Older Drivers' Acceptance of Vehicle Warning Functions and the Influence of Driving Experience

Lin Wang[(✉)]

Department of Library and Information Science,
Incheon National University, Incheon, South Korea
wanglin@inu.ac.kr

Abstract. Warning functions in vehicles can be very useful to older drivers for avoiding crashes due to failure to perceive the danger of a situation. This study investigated older drivers' acceptance of vehicle warning functions and the influence of driving experience. The results indicated that, in general, the perceived importance of external environment warnings is significantly higher than the perceived importance of car status warnings and driver condition warnings to older drivers. However, driving experience significantly influences the perceived importance of warning functions. With increasing driving experience, both the perceived importance of external environment warnings and the perceived importance of car status warnings significantly decrease. There is no decrease in the perceived importance of driver condition warning functions.

Keywords: Older drivers · Driving experience · Vehicle warning functions

1 Introduction

It was estimated that if the current traffic fatality rate for older people continues, especially as baby boomers reach their golden years, the number of older-occupant fatalities could approach nearly 20,000 per year in the U.S. in the near future. This is almost equal to the annual number of deaths caused by drunk driving on the nation's highways [1]. Declines in both physical and cognitive abilities due to aging create several problems for older drivers while driving. It was found that 60 % of the crashes involving older drivers were due to "informational" causes, such as failure to perceive the danger of a situation or failure to respond appropriately to a dangerous situation [2]. With the developments in sensing and information technologies, warning functions in vehicles can be very useful to provide full-scale information about the external environment, vehicles, and even drivers themselves. The warning messages would help older drivers perceive the danger of a situation.

This research studied older drivers' perceived importance of the vehicle warning functions and investigated the correlation between driving experience and the perceived importance of the warning functions. The research findings are expected to be useful to designers and researchers investigating older drivers.

2   Literature Review

Because of aging effects, older adults often experience many difficulties while driving. Vision impairment is one of the most important causes of driving difficulties of older adults [3]. The types of vision problems of older drivers reported include reduced visual field, reduced vision at night or in dim light, and reduced ability to visually define and separate objects [4]. Reduced muscle strength, endurance, flexibility, and motor speed also influence driving abilities [5]. For example, reduced neck rotation may impair the driver's ability to turn their head to see relevant stimuli in their periphery, which is necessary for safe driving in complex traffic situations and when changing lanes [5]. Besides the physical aging effects mentioned above, cognitive aging effects also influence driving abilities significantly. For example, older drivers often have difficulty dealing with unexpected situations due to the decrease in perceptual speed and reaction time [6]. A few aging effects and their influence on driving abilities are summarized in Table 1.

Table 1. Aging effects and their influence on driving ability

Aging effects	Influence on driving ability
Reduction in visual acuity and contrast sensitivity [7, 8]	Reduced ability to visually define and separate objects [4, 9–11]
Reduced ability to see at night [12, 13]	Reduced ability to see objects at night, dusk, or in dim light [4, 14]
Increased glare sensitivity [7]	Difficulty when driving into the sun or other glare [14]
Reduced visual field [4, 15, 16]	Higher accident rate in situations involving left turns, intersections, and overtaking [17]
More susceptible to fatigue [18]	Not suitable for long-distance driving or driving in very hot or cold weather [19]
Reduction in muscle strength, endurance, flexibility, and motor speed [5, 20, 21]	Reduced neck rotation may impair the ability of the driver to turn their head to see relevant stimuli in their periphery, necessary for safe driving in complex traffic situations and when changing lanes [5]
Decrease in perceptual speed and reaction time [6, 22, 23]	The speed at which visual information is processed is an important factor for successfully negotiating difficult or dangerous traffic situations [5]
Spatial ability loss [24, 25]	At risk of multiple-vehicle involvement at intersections [4]
Executive ability loss [26]	Difficulties occur at the level of executive function given that the types of crashes in which older adults are involved often occur in complex traffic situations [5]

Vehicle warning functions can be useful to older drivers whose perception abilities have declined because of aging. Vehicular crashes are often influenced by three factors —the environment, the vehicle, and the driver [27]. Warning functions can also be divided into external environment warnings, driver condition warnings, and car status warnings. External environment warnings include warnings of dangers outside the vehicle such as forward collision warning and pedestrian warning. Driver condition warnings are warnings about the drivers themselves such as fatigue warning systems. Car status warnings are warnings of vehicles such as car status check systems. This study sought to determine the type of warning function that was perceived to be the most important by older drivers. The study also investigated whether driving experience would influence the perceived importance of the warning functions. There were two research questions in this study:

Research question 1: How do older drivers rate the three types of warning functions?

Research question 2: Would their driving experience have an influence on their rating?

