EFFECTS OF CELL PHONE CONVERSATIONS ON YOUNGER AND OLDER DRIVERS

David L. Strayer and Frank A. Drews
University of Utah
Salt Lake City, Utah

Our research examined the effects of hands-free cell phone conversations on simulated driving. We found that driving performance of both younger and older adults was impaired by cell phone conversations. Compared to single-task conditions, cell-phone drivers' reactions were 18% slower, their following distance was 12% greater, and they took 17% longer to recover the speed that was lost following braking. These cell-phone induced impairments were equivalent for younger and older adults, suggesting that older adults do not suffer a significantly greater penalty for talking on a cell phone while driving than their younger counterparts. Interestingly, the net effect of having younger drivers converse on a cell phone was to make their braking reactions equivalent to those of older drivers who were not using a cell phone.

Summarizing the literature on aging and dual-task performance, Kramer & Larish (1996) concluded that "one of the best exemplars of a mental activity in which large and robust age-related differences have been consistently obtained is dual-task processing" (p. 106). Given that driving is a complex behavior involving the combination of activities that are task-relevant (e.g., navigating, maintaining lane position, following distance and speed, reacting to unexpected events, etc.) and task-irrelevant (e.g., using a cell phone, adjusting the radio, conversing with passengers, eating, lighting a cigarette, shaving, applying make-up, etc.), it is not surprising that older adults exhibit deficiencies in driving. For example, compared to younger drivers, older adults are 6 times more likely to be involved in a fatal traffic accident while making a left turn, an activity that requires drivers to divide attention between the control of their vehicle and oncoming traffic (DOT HS 809-328, 2000). As more advanced technologies make their way into the vehicle, the multitasking demands are likely to increase making the task of driving more demanding for older individuals.

The purpose of the current research is to test the hypothesis that age-related differences in the ability to divide attention between tasks commonly engaged in while driving contributes significantly to the increase in traffic accidents with senescence. Our current research focuses on a dual-task activity that is currently engaged in by over 100 million drivers in the United States: The concurrent use of cell phones while driving (CTIA, 2003; Goodman et al., 1999). It is now well established that cell phone use impairs the driving performance of younger adults (Alm & Nilsson, 1995; Briem & Hedman, 1995; Brookhuis, De Vries, & De Waard, 1991; Brown, Tickner, & Simmonds, 1969; Goodman et al., 1999; McKnight & McKnight, 1993; Redelmeier & Tibshirani, 1997; Strayer & Johnston, 2001; Strayer, Drews, & Johnston, 2003). In this article we explore the extent to which older adults are penalized by this real-world dual-task activity. Based on the aging and dual-task literature, we predict that as the dual-task demands increase, that the driving performance of older adults will deteriorate more rapidly than that of younger drivers.

Method

Participants. Twenty older adults and twenty younger adults participated in the experiment. Younger participants ranged in age from 18 to 25, with an average age of 20.2. Older participants ranged in age from 65 to 74, with an average age of 69.5. Table 1 reports several demographic and psychometric measures for the two age-groups. All participants were in good health, had normal or corrected-to-normal visual acuity, normal color vision (Ishihara, 1993), and a valid driver's license.

Stimuli and Apparatus. A PatrolSim high-fidelity driving simulator, manufactured by GE Capital I-Sim was used in the study. A freeway road database simulated a 24-mile multi-lane highway with on and off-ramps, overpasses, and two and three-lane traffic in each direction. A pace car, programmed to travel in the right-hand lane, braked intermittently throughout the scenario. Distractor vehicles were programmed to drive between 5% and 10% faster than the pace car in the left lane, providing the impression of a steady flow of traffic. Unique driving scenarios, counterbalanced across participants, were used for each condition in the study. In each scenario, the pace car was programmed to brake at 32 randomly selected locations. Measures of real-time driving performance, including driving speed, distance from other vehicles, and brake inputs, were sampled at 30 Hz and stored for later analysis.

Procedure. When participants arrived for the experiment, they completed a questionnaire assessing health status, psychometric information, and their interest in potential topics of cell phone conversation. Participants were then familiarized with the driving simulator using a standardized 20-minute adaptation sequence. Participants then drove four ten-mile sections on a multi-lane highway. Half of the scenarios were used in the single-task driving condition and half were used in the dual-task (i.e., driving and cell phone conversation) condition. The order of conditions and scenarios was counterbalanced across participants using a Latin square design, with the constraint that both single-and dual-task conditions were performed in the first half of the experiment and both single-and dual-task conditions were performed in the last half of the experiment. For data analysis purposes, we aggregated the data across scenarios for both the single-and dual-task conditions.

The participant's task was to follow a pace car that was driving in the right-hand lane of the highway. When the participant stepped on the brake pedal in response to the braking pace car, the pace car released its brake and accelerated to normal highway speed. If the participant failed to depress the brake, they would eventually collide with the pace car. That is, like real highway stop and go traffic, the participant was required to react in a timely and appropriate manner to vehicles slowing in front of them.

