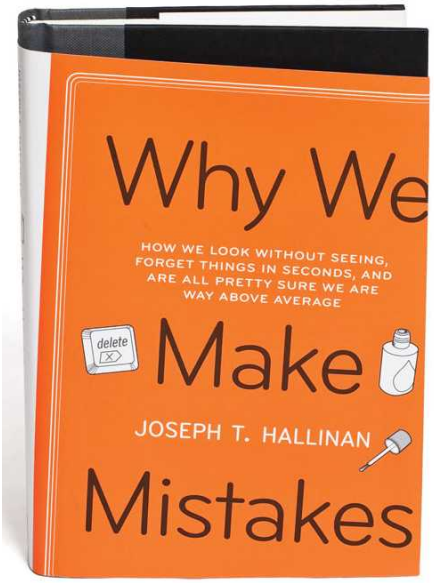
Sandia National Laboratories

Exceptional service in the national interest

SAND2016-3413C

NUCLEAR EXPLOSIVE SAFETY
NES
WORKSHOP 2016



Why We Make Mistakes

Judi E. See, Ph.D., CPE
Sandia National Laboratories/ New Mexico
Org. 0151, Nuclear Weapons Systems Analysis
jesee@sandia.gov, 505-844-4567

27 April 2016

U.S. DEPARTMENT OF ENERGY

Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000. SAND NO. 2011-XXXXP

Sponsored by: NNSA National Nuclear Security Administration

Purpose

- Examine what lies behind "human error," as presented in the book *Why We Make Mistakes*
  - Author: Joseph T. Hallinan
  - Published 2009
- Discuss implications for NES
  - ❖ *How we look without seeing…*
  - ❖ *Forget things in seconds…*
  - ❖ *And are all pretty sure we are way above average…*

Table of Contents

What *is* Behind Human Error?

- We are born to err due to the hardwiring of our brains
  - Natural human tendencies, capabilities, and limitations
  - Deeply ingrained biases
  - Limited conscious awareness of human shortcomings
- World is not built to accommodate natural human tendencies
  - Expectation is that people see or remember more clearly than they do
  - Systems are designed with little consideration of human capabilities
- Inquiry usually stops once a person is identified who can be blamed for the error
  - Errors get repeated because we fail to understand their root causes
  - The first step is a better understanding of why we make mistakes

We are all afflicted with certain systemic biases in the way we see, remember, and perceive the world around us, and these biases make us prone to commit certain kinds of errors.

We Look But Don't Always See

- People are not good at finding things that are rarely seen—we are built to quit early when a target is unlikely to be there
- Yet baggage screeners and radiologists are asked to search for extremely rare targets every day for long periods of time
  - 0.3% of routine mammograms reveal tumors ~ 3 in 1000
    - If it takes 5 minutes to read a mammogram, radiologists may not see any abnormal images for two weeks or more
  - Baggage screening finds ~one gun for every million passengers
- People are poorly suited for this type of task
  - Miss rates typically hover around 30%, but can be much higher
  - Targets are missed even though they are visible
  - Subsequent examination of "normal" chest X-rays indicated that up to 90% of tumors were visible, some for months or years

When asked to look for targets that are seldom seen, people simply quit trying to see.

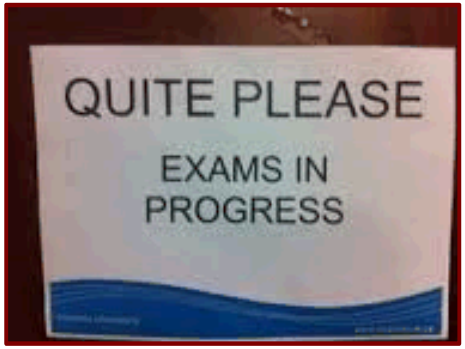
We Skim

- Human tendency to skim can lead to errors—accuracy is sacrificed and details are overlooked
  - We pay attention at the beginning and use context to assume the rest
  - Tendency to skim increases with expertise
  - When something is familiar, we tend to notice less, not more
  - Overlooked mistakes are so common they are called proofreader's errors
- Examples
  - When asked to read a text and cross out any occurrences of the letter *e*, people are more likely to miss if the letter appears later in a word
  - In 2008, a fifth-grade Michigan boy discovered an error in a Smithsonian Institution exhibit that had been there 27 years
    - Notation on an exhibit incorrectly identified the Precambrian as an *era*
    - Precambrian is a dimensionless unit of time between the origin of Earth and the beginning of the Cambrian Period of geologic time

Skimming – Goldovsky Error

- Piano teacher Boris Goldovsky discovered a misprint in Brahms' Opus 76, No. 2 after a student played the note as printed
  - Misprint was contained in all editions of the music
  - Nobody had ever detected the error—not the composer, the publisher, the proofreader, or hundreds of pianists
  - Everyone misread the music in the same way, playing G-sharp instead of G-natural, based on context, in bar 78
- Not one single skilled sight reader was able to spot the misprint, even after Goldovsky told them about it
- Tendency to misread music increases with familiarity—by as little as the second performance
  - Musicians look for patterns (skim) instead of playing each note

