

The effect of a new road safety device with auditory alerts on older drivers

**Michelle M. Porter, PhD, and Heather Ash, BKin
Faculty of Kinesiology and Recreation Management
University of Manitoba**

ABSTRACT

The purpose of this study was to examine a newly designed road safety device as used by older drivers. The Otto Driving Companion (Persen Technologies, Winnipeg, MB) is a portable device that provides drivers with "instant information about [their] driving environment" and can act as a data logger. The device has a global positioning system (GPS) receiver so it can determine the vehicle's location and speed approximately every second. If the speed limit has been exceeded, the driver will immediately be given an auditory alert telling them "Speed Limit Exceeded". In addition, the Otto will provide auditory alerts when the driver approaches potential hazards (e.g., a "Crosswalk"). Using the OttoLog feature and Persen Technologies' software, driving patterns can be captured, saved and analyzed offline. This means that, for example, actual driving speed can be compared to the speed limit, across many days of driving. Although older drivers are not as likely to speed as young drivers, older drivers are more limited in their ability to quickly process all the visual information available during driving. This means looking at their speedometer might result in difficulties with seeing everything in their driving environment. Also, because there is a lot of visual information on our roads today they might not see warning signs (such as speed limit signs) at the side of the road. Therefore, auditory alerts might improve their road safety. Older drivers (69 to 91 years old, n = 12) completed a two-week study examining their speeding behaviours as well as their responses to the Otto. In the first week of the study only the data logging features of the Otto were operational, whereas in the second week, the auditory alerts were turned on. During the first week the subjects were unaware that their driving between week one and two would be compared. At the end of the second week the drivers were asked to respond to several questions about the Otto. In addition, their speed information across both weeks was examined to determine if the Otto resulted in less time above the speed limit, when auditory alerts were provided. Most drivers found the Otto to be useful, although a few drivers found the Otto to be a distraction. The subjects did speed less often ($p < 0.05$) in week two when the auditory alerts were turned on as compared to week one when the auditory alert feature was turned off. As most subjects found the Otto useful, and speed reductions did occur, this device seems to hold some promise as a road safety device for older drivers.

RÉSUMÉ

La présente étude visait à examiner un nouveau dispositif de sécurité routière utilisé par les conducteurs âgés. L'Otto Driving Companion (Persen Technologies, Winnipeg [Man.]) est un dispositif portatif qui fournit des renseignements instantanés au conducteur sur l'environnement de conduite et peut servir d'enregistreur de données. Il est équipé d'un récepteur du système mondial de localisation (GPS) pour déterminer la position et la vitesse du véhicule à peu près toutes les secondes. En cas d'excès de vitesse, le conducteur est immédiatement alerté par un message sonore. L'Otto l'avertit aussi à l'approche de dangers éventuels (p. ex., les passages pour piétons). Grâce à la fonction Ottolog et à un logiciel de Persen Technologies, les habitudes de conduite peuvent être saisies, enregistrées et analysées en différé. Cela veut dire, par exemple, qu'il est possible de comparer les vitesses pratiquées par le conducteur pendant de nombreux jours aux vitesses limites. Les conducteurs âgés risquent moins que les jeunes de commettre des excès de vitesse, mais leur attention visuelle au volant est plus limitée. En d'autres termes, ils peuvent avoir du mal à voir tout l'environnement de conduite lorsqu'ils regardent leur indicateur de vitesse. De plus, comme il y a de nos jours beaucoup de renseignements visuels sur la route, il se peut que les conducteurs âgés ne voient pas des panneaux d'avertissement situés en bordure de la route, tels ceux de limitation de vitesse. Les alarmes sonores pourraient donc améliorer la sécurité de ces personnes sur la route. Les conducteurs âgés (de 69 à 91 ans, n = 12) ont fait l'objet d'une étude de deux semaines où l'on a examiné leurs excès de vitesse et leur réaction à l'Otto. La première semaine de l'étude, seules les fonctions d'enregistrement de données étaient utilisées, alors que les alarmes sonores étaient activées durant la seconde semaine. La première semaine, les sujets ne savaient pas qu'on comparerait leur conduite de la première semaine à celle de la seconde semaine. À la fin de cette dernière, les conducteurs ont été priés de répondre à plusieurs questions sur l'Otto. De plus, les données sur les vitesses qu'ils avaient pratiquées au cours des deux semaines ont été examinées pour déterminer si l'Otto avait réduit les excès de vitesse grâce aux alarmes sonores. La plupart des conducteurs ont jugé l'Otto utile, bien que quelques-uns y aient vu une source de distraction. Les sujets ont bien fait moins d'excès de vitesse la seconde semaine, lorsque les alarmes sonores étaient activées, que la première, où la fonction était désactivée ($p < 0.05$). Comme la plupart des sujets ont jugé l'Otto utile et qu'il y a bien eu des réductions de la vitesse, ce dispositif semble prometteur en tant que dispositif de sécurité routière pour conducteurs âgés.

