Thank You, I did not see that: In-car Speech Based Information Systems for Older Adults

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Abstract
Older adult drivers have more difficulty than the general driving public in attending to driving tasks especially in complex traffic situations. This study examines whether a speech based in-car information system can positively influence driver attitudes, driving performance and safety. Eighteen participants between the ages of 55 and 73 used a driving simulator for approximately thirty minutes in one of three conditions: in-car information system with a young voice informing the driver of upcoming hazards, in-car information system with an older adult voice, and no in-car system. There was a clear positive effect of driving with the in-car information system; drivers felt more confident driving, they completed the driving course in less time (without exceeding the speed limit), and had fewer accidents. There was also a clear positive effect of using a young adult voice for the in-car information system.

Categories & Subject Descriptors: H.5.2 User Interfaces; H.1.2 User/Machine Systems

General Terms: Design; Experimentation; Human factors

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In-Car Information System; Older adults; Driving performance; Attitudes; Safe Driving; Driving Simulator; Speech based Systems.

INTRODUCTION
There is overwhelming evidence to suggest that adult drivers, 55 years of age and older [1], have more difficulty with driving, especially when required to make complex decisions [12]. The task of driving places significant perceptual and cognitive demands on the driver and the normal aging process negatively affects many of the perceptual, cognitive and motor skills necessary for safe driving [2]. Older adults have difficulty determining speed and distance when dealing with merging traffic [3].

Older drivers often feel both unsafe and insecure as drivers. They are aware of their declining abilities [5], and change their driving behavior accordingly. They may refrain from driving in bad weather and at night. There is also a strong link between age, visual task load, stimulus location and reaction time to unexpected stimuli [9]. Previous studies show that most accidents involving older drivers occur at intersections [5]. Subsequent studies setup with older adults in intersections show that accuracy of Time-to-Contact estimations is influenced by age as well as recency of accidents. Common causes and dangerous risk factors include: Failure to maintain proper speed, Improper left turns (Right turns for LH traffic), Confusion in heavy traffic, Hesitation in responding to new traffic signs, signals, road markings and roadway designs [3].

Accidents caused by older adult drivers have also been attributed to neglect or inattention to relevant information from the road, cars and pedestrians [8]. Older adults are also more easily distracted by irrelevant information than young adults, and thus may direct their attention incorrectly and miss cues indicating potential hazardous situations [10].

Speech Based Support for Older Adults
Voice messages can play an important part in helping older people to execute everyday tasks. Voice prompts and speech messages provide reminders for those with poor memories [15]. Loss of memory and general awareness causes loss of confidence in one's actions. The ability to absorb information is age related and older people have been found less able to absorb long instructions than younger people [15]. Speech based support given at the point it is required removes the need for memorizing long instructions at the beginning of a task.

Speech based In-Car Information Systems
This study is part of a larger project that is aimed at finding ways in which speech interactions in cars can help people of all ages drive more safely. Previous studies have shown that alerting young drivers to hazards in the road results in a more cautious and safer driving style, e.g. allocating more attention to the driving task and therefore safer driving [6].

Previous studies for younger drivers together with indicators of the effect of speech help/information systems on attention and cognition, give inconclusive data on the

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use of speech based in-car information systems for older adult drivers [14]. We wanted to investigate if using speech systems in the car could assist older adult drivers by giving them relevant information (and thereby provide extra time and distance for them to evaluate the driving situation) or if the speech system would detract further from their driving performance. To investigate this we setup a driving simulator experiment. We created voice prompts to be used in the in-car system as follows; prompts that compensate for memory loss suggesting actions that have not been remembered e.g. speed limits; provide contextually relevant advice e.g. road conditions; and provide warnings in safety critical situations.

GOALS OF EXPERIMENT

The experiment was designed to find out if a speech based in-car information system would help or hinder older adults with the driving task. We examined each driver's perception of the in-car system and the impact of the speech prompts on driving performance to answer two questions:

1. *Does a speech based in-car system help or hinder the driving task for older adult drivers?*
2. *Does the age of the voice influence perception of the in-car system and driving performance?*

METHOD

The Driving Simulator

The STISim driving simulator was used in the experiment. Users sat in a real car seat and used a Microsoft Sidewinder steering wheel and pedals. The simulation was projected on a wall in front of the participants. A driving scenario was built involving several hazards to be as varied and realistic as possible. All drivers completed exactly the same driving task: a driving scenario in STISim is static and predetermined; it has a specific length and will take all drivers along the exact same road regardless of left and right turns. The simulator was set to automatically record driving performance for each participant.

