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Intelligent Speed Control Technology for Older Drivers

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Abstract:

1. Introduction

This paper describes one aspect of ongoing research at Newcastle which has been researching the decline in performance of some drivers with age and exploring whether Intelligent Transport Systems and services could have a role to play in supporting older drivers to continue driving safer for longer. The findings presented here are focused on one such service, Intelligent Speed Control Technology – which addresses one of the most commonly reported problems by older drivers themselves, speeding on urban roads.

The opportunity to continue driving is important for many older people, who have grown up in a largely car-dependant culture, in maintaining mobility, independent living and participating social activities. For many older people, no longer being able to drive a car is one of the most devastating experiences associated with growing old. It can mean loss of independence and is often accompanied by decreased life satisfaction and loss of self-esteem and growing social isolation (Gilhooly 2002; Musselwhite 2011). With the rapid growth of an ageing population, keeping older drivers driving safely for longer would benefit not just individuals, but also families and society.

However, due to age-related functional decline in physical, visual and mental abilities, older drivers are more susceptible to distraction and find it more difficult to perform multi-tasking, understand road signs and travel information delivered to them (Lundberg and Hakamies-Blomqvist 2003; Charlton et al. 2004; Dobbs 2005; Musselwhite and Haddad 2007). To compensate for such deterioration, they tend to drive less, deliberately avoid driving at night, in poor road conditions, risky situations and places, right turns (by taking routes that require left turns or routes where right turns have green-arrow signals) (Keskinen et al. 1998; Hong et al. 2008; Salisbury 2009) or any

complex road traffic situations. They display a coping mechanism for easing the driving tasks by creating more time (e.g. slowing down before turning to cross a traffic lane) to cope with a reduced capability to process information (Birren and Fisher 1995; Davidse 2006; de Waard et al. 2009). According to the general psychology literature, skills are retained and strengthened through task exposure (MacKay 1982; Cheng 1985; Anderson 1993). Hence exposure-related compensatory driving behaviour, such as avoiding junctions and other complex traffic conflicts would eventually affect their ability to operate the vehicle safely, reduce their confidence with driving and increase their propensity to driving errors.

In his model of driving behaviour, Michon (1985) suggests that driving needs three levels of skills and control: strategical (planning), tactical (maneuvering), an operational (control) respectively. In-vehicle technologies have the potential to improve driving skills required at all three levels, therefore to address the older drivers' functional decline, assist them with their driving activities, and increase road safety. Rakotonirainy and Steinhardt (2009) report that new in-vehicle technology could improve safety, comfort and maintain older people's mobility for longer. Clearly, with aging, not all drivers have the potential to be assisted by technology to continue driving for longer, however evidence suggest a proportion of older drivers could delay the onset of the cessation of driving, with such assistance.

In a previous field study undertaken in Newcastle it has been discovered that 80% of older drivers participated in the study had difficulty to maintain a relatively smooth speed under free-flow traffic conditions and went over the speed limit when driving on roads with a low speed limit such as 20mph or 30mph (Guo et al. 2012). The research described here is a study that was designed to examine whether an Intelligent Speed Control system has the potential to improve the older drivers' ability to maintain the speed, be more relaxed and confident when driving in the low-speed zone and bring them safety and comfort whilst driving. However, when this paper was written, the study was only half-way through, in the sense only half the target number of participants have so far undertaken their trials in the driving

simulator. Hence this paper will only set the scene and provide a flavour of the study rather than a full analysis.

2. Methodology

2.1. Driving scenarios

To explore whether an intelligent speed control (ISC) system could positively contribute to supporting older drivers to adhere to urban speed limits an experiment was designed to implement an ISC within the SiDE driving simulator.

Four driving scenarios were developed for this study using a road map with various speed limits: 20mph, 30mph, 40mph and 60mph. The length of the route was 3.5km. Oncoming traffic was generated randomly but no vehicle would be in front of, or following, the subjective driver to create a free-flow traffic condition.

Scenario #1 was designed to provide a normal drive where ISC technology was not available. This scenario was also used for participants to practice simulator driving and provide us with some baseline data.

In scenario #2, a speed limit sign (with a blue background colour) would stay in the left lower corner of the windscreen to remind the driver the current speed limit (see Figure 1). An audible message would be triggered when driving towards a road with a different speed limit. The trigger point was defined by the speed as well as the current and next speed limit:

- A. If driving towards a road with a higher speed limit, the trigger point was 5 seconds ahead of the speed limit sign.
- B. If driving towards a road with a lower speed limit, extra time would be given to the subjective driver for slowing down.

