

The DESIGN of EVERYTHING UI Design Concepts & Principles

User Interface Development
EECS 493 - Fall 2024



Questions?

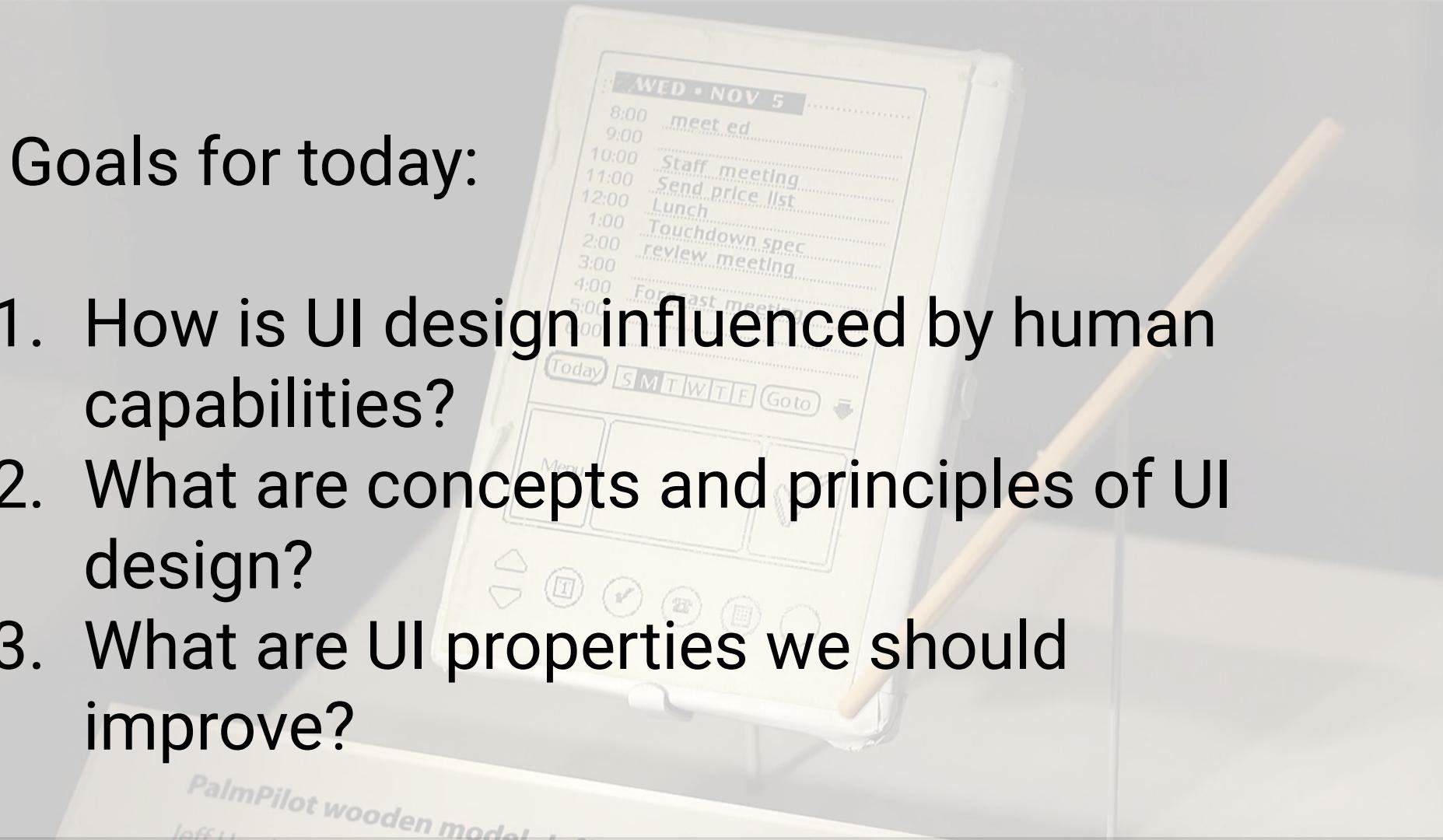


PalmPilot wooden model

Jeffrey

Goals for today:

1. How is UI design influenced by human capabilities?
2. What are concepts and principles of UI design?
3. What are UI properties we should improve?



Remember...

- Design is about “how things work” not “how things look”
- The user is not you!

12:01 ↗



Good afternoon, Anhong



Inbox Stores



134

Star balance

Rewards options ▾



Details

Redeem



Buy a drink, get a free drink

Order any drink and get one for you, just because.

Scan in store



Home



Scan



Order



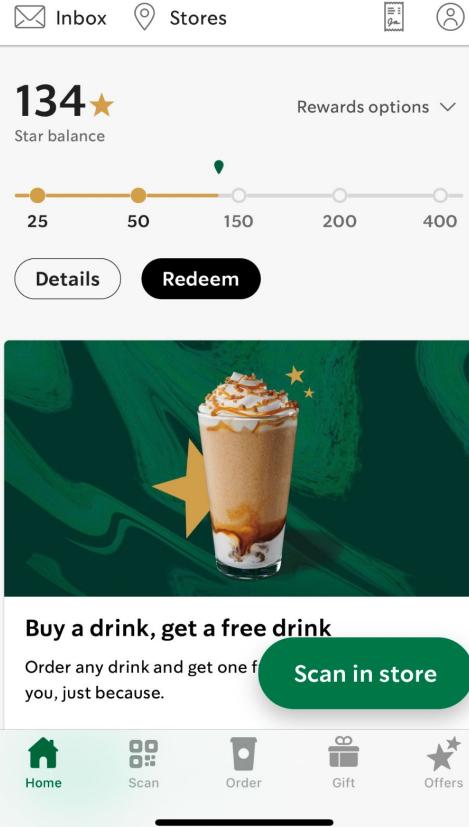
Gift



Offers

Functions vs. Aesthetics

Good afternoon, Anhong



Functions vs. Aesthetics

Starbucks Mobile App

- Need easy in-store payment
 - **Scan barcode**
- Need to repeat the same orders
 - **Can easily find previous orders**
- Need to reduce wait time
 - **Online order and pickup**
- Need to discover new drinks
 - **Show favorite drinks of the season**

Good afternoon, Anhong



Inbox Stores



134

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Offers

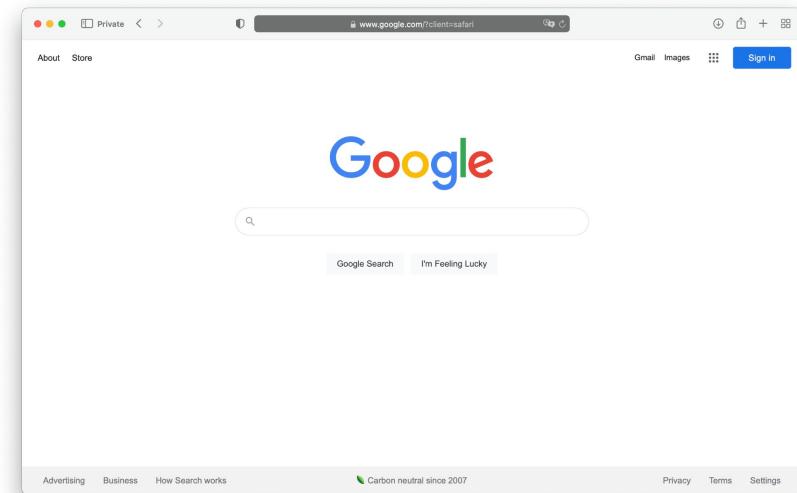
User-Centered Design Can Be Beyond Interfaces and Technologies

- Names write on cups for personalization
- Social events such as buy 1 get 1 free
- Reward programs to increase loyalty

User-centered design can be about the entire service users receive, and sometimes these services are provided through interfaces and technologies.

Function > Form

- ... but form can serve to aid function
- E.g., “clean looking” UIs make information easy to find and understand

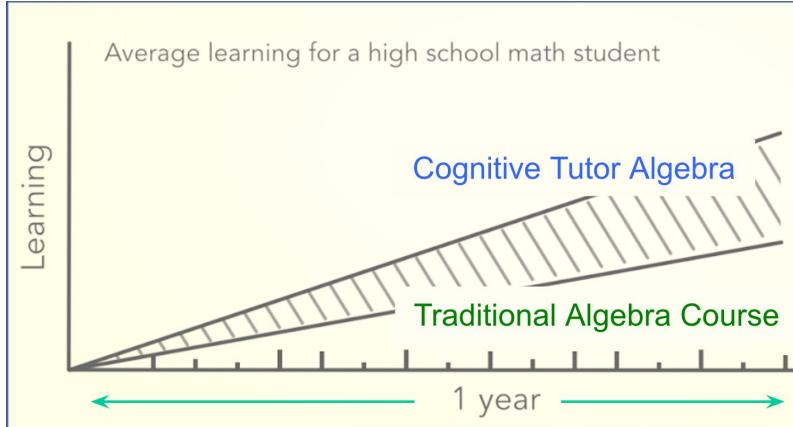


The User is Not You!

- First rule of HCI Design:
“The User is Not You!”
- You are not designing for yourself.

Cognitive Tutors lead to 2x better learning in US algebra classes

Using a cognitive model to adapt instruction to individual student needs



Area of Polygons and Circles

Answer the following questions approximating pi as 3.14.

Segment OA is circle O's radius. The table below will guide you through the steps of finding the area (A) of the circle. Use it to answer the following questions:

(1) If the radius is 2 inches, what is the area of circle O?

(2) Practice finding the area using a different radius, 5 inches. What is the area of Circle O this time?

Diagram Labels	1. Radius R	2. Square of the radius R^2	3. Area (A) $R^2 \times \pi$
Unit	in	sq. in	sq. in
1	2	—	—

?

Hint

Done

Enter given
Find area of simple polygon/shape

Koedinger et al. (1997). Intelligent Tutoring Goes to School in the Big City. *Artificial Intelligence in Education*.

