Human Cognition

SWE 632

Fall 2024

GEORGE MASON UNIVERSITY

Logistics

- Anyone still looking for a project group or tech talk group?

- HW0: due today
- HW1: due in 2 weeks
- Tech Talk Schedule
- Academic Standards Office Presentation today

A Note on Writing Use Cases

- Should be written from the **User's** perspective
- Should focus on a **specific goal** that the user is trying to complete
- Should *briefly* explain **how** the user gets there
- *Good Example:*
  - In the car rental page the user will be able to enter all of the required information to rent a car including the pickup and drop off location, the amount of time required, and the number of days required.
- *Bad Example:*
  - The car rental page provides information and actions for renting cars.

Class Overview

Class Overview

- *Part 1 - Human Cognition:* Why is this important for us?
- *Part 2 - Human Psychology 101:* Abridged for Engineers
- *Part 3 - Design Implications of Human Psychology:* People Matter
- *10 minute Break*
- *Part 4 - Group Activity:* Norman’s Designing for Action Principles

In Class Discussion

- *Today's question:*
  - What makes someone an expert?

What Makes Someone an Expert?

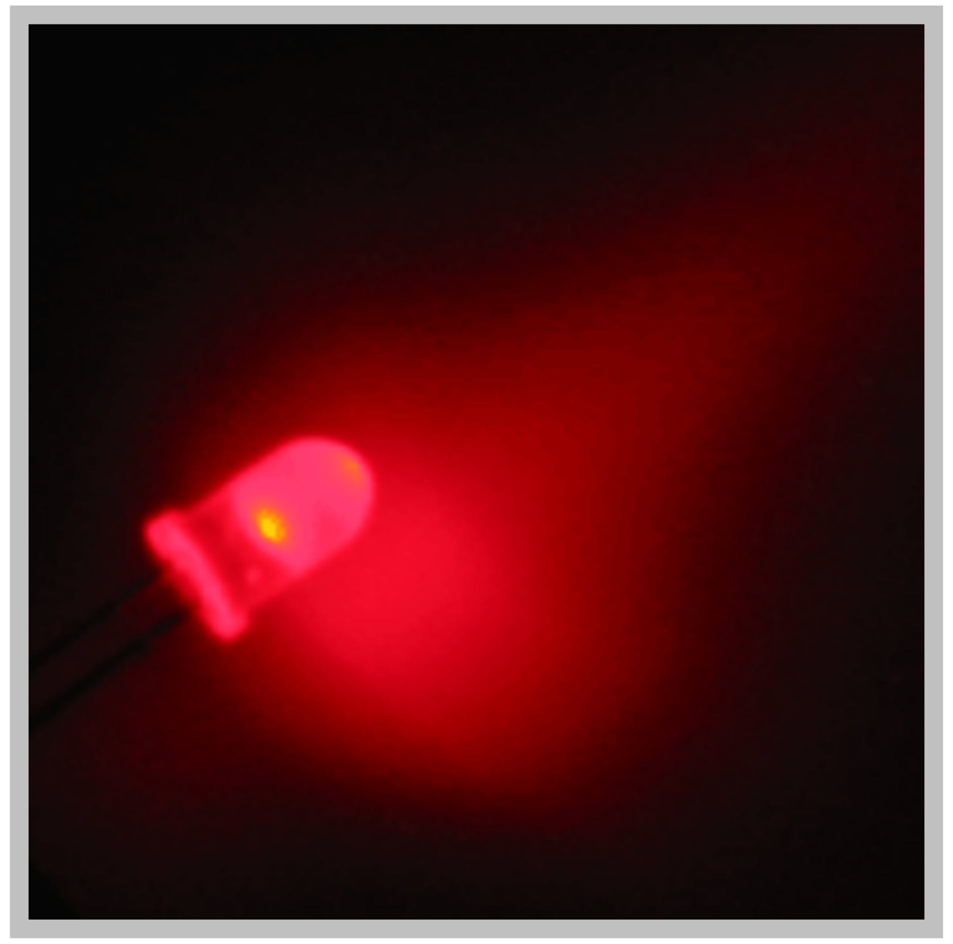
- We will revisit this later in the lecture…

Why is Human Cognition Important?

Importance of Understanding People

Real World Example: 3 Mile Island

Real World Example: 3 Mile Island



Thinking Fast and Slow

17 x 24 =

Two Types of Human Cognition

Type 1 System

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

Type 2 System

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

Examples of System 1

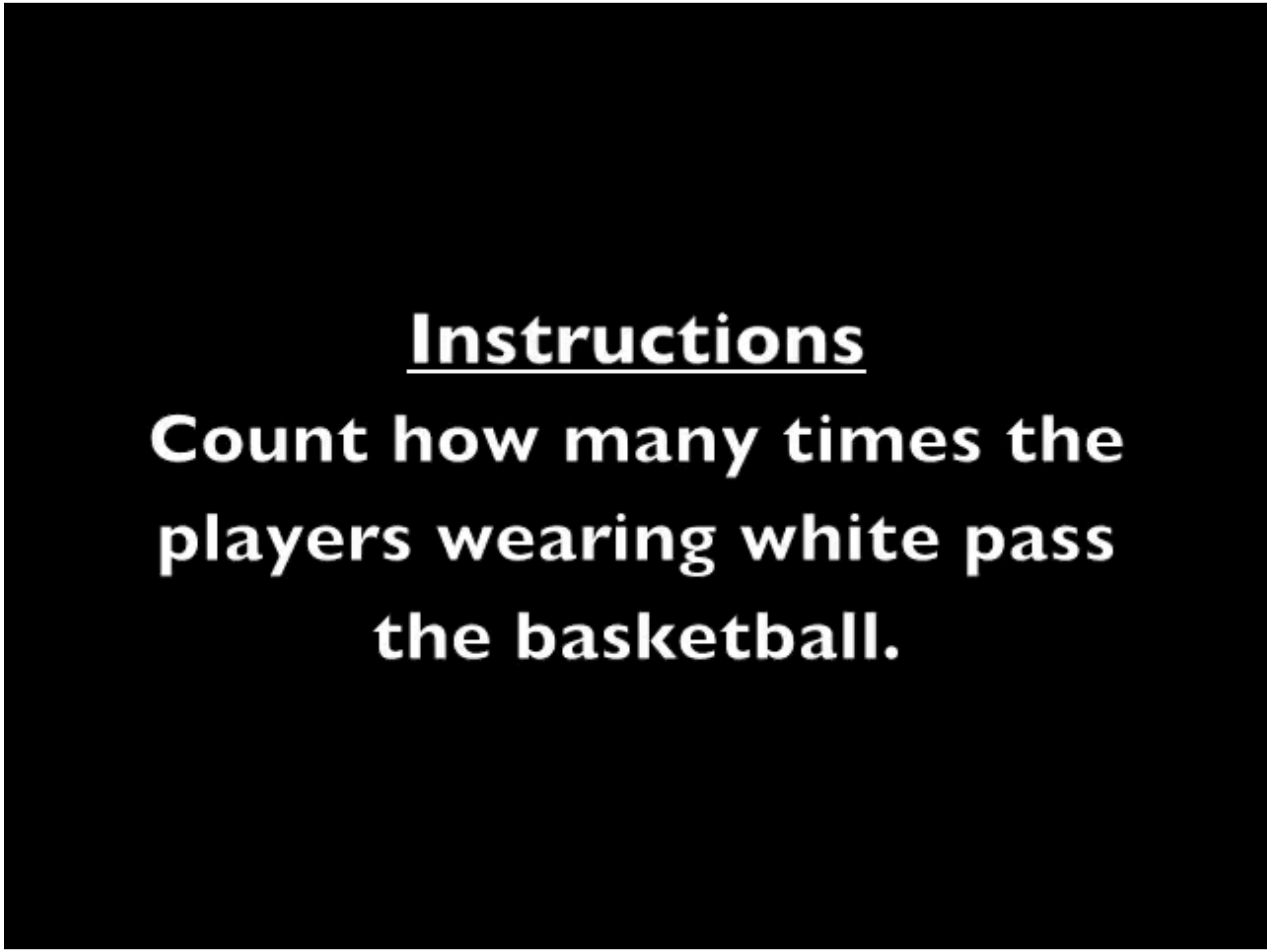
- Detect that one object is more distant than another.
- Orient to the source of a sudden sound.
- Complete the phrase “bread and…”
- Make a “disgust face” when shown a horrible picture.
- Answer to 2 + 2 = ?
- Drive a car on an empty road.
- Understand simple sentences.

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

<u>Psychology 101</u>: Attention

Attentional Resources are Fixed



Attentional Resources are Fixed

Attentional Resources are Fixed

- System 2 activity takes conscious 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

Attentional Limitations - Demo

- Remember the following digits:
- 8 3 5 2 1 9 0 5 1

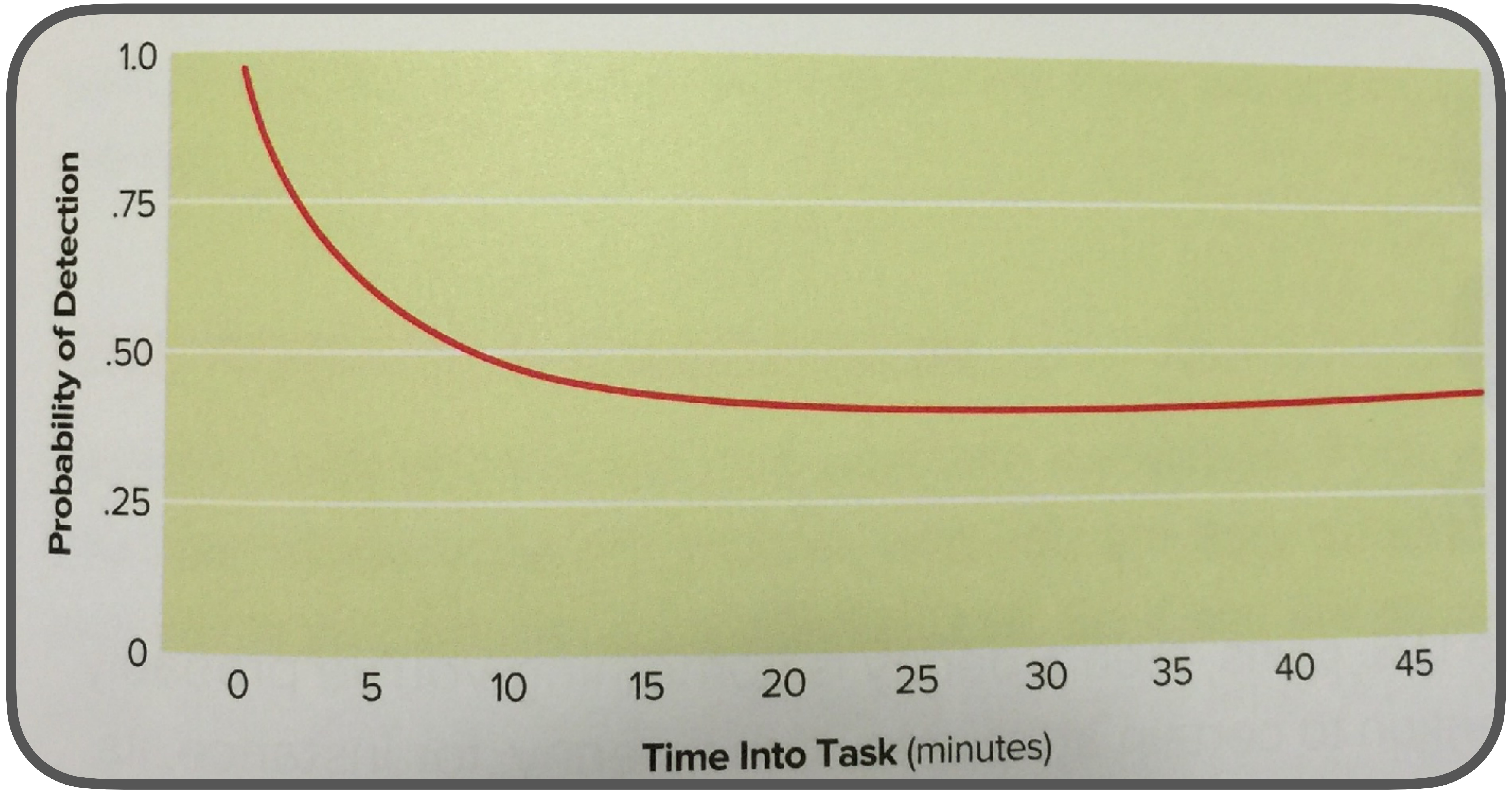
Attentional Limitations - Demo

- Would you prefer
- (a) (b)

Attentional Limitations - Demo

- More likely to choose (a) when attentional resources are stressed
- Self control require attention and effort

Intense focus is unsustainable



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.

Psychology 101: 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

Chunking - Demo

What is the easiest to remember?

