Human Factors in Traffic Engineering

CEE 6603 – Traffic Engineering Final Presentation

Ali Etezady
Daejin Kim

April 20, 2016
Introduction

• What is “Human Factors Engineering”
  • Science that applies knowledge from psychology, physiology, and kinesiology to the design of devices and systems for safe and effective human use
  • Many applications across the diverse fields of science such as biomedical engineering, industrial engineering, mechanical engineering, etc.

• Human Factors in Transportation engineering
  • Human physical, perceptual, and cognitive limitations → Potential causes of crashes
  • Highway design and design of vehicles
Literature review

- There are numerous studies in literature on the application of human factors principles in traffic engineering
- Intersections
  - Bellomo-McGee (2003): evaluating Intersection Collision Avoidance System concepts aimed at reducing the number of high-crash intersections. Human factors important to the selection and design of infrastructure-based technology were identified as driver age, vehicle gap acceptance, and response to emergency events.
  - Bonneson and McCoy (1994): driver understanding of protected and permitted left-turn signal displays. The results showed that only 70 percent of respondents correctly understood the meaning of Protected and Permitted Left Turn (PPLT) signs, and this understanding increased among the more educated, and decreased among the more experienced and older drivers.
  - Gattis and Low (1997): intersection angle and drivers’ field of view. The results indicated that a minimum intersection angle of 70 to 75 degrees will provide for an improved line of sight and consequently decrease the probability of crashes.
Literature review

• Speed management
  • Feng (2001): presented an overview of the research on the relationship between speed and safety. The studies show that drivers may not always accurately rate their driving behavior, so relying on subjective surveys may not be wise. In addition, weather has a close relationship with speed and safety because it affects visibility, stability, and controllability of drivers and cars.

• Pedestrian and bicyclists
  • Nabors et al (2012): the behavior and movement patterns of both cyclists and pedestrians are important predictors in the occurrence of crashes and should further be investigated.
  • DaSilva et al. (2003) showed the effect of age and time of day on the frequency of pedestrian crashes. Children and teenagers tend to have more accidents and more accidents occur at night time when visibility is limited.

• Visibility
  • Barker et al. (1998) conducted a study on improving the conspicuity of trailblazing signs for incident management. Their results indicated that using a color combination other than the traditional one will improve driver performance and safety.
  • Lewin et al. (2003) investigated the use of three different light sources for roadway lighting. The result showed the interrelationship between lamp spectrum, visibility, and safety.
Case Study

- Relevant research done by US government such as NHTSA,
- and some private automobile companies
- Traffic safety, human’s comfort, and productiveness of human users and operators
- Traffic accidents are mainly related to visibility and unsafe behaviors

<table>
<thead>
<tr>
<th>Program areas</th>
<th>Subcategory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety Problem Identification</td>
<td>Early adopters of technology studies</td>
</tr>
<tr>
<td></td>
<td>Naturalistic driving studies</td>
</tr>
<tr>
<td></td>
<td>Metric development</td>
</tr>
<tr>
<td>Visibility and Lighting</td>
<td>Headlighting</td>
</tr>
<tr>
<td></td>
<td>Rear signaling</td>
</tr>
<tr>
<td></td>
<td>Vehicle conspicuity</td>
</tr>
<tr>
<td></td>
<td>Visibility</td>
</tr>
<tr>
<td>Driver Assistance</td>
<td>Warning systems (Forward collision, Lane departure, Intersection violation warning)</td>
</tr>
<tr>
<td></td>
<td>Other driver assistance (ACC, Parking aids)</td>
</tr>
<tr>
<td>Reducing Unsafe Behaviors</td>
<td>Alcohol impairment</td>
</tr>
<tr>
<td></td>
<td>Distraction</td>
</tr>
<tr>
<td></td>
<td>Teen drivers</td>
</tr>
<tr>
<td></td>
<td>Seatbelt and child seat use</td>
</tr>
<tr>
<td></td>
<td>Encouraging Fuel Efficient Driving</td>
</tr>
</tbody>
</table>

Case Study (Visibility and Lighting)

- **Headlighting**
  - Public complaints about headlamp glare
  - Increased risks: two-lane highways and over the age of 50 (NHTSA 2001)
  - Also, glare increases discomfort for drivers

- **Rear signaling**
  - Rear-end crashes account for more than 29 percent of all crashes (NHTSA 2007)
  - Due to a failure to respond (or delays in responding) to stopped or decelerating lead vehicles
  - NHTSA (2010) tested enhanced break lights, and it shows to somewhat increase drivers’ detection rates

Enhanced break light invented by NHTSA
Case Study (Visibility and Lighting)

- **Daytime Running Lights (DRL)**
  - Arguments that high-intensity DRLs create problems with glare and turn signal masking and conspicuity of motorcycles
  - Motorcycle rider fatalities increased from 2294 to 5290 between 1998 to 2008 (NHTSA 2010)
  - NHTSA suggests enhancing the frontal conspicuity of motorcycles with lighting treatments

- **Backover crashes**
  - Due to vehicle blind zones, drivers’ inadequate visual scanning behavior, and drivers’ expectation that no obstacles are present behind the vehicle
  - The victims are frequently young children
  - Rearview video systems were invented to help drivers to widen the rear visibility


Case Study (Unsafe Behaviors)

