USEFUL FIELD OF VIEW AND RISK OF ACCIDENT IN SIMULATED CAR DRIVING

[1]T. Allahyari, *[1]G. Nasl Saraji, [1]J. Adl, [2]M. Hosseini, [3]M. Younesian, [4]M. Iravani

[1]Department of Occupational Health, School of Public Health, Medical Sciences/ University of Tehran, Tehran, Iran

[2]Department of Epidemiology and Biostatistics, Medical Sciences/ University of Tehran, Tehran, Iran

[3]Department of Environmental Health, Medical Sciences/ University of Tehran, Tehran, Iran

[4]Department of Psychology, Faculty of Psychology and Educational Sciences, University of Tehran, Iran

Received 15 January 2006; revised 20 February 2006; accepted 30 March 2006

ABSTRACT

This study investigated the relationship between Useful Field of View and simulator-driving performance measures. Ninety professional drivers, aged 22-65 years from several government organizations voluntarily participated at this study. Useful Field of View was measured by a computerized task was developed at the present study. The participants then performed a driving simulator task and experienced a scenario that could lead to an accident. Reaction time and speed were measured and recorded by simulator and general driving performance and collision events were recorded by examiner. The reduction of Useful Field of View based on subject's error score on Useful Field of View subtests between young and old group statistically was analyzed. Correlation analyses used to examine the relationship among the Useful Field of View as an independent variable and driving performance measures as a dependent variables. A univariate logistic regression analysis was used to determine the extent to which reduction of Useful Field of View predicts risk of accident in simulated car driving. There was a significant and negative correlation between Useful Field of View and simulator performance, on the divided peripheral subtest (Correlation Coefficient=-0.28). Student's t-tests revealed significant differences in peripheral scores of Useful Field of View subtests between accident involved and non-involved groups. The result of logistic regression indicated that 40% reduction of Useful Field of View, regardless of age, increased risk of accident involvement. Useful Field of View could be used to predict driving performance and risk of accident. The obtained result can help to identify a high risk driver which is useful to licensing authorities.

Key words: Useful Field of View, driving simulator, driving performance, BRT

INTRODUCTION

Inattention plays an important role in the traffic accidents which are due to human error. Attention is defined as the ability of individuals to process information from the environment or capability of receiving and processing stimuli. In different driving situations, drivers encounters with different types of stimuli, visual or auditory, from different sources, and for safe performance should have an accurate perception of them. Driving context also provide a complex information processing situation from view point of direction, continuous, quantity and ambiguity of stimulus. So, drivers' safety and performance are influenced significantly by attention skills of drivers. Previous studies revealed that, failure of attention and deficiency of information processing is one of the major causes of accidents (Shinar, 1993). From ergonomics prospective, any incompatibility between cognitive resources and job demands results in deterioration of performance and occurrence of errors. In driving tasks, fails of cognitive abilities in each phase of information

*Corresponding author-Email: *jnsaraji@sina.tums.ac.ir*
Telefax: +98 21 8895 1390

processing system, i.e. sensing, perception, attention, and decision making could threaten traffic safety. Practical research demonstrated that, individual differences in attention can be measured and used as a predictor for ranges of real world tasks (Arthur and Doverspike, 1992). One of the visual attention measures or tests is useful field Of view (UFOV). UFOV is defined as the region of the visual field, from which, information can be acquired without any movement of the eyes or the head (Ball *et al*., 1988).The size of UFOV is very important for rapid extracting and identifying of information details in the scene of driving. Recent studies concluded that, if there is any deterioration in UFOV performance, drivers may be act slowly in extracting information details and risk of accident would be increased.

The concept of the UFOV was originally described by Sanders (1970) who used the term "functional visual field" to define the visual field area, over which, information can be obtained in a brief glance without eye or head movements. Subsequently, Verriest *et al*., (1985) described UFOV as an "Occupational Visual Field". They distinguished it from the clinical visual sensory field, typically evaluated by perimetry in ophthalmologic settings. The term "useful field of view" was first used by Ball *et al*., and has subsequently come to be most widely associated with a specific computer-based test. UFOV was used to assess visual processing speed, divided attention, and selective attention.