A. A lock combination with 8 numbers in order: 10, 20, 30, 40, 50, 60, 70, 80

B. A lock combination with 8 numbers in order: 50, 30, 60, 20, 80, 10, 40, 70

C. A string of 10 letter: R, P, L, B, V, Q, M, S, D, G

D. 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
- —> schemas & mental models (next lecture!)

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.

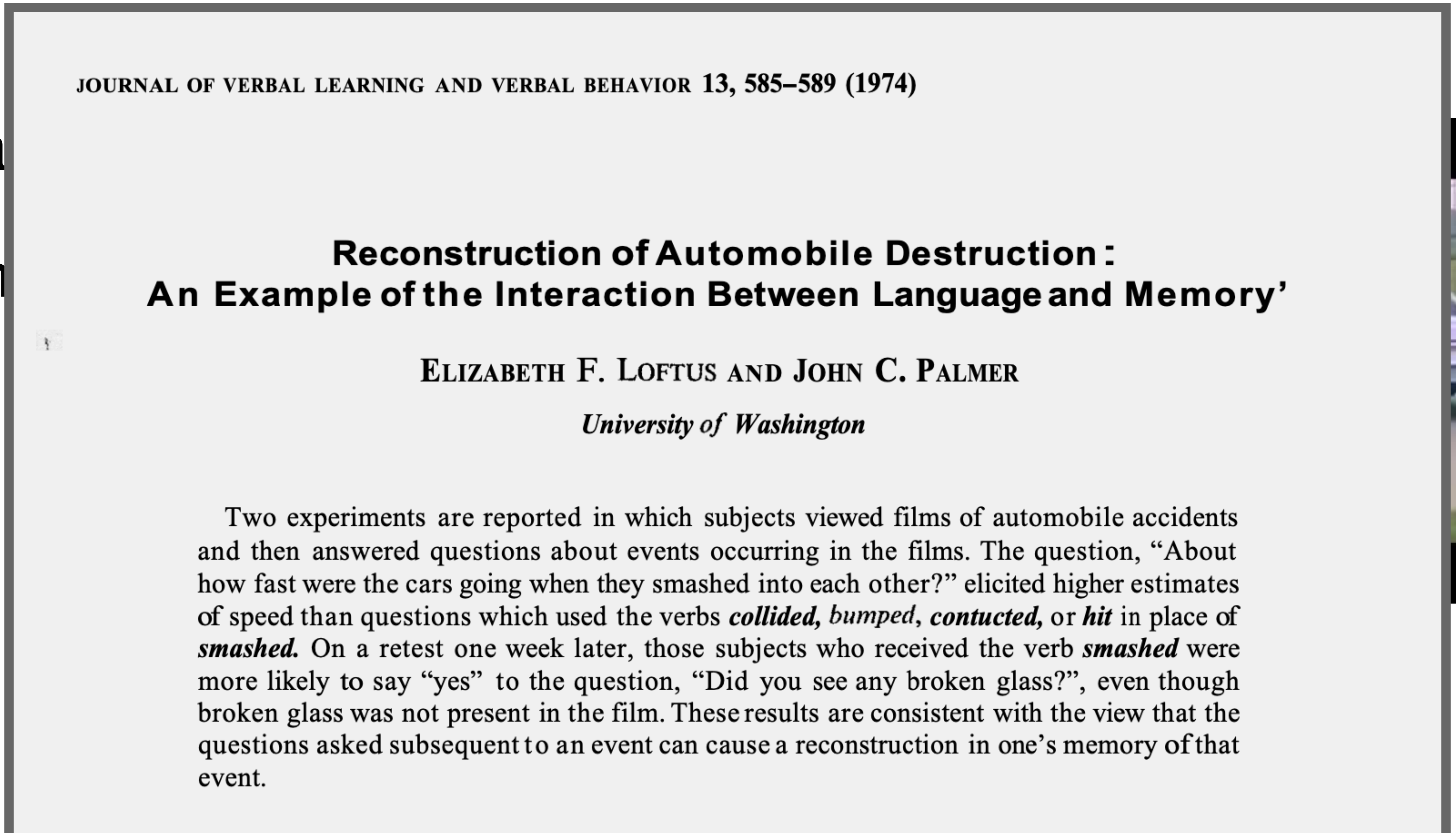
- How fast was the the car going when it smashed into the other vehicle?
- 2x more remember seeing broken glass

Memory is Reconstructive - Example

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

vs.

- How fast wa ?
- 2x more rem

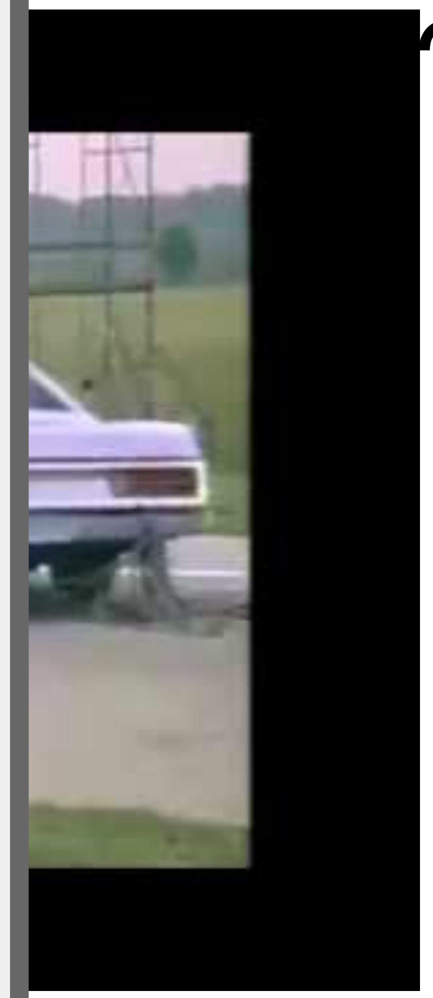

JOURNAL OF VERBAL LEARNING AND VERBAL BEHAVIOR 13, 585–589 (1974)

Reconstruction of Automobile Destruction: An Example of the Interaction Between Language and Memory'

ELIZABETH F. LOFTUS AND JOHN C. PALMER

University of Washington

Two experiments are reported in which subjects viewed films of automobile accidents and then answered questions about events occurring in the films. The question, "About how fast were the cars going when they smashed into each other?" elicited higher estimates of speed than questions which used the verbs ***collided, bumped, contucted,*** or ***hit*** in place of ***smashed.*** On a retest one week later, those subjects who received the verb ***smashed*** were more likely to say "yes" to the question, "Did you see any broken glass?", even though broken glass was not present in the film. These results are consistent with the view that the questions asked subsequent to an event can cause a reconstruction in one's memory of that event.



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

Psychology 101: Learning

Rehearsal

- Information may be repetitively experienced or actively repeated ("subvocalization")
- 232 535   487 235
- More times information is rehearsed, better memory

Depth of Processing

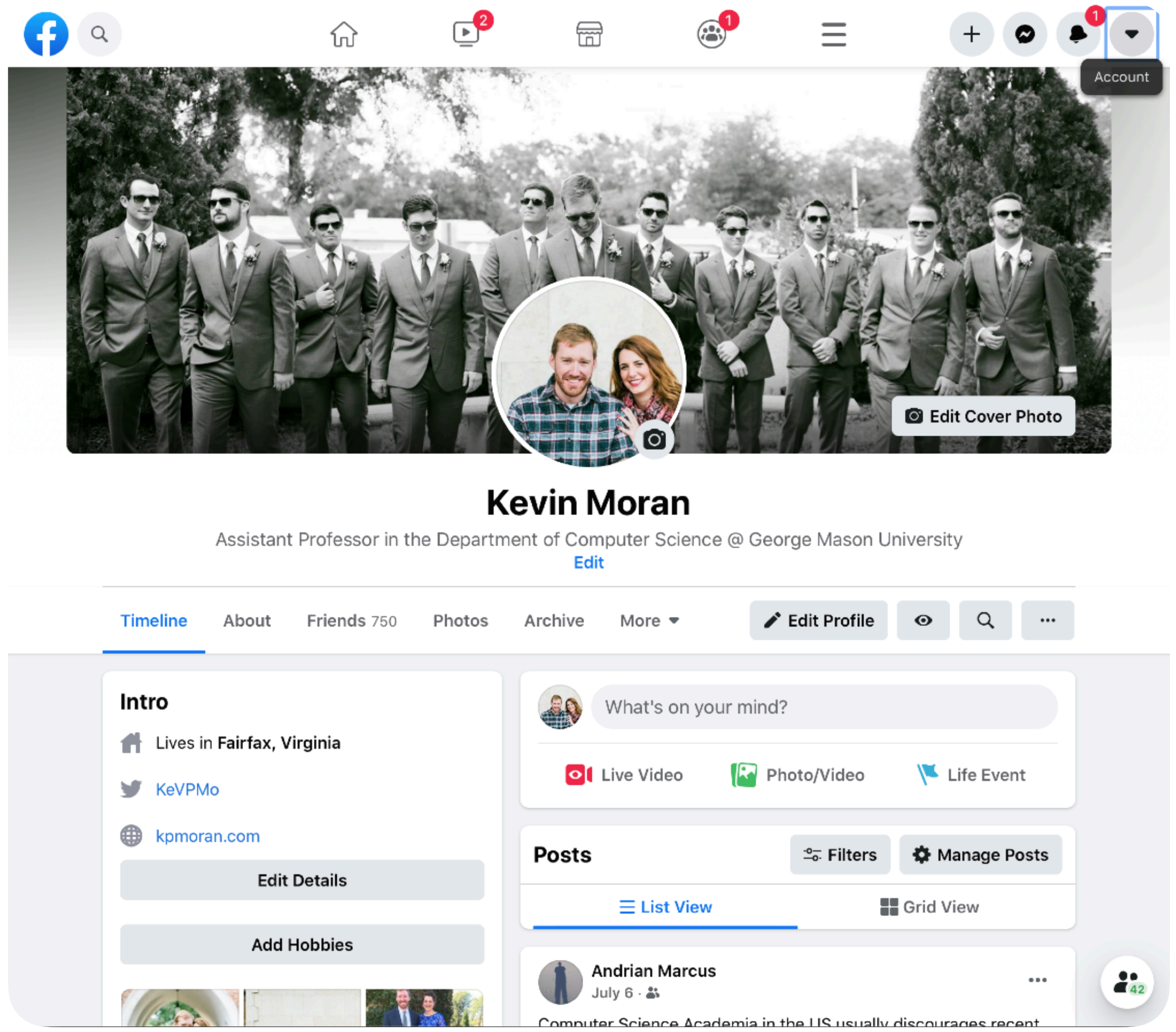
- More time spent interacting with information, more likely it is to be remembered

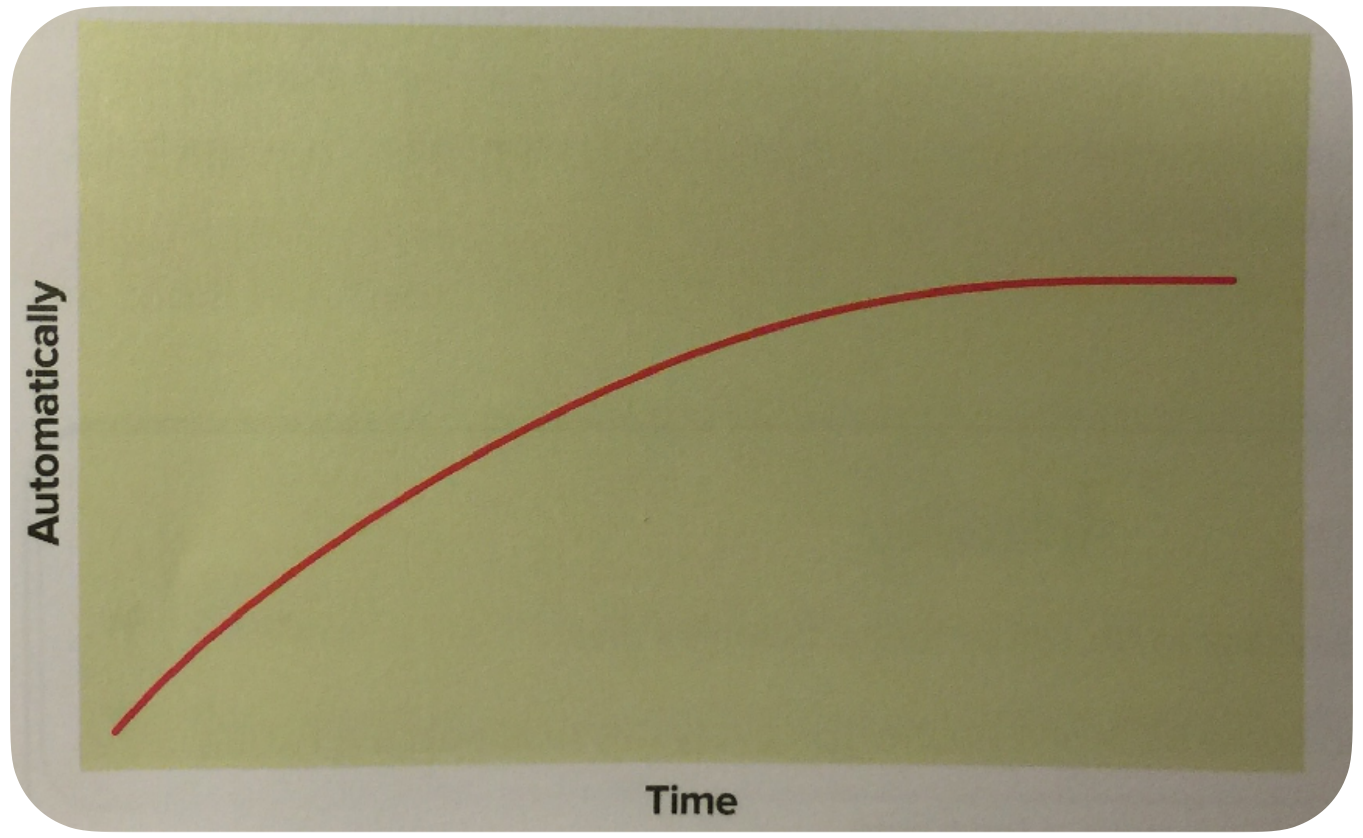
Automaticity

- 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 an eating, drinking, or checking FB before bed habit?
- Mean: 66 days, Min: 18 days, Max: 254 days
- More complex behaviors take longer to become habit





