公益財団法人 国際交通安全学会
International Association of Traffic and Safety Sciences

(1) Experimental Verification of the Relationship between Pedal-to-Pedal Distance and Pedal Misapplication
(2) Detection of Distress Caused by Pedal Misapplication and Its Application to Accident Prevention Systems

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Overview

- Experimental verification was conducted in this study concerning the separation between the accelerator and brake pedals and bodily reaction in the event that a driver feels distressed, which are among the factors causing pedal misapplication.
- With regard to the effects of pedal separation, we investigated whether the interaction between the driver's body height and pedal separation that has been reported by the NHTSA can be shown experimentally. As a result, it was observed that the error rate tends to change more for taller drivers than for shorter drivers.
- In addition, we attempted to detect reflexive eye blinking as an index for detecting pedal misapplication when the driver felt distressed due to video and audio while driving, and experimentally investigated whether reflexive eye blinking can be significantly detected depending on whether the driver was distressed. As a result, blinking of short latency such as that described in previous studies could not be detected, but it was observed that the average latency of blinking when the driver was subjectively distressed tended to decrease.

(1) Experimental Verification of the Relationship between Pedal-to-Pedal Distance and Pedal Misapplication

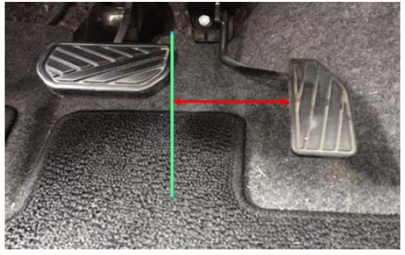
Problems with Pedal Design

- The layout of pedals and their shapes are different depending on various automobile companies (Furuya et al., 2010)
- It is necessary to examine the layout of pedals in order to prevent pedal misapplication (Nihei, 2000)

However

Pedals are not being designed with the prevention of pedal misapplication taken into consideration.

Because investigations into accidents have suggested the relationship between pedal separation in the horizontal direction and pedal misapplication (Collins, et al., 2015), a survey was conducted on variations in the distance between pedals in the horizontal direction.



Results of surveying 16 models

50 [mm] – 150 [mm]

There is a large variation in the distance between pedals on automobiles.

Purpose of the experiments

To verify the relationship between pedal separation and pedal misapplication through experimentation

Description of the Experiment

Participants in the experiment
14 male college students between the ages of 22 and 24 with driving experience

Conditions of the experiment
Five levels in the distance between pedals in the horizontal direction (30 mm to 150 mm)

Distance between pedals: 30 mm

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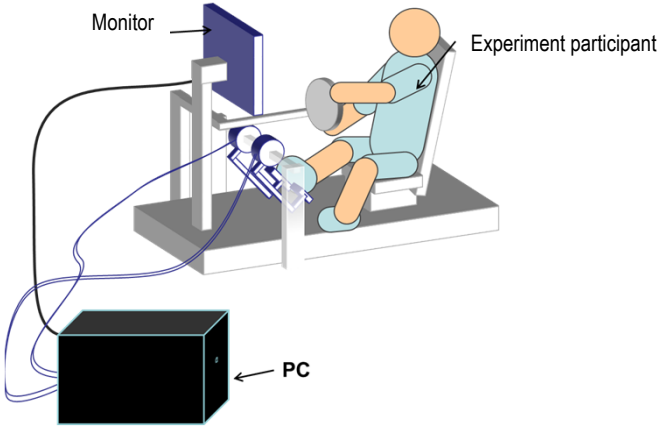
Distance between pedals: 150 mm

Experimental environment

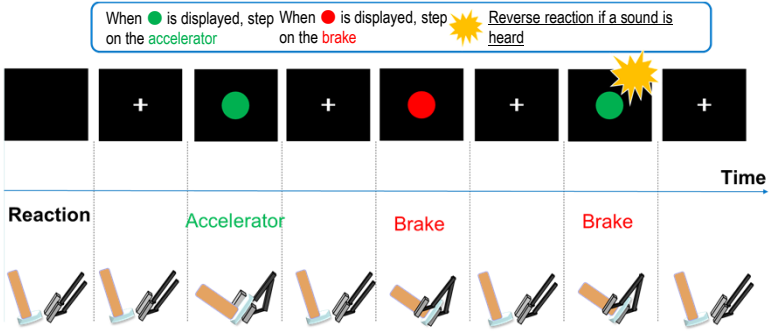


Task that induces pedal misapplication

Inhibition task
Used for evaluating the inhibition function, which is a function for inhibiting inappropriate actions or motor reactions