UFOV can be measured by instructing the subject to perform a dual task: a central task and a peripheral task. The size of the UFOV is smaller than peripheral visual field (Ball and Owsley, 1993). Some investigators assess the UFOV by simply instructing the subjects to detect the presence of a peripheral signal and identify it (Williams, 1982; 1995; Ball *et al*., 1993), whereas, others demand localization (Ball and Owsley, 1993; Sekuler *et al*., 2000). Ball *et al*., (1993) proposed that the limit of the visual field depends on the subject's ability to locate peripheral signals.

In the present study, the size of the useful visual field was measured through a computerized task, including detection followed by localization of the peripheral stimulus. Authors such as Ball and Owsley, (1994); Ball, (1993) attempted to examine the relationship between the reduction of the useful visual field and the number of accidents in real situations, using retrospective design, while the mentioned author described prospective design, in cooperation with Owsley, McGwin, 1999. A recent Meta-analysis revealed that, UFOV is a valid and reliable index of driving performance (Clay *et al*., 2005). However, some researchers take a different approach. For instances, Myers *et al*., (2000) revealed that poor performance on the UFOV test was associated with a high number of driving errors (failing to stop at a stop sign, missing important road signs, making errors of judgment or taking a wrong position on the road) in older drivers. Roge *et al*., suggested that, ability of processing peripheral stimulus and driving performance decreased with age. The reduction in target localization task of UFOV negatively correlated with managing of challenging scenario in simulated car driving and reaction time. Only speed, in their study showed a negative correlation with target detection tasks. Authors concluded that collision risk should be estimated only based on target localization task (Roge *et al*., 2004). Besides numerous studies on UFOV, effects of UFOV reduction on simulator driving performance are insufficiently investigated.

The present study examines the relationship between UFOV and driving performance and effect of UFOV reduction on driver's response to challenging scenario in driving simulator. The proposed hypothesis is people who have a poor performance on UFOV test because of delay and error in detecting of peripheral stimulus may be fail in successfully managing challenging scenario (suddenly entrance of pedestrian onto road) and may be experienced a collision. In addition, general driving performance in simulator and performance elements including reaction time and speed may be influenced. Finally determine which subtests of UFOV suggest a significant relationship with driving performance or collision at simulator.

MATERIALS AND METHODS

A sample consisting of 90 professional male drivers from government sectors, aged 22 to 62 (Mean =42.5, SD=9.9), voluntarily participated in this study. With coordination and justification of study objectives for transportation department managers of these organizations, they requested to provide possibility of drivers to participate at the current study as a part of traffic safety promotion program. Based on age, subjects were divided into two groups, young group with ages ≤42.5 (M=33.5, SD=6.1, n=47) and older group aged >42.5 (M=50, SD=5, n=56). All participants had normal or corrected-to-normal vision. The research adhered to the tenets of the ethic committee of the Tehran University of Medical Sciences, all subjects gave informed consent before participating in the research after explanation of the nature and possible consequences of the study.

Devices and instruments

A computerized task was developed same as Sekuler *et al.*, making some changes for measuring of UFOV (Sekuler *et al.*, 2000). The central stimulus included four geometric figures presented in the center of a grey background. From one trial to the next, the shape was selected randomly from the figures. The peripheral target was a white spot that could appear in one of 24 positions, each marked by a white circle, slightly larger than the target spot. The 24 locations were arranged into eight evenly spaced radial spokes, and each spoke contained three locations at eccentricities of 6, 12, and 18 degrees. Both central and peripheral stimuli were presented for 90 ms. In the divided and selective attention subtests, the central and peripheral tasks were presented simultaneously.

Procedures

Before driving in simulator, participants performed the UFOV test. Test consisted of four parts: central task, peripheral task, divided attention, and selective attention. Before each stage some practice trials were included. Total test completed for approximately 15 minutes. Participants used a mouse to start the test and indicated their responses. If a subject had difficulty to use the mouse, they were responded by pointing to the appropriate target position and a technician made the mouse responses for the subject's choice. Viewing was binocular from a distance of approximately 40 cm. There were three attention conditions: focused, divided, and selective. In the focused condition, participant performed the central and peripheral task in separate stages of tests. In divided and selective attention condition, central and peripheral stimuli presented simultaneously and selective condition is similar to the divided attention task, but, there were some distractors. Tasks were presented as following order: focused-central, focused peripheral, divided and selective (Fig. 1). Scores of all subtests calculated based on the proportions of errors that a transformation was used by the inverse sine of their square–root to normalize the variance (Sekuler and *et al.*, 2000). For peripheral task, error scores was based on the proportion of times a subject misidentified the radial and/or eccentric position of the stimuli.

