Changes of driving performance and skin conductance level of experienced taxi drivers due to distraction tasks

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Abstract
This study investigated the effects of distraction tasks, such as Sending Text Message (STM) task with cellphone and Searching Navigation (SN) task with car navigation system, on driving performance and Skin Conductance Level (SCL) of experienced taxi drivers. Twelve male taxi drivers (age 56.3±4.4 years, taxi driving experience 28.4±6.4 years) and fourteen female taxi drivers (age 55.5±3.5 years, taxi driving experience 19.4±5.0 years) were instructed to drive at a constant speed (90 km/hr) for 2 min while keeping a distance of 30 m from the front car also running at a speed of 90 km/hr. Subjects performed driving only for the first 1 min (Control phase). For an additional 1 min (Task phase), they performed Driving Only, Driving + STM, or Driving + SN while driving. For all events, driving performance during the Task phase was evaluated by car control data such as average following distance and speed deviation. For Driving Only, Driving + STM, and Driving + SN, change of SCL from the Control phase to the Task phase, relative change of SCL, was calculated. Compared to Driving Only, during Driving + STM or Driving + SN, relative change of SCL was increased. Compared to Driving Only, during Driving + STM or Driving + SN, average following distance and speed deviation increased. It can be concluded that, even for experienced taxi drivers, distraction tasks increase workload, increased the difficulty to control a car, and detracted from safe driving.

Introduction
Recently, there has been a rise in the vehicular use of electronic equipment, such as mobile phones and navigation systems. During driving, mobile phones are necessary communication tools and/or sometimes important contact tools in an emergency situation. Navigation systems not only provide path-finding information but also music, movie, and digital multimedia broadcasting (DMB) services. Navigation systems also increase driving convenience by providing real-time road and traffic information. While the use of in-vehicle electronics can increase the quality of the driving experience, it is conversely possible that the additional information can increase the drivers’ workload and/or decrease the driver’s attention, which could result in serious problems such as increased accidents [1, 2].

Numerous studies have been undertaken to evaluate the effects of performing a task or disruption of attention on driving. Use of a mobile phone or navigation system during driving increases average following distance, decreases average car speed, and increases variability of car speed [3,4,5,6]. Furthermore, mobile phone or navigation system use increases driver workload and influences the stress or tension experienced by the driver. These results activated sympathetic nervous system and increased heart rate and Skin Conductance Level (SCL) [7,8,9].

Driving performance is influenced by a combination of human, vehicular, and environmental factors. Due to a flaw in one or more one of these factors, accidents occur where the main cause is most often due to the human factor [10]. Accidents due to human factor occur when the driver is inexperienced or careless [11]. Driving is a complicated act requiring focused attention by the driver; secondary tasks performed driving result can impede driving ability [12]. Previous studies reported that driver distraction due to additional workload can trigger driver mistakes [3,4,5,6,7,8,9].

However, these studies were performed to young adults with a short driving experience and little studies for experienced drivers with sufficient driving experience. Since driving performance is influenced by driving experience, further knowledge is needed to clarify the effects of distraction on driving performance. This study was undertaken to investigate the effects of distraction on driving performance of experienced taxi drivers aged in their 50s. Distraction tasks used in
earlier studies, Sending Text Message (STM) and Searching Navigation (SN), were also selected in this study. Car control parameters including average following distance and speed deviation were used to evaluate driving performance. Change in activation level of sympathetic nervous system was investigated by SCL.

**Methods**

The GDS-300s driving simulator (Gridspace, Korea) provides front, left and right visual information through three 32-inch LCD monitors. The driving simulator is the same as the ‘Click’ model from Hyundai Motors. Twelve male taxi drivers (age 56.3±4.4 years, taxi driving experience 28.4±6.4 years) and 14 female taxi drivers (age 55.5±3.5 years, taxi driving experience 19.4±5.0 years) participated in this study. Before starting the experiment, each subject was familiarized with the driving simulator through a practice driving session. Subjects were instructed to drive without changing lanes, while keeping a constant 30 m headway distance from the car ahead on a three-lane straight road in a vacant downtown area. The front car maintained a speed of 90 km/hr. The headway distance was displayed on the screen of the simulator in real time. The experimental paradigm is shown in Fig. 1(a). After resting in the driver’s seat for 3 min (Rest phase), subjects drove for 2 min while maintaining constant distance (30 m) and speed (90 km/hr). Subjects performed driving only for the first 1 min (Control phase). For an additional 1 min, they performed Driving Only or performed a task [Driving + Sending Text Message (STM) or Driving + Searching Navigation (SN)] while driving (Task phase).

