

SWE 632 - Design & Development of User Interfaces



George Mason
University

Instructor:

Dr. Kevin Moran

Teaching Assistant:

David Gonzalez Samudio

Class will start in:

20:00

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Fall 2020



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Week 2: Human Cognition





Administrivia

- Project Checkpoint 0 and Tech Talk Signup were due today
- Project Checkpoint 1 is out and due in 2 weeks
- Schedule Update:
 - No class on Tuesday November 3rd (Election Day)
 - Make up asynchronous class on October 13th
- Week 2 Discussion Question will be posted after class

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
- Part 4 - Group Activity: Norman's Designing for Action Principles
- Part 5 - Research Tech Talk: V2S



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



Importance of Understanding People

“much of the design is done by engineers who are experts in technology but limited in their understanding of people. ‘We are people ourselves,’ they think, ‘so we understand people.’ But in fact, we humans are amazingly complex. Those who have not studied human behavior often think it is pretty simple. Engineers, moreover, make the mistake of thinking that logical explanation is sufficient: ‘If only people would read the instructions,’ they say, ‘everything would be all right.’”

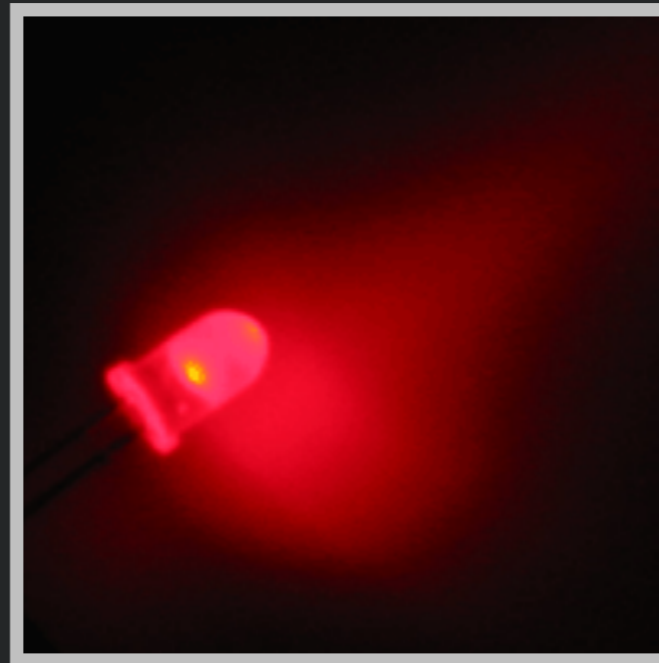
The Design of Everyday Things
Don Norman



Real World Example: 3 Mile Island

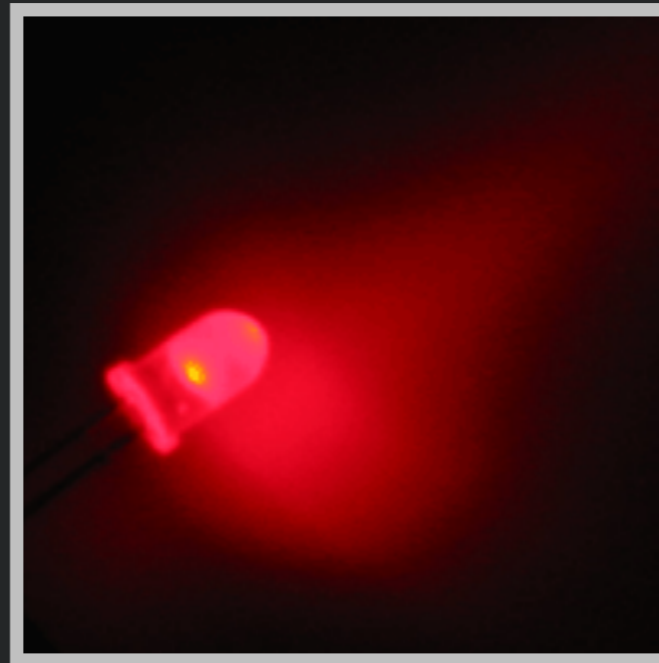


Real World Example: 3 Mile Island





Real World Example: 3 Mile Island



Psychology 101: Cognitive Systems





$$17 \times 24 =$$



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., 17×24)
- 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

Psychology 101: Attention





Attentional Resources are Fixed

Instructions

**Count how many times the
players wearing white pass
the basketball.**



Attentional Resources are Fixed

Instructions

**Count how many times the
players wearing white pass
the basketball.**

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 23×78
- 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)



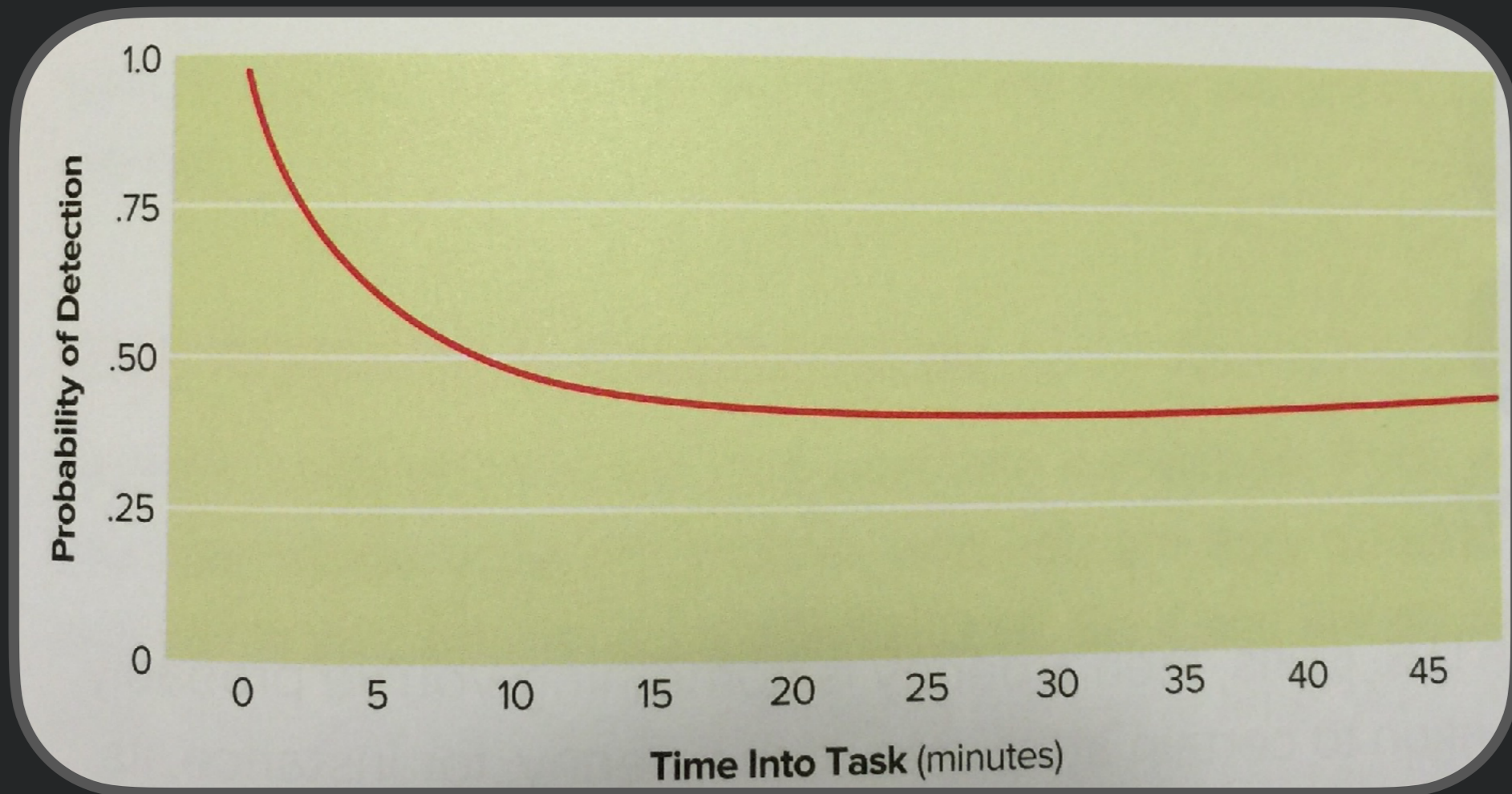


Attentional Limitations - Demo

- 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?

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*, *contacted*, 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.