Habit formation takes time

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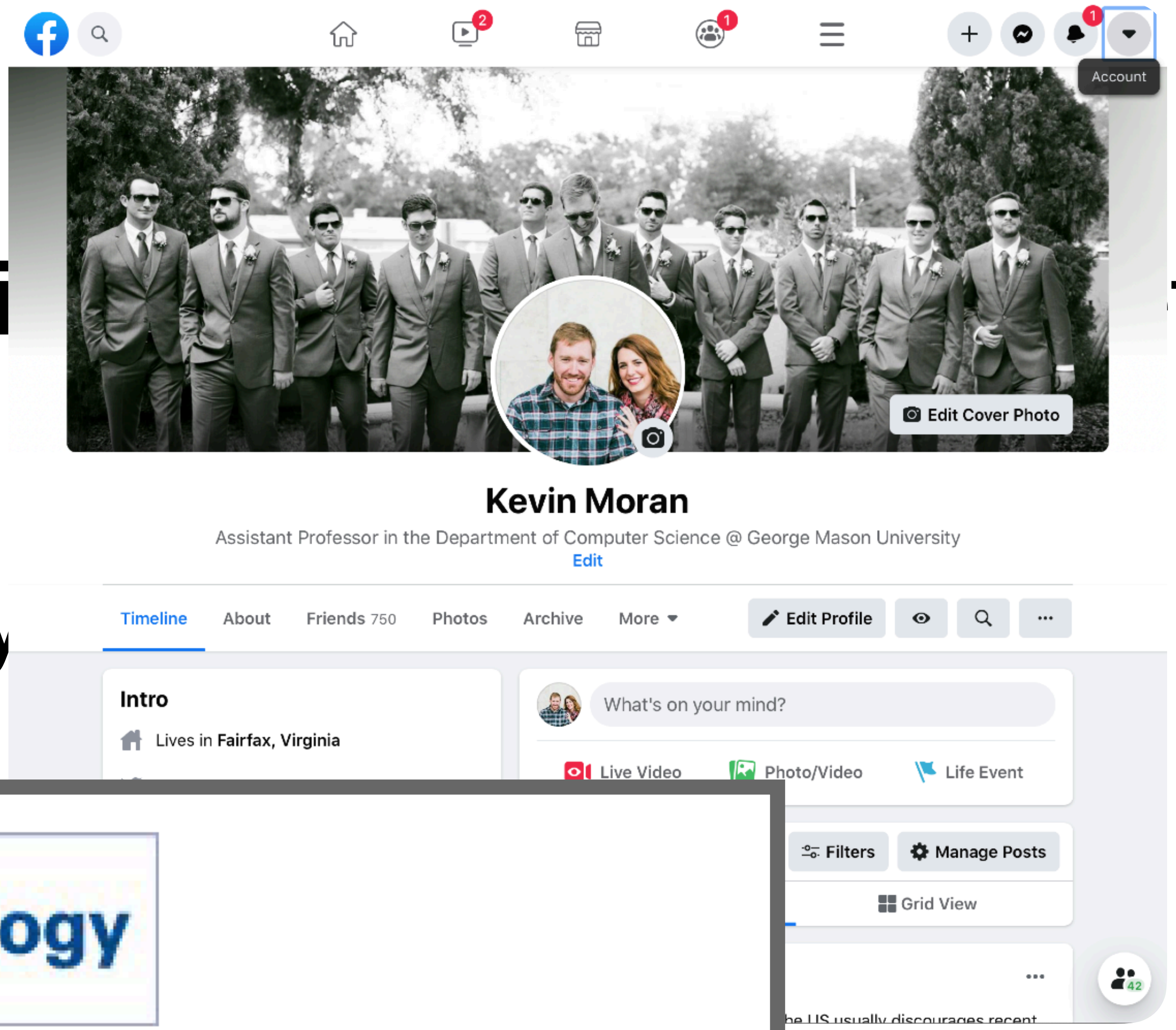
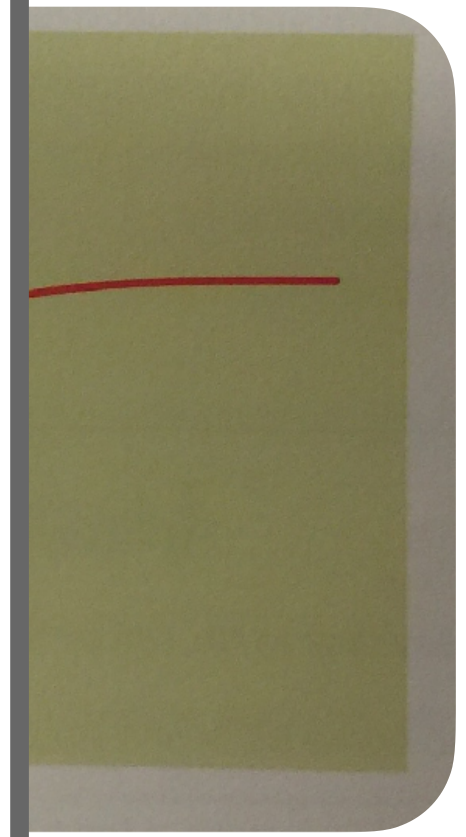




European Journal of Social Psychology

Research Article

How are habits formed: Modelling habit formation in the real world†

Phillippa Lally, Cornelia H. M. van Jaarsveld, Henry W. W. Potts, Jane Wardle

First published: 16 July 2009 | https://doi.org/10.1002/ejsp.674 | Citations: 500

† This research was conducted by Phillippa Lally when she held a Medical Research Council PhD studentship and has been written up during an Economic and Social Research Council postdoctoral fellowship.

Psychology 101: Affect

Affect

- Current emotional state
- ***Valence:*** positive or negative
- ***Arousal:*** strength of activation of sympathetic nervous system

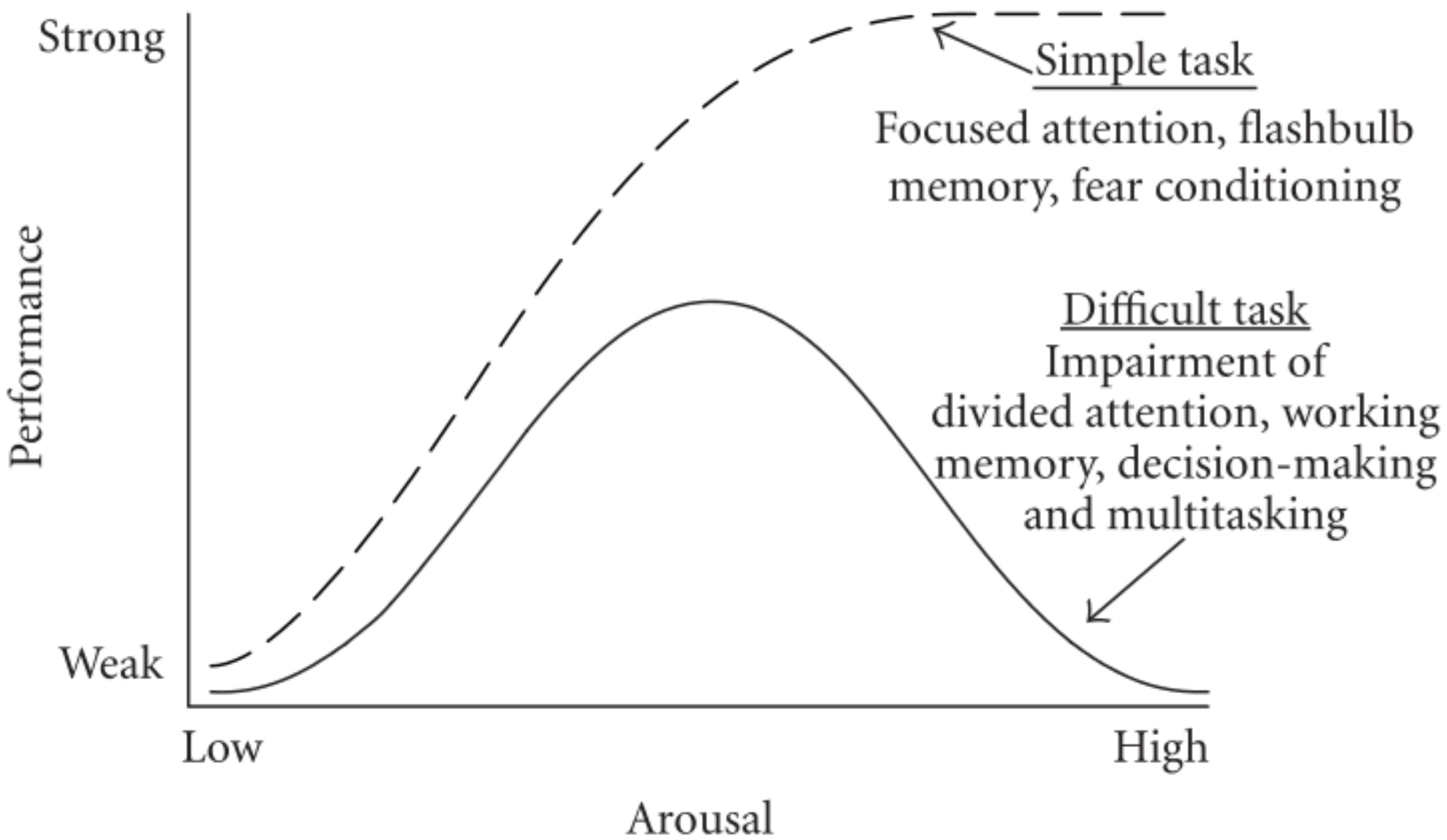
Affect Affects Focus and Creativity

- *Negative affect / high arousal*
  - Escape from danger
  - Fire & door doesn't open —> push harder
  - Neurotransmitted bias brain to focus on problem & ignore distractions
  - Tunnel vision on most salient aspects

- *Positive affect / lower arousal*
  - Better brainstorming and generating alternatives
    - More likely to work around minor difficulties —> better usability
    - See bigger picture, less focused

Performance / Arousal Curve

- Yerkes / Dodson law
- Arousal increases performance for System 1 tasks, but only increases performance on System 2 tasks up to a threshold



Design Implications from Psychology

General Design Implications

- Take advantage of System 1 where possible
- Don’t confuse System 1 (e.g., consistent mapping in next lecture)
- Users can be stubborn (sunk cost investment in current strategy)
- People can get upset when have goals they cannot accomplish, as attentional resources exhausted solving problem and less self control
- Let users doing something else while waiting

Design Implications: What Makes an Expert?

