Human Factors for Safety

Human Factors

- Physical
- Sensory and perception
- Cognitive (decision making)

Importance of Human Factors

- Human factors are involved in 85% of crashes
- Human factors are impeded by aging processes - diseases

Elderly Involvement in Crashes

- Elderly drivers over-involved in fatal accidents for mileage driven
- More elderly pedestrians per 100,000 population killed
- Older driver fatalities increased by 27% from 1991 to 2001

Physical

- Reaction Time
  - Movement Time after initiation of movement
    - Changes in muscle mass and elasticity
    - Joint strength- arthritis
- Strength
- Flexibility and ROM
- Head and Neck mobility
- Agility (new concept)

Strength

- Decrease in muscle tone
- But no research to show direct impact on driving
  - braking

Movement

- Older people often suffer from muscle and joint stiffness
- Makes it difficult to turn head and body
- Consequently, motor component of reaction time slows with increasing age

Agility

(World Health Organization classification)

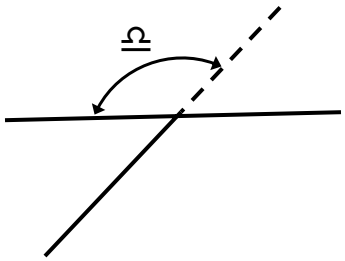
- Dexterity in the use of limbs
- Impact on use of controls
- Size of controls

Flexibility and ROM

- Decline in over all flexibility with age
- Increase in osteoarthritis-joint problems
- Can impact:
  - Entering and exiting vehicle
  - Backing up, parking, turning-etc
  - Lane Changing
- Decrease in Physical Fitness

Head and Neck Mobility

- Vehicle Operations
  - Scanning, mirror use
  - Problems with merging
  - Problems with Blind Spots
  - Skewed Intersections particularly a problem



Driver Fragility

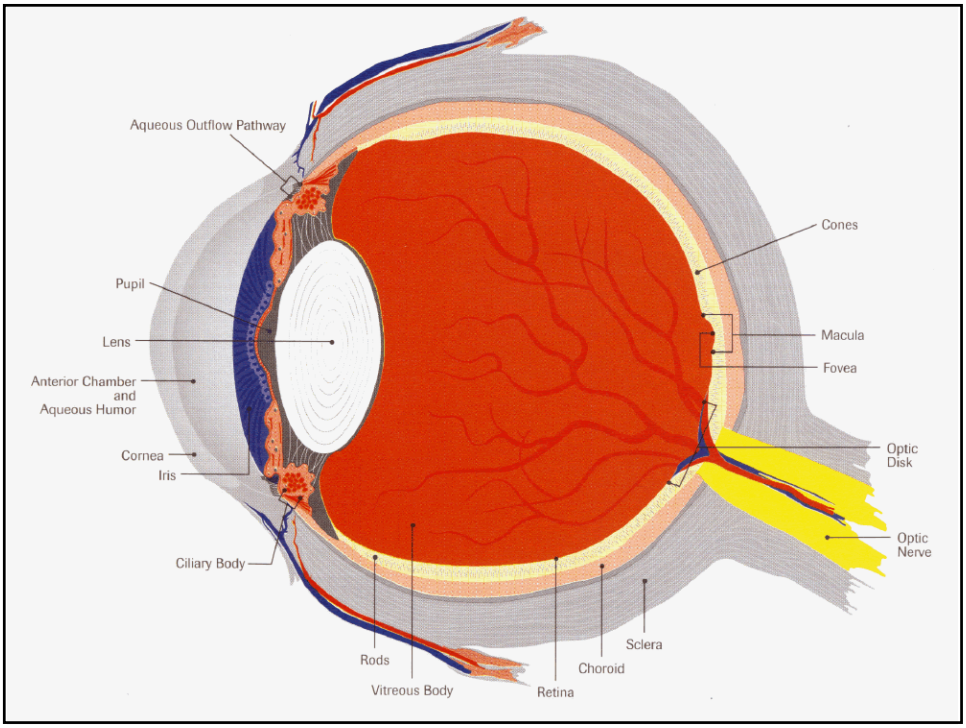
- Fragility increases beginning at 60-64 yrs.
- By age 80, elderly more likely than 20 yr. To die from injuries sustained in a crash:
  - 4 times – male
  - 3.1 times - female

Vision

- Primary external stimuli
- 90% of driver information is visual
- Required visual acuity
  - Static and dynamic
- Major problem for elderly drivers

