

**THE EFFECTS OF AGE AND DISTRACTION ON REACTION TIME  
IN A DRIVING SIMULATOR**

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**Summary:** The objective of this study was to investigate the effects of driver distraction – both cognitive and visual – on reaction time to unexpected road hazards. Participants operated a driving simulator while intermittently answering prerecorded questions of various difficulty (holding a “conversation” with the computer), or dialing specified numbers into a cellular telephone. Two road hazards were presented at unpredictable times and locations, including red brake lights and a red pedestrian-shape of approximately the same area as the brake lights. Targets were presented in two different locations: directly in front of the driver at the bottom of the screen, and off to the side of the road. The results showed a significant overall increase in reaction time for older subjects, as well as a strong interaction with the dialing task condition. There were no significant differences from the control for either easy or difficult verbal response conditions. In addition, stimuli on the side of the road took significantly longer to respond to, especially when combined with the dialing task. These data suggest a strong link between age, visual task load, stimulus location, and increased reaction time to unexpected stimuli.

## **INTRODUCTION**

Today’s society, with its almost universal fascination with computers and perpetual information availability, seems eager to accept every new technology which combines many functions into one. A prime example of this is the current move to integrate an office environment into automobiles; cutting edge technology is making it possible to allow an ever-increasing array of functions to occupy a driver’s attention, including but not limited to telephones, navigation systems, and even internet and email capabilities. As in many cases of technology, however, there may be a downside to counter the benefits. Here we refer explicitly to the effects of divided driver attention; increasingly, drivers must divide their cognitive and visual resources between talking on the telephone, reading a navigational map, drinking coffee, adjusting the stereo, and, finally, operating their automobile at highway speeds.

How does this affect drivers’ ability to perform driving (their primary task) competently; specifically, how does all this distraction (both cognitive and visual) influence drivers’ reaction times to unexpected stimuli? Our purpose was to quantitatively analyze the potentially dangerous effects of electronic devices in cars; to this end, we have concentrated on the effects of mobile telephones, which have become relatively commonplace in automobiles over the past ten years.

Several studies done in recent years have addressed this question, including two conducted by Alm and Nilsson in 1994 and 1995. The 1994 study attempted to analyze differences in reaction time to stimuli between groups of subjects who were performing a memory test while driving on

a simulator, and subjects who were doing simulated driving alone. The results indicated that during the easy driving task, the division of attention between driving and performing the memory task had a negative effect on the experimental group, producing significantly longer reaction times than participants in the control group. There was no significant difference in reaction times between these groups when driving the difficult course. The authors suggest that while driving the difficult course drivers are in a more aroused, frustrated state, and that they therefore pick up visual cues more quickly (this is supported by research done by Moss & Triggs (1997)). They also suggest that as the road is more difficult, drivers are paying more attention to the driving task to begin with than to the dual task. The 1995 study demonstrated increased reaction time for both age and task load. The current study focused on the effects of gender, age, hazard type and location, distraction task load, and distraction type (cognitive vs. visual). We hypothesized that reaction time would not be affected by gender, but that there would be a significant increase with age, and especially with increased task load (none, easy and hard cognitive tasks, and visual tasks). In addition, it was hypothesized that reaction times would increase for stimuli outside central visual focus; i.e. stimuli appearing on the side of the road.

## **METHODS**

### **Participants**

Participants were of equal numbers male and female college students (mean age 20.1 years) and middle aged members of the college community (mean age 46.4 years). There were 28 participants overall.

### **Apparati**

The driving simulator consisted of the Sony PlayStation program Gran Turismo II, run off a PlayStation connected to a EIKI LC color video projector. The image was projected onto a 2 meter by 1.7 meter white screen approximately 8 meters from the projector. The screen formed a visual angle of 33° 23.9' x 28° 4.3'. The test track was a circuit approximately 3.2 kilometers in length, with easy to moderately difficult left and right hand bends. There were no other cars on the track. Participants sat at a console approximately 3.3 meters from the screen. The console contained a steering wheel, with gas and brake pedals realistically positioned on the floor. Visual stimuli and verbal distracter instructions were presented by a program written for a Macintosh G3. The video feed from the computer was spliced into the video from the PlayStation console by means of a TeleGen electronic mixer, so that stimuli were overlaid on the test track.