In the case of STM, subjects were instructed to use their own mobile phones and put the phone in the most convenient place they could find within 30 cm of the steering wheel (Fig. 1(b)). In the case of SN, subjects were instructed to use the navigation provided by an experimenter by placing the car mounted-type navigation on the dashboard. All subjects participated in three types of experiments: Driving Only, Driving + STM and Driving + SN. The order of experiments was counterbalanced.

The activation level of the sympathetic nervous system was measured using SCL. Biopac MP100 and Acknowledge 3.8.1 (Biopac System, USA) were used to measure the SCL from the index and middle fingers on the left hand. The sampling rate of the physiological data was 500 samples/sec. The relative change of SCL was calculated. The relative change of SCL was obtained by dividing the difference between the SCL in the Task phase and SCL in the Control phase by the SCL in the Control phase.

Relative change of SCL was calculated for 40 sec. excluding the first 10 and final 10 sec in the Control and Task phases regarding Driving Only, Driving + STM and Driving + SN. Average following distance, and speed deviation were calculated for 40 sec. excluding the first 10 and final 10 sec in the Task phase regarding Driving Only, Driving + STM, and Driving + SN (Fig. 1(a)).

Concerning the relative change of SCL, average following distance, and speed deviation, a repeated one-way ANOVA analysis, which takes an independent variable condition (Driving Only, Driving + STM, Driving + SN), was conducted (Ver. 12.0k, SPSS, USA).

**Results**

There was a significant difference in the relative change of SCL among Driving Only, Driving + STM, and Driving + SN (p<.001). From the results of Bonferroni’s posteriori tests (Fig. 2(a)), the relative change of SCL of Driving + SN (p<.001) and Driving + STM (p<.01) increased significantly, compared to that of Driving Only.

There was a significant difference in the average following distance among Driving Only, Driving + STM and Driving + SN (p<.001). As a result of Bonferroni’s posteriori tests (Fig. 2(b)), the average following distance of Driving + SN increased significantly, compared to that of Driving Only (p<.001) and compared to that of Driving + STM (p<.05). The average following distance of Driving + STM increased significantly, compared to that of Driving Only (p<.001).

There was a significant difference in the speed deviation among Driving Only, Driving + STM and Driving + SN (p<.001). From the results of Bonferroni’s posteriori tests (Fig. 2(c)), the speed deviation of Driving + SN (p<.001) and Driving + STM (p<.001) increased significantly, compared to that of Driving Only.
Discussion
Compared to Driving Only, additional tasks increased relative change of SCL significantly. This means that distraction tasks increased driver’s workload, and then increased the activity of the sympathetic nervous system. Increase in workload resulted in decreased driving performance. Due to the distraction tasks, increases in average following distance and speed deviation made it difficult to maintain instructed following distance and speed. It can be concluded that, even for experienced taxi drivers, distraction tasks increased driver workload and made it difficult to control the car.

Compared to STM, SN was influential on the increase in relative change of SCL and on the decrease in driving ability. It is relatively easy to manipulate a mobile phone for the STM task during driving, compared to SN. However, for SN, additional workload due to increased movement made it difficult to control the car, since the navigation system was placed in the central upper part of the dashboard. Complementary research on this topic will be necessary.

Acknowledgements
This work was supported by a Research Fund of Hanbat National University in 2012.

References

Figure 2 (a) Relative change of skin conductance level (SCL), (b) Average following distance, (c) Speed deviation regarding the three types of experiments

(* ** *** p<.05, ** p<.01, * p<.001)