Speech prompts were inserted at 16 points in the course. The prompts were specifically scripted to suit older adults. Some prompts provided information about road conditions and traffic events, e.g. "There is thick fog ahead". Other prompts provided suggestions, e.g. "The police use radar here, you might need to slow down". All prompts were recorded in two voices using the exact same wording and speaking style. A 73 year old female recorded the "old voice", and a 20 year old female recorded the "young voice". The age ranges of the recorded voices were correctly rated by a small blind test. The older voice had lower pitch, increased breathiness, hoarseness and vocal tremor. There were no differences noted in speech rate (otherwise expected) due to the brevity of the utterances. The speech talents were furthermore instructed to read the sentences in a calm and neutral voice; the recorded voices were rated for amplitude and intelligibility. The test group did not detect any specific emotional content in either voice or any difference between the styles except the rated age of the voices.

Participants

Participants were volunteers aged 55 – 73 years (average 63) living in the United Kingdom. The selection of the age group, over 55 (i.e. 55 – 75), was based on a frequently used evaluation form and report, Drivers 55 Plus: Check your own performance, published by the AAA Foundation of Traffic Safety [1]. None of the participants was diagnosed with Parkinson's or Alzheimer's, and all were active drivers.

Procedure

Pre-driving questionnaires

All participants completed two pre-driving questionnaires. The first questionnaire was to self-report perceived driving abilities. The second questionnaire was a fifteen term DES (Differential Emotional Scale) [4] for current emotional status.

Driving Simulator Session

Each participant drove a test run to become familiarized with the simulator. Studies show that older adults need about three minutes of driving to adapt to the driving simulator [7]. For this experiment we used a five minute training course. Participants were then placed in three gender-balanced and age-balanced groups of six. **Group 1** - voice prompts provided by a young female voice. **Group 2 - v**oice prompts provided by an old female voice. **Group 3** – no voice prompts. Participants spent approximately 30 minutes completing the driving course in the simulator.

Post-driving questionnaires

After driving, all participants completed a post-task questionnaire with a fifteen term DES. Participants in groups 2 and 3 also completed a questionnaire on the properties and influence of the in-car system.

Measures

Emotional state before driving and after driving

The *emotional state* of each participant was measured *before and after the driving session*. Two positive emotion indices were created based on the DES questionnaire, using the terms calm, relaxed, at-ease, and happy in a 10-point Likert scale (1=Describes very Poorly to 10 = Describes very Well). The indices were very reliable (*alpha = .76 and .67 respectively*). We used the difference between the before and after measures of emotional state to indicate any increase in negative emotions after driving.

Source Credibility of Voice System

The credibility of the voice system was based on combining McCroskey's and Berlo's source credibility scales [13]. Participants were asked to rate adjectives based on their views of the system. Contrasting adjectives were paired on opposite sides of a 10-point scale. We combined 3 standard indices: authoritativeness, character, and safety, into one index.

Influence of Voice System on Driving Performance

Participants rated the influence of the voice system on driving performance based on "The Voice made me:" followed by a list of statements in a 10-point Likert scale (1 = Describes very Poorly to 10 = Describes very Well). The index was comprised of "Watch more carefully at intersections", "React faster to dangerous driving situations", "More comfortable driving at faster speeds" and "A better driver in low visibility conditions". The index was very reliable (*alpha .93*)

Driving Performance

Self Reported Driving Performance: Participants reported on *Accidents, Tickets* and *Warnings* over the past two years.

Measured driving performance: An index was created for Bad Driving based on data saved by the driving simulator: *Accidents while driving* (Collisions, off-road accidents and pedestrian accidents) and *Swerving* (centerline crossings and road-edge excursions). *Time to finish the driving session* was also measured.

RESULTS

The effects of the in-car information system on attitude and driving performance were evaluated by a one-way ANOVA with the variant of the in car information system as the between-participants factor.

