Relationship between Accelerator/Brake Position and Pedal Misapplication

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ABSTRACT

This study introduces results of the evaluation for the relationship between pedal separation and the driver's performance regarding pedal misapplication in a laboratory setting. A serious accident caused by pedal misapplication is very characteristic, gaining social attention. It has been reported that inadequate placement for the combination of accelerator and brake pedals in the automobile as well as the factor of drivers' height, may be the potential factors for the cause of accidents. We examined the optimum pedal separation by evaluating error rates using an experimental protocol where pedal misapplication was provoked in a laboratory setting. A total of six participants performed the suppression task paradigm with five different levels of pedal separation. As a result, except in the case of pedal separation of 150 mm, participants with a height of 168 cm or more tended to increase the error rates as the pedal separation increased. All in all, the results implied that there was a certain pedal separation which had an effect on the pedal misapplication errors.

Keywords: pedal misapplication, pedal separation, suppression task, car accident

1. Introduction

The operation of accelerator and brake is one of the most fundamental operations for driving cars. Institute for Traffic Accident Research and Data Analysis reported that there were 6402 serious accident cases in 2013, yielding 1.13% of serious automobile accidents (ITARDA information, 2016). A serious accident caused by pedal misapplication such as unintended acceleration and thrusting into a building outside the road was very characteristic and such incidents focus on social attention (Shinohara et al., 2009).

Since 1980s, regarding cases involved with pedal misapplication research has been conducted to explore the cause. Previous studies have analyzed automobile data and accident records in the United States and reported that the relationship between the height of the driver and the pedal distance may have a certain influence in pedal misapplication (Collins et al., 2015). However, this research has focused on the pedal layout of the manufactured car, and experimental verification has not been conducted to date. Finding the optimum pedal separation by the empirical study evaluating the relationship between the pedal separation and the occurrence of pedal misapplication would contribute to understanding the safe pedal design.

In this study, suppression task paradigm, one of the cognitive task paradigm used in the field of psychology, was chosen for simulating pedal misapplication scenario where drivers behave such misdirected movements in a laboratory setting. The suppression task was known to be used to evaluate the suppression function, which is a function that can be performed by starting and stopping the action as desired by the user (Tsudida, 2010).

Therefore, the objective of the study was to experimentally evaluate the relationship between pedal separation and pedal misapplication by monitoring driver's misdirected motions induced by changing the pedal distance under suppression task protocol.
2. Method

2.1 Participants

A total of six healthy male university students were participated on the study. Their ages ranged from 21 to 23 years old. They own a driver’s license.

2.2 Experimental apparatus

Figure 1 shows the experimental set up. Participants were seated on an experimental device, which simulated the driver’s seat of an automobile. A 27-inch monitor in front of the participants presented suppression tasks, and the error rates were detected by monitoring the behavior of participants when they made pedal misapplication. A high speed camera (HAS-L1, DITEC) was used to continuously monitor the participants’ operations around the pedal area.

2.3 Experimental condition

Table 1 shows the experimental condition for the pedal separation distances. Although pedal separation has been defined multifold in different studies (Mortimer, 2011), it was defined the horizontal distance of accelerator-brake separation. In this study Figure 2 shows the configuration of pedal separation where the distance of the pedal were 30mm (Figure 2(a)) and 150mm (Figure 2(b)). Relative position between seat and acceleration pedal was identical among the conditions, whereas brake pedal was moved horizontally to adjust the designated pedal separation.

Table 1 Experimental condition

<table>
<thead>
<tr>
<th>Pedal separation [mm]</th>
<th>30</th>
<th>50</th>
<th>70</th>
<th>110</th>
<th>150</th>
</tr>
</thead>
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Figure 2 Configuration of two pedals. (a) pedal separation 30mm, (b) pedal separation 150mm

2.4 Experimental task

Figure 3 shows the time chart of performance in suppression task. Participant pressed the brake pedal, as quickly as possible from the position where their right foot was on the floor when a square sign was shown on the display, whereas they stepped on the acceleration pedal when they saw a circle sign on the display. When they perceived an auditory signal after visual sign was presented, they needed to press the pedal opposite to the corresponding visual signs. By changing the interstimulus intervals between auditory and visual signs, pedal misapplication was provoked such as a response like “I was intended to step on the brake pedal, but I have mistakenly stepped on the accelerator”. A total of 50 visual signs were presented in one trial, and among them, 10 auditory signals were presented. For each participant, two trials at each pedal separation were given, and in total, 10 trials were given to each participant. The experiment was conducted by the following procedures (1) to (4).