- How
wh
vel
- 2x
gl



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

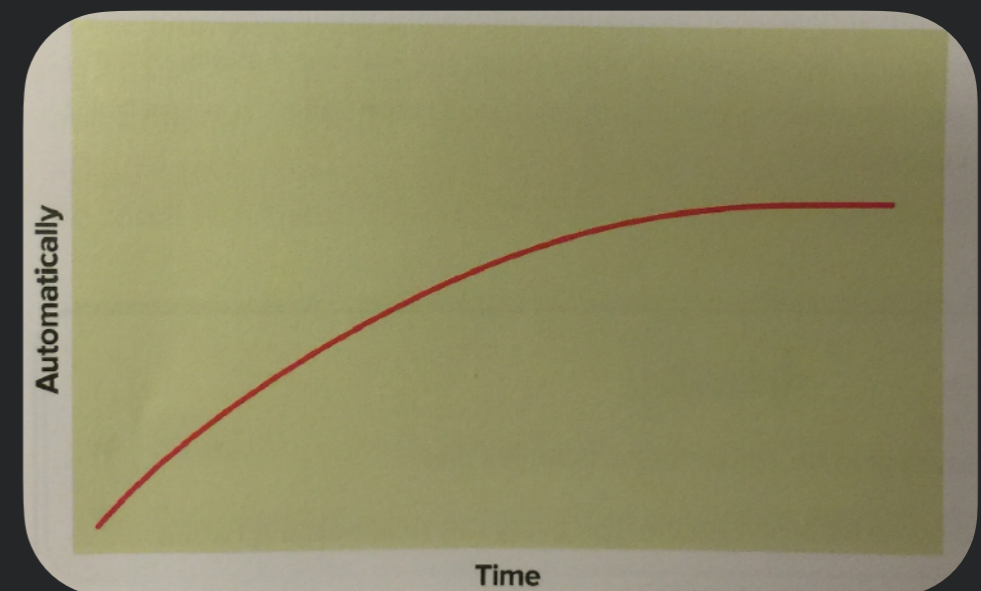
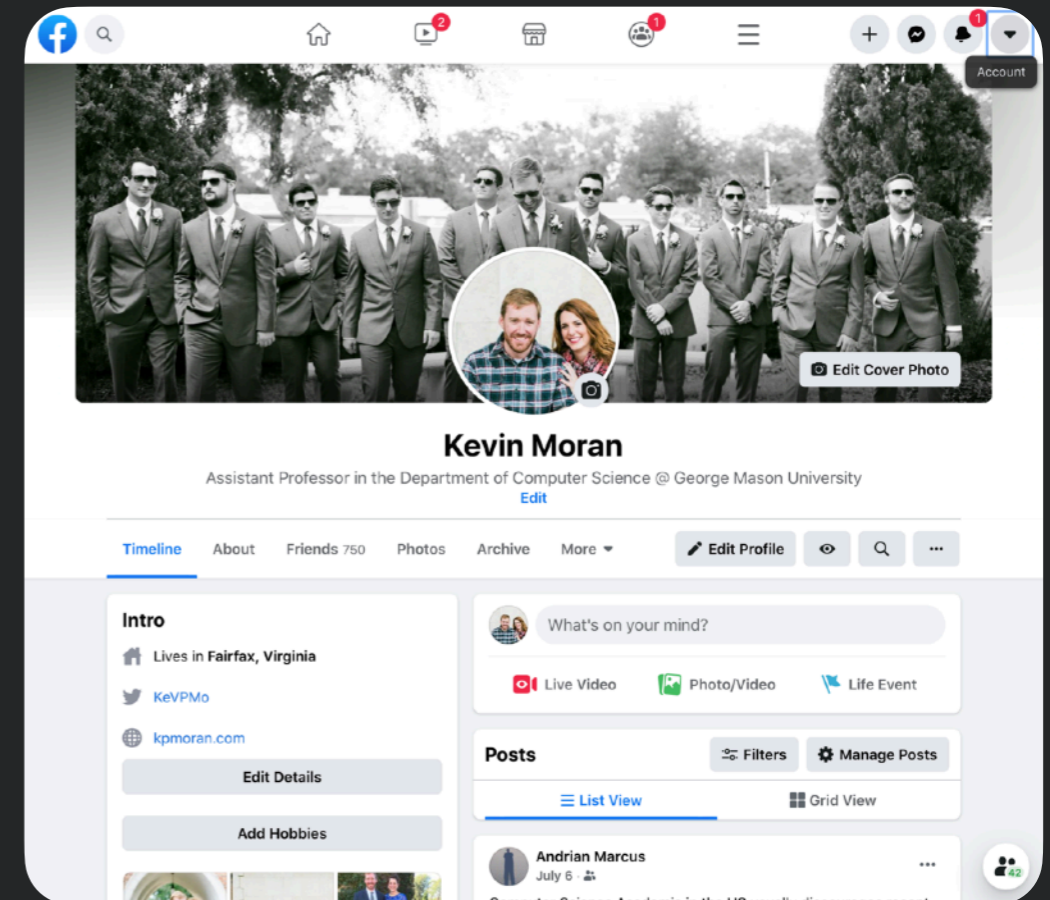


Automaticity

- 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



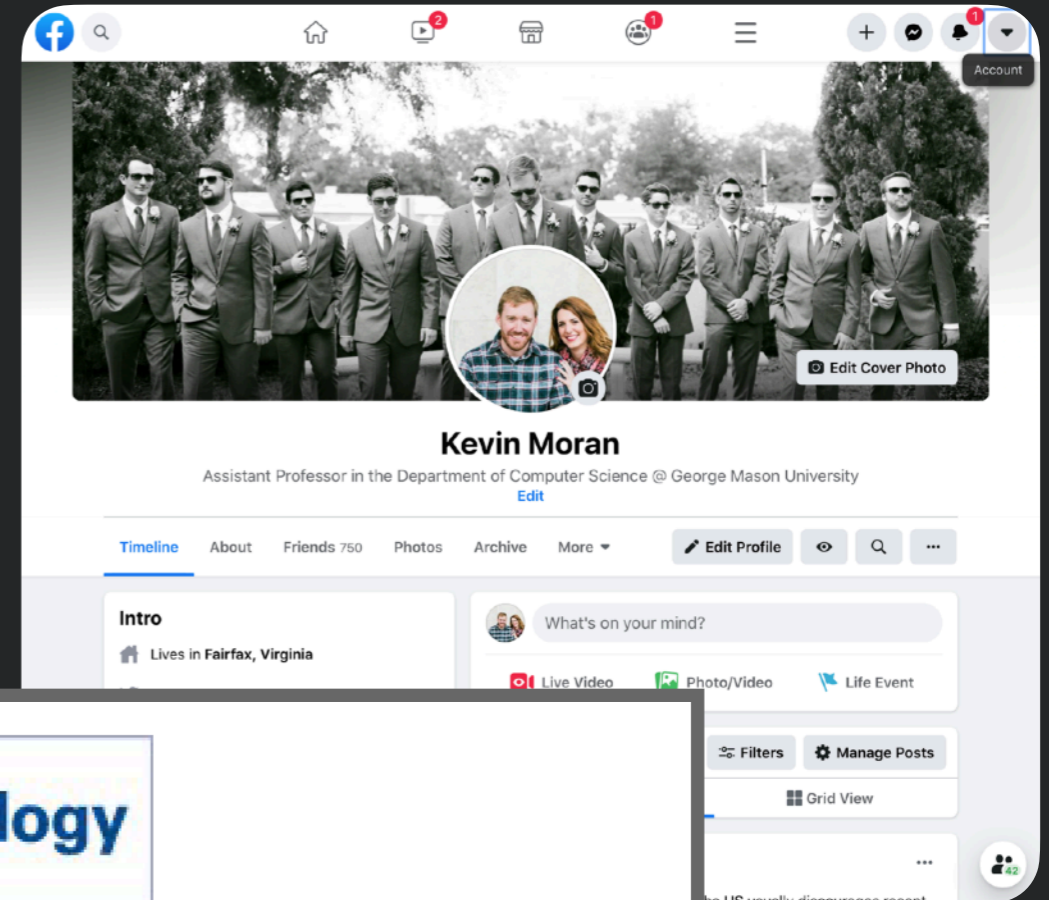
Habit formation takes time

- How long does it take to form an eating, drinking, or checking FB before bed habit?

