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Traffic accidents are one of the main causes of death in Indonesia, with human error being found to play a major role. The aim of this study is to analyze the human error factors that contribute to car and motorcycle traffic accidents. The data were collected from interviews with five car drivers and five motorcyclists from five Indonesian cities (Aceh, Pekanbaru, Semarang, Pontianak, and Gorontalo). The research found that there were no recognition error and decision error differences between car drivers and motorcyclists as both made recognition errors such as misestimations of distance and speed, and both made decision errors such as not avoiding a situation immediately, and performance errors such as stepping on the gas pedal by mistake. However, they were differences in other errors. For example, drivers tended to become sleepy, whereas motorcyclists felt tired, under time pressure, and did not have proper licenses. The results of this study could be used to make drivers/riders more aware of the cognitive aspects that contribute to road safety.

Keywords

Car driver, human error, motorcyclist, psychological factors, traffic accident

Indonesia has a young, actively mobile population that usually commutes long distances from their homes to the office every day. However, because of the poor public transportation in Indonesia, most young people prefer to use private vehicles or motorcycles. In 2017, there were 105,150,082 privately owned vehicles in Indonesia (Biro Pusat Statistik) (2017), 82% of which were motorcycles.

The increasing number of vehicles on Indonesian streets and roads has resulted in a commensurate increase in road accidents. The Police Traffic Corps (Korlantas) reported that road accidents increased from 88,897 in 2014 to 96,073 in 2015, an 8.07% increase (Maulana, 2017) to

105.374 accidents in 2016, an increase of 9.68%, with Korlantas (2016) reporting an increase in traffic accidents, most of which were caused by motorcycles (“Roda Dua, the biggest contributor to accidents in Indonesia (Roda dua penyumbang kecelakaan terbesar di Indonesia)”, 2017; “Ministry of Transportation: Two-wheeled vehicles are the biggest contributor to accidents (Kemenhub: Kendaraan roda dua penyumbang terbesar kecelakaan),” 2017).

However, as there are both internal and external factors associated with accidents, the accident rate cannot be automatically correlated to the number of vehicles on the road. External factors such as road conditions, weather, street lighting, and vehicle condition are related to road environment factors and are outside the riders/drivers control (Hammad et al., 2019; Lankarani et al., 2014; Manan, Várhelyi, Çelik, & Hashim, 2018; Wang & Zhang, 2017), and internal factors, such as personality (Alavi et al.,

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2017; Iversen & Rundmo, 2002), attitude toward road safety (West & Hall, 2008), cognitive aspects such as attention, concentration, and memory (Lundberg, Hakamies-Blomqvist, Almkvist, & Johansson, 1998; Anderson, Rizzo, Shi, Uc, & Dawson, 2005), and driving skills (McGwin & Brown, 1999), are related to the drivers/riders behavior and knowledge. Previous studies have found that the main causes of accidents were related to rider/driver characteristics (Issa, 2016; Rolison, Rege, Moutar, & Feeney, 2018; Zuraida, Iridiastadi, & Satalaksana, 2017), and detailed accident analyses in many countries including Indonesia have found that 70 to 90 percent of accidents were caused by the driver negligence or what is usually called human error (Rayanti, 2016; Singh, 2015; "Traffic accidents are commonly caused by human error (Kecelakaan lalu lintas umumnya karena human error)", 2015; Singh, Kushwaha, Agarwal, & Sandhu, 2016). Risky riding/driving behaviors such as speeding, running red lights, and dangerous overtaking have all been found to increase crash risks (Chang & Yeh, 2007, Ivers et al., 2009), s (Chang & Yeh, 2017; Elliott & Thomson, 2010), with hazardous external factor situations, also being found to effect risky behavior, especially in motorcyclists (Maulina, Danilasari, Nazhira, & Jufri, 2018).

Four driver factors that cause accidents have been identified: recognition errors, decision errors, performance errors, and other errors: with recognition and decision errors being related to cognitive negligence, performance errors being more related to driving skills, and other errors being found to be related to the driver's physical health (Singh, 2015).

Horswill and Helman (2003) found that there were no differences in risk-taking behavior and accident likelihood between car drivers and motorcyclists; however, they found that motorcyclists had better hazard perception than car drivers. Hazard perception has been identified as a cognitive aspect that has a significant influence on driver behavior as the failure to detect hazards can contribute to rider error and increase accident likelihood (McKenna & Horswill, 1999). Therefore, this study sought to compare the car driver and motorcyclist traffic accident errors. Studies on accident events tend to be relatively general in nature, with few studies having differentiated the human error factors

between motorcycle riders and car drivers. Because there are a higher number of motorcycle accidents than four-wheeled car accidents, this study focused on the following question: Are there any differences in the causes of motorcycle and car accidents in Indonesia?