3   Method

A survey was used as the research method to investigate older drivers' rating of the three types of warning functions and the relation between their driving experience and acceptance of different warning functions. The seven-point Likert scale was used to measure the perceived importance of each warning function.

3.1   Questionnaire Preparation

The questionnaire consisted of two parts. The first part collected the demographic and driving experience information of the subjects. The information pertaining to demographics included subjects' age, gender, education level, current occupation, driving experience, and frequency of driving. The second part investigated the perceived importance of the warning functions. The subjects were asked to rate the extent to which they agreed with the statements that followed.

Statements of external environment warning functions:

– Danger warning system is important to me.
– Pedestrian warning and braking system is important to me.

Statement of driver condition warning functions:

– Fatigue warning system is important to me.
– Driver condition warning system is important to me.

Statement of car status warning functions:

– Car status warning system is important to me.
– Lane departure warning system is important to me.

3.2 Subjects and Survey Details

Older drivers between 55 and 75 years of age who had a driving experience of more than one year could participate in the survey. A total of 163 subjects participated in the study including 118 males and 45 females. The average age of the subjects was 60.9 y (SD = 5.4 y). The average driving experience was 27.6 y (SD = 10.3 y). 107 subjects drove their cars almost every day, 36 subjects two to three times per week, and 20 subjects less then or approximately once per week. 118 subjects had high school or secondary school education, 43 subjects had bachelor or college degrees, and 2 subjects had masters or higher degrees.

3.3 Survey Conduction

The survey was conducted at transportation centers, taxi companies, and senior centers. Paper-based questionnaires were distributed in person by a research assistant. First, the research assistant provided a brief description of the research. Then, if the older drivers agreed to participate in the study, they were asked to sign an informed consent form and fill the questionnaire. After they finished the questionnaire, they could receive a token compensation worth $5 such as bread and milk.

4 Result

The ANOVA test was used to investigate the differences of the perceived importance of different types of warning functions to older drivers. The testing results showed that there was a significant difference between the ratings for external environment warnings and those for driver condition warnings. Moreover, there was a significant difference between the ratings for external environment warnings and those for car status warnings. The perceived importance of external environment warnings was 7.1 % and 5.3 % higher than that of driver condition warnings and car status warnings, respectively. Detailed data and p values are shown in Table 2.

Table 2. Comparison of the importance of external environment warning, driver condition warning, and car status warning to older drivers.

Variable 1	Variable 2	P value
External environment warning Mean = 6.0 SD = 1.01	Driver condition warning Mean = 5.6 SD = 1.19	0.002*
External environment warning Mean = 6.0 SD = 1.01	Car status warning Mean = 5.7 SD = 1.08	0.022*
Driver condition warning Mean = 5.6 SD = 1.19	Car status warning Mean = 5.7 SD = 1.08	0.377

Further, the influence of driving experience on the perceived importance of different types of warning functions was investigated. Correlation analysis was used to study the relationship between driving experience and the perceived importance of the warning functions. First, correlation analysis was used to test the relationship between driving experience and the perceived importance of external environment warnings. The testing result found a significant negative correlation (Pearson correlation = −0.216, p = 0.007). It meant that the perceived importance of external environment warnings significantly decreased with increasing driving experience. Further, there was a significant negative correlation between driving experience and the perceived importance of car status warnings (Pearson correlation = −0.207, p = 0.009), which meant that the perceived importance of car status warnings significantly decreased with increasing driving experience. There was no significant correlation between driving experience and the perceived importance of driver condition warnings (Pearson correlation = 0.017, p = 0.830).

In order to have an intuitive understanding of how these three variables changed with driving experience, linear regression was performed between these variables and driving experience. As shown in Fig. 1, with increasing driving experience, the perceived importance of external environment warnings and car status warnings significantly decreased. It meant that for experienced older drivers, the perceived importance of external environment warnings and car status warnings was not as important as for relatively inexperienced older drivers. On the contrary, there was no significant decrease in the perceived importance of driver condition warnings with increasing driver experience. This meant that for older drivers with different amounts of driving experience, driver condition warnings were equally important. For relatively inexperienced older drivers, the driver condition warning was still significantly less important than external environment warnings and car status warnings; however, with increasing driving experience, the driver condition warning was as important as the other two types of warnings.
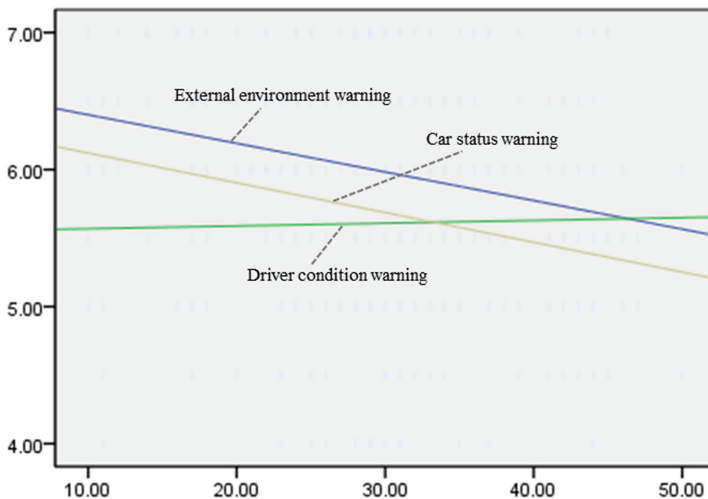