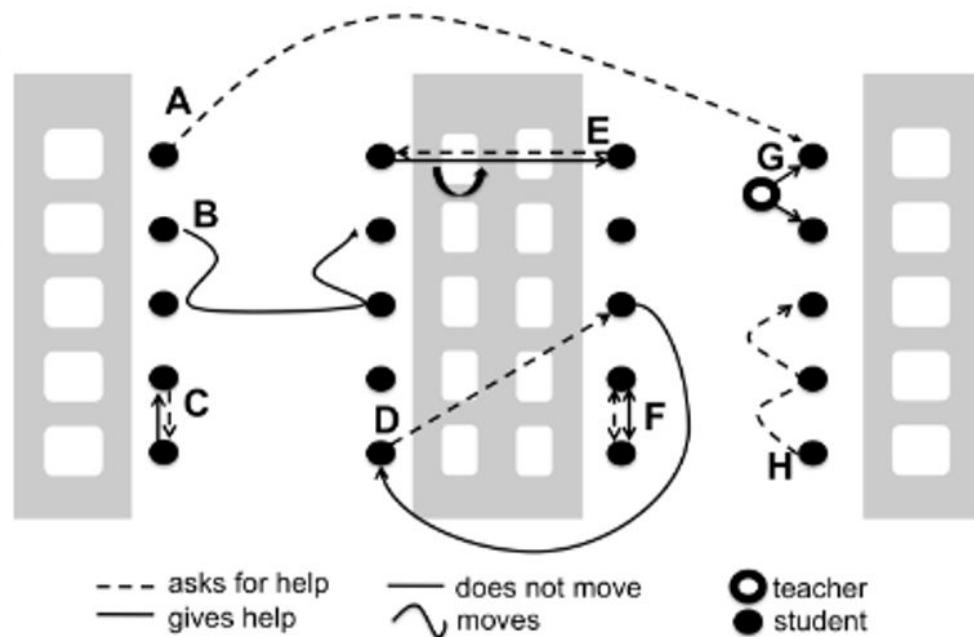
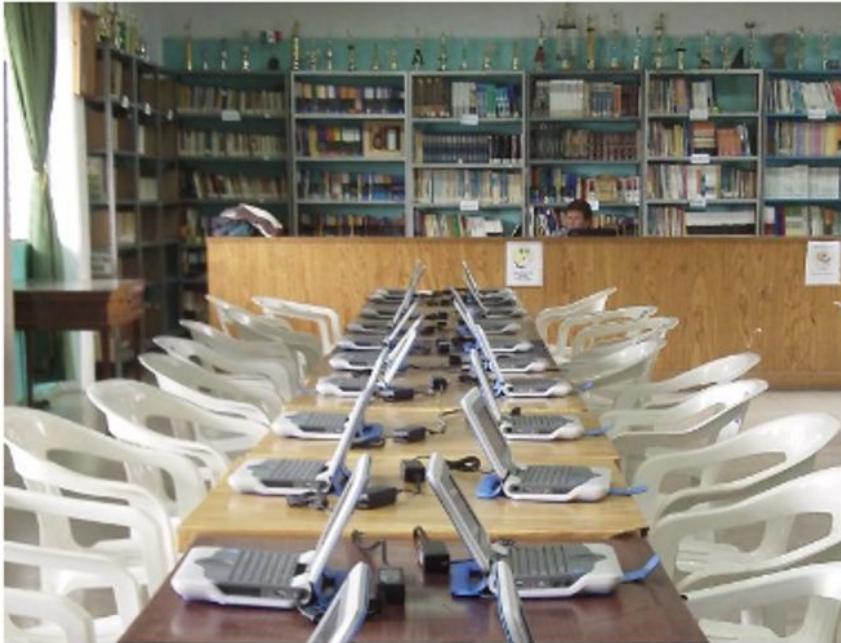
Pane et al. (2013). Effectiveness of Cognitive Tutor Algebra I at Scale. Santa Monica, CA: RAND Corp.

Researchers tried deploying this software in classrooms in South America.

But didn't work as expected...

Why?

Personalized cognitive tutors don't work in collaborative classrooms



Ogan, A., Walker, E., Baker, R. S., Rebolledo Mendez, G., Jimenez Castro, M., Laurentino, T., & De Carvalho, A. (2012, May). Collaboration in cognitive tutor use in Latin America: Field study and design recommendations. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (pp. 1381-1390).

Remember...

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- The user is not you!

Example Types of UIs

- Graphical User Interfaces
- Augmented / Virtual Reality
- Conversational and Speech Interfaces
- Ambient / Ubiquitous Interfaces
- Embodied Agents, e.g., robots

Human Capabilities

A Brief Primer

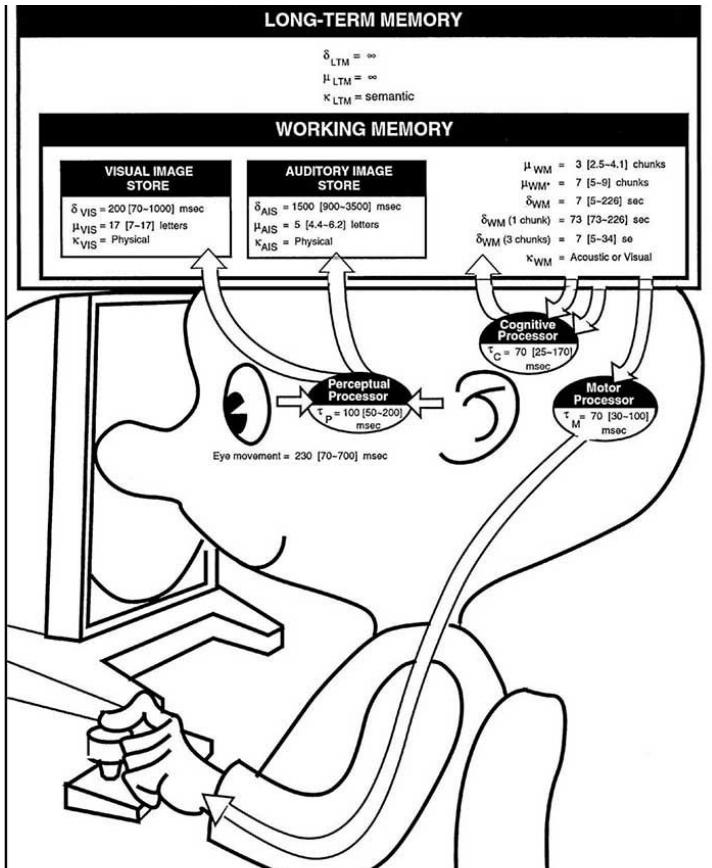


PalmPilot wooden model

Jeffrey

Model Human Processor

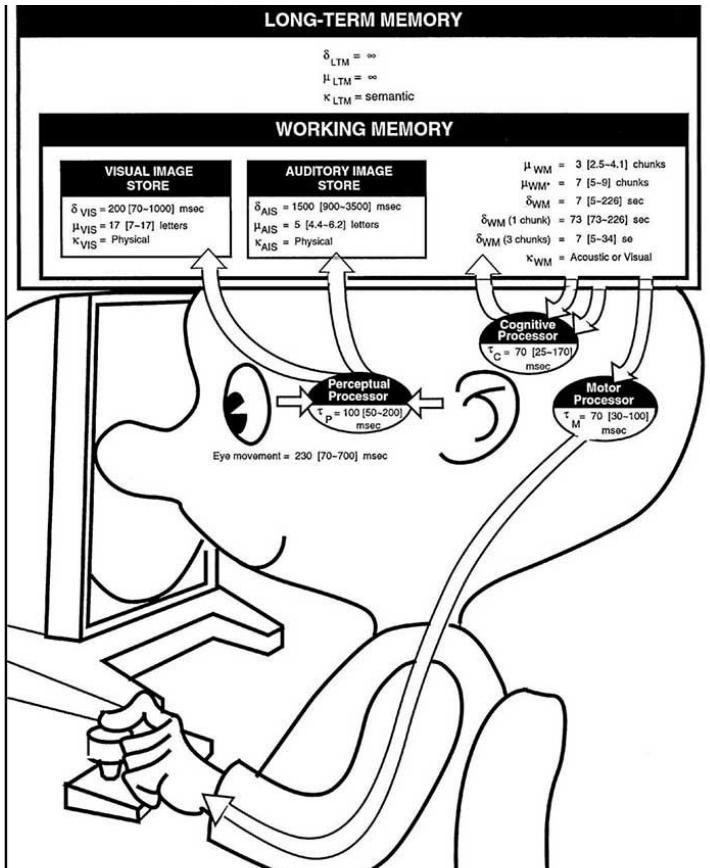
Card, Moran, and Newell (1986)



- Perceptual system
 - visual, auditory, etc.
- Motor system
 - Physical movements, e.g. typing, moving a mouse
- Cognitive system
 - Problem-solving, memory recall

Model Human Processor

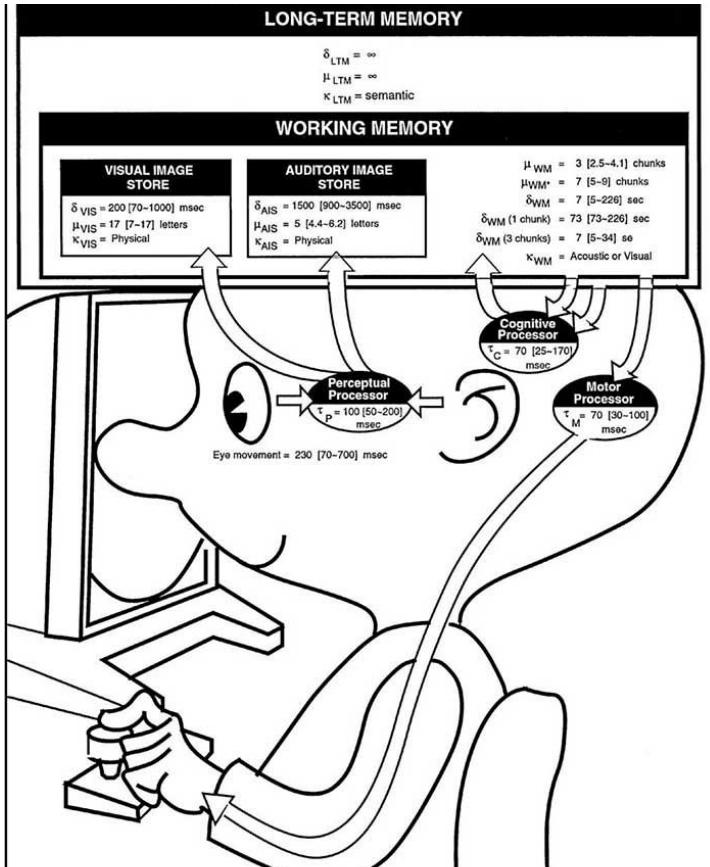
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It provides theoretical basis for understanding and predicting user behavior in interaction with computer systems.

