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NEW BRAKE PEDAL AND ACCELERATOR BAR SYSTEM TO PREVENT THE MISTAKE OF PRESSING DOWN THE ACCELERATOR INSTEAD OF THE BRAKE IN EMERGENCY SITUATIONS

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Abstract

It has been reported that some automobile accidents are caused by mistakenly pressing down the accelerator, when the intention was to press down the brake. Recordings of an electro-goniometer at the right knee joint on some subjects showed that upon receiving a fright due to a sudden loud noise, the knee initially became taut. It can therefore be supposed that some drivers have difficulty in removing their foot from the accelerator pedal and transferring it to the brake pedal quickly in emergency situations. To solve this problem, a new brake pedal and accelerator bar system (the Naruse pedal system or the N system) was examined. With the N system, the brake pedal is situated above the original position of both the conventional accelerator pedal and the conventional brake pedal, with an accelerator bar situated to the right of the new brake pedal. Therefore, when wanting to accelerate, a driver can push the accelerator bar to the right whilst resting his/her foot on the brake pedal, and then when wanting to brake, the driver can simply and immediately press down on the

brake pedal from the accelerating position. The N system thus provides a driving control mechanism which permits the quick and smooth transition from acceleration to braking, without needing to transfer the foot from one pedal to another. The stopping distance of a car (TOYOTA CRESTA) in which the N system had been installed was 1.6 meters shorter than that of a car installed with the conventional brake and accelerator pedal system at a driving speed of 40km/h.

Introduction

It was reported by the transportation authorities of Japan that there were 1,108 accidents or near-accidents caused by sudden acceleration of the car during 1994. (Nihei and Maruyama, 1995). It was reported that thirty-five of them were caused even whilst pressing down the brake pedal. Sixty-two of them could eventually stop. Eighty-six of them could not stop or had difficulty in stopping even though they pressed down the brake pedal. The authorities reported that there was no malfunction of the brake system in those cars according to their own inspection. The authorities suggested in the report that drivers need to press down the brake pedal more firmly.

On cars with the conventional brake and accelerator pedal system, a driver similarly presses down a pedal both to accelerate and to brake. If an emergency situation happened during driving whilst the driver had his/her foot on the accelerator pedal, the driver had to remove his/her foot from the accelerator pedal, transfer his/her foot to the brake pedal, and a press down again, this time on the brake pedal. However, in an emergency situation, people would be at high state of tension with an initial reflex of wanting to run away from dangerous objects or situations quickly. Therefore, it is thought that it may be difficult to transfer one's foot from the accelerator to the brake quickly because of leg tonus. Generally, drivers need to press down the brake pedal as quickly as possible in an emergency situation. Therefore, some drivers might mistakenly press down the accelerator pedal instead of the brake pedal in an emergency.

In this study, the human factor of the mistakenly pressing down the accelerator pedal instead of the brake pedal was examined experimentally.

Experiment 1

In a frightening situation, choice reaction times were measured to examine whether drivers were able to transfer their foot from the accelerator pedal to the brake pedal quickly or not.

Methods

Apparatus

Stimulus presentation and the choice reaction time measurements were both under the control of a personal computer (NEC: PC-9801EX) using the KM choice reaction time measuring software (the KM system: Matsunaga, 1989). Two foot switches which were similar to the accelerator pedal and the brake pedal of a conventional car, served as the response keys of the computer.

A sudden, loud noise (1kHz square wave; 85dBA) was emitted via a loudspeaker under the control of a personal computer, in order to frighten the subjects.

Subjects

The subjects comprised 15 university students of both sexes, whose ages ranged from 20 to 40 years old. They all possessed a driving license.

Procedures

The accelerator pedal was held in a depressed position by the subject's right foot prior to the initiation of each trial. When a red disc appeared, the subject was required to remove his/her foot from the accelerator pedal and to press down the brake pedal with the same foot. When a yellow disc appeared, the subject was required to remove his/her foot from the accelerator pedal. The subject was instructed to do this as quickly as possible. The return of the foot to the accelerator pedal was self-paced. When a green disc appeared, the subject was required to continue pressing the accelerator pedal down.

The red disc, the yellow disc and the green disc were displayed on the CRT screen for 3 seconds under the control of a personal computer, in a random order and at a random interval. The red disc and the yellow disc each appeared 20 times, while the green disc appeared 11 times during each session. It took 11 minutes to complete one session.