- Mean: 66 days Min: 18

da

- Mo
tak



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

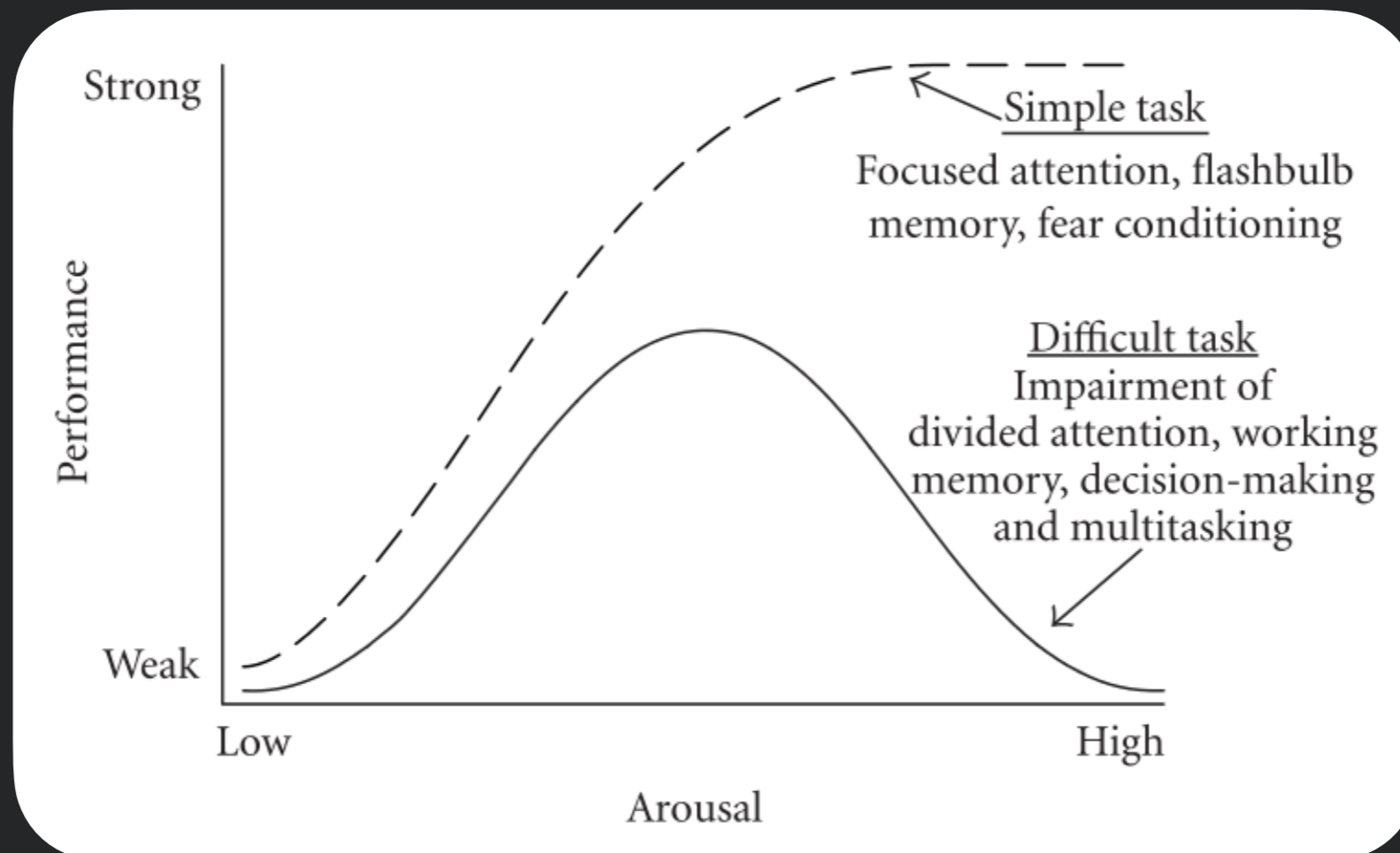
- Escape from danger
- Fire & door doesn't open —> push harder
- Neurotransmitted bias brain to focus on problem & ignore distractions
- Tunnel vision on most salient aspects

- 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 of Psychology





Some 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

7 Minute Break



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In the Chat List **one**
List one characteristic that
makes someone an **expert**.

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What Makes an Expert?





What Makes an Expert?

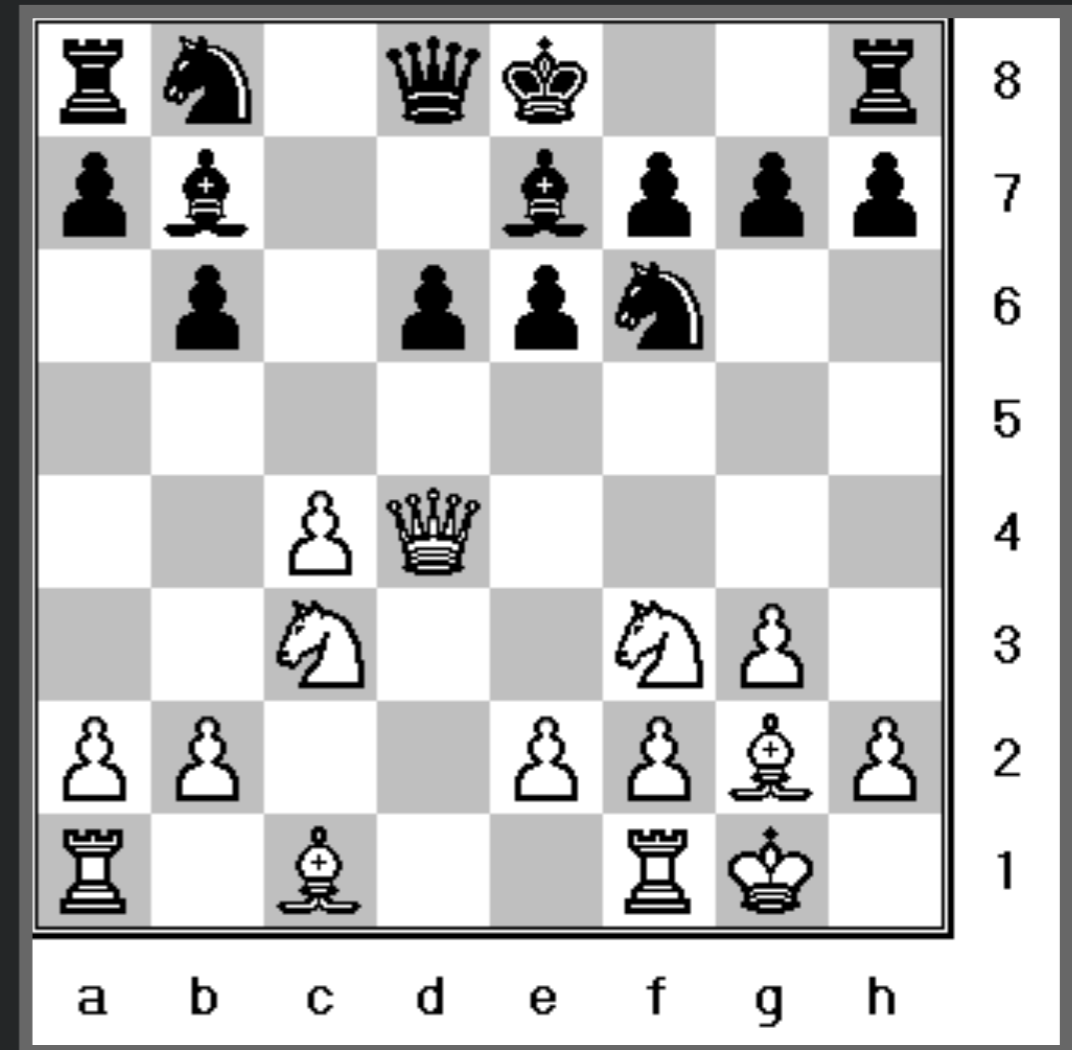


What Makes an Expert?

- 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]



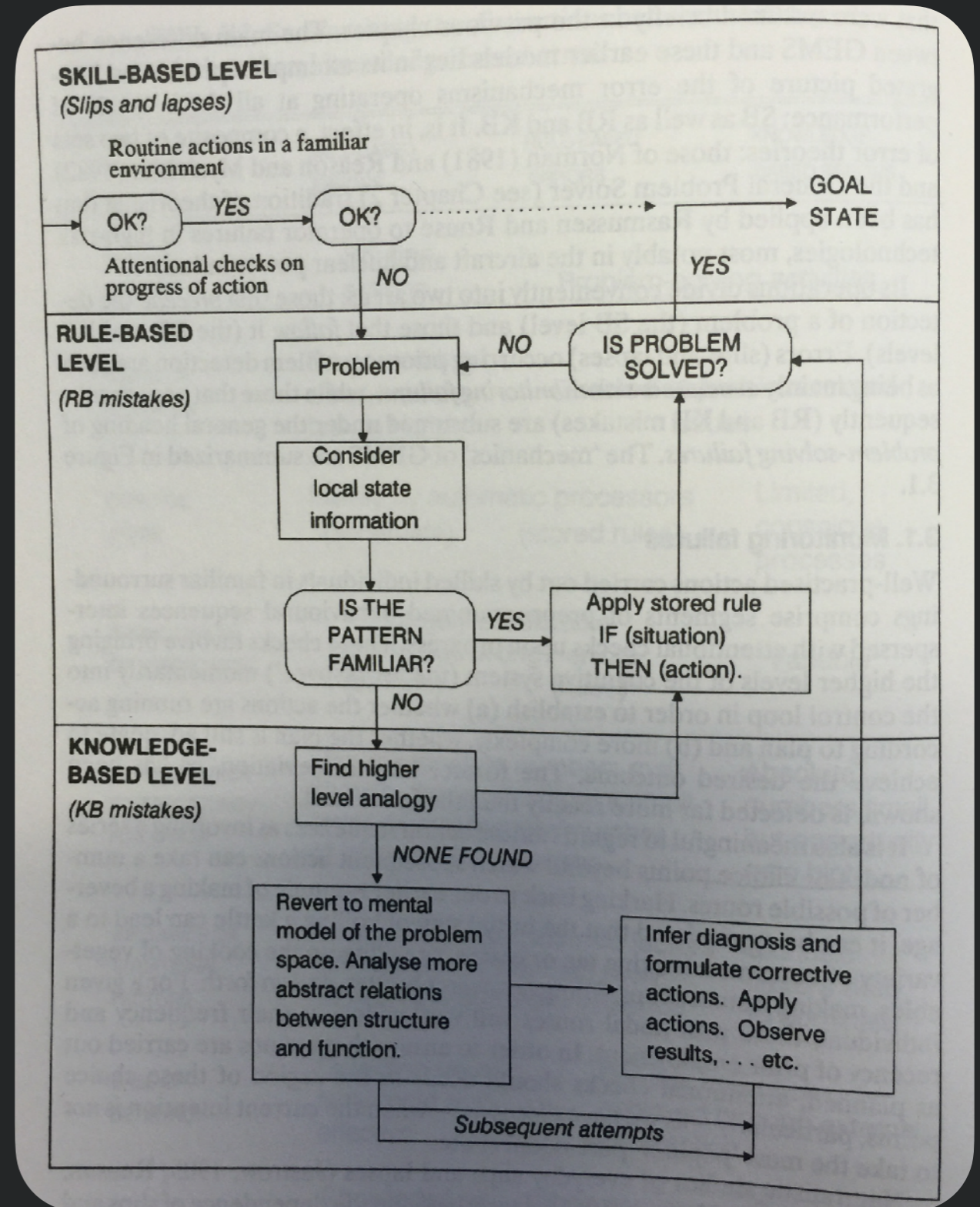


Schemas (a.k.a chunking)

