# Visual Forensics of Older Drivers

Marc Green Phd Human Factors
2009
http://www.visualexpert.com/Resources/olderdrivers.html

**Marc Green**
*Seminar Available on this topic*
*Central Bridge New York: A 79 year-old bus driver ignored a STOP Sign and plows into a dump truck resulting in 35 injuries, 7 serious. He was distracted by the need to find an unfamiliar location and by noise made by students.*

*Highway 401 outside of Toronto: An older driver fails to see a road worker under an overpass, and her vehicle strikes and kills him. The shadow cast by the overpass lowered light adaptation levels in the work area. Older drivers are unable to quickly compensate for rapid light adaptation changes and are effectively blind to shadowed areas.*

These and similar accidents will soon become commonplace. Human vision, perception and reaction time decline with advancing age, so the roads will be filled with sight-impaired drivers. Naturally, litigation involving older drivers (and workers) is likely to skyrocket. Here, I outline some of the forensic factors of aging on road safety and older drivers.

**How Big is the Problem?**

Many are unaware of the magnitude of the problem. Here's some numbers:

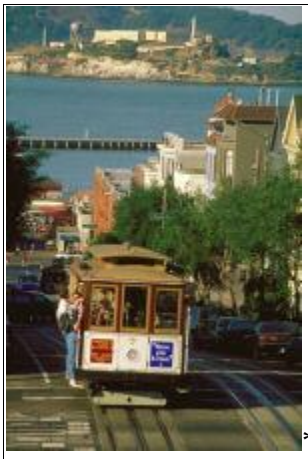
- 13% of the population is over 65
- 25% of the population is over 50, the age when decline begins
- in 30 years, the 65+ population will double (66 million people)
- over 85 is the fastest growing segment of the population
- these numbers don't include the large population of younger people with low vision from other causes.

**Causes of Visual Aging**

Although there are neural losses, the major decline is due to changes in the eye's optics. First, the lens becomes yellower, making discrimination of blue colors more difficult. More importantly, less light entering the eye reaches the photoreceptors. One problem is that the lens and other optical media become opaque. Further, the pupil shrinks, allowing less light to enter the eye. The following table shows how the pupil size shrinks with age. Note that the pupil's response to dim light also decreases with age and becomes virtually nil by age 80. This means the elderly have especially large vision problems in low light environments.

| Age (yr) | Day (mm) | Night (mm) | Diff (mm) |
|---|---|---|---|
| 20 | 4.7 | 8.0 | 3.3 |
| 30 | 4.3 | 7.0 | 2.7 |
| 40 | 3.9 | 6.0 | 2.1 |
| 50 | 3.5 | 5.0 | 1.5 |
| 60 | 3.1 | 4.1 | 1.0 |
| 70 | 2.7 | 3.2 | 0.5 |
| 80 | 2.3 | 2.5 | 0.2 |

As a result of all these factors, at age 60, the amount of light reaching the photoreceptors is only 33% of the amount seen at age 20. By the late seventies, the amount falls to 12%. Further aging reduces light transmission even more as the effect accelerates.
These pictures show how much aging changes the relative transmission of light through the optic media for viewers of age 20, 60 and 75.

| | | |
|---|---|---|
|  * |  * |  * |
| **Age 20** | **Age 60** | **Age 75** |

Of course, the aging viewer adapts to the lower luminance, so the world doesn't look as dark. These images are still startling and in many ways actually underestimate the decline in the aging eye's vision. There are many other effects, such as increased light scatter, microcateracts, and restricted field of view which further limit vision.

**Visual Losses**

*Contrast Sensitivity*

As a result of these factors, contrast sensitivity declines with age. The graph below shows how contrast must be increased with age. Using the sensitivity of a twenty year old as the base line, the graph shows the factor by which contrast must be increased in order to maintain visibility level. Required contrast increases gradually to a factor of two in the 60's. The loss of contrast

sensitivity then accelerates, reaching a factor of six by age 80.


These numbers are conservative. First, as already noted, the loss of vision is greater in low light environments. Second, these data include "normal observers." There are a variety of eye diseases, including macular degeneration, glaucoma and diabetic retinopathy, which often further impair vision in the elderly.

Contrast sensitivity is most impaired in low light because of the cloudy optics. As a result, older people have particular difficulties driving at night. One solution is creation of "brightways," a system of brightly illuminated streets. Older drivers could use the brightways for safer driving.

*Light and Dark Adaptation*

The eye adjusts when moving from light to dark or dark to light environments. For example, when we drive into a tunnel, we go from the relatively bright outdoor light level to a dimmer visual environment. The speed with which the eye adjusts to this change is called light adaptation. Aging causes a marked decrease in the speed of light adaptation, so older drivers are almost blind during such transitions. I once reviewed an accident where an older driver hit and killed a workman whose truck stopped under an overpass. The driver reported that he never saw the stopped truck. This doubtless occurred because the truck was in the shadows and the older driver did not dark adapt in time for the truck to become visible.

*Glare*

When the eye is adapted to a specific light level, sources much more intense than the prevailing level produce "glare." The most common situation occurs at night, when the eye is generally adapted to dark, but an oncoming car's headlights produce glare. The sun may produce glare even during the day due to its high intensity.