At around the 26th presentation of a disc, the sudden loud noise was emitted, lasting for three seconds, and this was synchronized with the red disc presentation to simulate a frightening situation.

Reaction times from the appearance of the red disc or the yellow disc to the appearance of removing their foot from the accelerator pedal, and reaction times from the onset of the red disk to the onset of pressing down the brake pedal were measured while subjects were performing their choice reaction time task on the KM system.

At first, the experiment was performed under the control conditions, in which no sound was emitted. Subjects took a rest for five minutes before the experiment was

performed under the experimental conditions.

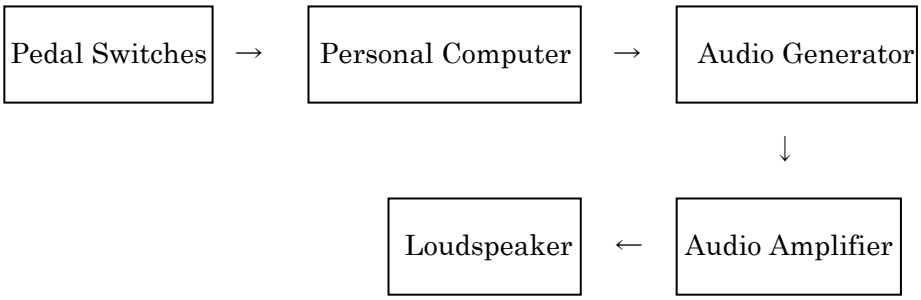

Fig. 1 Apparatus used in Experiment 1.

Stimulus presentation and the choice reaction time measurements were both under the control of a personal computer (NEC: PC-9801EX) using the KM choice reaction time measuring software (the KM system). Two foot switches which were similar to the accelerator pedal and the brake pedal of a conventional car, served as the response keys of the computer.

A sound (1kHz square wave; 85dBA) was emitted via a loudspeaker under control of the computer, in order to frighten the subjects.

Results and Discussion

Delays in reaction for removing a foot from the accelerator pedal and for pressing down the brake pedal were observed in six of the 15 subjects (Fig. 2) when a sound was emitted compared with when no sound is emitted. One subject's reaction time for removing his foot from the accelerator pedal became shorter, while in the other hand, his reaction time for pressing down the brake pedal became longer (Fig. 3). Three subjects showed a shorter reaction time regarding both the accelerator pedal and the brake pedal. The reaction times of the other subjects were not changed by the loud noise (Fig. 4).

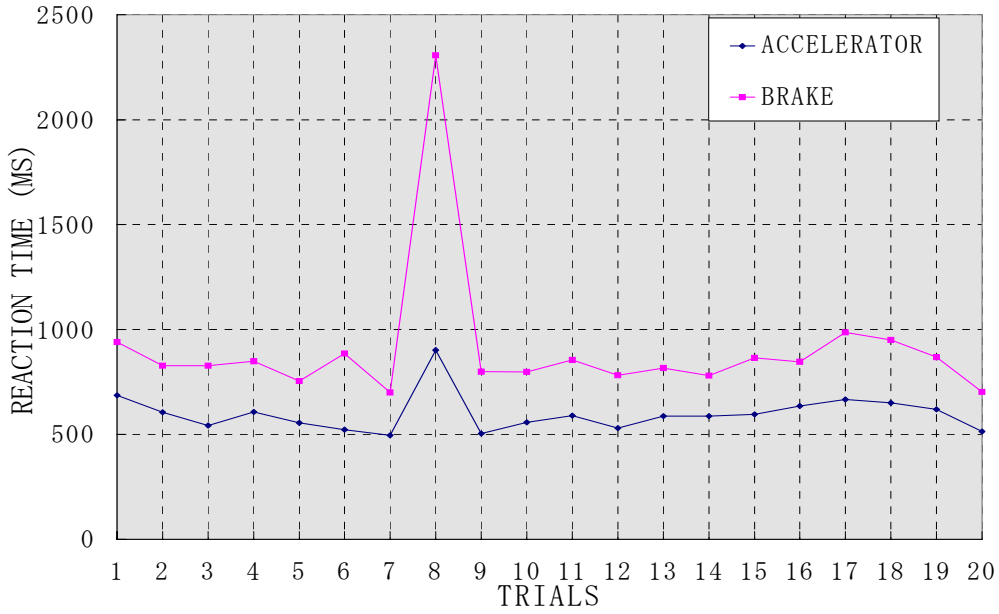

Fig. 2. One of the typical reaction times where delayed reaction can be observed both for removing the foot from the accelerator pedal and for pressing down the brake pedal when the sound was emitted. The sound was emitted at the eighth trial in this figure.

