Rural Intersection Collision Warning System (RICWS) Evaluation and Design Investigation

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Outline

• Background
• Rural Intersection Collision Warning System (RICWS)
• Primary Human Factors Concerns
• Project Goals
• Usability Test Results
• Driving Simulator Study
• Preliminary Findings
Background

- 55% of rural thru-STOP intersections in Minnesota has had at least one crash (Preston & Storm, 2003).
- Drivers’ failure to select sufficient gaps has been identified to be a major contributing factor for crashes at thru-STOP intersections.
- More than 50 RICWS signs have been deployed across the state of Minnesota to aid motorists to safely cross these intersections.
RICWS System

Primary Concerns

• Primary concerns:
  – Complaints reported from local road users
  – Potential road user confusion about signs
    • Ordering of message components
    • Saliency of “Traffic Approaching” component
    • Sign status
  – Overreliance on the sign
    • Behavioral Adaptation to Sign

Sign State 1

Sign State 2

Sign State 3
Project Goals

• Use iterative design modifications and usability tests to:
  – Identify critical human factors issues associated with the original RICWS sign and develop alternative design options
  – Evaluate the effectiveness of each sign’s ability to convey information for traffic approaching, sign-on, and sign-off states
  – Understand driver’s cognitive processes and decision making regarding each sign
  – Evaluate the clarity and appropriateness of terminology and other design elements

• Determine the most appropriate design that:
  – Best captures driver’s visual attention
  – Promotes sign acceptance
  – Promotes safe gap acceptance at rural thru-STOP intersections
Usability Testing

• 3 rounds of usability tests
  – Total N=30
  – Mean age=43.3, SD=16.5

Intersection layout provided to participants

Comparison examples of ‘sign states’ using a police officer

<table>
<thead>
<tr>
<th>Sign States</th>
<th>Traffic is too close to safely cross</th>
<th>Sign is on/operating</th>
<th>Sign is non-operational</th>
</tr>
</thead>
<tbody>
<tr>
<td>Police Examples</td>
<td>[Image of police officer waving]</td>
<td>[Image of police officer waving]</td>
<td>[Image of police officer asleep]</td>
</tr>
<tr>
<td>Message Conveyed</td>
<td>There is not enough time to cross.</td>
<td>There is enough time to cross.</td>
<td>This officer is not operational, like signs can sometimes be.</td>
</tr>
</tbody>
</table>
Usability Test

• Sign comprehension
• Decision making
• Overall design preferences
• Terminology preferences
  – Not safe to cross
  – Sign is on/operating
• Likes/Dislikes
Sign A

Red Frame Flashing

- **STOP**
- CROSS TRAFFIC APPROACHING
- CROSS TRAFFIC DOES NOT STOP
Final Usability Test Results

Sign B
- CROSS TRAFFIC TOO CLOSE
- CROSS TRAFFIC DOES NOT STOP
- [Diagram]

Sign C
- TRAFFIC APPROACHING WHEN FLASHING
- [Diagram]

Sign F
- TRAFFIC APPROACHING
- WATCH FOR TRAFFIC
- [Diagram]

Sign G
- WAIT CROSS TRAFFIC APPROACHING
- CROSS TRAFFIC DOES NOT STOP
- [Diagram]
Driving Simulator Study

• Recruitment goals (N=80)
  – 2 age groups (40 per group)
    • Older drivers (65-77)
    • Novice teenage drivers (<18)

• Experimental design
  – Randomly assigned to one sign option
  – ABAB design (reversal design)
  – 2 levels of visibility
  – 2 levels of traffic volume condition
  – Sign-off state
Driving Simulator Study

- Experimental design

**Drive 1 & 3:** Baseline

- Unobstructed
  - Low
  - Moderate

- Obstructed
  - Low
  - Moderate

**Drive 2 & 4:** Treatment

- Unobstructed
  - Low
  - Moderate

- Obstructed
  - Low
  - Moderate
  - Sign-Off

Unobstructed View

Obstructed View
Driving Simulator Study

- Materials and Apparatus

HumanFIRST partial motion-based driving simulator set up

Smart-Eye Pro Eye Tracking Camera
Data Collection

• On approaching the intersection:
  – Speed
  – Braking
  – Wait time
  – Stop sign violations

• When crossing the intersection:
  – Gap acceptance
  – Acceleration
  – Crossing behavior
  – Sign compliance
  – Collision rate
Data Collection

• Visual Attention
  – Percent of eyes-on and -off road
  – Frequency and duration of fixations on signs
  – Visual search patterns

• Subjective Measurements
  – Sensation Seeking
  – Driving History
  – Driving Behaviors
  – Mental Workload
  – System Trust
  – Usability Test
General Research Questions

• Which sign design most clearly conveys the information being presented to road users?
• Which sign design best captures drivers’ attention and requires less visual workload?
• Under which environmental (visibility and traffic volume) condition does the warning sign best aid road users to safely cross the intersection?
• To which extent do road users rely on the signs at these intersections?
• Do road users continue to adhere to stop signs once they become familiar with the signs’ operations?
Research Hypothesis

• Gap Acceptance Hypothesis
  – Older drivers are expected to be more likely to:
    • Misjudge the size of gap
    • More frequently reject a gap
    • Longer total wait time at intersections

• Visual Attention Hypothesis
  – Older drivers are expected to be more likely to:
    • Take longer time to process
    • Use more fixations
    • Higher visual workload
    • Less eye-off-road behavior
Preliminary Findings

• Sign Comprehension
  – Misinterpretations of sign states

• Sign Acceptance
  – Teenage Drivers
    • Overconfidence on signs
    • Less reliance on signs

• Sign Acquisition
Preliminary Findings

• An Example:
  – Eye Tracking on Sign C (*Original RICWS*)

![Teen Driver](image1.png)  ![Older Driver](image2.png)
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