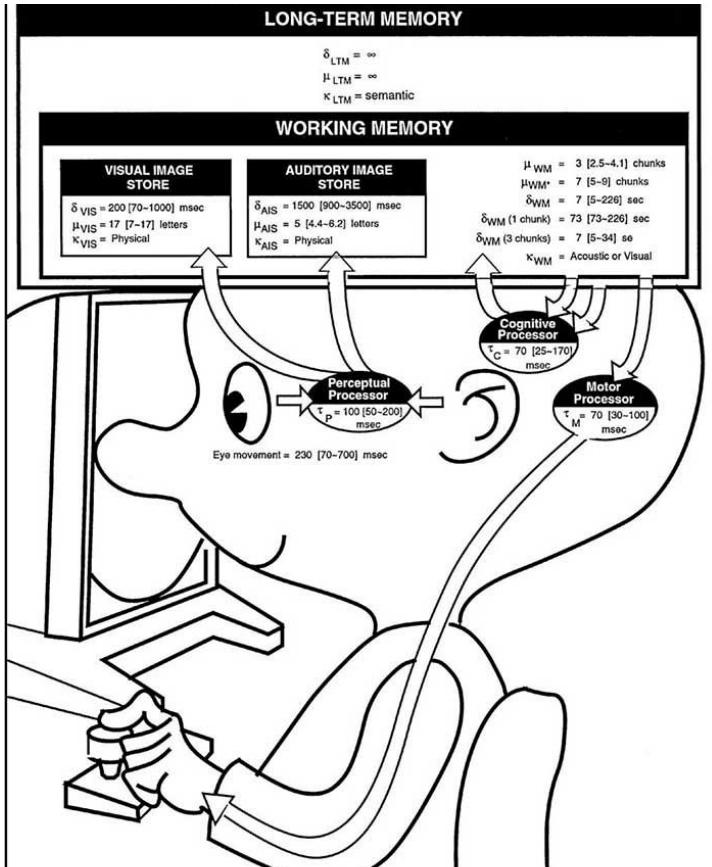
Model Human Processor



- Visual input: ~100ms
 - For a human interacting with a computer, it takes 100 ms to perceive visual stimuli and process it.
 - If an interface changes too quickly (faster than 100 ms), the user might not be able to perceive the change comfortably.

Card, Moran, and Newell (1986)

Model Human Processor



- Movement: ~70ms
 - The minimum time required for someone to execute a basic motor action in response to a stimulus, e.g., pressing a key on a keyboard or clicking a mouse button after processing a visual cue (100 ms).

Card, Moran, and Newell (1986)

Implications of Model Human Processor

- Motor
 - Fitts' Law
 - Steering Law
- Perceptual
 - Content layout/size
 - Dual coding theory
 - Movies
- Cognitive
 - Content grouping
 - Recognition vs Recall

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Motor Task (Pointing) “Laws”

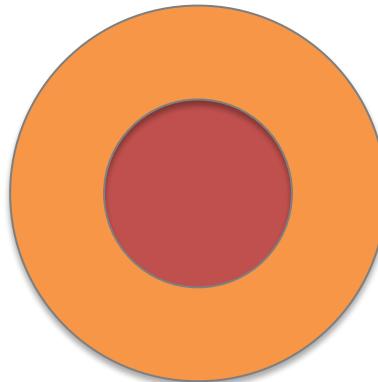
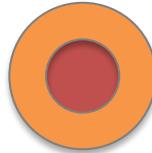
- Fitts' Law
- Steering Law



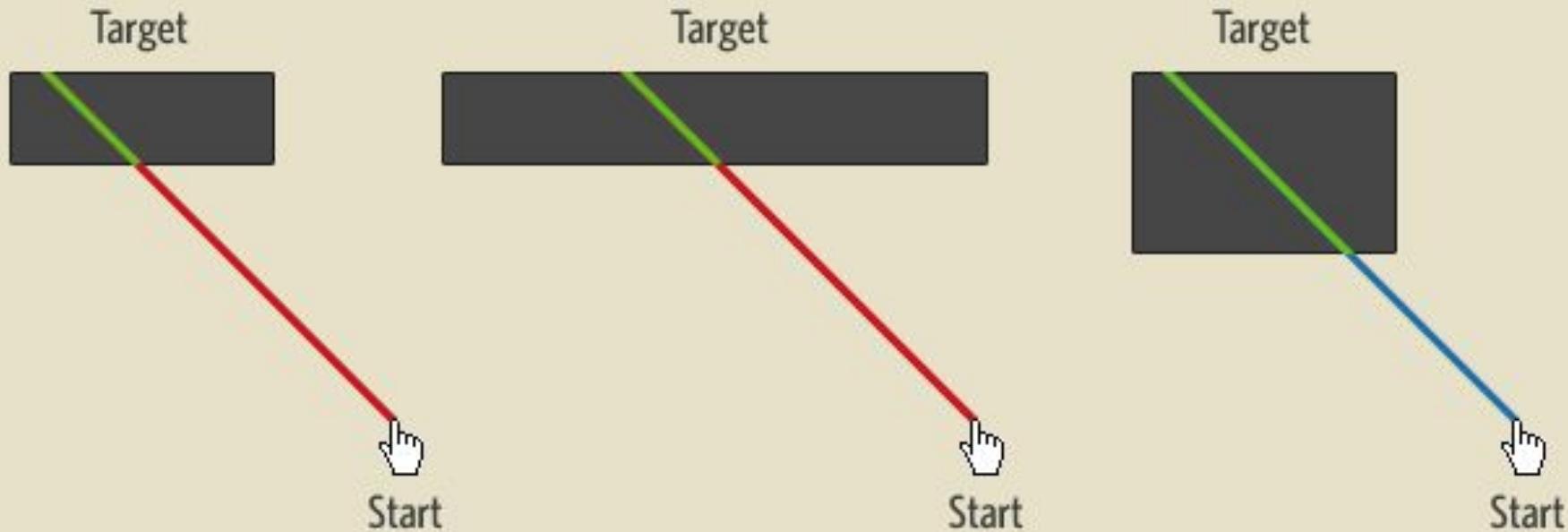
Fitts' Law

$$\text{Time} = a + b \log (\mathbf{D/S} + 1)$$

- **Distance**
- **Size**
- a, b = constants
- Index of difficulty is logarithmic



Fitts' Law



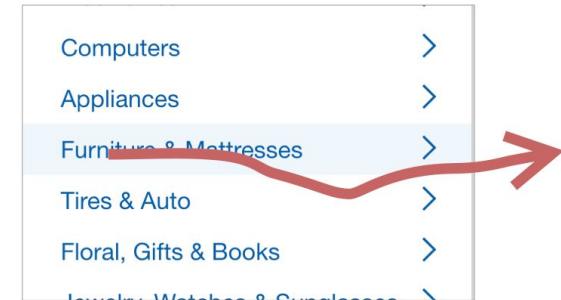
Steering Law

Time = $a + b^* \int_C ds/W(s)$ -> C is the path (could be curved)
When the path is a straight tunnel:

Time = a + b *Distance/Width

- **Distance (length of tunnel)**
- **Width (width of tunnel)**
- a, b = constants

Shop All Departments	
Electronics	>
Computers	>
Appliances	>
Furniture & Mattresses	>
Tires & Auto	>
Floral, Gifts & Books	>
Jewelry, Watches & Sunglasses	>
Patio, Lawn & Garden	>
Home Improvement	>
Home & Kitchen	>
Office Products	>
Clothing, Luggage & Handbags	>
Health & Beauty	>
Baby, Kids & Toys	>
Grocery & Household	>
Sports & Fitness	>
View More Categories	>



This design is error prone; People can easily miss the tunnel that leads to mistakes (right)



Expatistan

Data and tools for expats

Cost of Living ▾ Salary Calculator ▾ International Schools

Compare cost of living between

where you want to move

VS

Frankfurt am Main

Compare!

The original source for International Cost-of-Living Comparisons

3,170,000 prices

2,431 cities

230 countries

3

International Cost of Living Index

Salary



Expatistan

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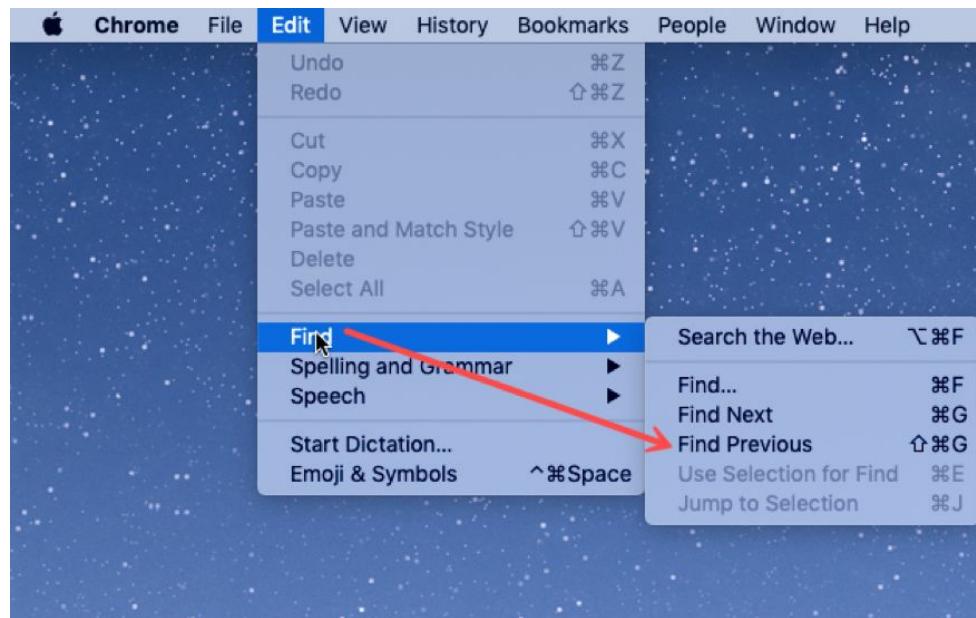
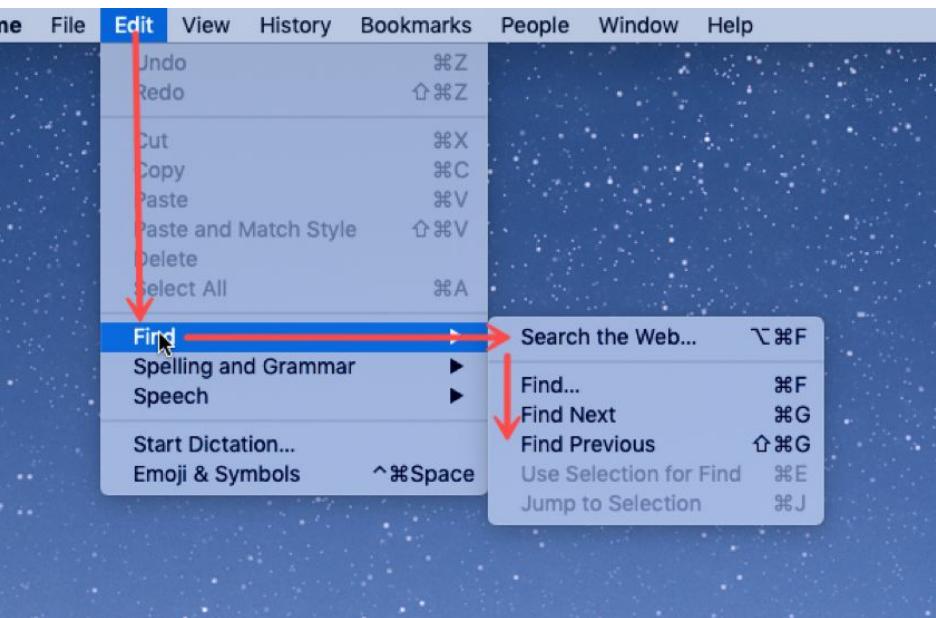
230 countries

