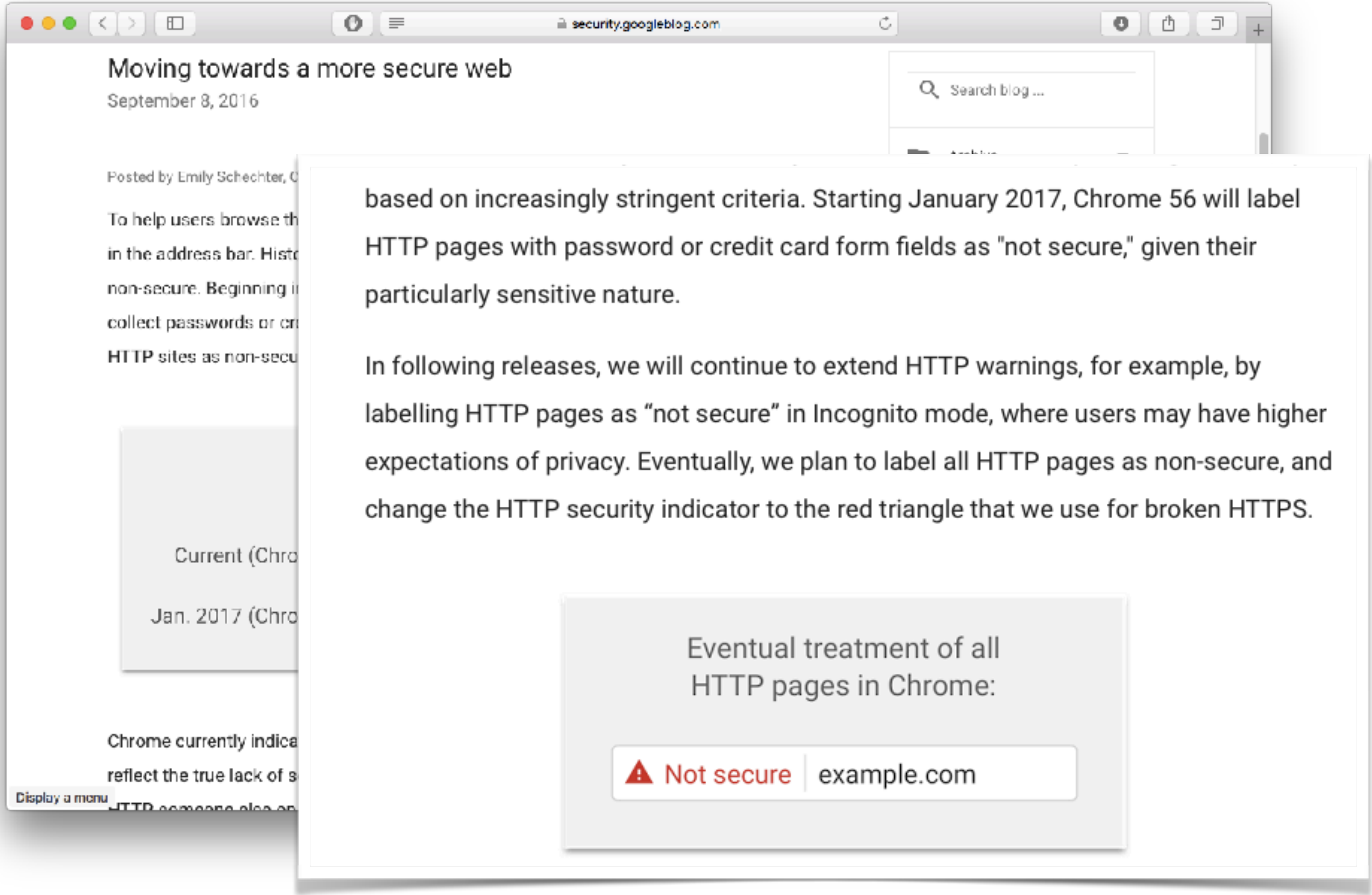
Human Cognition

SWE 432, Fall 2016

Design and Implementation of Software for the Web

GEORGE MASON UNIVERSITY

Show & Tell



security.googleblog.com

Moving towards a more secure web

September 8, 2016

based on increasingly stringent criteria. Starting January 2017, Chrome 56 will label HTTP pages with password or credit card form fields as "not secure," given their particularly sensitive nature.

In following releases, we will continue to extend HTTP warnings, for example, by labelling HTTP pages as “not secure” in Incognito mode, where users may have higher expectations of privacy. Eventually, we plan to label all HTTP pages as non-secure, and change the HTTP security indicator to the red triangle that we use for broken HTTPS.

Eventual treatment of all HTTP pages in Chrome:

Not secure | example.com

Today

- How do humans think?
- What makes taking action hard?
- Where do errors come from?

What is this emotion?

System 1 vs System 2

System 1

- Automatic (unconscious)
- Effortless
- “Fast” thinking
- Associative
- Heuristic
- Gullible
- Can’t be turned off

System 2

- Voluntary (conscious)
- Effortful
- “Slow” thinking
- Planning
- Logical
- Lazy
- Usually only partly on

Examples of System 1

- Detect that one object is more distant than another.
- Orient to the source of a sudden sound.
- Complete the phrase “bread and…”
- Make a “disgust face” when shown a horrible picture.
- Answer to 2 + 2 = ?
- Drive a car on an empty road.
- Understand simple sentences.

Examples of System 2

- When System 1 does not offer an answer (e.g., 17 x 24)
- When an event is detected that violates the model of the world that System 1 maintains (e.g., cat that barks)
- Continuous monitoring of behavior—(keeps you polite when you are angry)
- Normally has the last word

Attentional resources are fixed

- Demo

Attentional resources are fixed

- System 2 activity requires attention
- Attentional resources are fixed
- Pupils dilate as mental effort increase
- If demands exceed max, tasks prioritized.

Examples of attention limitations

- Can walk and talk
- But not walk and compute 23 x 78
- Constructing complex argument better when still

Coexistence of Systems 1 and 2

- System 1 processes normal, everyday, expected activities at low cost.
- System 2 takes over when necessary, at higher cost.
- Law of least effort: pays for System 2 to be lazy.

Memory

Short term memory (STM)

- Primary, active memory used for holding current context for System 2
- Unless actively maintained (or encoded to long-term memory), decays after seconds
- Capacity ~ 4 items
  - (classic estimate of 7 +/- 2 is wrong)

Chunking: What's easiest to remember?

- A lock combination with 8 numbers in order: 10, 20, 30, 40, 50, 60, 70, 80
- A lock combination with 8 numbers in order: 50, 30, 60, 20, 80, 10, 40, 70
- A string of 10 letter: R, P, L, B, V, Q, M, S, D, G
- A string of 52 letters: I pledge allegiance to the flag of the United State of America.

Chunking

- Items in memory encoded as **chunks**
- A chunk may be anything that has meaning
- # of chunks in STM fixed, but remembering bigger chunks lets you remember more
- Memory retention relative to the concepts you already have

Long term memory (LTM)

- Items in short term memory may be encoded into storage in long term memory
- LTM capacity not limited
- Information must be retrieved from long term memory (i.e., through System 1)
- Many factors influence what is encoded into LTM and how it is encoded

Memory is reconstructive - example

- How fast was the car going when it hit the other vehicle?

vs.

- How fast was the the car going when it smashed into the other vehicle?
- 2x more remember seeing broken glass

Memory is reconstructive

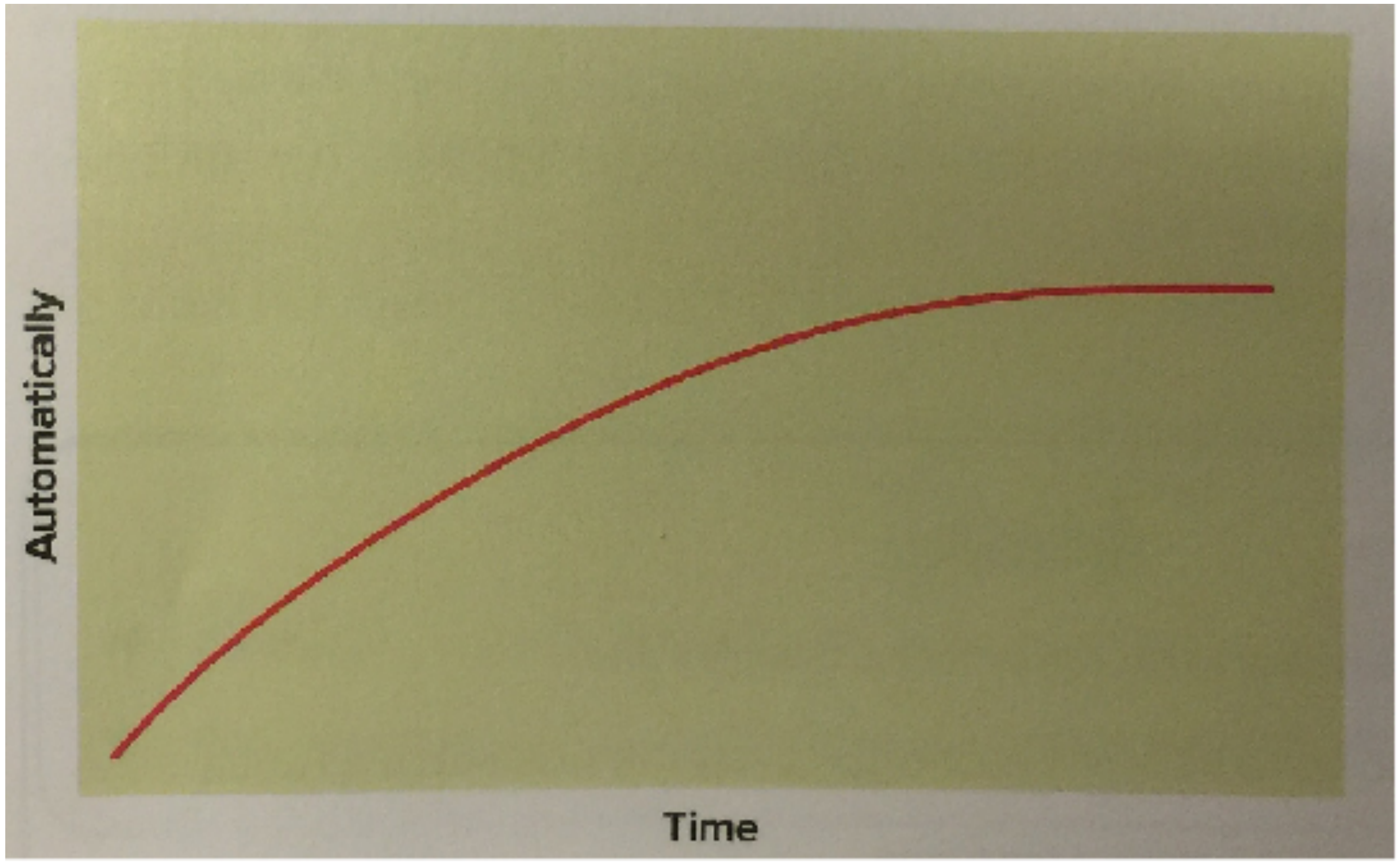
- Not stored files on a disk
- Encoded in brain, may be different every time retrieved
- Remember pieces, reconstruct other details based on expectations on what must have occurred
- Hard to distinguish similar memories