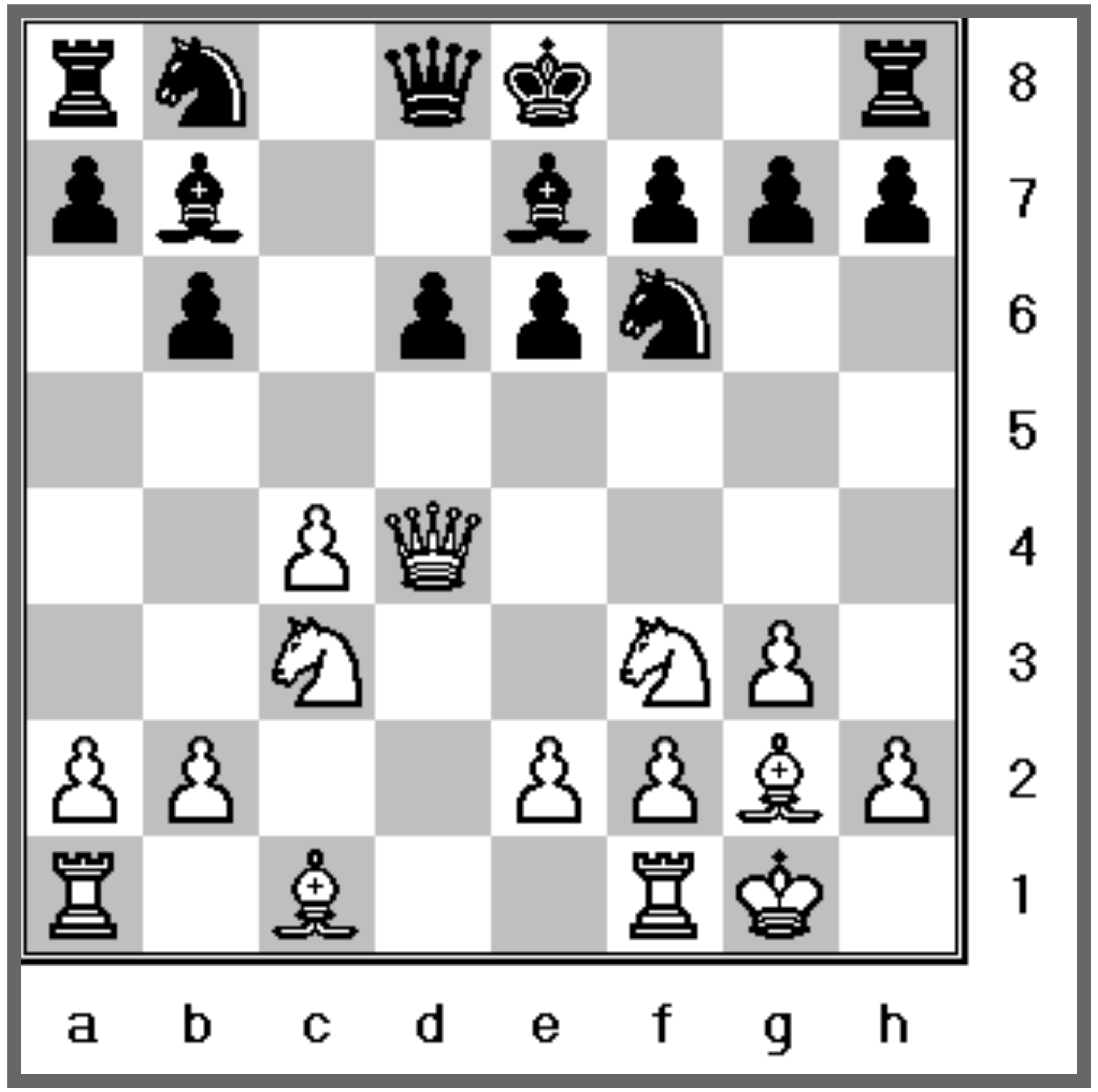
What Makes an Expert?

What Makes an Expert?

- Experts are more intelligent?
  - IQ doesn’t distinguish best chess players or most successful artists or scientists (Doll & Mayr 1987) (Taylor 1975)
- Experts think faster or have larger memory?
  - World class chess experts don’t differ from experts (de Groot 1978)

What Makes a Grand Master a Chess Expert?

- Memory for *random* chess boards: ***same*** for experts and novices
- Memory for position from ***actual*** game: much better for ***experts*** than novices
- [deGroot 1946; Chase & Simon 1973]



Schemas (a.k.a chunking)

- Experts *think differently*.
- Have schemas that help them to
  - Recognize and react to common situations through System 1
  - Encode the world in more abstract terms
  - Solve problems more effectively

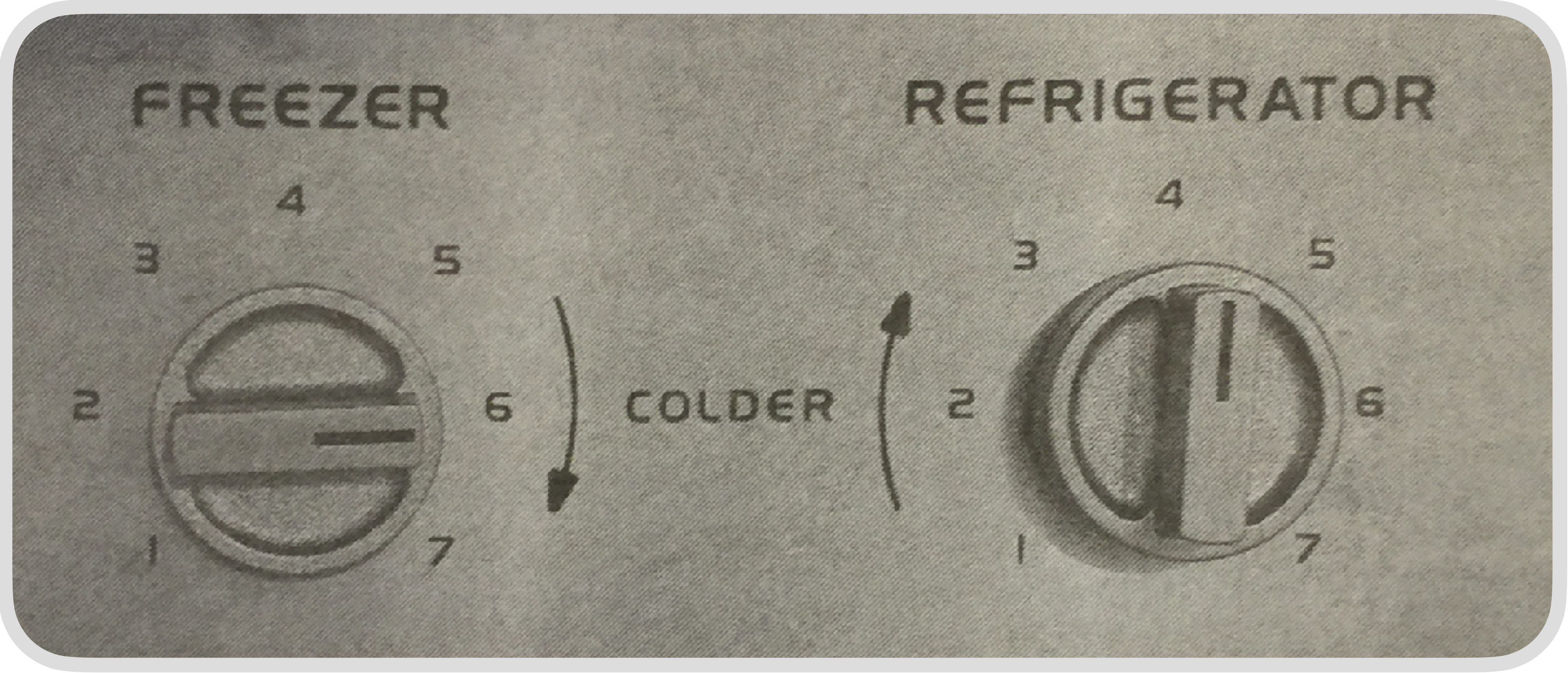
Don't Make the User Think

- Let users use (automatic) skills of System 1 rather than (conscious) knowledge-based problem solving of System 2
- Key principle (it's the title of one of the course textbooks....)
  - We'll come back to this idea often in the future
- What this means: let users think about everything except for interface interactions
  - If user goal is to write a document, want user thinking about what they're writing, not how to use word processor

Mental Models

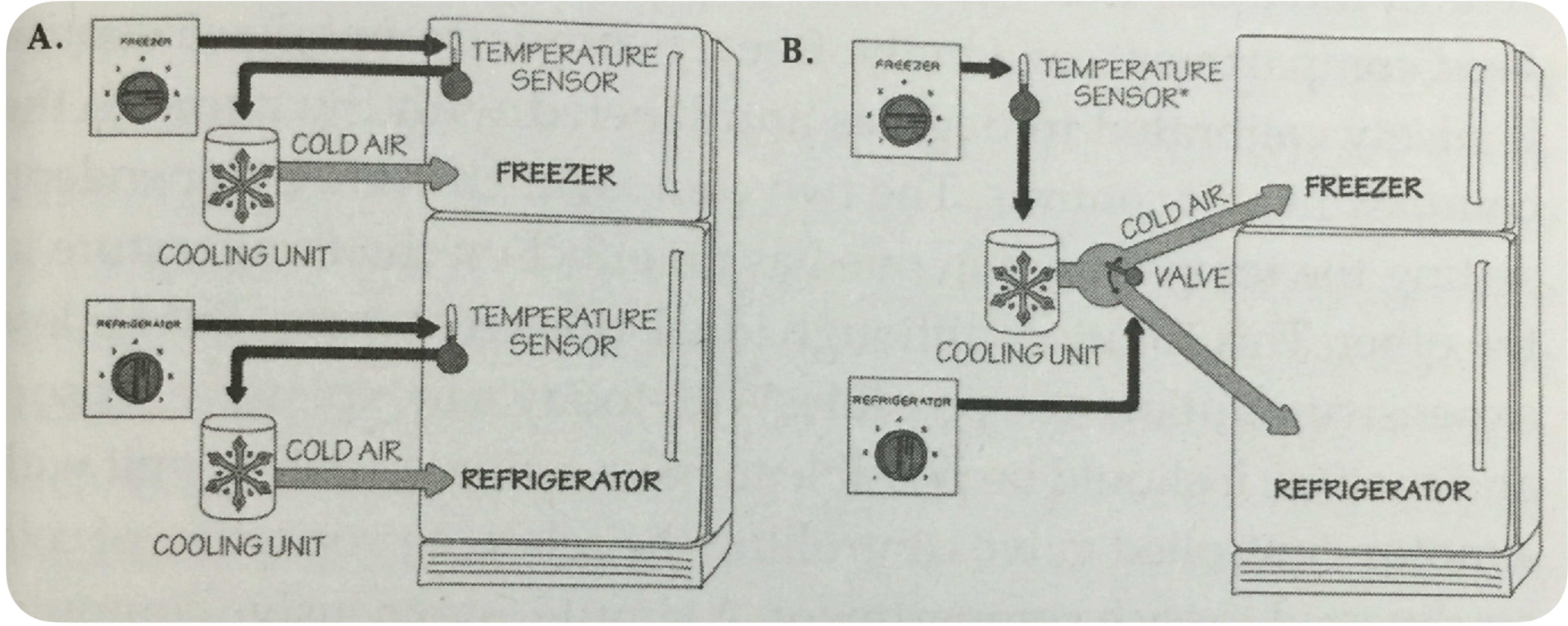
Mental Models (a.k.a Conceptual Models)

- 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)



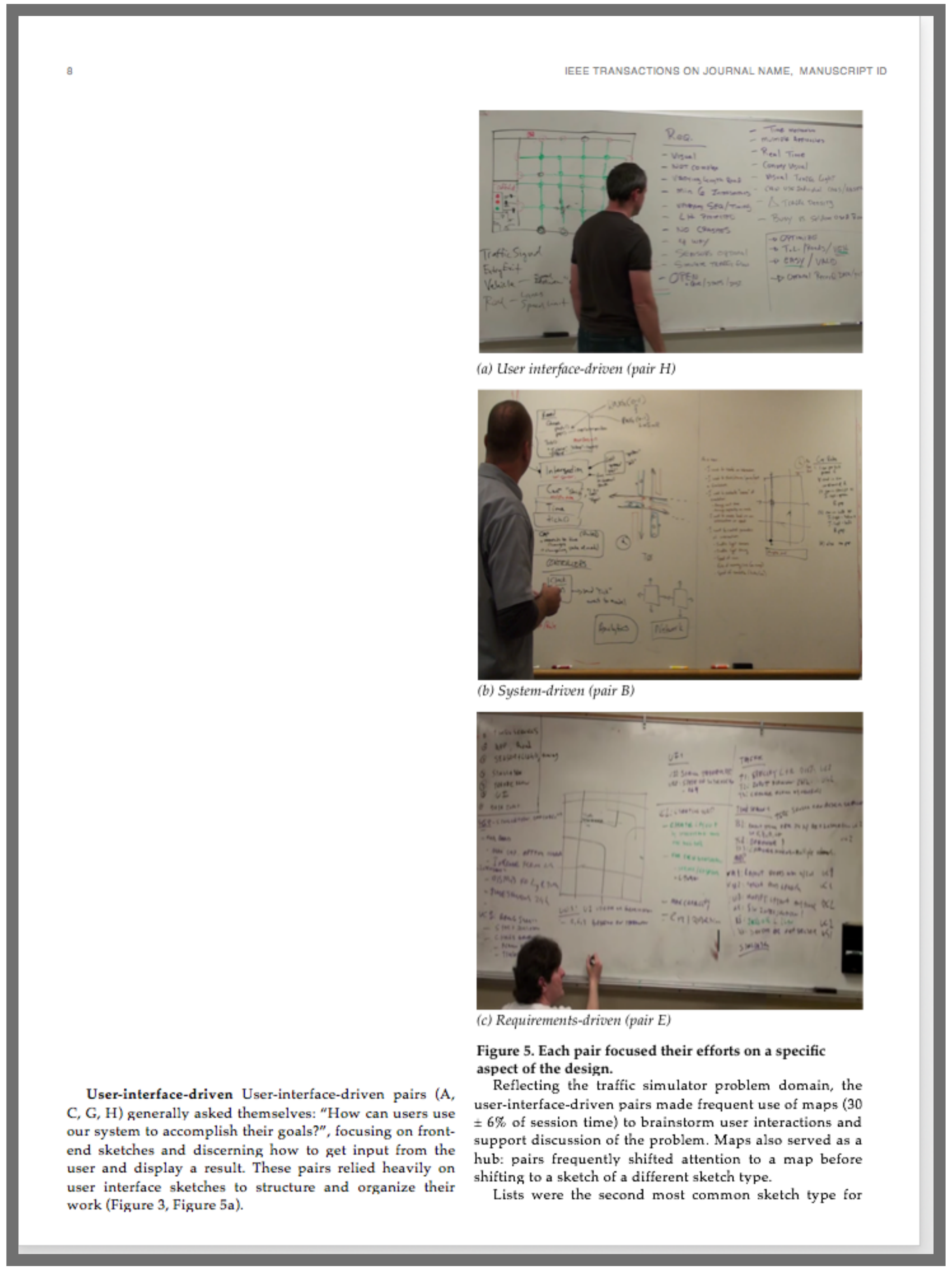
External Representations

- Reduce STM burden
- Help restructure and reframe problem w/ new abstractions, changing operators
- Encode information and relationships through use of space
- Serve as reminders for future goals