- 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

Different Behavior Types

- Skill / Rule / Knowledge





Don't Make the User Think

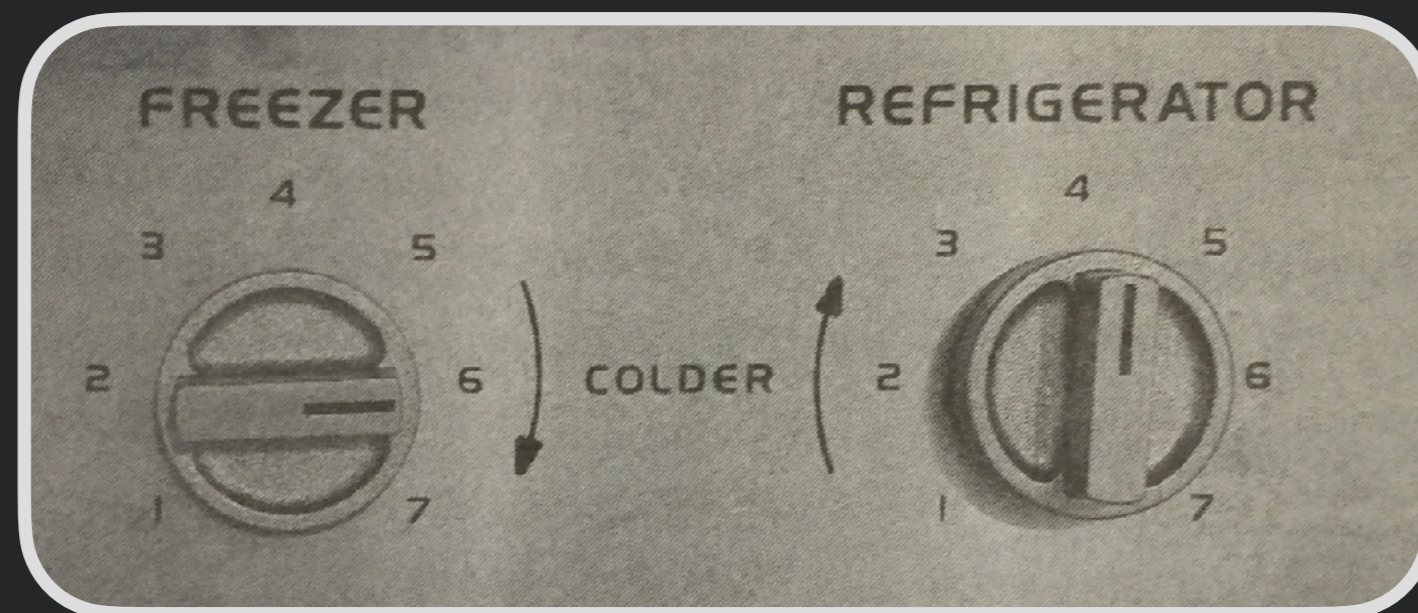
- Let users use (automatic) skills of System 1 rather than (conscious) knowledge-based problem solving of System 2
- Key principle (it's the title of one of the course textbooks....)
 - We'll come back to this idea often in the future
- What this means: let users think about everything except for interface 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



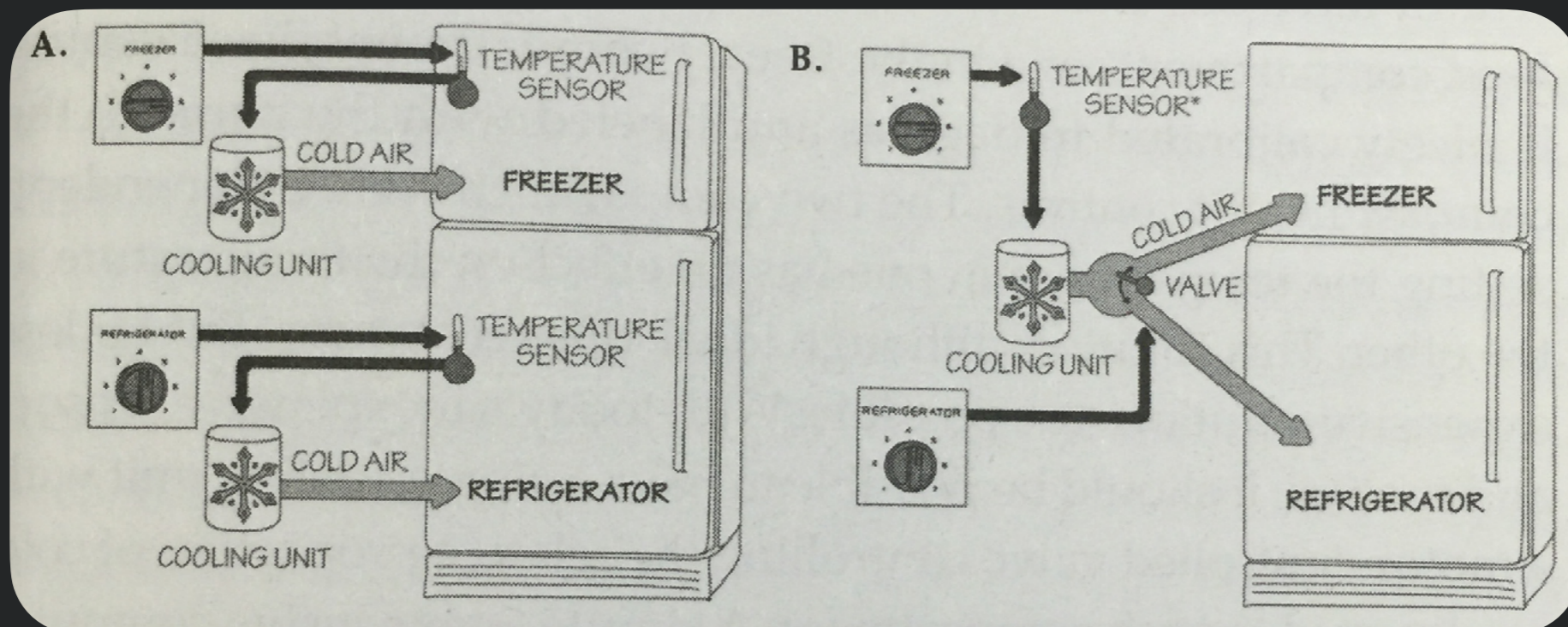
Mental Models (a.k.a Conceptual Models)

- 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)



Distributed cognition

TABLE 3.1. Tradeoffs Between Knowledge in the World and in the Head

Knowledge in the World	Knowledge in the Head
Information is readily and easily available whenever perceivable.	Material in working memory is readily available. Otherwise considerable search and effort may be required.
Interpretation substitutes for learning. How easy it is to interpret knowledge in the world depends upon the skill of the designer.	Requires learning, which can be considerable. Learning is made easier if there is meaning or structure to the material or if there is a good conceptual model.
Slowed by the need to find and interpret the knowledge.	Can be efficient, especially if so well-learned that it is automated.
Ease of use at first encounter is high.	Ease of use at first encounter is low.
Can be ugly and inelegant, especially if there is a need to maintain a lot of knowledge. This can lead to clutter. Here is where the skills of the graphics and industrial designer play major roles.	Nothing needs to be visible, which gives more freedom to the designer. This leads to cleaner, more pleasing appearance—at the cost of ease of use at first encounter, learning, and remembering.