Automaticity

- This effect happens for sequences of actions (“**scripts**”) as well.
  - Example: tying shoelaces
- More repetitions, faster, requires less conscious attention.
- Responsibility shifts from System 2 —> System 1

Habit formation takes time

- How long does it take to form a eating, drinking, or activity habit?
- Mean: 66 days, Min: 18 days, Max: 254 days
- More complex behaviors take longer to become habit



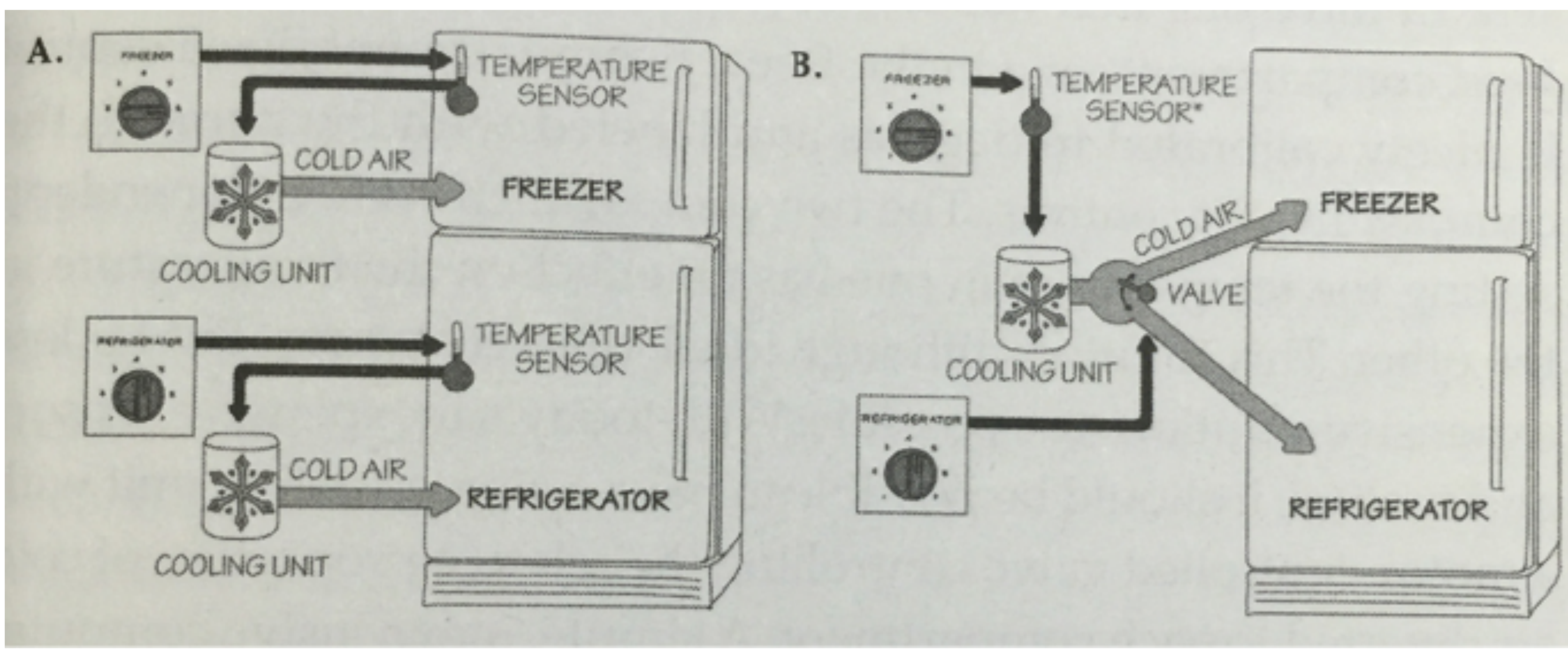
Mental models and taking action

Mental models (a.k.a conceptual models)

- Internal representation in the head of how something works in the real world
- E.g., changing appropriate knob adjusts temperature in freezer or refrigerator

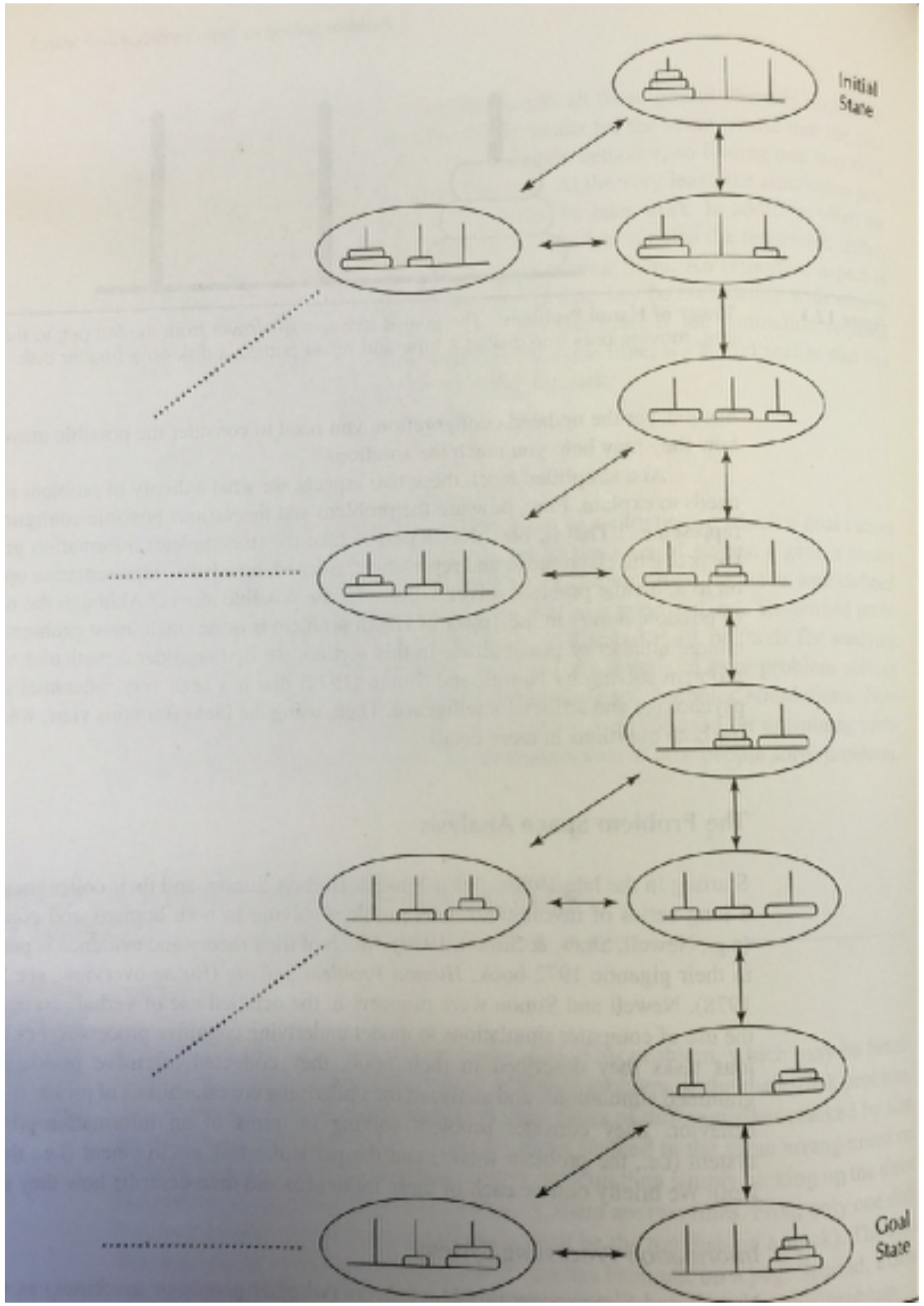
Mental models

- Only single temperature sensor.
- Controls not independent, need to adjust both.
- (also delayed feedback)



Problem solving

- Tower of Hanoi
- Move all the discs from left to right
- No larger disc may be above smaller disc
- "Planning Problem"

