PSYCHOLOGY AND COMPUTER SECURITY

Technology of Cybersecurity

Spring 2023

PSYCHOLOGY IS SIGNIFICANT

THE MOST POWERFUL SECURITY TECH

- Year ago a Dental Hygienist asked me what was the best home security for her computer.
- Her question was obviously broad
  - Security against worms/vulnerabilities?
  - Security against viruses?
  - Data security?
- Anyone wish to guess my answer?

WHAT IS A WARRIOR'S MOST POWERFUL TOOL?

NO! NO! NO! NO! NO!

- This scene convinced me the Jedi were idiots!
- It isn't the Lightsaber that made the Jedi so dangerous
- Battles aren't won ***during*** the fighting; they are won in the ***thinking*** before hand
- Weapons aren't you most powerful weapon
- What is your ***most powerful weapon***?
- My answer to my Dental Hygienist?

YOUR MIND!

YOUR MIND IS YOUR MOST POWERFUL TOOL

- "There is no knowledge that is not power"

  (Ralph Waldo Emerson)

- Tools serve to ***amplify, not replace***, mental powers
- Many effective attacks primarily target the brain, not computers
- The Hygienist was disappointed. ***She wanted to <u>not think</u>***
- Many want a technology ***that eliminates the need for thinking***
- At least at this point, such technology does not exist.
- "The real question is not whether machines think but whether men do"

  (B.F. Skinner)

SECURITY "SMARTS" WON'T GET BETTER

- Some of the problem is human weakness:
  - Laziness – don't want to learn
  - Ignorance – lack of opportunity to learn

- Bigger problem: ***specialization of complex society***
  - Nobody can be an expert in everything
  - Complex society requires experts to do things
  - Harder to self-maintain cars, houses, etc
  - Everyone trains, ***a lot***, for their specialty
  - Little time/energy less for studying something else

WHAT ABOUT OUT-SOURCING?

- For our cars, we can go to a mechanic every 15,000 miles
- For our houses, we can call a repair service to fix things
- For medical, we can have yearly check-ups
- Why can't we do this for cyber-security?

THE PROBLEM IS: ***THIS IS WAR!***

- Your car is ***not trying to break down***
- Your house is ***not trying to fall apart***
- Your body is ***not trying to kill you***

- Cyber-villains ***are actively strategizing about how to attack you***
  - ***THIS IS NOT RANDOM CHANCE***
  - ***THESE ARE HIGHLY MOTIVATED PEOPLE***

SOLUTION?

SOUNDS LIKE OUT-SOURCING?

- Maybe, but please understand the difference
- ***Somebody*** (or multiple somebodies) must do the thinking
- ***Somebody has to engage in the warfare with the bad guys***
- Thinking has to be contextualized to the target, not defender
- Understand protecting the mind, not just tech/assets
- "Only amateurs attack machines; professionals target people"

(Bruce Schneier)

THE MIND AS TECHNOLOGY

- Forces behind design and development
- Intended purposes
- Feature set
- Strengths
- Weaknesses
- Contextual requirements
- Deployment in practice (intentional or not)
- Lessons learned and future directions

HOW DID THE MIND DEVELOP?

- Evolutionary development of the mind
- Higher cognitive functions are very powerful
- ***BUT***, have limitations for the pre-historic world
  - Can't out think the predator running you down
  - Can't think without sufficient information
  - Can't think through certain necessary social cohesion
- Evolutionary Solution: ***Intuition and Reaction***
- Evolutionary Solution: ***DISABLE THINKING***

UNDERSTANDING HUMAN COGNITION

- Incorrect: ***humans minds are 100% logical and rational***
- More correct: ***logical thinking often fails***
  - Example 1: human error
  - Example 2: human manipulation
- Security impact:
  - Impacts correct human use/deployment of security systems
  - Impacts correct defenses of the human targets