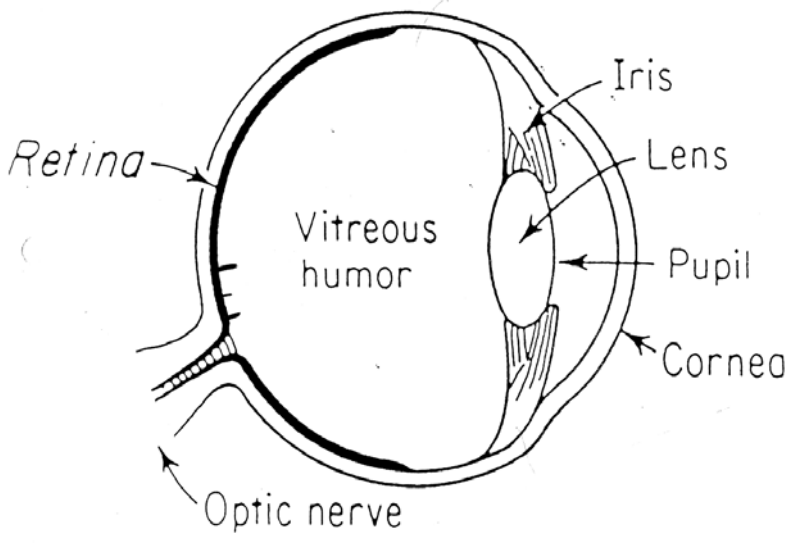
Vision

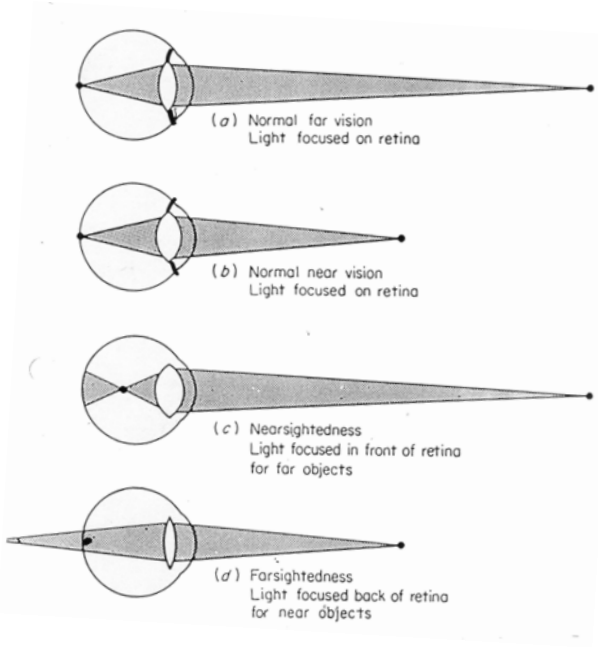
- Visual acuity standards must be met for licensing
  - 20:60 in Oregon
- Quality of vision deteriorates away from focal point
  - 3-5° cone, excellent vision
  - 10° cone, clear vision
  - 20° cone, satisfactory vision
    - MUTCD standard for important control devices
  - Beyond, increasingly blurred



Sensory Perceptual

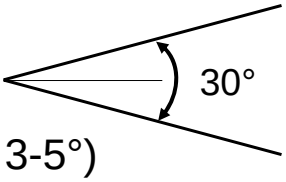
- Changing Eye Physiology
  - Requirements for increased lighting
  - Due to decrease in pupillary diameter
  - Optic media – more scattering of light
  - Changes in lenses





Foveal Vision

- Most acute vision central angle of 30^{o}
- Cones: color vision center of retina
- Rods: motion detection outer part of retina
  (Peripheral vision up to about 170^{o})



(actually 3-5°)

Terminology-Vision

- Acuity
  - Static
  - Dynamic
- Light Sensitivity
  - Glare recovery

Age Related Changes in Lenses

- Increase absorption of “blue” light
- Increase in thickness of lens
- Problems of muscles that adjust shape of lens
  - Difficulty in accommodation
  - Loss of visual acuity
  - Increased use of bi-focals

Age Related Changes in Lenses

- Dynamic Visual Acuity
  - Ability to see moving objects
  - Scanning
  - Most relevant to driving, but not measured

Visual Acuity

- Fewer receptor cells on retina with age results in:
  - Resolution of fine details is coarser
  - Solved by greater size and contrast of important details, and increased illumination
    - Use of large print media

Visual Acuity

- Younger drivers – average 20 / 20
- Older drivers – average 20 / 60

Visual Acuity

- Near age 70, progressive loss in ability to focus on near objects
  - Due to loss in lens elasticity
- Speed eye changes focus at various distances decreases
  - Problem: viewing dashboard to road scene
- Drivers typically become more long-sighted with age

Source: Corso, J.F. (1981) *Aging Sensory Systems and Perception*. Praeger: New York.