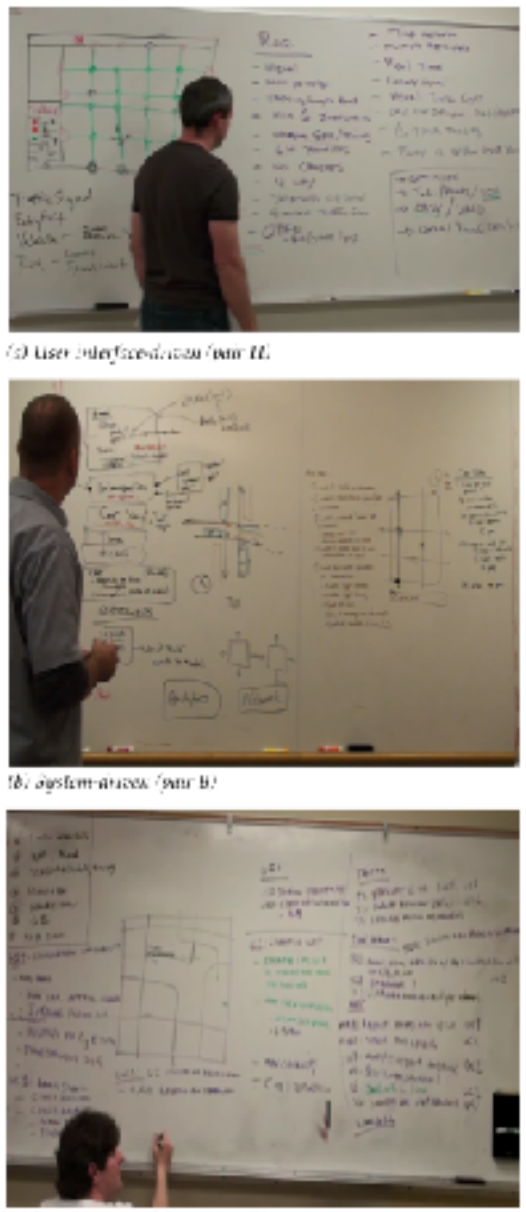


Problem solving as planning

- Goal state: state of the world to be achieved
- Operators: ways of changing the current state
- Plan: sequence of actions to take to achieve goal

Problem Solving in UIs

Achieving goals



(a) User interface-driven (pair H).

(b) System-driven (pair B).

(c) Requirements-driven (pair [illegible]).

Figure 5. Each pair focused their efforts on a specific aspect of the design.

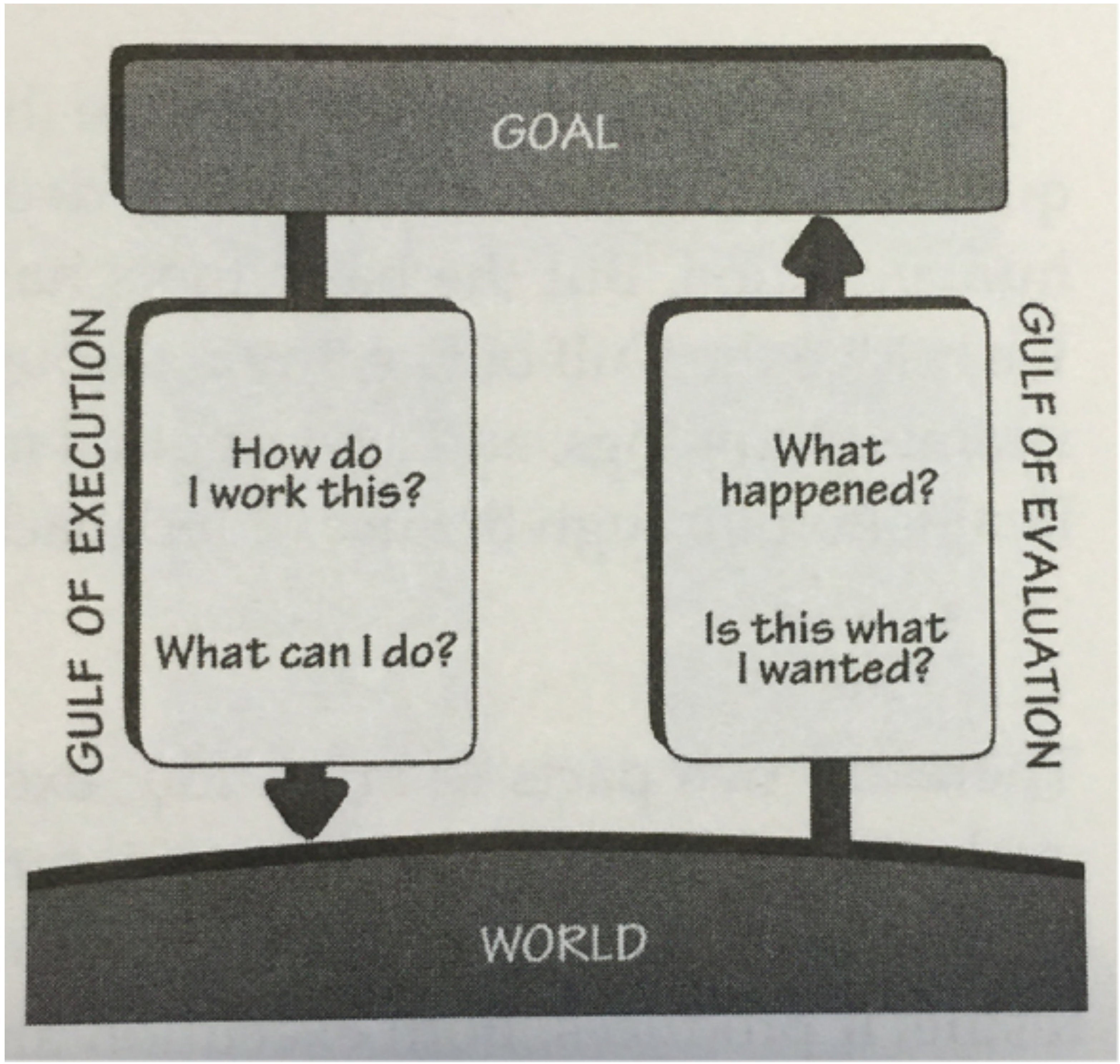
User-interface-driven. User-interface-driven pairs (A, C, G, H) generally asked themselves: "How can users use our system to accomplish their goals?", focusing on front-end sketches and discerning how to get input from the user and display a result. These pairs relied heavily on user interface sketches to structure and organize their work (Figure 3, Figure 5a).

Reflecting the traffic simulator problem domain, the user-interface-driven pairs made frequent use of maps ([illegible] of session time) to brainstorm user interactions and support discussion of the problem. Maps also served as a hub: pairs frequently shifted attention to a map before shifting to a sketch of a different sketch type.

Lists were the second most common sketch type for

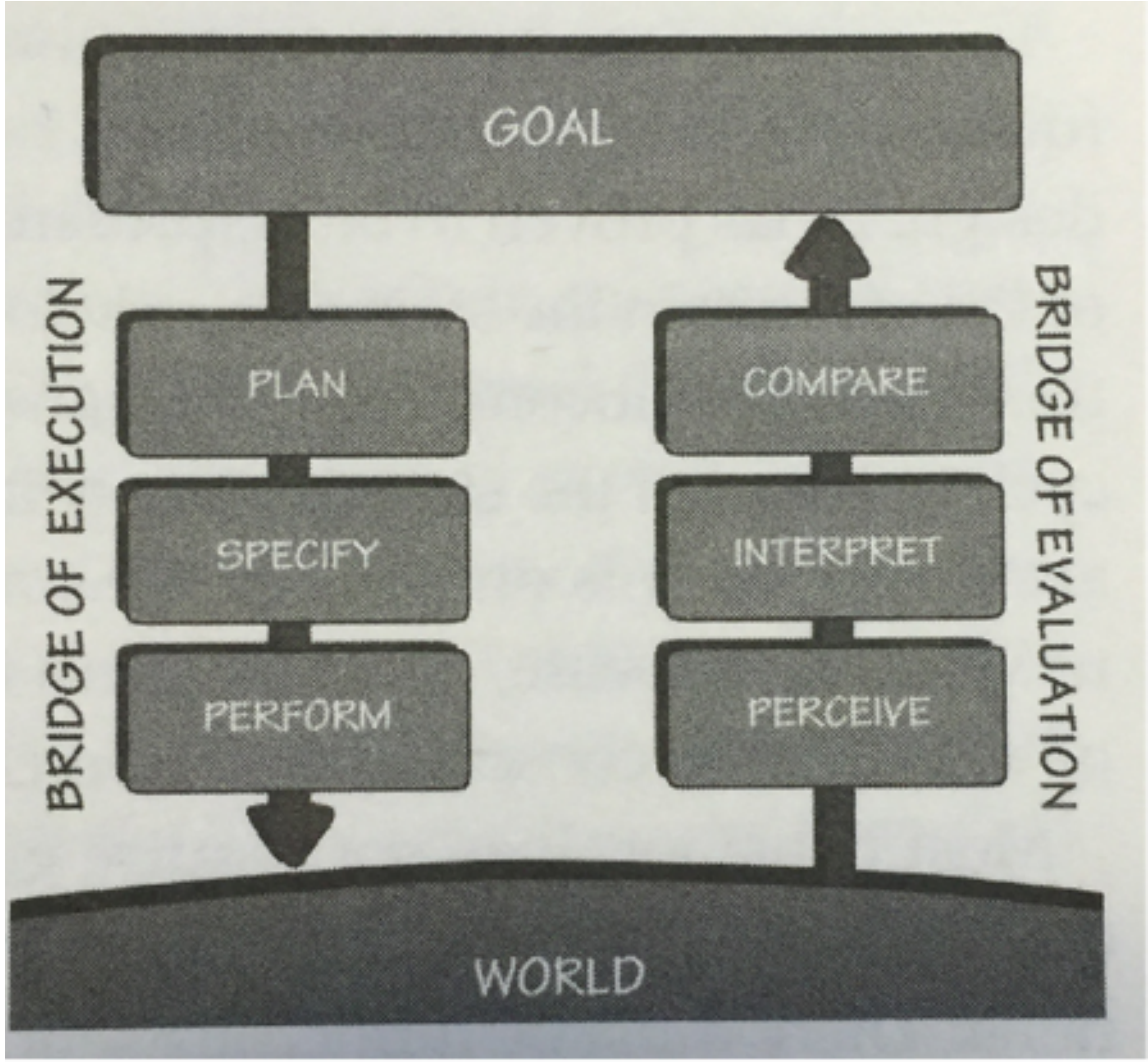
- Given this word document
- Make text flow into empty space
    - How?
- User takes action to problem solve