3

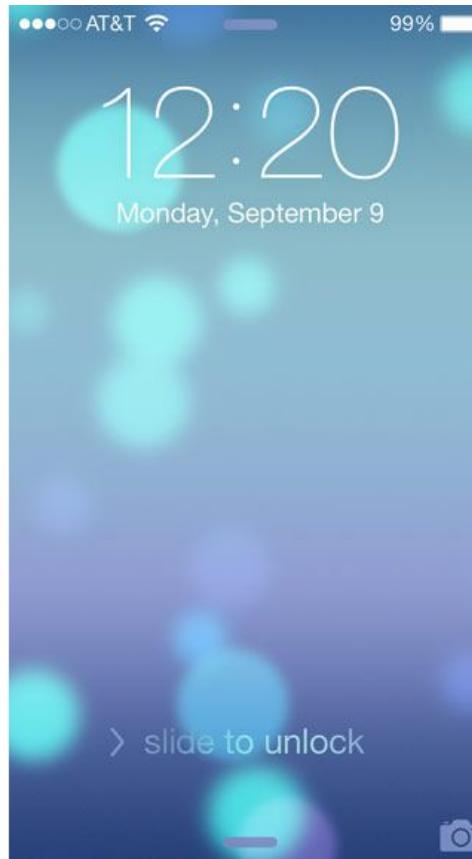
International Cost of Living Index

Salary

Steering Law (slow down animation, add delay for cascading menus)



Steering Law / Index of Difficulty



Create Account

Your Email

Password

Sign Up 

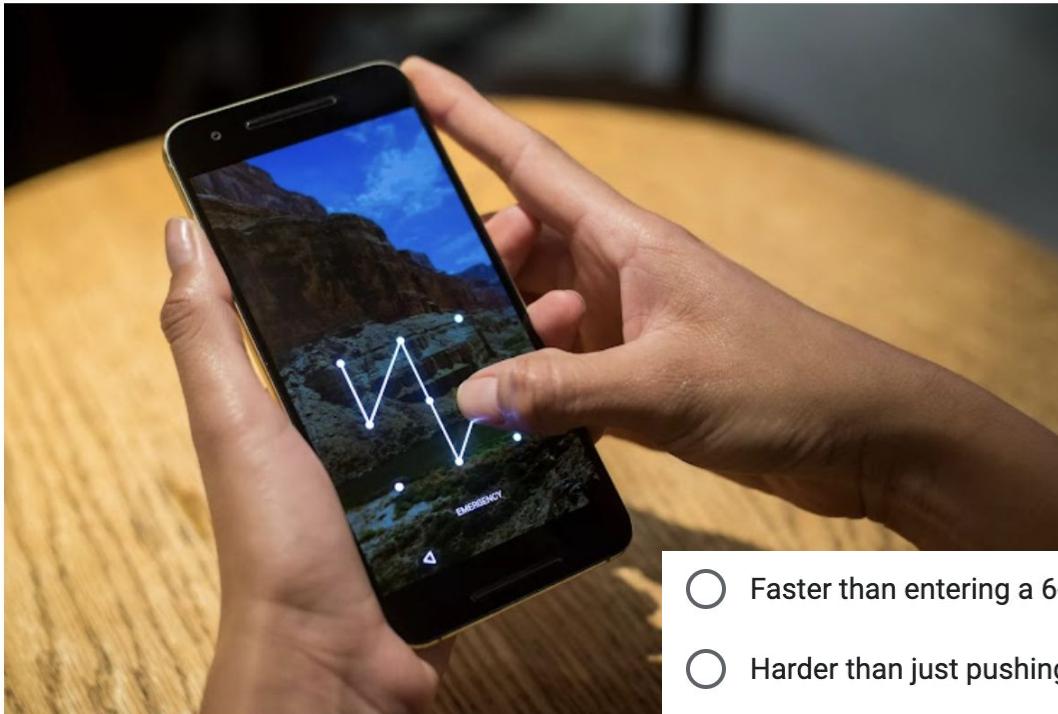
Create Account

Your Email

Password

Sign Up →

Unlocking your phone with a pattern is... *



- Faster than entering a 6-digit passcode.
- Harder than just pushing a button, which is described by the Steering Law.
- Is desirably harder, because you don't want to accidentally or easily unlock the phone with a button press.
- All of the above

You're designing a menu for a web app, according to Fitts' and Steering Laws,
which of the following are good design ideas?

*

- I want my menu list to be as comprehensive as possible, so I would include all possible options in a long list
- I will include more windows than pop-up menus.
- I want my menu list to be as concise as possible, shorter is better.
- For long menu lists with multiple categories that open up, I'll introduce a small delay.

Implications of Model Human Processor

- Motor
 - Fitts' Law
 - Steering Law
- **Perceptual**
 - **Content layout/size**
 - **Dual coding theory**
 - **Movies**
- Cognitive
 - Content grouping
 - Recognition vs Recall

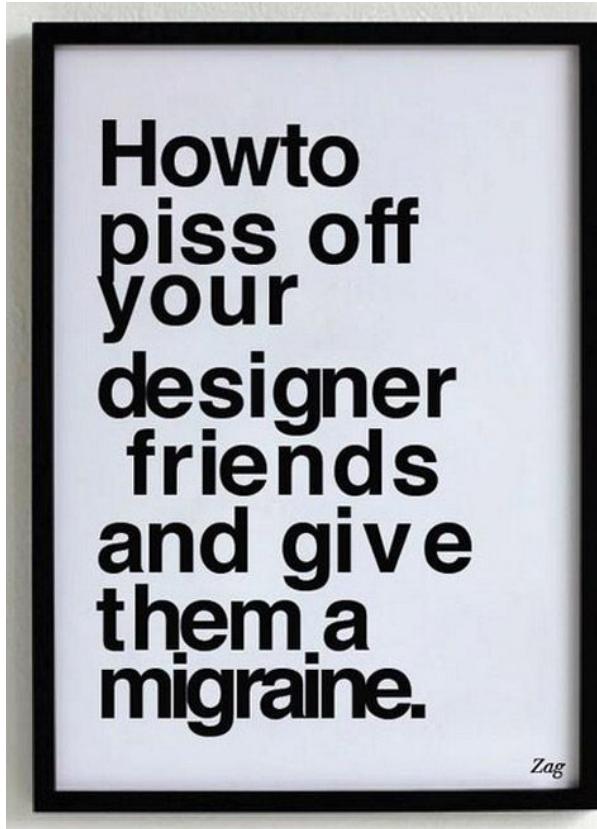
Reduce Perceptual Difficulty

- Aesthetics are not our focus, but...
 - They often are conflated with things that serve a purpose

perceptual ability | Content Size

- A really simple example is font size
- ...and style...
- *If you don't believe me, reading this paragraph should be quite a pain if it's long and uses hard to identify parlance or rarified lexicons given how this font seems indistinguishable from horrible chicken scratch. The most worsty mcworstest part is that if I keep going on like this, the block of text itself becomes so daunting that even without the insane font face, the task of reading this become not only viscerally unappealing, but downright challenging from a cognitive load and visual standpoint.*

perceptual ability | Content Layout



Theories/Practices that leverage Perceptual Processors

- Dual coding theory: You can learn more from images plus narration (visual input + auditory input) than images plus captions (both are image inputs).
- Change the screen fast enough, images fuse.
 - Thus, motion pictures

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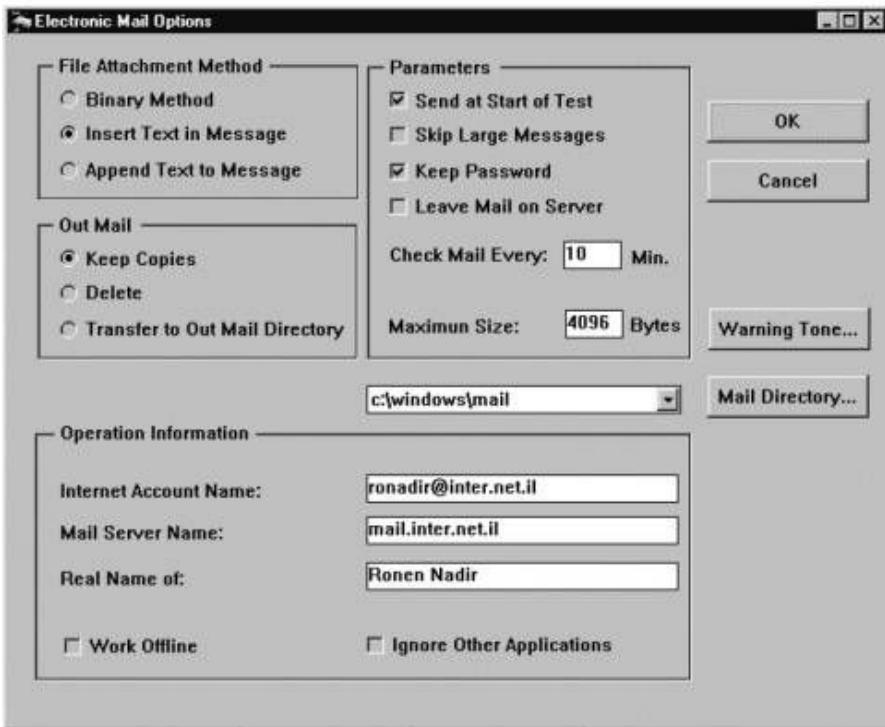
Reduce cognitive load

Miller's Law

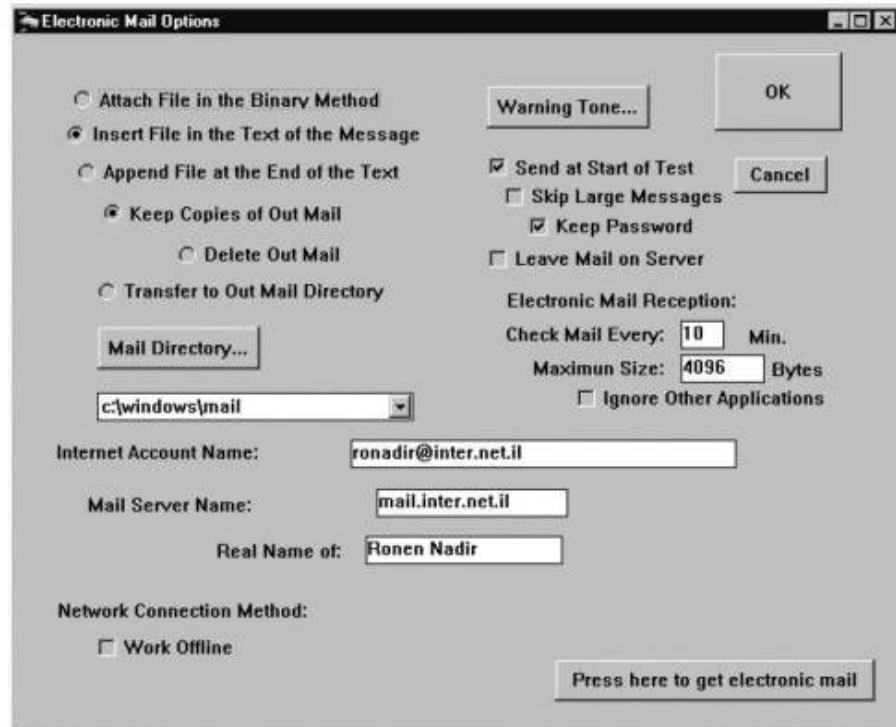
- 7 +/- 2 “chunks” can be held in working memory
 - Chunking = recoding items to be remembered as aggregates (e.g., phone numbers, menus)
 - Not always 7 +/- 2, but there are definite limits to what people can remember!