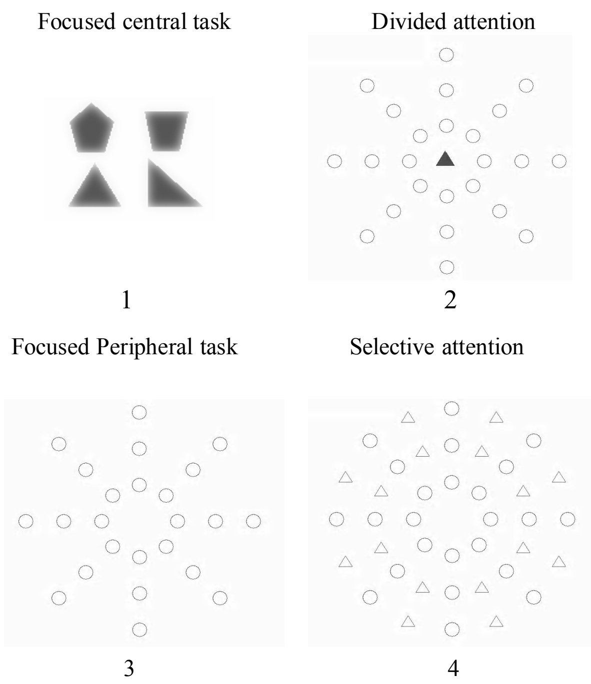

Fig. 1: The UFOV test used in the present study, consisted of four parts, stimulus were presented on a computer monitor. In part 1(Focused central), the observer identified a target stimuli (4 Geometric shapes) presented in the centre of the computer screen for a 90 Ms. In part2 (focused peripheral), and observer locate a stimuli that randomly presented on 24 situations. In stage 3 (divided attention), identify a central target stimuli and then locate a peripheral target that simultaneously presented. In stage 4 (selective attention), was similar to the part 3, but, there were some distracters making task more difficult.

Simulated driving task

After measuring of UFOV, subjects performed a simulated car-driving task on the driving simulator (Fater Technology Co., Iran). The simulator used in the study consisted of an open cabin with real car parts (steering wheel, gear shifter, clutch, accelerator, brake pedals, handbrake, light button and safety belt mounted on a solid base). Road scenes were presented on three seventeen inch LCD monitors giving a 120 degree field of view. Before driving, there was a familiarization with simulator elements. Then participants completed a practice trial for 10 minutes on simulator. Then, all participants experienced the same simulator scenario for comparison purposes. The road included highway and City Street as direct and curved. The simulator task completed approximately for 20 minutes. Drivers encountered with challenging scenario approximately 5 minutes after starting driving session. Our defined event was "suddenly entrance of pedestrian to road". This was a situation that could result in accident if driver has a delay on acquiring visual information about peripheral target stimuli (pedestrian). The point of entrance and speed of pedestrian for all samples was the same. Four indices about driver's performance were recorded: collision, braking reaction time, speed, and general driving performance in simulator.

After driving on simulator, examiner completed a scale consisted of 13 items that assessed driving behaviors and skills. Driving related components monitored were speed, using indicator and correct stop before junction and so on. All items rated on a 1- 3 Likert scale (corresponding to Not At All, Sometimes and Often, respectively). Total score calculated from sum of all item scores. The higher score indicated a better performance. The reduction of UFOV based on subject's error scores on all UFOV subtests between young and old age group was statistically analyzed. Pearson correlation coefficients between simulator driving performance parameters as a dependent variables and UFOV subtests as an independent were calculated. Student's t-test was used to examine significant differences between subtests error scores between accident-involved and non-accident groups. A univariate logistic regression analysis was used to determine the extent to which reduction of UFOV predicts accident in simulator as a dependent variable. In a second step, age was used as covariate in a multivariate logistic regression analysis. Regression analysis was used to examine the relationship between UFOV subtests and reaction time. All correlation coefficients and statistical analysis were considered to be significantly different when the probability of error was ≤ 0.05.