Norman's gulfs of execution and evaluation



Norman's 7 stages of action

1. Goal (form the goal)
2. Plan (the action)
3. Specify (action sequence)
4. Perform (action sequence)
5. Perceive (the state of the world)
6. Interpret (the perception)
7. Compare (outcome w/ goal)

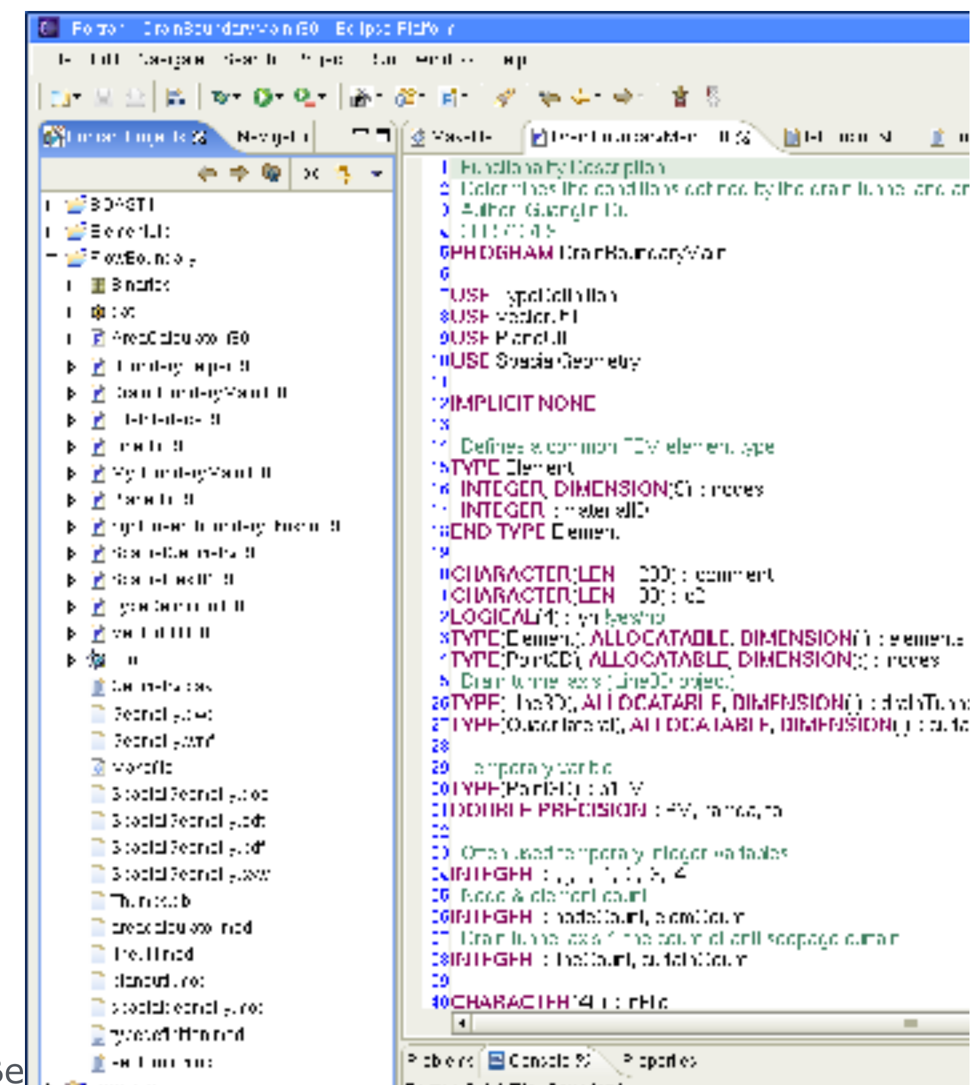


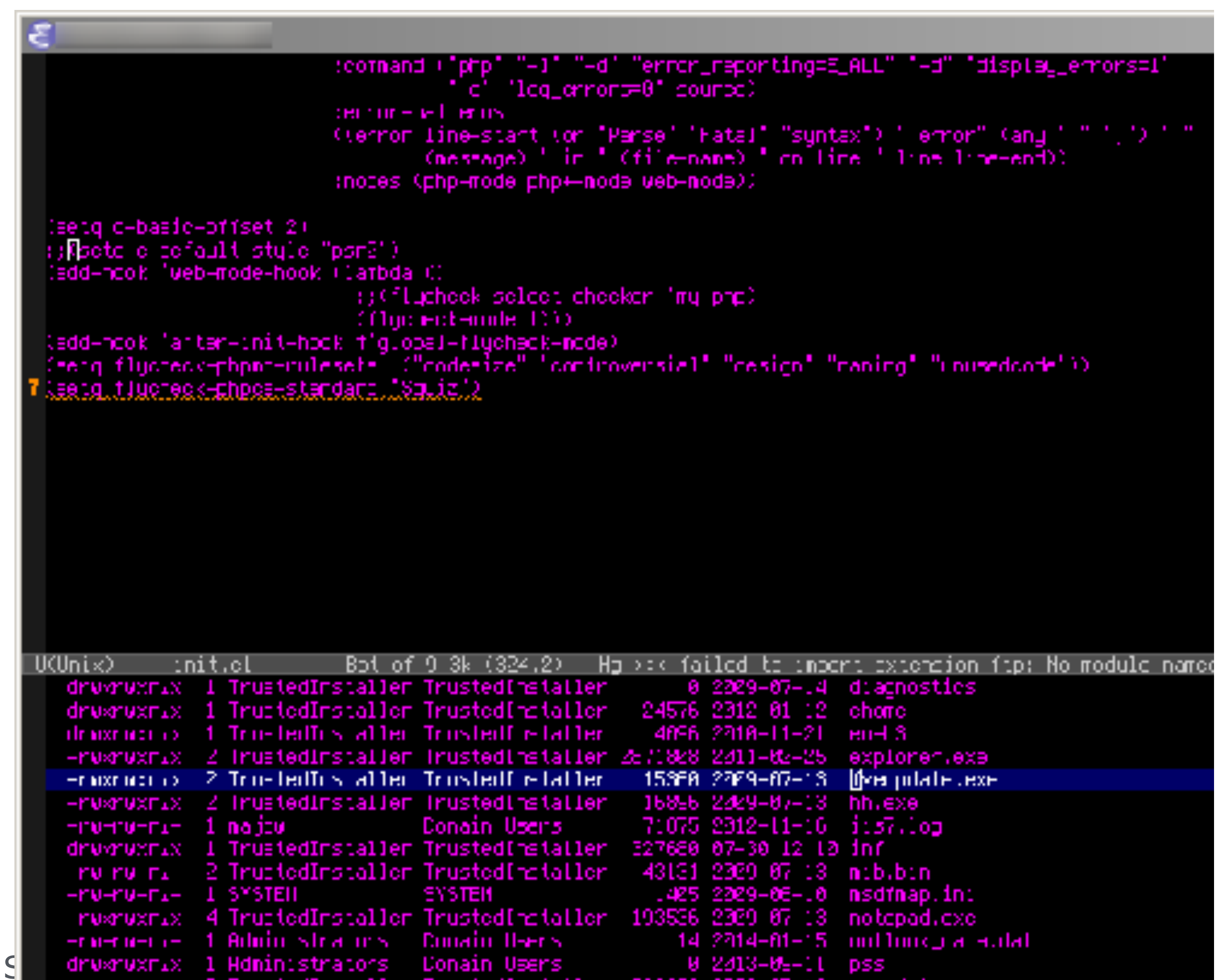
Designing for action

- Key challenge is designing interactions that help users to accomplish their goals

1. Discoverability

- Make it possible to determine possible actions and current state of device
- Which has more discoverable commands: Eclipse or emacs?



