Human Factors in Traffic Safety

Fall 2021
Important Resources


Human-Environment-Vehicle System

Provide a conceptual framework to analyze motor vehicle collisions.

Example: A 20-year old man with little driving experience, is taking an unfamiliar road on his way to an interview. His vehicle is not properly maintained. In fact, the tires are in poor shape. At some point on the trip, the rain starts to fall. Shortly thereafter he enters a horizontal curve with a radius below minimum standards, loses control of the vehicle and run off the road into a tree located within a few feet of the traveled way.

Question: What are the contributing factors that have lead to this crash?
# Human-Environment-Vehicle System

<table>
<thead>
<tr>
<th>System Component</th>
<th>Event</th>
<th>Circumstance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human</td>
<td>Trip</td>
<td>Young, inexperienced, stressed</td>
</tr>
<tr>
<td>Vehicle</td>
<td>Choice of vehicle</td>
<td>Tires in poor condition</td>
</tr>
<tr>
<td>Environment</td>
<td>Rain</td>
<td>Wet and slippery surface</td>
</tr>
<tr>
<td>Environment</td>
<td>Curve</td>
<td>Below standard</td>
</tr>
<tr>
<td>Human</td>
<td>Steering maneuver</td>
<td>Oversteering</td>
</tr>
<tr>
<td>Human</td>
<td>Loss of control</td>
<td>Unstabilized shoulder</td>
</tr>
<tr>
<td>Environment</td>
<td>Roadside conditions</td>
<td>Tree too close traveled way</td>
</tr>
<tr>
<td>Outcome</td>
<td>Impact (crash)</td>
<td></td>
</tr>
</tbody>
</table>
# Crash Contributing Factors

<table>
<thead>
<tr>
<th>Crash causation</th>
<th>Percentage (standard error)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drivers</td>
<td>94% (2.2%)</td>
</tr>
<tr>
<td>Vehicles</td>
<td>2% (0.7%)</td>
</tr>
<tr>
<td>Roadways</td>
<td>2% (1.3%)</td>
</tr>
<tr>
<td>Unknown</td>
<td>2% (1.4%)</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
</tr>
</tbody>
</table>
Crash Contributing Factors

FIGURE 2.1  Pre-crash causation factors for roadways, drivers, and vehicles (Rumar, 1985).

http://cyberlaw.stanford.edu/blog/2013/12/human-error-cause-vehicle-crashes
William H. Haddon, Jr., came up with a Matrix to systematically analyze car crashes in a 1972 paper.
Using the Haddon Matrix

<table>
<thead>
<tr>
<th>Event</th>
<th>Driver</th>
<th>Vehicle</th>
<th>Roadway</th>
<th>Social environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precrash</td>
<td>Poor vision, speeding</td>
<td>Failed brakes, worn out tire</td>
<td>Poorly timed traffic lights</td>
<td>Speeding culture, red light running</td>
</tr>
<tr>
<td>Crash</td>
<td>Failure to use seatbelt</td>
<td>Air bag failure</td>
<td>Poorly designed brake-away pole</td>
<td>Lack of vehicle regulations</td>
</tr>
<tr>
<td>Postcrash</td>
<td>Age (to sustain injury), alcohol</td>
<td>Poorly design fuel tank</td>
<td>Poor emergency communication</td>
<td>Lack of support for EMS trauma systems</td>
</tr>
</tbody>
</table>
Myth: “accident prone” individuals
Safe and successful operation is influenced by factors: physical, psychological and cognitive.
“Spare mental capacity”
Human errors: rule based, knowledge base, and skill based
Drivers capable of adapting to driving situations: strategic, tactical and operational
System Elements: The Vehicle

- Design of the vehicle: seats, easy ingress and egress, essential controls within reach
- Vehicle is dynamic device (must be in accordance to driver expectancy)
- Uniformity in operation of controls and displays (not always uniform from one vehicle to the next)
System Elements: The Road

- Uniformity for highway design and traffic control devices
- Provide proper navigational information
- System still not fully adequate
- Research still on-going for understanding the relationship between road design (geometric, control devices, etc.) and safety. Some relationships are better understood than others.
Perception and Information Processing
Perception

- Stimulus applied to any sense organs
- For motor vehicles: visual is the most important (also smell, auditory, tactile)
- Some important elements for driving task: color, contrast sensitivity, eye movement depth perception, static visual acuity, etc.
Fields of View

Peripheral vision

60° Visual Cone

Eye

10° Detection
Judgment of Spacing
Driver Perception and Response Time
Stages of Perception-Response Time

- Detection
- Identification
- Decision
- Response
## Deduced Perception-Response Time

### Table 3.2
Results of an Effort to Deduce Driver Perception-Response Time, Based on Summation of Assumed Components Taken from the Research Literature

<table>
<thead>
<tr>
<th>Element</th>
<th>Percentile of Drivers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>50</td>
</tr>
<tr>
<td>1. Perception</td>
<td></td>
</tr>
<tr>
<td>a. Latency</td>
<td>0.24</td>
</tr>
<tr>
<td>b. Eye Movement</td>
<td>0.09</td>
</tr>
<tr>
<td>c. Fixation</td>
<td>0.20</td>
</tr>
<tr>
<td>d. Recognition</td>
<td>0.40</td>
</tr>
<tr>
<td>2. Decision</td>
<td>0.50</td>
</tr>
<tr>
<td>3. Brake Reaction</td>
<td>0.85</td>
</tr>
<tr>
<td>Total A (1a–d+2+3)</td>
<td>2.3</td>
</tr>
<tr>
<td>Total B (1c–d+2+3)</td>
<td>2.0</td>
</tr>
<tr>
<td>Total C (1a–d+3)</td>
<td>1.8</td>
</tr>
</tbody>
</table>