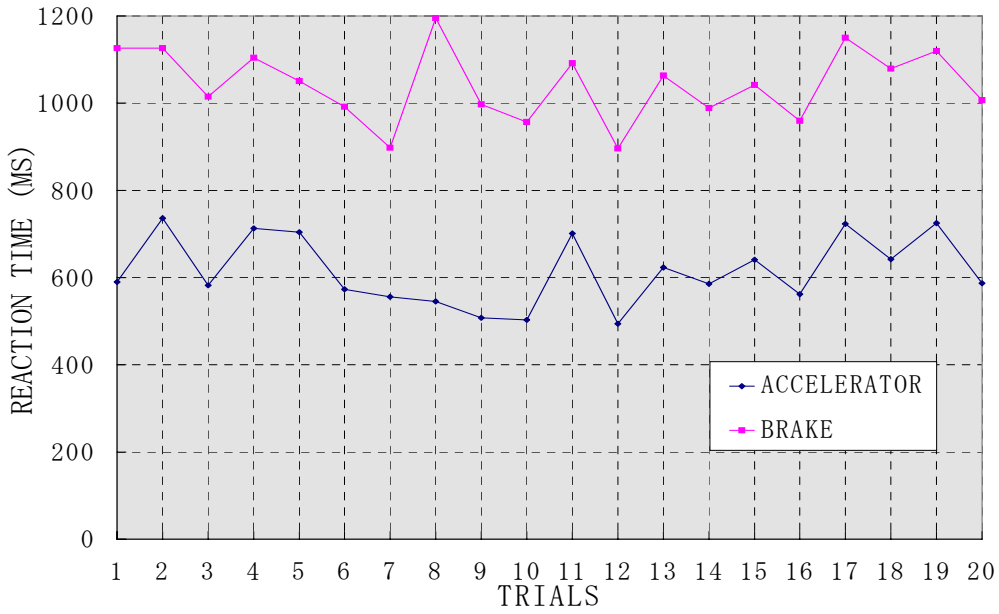

Fig. 3. One of the typical reaction times where delayed reaction can be observed for pressing down the brake pedal when the sound was emitted, however, the time taken for removing the foot from the accelerator pedal showed no change.

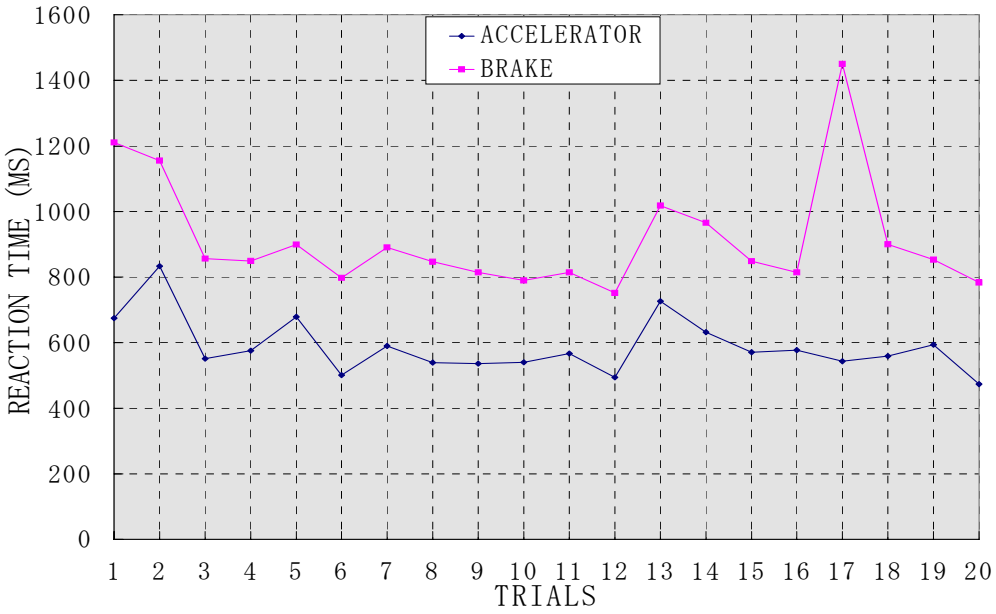

Fig. 4. One of the typical reaction times where delayed reaction was not observed either for removing the foot from the accelerator pedal or for pressing down the brake pedal when the sound was emitted.