Reduce Cognitive Load - Content Grouping

Good



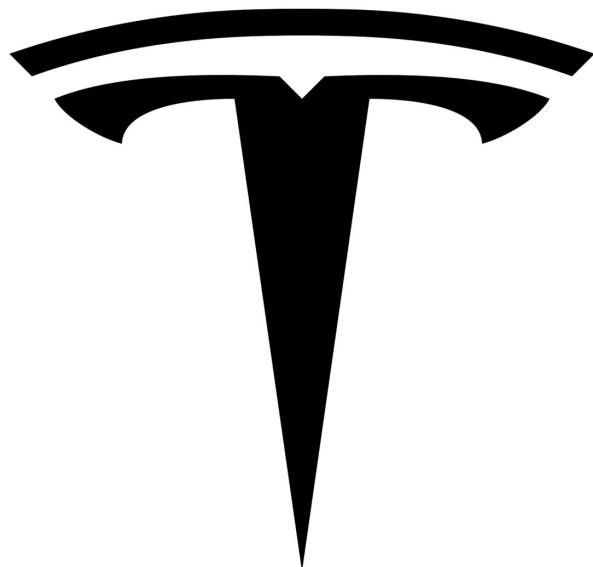
Bad



Reduce Cognitive Load - Recall



Reduce Cognitive Load - Recognition



Recognition is faster than Recall

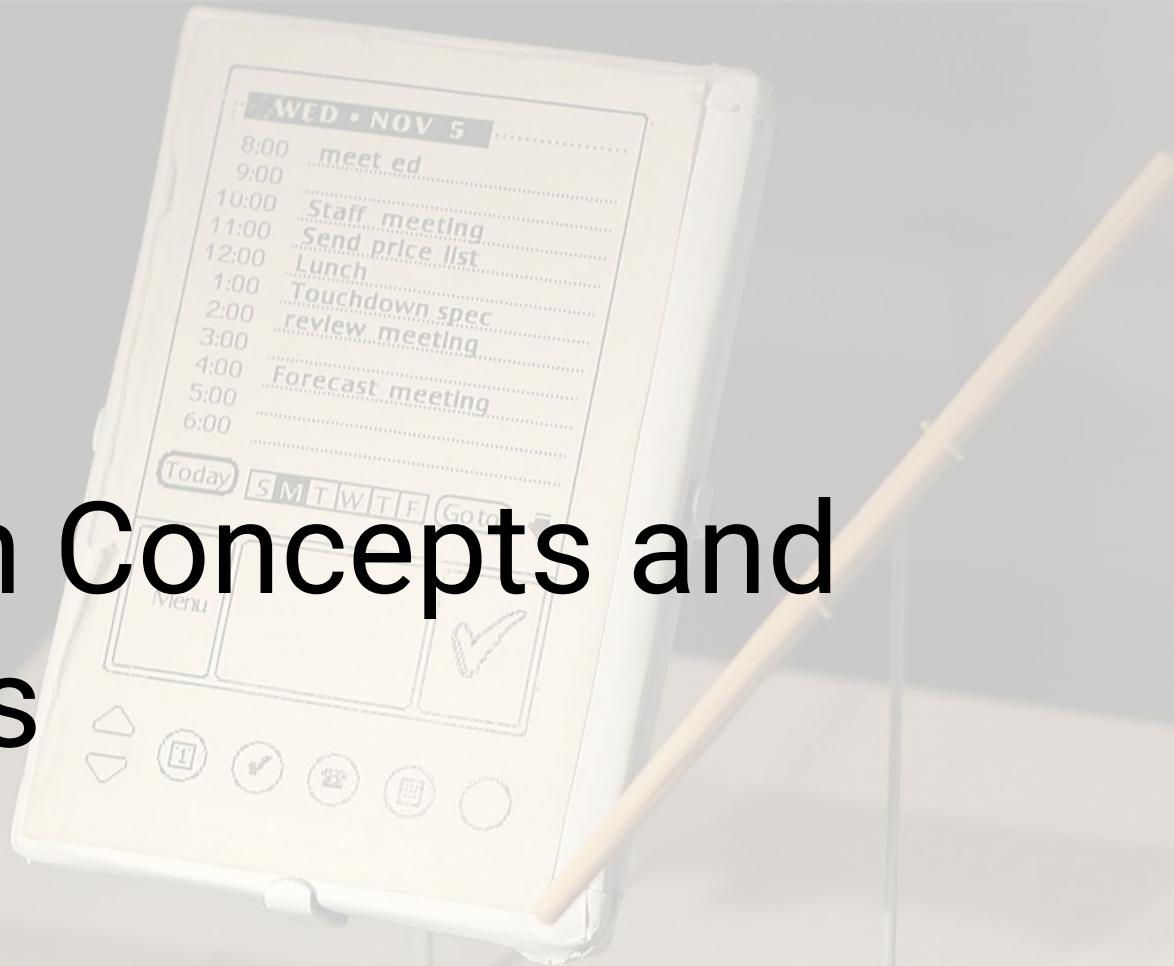
- Command line vs. Desktop example
- Course Registration example

```
[root@localhost ~]# ping -q fa.wikipedia.org
PING text.pmtpa.wikimedia.org (208.80.152.2) 56(84) bytes of data.
^C
--- text.pmtpa.wikimedia.org ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 540.528/540.528/540.528/0.000 ms
[root@localhost ~]# pwd
/root
[root@localhost ~]# cd /var
[root@localhost var]# ls -la
total 72
drwxr-xr-x. 18 root root 4096 Jul 30 22:43 .
drwxr-xr-x. 23 root root 4096 Sep 14 20:42 ..
drwxr-xr-x. 2 root root 4096 May 14 00:15 account
drwxr-xr-x. 11 root root 4096 Jul 31 22:26 cache
drwxr-xr-x. 3 root root 4096 May 18 16:03 db
drwxr-xr-x. 3 root root 4096 May 18 16:03 empty
drwxr-xr-x. 2 root root 4096 May 18 16:03 games
drwxrwx-T. 2 root gdm 4096 Jun 2 18:39 gdm
drwxr-xr-x. 38 root root 4096 May 18 16:03 lib
drwxr-xr-x. 2 root root 4096 May 18 16:03 local
lrwxrwxrwx. 1 root root 11 May 14 00:12 lock -> ../run/lock
drwxr-xr-x. 14 root root 4096 Sep 14 20:42 log
lrwxrwxrwx. 1 root root 10 Jul 30 22:43 mail -> spool/mail
drwxr-xr-x. 2 root root 4096 May 18 16:03 nis
drwxr-xr-x. 2 root root 4096 May 18 16:03 opt
drwxr-xr-x. 2 root root 4096 May 18 16:03 preserve
```

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UI Design Concepts and Principles

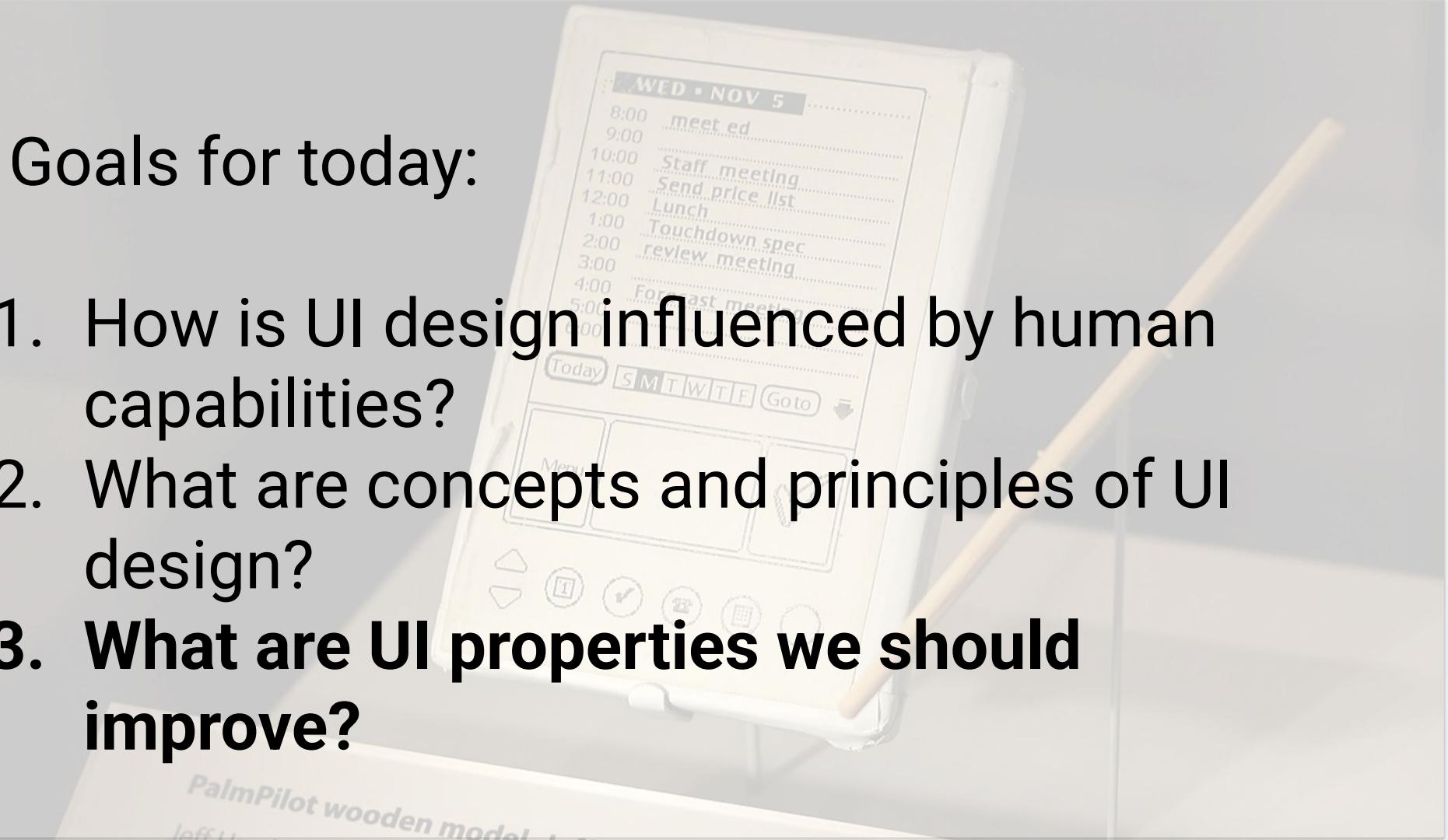


PalmPilot wooden model

Jeffrey

Goals for today:

