Acceptance of navigation systems by older drivers

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K.J. Bryden, J.L. Charlton, J.A, Oxley, G.J. Lowndes, Acceptance of navigation systems by older drivers. Gerontechnology 2014;13(1):21-28; doi: 10.4017/gt.2014.13.1.011.00 Some older drivers experience difficulties wayfinding whilst driving in unfamiliar areas. A navigation system (GPS) may be an effective strategy to help improve older adults' driving performance whilst wayfinding, however little is known about the use or potential safety and mobility benefits/disadvantages of these technologies by older drivers. This paper examined older Australian drivers' attitudes about potential acceptability (before use) and acceptance (following use) of navigation systems, and whether these attitudes affected intention to use. Two complementary studies were conducted; (i) a survey of 434 older adults who had not previously used navigation systems; and (ii) a pre-post study of usability and acceptance of a contemporary navigation system among a convenience sample of 20 older adults with limited or no previous experience with navigation systems. Drivers who reported wayfinding difficulties were more likely to report willingness to use a navigation system in the future, while other demographic characteristics, such as age, gender and educational level were not predictive. Some drivers indicated that they were satisfied with their current wayfinding methods and did not see a need to use navigation systems. Other barriers to acceptability and acceptance included concerns about how well a navigation system would perform and whether it would be distracting. In contrast, concerns about usability and learnability were less important for acceptance.

Keywords: navigation, wayfinding, GPS, aging, older drivers

Some older drivers have difficulty with wayfinding in unfamiliar areas[1-3]. Wayfinding whilst driving in unfamiliar areas is a complex activity which involves planning and remembering a route, finding information in the environment and using it to navigate, maintaining orientation to maps or directions and executing the correct driving manoeuvres[4,5]. Portable or built-in automotive navigation systems have the potential to provide automated solutions for many tasks associated with wayfinding. There is emerging evidence suggesting that newer generation navigation systems can reduce older drivers' driving performance decrements compared to use of paper or electronic maps[6,7].

An important element of the success of any Intelligent Transport System (ITS) technology is whether the technology is adopted by the target group[8]. A recent study has found that older drivers, particularly those aged over 75 years, are less likely to own and regularly use navigation systems compared with younger drivers[9]. Little is known about the characteristics of older drivers who are slow to adopt navigation technologies. Research findings describing use of other kinds of technologies amongst older adults found that that participants who were older, had poorer health, a lower education and female gender were, generally, less likely to be willing to use technology[10,11].

It is also important to determine whether some older drivers have concerns about aspects of navigation systems which lead to rejection of the technology. Attitudes towards the technology before (acceptability) and after use (acceptance) should both be considered[12]. The United Theory of Acceptance and Use of Technology (UTAUT) model[13] provides a systematic approach for the study of potential barriers and facilitators to use of ITS. The model describes categories of attitudes towards a system: Performance Expectancy (PE), Effort Expectancy (EE) and social influence. These attitudes predict intention to use a system. Intention to use, along with facilitating conditions (provision of support to use the system and having access to the system) predict actual use of technology[13]

Performance expectancy includes factors such as usefulness and performance of the system. Attitudes relating to the need for navigation systems and concerns about performance have been identified in previous qualitative and survey research[14-18.] Specific concerns regarding system performance included distractibility, poor directions and readability of the screen[15-18]. Effort expectancy includes factors such as ease of use, ease of learning and complexity. Attitudes towards these effort-related factors have also been identified in previous research[15,16]. Social influences relate to the extent to which the driver thinks that others believe they should use the system. Attitudes about social influence have been studied in a limited way, with respect to passenger assistance with the system[15,16]. Little attention has been directed towards access to navigation technology (i.e. facilitating conditions) as a potential issue of concern.

Notwithstanding these insights, what remains unclear is whether these findings reflect barriers to the purchase and use of navigation systems. To our knowledge, no previous studies have examined why some older drivers may be willing to use navigation systems while others reject the technology altogether.