1) The entire experimental to the participants were seated in a chair simulating the driver’s seat of a car in a posture where they actually drove a car comfortably.

2) Participants were asked to a perform practice session at a pedal separation of 70 [mm].

3) During the experiment, participants were asked to concentrate on the task and limited to change their posture as much as they could.

4) A signal was given to start the experiment. Pedal separation was changed in between trials.
2.5 Data analysis

Independent variables, consisted of the five different levels of pedal separation, and the dependent variable was the error rates. Error rates were analyzed by two levels of participant’s height, i.e., a height of 168 cm (66 inches) or more and a height of less than 168 cm, due to compare the differences in pedal misapplication rates reported by Collins, et al (2015). Error rates were calculated such that number of observed errors divided by number of cases that auditory signals were presented when participants performed suppression task. Average error rates and standard errors for each pedal separation were calculated and summarized by two levels of height categories and the level of pedal separations. There was only one participant whose height was less than 168 cm, thus statistical analyses were not conducted for the effect of height.

3. Results and Discussion

Figure 4 shows the error rates by two groups classified by height of participants when they perform suppression task where auditory signal were presented. As shown in Figure 4, except in the case that pedal separation was 150 mm, participants with a height of 168 cm or more showed a tendency that the error rates became high as the pedal separation increased. This result was in consistent with Collins, et al (2015), where they showed a tendency that the error rates became high as the pedal separation was increased by analyzing numbers of accidents categorized by pedal configurations. Low error rates in the condition of 150 mm of pedal separation may be found due to extra attention paid for the unusual distance of pedal separation. In addition, participants with the height less than 168 cm tended to differ the error rates depending on the pedal distance. This result was not in consistent with the previous study (Collins, et al, 2015). It is necessary to increase the number of participants with short height to verify whether the error rates were changed, since there was one subject with a height of less than 168 cm taken in this study. We set the experimental condition in which relatively extreme pedal separation distance was included. Participants may have been extra attention to secure stepping on the pedals since the pedal separation may be different from their normal configuration. Therefore, in this experiment, the error rates induced by different pedal distance may be influenced by individual reaction time. Further evaluation is necessary to clarify the relationship between the reaction time and the error rates.

4. Conclusion

In this study, we used a suppression task paradigm to reproduce pedal misapplication model in a laboratory setting and conducted an experiment by
were seated on a n experimental device, which made pedal misapplication. A high speed camera by monitoring the behavior of participants when they where brake pedal was moved horizontally to adjust accelerator-brake separation. In this study Figure 2 23 years old. They own a driver’s license. participated on the study. Their ages ranged from 21 to 2011), it was defined the horizontal distance of A total of six healthy male university students were 2.2 Experimental apparatus Table 1 shows the experimental condition for the pedal Figure 1 shows the experimental set up. Participants seated in a chair simulating the driver’s seat of a car The entire experimental to the participants were concentrate on the task and limited to change their 2.5 Data analysis Independent variables, consisted of the five different levels of participant’s height, i.e., a height of 168 cm and, this result was in consistent with Collins, W., Evans, L., Hughes, R. Driver Brake and Accelerator Controls and Pedal Misapplication Rates in North Carolina, NHTSA, 2015 Institute for Traffic Accident Research and Data Analysis, ITARDA INFORMATION, No.107, https://www.itarda.or.jp/itardainfomation/info104.pdf (retrieved February 1, 2016) Mortimer R: An Early (1969) Case of “Unintended Acceleration” Crash, Ergonomics in Design, pp.12-15, 2011 Shinohara Kazumitsu, Wu Jinglong, Kimura Takahiko, Shiraishi Shuji, Takubo Nobuaki: Misapplication between acceleration and brake pedal: Analysis of error causes and implication for Psychological and Engineering interference, IATSS, H2294project, 2009 Tsuchida Noriaki: Classification of Inhibitory Function, Ritsumeikan University, Vol.500, pp.100-109, 2007 changing pedal distance of the accelerator and the brake pedals. As a result, except for the case that pedal separation distance was 150 mm, participants with a height of 168 cm or more tended to show high error rates as the pedal separation increased and, this result was agreed with the previous study using field data associated with car accident cases. The results implied that there was a certain pedal separation which had an effect on the error rates. It is necessary to evaluate the results in view of detailed relationship between the pedal separation and the error rates.

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References


Figure 4 Changes in error rates observed by pedal separation and the factor of driver’s height