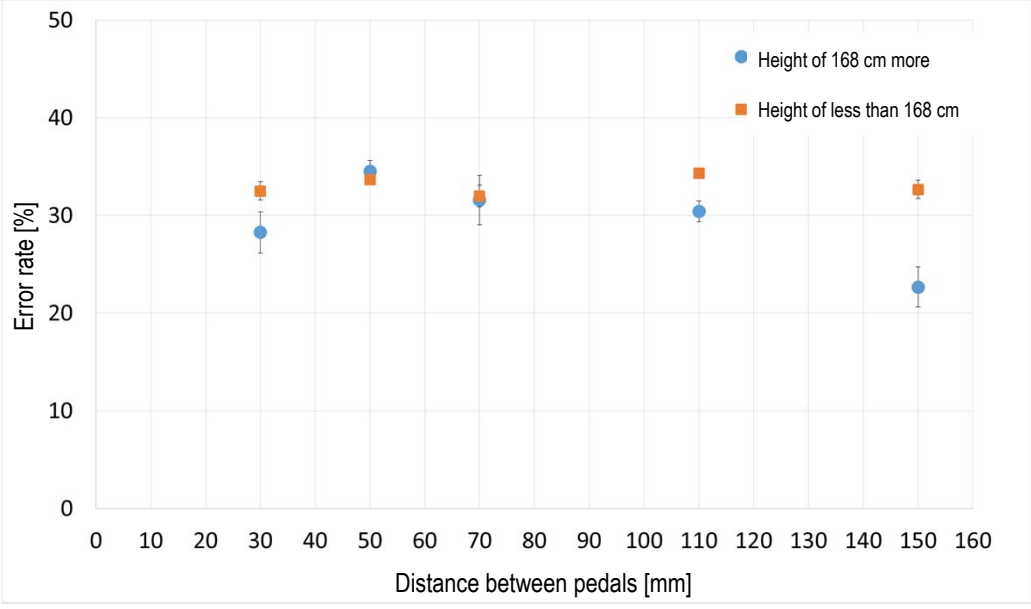
+

Automobile driving actions



Results of the Experiment

Previous studies (Collins, et al., 2015)
The wider the distance between the pedals in the horizontal direction, the more likely that pedal misapplication will occur among drivers who are 168 cm or taller.
The probability of pedal misapplication occurring among drivers who are less than 168 cm tall remains the same regardless of the distance between the pedals in the horizontal direction.



Results of the Experiment

Subjects who are 168 cm or taller
Opposite tendency compared to previous studies

Perhaps the narrowness of the driver's seat may have significantly impacted the error rate.

Conclusion

Changes in the distance between pedals affect the driver's performance in some way.

Point requiring improvement

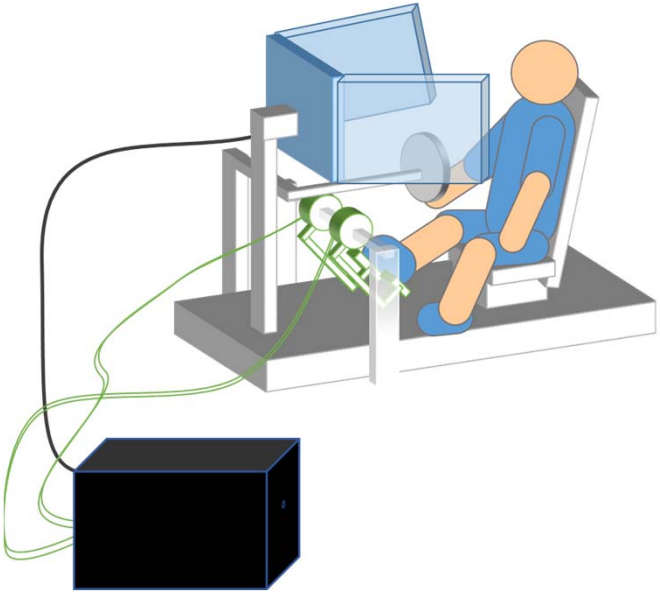
Problem in this experiment

- Significant difference from the actual driving environment

Point requiring improvement

- Conduct the experiment under an experiment system that is close to the actual driving environment