The current research reports on attitudes about acceptability (before use) and acceptance (following use) of navigation systems in the areas of performance expectancy and effort expectancy. The main aim of the research was to determine whether these attitudes were barriers to intention to use navigation systems before and after experience with the technology. Two complementary studies were conducted. First, a survey of older drivers with no experience with navigation systems was undertaken to explore acceptability of navigation systems and factors influencing willingness to use the technology. The second study involved a pre-post study of older drivers' attitudes towards navigation systems following a four week trial period of use of a contemporary navigation system, and whether factors continued to influence willingness to use the technology.

Method

Participants and recruitment

Participation in the research was voluntary and there was no financial incentive to participate. Both studies were approved by the Monash University Human Research Ethics Committee prior to commencement.

Study 1: Survey

Community-dwelling current drivers aged 65 years and over (n=534) were recruited from membership of an Australian motoring club. Three thousand potential participants were selected from the membership list using stratified random sampling based on age and residential location of the Victorian population[19] and were contacted by mail and invited to complete and return a survey using a postage-paid envelope. Of the 558 participants who responded (response rate=18.6%), 24 were excluded because they did not meet inclusion criteria (absence of self-reported dementia or Parkinson's disease, or aged 65 years or above) or because of excessive missing data. This paper reports on a subset of findings from the main survey[20] and includes responses from participants (*Table 1*) who reported no prior use of navigation systems in order to study attitudes prior to use (i.e. acceptability).

Study 2: Pre-Post Study

Participants from Study 1 and other previous studies conducted by Monash University Accident Research Centre who had consented to be contacted for participation in future research were contacted by mail and invited to complete and return an initial survey using a postage-paid envelope.

A total of 20 participants (60% male) aged 65 years and older who were not regular current users of navigation systems were recruited. Two participants had previously used navigation systems. One owned an older style system which she rarely used, and another had used one in a borrowed car.

Materials and procedure

Study 1: Survey

Participants completed a 20-minute self-report survey including a total of 87 items. Questions were designed to elicit self-reported information about wayfinding, use of different wayfinding strategies, and health and demographic characteristics. More detailed questions were included about the use of passenger-assistance and navigation systems whilst wayfinding. Questions regarding navigation systems included attitudes towards these systems (*Table 1*) and willingness to use them. A direct measure of future use of navigation systems was not feasible in this study. As a proxy, there is support for the use of 'intention to use' as an indirect measure of behavioural acceptance in early stages of research[21].

Study 2: Pre-post study

Participants completed three brief surveys and trialled a navigation system in their own vehicle over a period of four to six weeks. The first survey (pre-use survey) included questions designed to elicit information regarding wayfinding, demographic characteristics and health status as well as attitudes towards navigation systems (the same questions as described in Study 1). After completion of

Table 1. Characteristics of participating drivers in the survey (Study 1) and the trial (Study 2); when available, census data for Victoria[19] are given for comparison ; [a]=ability to "find their way to an unfamiliar location"; [b]=range=0-4, composite score with equal weight to each of 10 questions as adapted from[26,27]