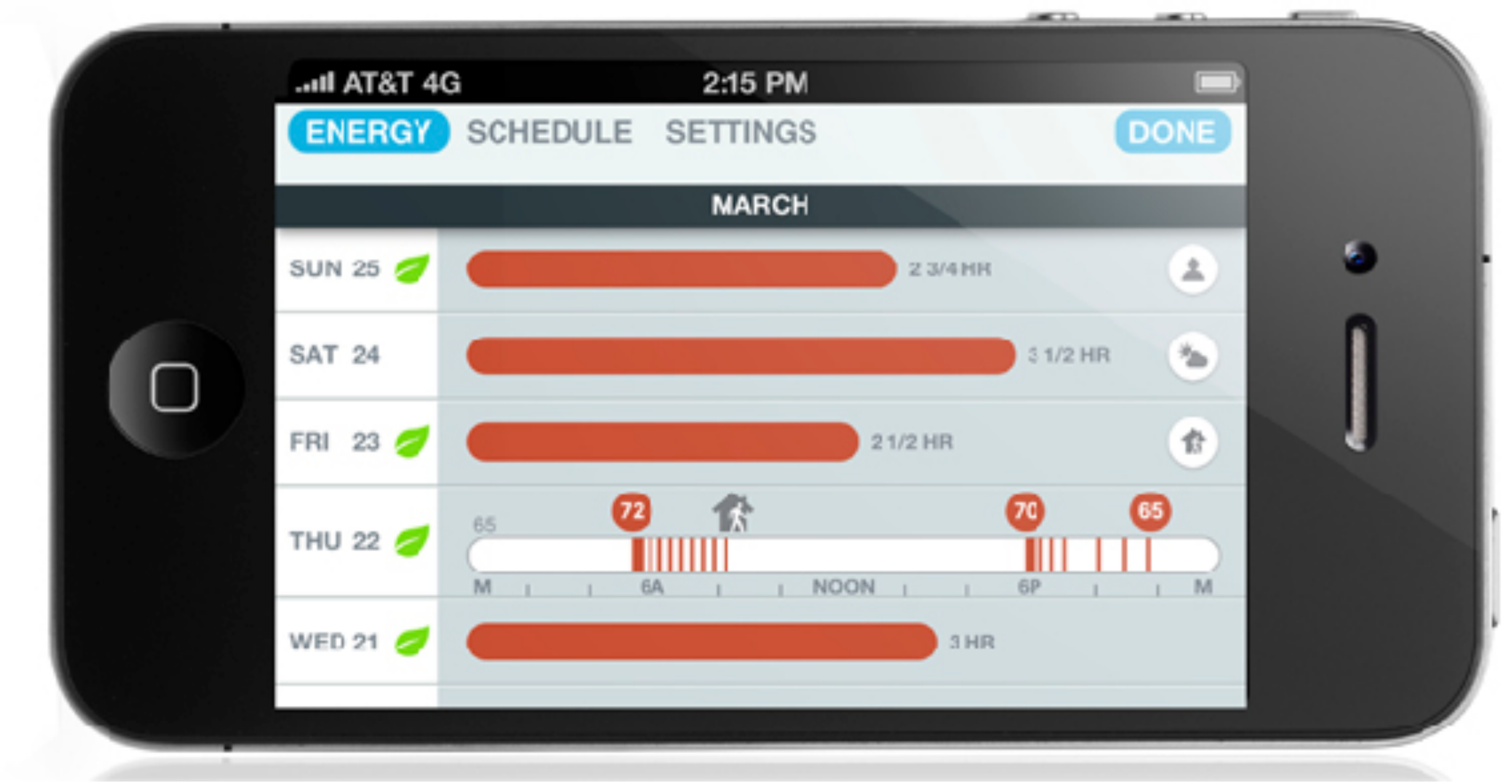


2. Feedback

- There is full and continuous info about the results of actions and the current state

3. Conceptual model

- Design projects all of the information needed to create conceptual model.



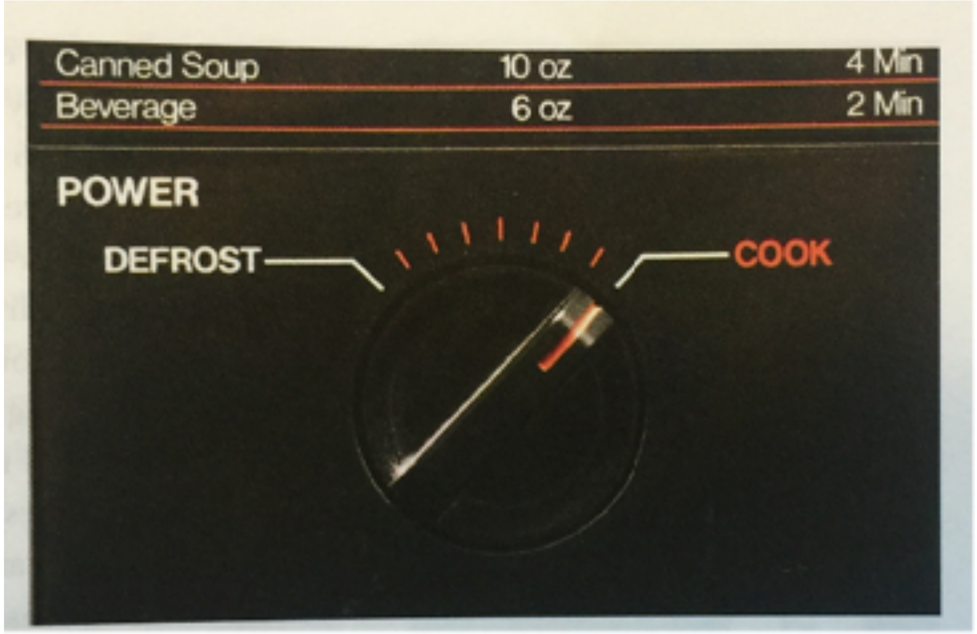
4. Affordances

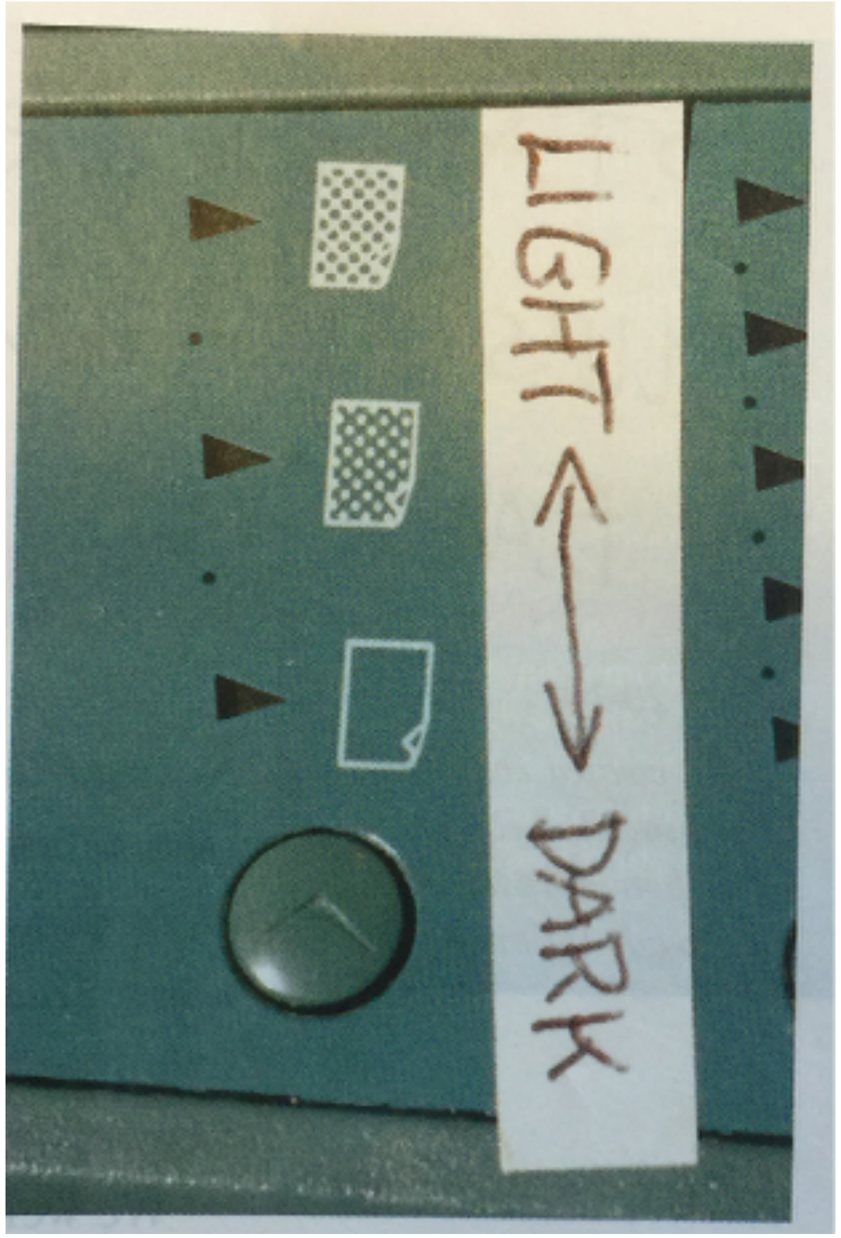
- The proper affordances exist to make the desired actions possible.
- Affordance: an action that can be taken with an artifact to change its state

Browser	Tabbed browsing	Pop-up blocking [note 1]	Incremental search	Ad filtering	Page zooming [note 2]	Full text search of history	Content-modal dialogs[note 3]
Amaya	Yes	N/A	No	No	Yes	No	?
AOL Explorer	Yes	Yes	No	No	Yes	No	?
Arora	Yes	Yes	Yes	Yes	Yes	No	No
Avant	Yes	Yes	No	Yes	Yes	No	?
Camino	Yes	Yes	Yes	Yes	Yes	No	?
Chromium	Yes	?	Yes	?	Yes	?	?
Dillo	Yes	N/A	No	No	No	No	No
Dooble	Yes	Yes	Yes	Yes	Yes	Yes	?
ELinks	Yes	N/A	Yes	N/A	N/A	No	No[note 4]
Flock	Yes	Yes	Yes	Yes	No	No	?
Galeon	Yes	Yes	Yes	Yes	Yes	No	No
Google Chrome	Yes	Partial [note 5]	Yes	No [note 6]	Yes	Yes	No[note 7]
iCab	Yes	Yes	No	Yes	Yes	No	?
Internet Explorer	Yes [note 8]	Yes [note 9]	Yes	Yes	Yes	Yes [note 10] [53]	No
Internet Explorer for Mac	No	No	No	No	No	No	N/A