Designing for Human Actions

Humans are Goal-Oriented

- Goal: Make text flow into empty space



8 IEEE TRANSACTIONS ON JOURNAL NAME, MANUSCRIPT ID

(a) User interface-driven (pair H)

(b) System-driven (pair B)

(c) Requirements-driven (pair E)

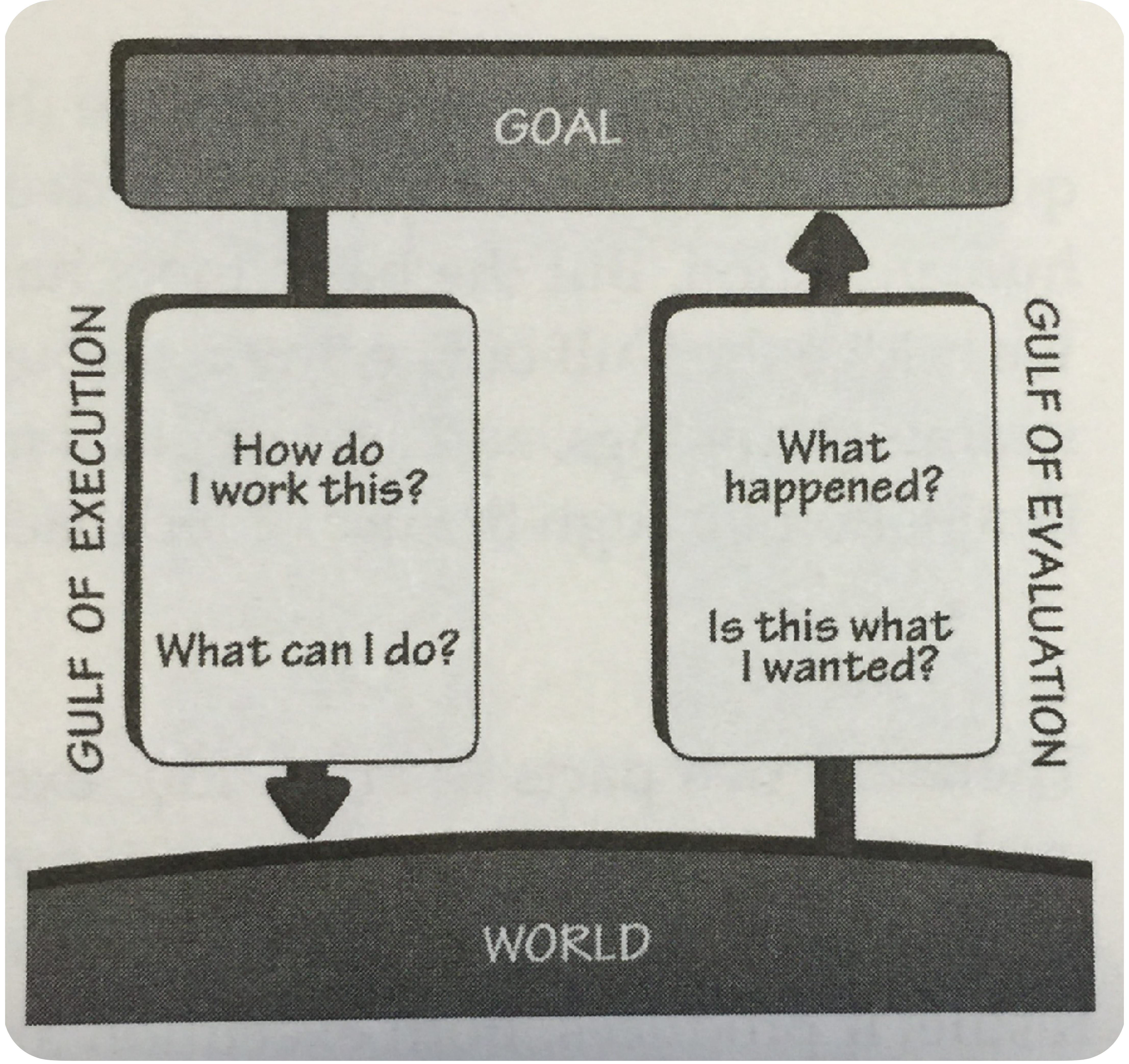
Figure 5. Each pair focused their efforts on a specific aspect of the design.

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 (30 ± 6% 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.

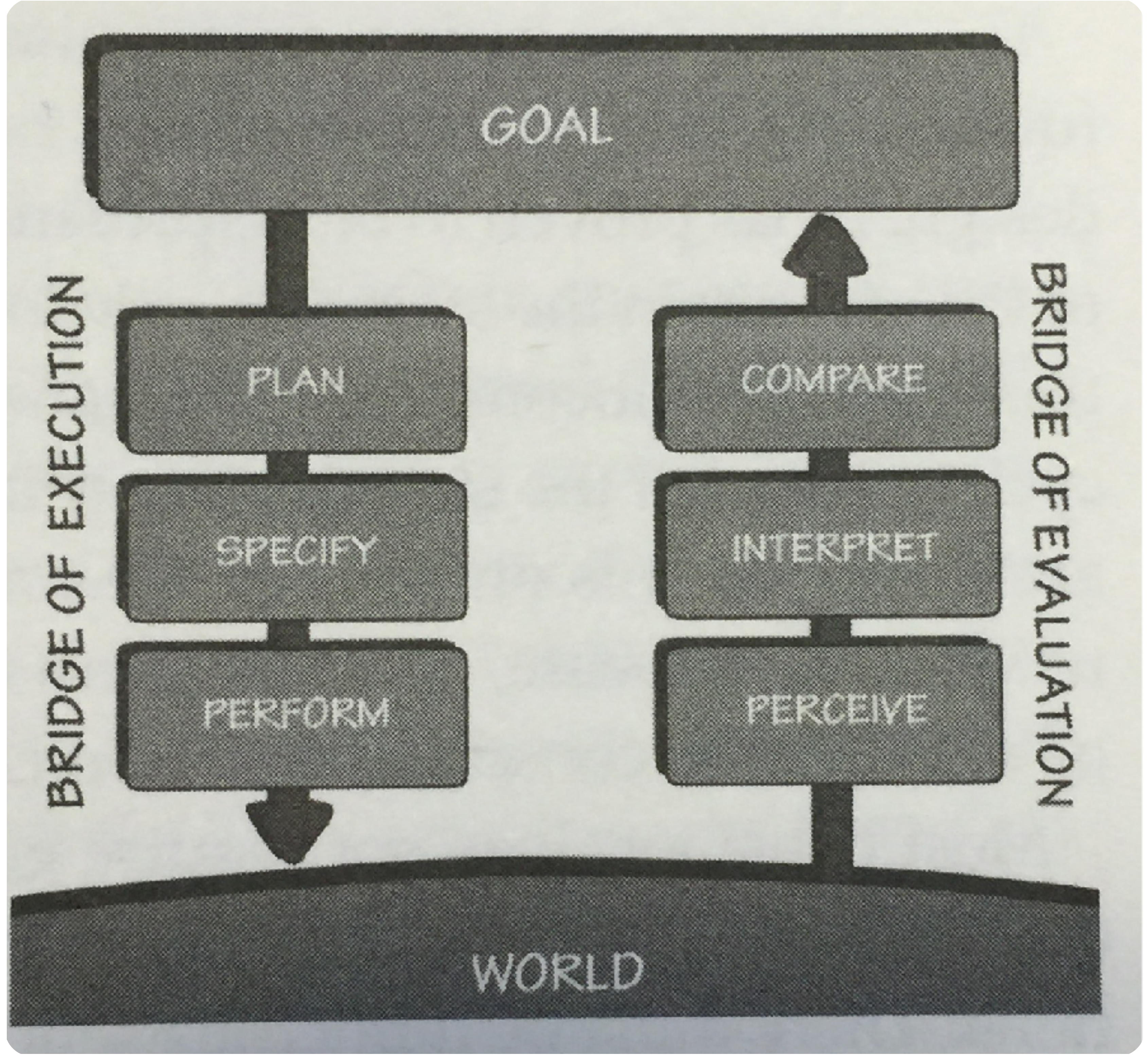
Lists were the second most common sketch type for

