

IE403

Winter 2023

Human-Computer Interaction

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TA:TBA

What is this class about?

- Why are things so hard to use these days?
- Why doesn't this thing I just bought work?
- Why is this website so hard to use?
- Why are users not liking my design?
- Why is my app not getting popular?

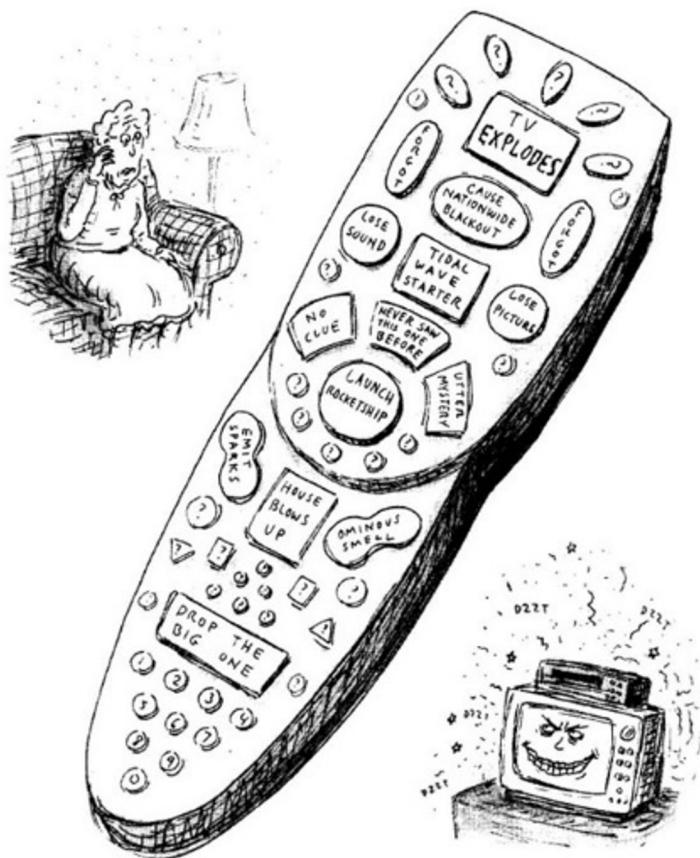
Outcomes

- Understand what makes interfaces more or less usable
- Design and Build usable interfaces
- Scientifically evaluate the usability of those interfaces

Grading Policy

Component	Weightage
Attendance	20%
In-Sem I	15%
In-Sem II	15%
Quizzes	10%
In-class Assignments	10%
Project	30%

HOW GRANDMA SEES THE REMOTE



EMI Calculator

Loan Amount:

Calculate Reset

Interest Rate: **7.30000000000000**

Tenure: **10 Years**

EMI: **Rs. 0.01**

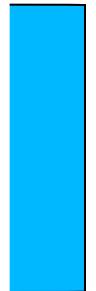
*How can we design human-centered Systems that people find **useful and usable**?*

This course introduces

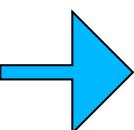
Designing,

Prototyping

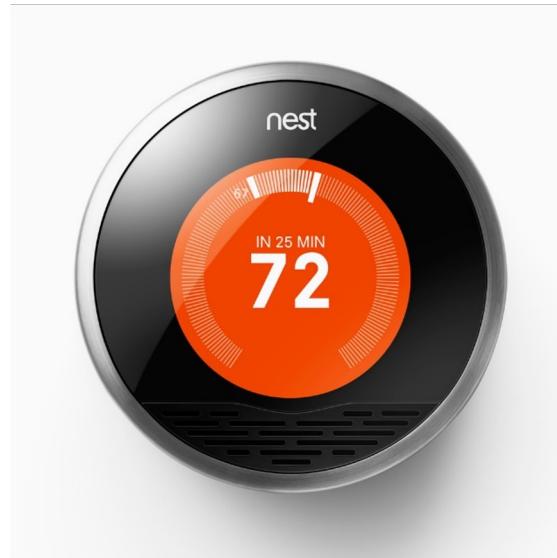
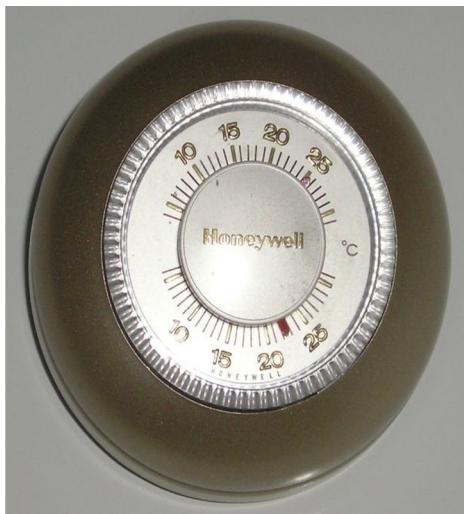
Evaluating



user interfaces.