Elderly Static Visual Acuity

- Visual Acuity
  - Relatively constant to 50 yrs.
  - Declines progressively faster with age

Source: Pitts, D.G., Aging and Human Visual Function, 1982 Liss: N.Y.

Elderly Static Visual Acuity

- Normal physiological changes causes:
  - Greater sensitivity to glare
  - Reduction in contrast sensitivity
- Diseases that reduce acuity:
  - Cataracts
  - Macular Degeneration
  - Glaucoma

Eye Movement

- Drivers shift their eyes to see full visual field
- Eye movement time
  - Eye shift, 0.15 – 0.33 sec
  - Eye fix/focus, 0.1 – 0.3 sec
- Elderly takes longer to
  - Shift eyes and focus
  - Recover from glare

Dynamic Visual Acuity

- Acuteness of vision for an object with angular movement or ability to see a moving target detail
- Performance improves with illumination
- Unrelated to static acuity

Dynamic Visual Acuity

- Acuity of moving target:
  - Decreases with increasing target velocity
  - Improves with increased exposure time
  - Is better when target is “foveal” on central rather than peripheral
  - Varies for drivers with the same static acuity

Source: Burg, A., Journal of Applied Psychology, 50, 1966.

Dynamic Visual Acuity

- Of visual factors, dynamic acuity relates strongest to driving record
- Regular deterioration in dynamic visual acuity with advancing age
- Dynamic visual acuity is strongly related to accident involvement regardless of age

Source: Burg, A., Journal of Applied Psychology, 50, 1966.

Glare

- Brightness in the field of vision that is substantially greater than luminance eyes are adapted
- Glare recovery
  - 15 year old person – 2 sec
  - 65 year old person – 9 sec

Light Sensitivity

- Contrast sensitivity function
  - Better predictor than visual acuity of ability to see
  - Problems with small objects
  - Need high levels of contrast
- Increased time to adjust to dark
  - Problems with tunnels and shadows
- Ability to see contrast begins to diminish in 40s

Glare Sensitivity and Recovery

- Light to dark : ~6 sec to full visual acuity
- Dark to Light : ~3 sec to full visual acuity
  - Due to increased lens opacity
  - Problem for people with cataracts
  - Problem with on-coming headlights
  - Glare recovery time increases with age

Glare Sensitivity and Recovery

- Due to increase opacity of lens
- Problem for people with cataracts
- Problems with on coming headlights
- Glare recovery time increases with age

Contrast Sensitivity

- Ability of an individual to process contrast information
- Provides driver's ability to see patterns in the environment
- In general, older adults have decreased contrast sensitivity

Visual Acuity in Poor Light

- Minimum amount of light needed to see, increases with age
- For every decade over 25, twice as much brightness at night is needed
- By age 75, drivers need 32 times the brightness of 25 yrs.

Dark Adapted Vision

- Minimum energy needed to elicit a sensory response after a period in dark
- Threshold for dark adapted vision increases with age (i.e., light sensitivity decreases)
- Increases over 4% per year between 22 and 43 yrs

Night Time Myopia

- Perhaps most important problem
- Affects large proportion of drivers over 40 years
- Also especially a problem for short sighted drivers of all ages

Night Time Myopia

- Many drivers with this problem avoid driving at night
- Elderly drivers most reported difficulty at night is:
  1) Seeing the road
  2) Glare
- Possible improvements:
  - Fog stripes and more street lighting

Source: AA Foundation for Road Safety

Vision in Poor Light

- Viewing a target 20/200 in poor light of 0.20 cd/m^2 resulted in:

Age group	18-25	60-64	65-69	70-74	75-79	80-87
% failing to see 20/200 target	1.7	23.1	48.3	57.1	70	75

Source: Sturr, et.al., Human Factors, 32

Depth Perception

- Primarily provided by environmental cues for driving
- Ability to judge depth decreases with age
- Requires two eyes
- Impact of dark environments

Peripheral Vision

- Useful field of View (UFOV)
  - Measure of spatial area and usually much smaller than visual field size
  - Involves binocular vision
    - Detection, localization and identification of targets

Peripheral Vision

- Visual field shrinks as people age
- Little decrease in visual field before 55
- Shrinkage is dramatic after 65-70

Peripheral Vision

- Shape and movement detected outside 65-90° (from line of sight)
- Less peripheral vision as speed increases
  - 37° at 40 mph
  - 29° at 50 mph
  - 20° at 60 mph