Human error in traffic accident

Human error can result in accidents when the driver/rider has high-risk driving behavior (Chang & Yeh, 2007; Parker, Reason, Manstead, & Stradling, 1995; Reason, Manstead, Stradling, Baxter, & Campbell, 1990). Reason et al. (1990) claimed that human error was evident in driving/riding mistakes and memory lapses and could occur when drivers/riders consciously performed illegal or harmful behavior (Reason et al., 1990). Nonetheless, these errors (slips, lapses, and violations) are related to errors of judgment in human information processing or cognitive functioning (Allahyari et al., 2008).

However, to what extent do these cognitive functioning errors cause traffic accidents? Allahyari et al. (2008) claimed that not all cognitive errors would result in traffic accidents as accidents occur when there is a high-level error or a mistake made in a high-risk situation. The risk of accidents is experienced not only by the driver/rider but also by other people; therefore, human error is the failure of the driver/rider to adjust to the task difficulties or conditions that need to be overcome (Elslande & Fouquet, 2007), which means that the ability to process information and adjust the skills to operate the vehicle are important for safe driving/riding.

Driving/riding skills are generally acquired through training, which generally continues until the trainee can pass the license test. However, in Indonesia, only car drivers are required to go to driver training schools and sit a test before getting their license, whereas motorcyclists usually learn how to ride from an experienced rider or by trial and error. Therefore, without a proper training process, a person would be more likely to make errors when driving/riding tasks as drivers/riders act based on their knowledge (Elslande & Fouquet, 2007). Therefore, as the significant differences in the training/licensing process could affect the cognitive functions of car drivers and motorcyclists, it is important to understand how these cognitive functions affect

the road accident degree for these two vehicle types.

As outlined, the four main driver/rider errors are recognition errors, decision errors, performance errors, or other errors (Singh, 2015). A recognition error happens when a person is easily distracted, cannot concentrate, and is unable to control the environment correctly; for example, when the traffic is complex, and there are many simultaneous stimuli, this places heavy demands on driver/rider concentration and control. Decision errors are mistakes made when poorly perceiving the distance and speed between the driver/rider's vehicle and another vehicle, not predicting another driver/rider's behavior, driving/riding too fast round a curve, or just driving/riding too fast. Performance errors occur when the driver/rider does not have the skill to exercise control in a new situation, and other errors include the effects of fatigue and/or sleepiness on driver/rider ability. As shown in Table 1, most traffic accidents are caused by recognition and decision errors in Indonesia (Singh, 2015).

Table 1. *Types of errors that cause traffic accidents*

| Type of error | Total | Percentage |
|-----------------------|---------|------------|
| Recognition error | 845,000 | 41% |
| Decision error | 684,000 | 33% |
| Performance error | 210,000 | 11% |
| Non-performance error | 145,000 | 7% |
| Other | 162,000 | 8% |

Data reference: NMVCCS (2005–2007).

Figure 1 shows a model to describe the human error mechanism (Hale, Quist & Stoop, 1988; Hale & Stoop, 1988; Michon, 1985 (in Elslande & Fouquet, 2007)).

Methods

Participants

The participants in this study were motorcyclists and car drivers who had been involved in an accident as the perpetrator. Most participants were males who came from several cities in Indonesia: Aceh, Pekanbaru, Semarang, Pontianak, and Gorontalo.

Research design and instrument

This was a qualitative study using an illustrative case study method. Data were collected from interviews based on interview guidelines that were designed to probe the participants' detailed driving/riding experiences associated with the accident. The participants were asked several questions about the cause of the accident in terms of the internal and external (environmental) factors and were also asked about the cognitive and affective aspects of the accident they had experienced. The researchers analyzed the dynamics of the traffic accident from a psychologist's point of view.

Procedure

The researchers consulted with regional police to identify traffic accident perpetrators that had interesting stories. The chosen participants were both motorcycle riders and car drivers who had caused an accident that had affected another rider/driver, pedestrian, or passenger. The interviews with the participants who were either prisoner of the police or home prisoners waiting for trials were conducted in a closed room inside the local police's office. The interviews were around 75 (seventy-five) minutes and were recorded using a voice recorder.

