Transportation Research Part F 31 (2015) 12–24

Contents lists available at ScienceDirect

Transportation Research Part F

journal homepage: www.elsevier.com/locate/trf

The effect of age, gender and roadway environment on the acceptance and effectiveness of Advanced Driver Assistance Systems

Joonwoo Son [a,*], Myoungouk Park [a,1], Byungkyu Brian Park [b,2]

[a] HumanLAB, DGIST (Daegu Gyeongbuk Institute of Science and Technology), 333 Techno-Jungang-Daero, Building R4-708, Dalseong-Gun, Deagu 711-813, South Korea

[b] Center for Transportation Studies, 351 McCormick Rd, University of Virginia, PO Box 400742, Charlottesville, VA 22904-4742, USA

ARTICLE INFO

Article history:
Received 23 June 2014
Received in revised form 15 January 2015
Accepted 12 March 2015
Available online 3 April 2015

Keywords:
Technology acceptance
Age and gender difference
Advanced Driver Assistance Systems
Forward collision warning
Lane departure warning

ABSTRACT

The purpose of this paper was to investigate the effect of age, gender and roadway environment on the acceptance as well as effectiveness of the Advanced Driver Assistance Systems (ADAS). Better understanding on the age and gender differences in technology acceptance and effectiveness toward the ADAS on various roadways could help encourage drivers' use of new technology for safe driving. In this study, 52 drivers participated in on-road field experiments with or without the ADAS providing a forward collision warning and a lane departure warning. Each participant drove approximately 5.5 km of rural road (about 10 min), 6.2 km of urban road (about 25 min) and 9.6 km of highway (about 10 min). Upon completion of these driving sessions, the ADAS-supported group participants (half of all participants) responded to questionnaire. Field experiment results showed that there were significant age and gender differences in the acceptance and effectiveness of the ADAS and the roadway environment affected the effectiveness of the ADAS. Findings from this study indicated that it is essential to assess age and gender differences in effectiveness and acceptance of new in-vehicle technology for avoiding unexpected negative effects on a certain age and gender segment.

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1. Introduction

With ever-increasing number of vehicles on the road, societies have faced with significant challenges in congestion, fuel consumption, emissions and traffic crashes. Among these, safety is a key area needing significant attention. A recent report from World Health Organization (2013) indicated that annually 1.24 million people die due to traffic crashes. The US alone has over 33,000 people died in motor vehicle crashes in 2012 and its cost was close to 1 trillion dollars in loss of productivity and loss of life (Rocky Mountain Insurance Information Association (RMIIA) (n.d.)). To address the safety challenge, governments, industries and non-governmental organizations have implemented many operational strategies, educational campaigns, enforcements, and technology-equipped vehicles. These include providing rational speed limit, promoting educational campaign, and implementing enforcement (Son, Fontaine, & Park, 2009), implementing variable speed limit (Lee,

* Corresponding author. Tel.: +82 53 785 4740; fax: +82 53 785 4759.
E-mail addresses: json@dgist.ac.kr (J. Son), violet1211@dgist.ac.kr (M. Park), bpark@virginia.edu (B.B. Park).
[1] Tel.: +82 53 785 4741; fax: +82 53 785 4759.
[2] Tel.: +1 434 924 6347; fax: +1 434 982 2951.

http://dx.doi.org/10.1016/j.trf.2015.03.009
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Dailey, Bared, & Park, 2013; Park & Yadlapati, 2003), establishing roadway geometry design guidelines (AASHTO, 2011), promoting educational campaign, investing advanced technologies into automobiles such as anti-lock braking system and electronic stability control.

Studies have shown that traffic crashes are mainly due to interactions among drivers, vehicles and roadways. As such, research should consider all three elements and their interactions. This research considers Advanced Driver Assistant Systems (i.e., Forward Warning System and Lane Departure Warning System) equipped in an instrumented vehicle that help assure drivers' attention. While it is important to consider age, gender and roadway conditions together, existing literature indicates studies have not considered full interactions of age, gender and roadway conditions in the evaluation of ADAS.