INTRODUCTION

Driving is the main means of transportation for older adults [1]. As the population ages the numbers of older adults licensed to drive will increase dramatically and so will the crashes that they experience [2]. In order to achieve a balance between safety and mobility for older adults, strategies need to be developed to reach a large number of older adults. These strategies could include: 1) reducing the injury rates of those who do crash by designing safer vehicles, 2) identifying those who are no longer safe to drive and either restricting their driving or revoking their licenses, and 3) identifying or developing interventions that will improve the driving performance of older drivers. Those interventions could include training programs [3] or technologies. A variety of technologies have and continue to be developed to improve road safety for all drivers. These include night vision, fatigue alerting systems and crash avoidance systems. While many

technologies such as these are being designed by the original manufacturers of motor vehicles, several after market options are also available to consumers.

The Otto Driving Companion (Persen Technologies, Winnipeg, MB) is a portable device that provides drivers with "instant information about [their] driving environment" to act as a road safety tool. The device has a global positioning system (GPS) receiver so it can determine the driver's location. It also has a pre-programmed internal map of a variety of traffic engineering elements, for select cities in Canada. Using this location information, it can warn drivers about several potential road safety issues in real-time, including warnings about dangerous intersections, red light cameras, pedestrian crosswalks, school zones, etc. It can also compare their actual driving speed to the speed limit. If the speed limit has been exceeded, the driver will immediately be given an auditory alert telling them "Speed Limit Exceeded".

It could be hypothesized that such a device may be beneficial for older drivers. Aging is associated with decrements in the ability to quickly process information in the visual driving field [4]. This means that an older driver may miss "seeing" a variety of important visual cues in their immediate driving environment. In fact, a decrement in visual attention has been linked to crashes in older drivers [5]. A device that provides auditory feedback about important elements of the driving scene could therefore help an older driver to focus their visual attention on necessary elements of the scene. For example, instead of having to frequently glance at the speedometer, with the required change in focus from a near to far scene, the older driver could maintain their view of the road. In addition, an older driver may be auditorily alerted to elements in the visual scene that they missed seeing (e.g., a sign indicating that they are approaching a school zone, or that there is a crosswalk ahead).

While these auditory alerts could be helpful, they could also pose a potential danger by introducing a distraction for the driver. Of course driver distraction is known to be a major cause of traffic crashes [6-7] and older drivers can be affected to a greater extent than younger drivers when they perform a secondary task while driving [8-10].

To determine whether a device such as the Otto would be beneficial or detrimental for older drivers we recently performed a separate study, in a simulated driving environment [11]. We found that older drivers had faster emergency brake responses when they had auditory alerts (the same as those provided by the Otto). We also found that trials with auditory alerts were associated with fewer crashes than trials without the auditory alerts. Overall, it appeared that the older drivers were better able to focus their attention on the actual driving task which improved their ability to respond to situations and crash less. This occurred even though speed was about 60 km / hr over all trials.