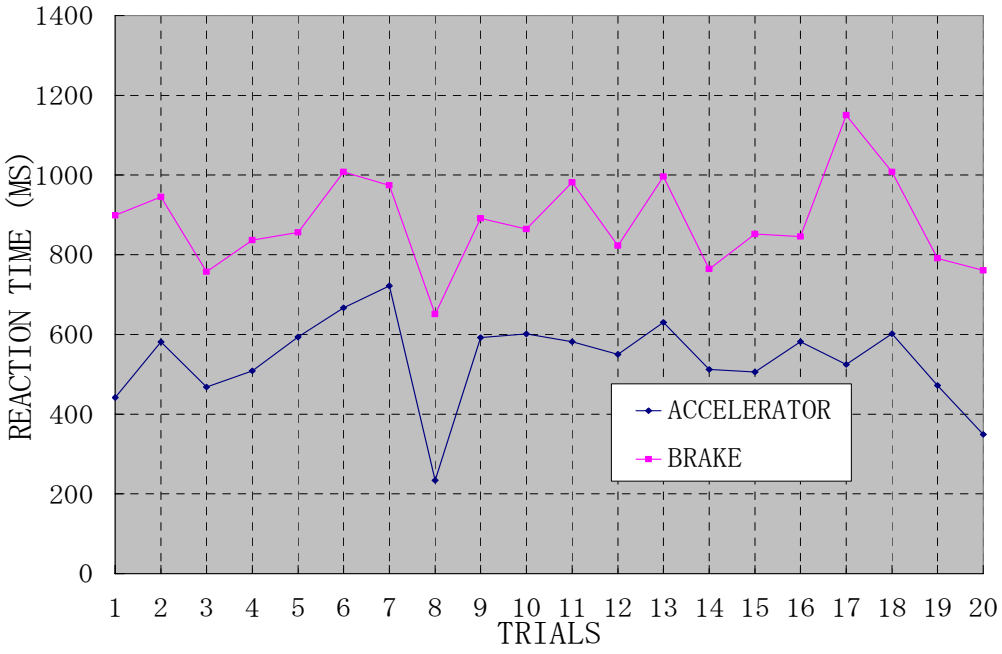

Fig. 5. One of the typical reaction times where the time taken both for removing the foot from the accelerator pedal and for pressing down the brake pedal became shorter when the sound was emitted.

Experiment 2

In Experiment 1, a delay in the reaction of the subjects was observed when a sudden, loud noise was emitted. The subjects may have been frightened by the sound and their reaction may have been delayed by the tautness of their leg muscles. In this experiment, movement of the knee was measured in a frightening situation.

Methods

Apparatus

As shown in Fig. 6, movement of the subject's right knee was measured using a goniometer which was made by our laboratory using a potentiometer of small friction. The goniometer was attached at the knee joint using sticky tape. A sudden loud noise was emitted in the same way as in Experiment 1. The output of the potentiometer was recorded by a frequency-modulated (FM) magnetic tape recorder (TEAC: R61). The output of the recorder was drawn on paper using a paper recorder (SAN'EI: RECTI-HORIZ). The choice reaction time task was given by the apparatus in the same way as in Experiment 1.

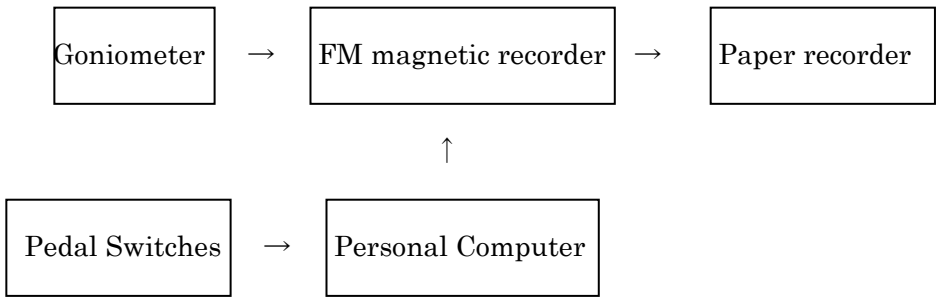

Fig. 6. Apparatus for Experiment 2.