⇒ Enlarging the driver's seat and providing a sense of operating a car



Future Outlook

- Carry out large-scale investigations into pedal-to-pedal distance
- Conduct experiments with pedal-to-pedal distances that were not added to the experiment conditions for this experiment
- In addition to pedal-to-pedal distance, the height, shape, and size of the pedals will also be studied.

(2) Detection of Shock Caused by Pedal Misapplication and Its Application to Accident Prevention Systems

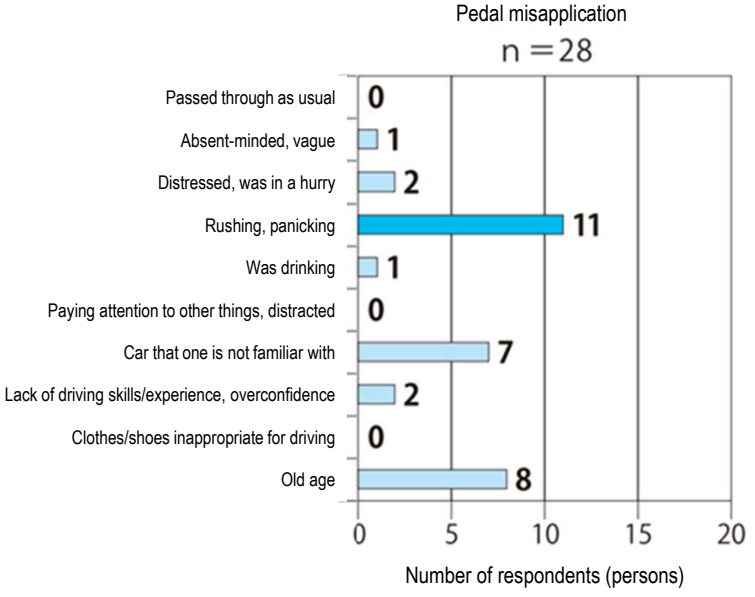
Detection of Distress Caused by Pedal Misapplication and Its Application to Accident Prevention Systems

Distress felt by the driver will lead to traffic accidents (pedal misapplication)

Many drivers who drive inappropriately fall into panic (become distressed) in order to evade danger, thus leading to accidents (ITARDA Information, 2014).

Is it possible to reduce accidents by detecting distress in drivers?

Method of detecting distress…
Focusing on reflexive eye blinking reaction
Characteristics:
Appears the fastest among human defensive reflexes (Yamada, 2002)
Brought about by clear external stimuli (Fukuda et al., 2015)



Will it be possible through experimentation to observe through blinking information that the driver becomes startled at the time of pedal misapplication (momentarily surprised and panicking, and subsequently shifting to a state of distress with the passage of time)...

