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Final Report

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Age related changes in cognitive response style in the driving task

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The degree and manner in which cellular phone conversations and other cognitive distractions affect driving performance remains an area of great interest. It is well known that cellular phone usage adversely impacts safety (Redelmeier & Tibshirani, 1997), but the extent to which the effect changes with age, conversation type, etc. has not been well-characterized. The potential for decline in driving safety with advancing age is of particular concern, as it is known that older adults do not perform as well as younger adults when attention is divided between complex cognitive tasks (McDowd & Craik, 1998). However, the age at which declines in cognitive ability begin to impact performance is not well established and is known to vary considerably by individual. The next generation of older adults is expected to drive more frequently than previous cohorts (Coughlin, 2005; Bush, 2005). Since today's aging driver has more exposure to cellular technologies, we believe that with age they are more likely than their predecessors to continue using cellular phones while driving. However, it remains unclear how cellular phone usage impacts driving safety with age.

Basic cardiovascular parameters have been shown to increase with escalating cognitive demand or workload (Bucks & Seljos, 1994; Veltman & Gaillard, 1998). It has been suggested that physiological measures may be more sensitive than traditional performance measures at detecting heightened cognitive load since motivated individuals are likely to invest additional cognitive resources to maintain a given level of performance as demands increase (Lenneman, Shelley & Bucks, 2005). Based on existing research (Brookhuis & Waard, 2001), there was the expectation that heart rate would increase in response to the added cognitive challenge of the cell phone task. If total available cognitive resources decline with age, it might be anticipated that older subjects would show a greater heart rate response to the demands of the secondary task. However, the regulation of physiological parameters such as heart rate and blood pressure show less elasticity, increasing sympathetic dominance and longer recovery times in response to stimulation with increasing age (Jones et al., 2001; Laitinen et al., 2004). Therefore, it is not well established if middle age and younger adults have comparable physiologic responses to the cognitive load associated with cell phone conversations and appeared worthy of investigation.

In this project, heart rate and driving performance were assessed while late middle age (51-66) and younger adults (19-23) engaged in a naturalistic hands free phone task that was designed to place objectively equivalent cognitive demands on all participants. Although heart rate measures have been used in evaluating driver workload, prior studies had not compared responses in late middle age and younger adults. The cellular phone task was devised to place equivalent objective demands on all participants and to allow for an assessment of performance. At the same time, it was designed to be a naturalistic, low to moderately demanding cognitive task that imposed a level of workload that could be equated to a time limited, non-emotional cell phone conversation. Under these conditions, it was anticipated that performance of drivers of both age groups would be similar.

The two age groups displayed equivalent performance on the cellular telephone task. The added demand of the cell phone task impacted driving performance of both the younger and the late middle age subjects as measured by an increase in the standard deviation in driving speed. It was observed that the late middle age subjects drove more slowly overall. An age by period interaction on stop sign pauses shows only the younger drivers increased their pause time while engaged in the conversation task, bringing them into the same pause range shown by older drivers throughout the driving task. Statistically, heart rate increased across the sample with the phone conversation task. However, the age by period interaction shows that the heart rate acceleration was limited almost entirely to the younger subjects (see Reimer et al., 2008 for additional discussion of these results).

When considered together, the increase in heart rate and longer pauses identified for the younger participants in this sample while engaging in the phone task suggest that younger drivers as a group have trouble regulating the workload involved with the driving task with even the most basic secondary conversation. These results also suggest that middle age adults appear at least as capable, if not more so, of appropriately managing the additional demands of a modest secondary task while driving. Although a

decline in speed control is observed, the middle age adults in this sample appear to balance the amount of attention placed upon the conversation with that of the driving task without compromising their ability to perform the scheduling task.

Reimer et al. (submitted for review) presents an alternative approach to viewing the heart rate data. In this paper we discuss setting aside a unidirectional arousal model and consider individual patterns of physiological response to the demands of the cell phone task that are being obscured by simply looking at the mean values obtained by grouping drivers into the younger and older age categories. This analysis considers that there are cognitively demanding situations where heart rate may increase or decrease, possibly depending on how attention is directed or allocated. It has been suggested that heart rate deceleration is associated with an attentional state involving the intake of environmental stimuli (a broad ranging external focus) while heart rate acceleration may be related to an attentional style that involves selectively ignoring or rejecting input that may be disruptive or distracting to a focused cognitive task (B. C. Lacey & Lacey, 1974; J. I. Lacey, Kagan, Lacey, & Moss, 1963). In this project, other than having consistently higher heart rates, what differentiates the late middle age and younger drivers is not so much a specific pattern of response to the cell phone task but the relative distribution of individuals showing increases, decreases and unchanged heart rates.

While there are significant reasons to discourage all individuals from engaging in phone conversations and other distracting tasks while driving, results of this project suggest that late middle age adults appeared as capable as young adults of managing the additional workload of a low to moderately demanding cognitive task. The tendency of individuals to adopt self-regulatory behaviors, such as a lower overall driving speed, as a function of age / experience may account for the equivalence in overt performance. Nothing in the findings of this project should detract from the fact that engaging in a secondary task such as a cellular phone conversation does divide attention; drivers of all ages need to be mindful of the conditions under which it is appropriate to utilize a phone while driving and the important of limiting the level of demand engendered by the conversation.

This project illustrates the need for additional research in the area of cognitive distraction during driving. Previous studies of cellular telephone conversations and similar cognitive distractions have largely involved complex cognitive tasks, often with unnaturally high levels of total demand. The work considered here suggests that the results of studies based on such tasks may overestimate likely changes in driving performance, particularly for older drivers, as compared to less demanding tasks that may be more typical of many cellular phone conversations.

The citations listed below are based upon components of this project and contain more detailed discussions of the results and conclusions from this project:

- Reimer, B., Mehler, B.L., Pohlmeier, A.E., Coughlin, J.F. & Dusek, J.A. (2006). The use of heart rate in a driving simulator as an indicator of age-related differences in driver workload. *Advances in Transportation Studies an International Journal*, Special issue, pp.9-20.
- Reimer, B., D'Ambrosio, L.A. & Coughlin, J.F. (2007). Secondary Analysis of Time of Day on Simulated Driving Performance. *Journal of Safety Research*, 38(5), pp. 563-570.
- Reimer, B., Mehler, B., Coughlin, J.F., Wang, Y., D'Ambrosio, L.A. Roy, N., Long, J., Bell, A., Wood, D. & Dusek, J.A. (2008). A Comparison of the Effect of a Low to Moderately Demanding Cognitive Task on Simulated Driving Performance and Heart Rate in Middle Aged and Young Adult Drivers. International Conference on Cyberworlds. Hangzhou, China.
- Reimer, B., Mehler, B., Coughlin, J., Roy, N. & Dusek, J.A. (submitted for review). Assessing the Impact of Hands-free Cellular Phone Conversations on Older Drivers Using Physiological Measurements and Driving Performance.