Eye Gaze-Based Human Error Prevention System: Experts vs. Non-Experts

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AGENDA

- Background on Eye Gaze Behavior and Eye Tracking
- Hypotheses
- Experiment Design
  - Tobii Pro Nano Eye Tracker
  - FortiGate-90D Firewall
  - Google Form Questionnaire and Two Network Configuration Tasks
- Observations & Findings
- Proposed Model for Human Error Prevention
BACKGROUND ON EYE GAZE BEHAVIOR

- **Gaze Behavior:** the way an individual uses their vision to extract relevant information from the environment to produce an optimal action

- Visible field of view vs. attention
  - What to capture in high resolution or observe in fine detail?

- **Fixations:** when gaze remains stable on an area of interest

- **Saccades:** rapid eye movements that typically occur when moving from one fixation location to another

- **Dwells:** an individual’s visual visits to an area of interest, where each visit is a dwell
**Spotlight Theory**

**Michael I. Posner, 1980**
- Attention is limited in spatial extent; spotlight
  - Independent of eye movement; parafoveal vision
- Research suggests that perceptual learning could enlarge an individual’s perceptual span
- **Saccade**: The eye movement from one area of interest to the next across the perceptual span

**Attenuation Filter and Dictionary Units Theory**

**Anne Treisman, 1960s**
- **Attenuation Filter**: the selection of sensory messages to filter out unwanted information so that attention is drawn to the necessary areas
- **Dictionary Units**: individual processes the selected information based on its importance, relevance and context to generate areas of interest
- Higher fixations in an area = area requires greater attention
Ericsson and Kintsch, 1995

- Working Memory: the temporary storage of information that is being processed for any cognitive task(s); Ericsson refers to this temporary storage as short-term working memory.

- Ericsson introduces long-term working memory: information stored in stable form and accessed when presented with sufficient retrieval cues.
  - Experts able to act proactively with skilled performance.
**Main Hypothesis:** Experts have different eye gaze behavior when compared to non-experts

**Hypothesis 1:** Spotlight theory on parafoveal vision: experts are expected to have less saccades in comparison to non-experts with a possibly higher amplitude of saccades.

**Hypothesis 2:** Attenuation Filter and Dictionary Units Hypothesis: experts are expected to make less fixations of shorter durations throughout each task in-comparison to non-experts.

**Hypothesis 3:** Long-term Working Memory Hypothesis: experts are expected to retrieve relevant information from working memory more rapidly than non-experts, therefore, experts will have shorter fixation durations and shorter dwell times in comparison to non-experts, while making fewer errors than non-experts.
EXPERIMENT DESIGN

- Tobii Pro Nano Eye Tracker
- Tobii Pro Lab Software
- FortiGate-90D Firewall
FINDINGS FOR EACH TASK

ENTIRE SCREEN AOI
RESULTS FOR QUESTIONNAIRE TASK

<table>
<thead>
<tr>
<th>T-test</th>
<th>Entire Screen AOI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Duration of Fixations</td>
<td>2.77E-07</td>
</tr>
<tr>
<td>Number of Fixations</td>
<td>2.02E-08</td>
</tr>
<tr>
<td>Total Duration of Whole Fixations</td>
<td>1.29E-07</td>
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<tr>
<td>Number of Whole Fixations</td>
<td>1.62E-08</td>
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<tr>
<td>Total Duration of Visits</td>
<td>6.64E-08</td>
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<tr>
<td>Number of Visits</td>
<td>N/A</td>
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<tr>
<td>Number of Saccades (AOI)</td>
<td>8.93E-08</td>
</tr>
<tr>
<td>Total Amplitude of Saccades (TOI)</td>
<td>1.36708E-05</td>
</tr>
</tbody>
</table>
RESULTS FOR NETWORK CONFIGURATION TASK 1

Common error: 9 non-experts failed to block the attacker from their network
Common error: 8 non-experts failed to enable successful access for the contractor, of which 4 non-experts didn’t create the service
HYPOTHESES

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A classifier was created with all the successful eye gaze metrics
• Classifies an expert with a “0” output and a non-expert with a “1” output

- KStar: 99.74%
- Random Forest: 99.47%
- J48: 99.23%
- JRIP: 96.93%
- Decision Table: 92.60%
- Logistic: 88.77%

An attribute selection method was executed using Wrapper Subset Evaluation for the best classifier
• The search method (Best First) concluded that KStar had the best features, which were: Fixation Duration and Fixation Number, with KStart 99.74%
**PROPOSED MODEL (High Level Flowchart)**

1. **Start: User Accesses Interface**
   - **Eye Gaze Recording ON**
   - **Collect User’s Eye Gaze Metrics**
   - **Did user request to save/execute changes?**
     - **No** → **Allow user’s changes to be saved/executed**
     - **Yes** → Validate recorded eye gaze metrics through classifier
2. **Did 1 or more metrics = non-expert classification?**
   - **No** → **Trigger notice for an expert’s evaluation**
   - **Yes** → Permit changes once expert’s credentials entered for validation
3. **End**

*This is a summarized, high-level flowchart of the proposed model; the detailed flowchart with all possible steps is available in the research paper*
THANK-YOU FOR WATCHING!

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