There were two types of visual targets presented in two locations. The first target was two round, red circles, which simulated brake lights. The second target was a stick-figure pedestrian; it too was red, and it covered approximately the same area as the brake lights. The stimuli were presented at either of two points on the screen: the first was in the center of the field of view at the bottom of the screen, and the second was at the far right edge of the screen. The computer was programmed to present these stimuli at seemingly random times (one stimulus/location at a time), and to measure the time elapsed between initiation of the stimulus and the time at which the brake pedal was depressed halfway. This timer was accurate to hundredths of a second. The stimuli were programmed to appear an equal number of times in control and dual task conditions,

and during each type of task. However, stimuli only occurred in 1/2 of the total tasks, to minimize predictability.

## Method

Participants were instructed in how to operate the simulator, and were asked to drive as though the test track were a highway with a speed limit of 55 mph. They were then given practice time driving around the track. When participants mastered control of the simulator, instructions were read and testing began. Approximately every 15 seconds, the computer either asked the participant a question that required a verbal response, or requested that a particular seven digit number be entered into the cellular telephone to the participant's right. Stimuli were presented 2.5 s after the completion of the command during 50% of the trials. An equal number of stimuli was presented between distractor trials.

## RESULTS

This study contained five independent variables and one dependent variable. The independent variables, as stated above, were age, gender, stimulus location, stimulus type, and driving condition (control, easy questions, difficult questions, and dialing). The dependent variable was reaction time, in hundredths of seconds.

### Age and Gender Main Effects

There was a significant difference in reaction times between the age groups in overall reaction time;  $F(1,761) = 6.75, p < 0.05$ . There was no significant difference between males and females, and no interaction between gender and age.

### Distracter Conditions x Age

Results from the dialing condition provided several significant findings. First, dialing the telephone produced significantly longer reaction times for both age groups than the control condition (for the young group  $p = 0.01$ ; for the middle age group,  $p < 0.001$ ). Second, for the middle age group, reaction times while dialing were significantly higher than during difficult question answering,  $p < 0.001$ . Third, there was an interaction between age and task load, as the only significant difference between age groups came during the dialing task ( $p = 0.002$ ). In the control condition, there was a nonsignificant trend for the young age group to respond more quickly. The easy question task showed similar results, with the middle age group taking slightly longer to respond; again, this was a nonsignificant trend. Difficult questions provided a larger young/middle age group reaction time gap, which approached significance at  $p = 0.07$ . Overall, however, there were no significant differences in reaction time among age and the first three distracter tasks.

### Stimulus Type x Age

There was no significant difference between age groups for the brake light stimulus, but the young age group responded more quickly to the figure shaped stimulus ( $p < 0.01$ ) than did the middle age group.

### **Stimulus Location x Age**

There was no significant difference between the age groups for stimuli presented in the middle of the road. However, participants in the middle age group had significantly longer reaction times to stimuli presented at the side of the road than did young participants;  $p=0.006$ . In addition, middle age participants had significantly higher reaction times to the roadside stimuli than to stimuli in the center of the road.

### **Task x Stimulus Location**

A significant interaction occurred between Task and Stimulus Location [ $F(3,761)=67.20$ ,  $p<0.0001$ ]. In the control condition, stimuli on the side of the road elicited significantly longer reaction times than centrally presented stimuli ( $p=0.001$ ). In addition, during the dialing task reaction times to stimuli presented at the side of the road were significantly longer than reaction times to central stimuli during dialing ( $p<0.0001$ ). They were also significantly longer than reaction times to side-presented stimuli during all other distraction conditions (for all cases,  $p<0.001$ ).