5. Signifiers

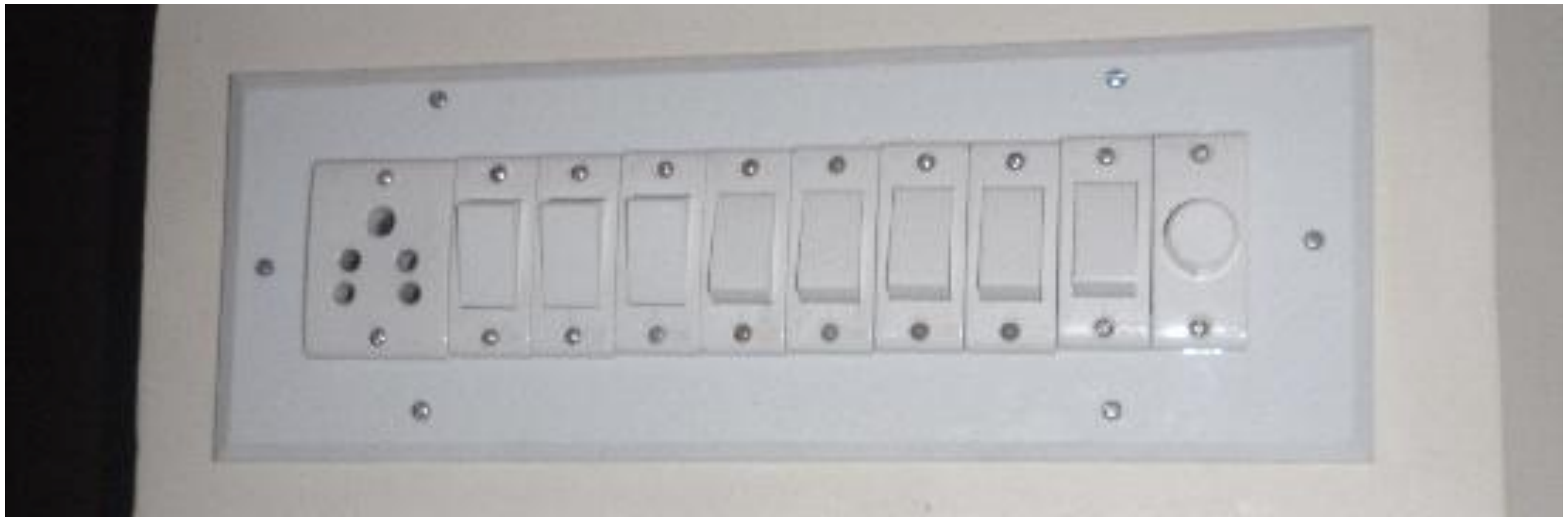
- Effective use of signifiers to communicate discoverability and feedback



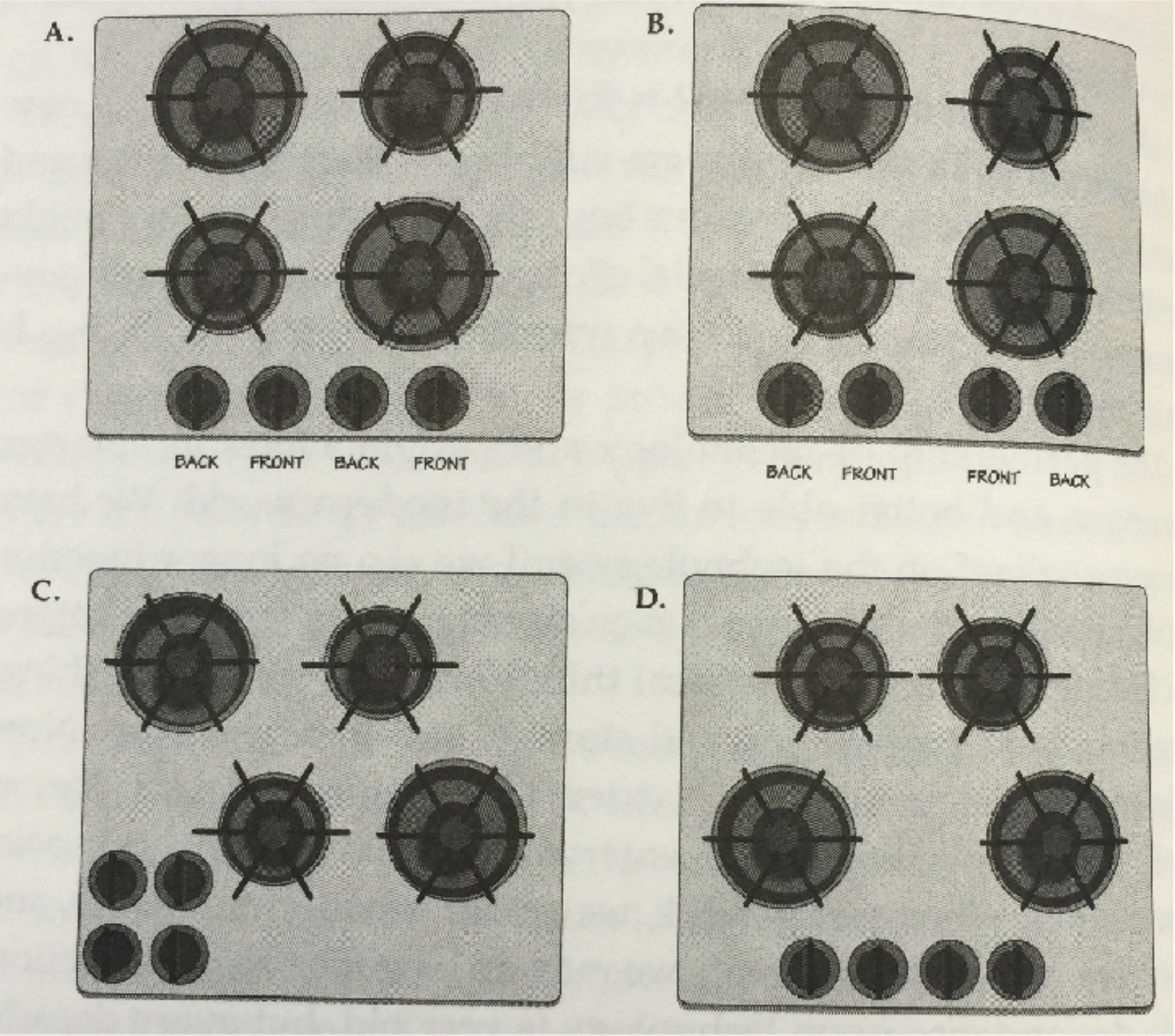


6. Mapping

- The relationship between controls and their actions follows the principles of good mapping



Example - burners

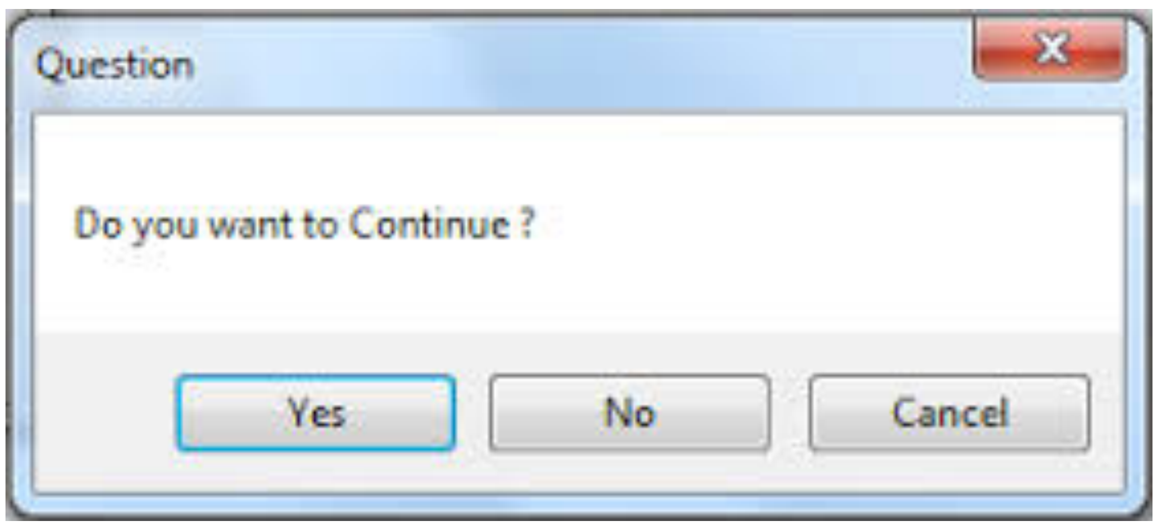


Natural mapping

- Best mapping: controls mounted next to item to be controlled
- Second best mapping - controls as close as possible to item to be controlled
- Third best mapping - controls arranged in same spatial configuration

Consistent mapping

- Control consistently leads to same action
- Facilitates System 1 - taking action always leads to the same effect



7. Constraints

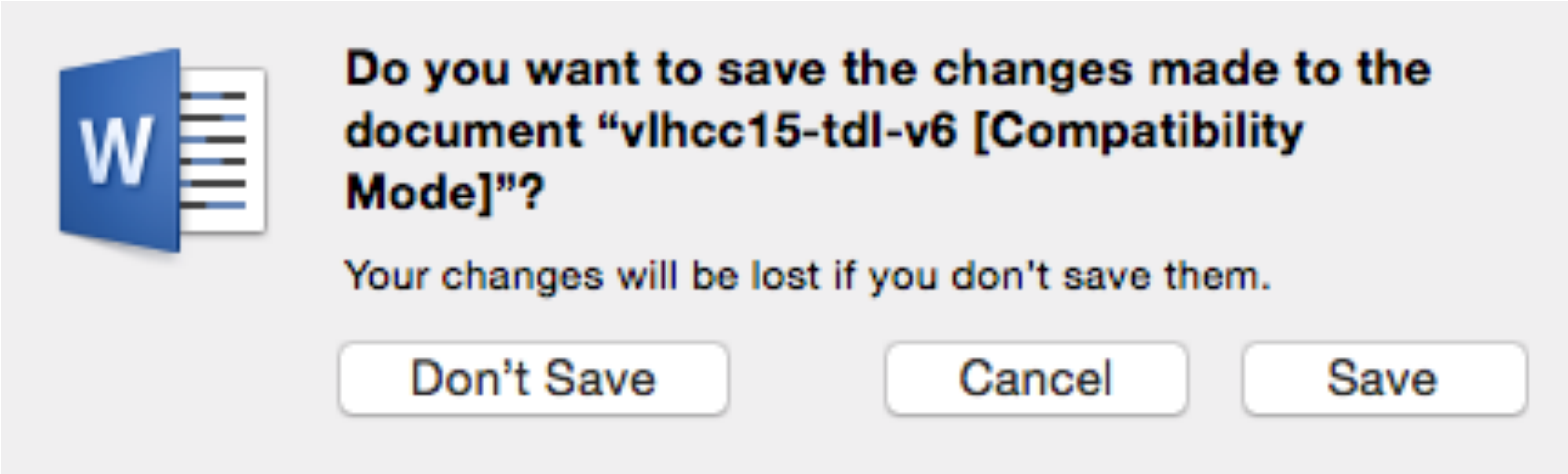
- Provide physical, logical, semantic, cultural constraints to guide actions and ease interpretation

