DRIVER MODELING
IN UNCONCIOUS DRIVING STATE

Kenta Yamazaki, Toshio Ito

Graduate School of Engineering and Science, Shibaura Institute of Technology

mf15077@shibaura-it.ac.jp

ABSTRACT

In this paper, driving operation by focusing on what is done in unconscious, it is considered to be able to build a driver model by the mental load of the disturbance.

We focus on human's readiness potential that the electrokinetic potential ingenerates about 0.3 seconds before the conscious potential. Formulating a hypothesis based on the electrokinetic potential ingenerate before the conscious potential, driving operations are considered to be reactive behaviors that the drivers settle their behavior unconsciously. The driving operations are configured two elements of the cognition and the operations. We consider the driving model which is expressed by the area of using driver's brain. The active region of their brain is divided into unconscious area and conscious area. Increase of the conscious area is considered to press the unconscious area, and this influences driving behavior.

In this paper, we give dual tasks to subjects, and set the context that unconscious area is pressed by the conscious area. In this situation, the correlation of the subtask and driving behavior is verified by measuring driving behavior changes.

In the experiments, the dual tasks are a mental arithmetic problem and a listening problem. The subjects drive without giving subtasks until they will get used to drive. Obtained date are brake pressure, throttle opening etc.

From the experimental results, they tend to get delayed response time and excessive action. And degree of the unconscious pressure differs subjects to subjects.

We use VACP and NASA-TLX for verifying the effect of driving by the subject of mental load. As a result, at without tasks, any subjects take almost the same value as these conventional techniques. However, added problems tend to cause impossible correlations around the hazardous area. We propose the driver model considering unconsciousness which is weighted to each element individually.

1. INTRODUCTION

In recent years, automation of automobile operation is progressing. An example of automation is accidents caused by the transition from MT to AT. As shown in Fig.1, the number of accidents has been decreasing, while human operation accidents have increased such as the right and left turn when the rear-end collision and head-on collision. These are from human factors because a safety non-confirmation or an inattentive driving is increased in AT. Like this, consciousness of the driver is away from the driving operation by the automation of the operation advances.

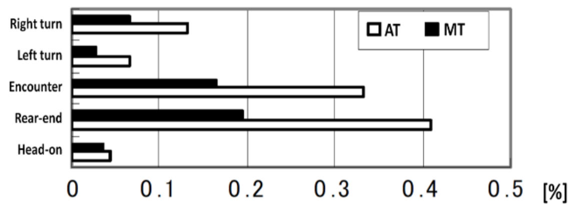

Fig. 1 Accident rate comparison of accident types

In this study, it is assumed that the cause of the safety non-confirmation and inattentive driving are caused by load tasks of additional non-driving operations. Therefore, it is necessary to verify how much the load tasks would impact on the driving operations.

We focused on a brain activity during the driving operation. From the brain activity point of views, person acts unconsciously rather than consciously. From this fact, driving operations are determined by the unconscious and the conditioned reflex from the situational awareness.

This is one that was proven by Benjamin Libet in 1983. In his study, the experiment observed the brain activity associated with the reaction. At this experiment, the reaction of the subject brain potentials was confirmed by two electrical signals.

The rise of the brain potential has occurred movement potential before about 0.3 seconds from the decision-making potential. Therefore, the driving have been reflected effected under unconsciousness. The driving assumed reflexive operation of two elements that is "cognition (decision), the operation". Therefore, the driving operation is affected by changes in physical condition and the car compartment environment.

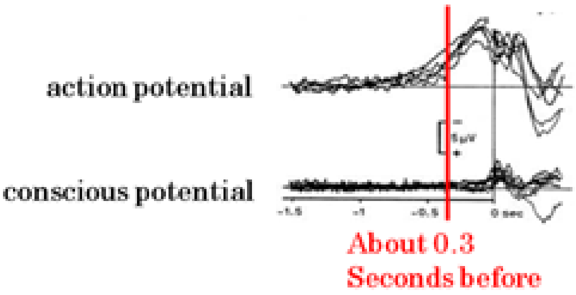

Fig. 2 Readiness potential

2. Driver model

In this study, we regard usual behaviors are decided by the unconscious. Driving operation is the usual behavior and decided by the unconscious. Fig.3 shows the brain activity area during the driver operation. As shown in Fig.3, the brain activity area divided into two. One is the unconscious area that is used to the driving operation, and another is the conscious area that is used for processing of subtasks. The brain active area is limited, and the unconscious area is compressed if the conscious area becomes larger. The driving operation by the unconscious is weaken by consciousness load increases. From these, the driving behavior is influenced by the subtasks.