The purpose of the present study was to perform an independent investigation of the Otto's auditory alerts in real-world driving as opposed to the experimental and controlled setting of the simulated driving study. One objective was to explore the responses of the older drivers to the alerts after they used the device for their everyday driving over a week. Did they find the alerts to be useful? Did they find the alerts to be distracting? Another main objective was to determine whether the auditory alerts related to speeding would have any direct influence on the older subjects' actual driving behaviours, over that same week. It was hypothesized that when the auditory alerts were provided the subjects would speed less often than when the auditory alerts

were not presented. It was also hypothesized that the older adults would find the auditory alerts to be helpful rather than detrimental.

METHODS

Overall design and procedures

This study used a single-group pre-test post-test design, with proportion of driving time spent above the posted speed limit as the dependent variable. Subjects drove their own vehicles over a two-week period according to their own needs. In week one the road safety device was set to collect data only. Subjects were not aware that the device had an auditory alert capability, and no auditory alerts were given. In the second week, the auditory alert feature was explained to the subjects and became operational.

Subjects

A convenience sample of older male and female drivers was recruited to participate in the study. To be eligible they had to have a valid driver's license and their own vehicle, and be driving in and around the city of Winnipeg over the two-week period of the study. Twelve subjects (10 men and two women, 69 to 91 years of age) completed all aspects of the study. All subjects provided written informed consent. The protocol was approved by the Education and Nursing Research Ethics Board of the University of Manitoba.

Subjects completed a background questionnaire prior to starting the study. This included questions about their driving history, their health and basic demographics.

Equipment and Protocol

An Otto Driving Companion (Persen Technologies, Winnipeg, MB, Canada) was installed in each subject's vehicle at the beginning of the study. In addition, a CarChip (Davis Instruments, Hayward, CA, USA) was also inserted into each subject's vehicle using the onboard diagnostics system (OBDII port). Subjects were told at the beginning of the study that the purpose of the study was to compare the data obtained with the CarChip to the data that was collected with the Otto. In fact, we were interested in making that comparison, but those data are not reported here, as the purpose of this particular study was to examine the responses to the auditory alerts. At the end of week one, subjects were told that the Otto also has an auditory alert feature. They were asked if they were willing to participate in the second week with the auditory alerts "On". Because the purpose of the study was different and the device was being used in a different fashion from the original study description in the ethics documents, subjects were allowed to withdraw from the study if they wished, at this point. No subject did withdraw and all provided their additional written informed consent for week two of the study.

Subjects were given some specific details about the auditory alerts that could sound while they were driving. For example they were told that alerts could be given for: exceeding speed limits, the approach of school zones or cross walks, red light camera zones, dangerous intersections,

and deer crossings. They were also told about the threshold setting for speeding that was specifically set for this study - 5% above the posted speed limit. They were not explicitly told that we would be examining whether they were speeding less in week two versus week one, although they did know that the Otto could log their driving data.

At the end of the second week, subjects were asked to provide their feedback about the Otto. See Table 1 for the questions that were asked. Most questions used a 5-point likert scale from "Strongly agree" to "Strongly disagree". Other questions were open-ended and the subjects could provide their comments.

Data analyses

The Otto data was downloaded and OttoLog was used to provide summary data as well as output each data point for all the driving data over the two weeks (e.g., every data point that was collected by the Otto at a rate of approximately 1Hz could be analyzed). The detailed output file contained the following variables: date, time, latitude, longitude, speed, and speed limit. This data is collected approximately every second depending on the satellite geometry and the ability of the Otto to receive GPS data (i.e., a blockage of the signal by a tall building or overpass would mean no GPS data for the time period when the signal was blocked).

In order to determine the proportion of time that each subject spent speeding in week one and week two, we took a number of steps. First, the speed data was filtered based on whether there was speed limit data from OttoLog. If someone drove outside the perimeter of the city, no speed limit data was available. This meant we were only examining instances where someone exceeded the speed limit within the city boundaries. We also filtered the data to remove times when the vehicle was not moving. The percentage of data points where vehicle speeds were greater than the speed limit (by 5%, 10%, 15% and 20%) were calculated for each subject.