The dual-task condition involved conversing on a cell phone with a research assistant. The participant and the research assistant discussed topics that were identified in the questionnaire as being of interest to the participant. To avoid any possible interference from manual components of cell phone use, participants used a hands-free cell phone that was positioned and adjusted before driving began. Additionally, the call was initiated before participants began the dual-task scenarios. Thus, any dual-task interference that we observe must be due to the cell phone conversation itself, because there was no manual manipulation of the cell phone during the dual-task portions of the study.

Dependent Measures. We examined four parameters associated with the participant's reaction to the braking pace car. *Brake-onset time* is the time interval between the onset of the pace car's brake lights and the onset of the participant's braking response. *Following distance* is the distance between the pace car and the participant's car. *Speed* is the average driving speed of the participant's vehicle. *Half-recovery time* is the time for participants to recover 50% of the speed that was lost during braking.

Table 1. Psychometric and demographic measures for younger and older adults.

	Younger Adults	Older Adults	F statistic (df=1,39)
Age	20.2 (0.4)	69.6 (0.6)	4299 *
Gender	13 Male, 7 Female	14 Male, 6 Female	0.2 †
Years of Schooling	9.6 (1.4)	15.5 (0.5)	17.1 *
Digit Symbol	84.6 (4)	59.1 (2.4)	32.1 *
Maze Tracing	15.1 (1)	8.1 (1)	34.5 *

*, p<.05; † ns Standard errors are presented in parentheses.

Design and Statistical Analysis. The design was a 2 (Age: Younger vs. Older adults) X 2 (Task: Single- vs. Dual-task) factorial. Age was a between subjects factor and single- vs. dual-task condition was a within-subjects factor. We used a Multivariate Analysis of Variance (MANOVA) to provide an overall measure of driver performance as a function of experimental conditions. We also performed univariate analyses on each of the dependent measures using a 2 (Age: Younger vs. Older adults) X 2 (Task: Single- vs. Dual-Task) split-plot Analysis of Variance (ANOVA). A significance level of $p < .05$ was adopted for all inferential tests and Cohen's d was used to estimate effect size for significant effects in the univariate analyses.

Results

Table 2 presents the four driving performance measures described above. The MANOVA indicated significant main effects of age, $F(4,35)=8.74$, $p<.01$ and single- vs. dual-task, $F(4,35)=11.44$, $p<.01$. However, the age X single- vs. dual-task interaction was not significant, $F(4,35)=1.46$, $p>.23$. This latter finding suggests that older adults do not suffer a significantly greater penalty for talking on a cell phone while driving than their younger counterparts. Statistical analysis of brake-onset times revealed slower reactions in dual-task than in single-task driving conditions, $F(1,38)=12.96$, $p<.01$, $d=1.17$. However, the main effect of age was only marginally reliable, $F(1,38)=3.13$, $p<.08$, $d=0.57$, and the age X single vs. dual-task interaction was not significant, $F(1,38)=0.26$, $p>.64$. Interestingly, the difference between dual- and single-task was exactly the same magnitude (153 msec) as the difference between older and younger adults (153 msec). That is, cell-phone conversations slowed participants' braking reactions by 18%; an amount comparable to the average slowing observed with senescence.

Analysis of following distance revealed that older adults drove with a greater following distance than younger drivers, $F(1,38)=21.97$, $p<.01$, $d=1.52$. Following distance was also greater in dual- than in single-task conditions, although this effect was only marginally significant, $F(1,38)=3.80$, $p<.06$, $d=0.63$. The age X single- vs. dual-task interaction was not significant, $F(1,38)=0.01$, $p>.98$. The increased following distance in dual-task conditions may be indicative of a compensatory strategy that drivers adopt to compensate for their slower braking reactions.

Analysis of driving speed revealed that older adults drove slower than younger adults, $F(1,38)=21.86$, $p<.01$, $d=1.52$. Neither the main effect of single- vs. dual-task, $F(1,38)=0.01$, $p>.97$, nor the age X single- vs. dual-task interaction were significant, $F(1,38)=1.53$, $p>.22$. Further analysis of driving speed indicated that it took older adults longer to recover 50% of the speed that was lost following braking, $F(1,38)=9.07$, $p<.01$, $d=0.98$, and the recovery time was greater in dual-task than in single-task conditions, $F(1,38)=21.43$, $p<.01$, $d=1.50$. The age X single- vs. dual-task interaction was not significant, $F(1,38)=2.58$, $p>.12$.

Discussion

Taken together, the data demonstrate that conversing on a hands-free cell phone impaired driving performance and that the distracting effects of cell phone conversations were equivalent for older and younger adults. Compared to single-task conditions, cell-phone drivers' reactions were sluggish; they drove 18% slower, their following distance was 12% greater, and they took 17% longer to recover the speed that was lost following braking. However, our study found that older drivers did not suffer a greater penalty for talking on the phone while

Table 2. Driving performance measures as a function of age and single-vs. dual-task.