Parameter	Scale	Percentages		
		Study 1 (n=434)	Study 2 (n=20)	Census
Age	65-69	29.2	40	27.9
	70-74	24.3	15	23.3
	75-79	24.1	40	20.8
	80-84	16.4	5	15.6
	85-90	5.6	0	8.2
	90+	0.5	0	4.2
Gender	Female	38.6	40	55.7
	Male	61.4	60	44.3
Residence	Metropolitan Melbourne	57.6	50	68.4
	Regional or Rural	42.4	50	31.6
Education	≥3 years secondary	30.2	15	-
	4-6 years secondary	30.4	40	-
	Tertiary	39.3	45	-.
Self-rated health	Very good	27.8	20	-
	Good	56.4	80	-
	Fair	14.9	0	-
	Poor	1.0	0	-
	Very Poor	0.0	5	-
	Missing	0.0	5	-
Self-rated wayfinding[a]	Good	39.0	70	-
	Poor/Fair	61.0	20	-
	Missing	0.0	10	-
Self-rated cognition[b]	Mean±Standard deviation	3.00±0.58	3.00±0.42	-
Years licensed	Mean±Standard deviation	51.71±7.57	-	-
Agree (slightly or strongly) with attitudes towards navigation systems	I don't need to use one because I can rely on other methods	65.4	-	-
	They are too complicated	34.6	-	-
	I am unsure about how it works	45.6	-	-
	They are too distracting	47.4	-	-
	You have to take your eyes off the road for too long	48.5	-	-
	You don't get enough warning before turns	20.3	-	-
	They do not let me choose the best route for me	41.1	-	-
	The navigation system might take me to the wrong destination	21.6	-	-
Intention to use in-vehicle navigation system when available	Very likely	26.5	55.0	-
	Somewhat likely	23.7	15.0	-
	Not very likely	34.3	25.0	-
	Don't know	15.4	5.0	-

the first survey, a navigation system was mailed to each respondent together with an instruction package inviting them to use the device "as you would if you just purchased the unit yourself". Participants were encouraged to use the navigation system at least three times over a one-month trial period. Over the course of the trial, drivers recorded how many driving trips they made (i) in total, (ii) in unfamiliar (new or nearly new) areas, and (iii) while using the navigation system.

Approximately two weeks after the devices were distributed to the participants, participants were invited to complete a second survey (mid-use survey) which included ratings of experiences learning to use the navigation system. At this time, participants were also provided with instructions to use different aspects of the system (e.g. changing preferences). Approximately two weeks after completing the second survey participants completed a third survey about their experiences with the navigation system (post-use survey). Participants returned the third survey and the navigation system to the experimenters using a self-addressed postage satchel.

The pre-use survey included participant demographics and self-reported health and functional abilities (Self-reported wayfinding ability, demographic information, self-reported health, self-

reported cognition) and attitudes towards navigation systems (as used in Study 1; *Table 1*). The mid-use survey included the System Usability Scale (SUS)[22]. The post-use survey included the Usefulness, Satisfaction and Ease of Use scale (USE)[23], questions related to attitudes towards navigation systems (again) and future use of navigation systems (as used in Study 1; *Table 1*). The questionnaire items were selected to reflect the PE and EE aspects of the UTAUT with appropriate modifications for ITS application[13].

SUS[22] measures usability of technology on a ten item scale with a five point response scale (0 strongly disagree - 4 strongly agree). Scores are rescaled into a range from 0 to 100[22]. Higher scores indicate better usability. (<50 not acceptable; 50-70 marginal; 70+ acceptable)[24]. The scale has been found to have excellent internal consistency (Chronbach's alpha 0.91)[24].

The USE[23] measures usability of technology on a 30 item scale within 4 dimensions: usefulness, satisfaction, ease of use and ease of learning. It was designed to assess usability of a range of different products, and was therefore applicable to navigation systems. For this study, a short version of 20 items was utilized and responses were measured on a five point scale (0 strongly disagree - 4 strongly agree). A mean score was taken for each subscale. Higher scores indicated better usability. Lund [23] reported good internal consistency and evidence that the items loaded on associated categories during a factor analysis, however no specific results have been reported.

The navigation system used in the current study was a TomTom ONE XL 340 IQ Routes Edition (Australian Version). This unit was selected for use as it was a simple-to-use entry level model which included simultaneous turn by turn visual and auditory navigation which has been demonstrated as useful to older adults[6,7], as well as other features including a 4.3 inch (11cm) LCD widescreen touchscreen (320x240 pixels), spoken street names and advanced lane guidance. The preloaded map utilised Whereis map data. The product manual, downloaded from the TomTom website and a hard copy was provided to each participant[25].

Statistical analyses

For both studies an alpha level of 0.01 was set for statistical significance to control for type 1 error. Statistical analyses were conducted using SPSS (version 15).