Statistical analyses

Descriptive statistics were used to examine the questionnaire data. A two way repeated measures analysis of variance was performed to determine whether there was a change in speeding behaviour. Repeated factors were week (one and two) and extent of speeding (5%, 10%, 15% and 20%). Post hoc tests used the Holm Sidak method. A p value < 0.05 was used as the criteria for achieving statistical significance.

RESULTS

Subjects and their self-reported driving history and behaviours

General demographic and health information. The subjects were fairly highly educated with all but one having completed high school and 75% having completed college or university. Subjects reported that their health was generally “excellent” or “good” (only one subject reported that their health was “fair”). Similarly subjects reported that their vision and hearing were “excellent” or “good” (only one subject reported “fair” vision and two subjects reported “fair” hearing). Four subjects indicated that they had had cataract surgery.

Driving information (according to their pre-study questionnaire). All twelve subjects had been driving for a long time, 48 to 71 years. However, the amount of driving reported for the previous week ranged from 0 to 7 days. In terms of their reporting regarding speed limits, all subjects said they check the speed limit while they drive and also know the speed limits on all types of roads (n = 1 for “sometimes”, 6 = “frequently”, 5 = “always”; for both questions). Only four subjects said they never find themselves speeding. Only two subjects avoided driving on highways at least sometimes. Seven of the subjects avoided peak hour driving, sometimes to frequently. Six of the subjects said that they find they sometimes or often are not following the traffic flow. Eight of the subjects reported that at least sometimes “red light cameras have been appearing out of nowhere”.

Subject responses to the Otto

Subject responses can be seen in Table 2. Overall the group found the Otto to be useful. Distraction did not seem to be a problem as no subject agreed with the statement about it being a distraction or interfering with their concentration. Not all subjects responded that they were listening for and using the alerts though. Perhaps not surprisingly then, many subjects did not indicate that they would recommend the Otto to their friends, and a majority (58.3%) would not consider buying it. Only one subject would consider buying it for the \$289 it was being sold for at the time of the study.

The open-ended comments ranged from “I don’t think it is very helpful” to “It helped to keep my attention on driving the car rather than other thoughts”. Some of the negative themes focused on it only working inside the perimeter of the city, and the fact that by keeping within 5% of the speed limit meant impeding traffic flow.

Table 2. Subject feedback on the auditory alerts after one week of use. Note that in some cases a row may not add up to exactly 100% because all numbers have been rounded to one decimal place.					
Questions	Strongly agree	Agree	Neutral	Disagree	Strongly Disagree

Table 2. Subject feedback on the auditory alerts after one week of**use.** Note that in some cases a row may not add up to exactly 100% because all numbers have been rounded to one decimal place.

I found the Otto auditory feedback to be useful.	16.7	58.3	25.0	0	0
I found the Otto feedback too much of a driving distraction.	0	0	41.7	16.7	41.7
I found the Otto was warning me of exceeding the speed limit on each trip.	58.3	16.7	8.3	8.3	8.3
I found myself listening for and using the Otto feedback.	16.7	50.0	16.7	16.7	0
I found the Otto to be annoying.	0	8.3	25.0	25.0	41.7
I found new school zones and cross walks in my neighbourhood.	0	16.7	16.7	16.7	50.0
I felt my thoughts wandering.	0	8.3	8.3	25.0	58.3
I felt the Otto provided great help for my driving.	8.3	33.3	50.0	8.3	0
I heard clear and concise messages.	33.3	50.0	0	16.7	0
I found the Otto often broke my concentration.	0	0	41.7	33.3	25.0
I will recommend the Otto to my friends.	25.0	16.7	50.0	8.3	0
I found myself driving slower than other traffic.	33.3	25.0	16.7	25.0	0
I could not concentrate on my normal driving.	0	0	25.0	16.7	58.3
I knew all the crosswalks in my neighborhood.	41.7	25.0	16.7	16.7	0
I did not need to use the Otto feedback function.	25.0	16.7	33.3	16.7	8.3
Otto did not change my driving patterns.	25.0	50.0	16.7	8.3	0
Questions	Strongly agree	Agree	Neutral	Disagree	Strongly Disagree

Table 2. Subject feedback on the auditory alerts after one week of

use. Note that in some cases a row may not add up to exactly 100% because all numbers have been rounded to one decimal place.