1. How is UI design influenced by human capabilities?
2. What are concepts and principles of UI design?
3. **What are UI properties we should improve?**





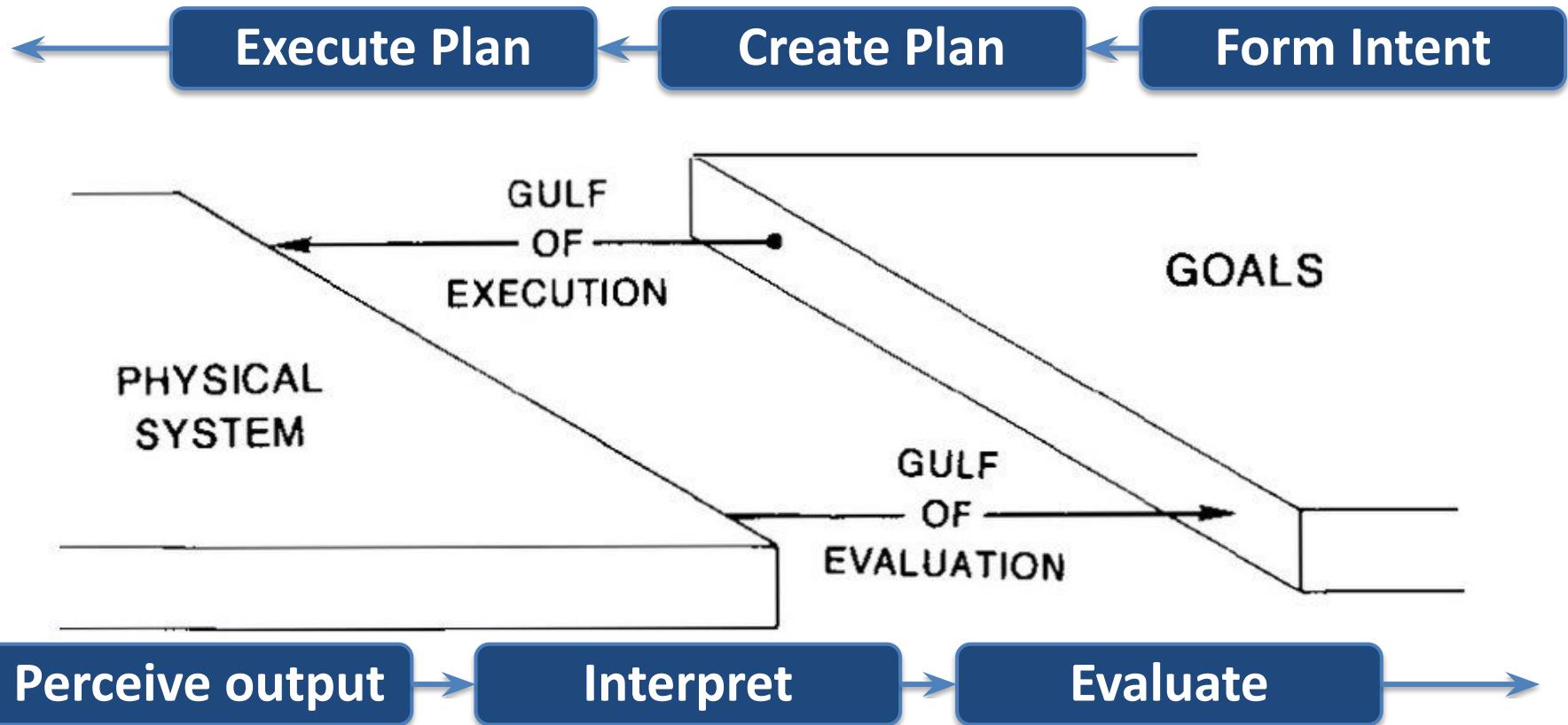
Vox

The Two Gulfs (from Don Norman)

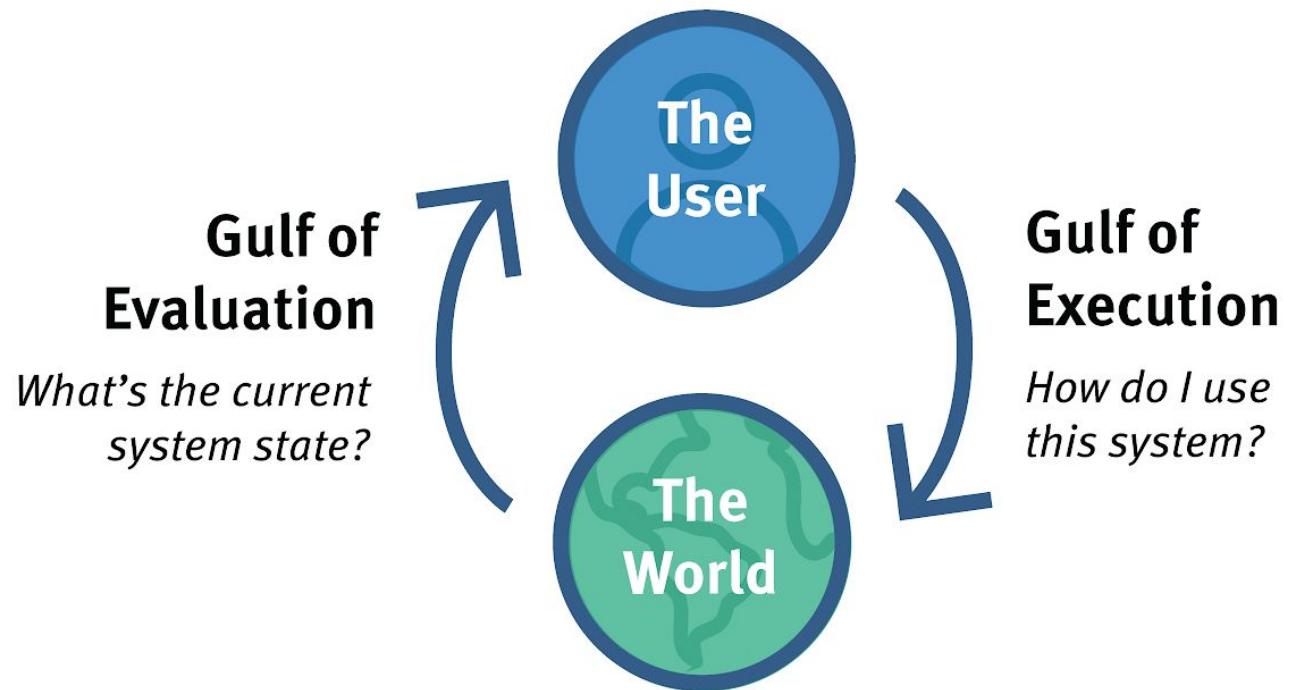
- Gulf of evaluation - difficulty of figuring out the state of a system
- Gulf of execution – difficulty of understanding how to get the system to accomplish your goal

A good interface minimizes both of these.

Gulf of Execution / Evaluation



Gulf of Execution / Evaluation



Important terminologies in UI design

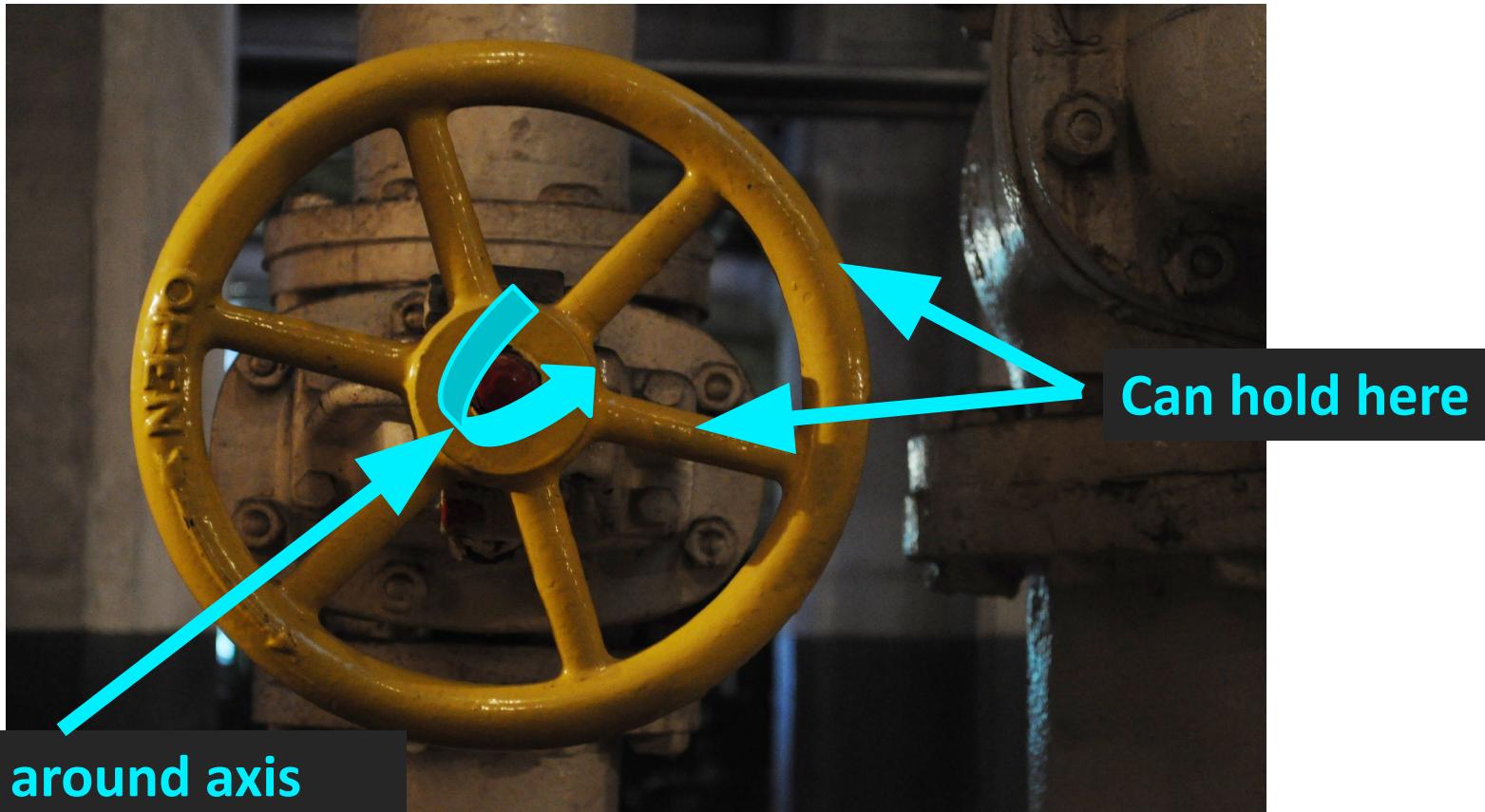
- Affordance
- Signifier
- Metaphor
- Learned Association

Affordance is opening door - “What?”