Status before Driving

All participants were in the same age range, and there was no significant difference between the groups on self reported driving style, driving abilities, driving performance (Drivers 55 Plus) and emotional state (DES).

There was no difference between the groups on *Self Reported Driving Performance* namely accidents, tickets and warnings over the last two years (See Table 1).

Emotional State after Driving

The emotional state measure shows that all participants felt less at-ease after driving than before driving. However, the increase in negative emotions was highest for drivers with the old voice. Drivers with the young voice and drivers with no voice saw a significantly smaller increase. $F\ (2,\ 15) = 17.48, p<.001$ (See Table 1).

This result can be explained by the fact that participant's believed this was a test of their abilities. Some participants even expressed fear that their license would be revoked if they did not pass. Despite our assurances that they were helping us test a new in-car voice system, some or most participants still saw this as a test of their driving skills.

Source Credibility of Voice System

There was a significant difference in the perceived credibility of the two voices. The young voice was considered much more authoritative, with more character and safer than the old voice. $F(1,10) = 45.65, P < .001$ (See Table 1).

Table 1: Results from ANOVAs

Variable	Young Voice		Old Voice		No Voice	
	Mean	SD	Mean	SD	Mean	SD
Self reported Driving Performance (Events)	.333	.52	.333	.52	.333	.52
Increase in Negative Emotional State after Driving (Index)	8.9	4.4	21.4	1.4	8.5	5.7
Measured Bad Driving Index	23.8	2.4	20.8	5.3	33.8	10.9
Measured Accidents (Number)	1.2	.75	1.8	.75	2.5	.54
Time to Finish Course (Seconds)	1600	98	2030	250	1876	96
Source Credibility of Voice System (Index)	2552	903	505	277	n/a	n/a
Influence of Voice System (Index)	27.1	3.3	12.9	5.2	n/a	n/a

Influence of Voice System on Driving Performance

Drivers that interacted with the young voice felt that the system had a more positive influence on their driving performance than drivers that interacted with the old voice. $F(1,10) = 31.38, p < 0.001$ (See Table 1).

Driving Performance

Drivers with the in-car information system had significantly better driving performance (Bad Driving index) than the group driving without the system. $F(2,15) = 5.51, p < 0.02$ (See Table 1). There were *twice as many* accidents for drivers with no system than for drivers with the young voice, $F(2,\ 15) = 5.58, p < 0.02$ (See Table 1).

One interesting effect of the in-car system was speed. Drivers interacting with the young voice finished the course much faster than the other groups. $F(2,15) = 10.09, p < 0.002$ (See Table 1). This speedup was done without exceeding the speed limit, indicating that drivers interacting with the young voice felt more comfortable driving at a higher speed.

CONCLUSIONS

Our goals with this experiment were to learn more about the effects of an in-car information system on older adults, and to learn about the effect of the system's voice.

The results from the experiment clearly demonstrate the answer to the questions posed in this paper.

1. *Does a speech based in-car information system help or hinder the driving task for older adult drivers?*

This experiment shows that driving safety was enhanced with the use of in-car systems, with the younger voice (see Table 1) providing better performance. Older adults also perceived that the in-car system with the younger voice positively influenced their driving. The answer to question 1 must therefore be Yes.

2. *Does the age of the voice influence perception of the in-car system and driving performance?*

Older adults found the young voice to be more credible than the old voice. Drivers also felt more at-ease after driving with the young voice than the old voice (see Table 1). The answer to question 2 appears to be Yes, although follow-up research should determine which aspects of the old voice caused the difference in performance and self-report results observed in this experiment.

This experiment demonstrates that there is significant potential for increasing the safety of drivers (over 55 years of age) by providing information concerning road hazards, and that these notifications are well received by the drivers. The experiment also demonstrates that the choice of voice for the system is very important. We plan to investigate further 1) the most important aspects of the voice 2) the impact of speech based in-car systems on different age groups above 55, and 3), what kinds of information to provide using the in-car system.

This work (conducted in a driving simulator) indicates that further investigations should be done with real cars to verify possibilities for increasing safety on the roads for older adults. Information on road conditions and hazards can be gathered from the police, weather forecasters, civil authorities etc and signaled to older adults as they drive, thus potentially making them better prepared for the road ahead.

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