Study 1: Survey

A logistic regression analysis was conducted to determine whether wayfinding, demographic and health variables predicted future use of navigation systems. A series of Mann-Whitney U tests were also conducted to determine whether attitudes of participants who were very likely to use navigation systems in the future differed from those who were not very likely to use these systems. A logistic regression was not appropriate for these analyses due to considerable intercorrelations between respondents' attitudinal statements.

Study 2: Pre-Post Study

A series of Wilcoxon tests were conducted to evaluate whether drivers' attitudes changed from before to after the navigation system trial. A series of Mann-Whitney U Tests were conducted to determine whether attitudes towards navigation systems, responses on the USE and responses on the SUS differed for participants who were very likely to use navigation systems in the future and those who indicated they were not very likely to use this form of assistance in the future.

Survey Results

Participant characteristics

Comparisons were made between the study demographic variables and the Victorian population aged 65 and over where available (*Table 1*). Both studies included a good representation in the sample across all age groups, with some underrepresentation from older age groups (80 years and over). There was also a good representation of participants from regional and metropolitan areas. Participants were more likely to be male and generally had considerable driving experience (as indicated by mean length of licensure). Self-rated health and self-rated cognition were generally reported as being fair to very good.

During the trial, the participants reported using the navigation unit an average of 20.79 times (SD=13.78), which represented an average of 39.5% of their driving trips (SD=26.4). The participants reported driving in unfamiliar areas an average of 8.84 times (SD=5.13), which represented an average of 15.7% of their driving trips (SD=12.2). Approximately one-third of participants reported receiving assistance of passengers often or sometimes when using the navigation system, whilst 70% rarely or never used the device with passenger assistance.

Predictors of future use

Among this sample of drivers, around one quarter of participants reported that they would be very likely to use a navigation system in the future if one was available to them and only around one third reported that they would not be very likely to use a navigation system in the future if one was available to them (*Table 1*).

Table 2. Logistic regression analysis predicting future use of navigation systems; confidence limit=0.01; significant difference in bold type; OR= Odds Ratio; CI=Confidence Interval, 'don't know' or 'somewhat likely' excluded from analysis

Variables	Wald	p	OR	95% CI
Age group	0.95	0.329	0.89	0.72-1.12
Gender	0.77	0.379	1.32	0.71-2.44
Education	0.03	0.866	1.03	0.73-1.44
Health	2.80	0.094	1.41	0.94-2.10
Cognition	3.12	0.077	1.63	0.95-2.79
Wayfinding	7.58	**0.006**	**0.44**	**0.24-0.79**
Constant	0.71	0.401	0.24	-

The logistic regression analysis (very likely vs not very likely) revealed an overall association between variables and predicted future use of navigation systems, $c^2(6)=13.70$, p=0.033, NagelkerkeR^2=0.08 (*Table 2*). Interpretation of individual predictors revealed that, compared with participants who indicated that they would not be very likely to use a navigation system, those who were very likely to use one in the future were twice as likely to report wayfinding difficulties, after controlling for the other variables. None of the other predictor variables were significant.

Attitudes towards navigation systems

Participants were most likely to agree (slightly or strongly) with attitude statements about not needing to use a navigation system, having to take eyes away from the road for longer periods, being too distracting and being unsure about how it works (*Table 1*).

There was a significant difference between 'very likely' and 'not very likely' future navigation-system users for all attitude statements except "I am unsure about how it works". For all other attitude statements, drivers who were not very likely to use a navigation system in the future were more likely to hold negative attitudes than drivers who were very likely to use a navigation system in the future (*Table 3*).

Future use following trial

After trialling the navigation system, over half (55%) of participants reported that they would be very likely to use a navigation system in the future if one was available to them and 25% reported that they would not be very likely to use a navigation system in the future if one was available to them (*Table 1*). Reported intention to use in the future did not differ by age group (Pearson $c^2(9,n=20)=6.53$, p=0.69), gender (Pearson $c^2(3,n=20)=1.62$, p=0.66), or wayfinding ability (Pearson $c^2(3,n=20)=2.20$, p=0.53).