Physical constraints

- Constrain possible operators (e.g., round peg, square whole)
- Rely on properties of artifact, no training required

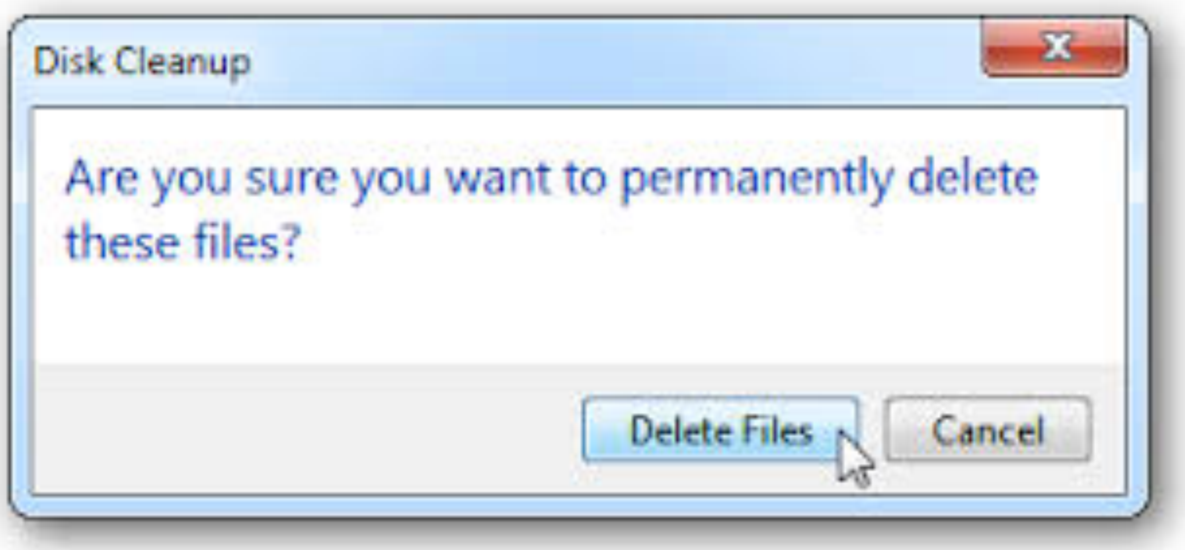
Lock ins

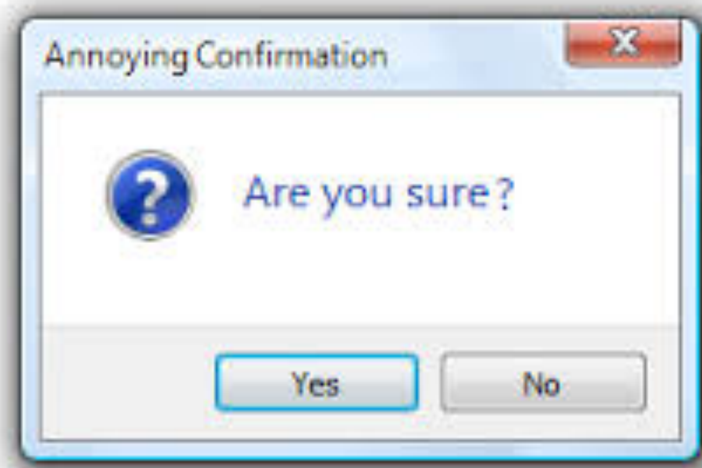
- Keeps an operation active, preventing someone from prematurely stopping



Lock outs

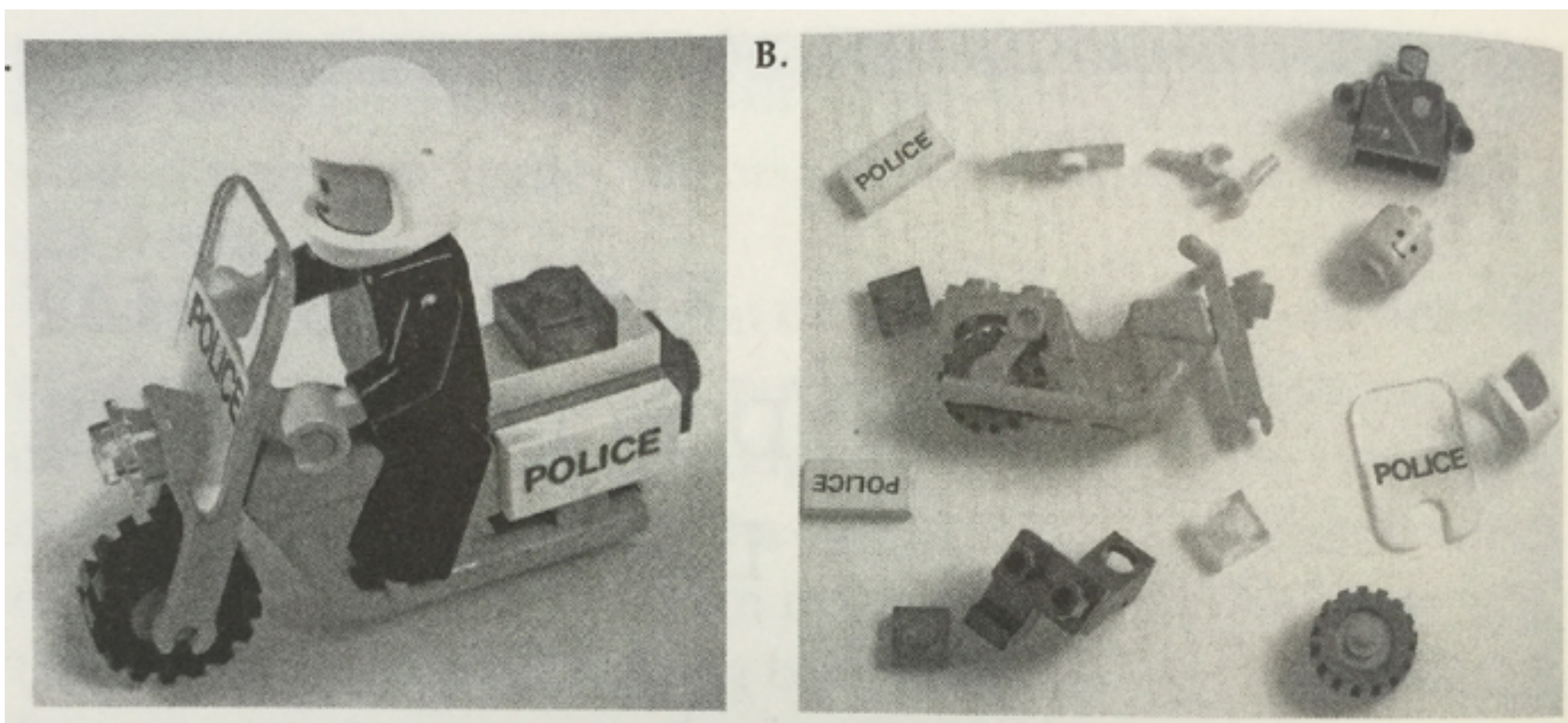
- Prevents an event from occurring





Cultural, semantic, logical constraints

- Norms, conventions that describe possible actions
- Some constraints come from our basic shared understanding of the world: where does the head go?



Example: faucets

- Control 2 variables: temperature, rate of flow
- Physical model: water enters through 2 pipes
- Solutions:
    - Separate controls for hot and cold
    - Control only temp / control only ant
    - On / off
    - One control

Example: faucets

- Mapping problems:
  - Which controls hot and which cold?
  - How do you change temperature w/ out flow rate?
  - How do you change flow w/out temperature?
  - Which direction increases water flow?

Example: faucets

- Standard conventions: left hot, right cold; counter-clockwise turns it on
- But
    - Not in England
    - Not always on shower controls
    - Not always for blade controls