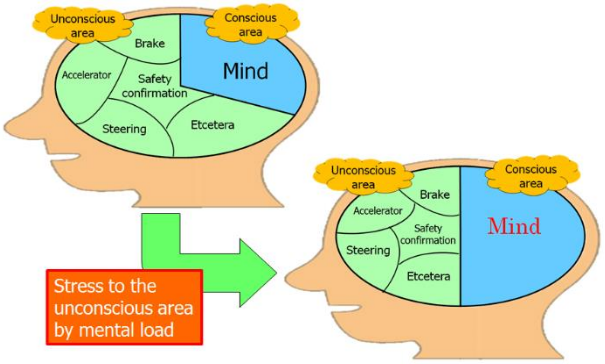

Fig. 3 Floor guide of audio-visual room in the library.

The brain active area is assumed score that consists of the consciousness area and the unconscious area.
Equation (1) is established.

$$\sum_i f(\alpha_i \cdot a_i) + \sum_j f(\beta_j \cdot I_j) = P_k \qquad (1)$$

In equation (1), the score of unconscious area is $\sum_i f(\alpha_i \cdot a_i)$, the score of consciousness area is $\sum_j f(\beta_j \cdot I_j)$, the scores of brain active area in the driver k state represent the P_k. This study is considered two elements that are a_i of the unconscious area and I_j of the conscious area. Two variables that α_i and β_j are individual differences in each elements.

3. Experiment summary

3.1 Experiment scenario

We considered reproducibility and the safety of subjects, etc., so this experiment used a 6 axis vibrating driving simulator, with 10 male Shibaura Institute of Technology students who held a regular driver's license as subjects. This experiment courses uses a highway. We measure the driving behavior that subjects add subtask after accustomed enough to the subject driving. We verify the type of task by the difference in load factor that the experiment measures six times by two times of 3 patterns (no sub-task, mental arithmetic problems and listening task).

In this course, we measure the two places where the drivers feel danger.

A) The falling objects performs a lane change for ahead. (Fig. 4)

B) The confluence to the right lane because the construction vehicle is stopped on the left lane. (Fig. 5)

Fig.4 Course sceneA

Fig.5 Course sceneB

3.2 Tasks

Main task

- Subjects should follow the lead vehicle traveling at about 100 [km / h]

Subtask

- "Mental arithmetic problem", Subjects should listen to the 2 digits number (10~99) about 6 seconds interval and answer the addition problem.
- "Listening task", Subjects should drive with listening to the radio, check and remember the contents.

3.3 Experimental result

This experimental measures the subject's driving load due to the presence or absence of sub-tasks. Fig.6 and 7 show time to collision(hereinafter TTC) that subjects during deceleration behavior start went for collision avoidance from the front of the vehicle stops about 100 [m]. TTC 0 [s] in Fig.6 shows a collision with the vehicle ahead. TTC is calculated by the following equation (2).

$$\mathrm{TTC} = \frac{\text{Distance of the stop vehicle and the vehicle} - 100[m]}{\text{Speed of the vehicle}} \quad (2)$$

As show in fig.6, the reaction results can be seen that reaction speed tends to order normal> Listening task> the mental arithmetic task, subjects 1,2,4,5,7,8,10. However, subjects 3, 6, and 9 have become a listening task> normal. These experiments were carried out leaving a sufficient period of time. But the experimental course is only. So subjects had worked learning effect. Therefore, future challenges verification in an environment that does not occur learning effect. As show in fig.7 in the second danger place, the subject 1,5,6,7,8,9,10 are not observed trend like normal> listening task> mental arithmetic problem. So, this is verification in an environment that does not occur learning effect. However, the low influence of the learning effect in situation A changes in the TTC in each type of subtask. Therefore, the reaction delay is the conscious area expanded by subtask and the unconscious area compressed by the conscious area.