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

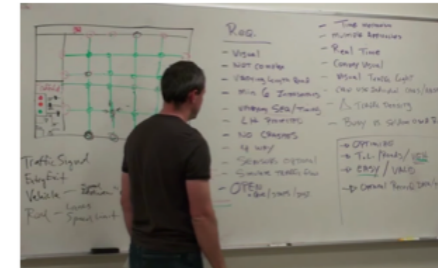


Humans are Goal-Oriented

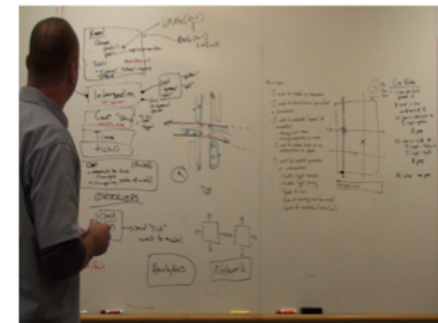
- Goal: Make text flow into empty space

8

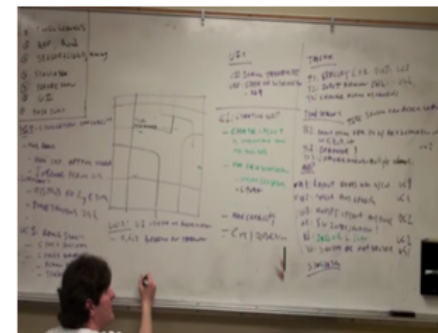
IEEE TRANSACTIONS ON JOURNAL NAME, MANUSCRIPT ID



(a) User interface-driven (pair H)



(b) System-driven (pair B)



(c) Requirements-driven (pair E)

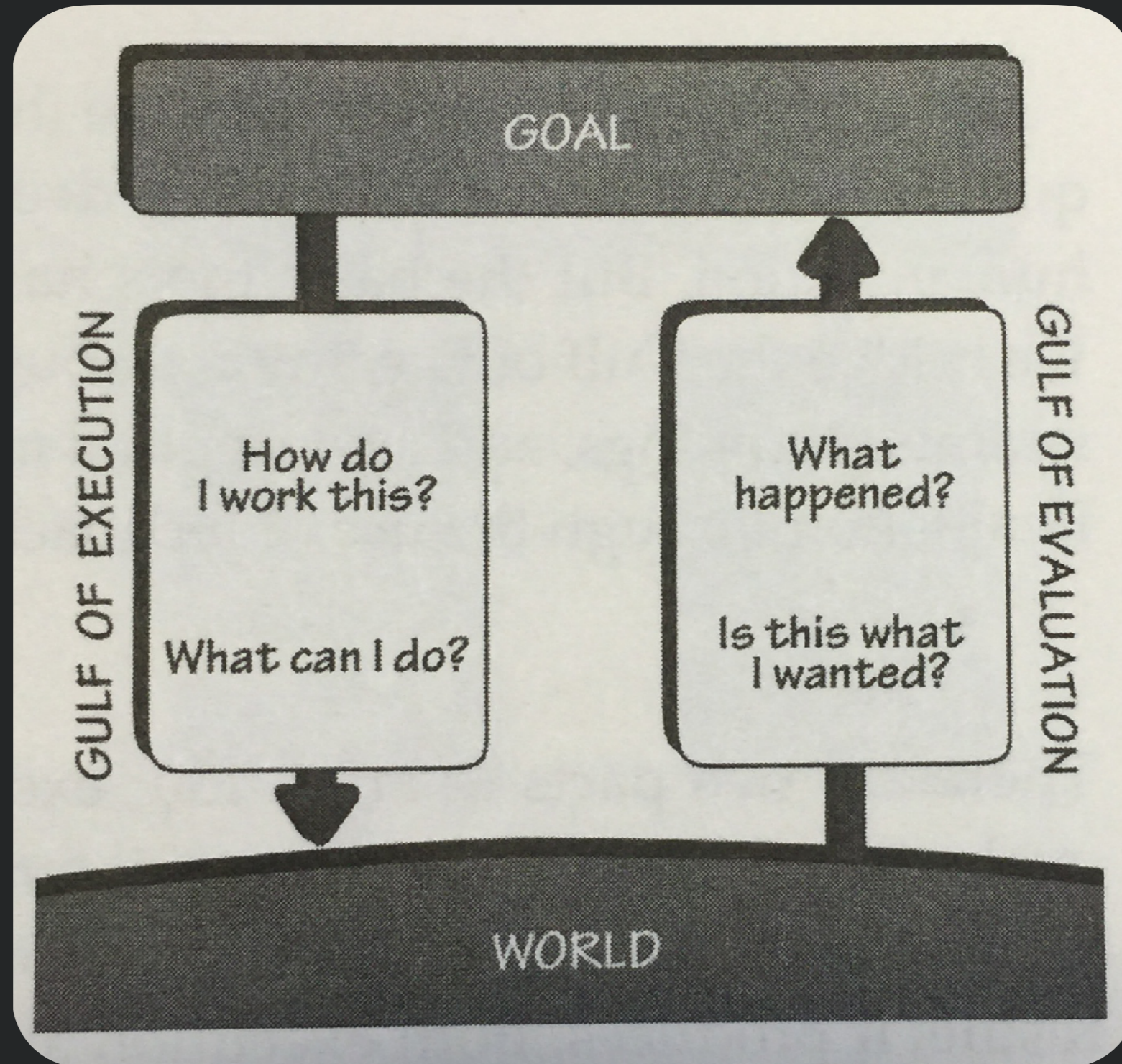
Figure 5. Each pair focused their efforts on a specific aspect of the design.

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 frontend 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.

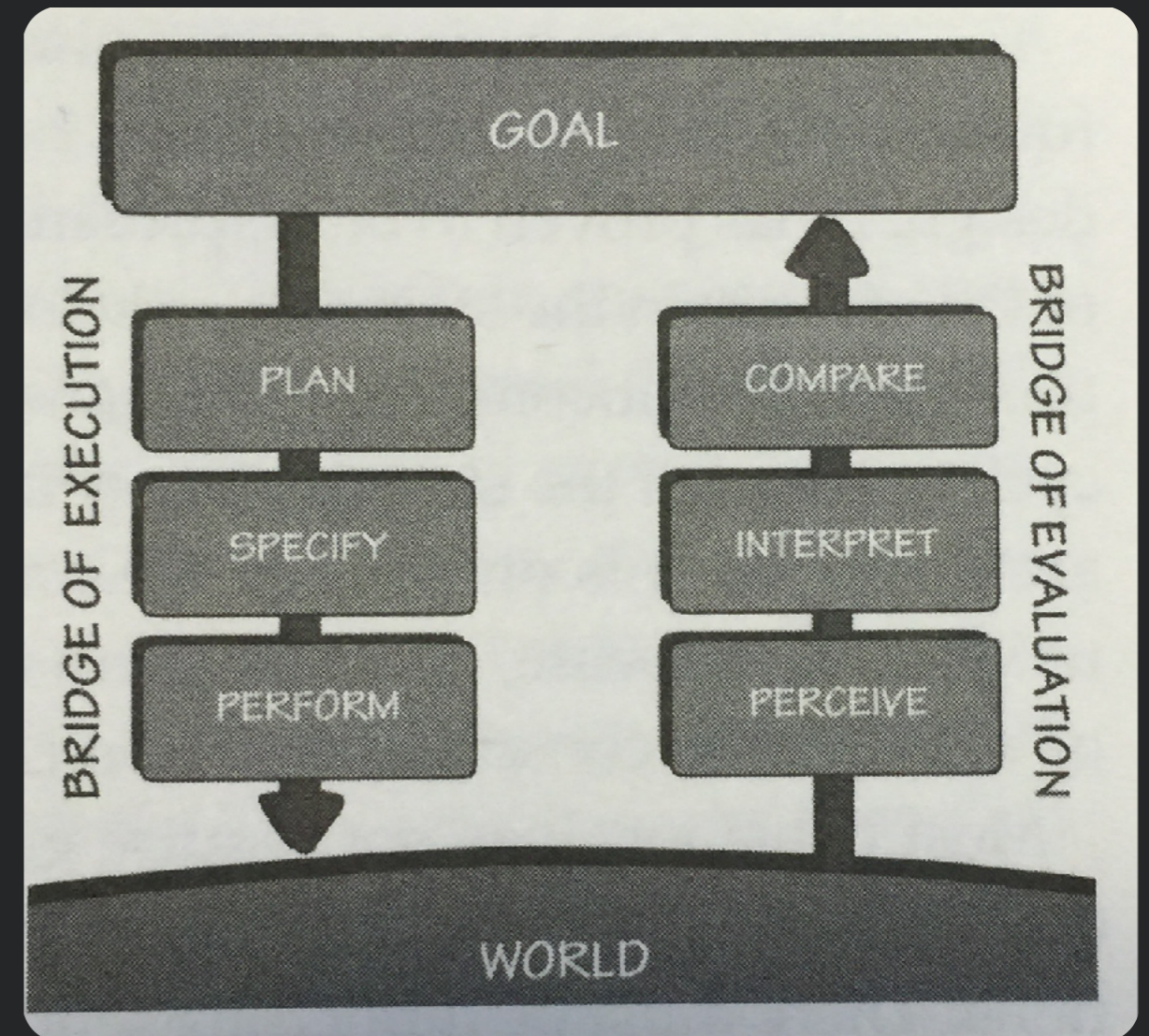
Lists were the second most common sketch type for

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



I. Discoverability

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

```
1! Functionality Description:
2! Determines the conditions defined by the drain tunnel and ar
3! Author: Guanglin Du
4! 2005/12/09
5PROGRAM DrainBoundaryMain
6
7USE TypeDefinition
8USE VectorUtil
9USE PlaneUtil
10USE SpacialGeometry
11
12IMPLICIT NONE
13
14! Defines a common FEM element type
15TYPE Element
16  INTEGER, DIMENSION(9) :: nodes
17  INTEGER :: materialID
18END TYPE Element
19
20CHARACTER(LEN = 200) :: comment
21CHARACTER(LEN = 30) :: c2
22LOGICAL(4) :: yn /yes/no
23TYPE(Element), ALLOCATABLE, DIMENSION(:) :: elements
24TYPE(Point3D), ALLOCATABLE, DIMENSION(:) :: nodes
25! Drain tunnel axis (Line3D object)
26TYPE(Line3D), ALLOCATABLE, DIMENSION(:) :: drainTunn
27TYPE(Quadrilateral), ALLOCATABLE, DIMENSION(:) :: curt
28
29! Temporary variable
30TYPE(Point3D) :: p1, M
31DOUBLE PRECISION :: PM, ramda, tol
32
33! Often used temporary integer variables
34INTEGER :: i, j, k, i1, i2, i3, i4
35! Node & element count
36INTEGER :: nodeCount, elemCount
37! Drain tunnel axis & the count of anti-seepage curtain
```