Subjects

The subjects comprised ten university students of both sexes whose ages ranged from 19 to 24 years old.

Procedures

The procedures for measurement were almost the same as in Experiment 1, except with the additional measurement of knee movement. The same sudden, loud noise as in Experiment 1 was emitted controlled by a hand-switch. The subjects were required to perform the task in the same way as in Experiment 1. The sound lasted for three seconds, and was emitted around seven minutes after the beginning of the session.

Results and Discussion

A typical recording is shown in Fig. 7. Three of the 10 recordings suggested that upon hearing the sudden noise, the knee initially became taut.

It can therefore be supposed that some drivers have difficulty in removing their foot from the accelerator pedal and transferring it to the brake pedal quickly during emergency situations.

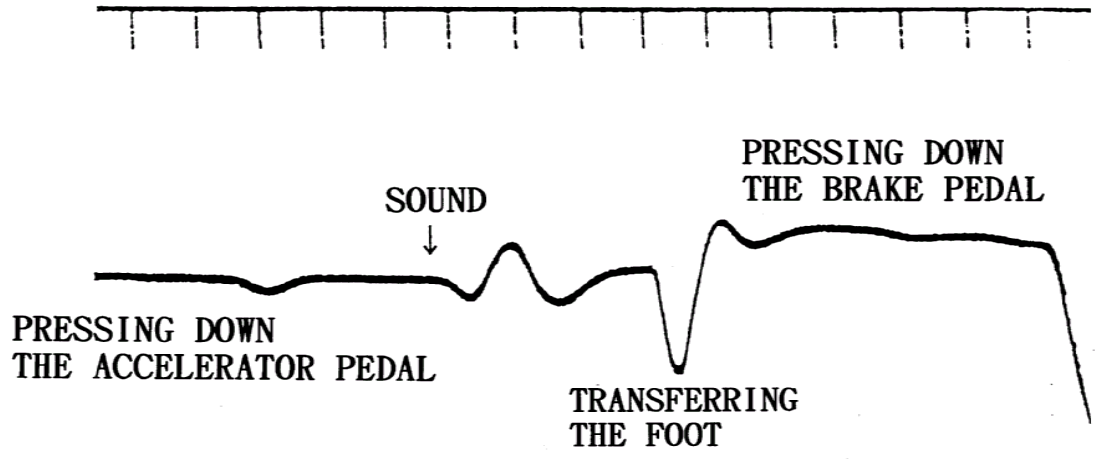

Fig. 7. A typical recording of movement of the knee.
Three of the 10 recordings suggested that upon hearing the sudden noise, the knee initially became taut.

Experiment 3

To solve the problem mentioned in Experiments 1 and 2, a new brake pedal and accelerator bar system (the Naruse pedal system or the N system) was examined. In this experiment, the reaction times both with the conventional system and with the N system were compared.

Methods

Apparatus

The N system: With the N system, the brake pedal is situated above the original position of both the conventional accelerator pedal and the conventional brake pedal, with an accelerator bar situated to the right of the new brake pedal (Fig. 8). Therefore, when wanting to accelerate, a driver can push the accelerator bar to the right whilst resting his/her foot on the brake pedal. and then when wanting to brake, the driver can simply and immediately press down on the brake pedal from the accelerating position. The N system thus provides a driving control mechanism which permits the quick and

smooth transition from acceleration to braking, without needing to transfer the foot from one pedal to another.

The measurement system of the reaction time: The KM system was used for the measurement of reaction times. When measuring the reaction time with the N system, the accelerator bar and the brake pedal of the N system were used as the response keys, in contrast to the accelerator pedal and the brake pedal with the conventional system.