My passenger(s) thought Otto was helpful.	8.3	58.3	8.3	16.7	0
I felt confident with my driving speed.	33.3	66.7	0	0	0

Speeding behaviour changes

The repeated measures analysis of variance determined that there were significant main effects for week ($p = 0.031$) and percent above the speed limit ($p < 0.001$). In addition, there was an interaction between week and percent speeding ($p < 0.001$). As can be seen in Figure 1, when the extent of speeding was set at 5% or 10% above the speed limit, there were significant differences ($p < 0.05$) between week one and week two, with week one having a greater portion of the driving data above the speed limit. At both 5% and 10% only two subjects did not decrease their amount of speeding (Figure 2). For 15% and 20% above the speed limit, there were no differences between week one and week two, although similar trends existed.

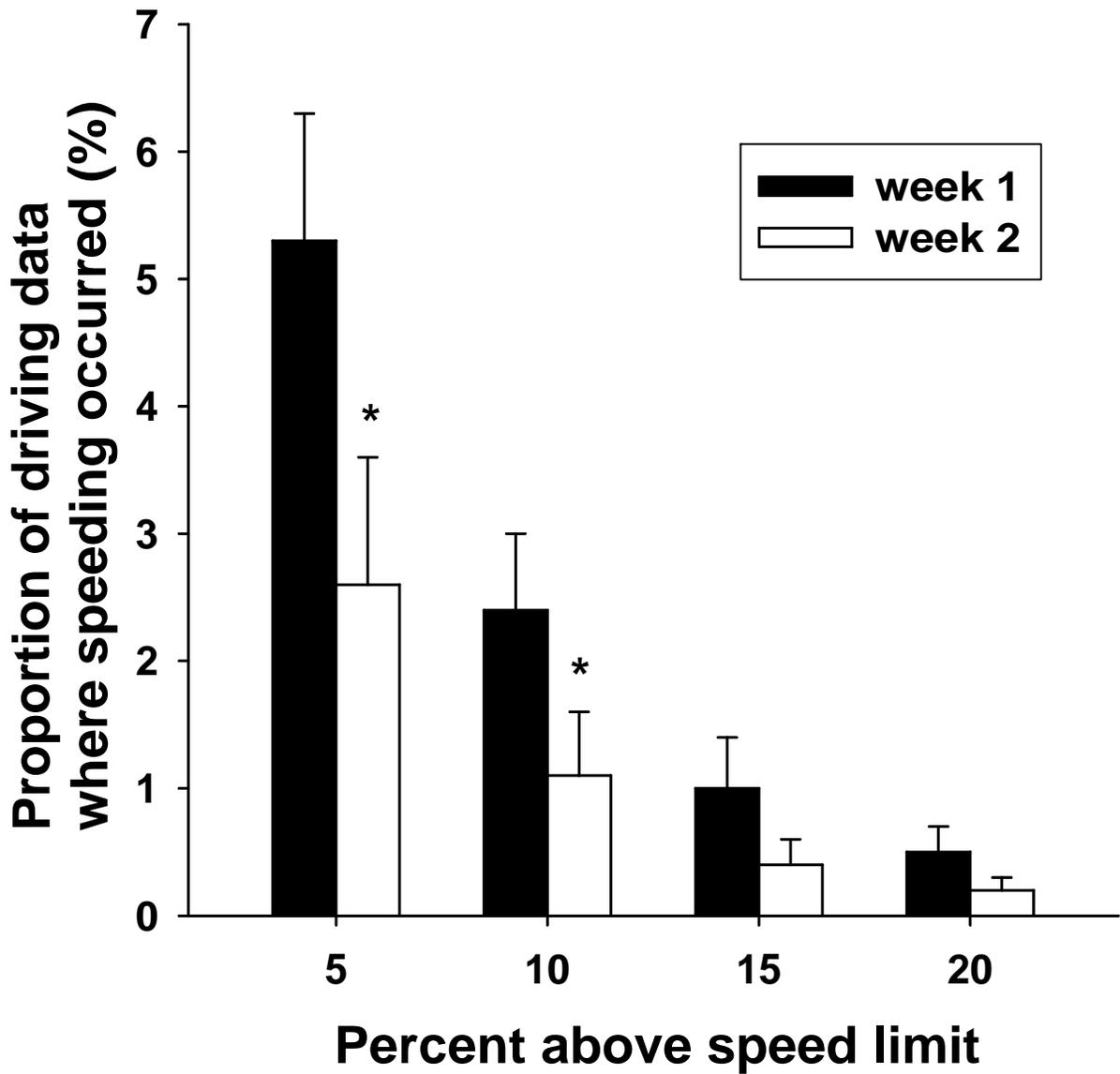


Figure 1. Proportion of data where speeding occurred is shown for each threshold for speeding (mean \pm SE; * $p < 0.05$) for week one and week two.

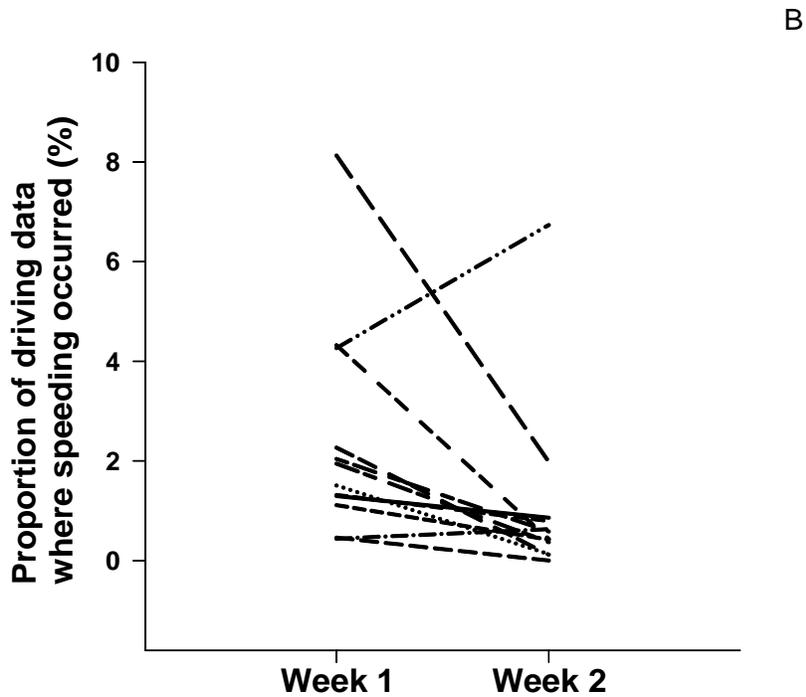
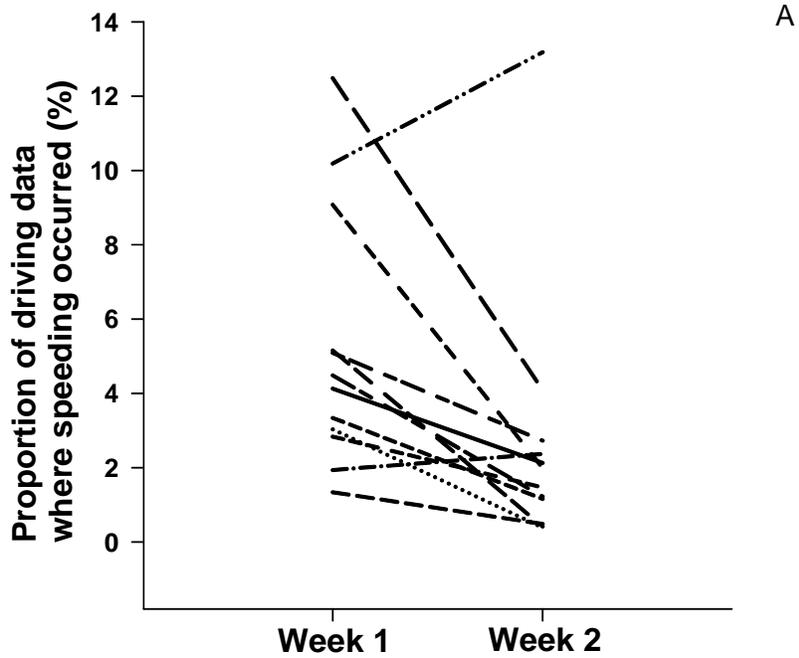