What do these have in common?



What do these have in common?



Gmail | rosewill usb camera camera | (1) WhatsApp | Get Microsoft Whiteboard | Online Shopping site in In... | Amazon.in

amazon.in prime

All | Search | Hello, kalyan Account & Lists Returns & Orders Your Prime | Cart

Deliver to Kalyan Gandhinagar 382007 | Mobiles | Pantry | kalyan's Amazon.in | Today's Deals | Amazon Pay | Best Sellers | Customer Service | Computers | amazon prime music | Madz Mix by Madhuri Dixit | Redirects to music.amazon.in

Redmi Note 9 Pro Max
Xiaomi | Pro camera, Max Performance

Qualcomm® Snapdragon™ 720G | 33W Fast charger in-box

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Home essentials | Amazon Brands & more

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Fast, convenient and secure | Over 17 crore products in your pocket
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Flipkart Explore Plus | Search for products, brands and more | Login | More | Cart

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INTEL DAYS
24 - 27 August 2020

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Deals of the Day 02 : 01 : 10 Left

- Headphones Upto 50% off JBL, Sony & more
- Smart Devices Grab Now Smart Watches Bands an...
- Speakers Upto 50% off JBL, Sony & more
- Hair Curlers, Clippers & ... From ₹499 By Chisel & Wahl
- Woodland, Red Chief.... Upto 40% Off Casual Footwear
- Branded Shirts & Trousers From ₹399 Peter England, Flying Ma...
- Badminton Racquets Upto 70% + 5% Off Yonex, Li-Ning & more

VIEW ALL

GRAND HOME APPLIANCES SALE
24th-28th August

Up to 75% Off
TVs & Appliances Season's Best Deals

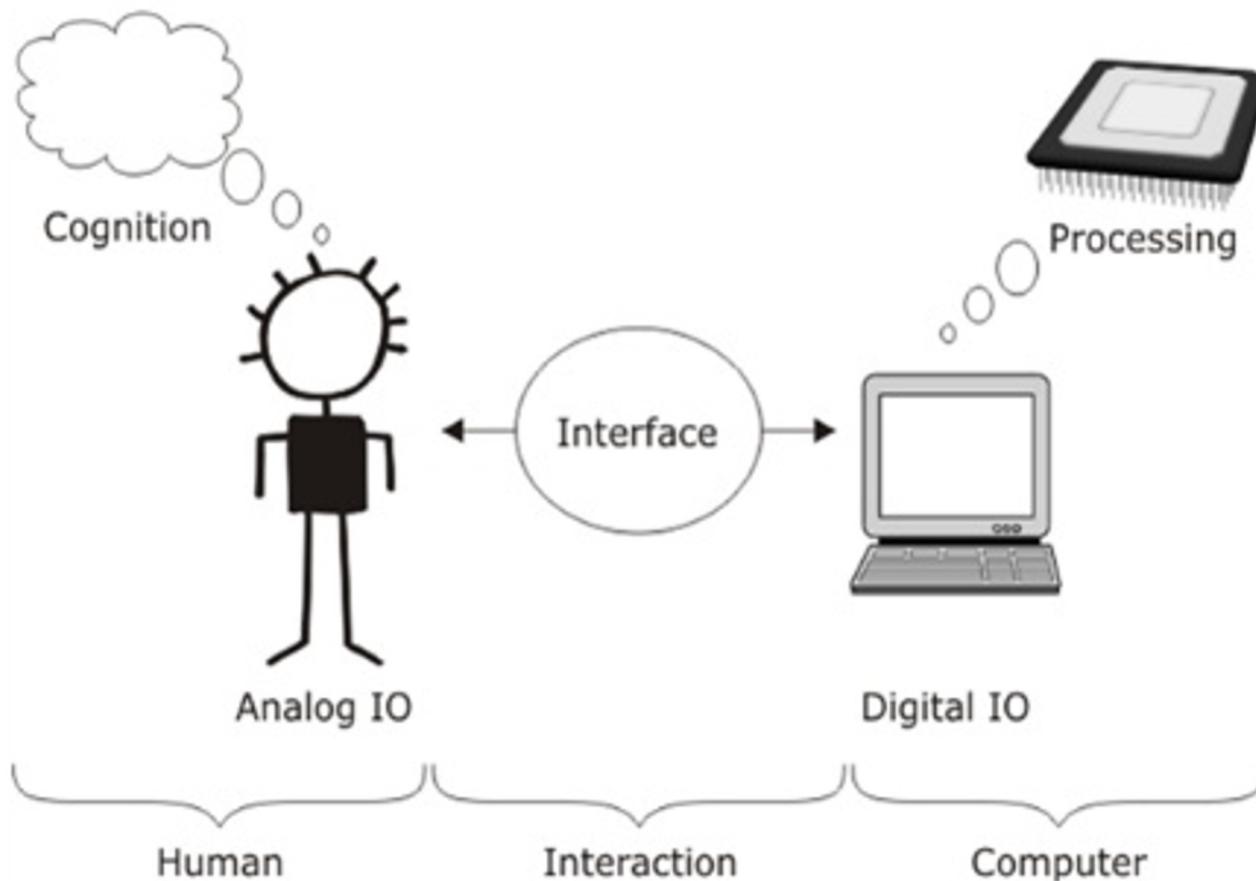
realme C15
6000mAh. Quad Camera
FROM ₹9,999