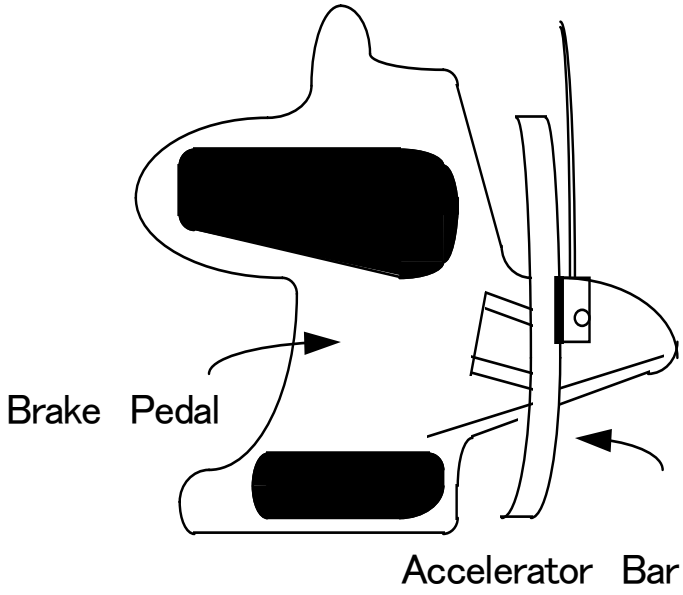

Fig. 8. The N system.

With the N system, the brake pedal is situated above the original position of both the conventional accelerator pedal and the conventional brake pedal, with an accelerator bar situated to the right of the new pedal. The N system thus provides a driving control mechanism which permits the quick and smooth transition from acceleration to braking, without needing to transfer the foot from one pedal to another.

Subjects

Two subjects who were aged 21 and 48 years old (both female), took part in this experiment. They had considerable experience in measuring their reaction time using the KM system with the conventional brake and accelerator pedals.

Procedures

At first, the reaction time using the conventional system was measured, and 5

minutes after that the reaction time using the N system was measured. The instructions to the subjects were the same as in Experiment 1.

Differences in the reaction time both for ceasing to accelerate and for commencing to brake were compared between the N system and the conventional system.

Results and Discussion

The results of the measurements are shown in Table 1. The mean transferring time from acceleration to braking with the Naruse system was 160 ms shorter than that with the conventional system, for both subjects.

Table 1. The average reaction times taken with the N system and with the conventional system. The transferring time from acceleration to braking with the new system was 160 ms shorter than with the conventional system.

	Sub. 1 : 48 years		Sub. 2 : 20 years	
	New type	Conv. type	New type	Conv. type
Brake pressing reaction time (BT;ms)	669	914	585	771
Standard deviation of BT (BT-SD)	68	71	91	60
Transferring time (tr)	65	233	44	240
Maximum BT(ms)	810	1,040	830	920
Minimum BT(ms)	560	780	440	640

n=20

Experiment 4

The stopping distances of the cars were measured under actual driving conditions. One car was installed with the N system. The other had the conventional brake and accelerator pedals and was used for the control experiment.

Methods

Apparatus

Two passenger cars which were the same model (Toyota Crest 1995 year model, 2,490cc engine; weight: about 3,500lb.; installed with automatic transmission) were used for the experiment. One was installed with the conventional pedal system

without any change in the pedals. The other car was installed with the N system instead of the conventional pedal system.

The measurement system of the stopping distance consisted of a traffic signal, optical object sensor, and a scale of 0-100 along the straight track of a driving school (Fig. 9).

Subjects

Seven subjects ranging from 18 to 64 years old (six males and one female) took part in this experiment. One (18-year-old male) was still learning to drive. The others had driving experience of more than 10 years. One of them had considerable experience in driving of a car with the N System. The others were time driving such a car for the first time.

Procedures

The traffic lights came on when the subject's car passed a certain point along the track of the school where an object-sensor was set. A red light, a yellow light or a green light came on in random order.

The subjects were asked to drive at 40km/h as accurately as possible. After practicing driving for 5 min., the subjects were asked to stop the car as quickly as possible when the red traffic light came on. One subject performed the task more than 3 times, for
each braking condition.