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

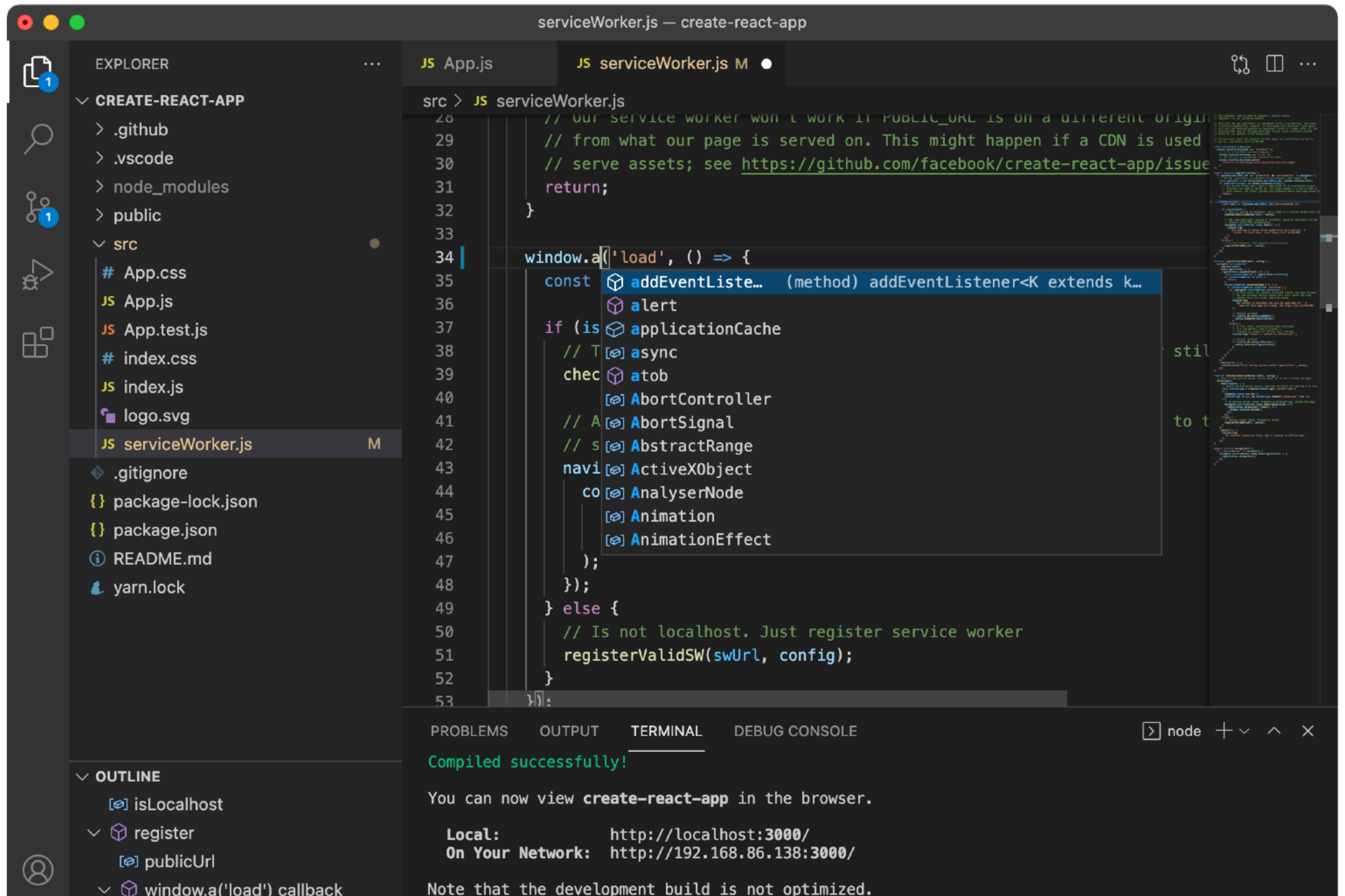
7 Principles of Designing for Action

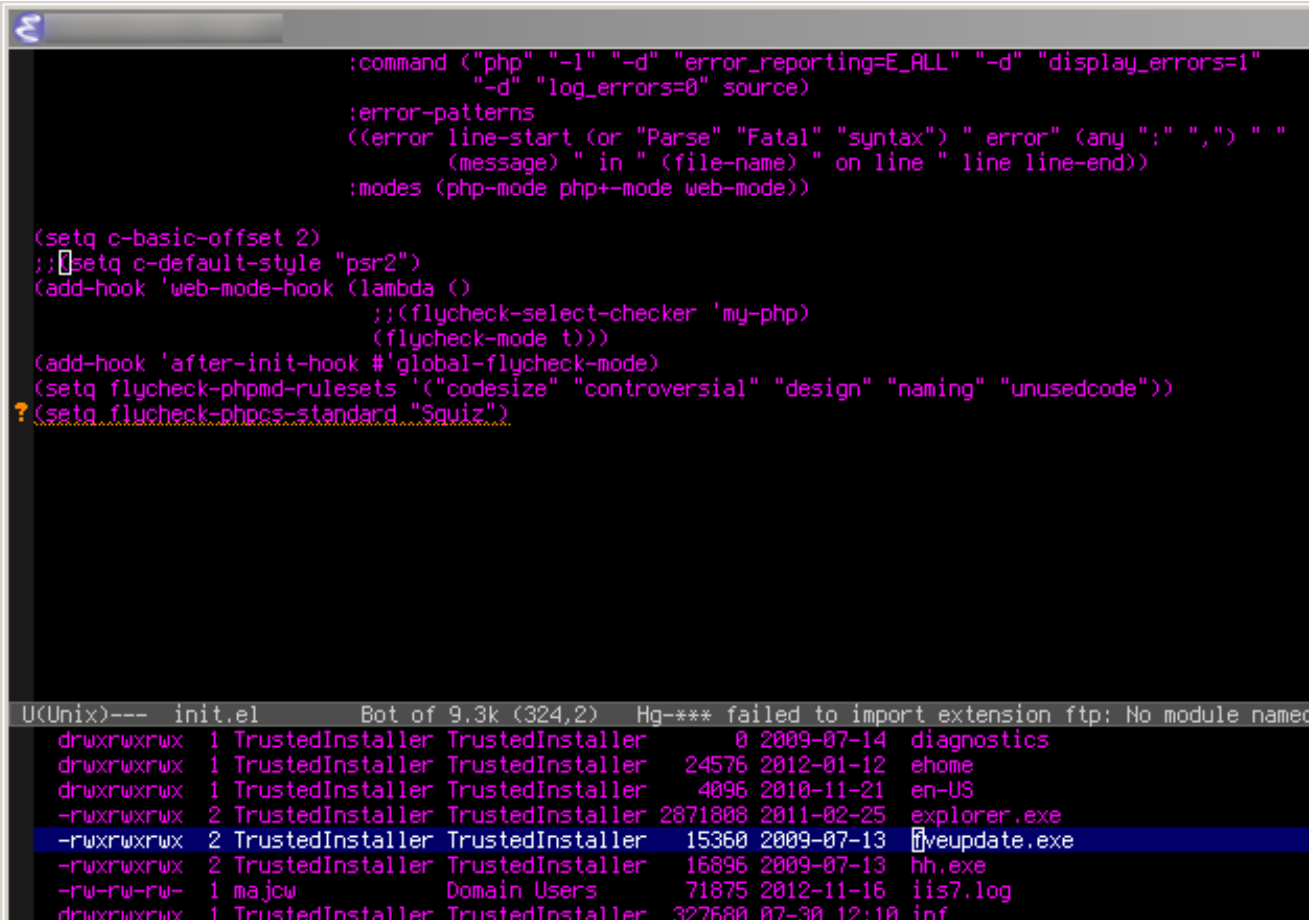
1. Discoverability
2. Feedback
3. Conceptual Model
4. Affordances
5. Signifiers
6. Mappings
7. Constraints

1. Discoverability

- It should be possible to determine possible actions and current state of device

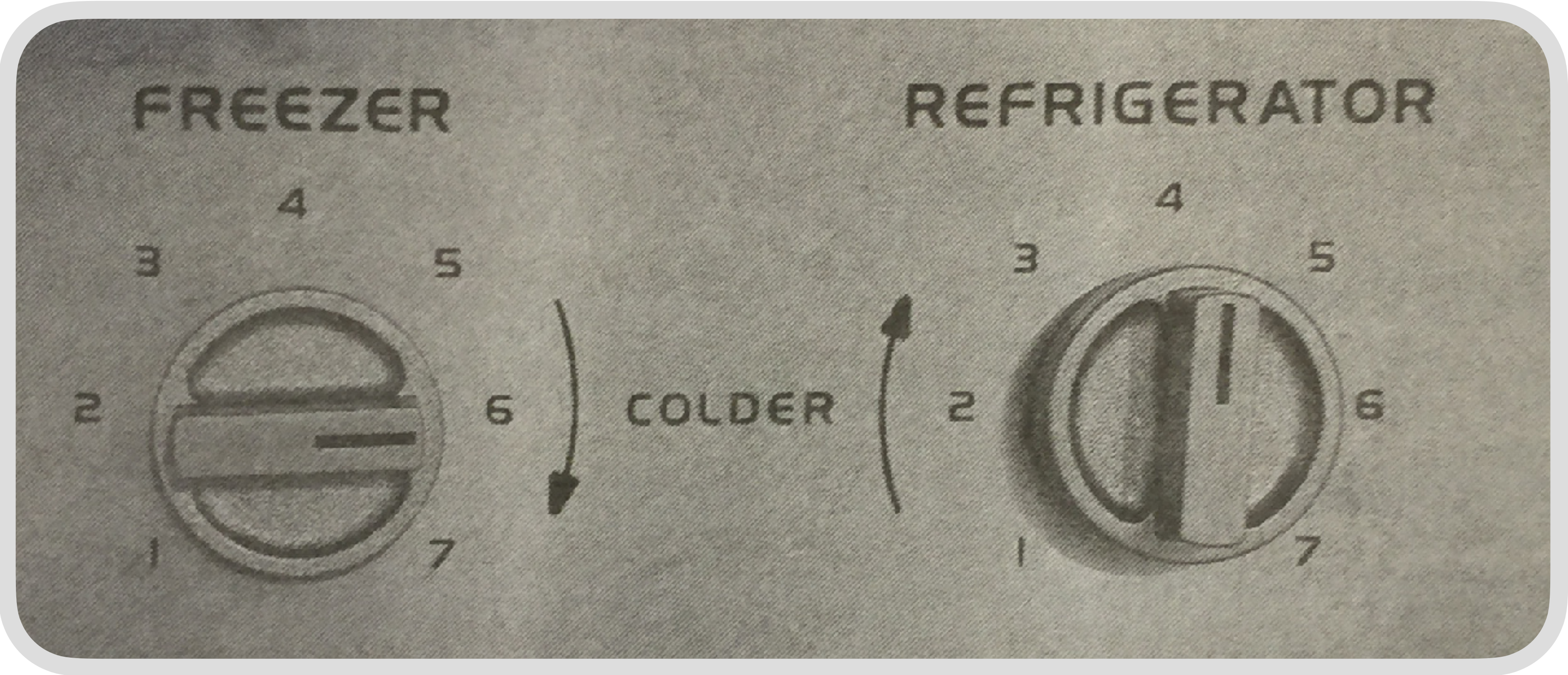
- Which has more discoverable commands: VS Code or Emacs?





2. Feedback

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



3. Conceptual Model

- Design should project all of the information needed to create an *accurate* conceptual model.