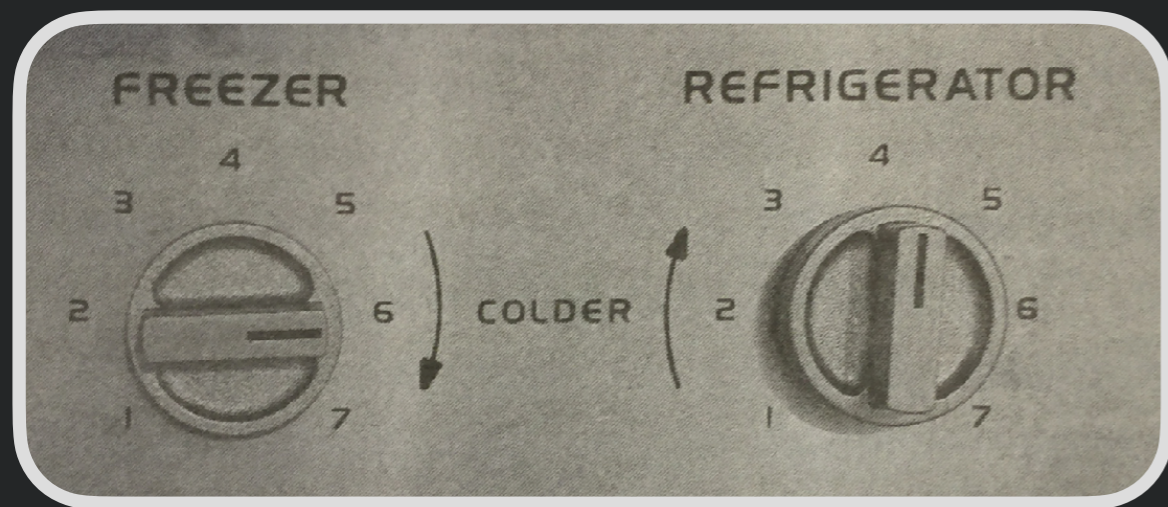
```
:command ("php" "-l" "-d" "error_reporting=E_ALL" "-d" "display_errors=1"
"-d" "log_errors=0" source)
:error-patterns
((error line-start (or "Parse" "Fatal" "syntax") " error" (any ":" " ") " "
(message) " in " (file-name) " on line " line line-end))
:modes (php-mode php+-mode web-mode))

(setq c-basic-offset 2)
;;[setq c-default-style "psr2")
(add-hook 'web-mode-hook (lambda ()
;;(flycheck-select-checker 'my-php)
(flycheck-mode t)))
(add-hook 'after-init-hook #'global-flycheck-mode)
(setq flycheck-phpmd-rulesets '("codesize" "controversial" "design" "naming" "unusedcode"))
? (setq flycheck-phpcs-standard "Squiz")

U(Unix)--- init.el Bot of 9.3k (324,2) Hg-*** failed to import extension ftp: No module named
drwxrwxrwx 1 TrustedInstaller TrustedInstaller 0 2009-07-14 diagnostics
drwxrwxrwx 1 TrustedInstaller TrustedInstaller 24576 2012-01-12 ehome
drwxrwxrwx 1 TrustedInstaller TrustedInstaller 4096 2010-11-21 en-US
-rwxrwxrwx 2 TrustedInstaller TrustedInstaller 2871808 2011-02-25 explorer.exe
-rwxrwxrwx 2 TrustedInstaller TrustedInstaller 15360 2009-07-13 @veupdate.exe
-rwxrwxrwx 2 TrustedInstaller TrustedInstaller 16896 2009-07-13 hh.exe
-rw-rw-rw- 1 majcw Domain Users 71875 2012-11-16 iis7.log
drwxrwxrwx 1 TrustedInstaller TrustedInstaller 327680 07-30 12:10 inf
```

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.



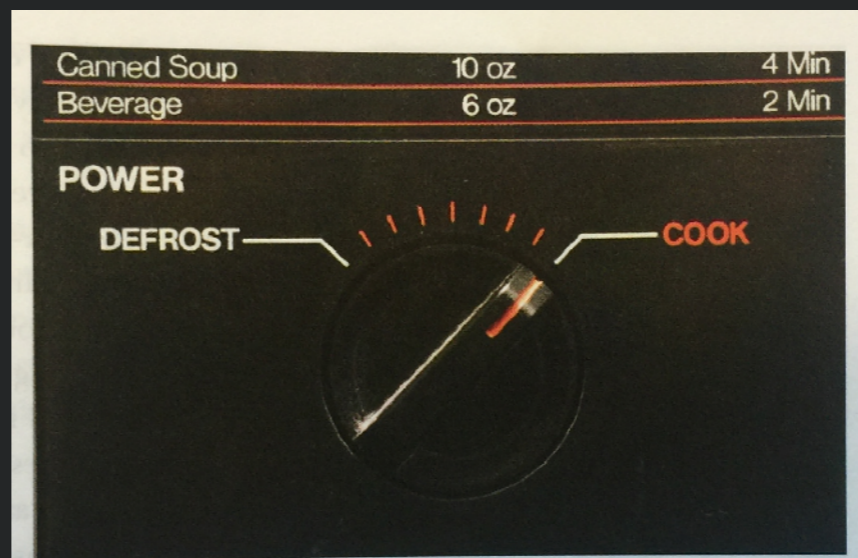
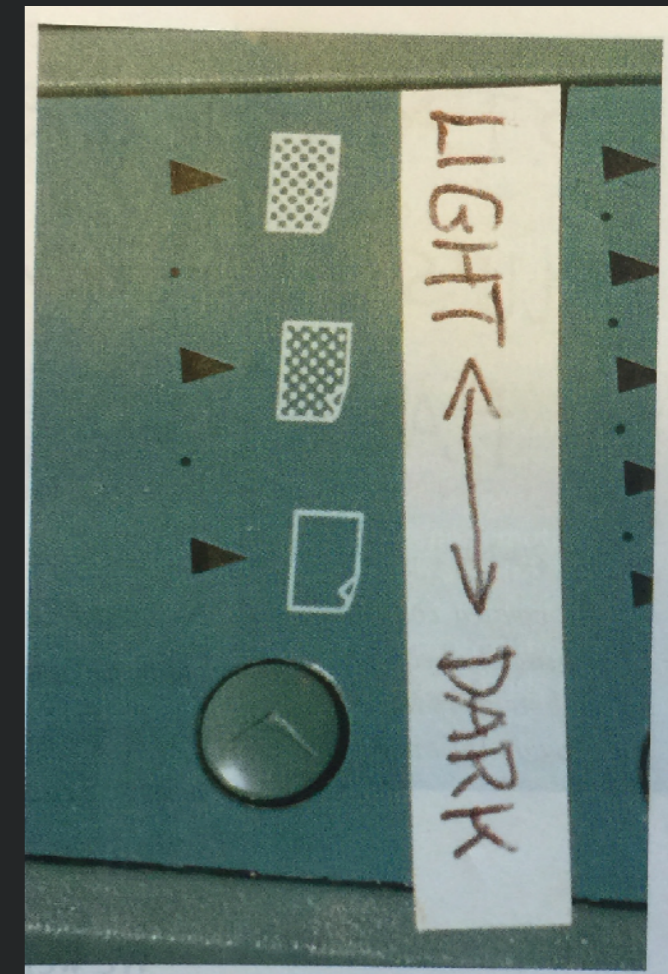
4. Affordances

- 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]
Iceape	Yes	Yes	No	Yes	Yes	No	?