[Source: McGee et al. (1983)]
Factors Affecting PRT

- **Detection**
  - Object conspicuity
  - Amount of information being processed by the driver

- **Identification**
  - Poor visibility: nighttime and fog
  - Speed and trajectory of the potential hazard
Factors Affecting PRT

- **Decision**
  - Choice: steering, braking (& accelerating?)
  - Choice may sometimes be more complex

- **Response**
  - Usually minor component of PRT
  - Time allocated for foot leaving the accelerator and hitting the brake pedal
Factors Affecting PRT

- Driver Expectancy
  - Predisposition on the part of drivers that something will happen or be configured in a certain way
  - Violation of expectancy will lead to longer PRT

- Night versus Day
  - Many situations have the same PRT (see next figure)
  - Detection may play a role in the difference
# Night versus Day PRT

Table 3.5

Median and 85th Percentile Perception-Response Time by Age, Situation Type and Day/Night Condition

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Freeway PRT in Seconds</th>
<th>Arterial PRT in Seconds</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>50th 85th 50th 85th</td>
<td>50th 85th 50th 85th</td>
</tr>
<tr>
<td></td>
<td>Day Night Day Night</td>
<td>Day Night Day Night</td>
</tr>
<tr>
<td>20–40</td>
<td>2.9 3.8 7.8 7.1</td>
<td>2.0 2.8 4.2 5.2</td>
</tr>
<tr>
<td>65–69</td>
<td>3.9 3.8 7.6 6.7</td>
<td>2.8 2.4 7.6 4.9</td>
</tr>
<tr>
<td>70+</td>
<td>4.2 4.0 7.8 7.0</td>
<td>3.4 2.8 7.1 5.6</td>
</tr>
</tbody>
</table>
Factors Affecting PRT

- **Driver Fatigue**
  - Difficult to measure, but increase in driver fatigue will increase PRT

- **Age and Gender**
  - PRT increases with age (0.44 sec for 20 years to 0.52 for 70 years of age)
  - Female drivers have longer PRT than male drivers
Looking Behavior
Changing Lanes at Intersections

Figure 4.2
Location of Eye Fixations

Read all signs

Read only important signs

Did not read any signs
Eye Fixation for Car Radios

Figure 4.3

\[ \bar{x} = 1.44 \]
\[ s = .5 \]
\[ N = 1250 \]
Eye Fixation by Daylight Conditions

Mean Fixation Duration (seconds) as a Function of Light Level

<table>
<thead>
<tr>
<th>Road geometry</th>
<th>Day</th>
<th>Night</th>
</tr>
</thead>
<tbody>
<tr>
<td>left curve</td>
<td>0.43</td>
<td>1.05</td>
</tr>
<tr>
<td>straight</td>
<td>1.93</td>
<td>1.18</td>
</tr>
<tr>
<td>right curve</td>
<td>0.47</td>
<td>1.35</td>
</tr>
</tbody>
</table>
Driver Performance
Acquisition of Driving Skills

- Cognitive Phase
- Associative Phase
- Autonomous Phase
Eye Fixations of Novice Drivers

First few hours

One month

Three months
Individual Differences

- Personality
  - Relationship between personality and crashes is weak (i.e., personality changes with time, confounding variables)
  - Some personality trait causing fatigue may lead to higher risk of crashes

- Emotions
  - Emotional disturbances affect all aspect of our life, including driving
  - Higher heart rate and blood pressure associated with increase traffic flow
Individual Differences

- Stress
  - Stress can be caused by emotional (e.g., divorce), cognitive (e.g., cut-off), and physiological (e.g., sick).
  - Leads to aggression, confusion and risky behavior

- Motivation
  - Car ownership important to people
  - Motivational elements: travel for necessity, social status, freedom, self-expression
  - Faulty motivation may lead to higher risk behavior
  - Marketing of motor vehicles
Individual Differences

- Risk Taking Behavior
  - Objective versus subjective risk
  - Sensation seeking (SS) individuals: relationship not established SS and risky driving
  - Risk homeostasis theory

- Social Factors
  - Drivers are influenced by other drivers “culture of driving”
  - Drivers are also influenced by passengers (family members versus teenagers)
# Male and Female Drivers

<table>
<thead>
<tr>
<th>Males more likely</th>
<th>Females more likely</th>
</tr>
</thead>
<tbody>
<tr>
<td>alcohol used within 12 hours before the accident (3:1)</td>
<td>drugs/medication present (2:1)*</td>
</tr>
<tr>
<td>lack of attention/alertness</td>
<td>distraction</td>
</tr>
<tr>
<td>had 1 or more “impairment features” out of 5**</td>
<td>look but failed to see (2:1)</td>
</tr>
<tr>
<td>had a previous accident</td>
<td>failed to look</td>
</tr>
<tr>
<td>had a previous driving offence</td>
<td>lack skill</td>
</tr>
<tr>
<td>drove too fast</td>
<td>lack of care</td>
</tr>
<tr>
<td>more often impaired** (2:1)</td>
<td>inexperience</td>
</tr>
<tr>
<td>more perceptual errors if over age 65</td>
<td>more difficulty merging right into major road</td>
</tr>
<tr>
<td>more often at fault in right turn, overtaking and head-on accidents</td>
<td>more often at fault turning right and at T intersections</td>
</tr>
<tr>
<td>more accidents on curves</td>
<td>more accidents in daylight</td>
</tr>
</tbody>
</table>

* Where ratios are indicated, the differences were that much greater for that sex.

** Impairments include: alcohol, fatigue, drugs, illness, emotional distress.
Male and Female Drivers

Severe crash involvements per million population
- Males
- Females

Arrests per thousand population
- Males
- Females