LECTURE ROADMAP

- Human Error
  - Source #1: Automation
  - Source #2: Complex Rules
  - Source #3: Meta Ignorance
  - Source #4: Wrong Model
  - How attackers manipulate errors
- Human Manipulation
  - Attacking human bias (e.g., toward action)
  - Attacking emotional fallback
  - Attacking via social engineering (e.g., tribal or authority)
  - Attacking via visual-emotional
- Psychology-aware Security Engineering

THE PSYCHOLOGY OF HUMAN ERROR

- Many cybersecurity incidents happen because of error
  - Giving the wrong access
  - Not updating a vulnerable system
- Some designers blow off errors as "stupid human errors"
  - Condescending attitude of "it's their own fault"
  - Doesn't understand limitations of the brain
  - Doesn't solve the problem
- Understanding ***why*** humans "fail" can improve design

SOURCE OF ERROR: AUTOMATION

- We spend a lot of time ***not thinking***
- When performing a skill:
  - Very conscious during the learning phase
  - Eventually shifts to automatic operation
  - Example: Driving
- "Slip and capture" errors: wrong automated task
- Dangerous to assume a person is thinking

SOURCE OF ERROR: COMPLEX RULES

- Some errors happen even while thinking
- Humans can consciously choose ***the wrong rule***
- Impacted by complicated hierarchies:
  - More general rules verses more specific
  - Rules that change the rules
  - ***Edge case rules***
- User doesn't recognize error because "followed the rules"
- Dangerous to assume a person follows the right rule(s)

SOURCE OF ERROR: META IGNORANCE

- Humans sometimes struggle to ask for help
- They either:
  - Don't ***know*** how much trouble they're in
  - Or, are ***pressured*** to act anyway
- For example, cybersecurity is hard because it is ***abnormal***
  - Up until the attack, everything looks/feels fine
  - When trouble starts, can be unpracticed getting help
  - Cryptography is also an example
- Dangerous to assume correctly skilled people are acting

SOURCE OF ERROR: WRONG MODEL

- Everything we "think" is based on models
- We cannot understand or know every possible detail
- Models help us understand, compare, predict, etc
- Models of things: *chair, car, window*
- Models of people: *spouse, friend, co-worker*
- **Wrong Model Error**
  - Incorrect or incomplete model
  - Application of wrong model altogether
- Dangerous to assume a person is using the correct model

NOTE ABOUT CIVIC DISCOURSE

One of the real challenges with healthy, respectful discourse in politics, religion, and other sensitive subjects is an inability to figure out ``the other side's'' modeling. If you find there are a large number of people that seem to take a point of view you just cannot understand, it may be worth exploring the models that you and they are using. Working to understand and explain your model, and figure out theirs, can lead to better mutual understanding and an improvement in working others.