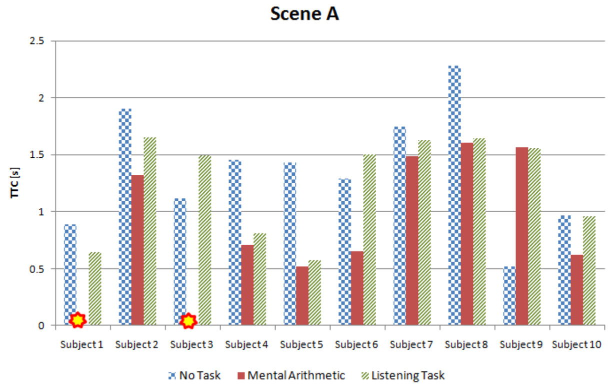

Fig.6 Time to collision in sceneA

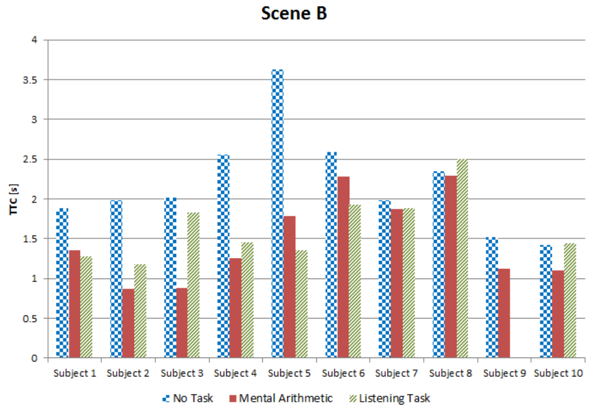

Fig.7 Time to collision in sceneB

4. Driver model in unconscious driving state

The experimental result in fig.6, subjects are affected by adds subtask for each individual. In this study, we propose a driver model additional subtask by using the work load score. We used the NASA-TLX and the VACP in order to build the driver model. The NASA-TLX is a positive workload score because it is subjective evaluation of the driver. VACP is difficult that the workload score evaluation of subtasks. From this fact, we considered to affect unconscious area by subtasks. Therefore, this study verifies a correlation NASA-TLX adding subtask that the driver model considers the conscious area and the unconscious area. The estimate of the driver status bases on VACP that this study's driver model adds variable α_i, β_j in ezch elements. We gives the subtasks in this experiment is an A (auditory) of physical impact. But, the questionnaires that performed after the driving test was found that mental load was larger than the physical effects. Therefore, this study is focused on the P (psychomotor) that shows mental resources.

Therefore, we do an estimate of the workload score for each individual that the conscious area defines Psychomotor, the unconscious area defines Visual, Auditory and Cognitive. For equation (1), we estimate the workload score added to the load task that unconscious area α_i and conscious area I_j give variable α_i, β_j as shown in Table 2. This method determines the workload scores using a load variable β in unconscious area. As shown in Figure 9, this method can be seen that the scores are closer than the conventional method at the crisis avoidance. The driver model is assumed to be able to perform more accurate estimation by verifying the change and biological reaction of the running environment because this score is able to evaluate the value close to feel the workload score of the subjects.

Table.1 VACP scales

Visual

Scale Value	Verbal Descriptor
1.0	Visually register, detect occurrence
3.7	Visually discriminate
4.0	Visually inspect / check
5.0	Visually locate / align
5.4	Visually track / follow
5.9	Visually read (symbol)
7.0	Visually scan / search / monitor

Auditory

Scale Value	Verbal Descriptor
1.0	Detect / register sound
2.0	Orient to sound (general)
4.2	Orient to sound (selective)
4.3	Verify auditory feedback
4.9	Interpret semantic content (speech)
6.6	Discriminate sound characteristics
7.0	Interpret sound patterns

Cognitive

Scale Value	Verbal Descriptor
1.0	Automatic, simple association
1.2	Alternative selection
3.7	Sign / signal recognition
4.6	Evaluation / Judgment (Consider Signal Aspect)
5.3	Encoding / decoding, recall
6.8	Evaluation / Judgment (Consider Several Aspect)
7.0	Estimation, Calculation, Conversion