Figure 2. Individual data for speeding are shown for week one and week two when the threshold for speeding was set to 5% above the speed limit (A) and 10% above the speed limit (B).

DISCUSSION

In this study we were able to show that in-vehicle auditory alerts appear to reduce the extent of speeding in older drivers, as we had hypothesized. While some drivers sped very little and only slightly decreased the amount of speeding when the auditory alerts were provided, two drivers reduced their amount of speeding by about three to four fold.

In general, the feedback from the older drivers indicated that the auditory alerts were not a major distraction, and that several of the subjects were favourable about the device. However, subjects were not very enthusiastic about buying the Otto, particularly not for the price at which it was being sold at the time. Another issue that some subjects raised was that driving at the speed limit meant they were impeding traffic flow and so they ignored the warnings from the Otto that they were exceeding the speed limit. In fact, a majority of subjects indicated that they were driving slower than other traffic. For this study we selected a conservative setting of 5% above the speed limit for the device. Future studies could explore less conservative settings (e.g., 10%) as some subjects felt that 5% was too restrictive.

Future studies could also investigate whether the effect on speeding would wear off over time. Do drivers become habituated after long term use? In this study the subjects used the device for only one week. Over many weeks or months, drivers may begin to ignore any warnings they receive. Other areas for future research include studying a larger sample of drivers of different ages and ability levels.

While it is unclear from this study whether auditory alerts would have any effect on actual road safety, we did find, in a simulated environment, that auditory alerts improved brake response times as well as reduced crashes in older drivers [11]. Others have also found that auditory type alerts can be beneficial for older drivers in a simulated driving situation [12]. In real-world driving it is difficult to examine the responses of drivers to emergency situations and of course planned experiments cannot be conducted to see if auditory alerts affect crash rates. Observational studies could be conducted but the number of drivers would need to be very large and the time period for follow up would need to be very long in order to detect any changes in crashes that may occur. Also, in real-world driving the effect of auditory alerts that reduce the speeds of drivers may be more complex than in a simulated environment. As some of our subjects indicated they did not always want to obey speed limits because this meant that traffic flow was affected. Research has indicated that the interaction between driving speed and crash rates is very complex [13]. For example, the evidence available suggests that tools like red light cameras or other speed enforcement detection devices are effective in reducing traffic injuries [14-15]. However it is also known that larger speed variances (discrepancies in speeds of motor vehicles traveling together down a roadway) can increase the risk of crashes, although it is not clear whether a slow moving vehicle is at a higher risk of being involved in a crash [16].

In our previous study, we found that the older drivers' emergency braking in response to events was improved and crashes were reduced, even though driver speed did not differ significantly between the auditory alert and no auditory alert conditions [11]. This was also true for situations where the auditory alerts and events were not directly related. We speculated that overall attention was improved with the auditory alerts and drivers were able to focus better on relevant

visual information in the scenarios. Quotes from two subjects in the present study using the Otto in the real-world environment may capture this effect:

1. "I quite like Otto's function. It helped to keep my attention on driving the car rather than other thoughts."
2. "The device helps to concentrate more of my attention to driving than I would otherwise."

Therefore, the Otto may be beneficial for older drivers even if speed behaviour is not changed. This could be the case if the threshold for exceeding the speed limit were relaxed, as suggested above.