RESULTS

Table 1 presents descriptive data for UFOV subtests. The correlation analysis between UFOV and age revealed a high and significant relationship except for focused attention condition (Table 2). Student's t-test was used for comparing the mean of UFOV subscales between young and old groups. The analysis suggested significant differences between two groups on UFOV performance in central divide attention t (87)= -5.4, P<0.001), peripheral divided attention t (87)= -4.3, P<0.001), central selective attention t (87)= -3.0, P<0.01) and peripheral selective attention t (87)= -2.5, P<0.01).

Table 1: Descriptive information for UFOV subtest error rate

UFOV subtests	Min	Max	M	SD
Subtest1: Focused attention:				
central (Stimulus identification)	0	1.57	0.18	0.24
peripheral (Target localization)	0	0.61	0.22	0.15
Subtest 2: Divided attention				
Central(Stimulus identification)	0	0.74	0.31	0.19
peripheral (Target localization)	0	0.95	0.43	0.19
Subtest 3: Selective attention				
central(Stimulus identification)	0	0.78	0.32	0.18
peripheral (Target localization)	0	0.86	0.46	0.20

Note: smaller scores reflect better performance

Table 2: Correlation coefficients between UFOV subtest scores and age

Correlation	r	p
Focused attention with age	0.09	Not Sig
Divided attention (central task) with age	0.64	0.000
Divided attention (peripheral task) with age	0.49	0.000
Selective attention (central task)	0.28	0.007
Selective attention (peripheral task) with	0.40	0.000

The correlation coefficients between target detection (central task) and target localization (peripheral) error scores suggested a significant correlation in central attention condition (r=0.29, P=0.004), divided attention (r=0.553, P=0.000) and selective attention(r=0.442, P=0.000). The more error in detection task, the more limited the localization task.

Analysis of simulator driving data

Correlation analysis was used to examine the relationship between simulator performance and UFOV subscales. A negative significant correlation was found between the divided attention (peripheral) score and driving performance (r=-0.281, p<0.01). In other words, subject who have more error on divided attention subtest show a poor performance in simulator driving. Of 85 participants that completed all of study tests, 45 people having no accidents in simulator driving session, 38 people had one accident and 14 people had two accidents. As an exploratory analysis the sample divided into an accident-involved and non-involved. Student's t-test revealed significant differences in divided attention (central and peripheral) and selective peripheral scores between two groups (Table 2).

Table 2: UFOV subtests performance between accident involved and non accident group

UFOV subscales	Accident group (n=38)		Non accident group (n=47)
	M±SD		P-value*
Focused central	0.14±0.19	0.21±0.27	0.252
Focused peripheral	0.20±0.14	0.23±0.15	0.301
Divided central	0.27±0.18	0.35±0.18	0.04
Divided peripheral	0.36±0.16	0.50±0.18	0.001
Selective central	0.30±0.14	0.33±0.20	0.420
Selective peripheral	0.39±0.20	0.53±0.19	0.002

*T- test

Assuming a 40% reduction in UFOV as the pass-or-fail cutoff score, it was that, we defined 40% or more reduction in UFOV if any subtests of UFOV had a 40% or more errors. Then, a logistic regression was conducted to determine whether UFOV could be used to predict whether a driver was involved in crashes and or not. The result revealed that 40% reduction of UFOV, regardless of age, increased risk of accident involvement (OR=12.1, 95% CI, 2.6-56.3). The resulting logistic regression coefficients and relevant statistics are shown in Table 3.

Table 3: Logistic regression analysis of accident risk in simulated car driving in subjects with 40% or more reduction in UFOV

Parameter	B	S.E.	P-value	OR=Exp(B)
UFOV	2.50	0.78	0.001	12.1
Age	0.10	0.44	0.826	1.10
Constant	-0.30	0.32	0.334	0.73

Regression analysis was used to examine the effect of UFOV reduction on braking reaction time. Divided attention (peripheral) task and selective attention (peripheral) showed a significant prediction on braking reaction time, F (1, 78) = 4.7, P<0.05, r=0.241) and F (1, 78) = 4.2, P<0.05, r=0.22), respectively. In other words, subjects with more error in these subtests have a long reaction time.

DISCUSSION

Age showed significant correlation with UFOV subtests except for focused attention conditions. There was also a correlation between central (target detection) and peripheral (target localization) tasks. These result confirmed the result of Roge *et al.*, 2005.