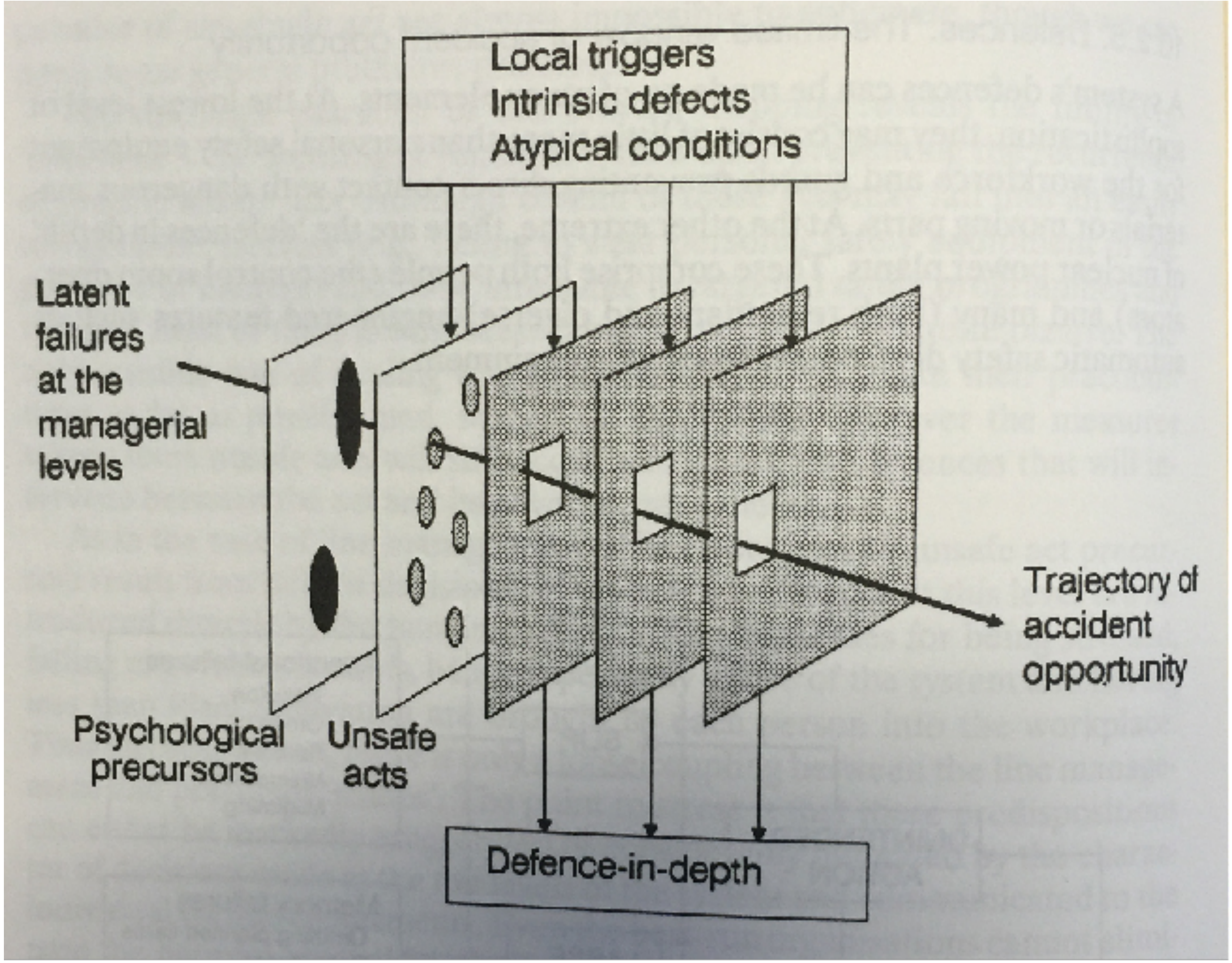
Human Error

What causes disasters?

- Mechanical malfunction?
- Poor design?
- Human error?

Swiss cheese model

- Accidents must penetrate levels of system defenses



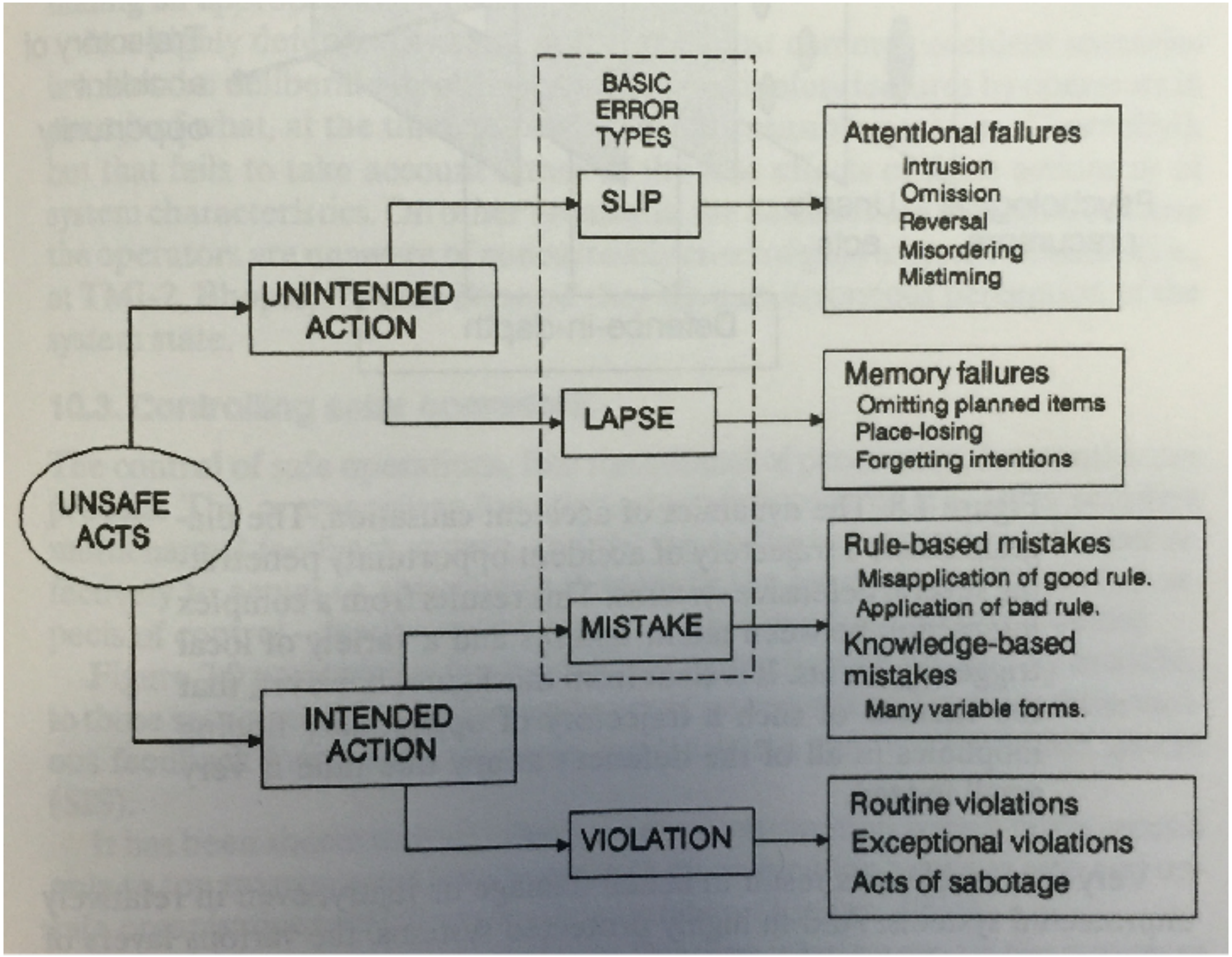
Root cause analysis

- Keep asking question to determine causes for actions
- Human error only part of the chain
- Example
  - 2010 F-22 crash that killed pilot
  - Official cause: pilot error - pilot failed to take corrective action
  - IG report: pilot was probably unconscious

Case Study No. 1: Three Mile Island

Chain of events and active errors	Contributing conditions and latent failures
Maintenance crew introduces water into the instrument air system.	Although this error had occurred on two previous occasions, the operating company had not taken steps to prevent its recurrence. *(Management failure)*
Turbine tripped. Feedwater pumps shut down. Emergency feedwater pumps come on automatically, but flow blocked by two closed valves.	The two block valves had been erroneously left in the closed position during maintenance, probably carried out two days prior to the accident sequence. One of the warning lights showing that valves were closed was obscured by a maintenance tag. *(Maintenance failures)*
Rapid rise in core temperature and pressure, causing the reactor to trip. Relief valve (PORV) opens automatically, but then sticks in the open position. The scene is now set for a loss of coolant accident (LOCA) 13 seconds into the emergency.	During an incident at the Davis – Besse plant (another Babcock & Wilcox PWR) in September 1977, the PORV also stuck open. The incident was investigated by Babcock & Wilcox and the U.S. Nuclear Regulatory Commission. However, these analyses were not collated, and the information obtained regarding appropriate operator action was not communicated to the industry at large. *(Regulatory failure)*
Operators fail to recognise that the relief valve is stuck open. Primary cooling system now has hole in it through which radio – active water, under high pressure, pours into the containment area, and thence down into basement.	1. Operators were misled by control panel indications. Following an incident 1 year earlier, an indicator light had been installed. But this merely showed whether or not the valve had been commanded shut: it did not directly reveal valve status. *(Design and management failures)* 2. Operators wrongly assumed that high temperature at the PORV drain pipe was due to a chronically leaking valve. The pipe temp – erature normally registered high. *(Management/ procedural failure)*
Operators failed to diagnose stuck – open PORV for more than 2 hours. The resulting water loss caused significant damage to the reactor.	1. The control panel was poorly designed with hundreds of alarms that were not organised in a logical fashion. Many key indications were sited on the back wall of the control room. More than 100 alarms were activated with no means of suppressing unimportant ones. Several instruments went off – scale, and the computer printer ran more than 2 hours behind events. *(Design and management failures)* 2. Operator training, consisting largely of lectures and work in the reactor simulator, provided an inadequate basis for coping with real emergencies. Little feedback given to students, and training programme was insufficiently evaluated. *(Training and management failures)*
The crew cut back the high – pressure injection (HPI) of the water into the reactor coolant system, thus reducing the net flow rate from around 1000 gallons/min to about 25 gallons/min. This 'throttling' caused serious core damage.	1. Training emphasised the dangers of flooding the core. But this took no account of the possibility of a concurrent LOCA. *(Training and management failures)* 2. Following the 1977 Davis – Besse incident, the Nuclear Regulatory Commission issued a publication that made no mention of the fact that these operators had interrupted the HPI. The incident appeared under the heading of "valve malfunction" not "operator error". *(Regulatory failure)*

Reasons's Model of Unsafe Acts



Violation

- Error occurred because user **intended** the erroneous output
- Routine violation - user always intends to do it
    - Noncompliance is so frequent it is ignored
    - E.g., running a red light
- Exceptional - only in some cases
- Sabotage - intended destruction

Mistakes

- User **formulated** the wrong goal or plan
  - Executing action will not achieve goal
- Rule based: appropriately diagnosed situation, but chosen erroneous course of action
- Knowledge based: does not have correct information

Slips

- Attentional failure - user **intended** to do correct action, but did not actually execute action
- Example: forgot to turn off the gas burner on the stove after cooking

Lapse: Strong habit intrusion

- Performance of some well-practiced activity in familiar surroundings
- Intention to depart from custom
- Failure to make an appropriate check
- Example: start trip to frequent destination, forget going somewhere else

Lapse: Omissions

- May be interrupted, forgetting intention to act
- “I picked up my coat to go out when the phone rang. I answered it and then went out of the front door without my coat.”