Understanding the Skill-based Error Problem

Raj Ratwani, PhD
Scientific Director
National Center for Human Factors in Healthcare
MedStar Health
Types of Errors

Knowledge Based (novel situations)

Perform the wrong step because of a lack of knowledge (e.g., Don’t know which medication is appropriate)

Rule Based (familiar situations)

Perform the wrong step because of the misapplication of a rule (e.g., I think it is medication x)

Skill-based (experienced situations)

Perform the wrong step because of a slip or lapse (e.g., intend to give the correct medication, but mistakenly give medication x)

(Rasmussen, 1982)
Skill-based (automaticity) errors

• Occur despite having the correct knowledge of how to perform the task
• Occur even with hundreds (or thousands) of hours of experience
• Occur on simple tasks (making coffee) and complex tasks (surgery, flying an airplane)
# Prevalence of Skill-based Errors

<table>
<thead>
<tr>
<th>Domain</th>
<th>% Accidents/Incidents due to skill-based errors</th>
<th>Dataset &amp; Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aviation (Commercial)</td>
<td>60.5%</td>
<td>199 accidents in the United States from 1990-1996; data from NTSB and FAA (Wiegman &amp; Shappell, 2001)</td>
</tr>
<tr>
<td>Aviation (Maintenance)</td>
<td>48%</td>
<td>Survey of 550 aircraft maintenance personnel in Australia (Hobbs et al., 2007)</td>
</tr>
<tr>
<td>Mining</td>
<td>~58.9%</td>
<td>508 cases from Australia (2004-2008) (Patterson &amp; Shappell, 2010)</td>
</tr>
<tr>
<td>Medical Intensive Care</td>
<td>~53%</td>
<td>120 adverse events in 79 patients; 54 preventable adverse events. In total examined 391 patients with 420 unit admissions in 1490 patient days (Rothschild, 2005)</td>
</tr>
<tr>
<td>Railways</td>
<td>63%</td>
<td>19 rail accidents in Australia (Baysari et al., 2009)</td>
</tr>
</tbody>
</table>
Approaches to Dealing with Errors

• *Person Approach*: Focus on the *errors of individuals* and blame them for failures of memory and attention

• *Systems Approach*: Focus on the *conditions under which individuals work* and build defenses to avert errors or mitigate their effect

Reason (2000)
## Types of Errors

<table>
<thead>
<tr>
<th>Knowledge Based (novel situations)</th>
<th>Training</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perform the wrong step because of a lack of knowledge (e.g. Don’t know which medication is appropriate)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rule Based (familiar situations)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perform the wrong step because of the misapplication of a rule (e.g. I think it is medication x)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Skill-based (experienced situations)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perform the wrong step because of a slip or lapse (e.g. intend to give the correct medication, but mistakenly give medication x)</td>
</tr>
</tbody>
</table>

(Rasmussen, 1982)
My Goals for Today

• (1) Convince you that no matter how capable we are, there is variability in our performance.
  
  **Errors are going to happen**

• (2) Demonstrate how human factors and our understanding of cognition can help predict where errors might occur.
  
  **Build robust systems**
Our Work Conditions

• All of us come to work with intentions to perform at our highest levels, but:
  – Our work environment is full of interruptions
  – Workload is generally high
  – Fatigue and stress are *real* issues

• How do we perform given these conditions?
  – Research is VERY limited, but we have some info...
How Disruptive are Interruptions?

Skill-based Error Rates by Condition

10 Fold Increase !!!

(Ratwani & Trafton, 2008)
Errors by Interruption Length

10-30 Fold Increase !!!

(Ratwani & Trafton, 2010)
Workload and Error Rates

~5 Fold Increase !!!

(Byrne and Bovair, 1997)
Fatigue and Skill-based Errors

Errors in airline maintenance crews by circadian rhythms
(Hobbs et al, 2010)

~3-4 Fold Increase !!!
Accept these Conditions as Normal

• None of us are resistant to the influence of interruptions, workload, or fatigue!

• Begin to accept that there is natural variability in our performance—plan accordingly
How do we Leverage a Systems Approach?

• Focus on our interaction with the environment and design for error

“Make it easy to do the right thing”
How do we Design for Error?

• Study the work environment, work conditions, and dissect the tasks to be performed

• Focus on understanding human capabilities in context

• Identify high risk areas and mitigate risk
Defibrillator Example

• Cardiac Arrest Work Conditions
  – Interruptions?
  – High workload?
  – Fatigue, stress?
Task Analysis

Goal: Deliver Shock

1. Push ON Button (takes 30 sec to start)
2. Select Energy
3. Charge
4. Shock
5. Push ON Button to TURN OFF

Up/down arrow to desired level

Is this is a good design?
Understanding Skill-based Error Patterns

- If you do make an error, where will it land?

(Trafton, Altmann, & Ratwani 2009)
Understanding the Task in Relation to Error Patterns

Goal: Deliver Shock

1. Push ON Button (takes 30 sec to start)
2. Select Energy
3. Charge
4. Shock
5. Push ON Button to TURN OFF

Up/down arrow to desired level

What happens if you are interrupted here and make an error?

There is a high likelihood you will repeat the previous action
Consequences

• Defibrillator will power down and it can take 2-3 minutes to restart

• Solution?
  – Anticipate that a “repeat” action is likely
  – Design for the error

(Hoyer, Christensen, et al., 2008)
(Fairbanks & Wears, 2008)
Where do we go from here?

• Skill-based errors are prevalent and have fundamental cognitive underpinnings
• We **cannot** reduce these errors by policy or training
• We **can** develop robust systems by applying cognitive theory to the design of systems
Discussion

Raj.Ratwani@MedicalHFE.org
www.MedicalHumanFactors.net