- **Signify** is how to open door - “How?”



Affordances

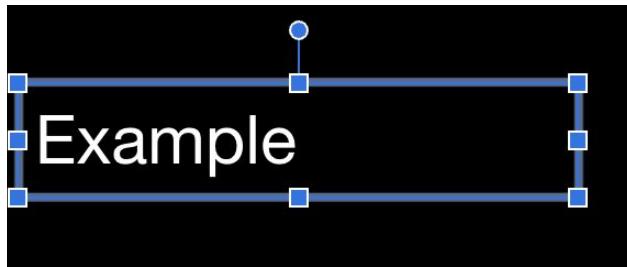


Signifiers



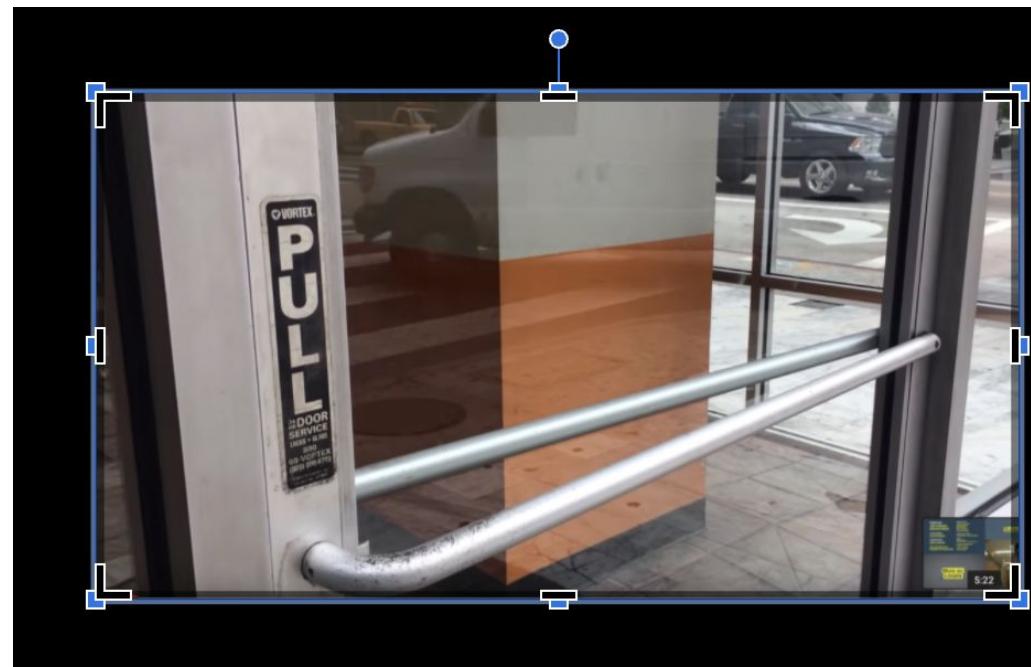
Communicate which way you *should* use it

Affordances and Signifiers in Slides



Helvetica ...

- 44 +



Affordances vs. Signifiers

- Affordances: What you can do in terms of interaction (this affords that)
- Signifier: Signals where and how interaction should take place (this shows how you can do that)

Metaphors

- exploit specific knowledge that users already have of other domains
- It gives users an instantaneous knowledge on how to use the user interface.

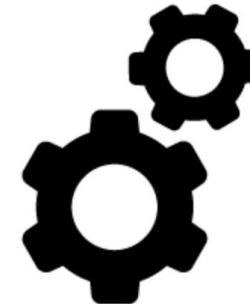
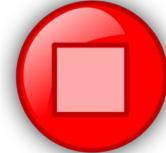


Image credit AFY Studio, Viktor Vorobyev

Learned Association

- Green = GO; Red = STOP
- Thus... Green means call; Red means hang up
- ... Green means add; Red means remove
- ... Green means play; Red means stop
- Etc. etc.



Learned Association

Menus



Bookmark

etc.

Gmail Images



Search Google or type a URL

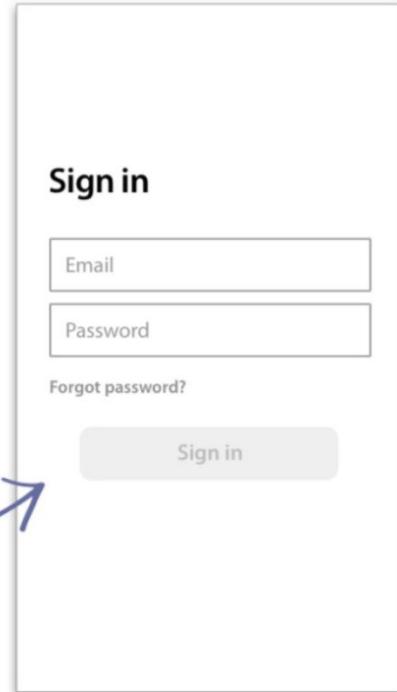


Learned Association

- Of course, all metaphors are learned associations.
- Not all learned associations are metaphors.



What is affordance, what is signifier in this screen? *



Short answer text

Interface Design Properties

- Usability
 - Efficiency
 - Understandability
 - Discoverability
 - Learnability

UI Properties - Efficiency

Can you get the job done quickly + well?

Example: Predictive text helps people type more efficiently



] Predictive text; tap a suggestion to apply.

UI Properties - Efficiency

Can you get the job done quickly + well?

Example: The dock helps people easily access the frequently-used apps



UI Properties - Understandability

Do you understand what is happening?

Example: The Nest interface shows the current and goal temperature.



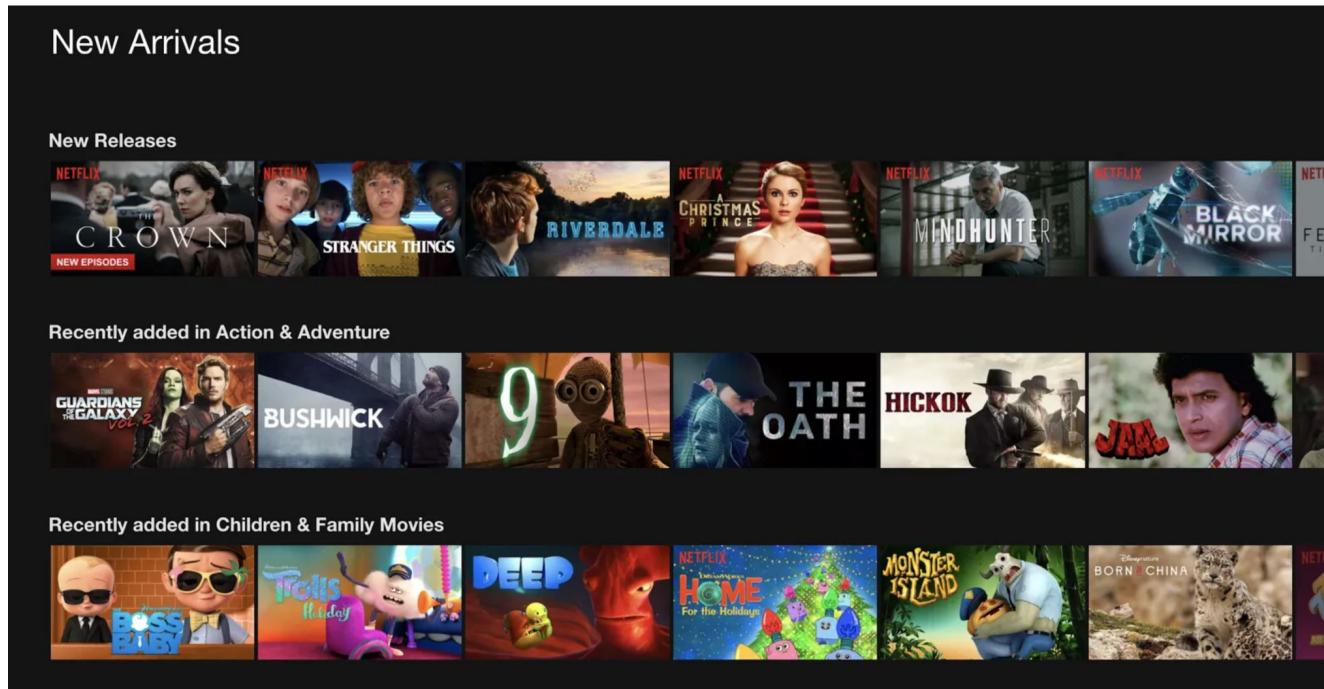
UI Properties - Understandability

The use of metaphors and learned associations could enhance understandability.