Aging Characteristics in UFOV *(Usable Field of Vision)*

- Reduced speed of visual processing
- Reduced ability to divide attention
- Reduced ability to discriminate against a background

Visual Localization

- Older drivers have difficulty in identifying a target among distractions
- Changes of vision and cognition make it difficult for elderly drivers to detect moving or stationary objects in the periphery

Detection and Tracking of Moving Objects

- Driver in 60's and 70's lag farther behind targets
- Elderly less able to detect movement and changes of vehicles in visual field
- Also difficulties of understanding behavior of vehicles in front: stopping, slowing, speeding up and reversing

Eye Movements Slow

- Eye muscles commonly atrophy with increasing age
- Elderly less able to raise their eyes
- Much slower to make eye movement to fixate object

Diseases

- Cataracts: Opacity of eye
- Glaucoma: high pressure within eyeball
  - Prevents cataract surgery
- Macular degeneration
  - Impaired central vision

Perception-Reaction Time

PIEV Process – Reaction to external stimuli

- Perception – time to see
- Intellection – time to understand
- Emotion – time to decide
- Volition – time to execute

Perception-Reaction Time

- Range from 0.5 – 5.0 sec for a simple event
- Minimum 0.5 PRT for emergency event
- Added conflicts and complexity increase PRT, depending on amount of data

Control Perception-Reaction Time

- PRT for traffic signal control is assumed = 1.0 sec
- Recent research shows
  - Alerted PRT for control ~ 0.9 sec
  - Unalerted PRT for control ~ 1.3 sec

Design Perception-Reaction Time

- Assumed to be 2.5 sec
- Based on 85% PRT
- Recent research shows
  - 95% of PRT = 2.5 sec
  - 85% of PRT = 2.0 sec

Decision Perception-Reaction Time

- PRT for complex conditions with numerous conflicts
  - AASHTO decision PRTs range from 3 – 14.5 sec
  - Each additional conflict adds increment of time, ~ 1.5 sec

Elderly Driver's PRT

PRT times for elderly drivers are slower

	Average	Elderly
Stopping Sight Distance (Design = 2.5^s)	2.5^s	4.95-5.95^s
Traffic Control (Control = 1.0^s)	0.82	0.98-1.61^s
Crossing Road from Stopped Position	2.99^s	3.31-4.56^s
Left-Turn thru Traffic (Design = 2.0^s)	2.24^s	2.56-3.81^s

Attention

- Problems with attention switching abilities problems
- Dementia
  - Problems getting lost
  - Following directions
  - Stopping for directions
  - Failure to yield

Complex Situations

- Elderly drivers take about 1.5 sec to scan each item

Prescribed Drug Effect

- Reliable evidence that prescribed drugs increase risk of crashes, especially for elderly drivers
- For elderly, many drugs have higher active level of drugs for longer
- Central nervous system effects increase with age

Cognitive Functions

- Important factors in aging cognition
  - Variability of performance increases with age
  - Speed of processing information decreases with age
  - Therefore, amount of processing is reduced

Difficulty Judging Gaps

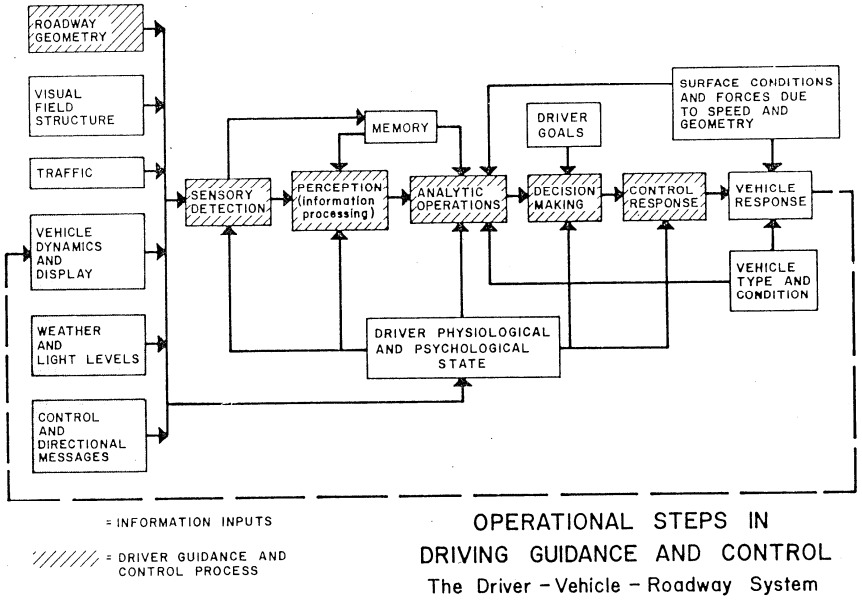
- Older drivers tend to accept a gap to cross based on spacing distances, regardless of speed
- Older drivers' poor distance/speed perception and judgment may account for right-of-way accidents, such as improper left-turns