Results

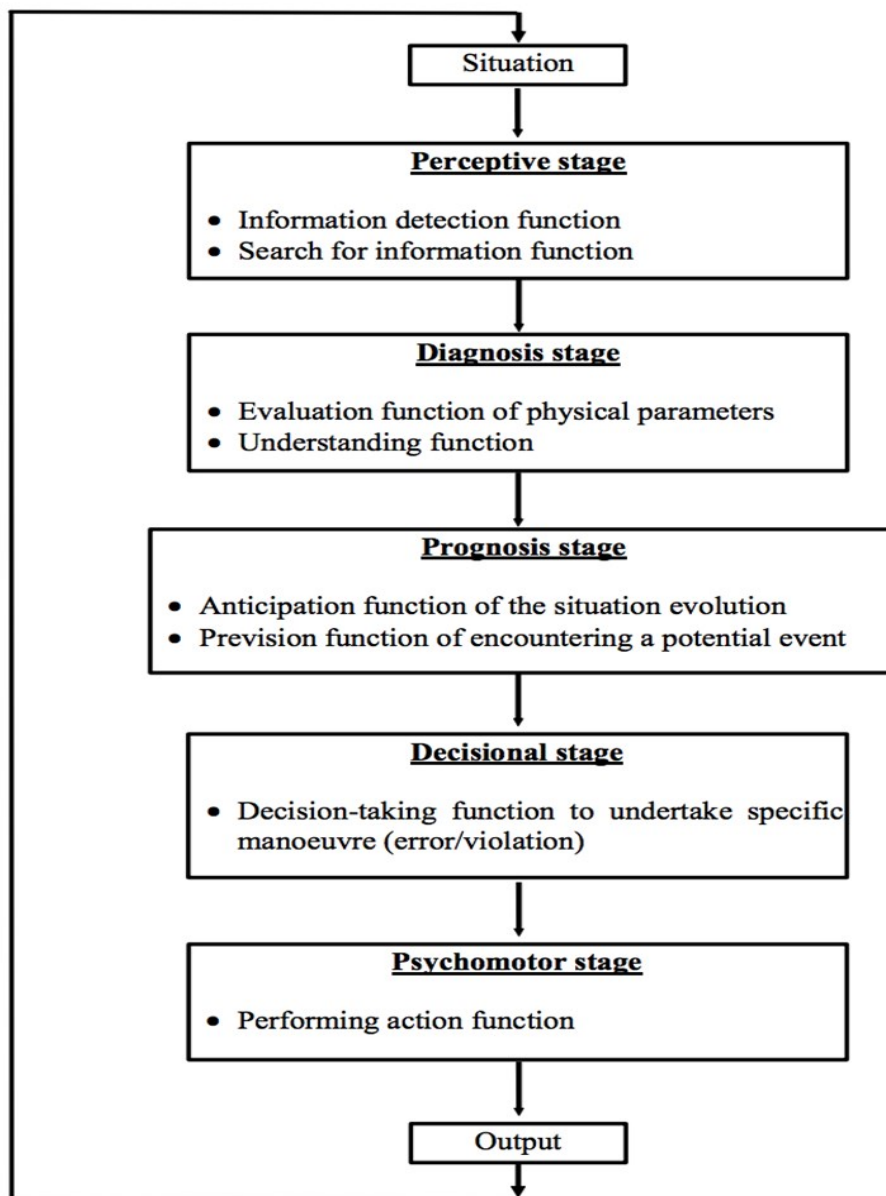
Interview with the car drivers

Interviews were conducted with five accident perpetrator car drivers that ranged in age from 21 - 52. Four of the drivers had a SIM A (car license), and one person did not have a license.

Driver 1 (D-1). D-1's accident happened at noon when there was heavy traffic but no traffic jams. D-1 felt sleepy while driving and had fallen asleep (other error). He was woken by his kids' screaming when the car swerved to the right. When he woke up, the gap between his car and a car in front was very close (0.5 meters); hence, the crash could not be avoided (decision error). Therefore, this accident was categorized as a decision error and other errors.