Fig. 1. Output graph of linear regression between the scores of warning functions and older drivers' driving experience.

5 Discussion

This study investigated older adults' acceptance of different vehicle warning functions and the influence of driving experience on the acceptance. The study results indicated that, in general, the perceived importance of external environment warnings is significantly higher than the perceived importance of car status warnings and driver condition warnings to older adults. Owing to declines in perceptive abilities and speed, the external environment warning is very important for them. About 60 % of crashes involving older drivers were due to "informational" causes such as failure to perceive the danger of a situation or failure to make an appropriate response to a dangerous situation [2]. It is essential to ensure information accuracy as older drivers' perception of the external environment is very important.

Also, the results indicated that driving experience significantly influences the perceived importance of warning functions. With increasing driving experience, both the perceived importance of external environment warnings and perceived importance of car status warnings significantly decreased. However, there was no decrease in the perceived importance of driver condition warning functions. The literature suggested that with practice, drivers learn where to search for relevant information and respond to it more quickly [28, 29]. Experienced drivers look at the road farther ahead than novices [30]. For experienced older drivers, the perceived importance of external environment warnings and car status warnings were found to be lower than that for relatively inexperienced older drivers. However, the importance of driver condition warnings does not change for both experienced and novice older drivers. Recently, researchers have begun to investigate and develop technologies to monitor the vital signs of older drivers. For example, Walter et al. investigated embedded measurement techniques for non-contact monitoring of vital signs, including capacitive electrocardiogram monitoring (cECG), mechanical movement analysis (ballistocardiogram, BCG) using piezo-foils, and inductive impedance monitoring [31]. Older drivers may be easily tired and may feel sleepy owing to the effects of medication. Moreover, their health condition may suddenly deteriorate owing to health problems such as hypertension and heart disease. Monitoring of driver function and driver condition warnings could help prevent crashes to some extent.

The subjects' past exposure to the warning functions, which may have had an influence on their ratings, was not investigated; this is a limitation of this study. In future studies, more warning functions should be studied with a more detailed description of each function.

References

1. Burkhardt, J.E., Berger, A.M., Creedon, M.: Mobility and Independence: Changes and Challenges for Older Drivers. Ecosometrics, Bethesda (1998)
2. Fell, J.C.: A motor vehicle accident causal system: the human element. Hum. Factors: J. Hum. Factors Ergon. Soc. **18**, 85–94 (1976)