1.1. Effect of age, gender and roadway environment on driving behavior

Despite older drivers' diminished capacity, driving judgment increases with experience and age that may compensate for decreased capacity (Reimer et al., 2008). However, they sometimes fail with severe consequences, in situations producing very high momentary mental workload (Hakamies-Blomqvist, Mynttinen, Backman, & Mikkonen, 1999; Harms, 1991). In general, not all older drivers are unsafe, and driving capability is very important for maintaining the independence of elderly adults, especially for those who live in rural or remote area (Anstey, Wood, Lord, & Walker, 2005). However, older drivers have shown higher crash rates than other age groups except teenagers and the increased risk is associated with degradations in cognition, vision and physical functions (Anstey et al., 2005). Reimer, Mehler, Coughlin, Roy, and Dusek (2011) and Son et al. (2010) reported older drivers showed significant degradation in maintaining speed under cognitive secondary workload compared to the younger drivers, as expected based on age related declines in cognitive capacity (McDowd, Vercruyssen, & Birren, 2003; Rogers & Fisk, 2001). Lam's (2002) finding that older drivers are more likely to be susceptible to the effects of distraction than younger drivers supported age had affected the relationship between distractions and the risk of crash injury.

In gender differences, Özkan and Lajunen (2006) found that gender is influential in expressing their general driving style. Risky driving style increased as a function of masculinity and being male whereas femininity decreased risky behavior. Turner and McClure (2003) also suggested that gender and age are significantly associated with drivers' aggression and high-risk acceptance. It may be related to difference in social influence and confidence in driving skill. D'Ambrosio et al. (2008) suggested that women reported lower levels of confidence in their driving skills than men. Lesch and Hancock (2004) also indicated that age and gender had different implications on confidence and the associated performance of driving while subjects were being distracted.

Researchers have studied on the relationship between the roadway complexity and driving performance. Horberry, Anderson, Regan, Triggs, and Brown (2006) found that older drivers drove at overall lower average speed in complex road environment with larger speed variation. Son, Lee, and Kim (2011) reported that older drivers were affected by road complexity. For example, the effect of the cognitive distraction was relatively higher in an urban road than a highway.

While studies have shown effects of age, gender and roadway environment, none of these studies explored the effects of all three factors.

1.2. Effectiveness of Advanced Driver Assistance Systems (ADAS)

Previous studies have discussed the Advanced Driver Assistance Systems (ADAS) could provide useful assistance to older drivers by supporting the difficulties resulting from limitations in motion perception, peripheral vision, selective attention and decreased speed of processing information and decision-making (Mitchell & Suen, 1997; Shaheen & Niemeier, 2001). These include electronic stability control, braking assistance, forward collision warning system, lane departure warning system, adaptive cruise control, and night vision. Among these assistance systems, forward collision warning (FCW) system is one of the most useful in-vehicle safety systems for older drivers by drawing an attention of the driver to traffic (Davidse, 2006). The acceptance of the forward collision warning was verified by a previous study through questionnaire. All older drivers answered that the system was either very useful or useful at nighttime and 63% of the older drivers said it was either very useful or useful at daytime. Almost half of the older drivers were willing to buy the system (Oxley & Mitchell, 1995). Another assistant system for compensating older drivers' diminished capability is a lane departure warning (LDW) system (Insurance Institute for Highway Safety (IIHS), 2010). Researchers have studied on the effectiveness of FCW and LDW and reported that significant improvements in driving safety behavior were observed (Ben-Yaakov, Maltz, & Shinar, 2002; Birrell, Fowkes, & Jennings, 2014; Blaschke, Breyer, Färber, Freyer, & Limbacher, 2009). However, these studies did not investigate age, gender and roadway differences in the effectiveness.

1.3. Previous findings on user acceptance of Advanced Driver Assistance Systems (ADAS)

A number of research efforts on in-vehicle technology acceptance including Advanced Driver Assistance Systems (ADAS) were conducted over last few decades. A standardized checklist for the assessment of acceptance of new in-vehicle technology was proposed by Van der Laan, Heino, and De Waard (1997) to compare the effect of new devices with other systems. Regan, Mitsopoulos, Haworth, and Young (2002) stated that usefulness, ease of use, effectiveness, affordability and social acceptance are the key components for technology acceptance. Brookhuis, van Driel, Hof, van Arem, and Hoedemaeker

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