Change in attitudes

Drivers were significantly more likely to hold positive attitudes (i.e. disagree with negative statements) after using the navigation system compared with before use. Differences were significant for three attitudes: 'Unsure how it works', 'eyes off road' and 'not enough warning' (*Table 3*).

Predictors of future use

Compared to drivers who were very likely to use a navigation system in the future if one was available to them (n=11), drivers who were not very likely to use this technology (n=5) were more likely to agree that they did not need a navigation system, that navigation systems were too distracting, and that navigation systems required drivers to take their eyes off the road for too long (*Table 3*). There were no significant differences between the groups for the other attitudes assessed.

With regard to USE and SUS ratings, compared to drivers who were very likely to use navigation systems in the future if one was available to them, drivers who were not very likely to use this technology following a trial were significantly less likely to agree with statements about usefulness, and satisfaction on the USE. There were no significant differences between the groups for the ease of use and ease of learning (*Table 4*).

Discussion

A key finding of the survey research was that navigation systems appear to be an acceptable method of wayfinding for many older drivers in Victoria. This is inconsistent with usage statistics which have demonstrated that older drivers, particularly those aged over 75 years, are slower adaptors to new technology than younger drivers[9]. The only characteristic which predicted willingness to use navigation systems was perceived wayfinding difficulties. These results suggest that drivers with concerns about their wayfinding may be more likely to seek out alternative

Table 4. Mann-Whitney U test for differences of USE (Usefulness, Satisfaction an Ease) and SUS (System Usability) scales by future use after trial; confidence limit=0.01; significant differences in bold type; [a]=5 pts scale: strongly disagree to strongly agree; [b]=100 pts scale, the higher the better usability; SD=Standard Deviation

Parameter		Mean±SD		z	p
		Very likely	Not very likely		
USE	Usefulness[a]	3.43±0.79	1.60±1.51	-2.57	**0.009**
	Satisfaction[a]	3.40±0.78	1.32±1.55	-2.62	**0.005**
	Ease of Use[a]	2.79±0.98	2.09±1.12	-0.91	0.377
	Ease of Learning[a]	2.64±1.26	3.50±0.73	-1.62	0.115
SUS[b]		56.82±18.98	47.50±21.14	-0.91	0.377

Table 3. Attitudes towards navigation systems: by likelihood of future use before experience with a navigation unit (column 1); by likelihood of future use following trial (column 2); change before and after trial (column 3); confidence limit 0.01; significant differences in bold type; attitude statements rated on a 5-pts scale from strongly disagree (0) to strongly agree (4);SD=Standard Deviation