	Younger Adults		Older Adults	
	Single-Task	Dual-Task	Single-Task	Dual-Task
Brake Onset Time (msec)	780 (49)	912 (83)	912 (49)	1086 (83)
Following Distance (meters)	22.7 (3)	26.4 (2)	37.1 (3)	40.7 (2)
Driving Speed (MPH)	63.3 (2)	62.1 (1)	52.4 (2)	53.7 (1)
½ Recovery Time (secs)	4.6 (0.4)	5.9 (0.4)	6.4 (0.4)	7.0 (0.4)

driving than younger drivers. Interestingly, the reaction time of younger drivers talking on the cell phone was equivalent to the reaction time of older drivers who were not using the cell phone.

The absence of age-related differences between single- and dual-task performance would appear to contradict findings from laboratory-based studies showing “large and robust age-related differences … in dual-task processing” (Kramer & Larish, 1996, p. 106). However, one important difference between the current research and much of the earlier laboratory-based studies is that our task used a high-fidelity driving simulator to study a skill that older adults have performed for 50 years. It may be that highly practiced, real-world skills such as driving are less sensitive to the dual-task impairments normally associated with aging. If this hypothesis is correct, then it implies that novel laboratory-based tasks may significantly overestimate the age-related dual-task deficits.

Nevertheless, the epidemiological evidence clearly indicates that older drivers, on average, are more likely to be involved in fatal traffic accidents (DOT HS 809-328, 2000). Another possibility for our failure to find a significant age X single- vs. dual-task task interaction is that the older adults in our study may have been in better mental and physical fitness than the general population of older drivers. Our subjects were recruited from advertisements in local papers and all were in good health and exercised regularly. It may be that the older drivers who are at greater risk for accidents are less likely to participate in driving-related research.

It is also important to note that performance decrements for cell-phone drivers were obtained even when there was no possible contribution from the manual manipulation of the cell phone. Thus, these data are consistent with an attention-based interpretation in which the disruptive effects of cell phone conversations are due primarily to the diversion of attention from driving to the phone conversation itself (cf. Strayer & Johnston, 2001; Strayer, Drews, & Johnston, 2003).

In sum, our research found that the driving performance of both younger and older adults is significantly impaired when they are conversing on a hands-free cell-phone. These dual-task impairments were equivalent in magnitude for younger and older adults. Our data further indicate that the net effect of having a younger driver converse on a cell phone was to make their braking reactions similar to those of older drivers who were not using a cell phone.

References

Alm, H., & Nilsson, L. (1995). The effects of a mobile telephone task on driver behaviour in a car following situation. *Accident Analysis & Prevention*, *27*(5), 707-715.

Briem, V., & Hedman, L. R. (1995). Behavioural effects of mobile telephone use during simulated driving. *Ergonomics*, *38*(12), 2536-2562.

Brookhuis, K. A., De Vries, G., & De Waard, D. (1991). The effects of mobile telephoning on driving performance. *Accident Analysis & Prevention*, *23*, 309-316.

CTIA (2003). Cellular Telecommunications Industry Association,1250 Connecticut Avenue, NW Suite 800 || Washington, DC 20036, Phone : (202) 785 - 0081. (http://www.wow-com.com/).

DOT HS 809-328 (2000). *Traffic Safety Facts 2000: Older Population*. DOT HS 809-328. http://www-fars.nhtsa.dot.gov/pubs/7.pdf

Goodman, M. F., Bents, F. D., Tijerina, L., Wierwille, W., Lerner, N., & Benel, D. (1999). *An Investigation of the Safety Implications of Wireless Communication in Vehicles. Report Summary.* Department of Transportation electronic publication. Report summary (http://www.nhtsa.dot.gov/people/injury/research/wireless/#rep).

Ishihara, S. (1993). Ishihara’s test for colour-blindness. Tokyo: Kanehara.

Kramer, A. F., & Larish, J. (1996). Aging and dual-task performance (pp. 83-112). In W. Rogers, A. D. Fisk, & N. Walker (Eds.), *Aging and skilled performance*. Hillsdale, N.J. :Erlbaum.

McKnight, A. J. & McKnight, A. S. (1993). The effect of cellular phone use upon driver attention. *Accident Analysis & Prevention*, *25*(3), 259-265
.

Redelmeier, D. A., & Tibshirani, R. J. (1997) Association between cellular-telephone calls and motor vehicle collisions. *The New England Journal of Medicine*, *336*, 453-458.

Strayer, D. L., & Johnston, W. A. (2001). Driven to distraction: Dual-task studies of simulated driving and conversing on a cellular phone . *Psychological Science*,*12*, 462-466.

Strayer, D. L., Drews, F. A., & Johnston, W. A. (2003). Cell phone induced failures of visual attention during simulated driving. *Journal of Experimental Psychology: Applied, 9,* 23-32.