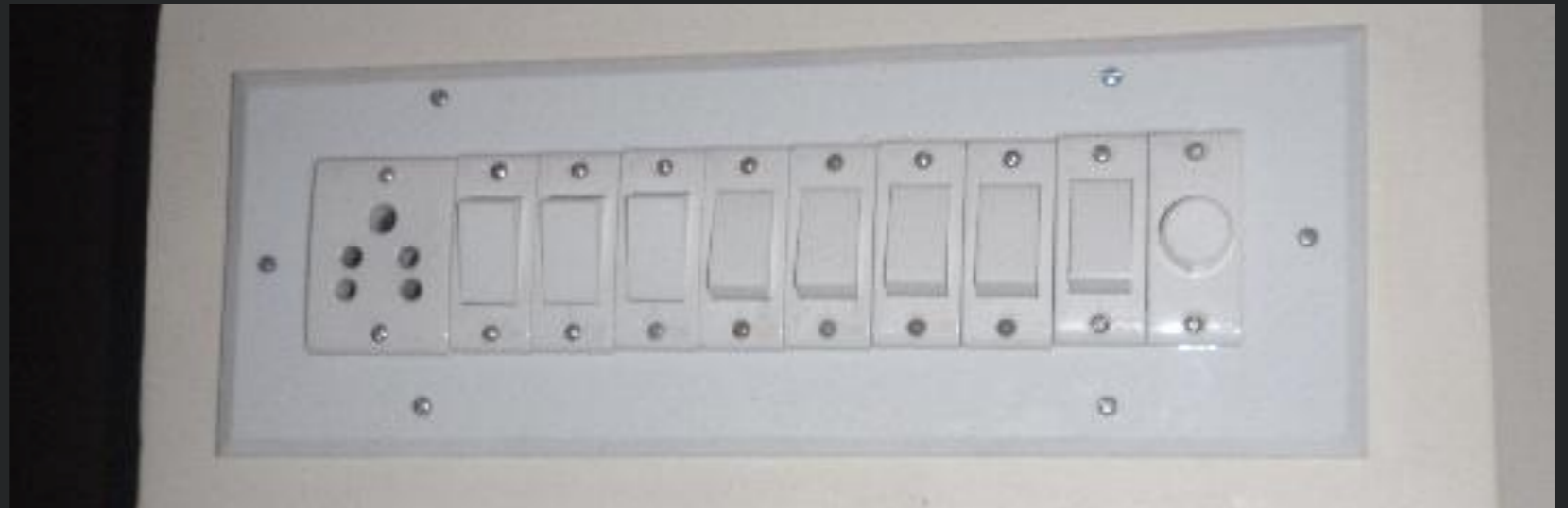
5. Signifiers

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

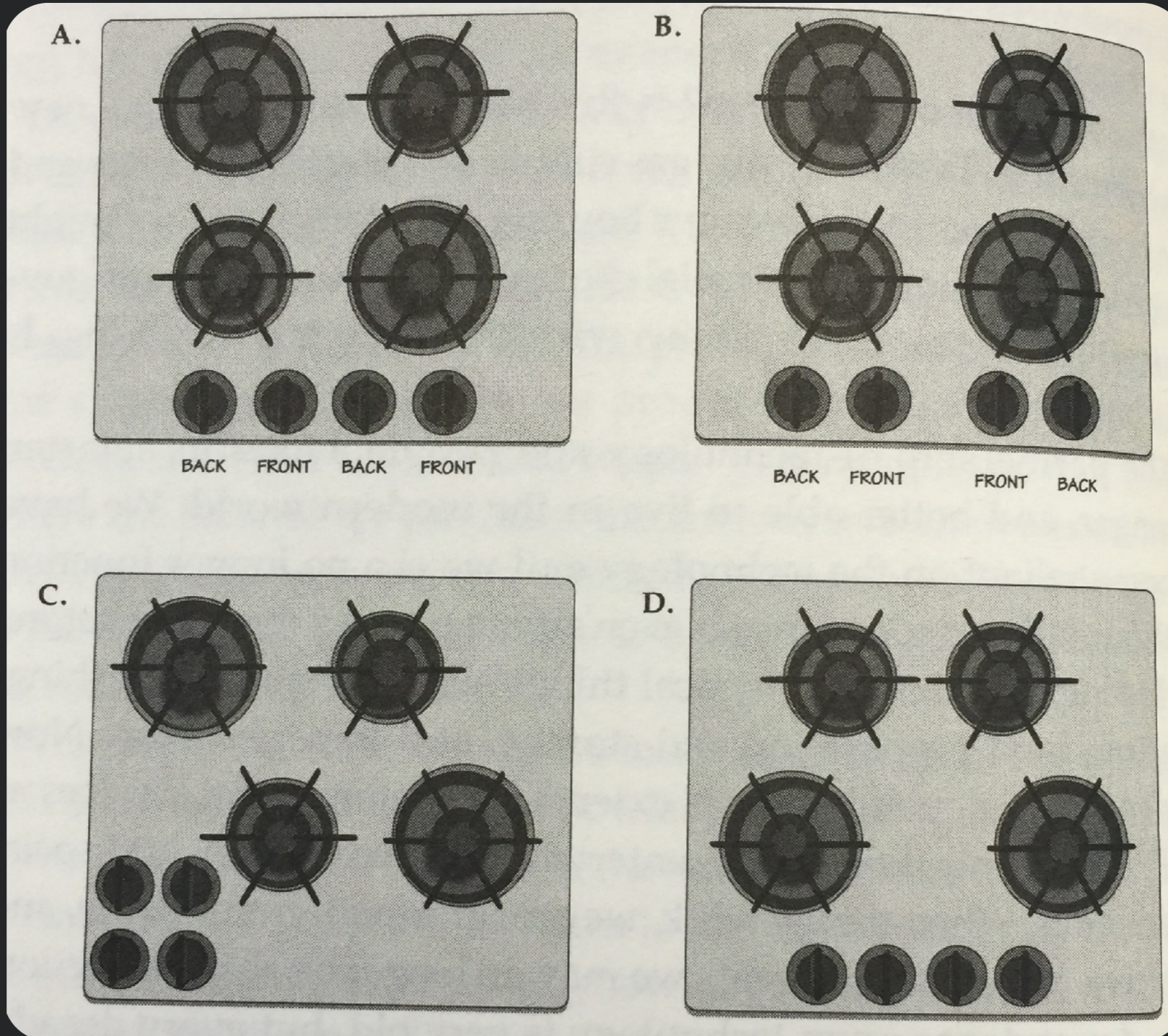


6. Mapping

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



Example - Stove Burners



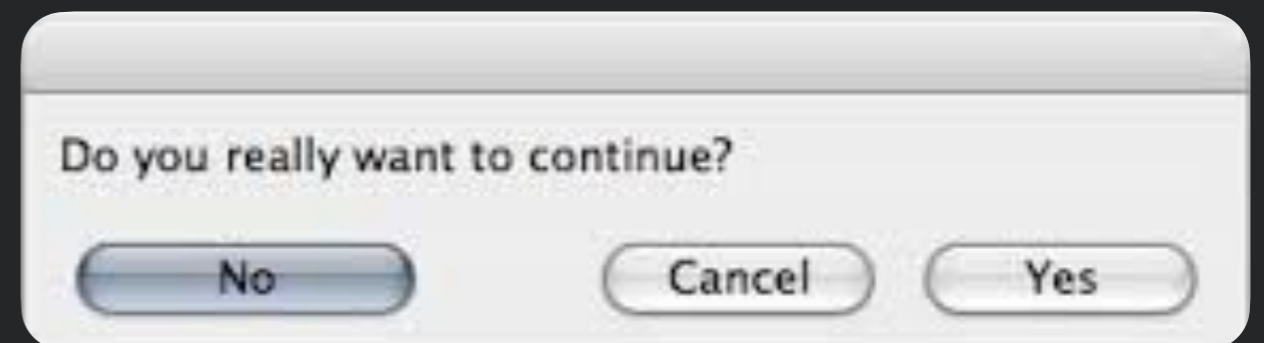
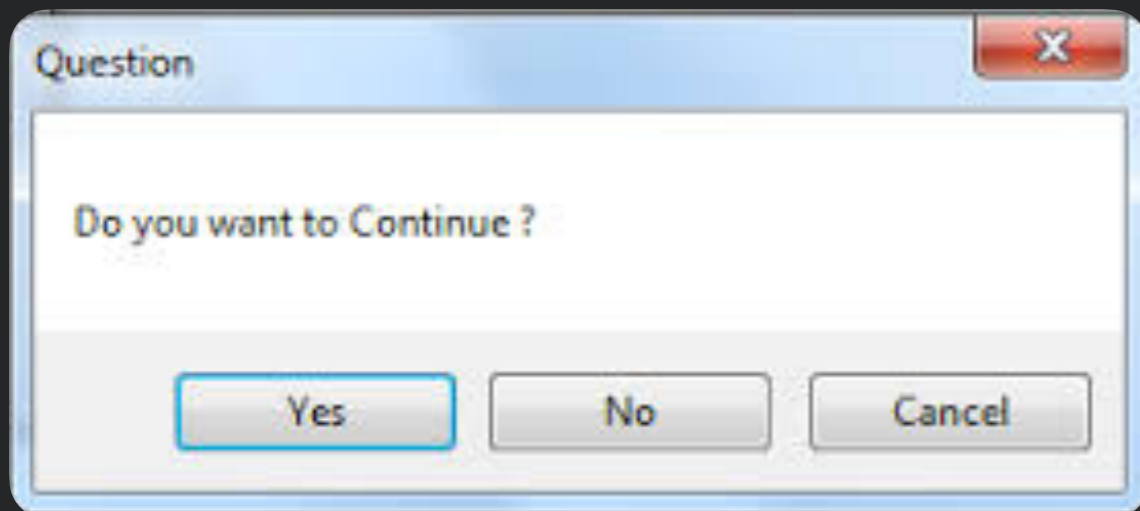