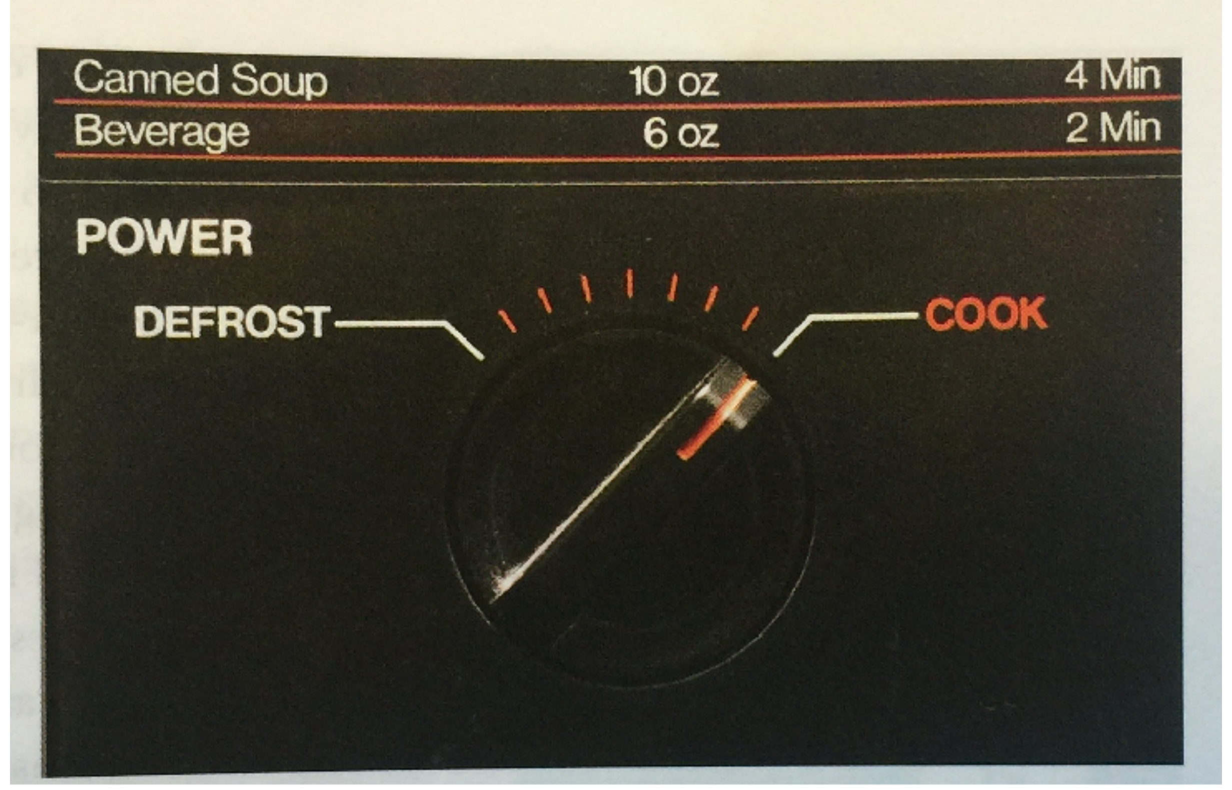
4. Affordances

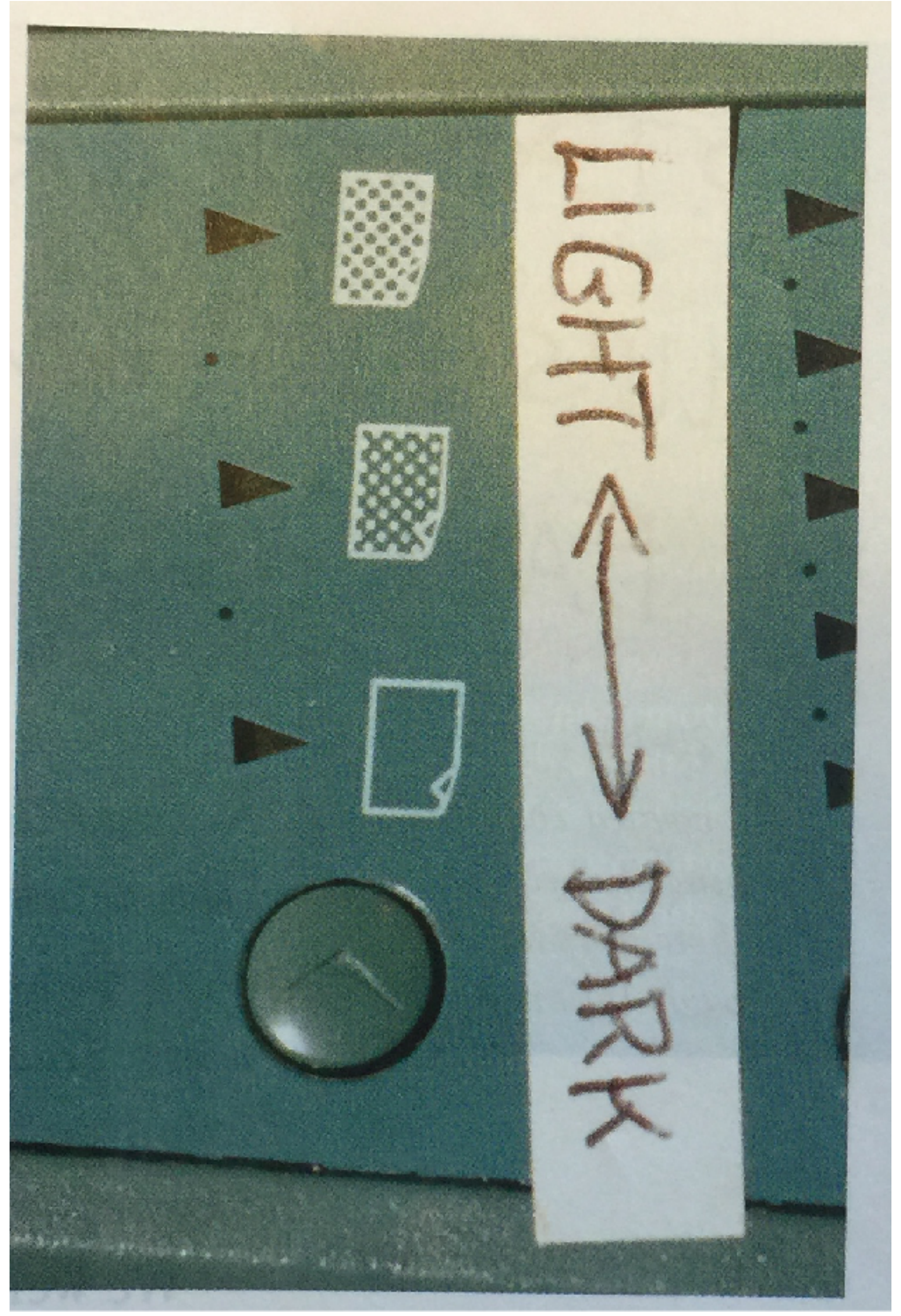
- The proper affordances exist to make the desired actions possible.
- Affordance: Relationship between an object and a user that determines how it can be used.

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]

5. Signifiers

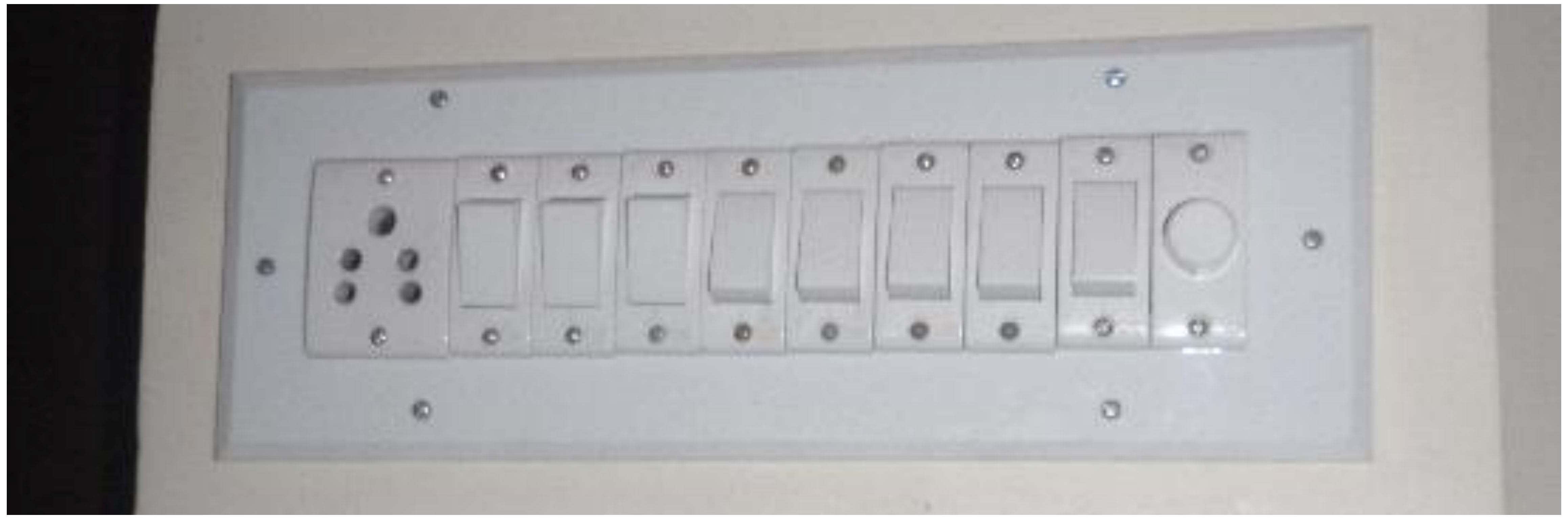
- Signifiers should communicate the affordances of an object, and provide feedback



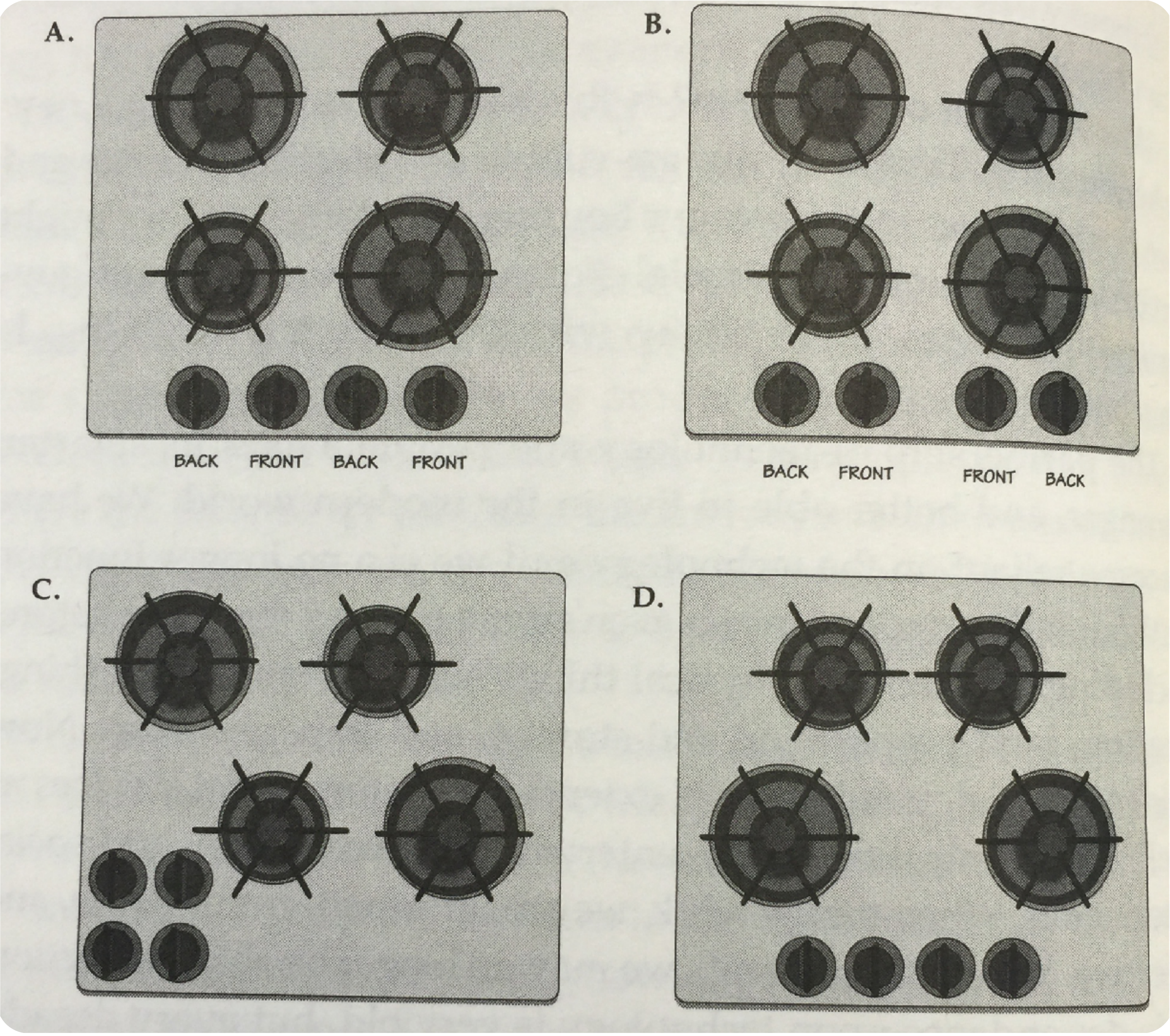


6. Mapping

- The relationship between controls and their actions should follow intuitive spatial layouts and temporal contiguity.



Example - Stove Burners



Natural Mapping

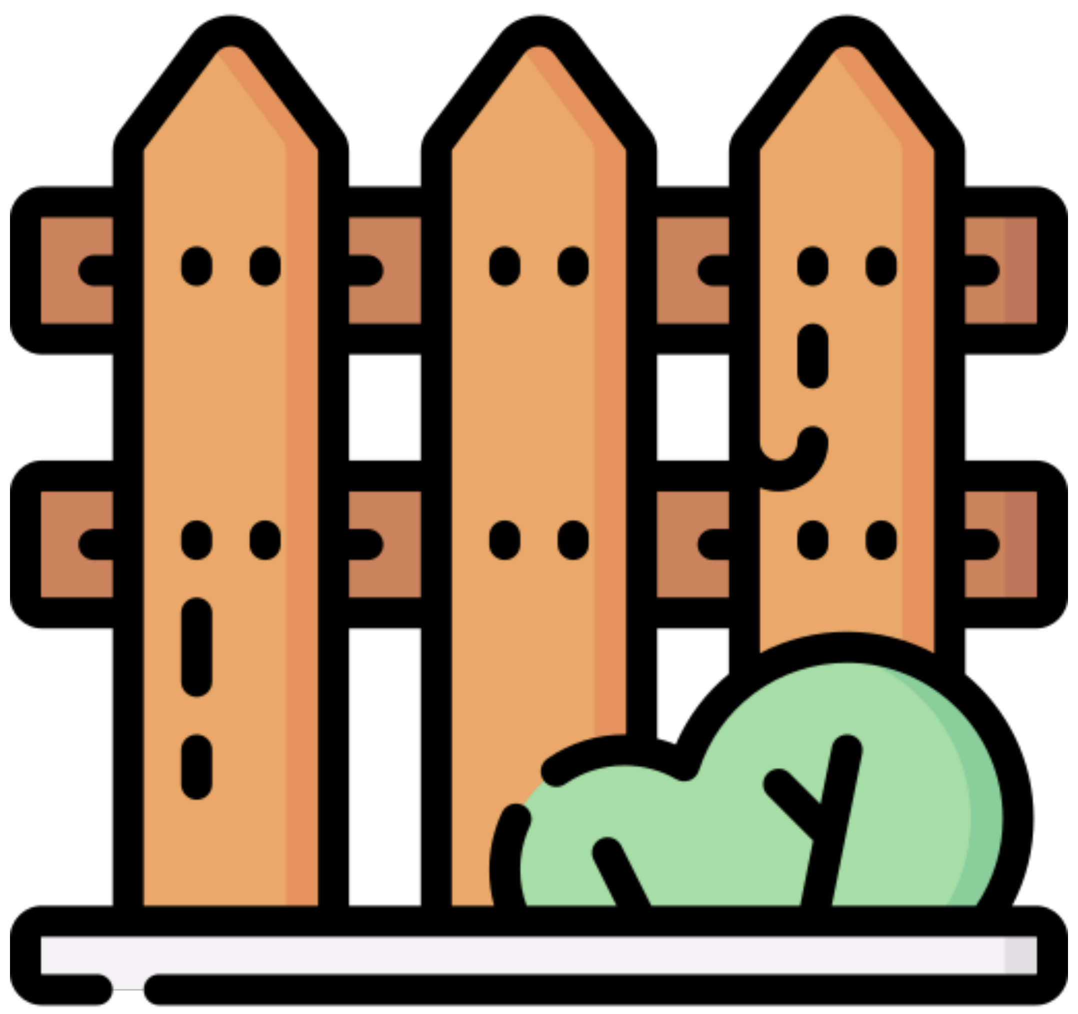
- Best mapping: controls mounted next to item to be controlled
- Second best mapping - controls as close as possible to item to be controlled
- Third best mapping - controls arranged in same spatial configuration