Stability Sensations

- Drivers react to
  - Curves
    - Limited by tangential accelerations or friction
  - Rough roads
    - Rough surface texture, RPMs for rumble strips
  - Cross slope / superelevation
    - Reduced or negative superelevation increases side friction and accelerations

Modifying Factors

- Fatigue
  - Reduces alertness and slows reactions
- Alcohol and Drugs, affects
  - Alertness
  - Judgment
  - Self control
  - Physical coordination
- Weather
  - Gives unexpected vehicle/pavement response
  - Limits visibility



Conditional Response

- Driver responses are dictated by habit, standardized design, and control
- Drivers attempt to maintain speeds

Drivers Scan and Sift Data

- Driver scans, samples and selects from available information to guide driving
- Complex situations and numerous conflicts;
  - Increase the workload
  - May not give adequate time to select and judge conditions
  - Are difficult for elderly drivers

Divided Attention

- Brake reaction time slowed 0.5 sec. for young drivers, for using cell phone
- Older drivers not tested. Likely elderly are already using their compensatory capacity to cope with other declines

ITS

- In vehicle devices:
  - Navigation
  - Audio
  - Cell phones
- European Trends
- Japan

Primary Concept

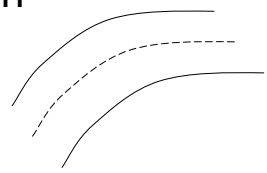
- Driver must sift through all information and determine relative importance
  - Control – driver/vehicle interaction most important
  - Guidance – path selection, next in importance
  - Navigation – route selection, least important
- Elderly drivers have difficulty assessing and shifting importance

Expectancy

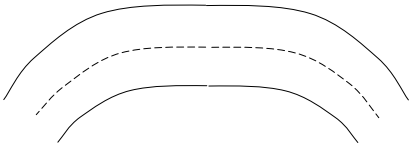
- A driver is led to expect a given design/control condition due to the information presented
  - Formal information – roadway alignment, centerline stripes, regulatory signs, etc.
  - Informal information – brushlines, tree lines, fences, roadside barriers, etc.

Example of Expectancy

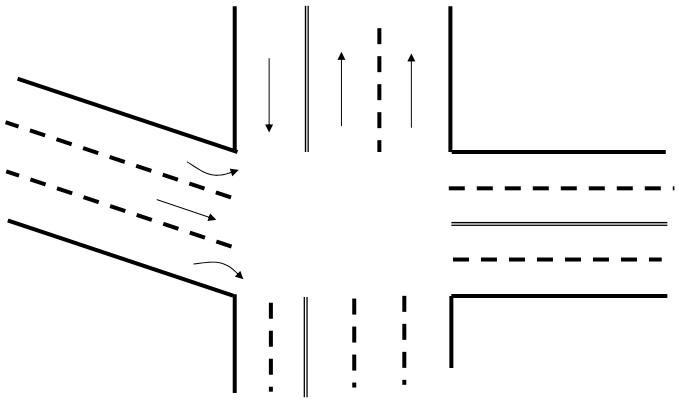
Curvature in one direction



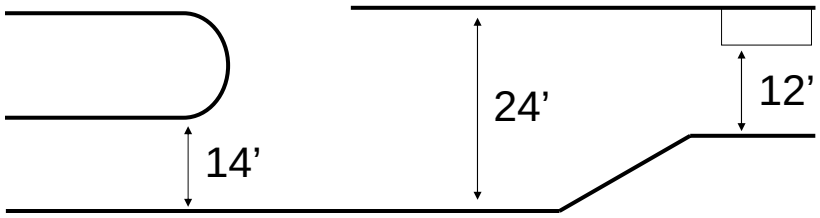
Next curve, opposite direction; NOT



Example: Intersection Lanes Should Line Up



Example: Driver Assumes Two Lanes are Presented



Future Implications

- Presently, 85% crashes involve human factors
- Elderly drivers are over-involved in fatal crashes and pedestrian fatalities
- Older segment of population is growing twice the rate of the rest of the population
- Traffic volumes and travel are increasing, adding complexity and conflicts to present day conditions

Road Signs

- Difference between Text and Symbols
  - Better performance for distance
  - Interpretation of symbols may be a problem
    - Cultural Context
    -