The relationship between simulator driving performance and UFOV subtests indicated that, only peripheral task score in divided attention subtest had a negative correlation with diving performance. On the other hand, the analysis of UFOV subtest's means between accident involved and non-involved subjects in simulator driving session revealed that only peripheral tasks scores in divided and selective conditions have significant differences between two groups. These findings emphasized on the important role of peripheral vision on safety and performance of driving. Also confirmed the finding of Roge *et al.*, that showed risk of accident only could be estimated by localization task (Roge *et al.*, 2004). When a noticeable reduction in UFOV considered (as defined) and entered to the logistic regression model, risk of being involved in accident increased

(OR=12.1). These results are the same as the study of Ball *et al.*, that, revealed a strong association between UFOV performance and retrospective crashes (Ball *et al.*, 1993) and prospective crash involvement (Owsley *et al.*, 1998). They reported that UFOV was a significant predictor of crash rate, and individuals with UFOV reduction of 40% or more were 2.2 times more likely to be involved in a crash than those with less than 40%. Ball *et al.*, in their retrospective study found that older drivers with serious-more than 40%- loss in the UFOV were 6 times more likely than those with minimal or no UFOV reduction to have been at least partially responsible for a crash within the last five years. However, none of these studies specifically reviewed risk of accident in a simulated car driving experiment. Between UFOV subtests only peripheral tasks scores in divided and selective conditions have significant differences between accident involved and non involved groups. Also, only peripheral condition scores showed a negative correlation with driving performance. In other analysis on braking reaction time it was found that, subjects with high error in peripheral subtest of UFOV had a long reaction time.

It could be concluded that driving safety and performance most affected by peripheral task in UFOV and effect of all subtests were not the same. This confirm finding of Roge *et al.*, study (Roge *et al.*, 2004).

In conclusion, the result of our study demonstrated that, UFOV could be used to predict driving performance and risk of accident. The result can help to identify high risk drivers which may be useful to licensing authorities. Although license examiners more involved with screening of drivers, occupational physicians and occupational health professionals should assess the UFOV and other cognitive abilities of drivers for determining fitness to drive.

ACKNOWLEDGEMENTS

The research has been supported Center for Environmental Research (CER), Tehran University of Medical Sciences, grant #132.5959.

REFERENCES

Arthur, W., and Doverspike, D., (1992). Locus of control and auditory selective attention as Predictors of driving accident involvement: A comparative longitudinal investigation. J. Safety. Res., **23** (2): 73-80

Ball, K., Owsley, C., (1993). The Useful field of view test: a new technique for evaluating age related declines in visual function. J. Am. Optom. Assoc.; **64**:71-79.

Ball, K., Owsley, C., Sloane, M. E., Roenker, D. L., Bruni, J. R., (1993).Visual attention problems as a predictor of vehicles crashes in older drivers. Invest Ophthalmol. Vis. Sci., **34**: 3110-3123.

Clay, O. J., Wadley, V. G., Edwards, J. D., Roenker, D. L., and Ball, K. K., (2005). Cumulative meta-analysis of the relationship between useful field of view and driving performance in older adults: Current and future implications. Optometry. Vision. Sci., **82**: 724-731.

Myers, R., Ball, K., Kalina, T., Roth, D., Goode, K., (2000). Relation of useful field of view and other screening tests to on-road driving performance. Percept. Mot. Skills., **91**: 279–290.

Owsley, C., (1994). Vision and driving in the elderly. Optom. Vis. Sci., **71**: 727-735.

Owsley, C., McGwin, G., (1999). Vision impairment and driving. Surv. Ophthalmol., **43**:535-550.

Roge, J., Pebayle, T., (2005). Campagne A. and Muzet Alain. Useful Visual Field reduction as a function of age and risk of accident in simulated car driving. Investigative Ophthalmology. Visual. Sci., **46**: 5.

Sekuler, A. B., Bennett, P. J., (2000). Mamelak M. Effects of aging on the usef ul field of view. Exp. Aging Res., **26**: 103-120.

Shinar, D., (1993). Traffic safety and individual differences in driver's attention and information processing capacity. Alcohol, Drug. Driving., **9**: 219-237.

Sekuler, L. J., (1982). Cognitive load and the Functional field of view . Human. Fact. Soc., **12**:684-692.

Williams, L. J., (1995).Visual field tunneling in aviators induced by memory demands. Gen. Psychol., **122**: 225-235.