REFUSAL TO ABANDON WRONG MODELS

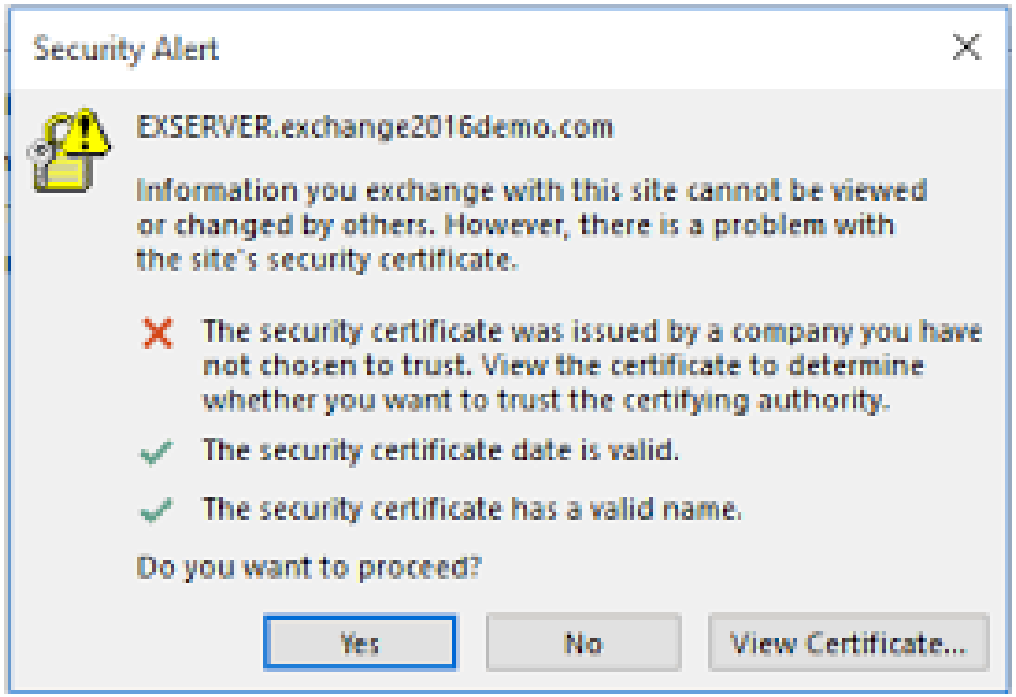
- This is another "wrong model error" problem
- It appears to be human nature (pride, ego, etc)
- Unfortunately shows up in the justice system
  - Officers become convinced of a "theory" (***model***)
  - Prosecutors don't change their minds after DNA evidence

WRONG MODEL ERROR!

The recurring theme of these cautionary tales—and the dynamic on which this article will focus—is the prosecutor's tendency to develop a ***fierce loyalty to a particular version of events***; the guilt of a particular suspect or group of suspects. ***This loyalty is so deep it abides even when the version of events is thoroughly discredited, or the suspect exculpated***. It results in a refusal to consider alternative theories or suspects during the initial investigation, or to accept the defendant's exoneration as evidence of wrongful conviction.

ATTACKING HUMANS VIA HUMAN ERRORS

- Attackers often want to ***control*** the target's behavior
- If attackers can induce an error, may lead to desired behavior
- Example, redirect a user to a fake website
- What problems might a user have with this?



ATTACKING MACHINES VIA HUMAN ERRORS

- Many systems are error-prone already
- Attacker need not directly manipulate to induce the problem
- For example, many devices ship with default passwords
- Users are supposed to change the password before deploying
- But many don't. This was used to create a "bot net" in 2016

DDoS attack that disrupted internet was largest of its kind in history, experts say

Dyn, the victim of last week's denial of service attack, said it was orchestrated using a weapon called the Mirai botnet as the 'primary source of malicious attack'

PSYCHOLOGY OF MANIPULATION

- To repeat: attackers want to ***control*** target behavior
- Even if attacking a system, want defender behavior ***predictable***
- ***We all like to think we're to smart to be tricked.***
- ALL Human minds have vulnerabilities (yours and mine too)
- Understanding these limitations leads to solutions

HUMAN BIAS TOWARD ACTION

- Humans are designed with a bias toward action
- There are GOOD reasons for this:
  - If we thought about everything we'd never do anything
  - Can lead to an initial action with follow-up refinement
- But there are some very BAD consequences
  - Act without sufficient information is sometimes worse than not acting
  - In the 21st century, there is a lot of information required to act
  - This is especially true in cybersecurity

A WORD ABOUT "BIAS"

- Bias has a negative connotation (e.g., racial, gender, etc)
- Bias means *preferences* that are automatic, not based on study
- Bias is an essential part of life for basic function/operation
- We accept as an axiom that some biases are immoral
- Through social/other training, can increase/reduce biases
- This is probably also evolutionary

EXPLOITING BIAS

- If an attacker knows/predicts bias, can predict human behavior
- Serious problem:
  - A "good" bias might lead to the "right" decision 99% of the time
  - Attacker will still figure out how to exploit the 1%
- With action bias, attacker knows that urgency leads to action
- If the target believes the urgency, will act unless trained
- Commonly seen in phishing