Overview of Blink Detection Experiment

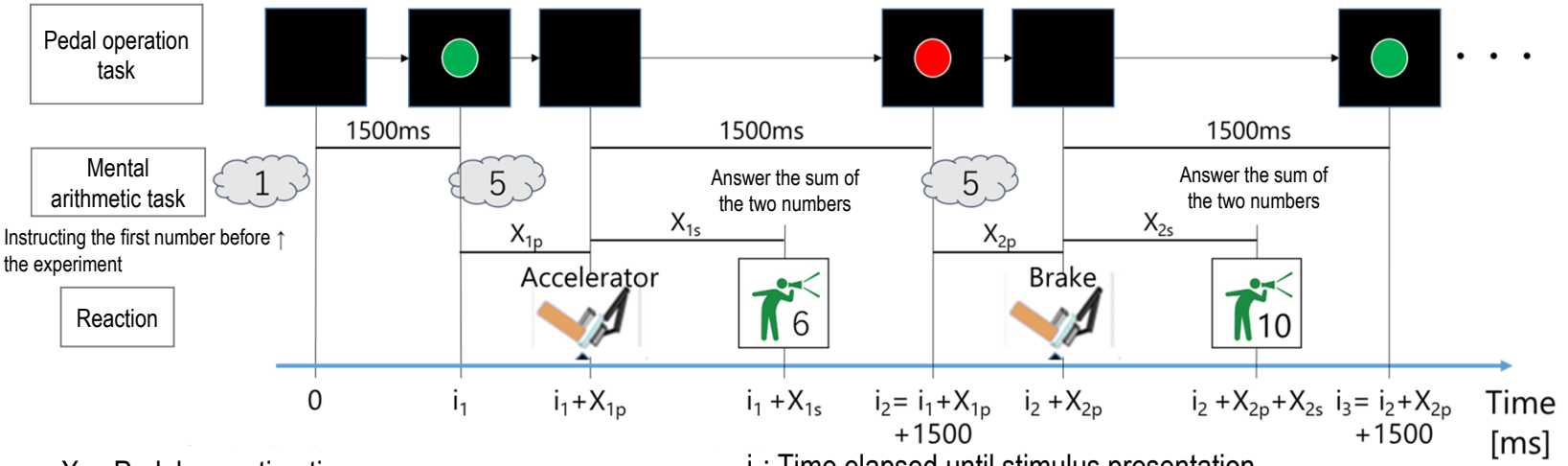
Purpose of the experiment
Investigate whether the distress that appears in the subject at the time of pedal misapplication can be detected by startle blinking reflexes

Description
En people are subjects
Investigate whether blinking appears when the subjects who simultaneously perform pedal operations through information on the monitor and mental arithmetic with numbers that are heard through the monitor step on the wrong pedal

Scene of an experiment

Description of the Tasks

Pedal operation task: Step on the accelerator when ● appears, and step on the brakes when ● appears
Mental arithmetic task: Verbally answer the sum of the number heard immediately before and the number heard most recently (during the preceding pedal operation task)



X_{np}: Pedal operation time

$X_{np} + X_{ns}$: Response time for the mental arithmetic task

i_n: Time elapsed until stimulus presentation

n: Number of trials

Analysis

Independent variables: Presence or absence of arousal of distress; two levels
Define the FB stimulus (sound and image that the driver who has stepped on the wrong pedal is thought to perceive) that causes the subjects to become distressed. There are two levels: Case where the FB stimulus is presented when the driver steps on the wrong pedal (FB: driver distressed), and the case where the FB stimulus is not presented (NO-FB: driver not distressed).
→ This is to compare the case of actual pedal misapplication and the case when that does not occur.

Dependent variables:
These shall be the number of startle blinking reflexes observed when there is pedal misapplication, the time (latency) when blinking appears, and the amount of distress evaluated by the subject (figure between 0 and 10).
Definition of blinking: Blinking that appears within 80 ms from the moment of pedal misapplication

FB stimulus
Driver's perception at the time of pedal misapplication reproduced by presenting this.

Image of accident

Or

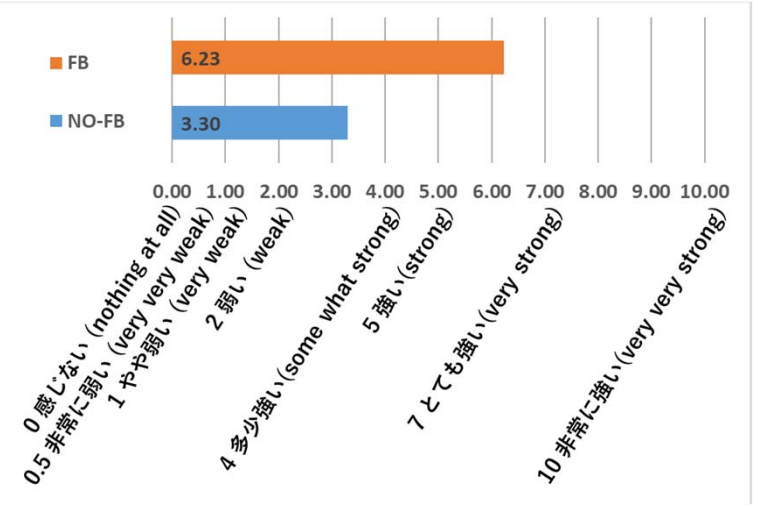
Stimulation by sound
(sound associated with sudden acceleration of the automobile)

Result of the Experiment: Changes in Distress Due to Presence or Absence of FB

Changes in the amount of the subject's distress due to the presence or absence of presentation of FB stimulus

In this experiment, the subjects were distressed every time that pedal misapplication occurred.