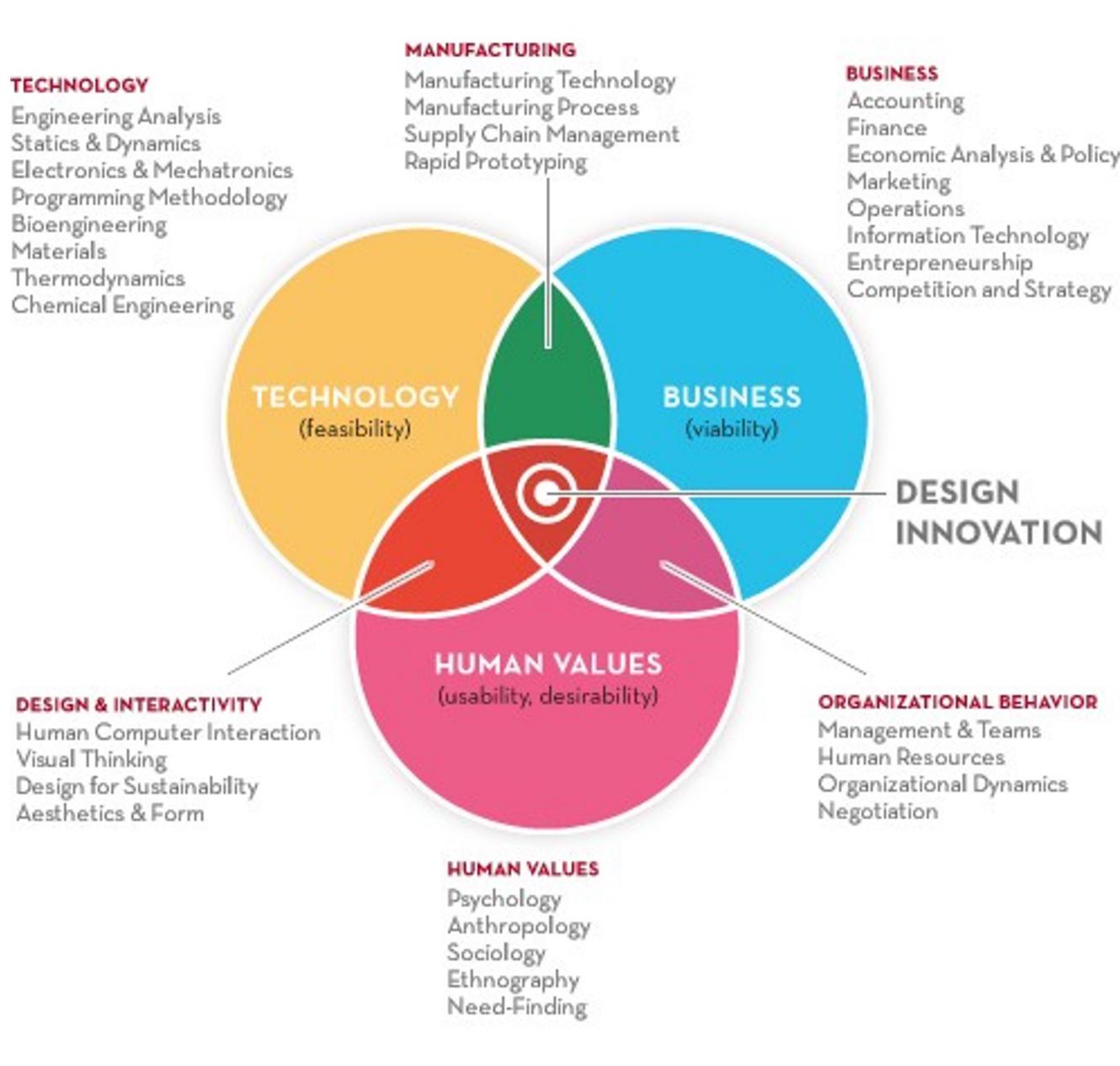
Computer Peripherals
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What is HCI?