Figure 1 Position of the speed limit sign

In scenario #3, except A and B described in scenario #2, the driver would also receive:

- C. speed limit sign with a red background colour if the driver exceeded the speed limit (see Figure 2);
- D. speed limit sign with a green background colour if the threshold of the driver being

more than 20% slower than the current speed limit was met (see Figure 3);

- E. a visual warning about driving towards a road with a lower speed limit (see Figure 4).

Figure 2 Speed limit image when the driver exceeds the limit

Figure 3 Speed limit images when the driver goes more than 20% slower than the limit under free-flow traffic conditions

Figure 4 Speed limit warning when driving towards a road with a lower speed limit than the current one

In scenario #4, the driver would not receive C and E but A, B and D described in scenarios #2 and #3 as the ISC system would slow down the simulator when the driver was going to exceed the speed limit. This guaranteed that the driver would never speeding.

No.	Scenario	Description
1	No ISC	ISC technology is not available.
2	Advisory ISC	The driver only receives information on speed limits.
3	Voluntary ISC	The driver receives the following information: <ul style="list-style-type: none"> • speed limit • warnings about driving towards a lower speed limit • warning about exceeding the speed limit, and • speedup messages when going too slow
4	Mandatory ISC	The car slows down when the driver exceeds the speed limit.

Table 1 Four driving scenarios

2.2. Driving simulator

The study was performed using the SiDE driving simulator at Newcastle University (see Figure 5). This is a cockpit simulator equipped with 5 large 50 inch displays with high resolution, all control actuators, dynamic force feedback steering wheel, clutch, brake and acceleration pedals, adjustable car seat, and safety belt with a sensor. It also has 3 graphical channels and 3 simulated mirrors. The dimensions of the simulator are 2.6 x 1.80 meters.

Figure 5 SiDE Driving Simulator at Newcastle University

2.3. Measures

The following data were collected through the trials:

- Workload
- Self-reported driving behaviour change
- User preference towards the speed limit signs and audible messages

The above data were collected after the participant completing each driving scenario.

- Personal data - were collected once the participant has completed all 4 driving scenarios.
- Simulator speed – were collected through log files.

3. Results

3.1. Participants

Participants were recruited from an existing user panel established by the SiDE project. When this paper was written, twenty-one people had participated in the speed control study with 15 aged over 60 and 6 aged under 60 (see Figure 6). Those aged over 60 form an experimental group while those under 60 form a control group which allows for comparisons between older drivers and their younger counterparts. Each participant was given considerable practice time to become comfortable with and competent at using the simulator prior to data collection and to gain familiarity with the route. During the simulator study, 3 participants fell sick and complete only 2 out of 4 driving scenarios.

Figure 6 Participants' age and gender (n=21)

For those aged over 60, only 1 participant was self-employed. All other participants were retired but 8 were still doing volunteer work. To most of them, driving is either 'an efficient mode of transport' or 'a necessity'. However, 2, aged 66-70 and over 80s respectively, claimed that it was 'a happy, joyful experience'. In terms of when and where they drove typically, one female participant indicated that she only drove during daylight hours whilst others stated they drove at any time during the day; 5 participants reported that they never drove on the motorway. The distances they drove in a typical year varied greatly, with only one male participant aged over 80 reported that his annual mileage was under 3000 miles while the other 2 aged over 80, also male, still drove over 10,000 miles in a typical a year (see Table 2). There seems no significant correlations between annual mileage and age or gender.

Annual mileage (,000's)	Gender	Age				Total
		Under 60	61-70	71-80	81+	
0-3	M				1	1
3-6	M		1			1
	F	2	3			5
6-10	M	3	1	1		5
	F		1			1
10-15	M		2		2	4
	F	1		1		4
Total		7	7	2	3	21

Table 2 Cross comparison of participants' age, gender and annual mileage (n=21)

In total, 10 participants admitted that they had been caught speeding in the past. In the trial cohort 70% of speeding events reported by the driver who were aged over 60 occurred on a road with a 30 mph speed limit (see Figure 7).

Figure 7 Comparison between the speed limit and actual speed when speeding (n=10)

3.2. Participants speed in comparison with the speed limit with varying levels of ISC

Shown in Figure 8 are the typical results of a participant's speed variation with each level of ISC simulated.

This section of data was taken over a 30 mph zone, just after the participant had slowed from a 60mph zone - thus nearly all participants were actively aware of their speed.

Figure 8 Comparison between the speed limit and different levels of ISC

In order to have a better understanding of the driver performance in terms of their speed control, the data presented in Figure 8 were converted into 4 levels (see Figures 9-12):

- Level 1 – slow: when the speed is between 20-25 mph exclusive;
- Level 2 – quite slow: when the speed is between 25-27 mph inclusive;
- Level 3 – perfect: when the speed is between 27-33 mph exclusive;
- Level 4 – speeding: when the speed is 33 mph and over.

