Why Humans Struggle To Recover After Automation Failure

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Introduction

Some of the most devastating accidents in history have been due to human error

- Automated systems still require human involvement, though the role of the human has evolved from operator to monitor
- Accidents are typically the result of a complex sequence of events, yet humans tend to take the blame
- Rather than simply reducing instances of error, evolution of automation has instead changed the nature of error

Human Role in Automation

- Humans are users of automation
- The role of humans in automated systems has shifted from operator to monitor
- Reliance on (and use of) automation and automated systems is determined by level of trust

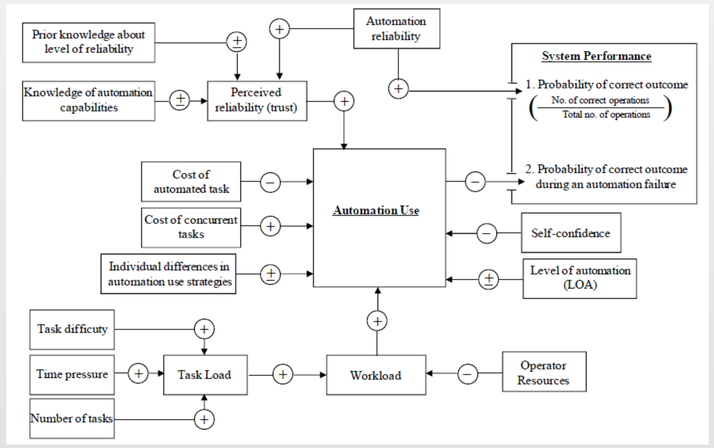

Figure 1. *Conceptual model of human-automation integration (Sanchez, 2009). The "+" indicates a positive relationship, the "-" indicates a negative relationship, and the "+-" indicates a potentially positive or negative relationship.*

Human Error

"Something has been done that was not intended by the actor; not desired by a set of rules or an external observer; or that led the task or system outside its acceptable limits." (Senders & Moray, 1991, p. 25)

- Human errors are the result of endogenous or exogenous factors
- **Endogenous (Internal) Factors:** fatigue, distraction, complacency, confusion, stress, inadequate skills/knowledge, etc.
- **Exogenous (External) Factors:** design of equipment, operating procedures, elements of the task, inadequate/lack of training, etc.
- *Severity* of error is determined by its *consequences* (Whittingham, 2004)

Evolution of Human Error

- Evolution of automation → evolution of human error
- Automation reduces cognitive load of operator
  - Fewer opportunities for human error
- Cognitive Overload → Cognitive Underload (Young & Stanton, 2002)
  - Humans left largely out-of-the-loop
  - Increase in automation → decrease in cognitive demands → decrease in attention → increase in reaction times

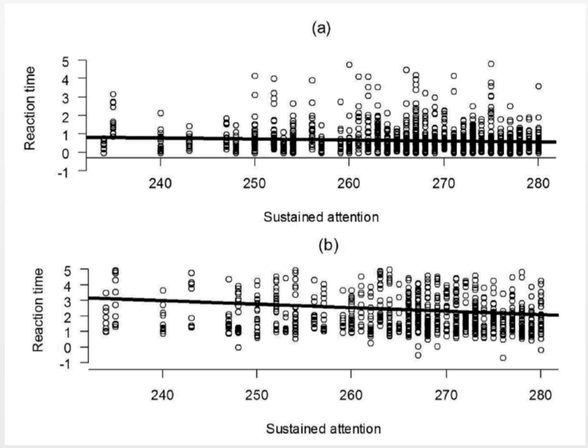

Figure 2. ***Visual representation of the relation between sustained attention and reaction time in seconds (Jipp, 2016).*** *Scatterplots with regression lines show (a) initial automation failure, and (b) consecutive automation failure*

Responding to Automation Failure

Previously manual tasks now performed by automated systems, resulting in:

- **Deskilling/Skill Atrophy** (Proctor & Van Zandt, 2008)
  - Operators lack skills required to complete tasks when automation fails
- **Increase in Complacency** (Singh, Molloy, & Parasuraman, 2001)
  - Poor monitoring of performance of automated systems due assumption of a satisfactory system state (over-trust in automation)
  - Operator fails to identify a system error
- **Cognitive Lockup** (Jipp, 2016)
  - Failure in one function causes subsequent failures at a pace too rapid for the operator to keep up with
  - ***Attentional Tunnelling:*** Operators focus their attention exclusively on one task goal
- **Decrease in Situational Awareness** (Omnasch, Wickens, Li & Manzey, 2014)
  - Loss of awareness of the state of the system supported by automation, or the state of automation itself
- **Out-of-the-loop-unfamiliarity** (Endsley, 2016)
  - Unaware of processes undertaken to fulfil automated tasks

Potential Solutions

- **Personnel Selection and Individual Differences** (Endsley, 2016)
  - Match appropriate individual to specific task
- **Information and Training** (Dehais, Causse, & Tremblay, 2011)
  - Pre-performance exposure to system failures increases likelihood of quickly diagnosing and addressing failures
- **Transparency and Feedback** (Endsley, Bolte, & Jones, 2003)
  - Systems provide salient information and critical feedback regarding system status, avoiding ambiguous or excessive information

Conclusion

- Advancements in automation have decreased operator workload, resulting in more efficient systems and decreased cognitive load
- Reduced cognitive demands decrease attention and thus increase reaction times when responding to automation failures
- A multifaceted approach should be taken toward automation design that includes matching the appropriate individual to specific tasks, training the user appropriately, designing interfaces to improve operator's situational awareness, and discovering the correct balance between automation and the human operator

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