The Measurement of Situation Awareness for Automobile Technologies of the Future

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Situation awareness is key to good decision making and good performance.
What is Situation Awareness?

Situation Awareness is the **Perception** of the Elements in the Environment within a Volume of Time and Space, the **Comprehension** of their Meaning, and the **Projection** of their Status in the Near Future.

Endsley, 1988
Situation Awareness

**Perception**
- Fuel level
- Speed
- Speed limit
- Headlights state
- Planned route
- Location
- Weather
- Traffic on route
- Accidents on route

**Comprehension**
- Distance to next turn on route
- Deviation between speed limit and current speed
- Distance to next car
- Impact of hazard on own safety

**Projection**
- Projected time to destination on current route
- Projected time to destination on alternate route
- Projected hazard level of weather
- Projected likelihood of getting a ticket
What Kinds of SA Problems Do People Have?

- Don’t Correctly Understand Information They Do Get: 17%
- Don’t Project What Will Happen in Future: 5%
- Don’t Get Information That Is Needed: 78%
Advanced Technologies for Driving

• External Devices
  – Cell phones
  – PDAs
  – DVD players

• Advanced Automotive Technologies
  – Cruise control
  – Automatic headlights
  – Navigation systems
  – Rear/Side facing cameras
  – Self Parking
  – Automated car following
  – The driverless car?
Why Are We Automating?

- **Enhanced Performance**
  - **Monotonous tasks**
    - Cruise control
  - **Hard to do tasks**
    - Parallel parking
    - Remembering to turn on headlights
    - Navigation
  - **Increased Perception**
    - Side/rear cameras
- **Increased traffic flow**
  - Automated following
  - Brake detection

Where are the hidden costs?

Know the Situation. Know the Solution.
Situation Awareness Issues with Advanced Driving Technologies

So where is the problem?

- Attention Allocation (distraction)
- Out-of-the-loop Performance Problems
- Misplaced Salience
- Complexity Creep
- Attentional Tunneling
- Data Overload
- Out-of-the-loop Syndrome

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Know the Situation. Know the Solution.
Deployment of Attention Underlies Much of SA

Data Driven Processing

- Salient Cues Catch Attention

Focused Attention

- Current Goals Direct Attention

Goal Directed Processing

- Goal Prioritization

Divided Attention

- Mis-Directed Attention

Attentional Narrowing

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SA Metrics Are Needed

- Metrics are needed to objectively assess the attentional capacity and ultimately the SA of the driver
  - Do new technologies actually improve SA?
  - Which aspects of SA are hurt by technology?
- SA measures an individual’s ability to dynamically integrate multiple pieces of information into a coherent picture under operational challenges
- Multiple metrics have been proposed
  - Not measure the same thing
  - Many not suited to real-time tasks
  - Difficult to analyze data
  - Costly to implement
Different SA Metrics

**Process Indices**
- Eye Movements
- Information Acquisition
- Communications & Verbalizations

**State of Knowledge**
- Questionnaires
- Post-test
- On-line probes
- SAGAT
- Subjective Measures
- Modeled Measures

**Behaviors**
- Actions
- Verbalizations

**Performance**
- System Performance
- Emergency Performance

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**Moderating Factors:**
- Strategies
- Skills
- Knowledge
- Abilities

**Strategies**
- Rules & Procedures
- Training
- Personality Factors

**System Capabilities**
- Others Capabilities & Actions

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Process Indices

- Eye Tracking
- Information Acquisition
- Verbalizations & Communication
  - **Pros**
    - Objective
    - Indication of information access / utilization
  - **Cons**
    - Difficult to implement in real-world environment
    - Can’t infer what is done with information (processing)
    - Can’t tell whether information is registered correctly
    - Can’t tell what is retained in memory
    - Create large amounts of data to analyze
  - **Recommendations**
    - Best for examining SA processes rather than product
    - Examine specific research questions
State of Knowledge Metrics – Post Test Questionnaires

• Pros
  – Objective
  – Detailed assessment
  – Less intrusive
  – Easy to implement in simulated or real-world environment

• Cons
  – Rationalization/Generalization after the fact

• Recommendations
  – Provide reliable SA for end of event
  – Can be used to determine overall success of a new technology
Audio Questions asked during the scenario
Measures accuracy and response time

