A Driving Simulator Study: Elderly and Younger Drivers' Physiological, Visual and Driving Behavior on Intersection

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1. Introduction
Driving is considered as a complex task which involving coordination and execution of various cognitive, physical, sensory, and psychomotor skills (Young and Regan, 2007). As the population ages, risks for cognitive decline threaten safety and quality of life for elder. One of the main causes of the traffic accidents by the elderly drivers is the decline of physical functions (Unverzagt et al., 2009). As the population in the developed world is aging (Cohen, 2003) so the number of older drivers is increasing. Korea became an “aging society” in 2010, it will become an “aged society” by 2019 with 14.4\% elderly population (people aged 65 and over), and a “super-aged society” with 20\% by 2026. Korea is not only aging faster than any other nations, it is expected to become the most aged country by 2050 with 35.1\%. Therefore, the total number of older drivers on the roads is rapidly increasing. In Korea, the number of traffic accidents by the elderly drivers has gradually been increasing for the last 10 years. In Korea, as of the end of 2013, 5,092 persons killed in the traffic accidents, in that 35.9\% (1,833 persons) were elderly age above 65 years. In terms of casualties by age and traffic participation, for age above 65 years, 951 persons (51.9\%) out of 1,833 were killed in pedestrians (KoROAD, 2014). This result suggests that intersection is a relatively dangerous situation, especially with aging. This study examined the characteristics of elderly driver's physiological, visual attention and driving behavior on intersections. In order to focus on aging, the eye movements, physiological and driving behavior of both younger and older drivers were compared and analyzed.

2. Materials and Methods
2.1 Subjects
The participants were healthy male drivers with driving experience of 32.5±9.4 years (elderly group) and more than 3 years (younger group). They were 10 participants from each group; the average age of them was 65.6±5.0 years (elderly), and 26.3±2.0 years (younger). All participants had no clinical history of mental diseases and visual problem to drive a car in the driving simulator. They gave their informed consent after having been informed about the main contents of the experiment but not about the objectives.

2.2 Driving Simulator and Driving Scenario
A driving simulator located in the Chungnam Techno Park (CTP), Korea Automobile Technology Institute was used (Fig. 1). Notable specification of the simulator was follows: VGA to QXGA (2048 X 1536), True SXGA+1400 X 1050 resolution, and scan rates of 15 kHz to 120 Hz (horizontal) and 23.97 to 150 Hz (vertical). A 10-min practice was allowed for each participant to adjust to the simulator. Ample rest time was given between practicing and real test. The simulator was operated in the controlled environment with temperature (25 °C) and relativity humidity (40-50\%). Driving scenario involving lots of right turns, signal, and the unprotected left turn was considered (Fig. 2).

2.3 Subjective and Objective Measurement
For the subjective evaluation, 30 questions were asked to all participants regarding the simulation sickness and sensation. Visual analogue scale (VAS) was used to measure the subjective feeling (highest score = 10). The physiological parameters were recorded using a Biopac MP 150 system and analyzed in AcqKnowledge 4.2 software. The sampling frequency for measuring physiological signals was set at 1000 Hz. The physiological behavior recorded were: electroencephalogram (EEG) in the area of the frontal lobe (F\textsubscript{z}) and
occipital lobe (Oz) for α-relative band ratio and β-relative band ratio; and electrocardiogram (ECG). The EEG electrodes were attached in accordance with the 10-20 international system. For processing the EEG, data were digitized (A/D transformation), and then low-pass filtered. Frequency analysis was done using an FFT transform: for signals from Fz and Oz, the parameters of α/(α+β+θ+δ) and β/(α+β+θ+δ) were calculated. Skin impedance was under 10 kΩ. From the ECG measurements, the time between successive R-peaks (i.e., R-R interval) was calculated. Eye movements and eye positions were collected by the faceLAB eye-tracking system. The eye movements measured were: a ratio of visual scanning time of left direction and right direction. The driving behavior measured were: difference in passing time, and difference in approaching velocity.

3. Results

Analysis of the central and autonomic nervous systems showed the significant differences in the bands of EEG, and the R-R interval while driving at the intersection between younger and elderly drivers. In terms of driving performance, compared with younger drivers, elderly drivers showed a poor driving performance, and high ratio of visual scanning time while driving at the intersection. The subjective discomfort results that the elderly drivers showed stronger discomfort during driving simulation, while the younger drivers showed mild to moderate discomfort for the simulation sickness.

Figure 1. Driving simulator used in this study.

Figure 2. Driving scenario involving: unprotected left turn, signal, and right turns.
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References

http://taas.koroad.or.kr