UI Properties - Understandability

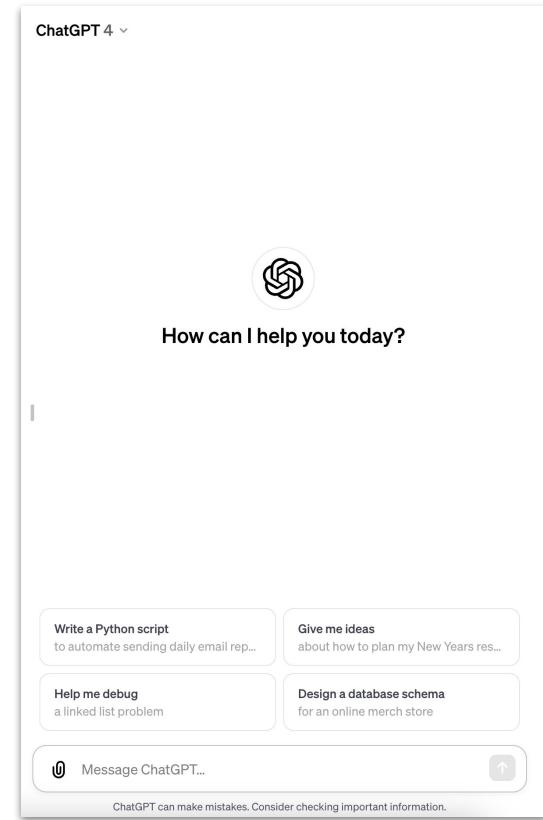
Grouping of content could enhance understandability.



UI Properties - Discoverability

- Can you find new/existing UI features/tools?
- Tied to learnability

Example: ChatGPT gives some inspirations for people to try cool functionalities.



UI Properties - Learnability

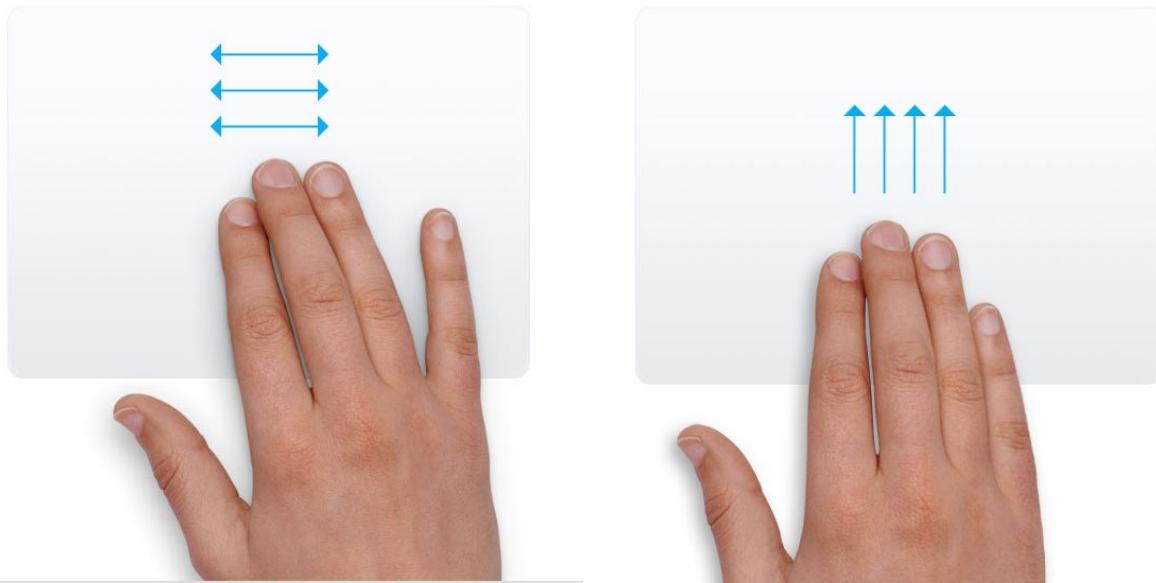
Can you get better at using the interface?

The screenshot shows a web browser window on the Figma community platform. The URL in the address bar is `figma.com/community/search?resource_type=mixed&sort_by=relevancy&query=app+design&editor_type=all&price=all&creators=all`. The search bar contains the text "app design". The results page is titled "Results for app design". It features a sidebar on the left with filters: "All" (selected), "Products", "Paid + free", "All creators", "Relevancy" (selected). Below the sidebar are categories: "Files + templates" (100), "Plugins" (100), "Widgets" (7), and "Creators" (37). The main content area displays a grid of 18 cards, each representing a different app or template. Some cards are from Apple Design Resources, while others are from community members like "Xu Wang". The cards include titles such as "iOS 17 + iPadOS 17 Design library and templates", "Finance MOBILE APP UI/UX DESIGN", "Fintech Investment App", "visionOS Design library and templates", and "macOS Sonoma Design library and templates". Each card includes a thumbnail image, the title, the creator's name, and some statistics like views and likes.

Example: Figma community gives a lot of examples

UI Properties - Learnability

Can you get better at using the interface?



Example: Apple trackpad offers a handful of easy gestures (not too much for people to remember)

Consider Google Maps

Affordances?

Signifiers?

Metaphors?

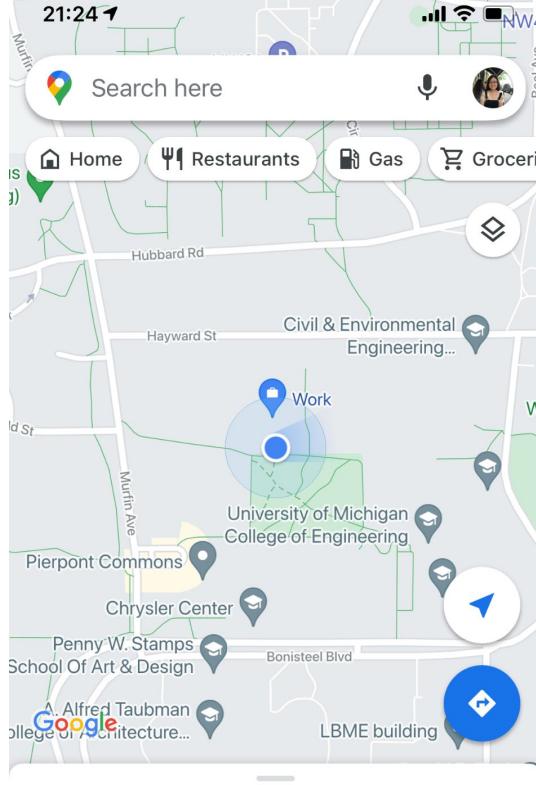
Gulf of Evaluation?

Gulf of Execution?

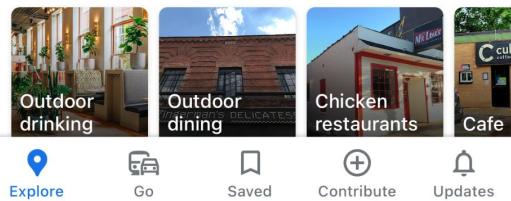
Efficiency?

Discoverability?

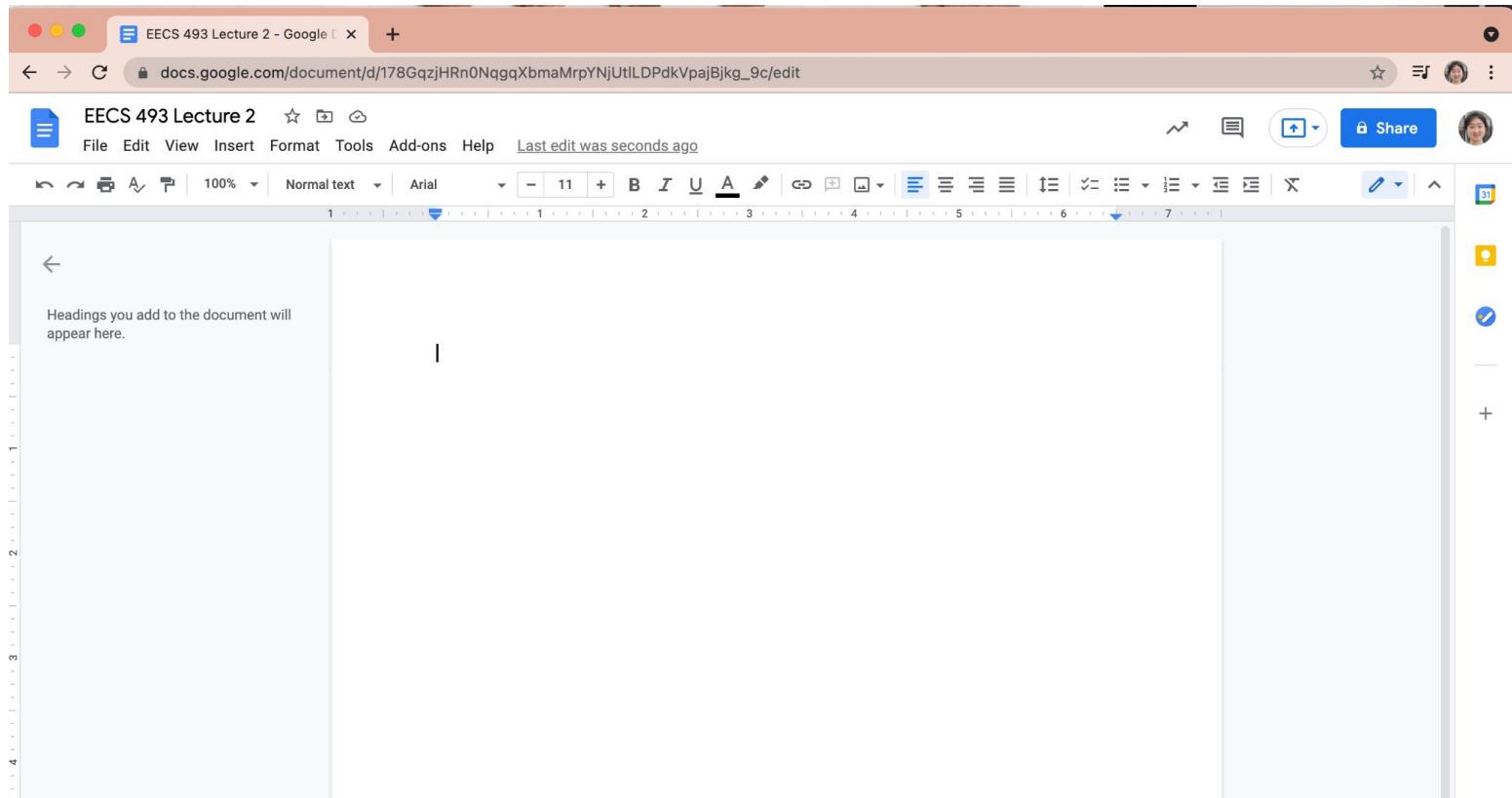
.....



Latest in Ann Arbor



Consider Google Docs



Summary of Learning Objectives

- UI design must fit human abilities
 - Perceptual, cognitive, and motor capabilities
- Design is solving the two gulfs matching the representations we can use and expectations of the users
- Frequently used UI design concepts (affordances, signifiers, metaphors, and learned associations)
- Principles to guide design and UI properties we aim to improve. (Efficiency, understandability, discoverability and learnability)