- Measures accuracy and response time
- Pros
  - Can be used during the task
  - Can easily look for needed information
  - Measure response time as well as accuracy
- Cons
  - May interfere with task performance
  - Can collect a more limited amount of information
  - Multiple measures needed for reliability
- Recommendations
  - Requires careful synchronization with mission tasks/events
  - One question at a time
State of Knowledge Measures – SAGAT

• Situation Awareness Global Assessment Technique (SAGAT)
  - At random times, freeze the exercise
  - Administer a rapid battery of queries
  - Score on the basis of objective data

• SAGAT Pros
  – No post data collection
  – Minimizes potential biasing of subject SA
  – Direct measure of SA
  – Random sampling provides unbiased measure of SA
  – Heavily validated

• SAGAT Cons
  – Requires the interruption of the simulation
  – Need to gather SA information requirements for query generation
SAGAT Performance for Simulated Driving Task

Mean Percent Correct

<table>
<thead>
<tr>
<th>Age Category</th>
<th>Mean Percent Correct</th>
</tr>
</thead>
<tbody>
<tr>
<td>Young</td>
<td>62.5</td>
</tr>
<tr>
<td>Middle</td>
<td>59.38</td>
</tr>
<tr>
<td>Old</td>
<td>56.25</td>
</tr>
</tbody>
</table>
Percentage of Cars Correctly Located

Instructions: Please indicate the location of yourself and other cars. Mark yourself with an “O” and other cars with an “X”. Each square represents one car length.
Direct Measures - Subjective Ratings

- **Self Ratings**
  - Situational Awareness Rating Technique (SART)
  - SA- SWORD

- **Observer Ratings**
  - **Pros**
    - Easy
    - Inexpensive
  - **Cons**
    - Do you know what you don’t know?
    - Observers don’t know what the person knows
    - Maybe tainted by performance outcomes
    - Related to confidence in own SA
  - **Recommendations**
    - Must modify existing scales for driving task
    - Should be used to complement objective techniques
Imbedded Tasks
Testable Response Method

• Pros
  – Objective
  – Desired outcome
  – Non-intrusive

• Cons
  – Sensitivity
  – Diagnosticity
  – Interpretability of measure
    • Assumes certain behavior given SA
  – Must infer SA

• Recommendations
  – Best used in conjunction with other measures
  – Must cover a wide range of tasks/scenarios

Did he notice the ball rolling across the street?
Did he brake in time?
Consistent speed?
Did she respond to an Inaccurate display setting?
Measurement Summary

• Measurement of SA in the evaluation of system design options provides critical information with greater sensitivity than simple performance measures
  – Displays
  – Automation & Decision Support Systems

• Choice of measures is important
  – Objective measures of SA most sensitive and diagnostic
  – Subjective measures of SA more related to confidence in one’s SA
  – Performance measures can be used if carefully selected, but interpretation is tricky
Conclusion

- Situation awareness is and will remain critical for driving
- New technologies may aid performance and SA in some cases
- But they may also reduce SA, leaving drivers with a low ability to intervene in automated activities when needed
- The development of successful and appropriate new technologies for the automobile is dependant on consideration of factors that impact on SA as well as careful measurement of driver SA
Questions???
• What do we want to know?
  – Ability of drivers to attend to correct information needed for SA development
    • Process indices like eye tracking
  – Continuous levels of SA during driving
    • State of knowledge measures such as SAGAT, ACASA, real-time probes
  – Drivers confidence in their SA abilities
    • State of knowledge metrics such as post test questionnaires
Measurement of SA: Requirements/Issues

• Validity
  – Are we measuring what we intend to measure?

• Reliability
  – Does measure remain consistent?
  – What else does it correlate with?

• Sensitivity
  – Will measure detect differences in SA?
  – What is a good SA score?

• Operational Constraints
  – Dynamic priorities
  – Measurement Location
  – Cost to implement
  – Time to analyze data
SA Measure Comparisons

• Endsley & Selcon, 1998
  – SART highly correlated ($r^2 = .69$ to $.74$) with:
    • Subjective SA
    • Confidence level
  – SAGAT & SART compared on common trials
    • NO relationship between SART and any SAGAT measure

• Endsley, Sollenberger & Stein, 2000
  – Measured SA via real-time probes, SAGAT, SART in ATC task
  – Some relationship between SART and other SA measures but **NOT** SAGAT