3. Owsley, C., Ball, K., Sloane, M.E., Roenker, D.L., Bruni, J.R.: Visual/cognitive correlates of vehicle accidents in older drivers. Psychol. Aging **6**(3), 403 (1991)
4. Preusser, D.F., Williams, A.F., Ferguson, S.A., Ulmer, R.G., Weinstein, H.B.: Fatal crash risk for older drivers at intersections. Accid. Anal. Prev. **30**(2), 151–159 (1998)
5. Anstey, K.J., Wood, J., Lord, S., Walker, J.G.: Cognitive, sensory and physical factors enabling driving safety in older adults. Clin. Psychol. Rev. **25**(1), 45–65 (2005)
6. Salthouse, T.A.: The processing-speed theory of adult age differences in cognition. Psychol. Rev. **103**(3), 403 (1996)
7. Haegerstrom-Portnoy, G., Schneck, M.E., Brabyn, J.A.: Seeing into old age: vision function beyond acuity. Optom. Vis. Sci. **76**(3), 141–158 (1999)
8. Wang, L., Sato, H., Rau, P.L.P., Fujimura, K., Gao, Q., Asano, Y.: Chinese text spacing on mobile phones for senior citizens. Educ. Gerontol. **35**(1), 77–90 (2008)
9. Wang, L., Rau, P.L.P., Salvendy, G.: Older adults' acceptance of information technology. Educ. Gerontol. **37**(12), 1081–1099 (2011)
10. Wang, L., Rau, P.L.P., Salvendy, G.: A cross-culture study on older adults' information technology acceptance. Int. J. Mobile Commun. **9**(5), 421–440 (2011)
11. Li, H., Rau, P.L.P., Fujimura, K., Gao, Q., Wang, L.: Designing effective web forms for older web users. Educ. Gerontol. **38**(4), 271–281 (2012)
12. Rubin, G.S., Roche, K.B., Prasada-Rao, P., Fried, L.P.: Visual impairment and disability in older adults. Optom. Vis. Sci. **71**(12), 750–760 (1994)
13. Freeman, E.E., Munoz, B., Turano, K.A., West, S.K.: Measures of visual function and their association with driving modification in older adults. Invest. Ophthalmol. Vis. Sci. **47**(2), 514–520 (2006)
14. Wood, J.M., Lacherez, P.F., Anstey, K.J.: Not all older adults have insight into their driving abilities: evidence from an on-road assessment and implications for policy. J. Gerontol. Series A: Biol. Sci. Med. Sci. **68**, 559–566 (2013)
15. Asano, Y., Saito, H., Sato, H., Wang, L., Gao, Q., Rau, P.L.P.: Tips for designing mobile phone web pages for the elderly. In: Jacko, J.A. (ed.) Human-Computer Interaction. Interaction Design and Usability, pp. 675–680. Springer, Heidelberg (2007)
16. Ball, K., Rebok, G.: Evaluating the driving ability of older adults. J. Appl. Gerontol. **13**(1), 20–38 (1994)
17. Stalvey, B.T., Owsley, C.: Self-perceptions and current practices of high-risk older drivers: implications for driver safety interventions. J. Health Psychol. **5**(4), 441–456 (2000)
18. Summala, H., Mikkola, T.: Fatal accidents among car and truck drivers: effects of fatigue, age, and alcohol consumption. Hum. Factors: J. Hum. Factors Ergon. Soc. **36**(2), 315–326 (1994)
19. Brenton, M.: The Older Person's Guide to Safe Driving. Public Affairs Pamphlet No. 641. AAA Foundation for Traffic Safety, Falls Church (1986)
20. Hawthorn, D.: Interface design and engagement with older people. Behav. Inf. Technol. **26**(4), 333–341 (2007)
21. Hawthorn, D.: Possible implications of aging for interface designers. Interact. Comput. **12**(5), 507–528 (2000)
22. Wang, L., Sato, H., Jin, L., Rau, P.L.P., Asano, Y.: Perception of movements and transformations in flash animations of older adults. In: Jacko, J.A. (ed.) Human-Computer Interaction. Interaction Design and Usability, pp. 966–975. Springer, Heidelberg (2007)
23. Sato, H., Fujimura, K., Wang, L., Jin, L., Asano, Y., Watanabe, M., Rau, P.L.P.: The impact of moving around and zooming of objects on users' performance in web pages: a cross-generation study. In: Jacko, J.A. (ed.) Human-Computer Interaction Interaction Design and Usability, pp. 921–928. Springer, Heidelberg (2007)

24. Myerson, J., Hale, S., Rhee, S.H., Jenkins, L.: Selective interference with verbal and spatial working memory in young and older adults. J. Gerontol. Series B: Psychol. Sci. Soc. Sci. **54** (3), P161–P164 (1999)
25. Schaie, K.W., Willis, S.L.: Psychometric intelligence and aging. In: Perspectives on Cognitive Change in Adulthood and Aging, pp. 293–322. McGraw Hill, New York (1996)
26. Bryan, J., Luszcz, M.A.: Measurement of executive function: considerations for detecting adult age differences. J. Clin. Exp. Neuropsychol. **22**(1), 40–55 (2000)
27. Marshburn, E.G.: Beyond human factors: examining the underlying determinants of recreational boating accidents with spatial analysis and modeling (2014)
28. Summala, H., Lamble, D., Laakso, M.: Driving experience and perception of the lead car's braking when looking at in-car targets. Accid. Anal. Prev. **30**(4), 401–407 (1998)
29. Theeuwes, J., Hagenzieker, M.P.: Visual search of traffic scenes: on the effect of location expectations. Vis. Veh. **4**, 149–158 (1993)
30. Mourant, R.R., Rockwell, T.H.: Strategies of visual search by novice and experienced drivers. Hum. Factors: J. Hum. Factors Ergon. Soc. **14**(4), 325–335 (1972)
31. Wartzek, T., Eilebrecht, B., Lem, J., Lindner, H.J., Leonhardt, S., Walter, M.: ECG on the road: robust and unobtrusive estimation of heart rate. IEEE Trans. Biomed. Eng. **58**(11), 3112–3120 (2011)