In conclusion, in-vehicle auditory alerts appear to offer promise for road safety. The older subjects were generally positive about the device, but most would not buy it, at least not at the market price at the time. Future research could examine the use of auditory alert type devices by more subjects with varying characteristics (age, gender, experience in driving), over a longer period of time, and with different threshold settings for exceeding the speed limit.

ACKNOWLEDGMENTS

Funding for this study was provided by the Canadian Institutes of Health Research, Mobility Initiative of the Institute of Aging. Technical assistance was provided by Satoru Nakagawa. No funding was provided by Persen Technologies.

REFERENCES

1. COUGHLIN, J. Transportation and older persons: perceptions and preferences - a report on focus groups, *American Association of Retired Persons*, Washington, DC, 2001.
2. BEDARD, M., STONES, M.J., GUYATT, G.H., and HIRDES, J.P. Traffic-related fatalities among older drivers and passengers: past and future trends, *Gerontologist*, 41: 751 - 756, 2001.
3. KUA, A., KORNER-BITENSKY, N., DESROSIERS, J., MAN-SON-HING, M., and MARSHALL, S. Older driver retraining: a systematic review of evidence of effectiveness, *J.Safety Res.*, 38: 81 - 90, 2007.
4. BALL, K. and OWSLEY, C. The useful field of view test: a new technique for evaluating age-related declines in visual function, *J.Am.Optom.Assoc.*, 64: 71 - 79, 1993.

5. BALL, K.K., ROENKER, D.L., WADLEY, V.G., EDWARDS, J.D., ROTH, D.L., MCGWIN, G., Jr. et al. Can high-risk older drivers be identified through performance-based measures in a Department of Motor Vehicles setting?, *J.Am.Geriatr.Soc.*, 54: 77 - 84, 2006.
6. MCEVOY, S.P., STEVENSON, M.R., and WOODWARD, M. The impact of driver distraction on road safety: results from a representative survey in two Australian states, *Inj.Prev.*, 12: 242 - 247, 2006.
7. STUTTS, J.C., REINFURT, D.W., and RODGMAN, E.A. The role of driver distraction in crashes: an analysis of 1995-1999 Crashworthiness Data System Data, *Annual Proceedings of the Association for Advanced Automotive Medicine*, 45: 287 - 301, 2001.
8. MERAT, N., ANTTILA, V., and LUOMA, J. Comparing the driving performance of average and older drivers: the effect of surrogate in-vehicle information systems, *Transport.Res. Part F*, 8: 147 - 166, 2005.
9. CHAPARRO, A., WOOD, J.M., and CARBERRY, T. Effects of age and auditory and visual dual tasks on closed-road driving performance, *Optom.Vis.Sci*, 82: 747 - 754, 2005.
10. RIZZO, M., STIERMAN, L., SKAAR, N., DAWSON, J.D., ANDERSON, S.W., and VECERA, S.P. Effects of a controlled auditory-verbal distraction task on older driver vehicle control, *Transport.Res.Rec.*, 1865: 1 - 6, 2004.
11. PORTER, M.M., IRANI, P., and MONDOR, T.A. Effect of auditory road safety alerts on brake response times in younger and older male drivers - a simulator study, *Transport.Res.Rec.*, in press.
12. JONSSON, I.M., ZAJICEK, M., HARRIS, H., and NASS, C. Thank You, I did not see that: In-car speech based information systems for older adults, *Proceedings of the Conference on Computer-Human Interaction*, 1953 - 1956, 2005.
13. NAVON, D. The paradox of driving speed: two adverse effects on highway accident rate, *Accid.Anal.Prev.*, 35: 361 - 367, 2003.
14. AERON-THOMAS, A.S. and HESS, S. Red-light cameras for the prevention of road traffic crashes, *Cochrane Database Syst.Rev.*, 2005.
15. WILSON, C., WILLIS, C., HENDRIKZ, J.K., and BELLAMY, N. Speed enforcement detection devices for preventing road traffic injuries, *Cochrane.Database.Syst.Rev.*, 2006.
16. AARTS, L. and VAN, S., I Driving speed and the risk of road crashes: A review, *Accid.Anal.Prev.*, 38: 215 - 224, 2006.