The subjects were further distressed as a result of the presentation of FB stimulus (perception of the driver at the time of pedal misapplication).
(Student's t test; t(40)=5.429, P<.000)



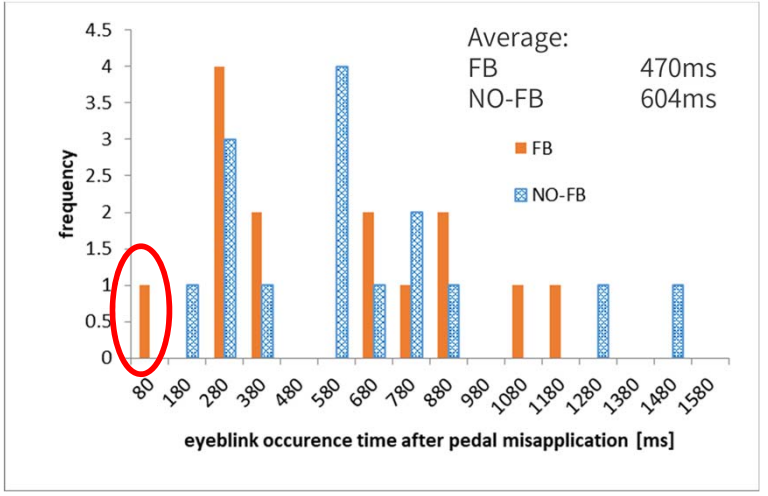
The average value of the subjective evaluation of the distress felt by the subjects depending on the presence or absence of FB stimulus at the time of their pedal misapplication

Result of the Experiment: Blinking Latency

Comparison between blinking latency (time that blinking appeared) and frequency due to the presence or absence of FB stimulus

A reaction (red circle) thought to be a blinking reflex was observed in one case only.

It could not be said that there were differences in the average value of latency depending on the presence or absence of FB stimulus presentation.
(Student's t test; t(26)=-.250, n.s.)



All data of 10 subjects who showed blinking

Summary

There is difficulty in using blinking information alone as a method of detecting distress in drivers who stepped on the wrong pedal; it is necessary to combine this with another index.

In this experiment, the subjects were distressed every time that pedal misapplication occurred.

In this experiment system, it is not clear whether differences appeared in the average latency value of blinking due to the amount of distress felt by the subjects.

It is possible that blinking latency may change because the timing of the occurrence of blinking changes when the timing where the subject is startled is different from the timing where the subject steps on a pedal.

Future Outlook

- Distress detection will be conducted not only using blinking but also using it in combination with other physiological indices.
  → The subjects' muscle contraction information, heart rate information, etc.

- Build a system where distress information is entered into an automobile control system for reducing accidents

FAQ

Q. Will the distance between the accelerator and brake pedals affect pedal misapplication?

A. In the NHTSA report, there is no mention that pedal separation directly affects pedal misapplication. However, there exists statistical information from accident data that people who are tall are affected by the distance between the pedals. In other words, it is reported that tall people are more prone to pedal misapplication accidents when the distance between the pedals becomes wider, while there is no such tendency among people who are short. In this experiment using a driving simulator, such tendency has not appeared directly, but if the distance between the pedals changes due to body height, it is thought that there is a possibility that as a result, this could lead to pedal misapplication.

Q. Can the distress felt by a driver in the event of a driving error be detected before it leads to an accident?

A. It is believed that prediction/detection of the distress felt by drivers in the event of a driving error is sufficiently possible using biological signals. This time, we focused on “startle blinking reflex,” blinking that occurs when a person is surprised, but unfortunately, the driver’s state of distress could not be detected. However, we believe that by using the “contraction of muscles of the face and upper body” that appears when a person is surprised, “hear rate information,” and other biological indicators, distress can be detected, and we also believe that such information can be used to control automobiles to reduce accidents.

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