In older people, the clouding of the eye's optics causes entering light to scatter and to produce blinding glare. It is usually difficult for younger people, with their clearer optics, to appreciate the enormous debilitating effect that glare has on the elderly.

*Motion Perception*

Studies of motion perception usually find some loss for older people, especially when judging very slow or very fast motion.

*Color*

The yellowing of the eyes optic produces changes in color perception. Since "blue" light (i .e., short wavelengths) is filtered away, blues look darker. Moreover, mixtures containing blue appear different. Purple, which is a mixture of red and blue, will appear to be red, since the blue becomes invisible. Older people would also have a more difficult time seeing a purple object on a red background.

*Restricted Field of View*

When driving, we spend most of our time looking straight ahead but are still able to notice objects in the visual periphery. Older drivers lose some of the ability to see objects off to the side and have a restricted "functional field of view." For example, an older driver would have a more difficult time detecting a car cutting across the intersection ahead, a car pulling out from a parking sport or a pedestrian walking across the road. It's unclear whether this effect is purely sensory or is due in part to a cognitive and attentional decline.

*Reaction Time*

Older people are slower to respond when driving. The best estimate is that they are about 0.2-0.3 seconds slower than younger drivers. However, as tasks become more complex, the effect of aging may be bigger.

**Functional Problems of Older Drivers**

The National Institute on Aging held a symposium where 400 older drivers could explain their biggest difficulties in driving. The general consensus was that they had greater difficulty with speed judgments, and that instrument panels were too dim. They also found that older drivers believed that vehicles moved too quickly, and that they had particular problems merging with traffic. There were also problems seeing the peripheral field, and they had difficulty noticing the unexpected appearance of vehicles away from the direct line of sight. All of these problems are consistent with the scientific facts on visual aging that I've already described.

Research studies have confirmed these introspections and have further identified several driving tasks that cause older drivers significant difficulty:

- Judging whether a rear-end collision will occur
- Judging correct speed
- Braking rapidly
- Steering smoothly
- Judging when to merge into traffic
- Judging when to turn corners

**Are Older Drivers Really Poorer Drivers?**

Many authors have stated that older drivers are less safe, basing their conclusion on statistical analyses that found older drivers to have more accidents per mile driven. However, recent research (e .g, Hakamies-Blomqvist, Raitanen, & O'Neill, 2002) suggests that these studies failed to control for important variables, such as actual mileage driven. Older and younger drivers who drove the same number of miles had about the same accident rates. The authors concluded that this proves older drivers to be as safe as younger drivers.

The new finding illustrates important points both about the effects of age on driving and on interpretation of epidemiological studies. The original studies simply averaged over miles driven and did not consider actual driving habits. Older people drive less in general but, more importantly, also make many fewer long trips (between cities, etc) which builds up total mileage. Accidents on interstates are spectacular but relatively low per mile because traffic is lighter, attentional demands lower and quick reaction is less often required. Older drivers are more likely

to drive shorter trips within more congested urban areas where overall accident rates are higher and where demands on perception, attention and decision-making are great. One the other hand, people who limit their driving for any reason, young or old, may be poorer drivers. People who drive longer distances may be more skilled drivers. It would then be difficult to tell whether the accident rate variation is due to age or to the driving environment. However, there are other epidemiological biases such as the "frailty bias" which might skew accident statistics. Older drivers are more likely to suffer major injury, so their collisions are more likely to be reported and to appear in accident statistics.

This conundrum is a classic example of why epidemiological studies should always be viewed with intense skepticism. They are based on hunches about what independent variables matter and should be controlled and which do not matter. At best, they obtain general correlations that contain no real insight about actual causes and effects. (Is the accident rate due to aging or the the more complex roads environment on which they drive?) Without an understanding of causal mechanisms, for example, epidemiological studies could be used to "prove" that ice cream consumption in New York City causes malaria in India (Green, 2001.) Lastly, they are almost invariably based on source data, such as police reports, whose accuracy is questionable.

Even if accepted, however, the new studies (e .g, Hakamies-Blomqvist, Raitanen, & O'Neill, 2002) should not be taken to mean that older drivers are as good as younger drivers. The perceptual and cognitive losses described above will certainly impair driving performance under specific circumstances such as low visibility, high complexity and uncertainty. The failure to find higher accident rates per km likely reflects the driving habits of older drivers. They presumably drive more slowly and less aggressively, and their experience may give them an advantage in hazard anticipation. Moreover, many choose not to drive at night or in heavy traffic, situations where accident rates are high. In situations that require greater attention, better vision and faster response, however, the older driver is working at a disadvantage.

**References**

[1]e .g., Hakamies-Blomqvist, L., Raitanen, T., & O'Neill, D. (2002) Driver ageing does not cause higher accident rates per km., *Transportation Research Part F: Traffic Psychology and Behaviour*, 5, pp. 271-274.

[2]Green, M. (2001). Lies, Damned Lies and . . . Controls, *Risk Management*, pp. 8-9, November.