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

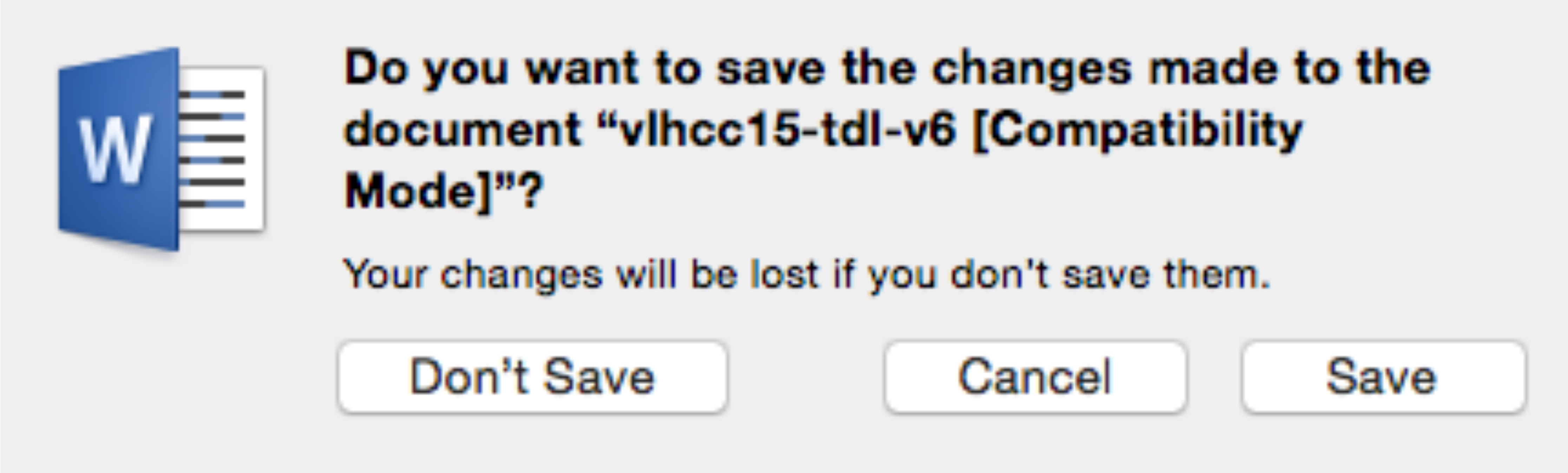


Physical constraints

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

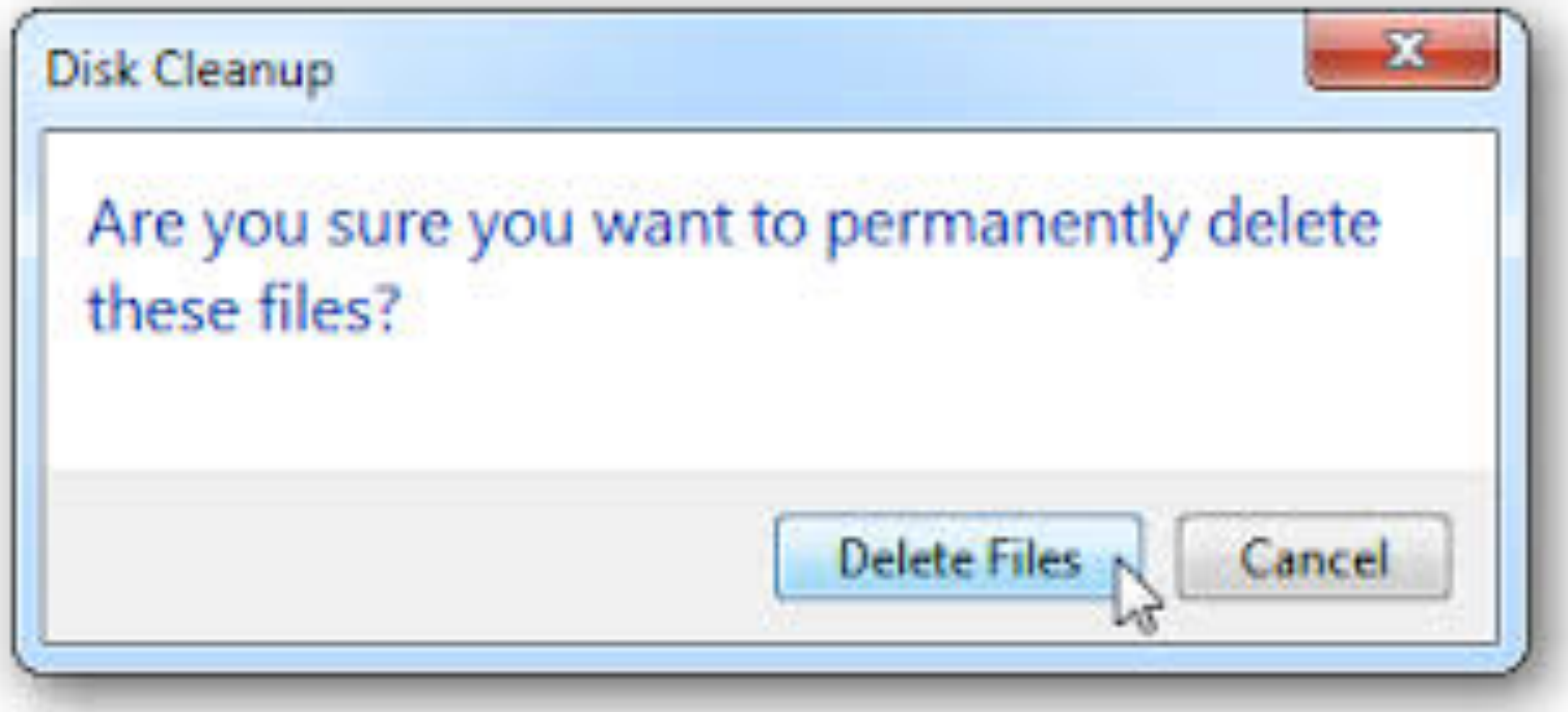
Lock-Ins

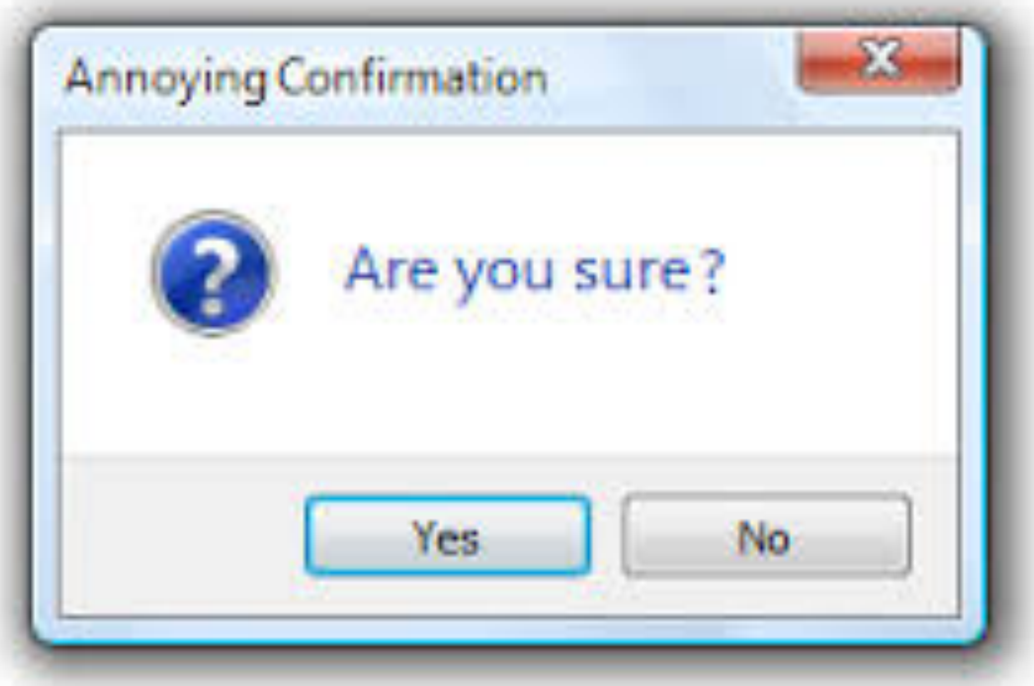
- Keeps an operation active, preventing someone from prematurely stopping



Lock-Outs

- Prevents an event from occurring



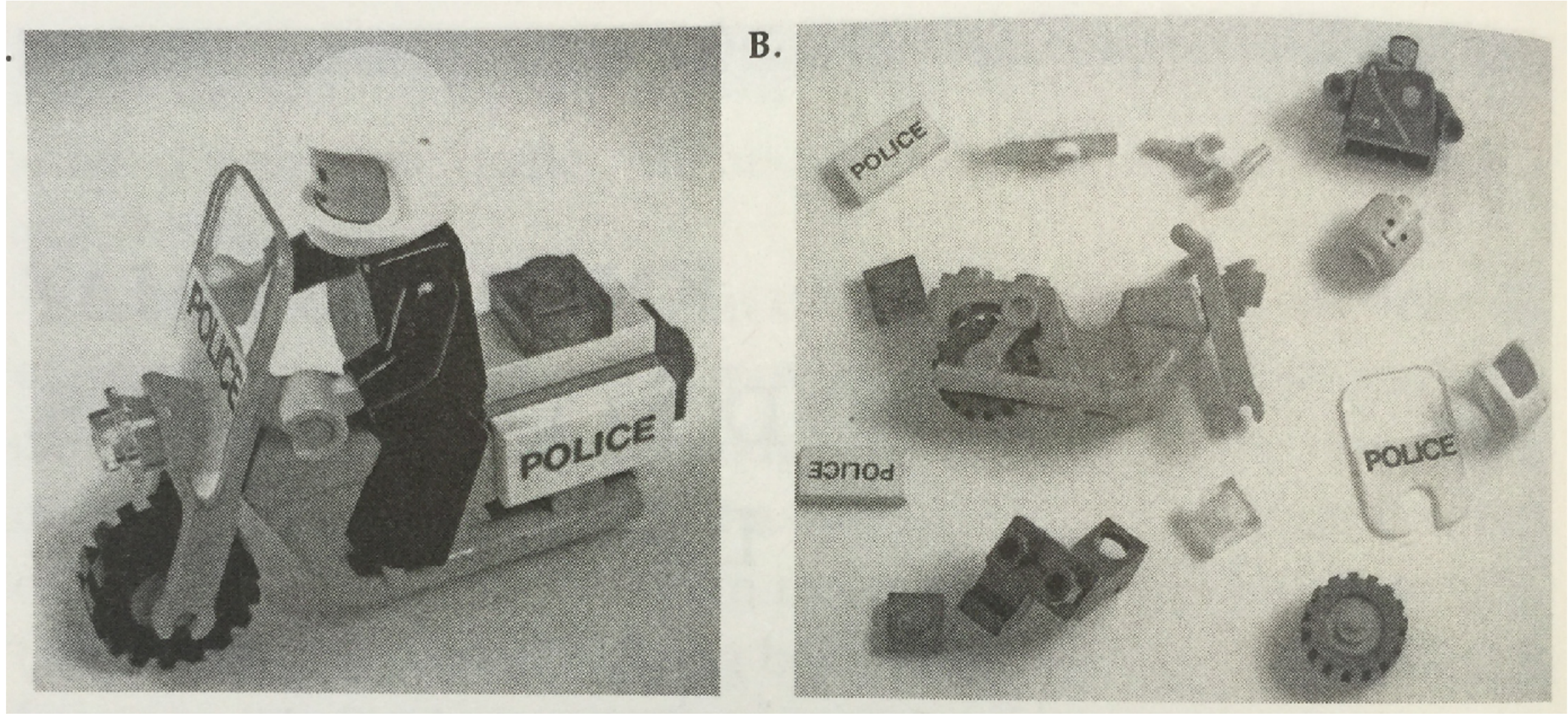


Inter-Locks

- Force actions to take place in the proper sequence

Cultural, Semantic, & Logical Constraints

- Norms, conventions that describe possible actions



Example: Faucets

- ***Control 2 Variables:*** temperature, rate of flow
- ***Physical Mental Model:*** water enters through 2 pipes
- ***Potential Solutions:***
  - Separate controls for hot and cold
  - Control only temp / control only flow
  - 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

10 Minute Break

Group Activity

Group activity (see course website for slides)

- In groups of 3 or 4
- Pick a **complex** application or website (anything that's **not** a static webpage)
- List **5 violations** of Norman’s principles for designing for action
  - List name of principle (e.g., discoverability)
  - Identify a user goal and relevant features of the application
  - Explain how the design violates the principle

- Submit on paper by the end of class

Norman's designing for action principles

1. Discoverability - make it possible to determine possible actions and state
2. Feedback - full and continuous feedback about result of action
3. Conceptual Model - design communicates info for conceptual model
4. Affordances - desired affordances exist
5. Signifiers - effective use of signifiers to communicate
6. Mapping - relationship between controls and goals uses good mapping
7. Constraints - physical, logical, semantic, cultural constraints

Acknowledgements

- Incorporates revisions from Dr. Kevin Moran's SWE 632 course