- Alcohol Impairment
  - 16,694 alcohol-related fatalities in 2004 which is equal to one alcohol-related fatality every 31 minutes and representing 39% of the total traffic fatalities for the year (NHTSA 2004)
  - Distinguished by their severity, overrepresentation of recidivist offenders and certain age groups, and a disproportionate occurrence at certain times of day
  - Table shows alcohol-related crashes are more likely to result in loss of life and to involve single vehicles
    ✓ Breath-alcohol ignition interlock device (BAIID)
    ✓ Solid-state breath alcohol monitors
    ✓ NHTSA is also considering new technologies to detect alcohol vapor

<table>
<thead>
<tr>
<th>Alcohol-Related</th>
<th>Alcohol-Related</th>
<th>Alcohol-Related</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Single Vehicle</td>
<td>Multiple Vehicle</td>
</tr>
<tr>
<td>Number</td>
<td>Percent</td>
<td>Number</td>
</tr>
<tr>
<td>Fatal Crashes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10,307</td>
<td>47</td>
<td>4,661</td>
</tr>
<tr>
<td>Injury Crashes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>92,000</td>
<td>16</td>
<td>76,000</td>
</tr>
<tr>
<td>Property Damage Only</td>
<td></td>
<td></td>
</tr>
<tr>
<td>138,000</td>
<td>11</td>
<td>110,000</td>
</tr>
</tbody>
</table>

Case Study (Unsafe Behaviors)

• Distraction
  • Defined as “drivers divert their attention away from the driving task to focus on another activity instead”
  • Main causes: electronic distractions, such as navigation systems and cell phones, or more conventional distractions such as interacting with passengers and eating
  • Table shows the relative risk of crashes
    ✓ The most influential factor is reaching for a moving object
    ✓ Looking at external object, reading, applying makeup, dialing hand-held device, and passenger in adjacent seat are significant factors

<table>
<thead>
<tr>
<th>Type of Secondary Task</th>
<th>Odds Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reaching for a moving object</td>
<td>8.82</td>
</tr>
<tr>
<td>Insect in vehicle</td>
<td>6.37</td>
</tr>
<tr>
<td>Looking at external object</td>
<td>3.70</td>
</tr>
<tr>
<td>Reading</td>
<td>3.38</td>
</tr>
<tr>
<td>Applying makeup</td>
<td>3.13</td>
</tr>
<tr>
<td>Dialing hand-held device</td>
<td>2.79</td>
</tr>
<tr>
<td>Inserting/retrieving CD</td>
<td>2.25</td>
</tr>
<tr>
<td>Eating</td>
<td>1.57</td>
</tr>
<tr>
<td>Reaching for non-moving object</td>
<td>1.38</td>
</tr>
<tr>
<td>Talking/listing to a hand-held device</td>
<td>1.29</td>
</tr>
<tr>
<td>Drinking from open container</td>
<td>1.03</td>
</tr>
<tr>
<td>Other personal hygiene</td>
<td>0.70</td>
</tr>
<tr>
<td>Adjusting the radio</td>
<td>0.50</td>
</tr>
<tr>
<td>Passenger in adjacent seat</td>
<td>0.50</td>
</tr>
<tr>
<td>Passenger in rear seat</td>
<td>0.39</td>
</tr>
<tr>
<td>Child in rear seat</td>
<td>0.33</td>
</tr>
</tbody>
</table>

Note: Statistically significant results are colored red
Klauer et al., 2006
Case Study (Unsafe Behaviors)

- **Teen Drivers**
  - Novice teen drivers have exceptionally high rates of crash involvement (NHTSA 2010). In 2006, 5,658 young drivers between the ages of 16 and 20 were killed in traffic crashes, and an additional 410,000 were injured (NHTSA, 2007)
  - Traditional measurements: driver training, graduated licensing, enforcement, and safety education
  - NHTSA is exploring new approach using advanced in-vehicle technologies to monitor novice teen driver’s behavior
    - Vehicle Adaptations: Automatically prohibiting behaviors detected, e.g., safety belt interlocks;
    - In-Vehicle Feedback: Providing drivers with real time information, e.g., speeding in curves;
    - Reporting: Recording behaviors to transmit them at a later time to parents, insurance companies, driver educators, etc.

- **Drowsy Driving**
  - Drowsy driving is a significant contributor to death and injury crashes, accounting for more than 80,000 crashes and 850 fatalities per year (NHTSA 2014)
  - Successful detection of drowsiness is a crucial step
  - NHTSA’s research showed the feasibility of detecting drowsiness with vehicle-based sensors
Case Study (Human factors in connected vehicle)

- **Crash Warning Interfaces**
  - The human factors issues concern how to integrate and display all of the information a driver may want or need in a manner that is safe and usable.
  - The challenges are that the CV concept may provide drivers with a large number of safety messages, many sorts of non-safety information, and a variety of different design and display concepts implemented by various manufacturers and developers.

Conclusion and Future research

- Human factors are widely used in developing vehicle equipment, transportation facilities and relevant regulations to enhance traffic safety and drivers’ comfort.

- The early stage of human factor engineering in the transportation field focused on physical abilities (e.g. visualization ability) and unsafe behaviors of human.

- Nowadays, the human factors engineering in the transportation field has broadened its research area with the advent of new technologies such as connected vehicle program.

- To sum up, this research recommends that engineers and researchers better understand the impact of human factors on a variety of traffic situations.

- Also, engineers need to understand that many traffic situations are not only affected by one specific human factor, but also by a combination of several human factors.
QUESTIONS?
17. NHTSA (2014) Assessing the Feasibility of Vehicle-based Sensors to Detect Drowsy Driving

Resources