EMOTIONAL FALLBACK

- Pushing someone out of logical thinking into emotional response
- Can be explicitly triggered through emotional statements
- Can also happen when the target "runs out" of logic
- This appears to also be evolutionary
  - We cannot know or reason through everything
  - What should we do when we don't know what to do?
  - People often call this "intuition"

INTUITION

- Intuition (gut feel) only works with evolution (lots of time!!!)
- Humanity has not had time to evolve with the technology
- Complexity is accelerating (this will continue to get worse)

EXPLOITING EMOTIONAL FALLBACK

- Extremely emotional language triggers emotional responses
- Anterior Cingulate Cortex
  - Reciprocal Repression Model
  - Emotion shuts down Logic
- Push the target to the "edge" of training
  - No matter how well trained, always something unknown
  - ***Attacker will almost always know more than the target***

SOCIAL ENGINEERING - TRUST

- Obtaining unauthorized services through false pretenses
- Often obtained in stages, across multiple targets
- Build a small degree of trust, then leverage for more trust
- Common tricks to build trust:
  - We're part of the same group: gossip, banter
  - I'm already part of the system: I know how it works
  - You can help me out: I need you
  - I can help you out: you need me

SOCIAL ENGINEERING - AUTHORITY

- Thinking also tends to shut down in deference to authority
- Of course there are examples during war time
- But how many of us have deferred to social authority?
- Ironically, "rejecting" authority is often deferring to ***other*** authority.

EXAMPLE ABUSE OF AUTHORITY

LET'S ANALYZE THIS SCENE

- Dead Poets Society was a whole movie about learning to think
- Yet, here in a key scene, how does this teacher convince
- Thinking? Analysis? Debate? Discussion?
- No. He uses emotional statements and emotional activities
- He doesn't accept any opposition.
- Students ***required*** to think the way he does

VISUAL-EMOTIONAL STIMULATION

- Our visual processing system is complicated
- Pattern matching, video smoothing, etc
- But also, there is ***emotional*** processing in it as well
- Man with brain damage studied for his issues in this
  - He could ***recognize*** his parents
  - But it didn't feel right.
  - Convinced they were ***imposters***
- ***We feel when we see things***
- Attackers attempt to manipulate with ***emotional visuals***

VISUAL STIMULATION EXAMPLE

- This was a phishing submission from a previous class
- It "got" me

Updating Direct Deposit


Ellie Daw <Ellie.Daw@crims0nvista.com>

1:16 PM

To: Seth Nielsen <Seth.Nielsen@crimsonvista.com>

Hi Seth,

I recently switched banks and need to update my direct deposit information. My new bank account information is:

Acct #: 9089273541

Routing #: 011401533

Please use this account to deposit my next paycheck. Thanks.

