The Unintended Consequences of Focusing on Human Error (And How You Can Help)

To explore new views of behavior that balance human capabilities & limitations

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To seek out new data to improve our understanding of how people adapt

NASA
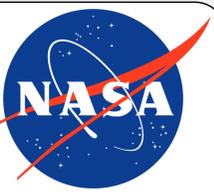
National Aeronautics & Space Administration

Abstract

The literature on human performance is rich with findings of cognitive failures and methods to identify, label, and measure them. In many real-world contexts, however, outcomes are driven far more by successful than failed cognition. Designers of systems intended for human use, in an effort to be "data driven," rely upon findings from the cognitive performance literature to inform their system designs. When most available data are about human error, data-driven designs focus on the human primarily as a source of failure. Designs intended to support or replace humans often fail to acknowledge or understand the capabilities that humans routinely contribute to successful performance. Consequently, designs intended to "protect" the system from "error-prone" humans can design-out the capability for the human to effectively intervene or adapt. The development of paradigms to study successful human performance represents a significant and largely untapped opportunity for research in cognition.

Background: Ubiquitous focus on human error

Measuring errors is a common practice in the study of cognition. We explore the limits of memory and attention, thresholds of perception, illusions, cognitive biases, etc.

- Systematic errors can inform understanding of the logic by which our cognitive systems work (Gilchrist, 2006).
- The human performance literature is rich with findings of cognitive failures, paradigms for studying them, and methods to identify, label, and measure them.

Safety-critical industries seek to be "data driven" in applying human performance research to system design

- Human error is increasingly emphasized in product and system design (Sharit, 2012).
- The field of safety science has largely become the study of human error prevention: "Modern technology has now reached a point where improved safety can only be achieved through a better understanding of human error mechanisms" (Reason, 1990).
- The role of human error in accidents has been broadly reported in domains from aviation to driving to medicine (e.g., Erwin, 2000; Treat et al., 1977; McFadden et al., 2004).
- However, when the only data about human performance are about failure, then data-driven designs only consider that humans fail.
- In arguing for pilotless air taxis, Uber (2016) asserted, "To fast forward to the safest possible operational state … network operators will be interested in the path that realizes full machine autonomy as quickly as possible," suggesting that air taxi operations would be made safer by removing human pilots.
- Widely available statistics on human error, along with suggestions that humans are "inherently bad" various tasks from monitoring to handling uncertainty (e.g., Claybrook & Kildare, 2018; Bocskocsky et al., 2014), can paint a picture of humans as poorly suited for operating in today's technology-rich environment (Figure 1).
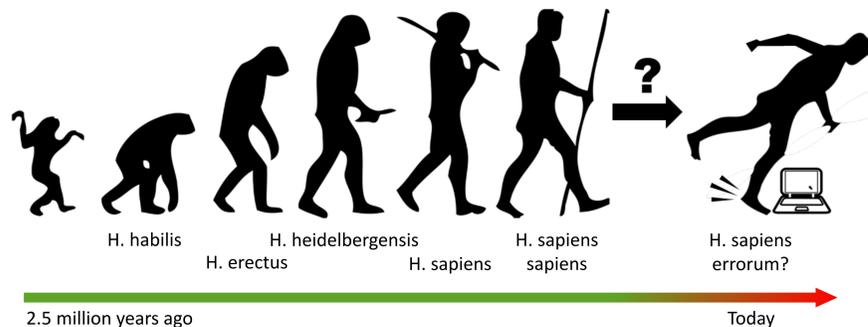
Figure 1. *Are human inherently maladapted to function in modern sociotechnical systems?*

Humans are a source of safety, not just errors

- Human performance includes both desired and undesired actions. Most of the time, those actions promote safety, but sometimes those actions can reduce safety.
- Most of our learning about human performance in aviation comes from studying relatively rare errors and failures.
- The magnitude of the discrepancy between representative human performance and analyzed human performance can be difficult to appreciate without data to provide some base rate context (Holbrook, 2021).
- Human error has been implicated in up to 80% of aviation accidents (e.g., Erwin, 2000; Wiegmann & Shappell, 2003).
- Observational analysis of flight crews during line operations indicate that pilots intervene to manage aircraft malfunctions on 20% of normal flights (PARC/CAST, 2013).
- If those percentages are examined in the context of 10 years of world-wide jet data (Boeing, 2017), a contingency table can be constructed, depicting outcome (not accident or accident) by whether human intervention was identified as being associated with that outcome (see Figure 2).

Outcome

Attributed to Human Intervention	Not Accident	Accident
No		
Yes	20%	80%
	388	244,000,000

Outcome

Attributed to Human Intervention	Not Accident	Accident	
No	195,199,690	78	195,199,768
Yes	48,799,922	310	48,800,232
	243,999,612	388	244,000,000

Frequently Studied

Rarely Recognized

Figure 2. *Human contributions to safety successes (solid oval) far outweigh their contributions to failures (dashed oval), but successes are relatively unstudied and poorly understood.*

Consequences of focusing on human error

- Focusing on undesired operator behaviors limits the data that are collected, the questions that are asked during data analysis, and therefore our learning and understanding of human performance in everyday work.
- When the only human performance data that are available are about human failure, then data-driven designs only consider that humans fail.
- Removing or restricting the only demonstrated reliable source of safety-producing behavior without first understanding the capability being removed or restricted introduces unknown risks
  - Designs intended to "protect" the system from "error-prone" humans can design out the capability for humans to effectively intervene/adapt, which is a far more common behavior.
  - Designs intended to replace or support humans often fail to acknowledge or understand the capabilities that humans routinely contribute to successful performance, and therefore do not design that into the system.
- The ubiquitous backdrop of non-representative human error data affects how other findings and demonstrations of cognitive performance are interpreted

How the Cognitive Science community can help

New views of behavior that balance human capabilities and limitations are needed.

- How do cognitive processes support both success and failure?
- Can help interpret human failure data (e.g., when is failure an inherent limitation of the human versus consequence of a design that is misaligned with how our cognitive systems work?)

Data to improve our understanding of how people adapt to sustain performance and achieve goals are needed.

- How can we measure performance that prevents or avoids undesired outcomes?
- Absence of failure does not mean "nothing happened" (i.e., the "paradox of prevention" [Fineberg, 2013]).
- The processes that affect what occurs and what does not are still present but poorly understood.
- What laboratory paradigms could be devised to study adaptation and resilience? New testing paradigms can spur new insights, opening avenues to research that have been previously unexplored.

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Figure 1 (human evolution) image with labels: H. habilis, H. erectus, H. heidelbergensis, H. sapiens, H. sapiens sapiens, H. sapiens errorum? — 2.5 million years ago → Today