk than drivers in other age groups, hard measures that target the elderly—including ever more efficient systems designed to suppress accidental acceleration—may be necessary in addition to the measures described above. Brake systems (systems that avoid or mitigate crashes by detecting the movement of an oncoming, straight-traveling vehicle) that work to mitigate crashes with oncoming vehicles when turning right have begun to be installed in cars and the increased adoption of such systems is urgently needed. Furthermore, the development of functions that warn drivers of oncoming/approaching vehicles utilizing road-to-vehicle communications may also prove effective in reducing such accidents.

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