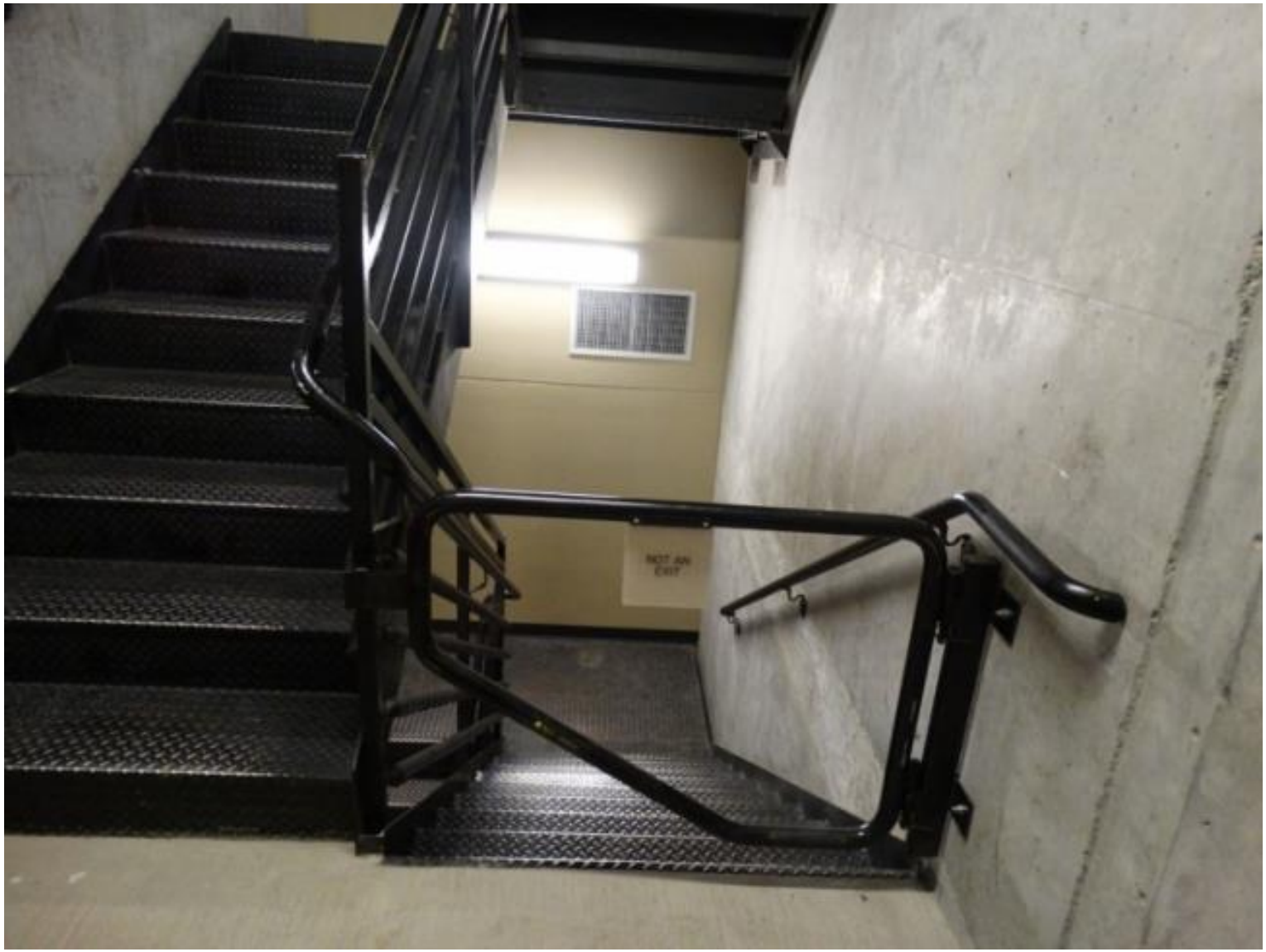
Best,

Ellie Daw
Research Scientist
Crimson Vista
Main: (512) 387– 4310
Ellie.Daw@crims0nvista.com
www.CrimsonVista.com

PSYCHOLOGY-AWARE DESIGN

- First, recognize that everyone is, in fact, human
- Design to ***mitigate*** human weaknesses
- Build on human psychology rather than fighting it

AN EXAMPLE OF GOOD PSYCHOLOGY



WHY IS THE PSYCHOLOGY GOOD?

- ***ASSUMES*** that the human will panic!
- ***Understands*** that they just need a mild cue to go the right way
- No training required, expected

- **NOTE:** still dealing with fires, which are not conscious enemies

SIX PSYCHOLOGY-AWARE DESIGN POINTS

- Affordance – Design for proper thinking/use
- Modes for irrational user behavior
- Inhibit emotional response (logic inhibits emotion)
- Design to be resilient in the face of mistakes
- Design to be resilient to failures
- Pushing decisions to experts

SECURITY EXAMPLE: CAPTCHAS

- Good case study!
  - Combine psychology, usability, and system design nicely
  - Designed around what humans do well that computers do not
  - "Completely Automated Public Turing Test to Tell Computers and Humans Apart"
  - Thanks Alan Turing!