Psychomotor

Scale Value	Verbal Descriptor
1.0	Speech
2.2	Discrete Actuation (Button, Toggle, Trigger)
2.6	Continuous Adjustive
4.6	Manipulative
5.8	Discrete Adjustive
6.5	Symbolic Production (Writing)
7.0	Serial Discrete Manipulation (Keyboard Entries)

Tab.2 Scales of driver tasks for VACP

	Visual		Auditory		Cognitive		Psychomotor	
Adjust the speed	α_{V1}	0.0	α_{A1}	0.0	α_{C1}	1.0	β_{P1}	2.6
Sudden braking	α_{V2}	5.0	α_{A2}	0.0	α_{C2}	7.0	β_{P2}	4.6
Track the object	α_{V3}	4.0	α_{A3}	0.0	α_{C3}	3.7	β_{P3}	2.6
Keep the lane	α_{V4}	0.0	α_{A4}	0.0	α_{C4}	1.0	β_{P4}	2.6
Lane change	α_{V5}	0.0	α_{A5}	0.0	α_{C5}	4.6	β_{P5}	2.6
Check the front	α_{V6}	4.0	α_{A6}	0.0	α_{C6}	1.0	β_{P6}	0.0
Check the side	α_{V7}	4.0	α_{A7}	0.0	α_{C7}	1.0	β_{P7}	0.0
Check the rear	α_{V8}	4.0	α_{A8}	0.0	α_{C8}	1.0	β_{P8}	0.0
Scan the front	α_{V9}	7.0	α_{A9}	0.0	α_{C9}	3.7	β_{P9}	0.0
Scan the side	α_{V10}	7.0	α_{A10}	0.0	α_{C10}	3.7	β_{P10}	0.0
Scan the rear	α_{V11}	7.0	α_{A11}	0.0	α_{C11}	3.7	β_{P11}	0.0

Unconscious area   Conscious area

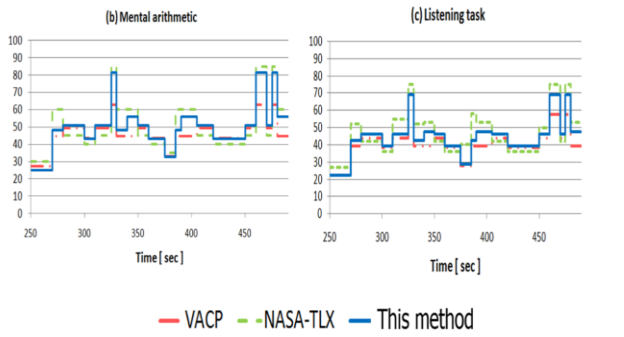

Fig.8 Comparison of three methods

CONCLUSION

In this study, we verify the effect of the load task by the driving test. The results obtained from the driving test are as follows.

1. The driver's brain activity area is delay driving operation of the unconscious area when add load tasks because percentage of consciousness area increases by load tasks. The unconscious area effects individual differences by the load task, driver model is necessary to consider the effect of individual differences.
2. This proposed method verifying the effect of the load tasks by fitting the VACP. The driver's stress is confirmed that the psychological effect is involved greater than the physical effect.
3. We have found to have a correlation from the results of score evaluation by the driver model that weight on unconscious area.

From this experiment, the driver is involved that the psychological effect is greater than the physical effect. As future work, we consider necessary to verify the following.

1. This experiment is considered a learning effect for an experiment was performed by the same course. We are necessary further validation of the courses without a learning effect.
2. We need to verify the change in the psychological effect when the driver is accustomed to the load tasks.
3. We are additional test if the different tasks (e.g. severe mental load and physical load such as tracking task or inattentive task) are changed in the mental effects and physical effect.

From these, We will make decisions variables α_i, β_j.

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Kenta Yamazaki received B.E. (2015), degrees in systems engineering and science from Shibaura Institute of Technology He is a Student, Department of Machinery and Control Systems, Shibaura Institute of Technology His Current interest includes the driver behavior.

Toshio Ito received B.E.(1982) and D.E. (1995) degrees in system engineering from Kobe University. He is a Professor, Department of Machinery and Control Systems, Shibaura Institute of Technology. His current interests include the driver behavior and machine vision for advanced driving support systems.