Figure 9 Driving performance with 'no ISC'

Figure 10 Driving performance with 'Advisory ISC'

Figure 11 Driving performance with 'Voluntary ISC'

Figure 12 Driving performance with 'Mandatory ISC'

Due to the nature of simulator trials, participants varying driving behaviour, and the fact that the trials are incomplete it is difficult to generalise the results at this time. However the following patterns were seen in most participants including some of those aged under 60.

With no ISC implemented we can see that the drivers speed is determined by the road conditions and their own observations and fluctuates around the speed limit.

With the addition of advisory ISC the participant is warned both audibly and visually to reduce speed whilst approaching the new 30 mph zone. These results indicate that for this participant this mode was the most beneficial in reducing and

maintaining their speed smoothly within the speed limit when the driver was in full control of the vehicle.

With the inclusion of Voluntary ISC the data shows that on the acknowledgement of a speed limit warning the driver reduces speed by the largest magnitude before being given advice to increase speed to maintain driving performance.

The data shown for the inclusion of Mandatory ISC are occurred with numerous subjects, the participant tries to increase speed but the active speed reduction technology has proved to be successful in terms of driving with a perfect speed consistently.

3.3. Workload

Participants were invited to rank the workloads of each driving scenario so to understand the effect of various levels of workloads on driving performance.

Items	N	S1		S2	
		Mean	SD	Mean	SD
Mental demand	15	3.00	1.115	3.00	1.225
Physical demand	15	1.92	1.115	1.69	0.751
Hurried	15	1.69	0.947	1.62	0.870
Success	15	3.54	1.664	4.62	1.557
Hard	15	3.23	1.691	3.62	1.502
Irritated	15	1.46	0.660	1.23	0.599
Items	N	S3		S4	
		Mean	SD	Mean	SD
Mental demand	15	2.85	1.725	2.54	1.526
Physical demand	15	1.77	0.927	1.69	0.911
Hurried	15	1.62	0.870	1.77	1.013
Success	15	4.23	1.691	4.46	1.898
Hard	15	3.54	1.330	2.92	1.188
Irritated	15	1.46	0.967	1.15	0.376

Table 3 Self-reported workload of Scenarios

Table 3 shows that younger people generally assessed themselves as having a lower level of mental and physical demand and higher level of success to complete the driving task, but older participants claimed to be less irritated but harder to complete the tasks than those younger

participants when the speed control systems were presented.

Overall, it seems that scenario #4 required the least mental demand, scenario #3 required the least physical demand. However, as the trials were still ongoing, the result cannot yet be generalised.

4. Conclusion

Due to the study's partial completion at this time only preliminary conclusions can be drawn. Although each participants driving behaviour is varied from the recorded simulator data we can see that the majority of the participants perform better with the inclusion of either Advisory ISC or Mandatory ISC in terms of maintaining their speed.

We also see a performance increase as each participant becomes more familiar with driving the simulator, allowing them to more consistently remain within the speed limit.

Through analysis of our questionnaire results we see the emergence of distinct groups, participants who prefer audio or visual cues, but also a group which has no preference for the addition of this form of technology.

We found that generally older drivers preferred audio cues only as they often found the visual cues distracting, whereas the younger drivers preferred visual cues more in common with common satellite navigation technologies. However audio messages will not suit everyone as hearing loss is a common functional decline among the older population

Overall most of the participants could see the value of this technology and welcomed the possibility of ISC technology within their own vehicles. This was also the view of the younger drivers – which suggests such an ITS system could have benefits to all and not just the older population.

5. Implementation of ISC systems

In most countries, road speed limits are set to regulate road traffic speed, improve safety and reduce casualties from traffic collisions. According to the World Health Organisation (WHO) (2004), speed control as one of many interventions is likely to contribute to a reduction in road casualties. Although speed limit signs have been implemented at the roadside, the results from this study suggests that it is more effective to bring the information to the driver inside the vehicle than at the roadside, particularly for local roads which often have low speed limits.

This study also suggests that the implementation of ISC systems could have a positive impact on smoothing the traffic, reducing lane changing, and improving road safety and traffic density distribution. Further research will also look into the possibility of environmental impact and energy efficiency by the smoothness of the traffic and the vehicle speed. Much of the ISC system developed for the simulator study could readily be incorporated into a SatNav system or a stand-alone mobile phone application. Thus, if the benefits of ISC can be measured and quantified then maybe there is a case for ITS suppliers or OEM's to consider offering systems with this functionality could be made. What is clear is that providing the speeding advice information inside the car, rather than through static or VMS signs at the roadside does have a positive effect of driving behaviour and attentiveness.

Bear in mind that this study was only half-way through when the paper was written. Upon completion of the study, a thorough analysis would be able to provide road and infrastructure operators with more specific information on the how the system should be implemented.

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