Driver 2 (D-2). The accident occurred in the

Figure 1. Series of riding activity functions



morning on a rocky road. At that time, D-2 had only been driving for six months. Even though there was little traffic, D-2's vision was blocked by dust after a big truck passed his car. As he was driving quite slowly, he was shocked and panicked when he realized he had hit something; however, he could not see what it was because his car was quite high (recognition error). Panicking, D-2 tried to hit the brakes but unexpectedly hit the gas pedal (performance error), which dragged the person/s along until his car stopped. When D-2 looked under the car, there was a mother and three children lying on the street. This accident was categorized as a recognition error and performance error.

Driver 3 (D-3). D-3's accident happened at noon in the middle of a straight, quiet road. He was driving around 40-50 km/hour and was in a rush to reach his destination (other error). When he tried to overtake a car in front of him from the left side, he saw a motorcycle behind him and thought it was safe to move and change lanes as he had already turned on his signal (decision error). Therefore, he was shocked when he realized that the motorcyclist had grazed his car and fallen. D-3 did not have time to avoid the accident as he had misjudged the speed of the motorcycle and its distance from his car (recognition error); therefore, this accident was categorized as a recognition error,

decision error, and other error.

Driver 4 (D-4). The accident happened in the evening on a deserted road. Different from the previous three drivers, the road was slightly curvy. D-4 was on the way home from lunch with his family and felt very sleepy (other error) and wanted to take a rest; however, his child was sick and wanted to go home. Therefore, D-4 continued to drive, but as he was not fully aware of the situation around him (recognition error), he hit several motorcycles in front of his car. He was only going about 40 km/hour but made no effort to avoid the accident because his awareness was low due to sleepiness (other error). D-4 admitted that the accident was caused by his sleepiness (other error); therefore, the accident was categorized as a recognition error and other errors.

Driver 5 (D-5). The accident happened in the morning and the weather was fair. While driving along a two-way road, D-5 was thinking about his sick mother, which distracted his attention. Unconsciously, he took the wrong lane when turning right (performance error) from the left lane at 30 km/hour (decision error). He also did not pay attention to the vehicles coming from behind (recognition error) and was therefore shocked when a motorcycle suddenly hit his car from behind; therefore, the accident was caused by recognition error, decision error, and performance error.

Summary of the interviews with the car drivers. Road conditions such as dust can affect a driver's vision. The car drivers also made errors because of a lack of attention to the surroundings, so they were shocked when they saw another car/motorcycle in front/behind them (recognition error and other error). The lack of concentration factors were sleepiness and personal matters such as hurrying. Lack of driving experience also affected one driver's ability to deal with the situation and he hit the gas pedal instead of the brakes (performance error).

Interview with the motorcyclists

Interviews were conducted with (five) motorcycle traffic accident perpetrators, four of which were in early adulthood, and one of which was

underage. All interviewees were asked to describe the accident situation, the time it happened, the victims involved, and the cognitive factors they felt contributed to the accident.

Rider 1 (R-1). R-1's confession claimed that the accident happened on a wide, straight road, and the weather was fine. The accident occurred because he was not aware that a person was crossing the road (recognition error). He also did not realize that he had hit the person because he blacked out immediately after the accident (recognition error). R-1 said that as he suffered from cataracts, he was unable to see clearly, and didn't see a person crossing the road. Therefore, what happened to R-1 could be categorized as a recognition error. Further, because he could not see clearly, R-1 was unable to make a decision to avoid the accident; therefore, R-1 also made a decision error.

Rider 2 (R-2). The accident happened during sunny weather. R-2 was riding his motorcycle alongside a car on a wide street. However, R-2 was still moving when the car beside him stopped to give way to a person crossing the street; therefore, R-2 said that he did not see the person crossing the street because the car beside him had blocked his vision (recognition error). Therefore, the accident happened because R-2 did not pay attention to the situation around him and did not realize that the car beside him had stopped. As he was on the left lane, he had not anticipated that a person would be crossing the street and did not stop (decision error). Therefore, R-2 made a recognition error and a decision error.

Rider 3 (R-3). Different from the other two drivers, R-3 had an accident on a wet winding road at night. A motorcycle coming from the opposite direction suddenly turned its headlights on, which dazzled R-3, and he could not see clearly until he saw a motorcycle in front of him (recognition error). As the gap between them was very small, the accident could not be avoided (performance error). After the crash, he blacked out. According to R-3, he was in shock and did not have time to hit the brakes (decision error). In the interview, R-3 also admitted that he was in a hurry on the night of the accident because it was late, and he had been asked to get

home quickly by his parents (other error). Therefore, R-3 made a recognition error, a decision error, a performance error, and another error.