Skimming Examples



Diploma Goofs

Local Skimming Example

Men Shoot First

- Overconfidence is a leading cause of human error
  - People are more sure they are correct than they should be
  - 93% of American drivers rate themselves as better than the median
  - 94% of college professors report performing above-average work
  - 98% of high school seniors believe their leadership skills are above average
- 10-question “confidence quiz” administered to over 2000 people revealed that 99% of people are overconfident
- Men tend to be more overconfident than women
  - Men estimate their IQ as higher than it actually is (while women turn out to be smarter than they think)
  - Men, but not women, overestimate their own attractiveness
  - In simulated friendly fire incidents, men were more likely than women to be involved

We Don't Constrain Ourselves

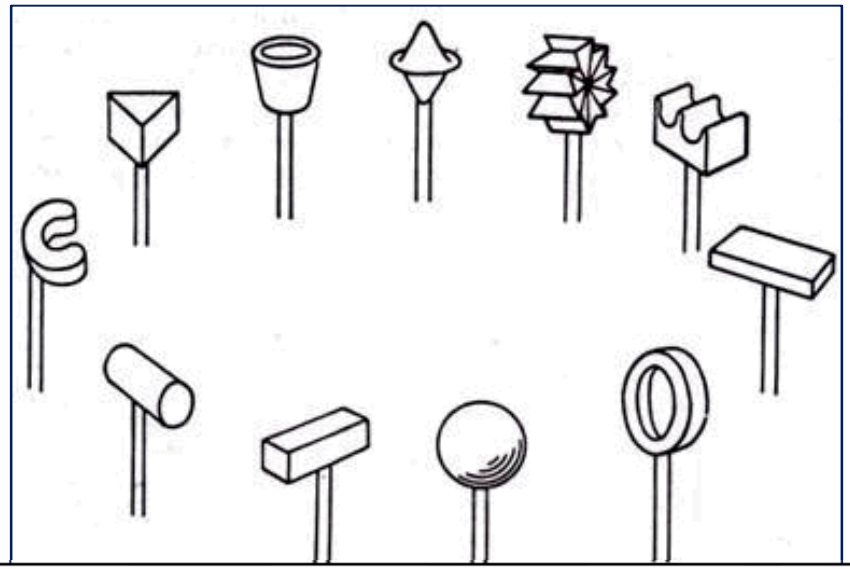
- We live and work in environments that increase the odds of mistakes because they do not constrain our behavior
- Dennis Quaid's newborn twins received heparin overdose in 2007
  - Anticoagulant used to prevent blood clots
  - Adult dose (10,000 units/mL) is 1000 times stronger than infant dose
  - Both bottles had similar shapes and blue labels with white text
- Feedback of >100 pharmacists, physicians, and nurses guided new packaging design
  - Unique color combinations for two dose vials
  - 20% larger type fonts
  - Large red cautionary tear-off label

We Don't Constrain Ourselves

- Poorly designed knobs, dials, and switches can increase the odds of mistakes because they do not constrain our behavior

Press this button  **Not this one** 

- Well-designed controls minimize confusion and use redundant coding like texture and shape to assist operators



11 shapes can be distinguished by touch alone

We Don't Constrain Ourselves

- Poorly designed user interfaces can increase the odds of mistakes because they do not constrain our behavior

An interface plastered with additional notes and instructions is a sure sign of a poorly constrained system

Solutions to Minimize Errors

- Combat overconfidence
  - Incorporate feedback to help people better match confidence and accuracy
  - Think negatively about what can go wrong to counteract a Pollyanna tendency to think that every decision or action will end in success
- Understand the role of context and build in controls to constrain behavior
- Adapt the task to account for human characteristics
- Use peer review to identify errors that occur due to familiarity and expectations—we see what we expect to see
- Be wary of financial incentives—they do little to reduce errors

By gaining better insight into the things we do well and the things we do poorly, we might do more of the former and less of the latter.

Applications to NES

- Human error concerns apply to all NSE personnel, including NESSG members and production technicians
- *Why We Make Mistakes* provides practical guidance to better understand ORPS events
  - When an event is attributed to "human error," consider what might lie behind the error
  - Did a poor system design actually set people up to commit the error?
  - Could controls be designed to constrain behavior and prevent future occurrences?
  - Are people being asked to perform beyond their capabilities?
  - Did overconfidence have a role?

Systemic errors have their roots at a level above the individual.

Conclusions

- When something goes wrong, we tend to look for the last person involved and start the “blame and train” game
- Most errors are actually a natural response based on human hardwiring or situational factors
- Recognizing the impact of such factors can lead to system designs that are more robust to human error

The key is to acknowledge human limitations first and then design the system around those limitations.

References

Hallinan, J. T. (2009). *Why we make mistakes.* New York: Broadway Books.