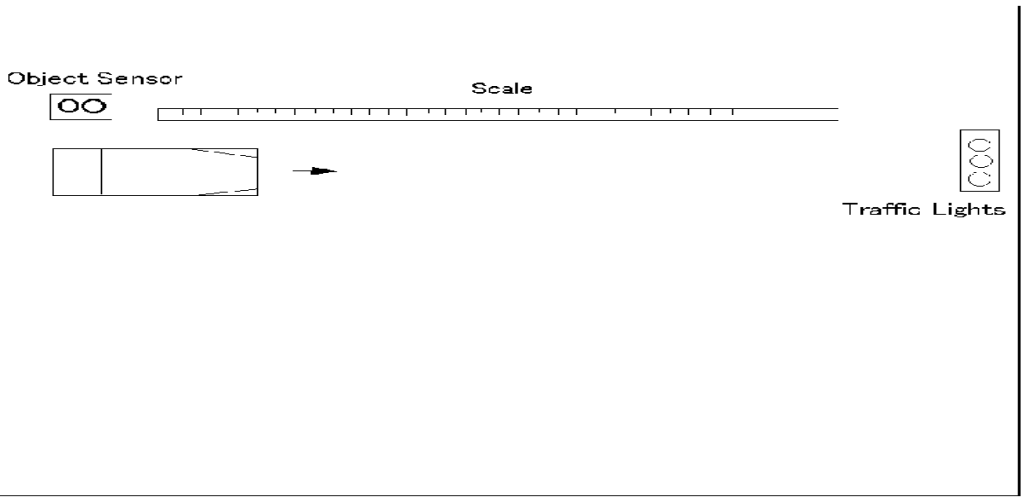

Fig. 9. Apparatus for measuring the stopping distance.

Results and Discussion

As shown in Table 2, the stopping distances of the car installed with the N system were shorter than those of the conventional car for six of the seven subjects. Surprisingly, one of the seven subjects showed a shorter stopping distance with the conventional pedal system than with the N system. He was a instructor of the driving school and said that he had driven the new-style car with his mind constantly focused on the N system.

The stopping distance of the car in which the N system was installed was 1.6 meters shorter on average than that of the car installed with the conventional system at a driving speed of 40km/h.

It is supposed that the shortened stopping distances in the N system was derived from that the N system did not require drivers to remove their foot from the accelerator pedal, and then transfer their foot to the brake pedal.

Table 2. Stopping distances of the car with the N system and of the car with the conventional system for the seven subjects.

		Mean Stopping Distance (MSD) ms	SD of Stopping Distance	Number of Trials	Difference of MSD between New and Conv. Systems
Sub.1, 53 years, Male	New type	14.57	1.738	10	
	Conv. Type	16.68	1.462	5	2.11 ($p<0.05$)
Sub.2, 48 years, Female	New type	13.74	1.11	10	
	Conv. Type	16.9	1.62	5	3.16($p<0.00$)
Sub.3, 64 years Male	New type	13.82	0.973	5	
	Conv. Type	15.37	1.788	10	1.55($p<0.12$)
Sub.4, 54 years Male	New type	11.63	1.024	4	
	Conv. Type	11.47	0.289	3	-0.16($p<0.83$)
Sub.5, 18 years Male	New type	16.2	1.873	3	
	Conv. Type	18.37	1.704	3	2.17($p<0.29$)
Sub.6 37 years Male	New type	12.34	0.68	5	
	Conv. Type	12.92	0.327	5	0.58($p<0.16$)
Sub.7 39 years Male	New type	11.25	1.48	4	
	Conv. Type	13.05	0.465	4	1.8($p<0.14$)
Mean	New type	13.36			1.61
	Conv. Type	14.97			

Summary

1) Delays in reaction for removing a foot from the accelerator pedal and for pressing down the brake pedal were observed in six out of 15 subjects (Fig. 2) when a sudden, loud noise was emitted compared with when no noise was emitted.

2) Recordings of an electro goniometer at the right knee joint showed that upon receiving a fright by the sound, some subjects' knees became taut. It can therefore be supposed that some drivers have difficulty in removing their foot quickly from the accelerator pedal and transferring it quickly to the brake pedal in emergency situations.

3) To solve the above problem, a new brake pedal and accelerator bar system (the Naruse system or the N system) was examined. With the N system, the brake pedal is situated above the original position of the conventional accelerator pedal and the conventional brake pedal, with an accelerator bar situated to the right of the new brake pedal. Therefore, when wanting to accelerate, a driver can push the accelerator bar to the right whilst resting his/her foot on the brake pedal, and then when wanting to brake, the driver can simply and immediately press down the brake pedal from the accelerating position. The N system thus provides a driving control mechanism which permits the quick and smooth transition from acceleration to braking, without needing to transfer the foot from one pedal to another.

4) The stopping distance of a car (TOYOTA CRESTA) in which the N system had been installed was 1.6 meters shorter than that of a car installed with the conventional brake and accelerator pedal system at a driving speed of 40km/h.

Acknowledgment

The English used in this manuscript was revised by Miss K. Miller (Royal English Language Center, Fukuoka, Japan)

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