Natural Mapping

- 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

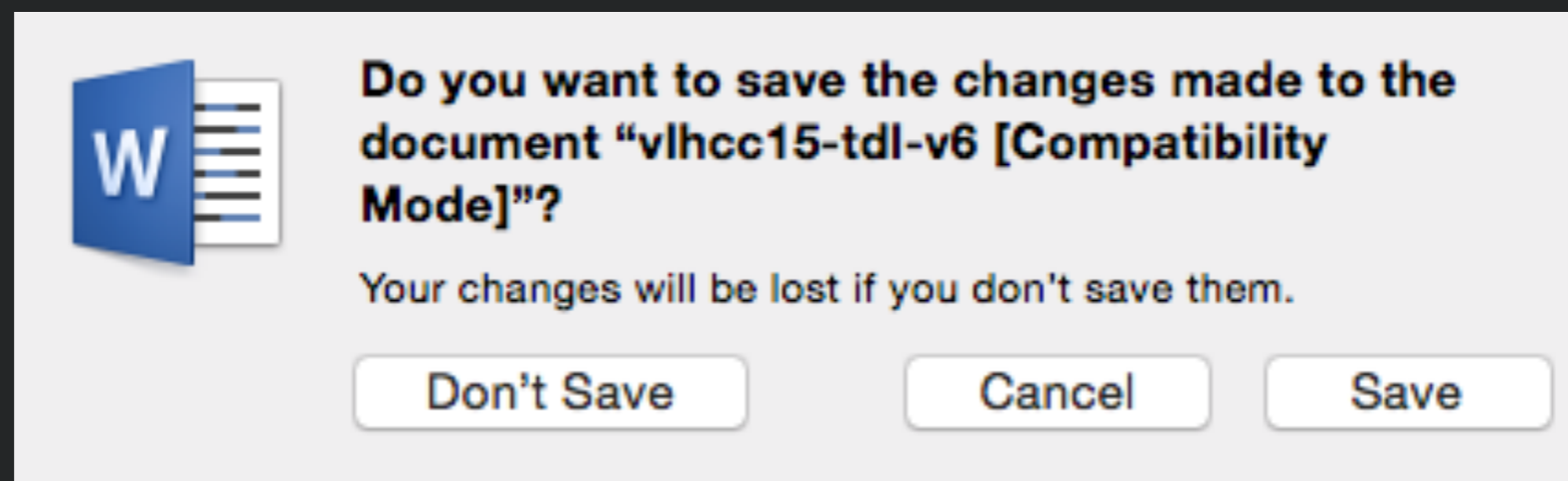


Physical constraints

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

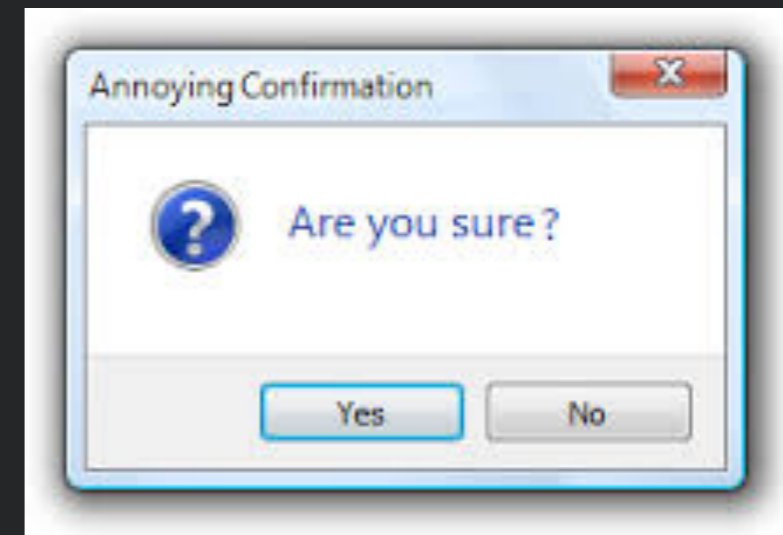
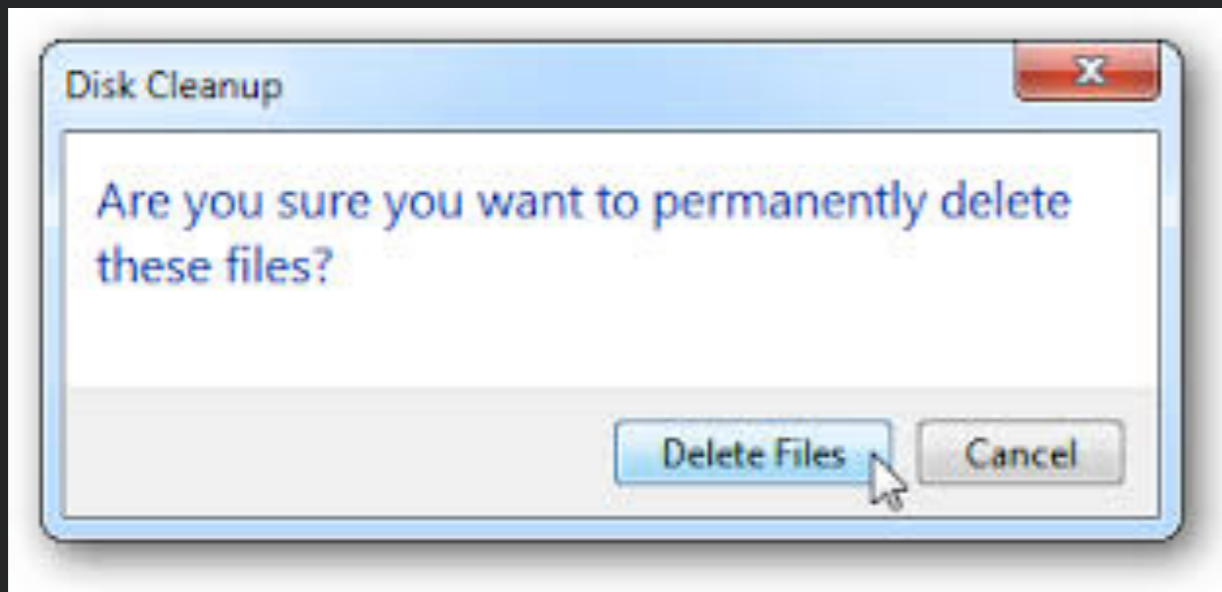


- Keeps an operation active, preventing someone from prematurely stopping



Lock-Outs

- Prevents an event from occurring





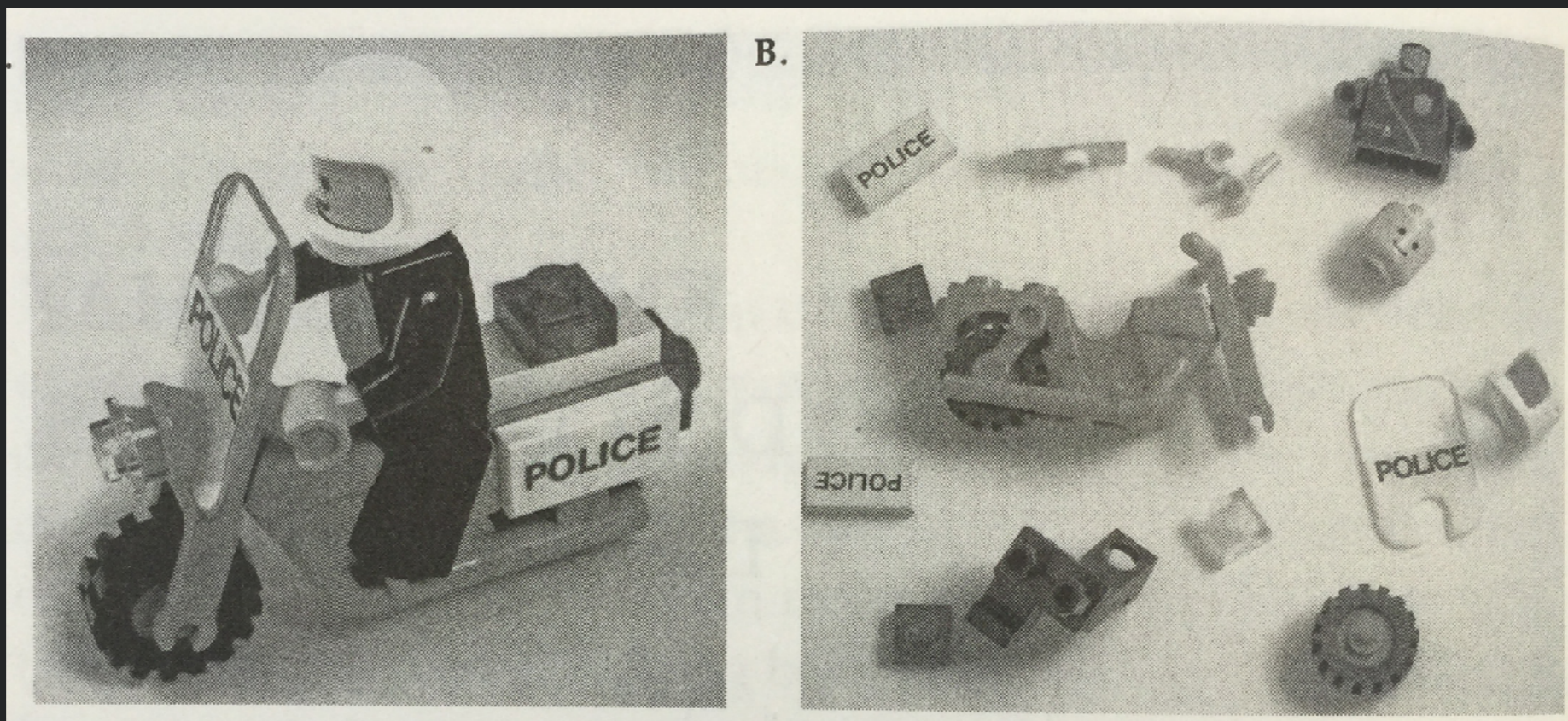
Inter-Locks

- 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

Group Activity





Group activity

- In groups of 3 or 4
- Pick a **complex** application or website
- List 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



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

- Slides adapted from Dr. Thomas Latoza's SWE 632 course