### **Age x Task x Stimulus Location**

There was a significant three-way interaction between age, task load, and stimulus location [ $F(3,761)=15.10$ ,  $p=0.003$ ]. Post-hoc tests revealed several significant differences. First, in the control condition, side-appearing stimuli elicited significantly longer reaction times for the middle age group ( $p=0.002$ ), but not for the young group. Second, when answering difficult questions, participants in the middle age group took significantly longer than participants in the young group to react to stimuli at the side of the road ( $p=0.01$ ). When reacting to stimuli in the center of the road, however, there was no significant difference between the age groups.

In the dialing condition, reaction times to stimuli at the side of the road were the largest for both age groups of any distracter/location combination. The young group had significantly higher reaction times in the dialing/side condition than in the control/side condition ( $p<0.0001$ ). In addition, they had a significantly higher reaction time during the dialing/side condition than to stimuli appearing in the dialing/center condition. The effect was even greater for participants in the middle age group; for them, reaction times in the dialing/side condition were significantly greater than the dialing/center ( $p<0.0001$ ), as well as for all other tasks and locations for either gender (for all,  $p<0.05$ ).

## **DISCUSSION**

These data show several interesting trends, both consistent with and contrary to the hypotheses. In general, the hypothesis of increasing difficulty in dual-task processing with increasing age and task complexity was supported. However, not as much evidence was found to support the hypothesis that cognitive distractions can degrade reaction times on a level comparable to visual distractions.

Age proved to be a complex and rich variable; it was significant not only as a main effect, but in several interactions with other variables. This is very important, and cuts to the central point of

the experiment: the ability of humans to divide their attention to performing two complex tasks seems to suffer degradation with advancing age. This is especially interesting when one considers that there were no participants over the age of 54 in this study, and that the mean age for the “middle” age group was 46.4. It would be fascinating to do a similar study on retirement-age participants; however, it is possible that they would find a simulator quite difficult to operate.

The distraction conditions also provided a valuable source of data. Of primary importance, and counter to prediction, there was practically no difference in performance between the control and question-and-answer conditions. Indeed, reaction times in general were not significantly affected by even complex questions. There are two potential explanations for this fact. The first is simply that people, even into their middle years, are quite good at thinking and speaking one thing while looking for and reacting to another. The second possibility is that there was a ceiling effect among the questions conditions; although counterbalancing was used, there was still a greater probability that stimuli would appear on any given trial than in the real world.

Dialing, on the other hand, contributed to significantly longer reaction times for both age groups. When combined with stimuli that were to the side of the road, the effect became particularly prominent. Several times during the study, participants (particularly those in the middle age group) completely failed to see roadside obstacles while driving. When one pauses to consider that this was an environment with high-contrast obstacles that appeared in fully half of the trials, the real hazards of looking away from the road become apparent.

Stimulus location was shown to significantly affect reaction time; in conjunction with the task and age variables, some interesting interactions occurred. In every distracter condition besides the Easy Question condition, reaction times were higher for stimuli appearing on the side of the road. These differences were significant in the Control, Difficult Question, and Dialing conditions for middle age participants, and in the Control and Dialing conditions for younger subjects. This discrepancy is interesting - it is important to remember that roadside targets appeared equally as often as central targets. Even with counterbalancing, there was far more likelihood of hazards appearing in this study than in an actual driving environment, and all stimuli had a high contrast with the surround road and scenery. At a speed of 55 m.p.h., the difference in mean reaction times (nearly a second) between middle and young conditions could cost drivers almost 65 feet. This effect is largely due to the influence of the dialing task. There was a very sizable interaction between dialing and stimuli location, especially for middle-age participants.

There seem to be two major trends at work here. First, in nearly all cases, the middle age group had longer reaction times. This difference grew as the difficulty of the task increased, especially when the stimuli were presented at the side of the road. The second trend, related to the first, was the tendency for reaction times in general to be longer for stimuli at the side of the road, especially while dialing. For example, in the dialing/side condition for the middle age group, reaction time was nearly *double* that of the young age group, and was significantly different from every other task/location combination for either age group. This effect was predicted and is of course reasonable. Primarily, these data underscore the true danger of unexpected hazards emerging from the roadside, in combination with age and driver distraction.

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