Statements assessed	Attitude to navigation systems by future use (Mann-Whitney U test)								Change in Attitude to navigation systems (Wilcoxon test)			
	Before use				After trial				Mean±SD (n=20)			
	Mean±SD				Mean±SD				Before trial	After trial	z	p
	Very likely (n=115)	Not very likely (n=149)	*z*	p	Very likely (n=11)	Not very likely (n=5)	*z*	p				
I don't need to use one because I can rely on other methods	3.53±0.83	2.23±1.27	-8.573	**<0.001**	1.73±1.27	4.00±0.00	-3.24	**<0.001**	2.90±1.02	2.70±1.46	-0.606	0.545
They are too complicated	2.51±0.96	1.98±1.12	-3.421	**<0.001**	1.09±1.14	2.20±1.79	-1.29	0.221	2.15±1.14	1.55±1.40	-1.805	0.071
I am unsure about how it works	2.49±1.13	2.21±1.26	-1.477	0.140	0.55±0.69	0.80±1.10	-0.32	0.827	2.50±1.28	0.85±1.09	**-3.472**	**0.001**
They are too distracting	2.87±1.06	2.05±1.14	-5.525	**<0.001**	0.91±0.94	3.40±0.89	-2.97	**0.003**	2.30±1.08	1.80±1.51	-1.687	0.092
You have to take your eyes off the road for too long	2.79±0.95	2.14±1.13	-4.390	**<0.001**	0.36±0.92	2.80±1.30	-3.07	**0.003**	2.35±1.09	1.35±1.57	**-2.624**	**0.009**
You don't get enough warning before turns	2.28±0.84	1.90±1.06	-2.942	**0.003**	0.09±0.30	2.00±1.58	-2.90	0.013	2.00±0.65	0.70±1.17	**-3.133**	**0.002**
They do not let me choose the best route for me	2.75±1.02	2.06±1.07	-4.730	**<0.001**	1.36±1.29	2.80±0.83	-2.08	0.038	2.65±0.81	1.90±1.25	-2.047	0.041
The navigation system might take me to the wrong destination	2.18±1.08	1.54±1.19	-4.302	**<0.001**	1.09±1.45	1.60±2.19	-0.31	0.827	1.90±1.12	1.25±1.52	-1.769	0.077

strategies, including navigation systems, to assist with wayfinding. This has implications for the need to investigate the safety and usefulness of navigation systems for older drivers, particularly those with wayfinding difficulties.

The survey study confirmed previous findings that some older drivers had concerns about performance expectancy (need, distraction and performance) and effort expectancy (how to use the system and complexity of the system)[14-18]. In addition, the current study revealed that drivers who were not willing to use navigation systems were more likely to have negative attitudes about need, distraction, performance and complexity of systems than those who were willing to try the technology. This finding suggests that performance expectancy and some aspects of effort expectancy may be barriers to use of navigation systems by older drivers who have no experience with the systems. Knowledge about how the navigation system works was not a barrier to future use, suggesting that effort expectancy may be less important than attitudes about need and effectiveness of the unit.

The results of the pre-post trial demonstrate that some attitudes towards the navigation systems changed after use. Before the trial, participants expressed no strong preference about navigation systems, while after use, they were more likely to express positive attitudes about these technologies. These findings demonstrate that a trial of the navigation system was useful to help clarify older drivers' attitudes towards navigation systems, and that they had fewer concerns about some use and performance issues after the trial.

Attitudes about performance expectancy (usefulness and satisfaction) were more likely to be barriers to acceptance compared with effort expectancy (ease of use and learning). The technology rating scales (particularly USE), revealed that participants who were very likely to use navigation systems in the future were more likely to find the navigation system was useful and satisfactory compared with those who were not very likely to use navigation systems in the future. In contrast, responses regarding ease of use of and learning were more neutral. Investigation of statements about specific aspects of navigation systems also revealed that performance expectancy factors were barriers to acceptance. The most divisive aspects with respect to acceptance included the ability to rely on other wayfinding methods and distractibility of the navigation system.

It is important to note that self-selection and small sample size may have limited generalisability of results, and thus future research is required to confirm these results. Additionally, while just one navigation system was evaluated in this study, this device reflected state-of-the-art technology available at the time of commencement of the study and met criteria for usefulness for older drivers based on previous research[6] including audio feedback and turn by turn features as described above. Notwithstanding these limitations, the results presented here indicate that issues of performance expectancy differentiate those who are willing to using navigation systems from those who are not.

Implications and conclusions

The results of the current research can be used to identify ways to increase acceptability and acceptance of navigation systems. Distractibility and performance issues should be addressed through optimal design of navigation systems for older drivers. It is acknowledged that this study did not evaluate safety aspects of navigation system use in a real-world driving setting. Naturalistic driving methods would be useful to explore older drivers and particularly those with age-related cognitive decline have particular issues with distractibility or performance when using navigation systems. Further research should also be conducted to determine if other aspects of the UTAUT model (e.g. social influences and facilitating conditions) influence acceptability of navigation systems.

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