Rider 4 (R-4). R-4 did not have a license (SIM C). It was drizzling on the day of the accident and R-4 wanted to reach his destination quickly (other error); therefore, he decided to speed at 120 km/hour (decision error). At that time, he was riding with his brother and there was another motorcycle crossing the street without lights (recognition error). On seeing the other motorcycle, R-4 quickly turned the bike but unexpectedly hit a pile of stones. Therefore, R-4 made a recognition error, a decision error, a performance error, and another error.

Rider 5 (R-5). The accident happened in the morning and the weather was fine. R-5 was riding down quite a wide street with a treed center island that was blocking R-5's vision (recognition error). He was riding his motorcycle quite fast (around 70 km/hour) because he wanted to reach his hometown quickly to see his sick parent-in-law (decision error). Suddenly, he saw a foot come down from the center island to cross the street (recognition error) and he decided to swerve to the left, which caused the accident. Therefore, R-5 made a decision error and performance error because he was speeding and was not paying attention.

The summary of interview with the motorcyclists. The road condition was not the reason for motorcycle accidents and therefore, there were no external factors that contributed to the accidents. In all cases, a lack of awareness made each of them fail to anticipate the situation around them, which was evident from their surprise when a person or vehicle suddenly appeared (recognition error). The poor driving behavior was aggravated by high speed (other error) and riding too close to another vehicle (decision error). Therefore, inappropriate riding behavior also contributed to accidents (performance error).

Discussion

The aim of this study was to identify the human error factors that contributed to motorcycle and car accidents. It was found that both car drivers

and motorcyclists made the same sort of recognition, decision, and performance errors, but made different other errors.

Most accidents were found to be caused by recognition error; for example, one driver's view was blocked by dust, and one rider was blocked by an adjacent car. This result was in line with the findings in Singh (2015), MAIDS (2004), and Penumaka, Savino, Baldanzini, and Pierini (2014), in which it was found that perception failure; that is, a failure to detect risky/dangerous situations; was a major factor in car and motorcycle accidents. Basically, recognition errors are made when motorcyclists or car drivers fail to comprehend the environment; that is, they lack situation awareness (Endsley, 1995).

One aspect that has to be considered is hazard perception. McKenna and Horswill (1999) claimed that the failure to perceive hazards contributed to the occurrence of accidents; however, Horswill and Helman's study (2003) found that motorcyclists have better hazard perception than car drivers, which was not in line with the results in our study as both driver groups were found to have made recognition errors, and that this was a major reason for their accidents.

This study also found that there were no differences between the car drivers and motorcyclists in terms of decision errors and performance errors as both were found to wrongly anticipate unexpected situations and both were unable to properly estimate the speed or the distance between their vehicles and other vehicles. This finding was in line with Rizania, Santoso, and Maulina's (2009) study on motorcyclists, which found that the perceptual judgment of distance and speed was very low, which meant that the drivers/rider acted incorrectly when trying to avoid an accident.

There were some differences found between car drivers and motorcyclists in the other errors. In car drivers, the other error was drowsiness whereas for motorcyclists, they were fatigue, time pressure, and not having a license; however, all types of other errors reduce a driver/rider's perceptions. For example, a sleepy driver (other error) is less aware of the potential dangers on the highway (recognition error), and therefore, they are unable to respond appropriately to avoid an accident.

If the findings of this study were applied to the functional driving/riding model in Figure 1

(Hale, Quist & Stoop, 1988; Hale & Stoop, 1988; Michon, 1985, in Elslande & Fouquet, 2007), it could be said that recognition error occurred at the perception stage. When a driver is unable to perceive their surrounding environment properly (e.g., view is blocked by other vehicles), they are unable to make a proper diagnosis or prognosis, which means they have a greater probability of making the wrong decision, which results in poor performance, which then results in an accident. For example, when a driver who is about to overtake misjudges the distance and speed of the vehicles on both sides of the road, they could make the wrong decision.

Conclusion

Human error, and mainly recognition error, plays an important role in car and motorcycle traffic accidents. The failure of car drivers and motorcyclists to properly perceive road situations can also result in decision errors and performance errors.

Implications of the study

As most errors were found to be recognition errors, situation awareness, and proper driving/riding training needs to be given to future drivers/riders to ensure that they are aware of the importance of perception when on the road. In addition, a cognitive ability test should be part of the driving or riding license tests.

Declaration of Conflicting Interest

There is no conflicting interest in the authorship and/or the publication of the manuscript.

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