HCI is the study of interaction between people (users) and computers





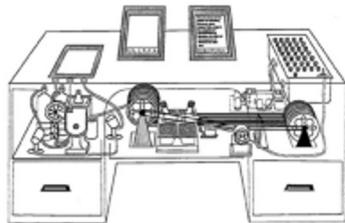
HCI Evolution

- **50s** - Interface at the hardware level for engineers - switch panels
- **60-70s** - interface at the programming level - COBOL, FORTRAN
- **70-90s** - Interface at the terminal level - command languages
- **80s** - Interface at the interaction dialogue level - GUIs, multimedia (<http://www.cs.cmu.edu/~amulet/papers/uihistory.tr.html>)
- **90s** - Interface at the work setting - networked systems, groupware
- **00s** - Interface becomes pervasive
 - RF tags, Bluetooth, mobile devices, consumer electronics, interactive screens, embedded technology
- **10s** -Interface disappears
 - Focus on tasks, experiences, emotions, social connections, beauty

HCI Evolution

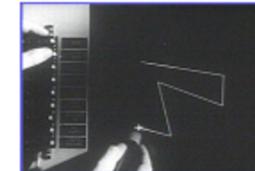
Memex - Vannevar Bush (1945)

Vision for a desktop information management system
Electromechanical system
Seen as the ancestor of the notion of hypertext



Sketchpad - Ivan Sutherland (1963)

Direct manipulation geometric shapes
Geometric constraints, zoom, click-drag



NLS / Augment - Douglas Engelbart (1968)

Inventor of the mouse (1963)



Bimanual interaction



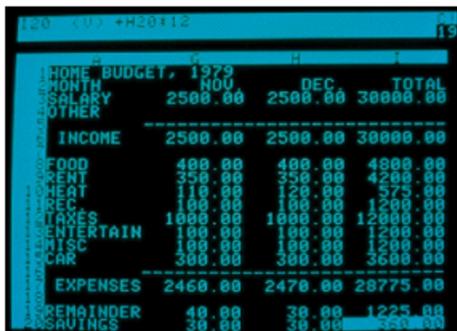
Hypertext, cooperative work,
document sharing, video-conferencing



History

Visicalc - Dan Bricklin (1979)

First spreadsheet (Apple II)



HOME BUDGET, 1979			
	NOV	DEC	TOTAL
SALARY	2500.00	2500.00	30000.00
OTHER			
INCOME	2500.00	2500.00	30000.00
FOOD	400.00	400.00	4800.00
RENT	350.00	350.00	4200.00
HEAT	110.00	120.00	575.00
REC	100.00	100.00	1200.00
TAXES	1000.00	1000.00	12000.00
ENTERTAIN	100.00	100.00	1200.00
MISC	100.00	100.00	1200.00
CAR	300.00	300.00	3600.00
EXPENSES	2460.00	2470.00	28775.00
REMAINDER	40.00	30.00	1225.00
SAVINGS	30.00	30.00	300.00

Xerox Star - Xerox PARC (1981)

First commercial graphical workstation
Document-centric approach



Macintosh - Apple (1984)

Graphical personal computer

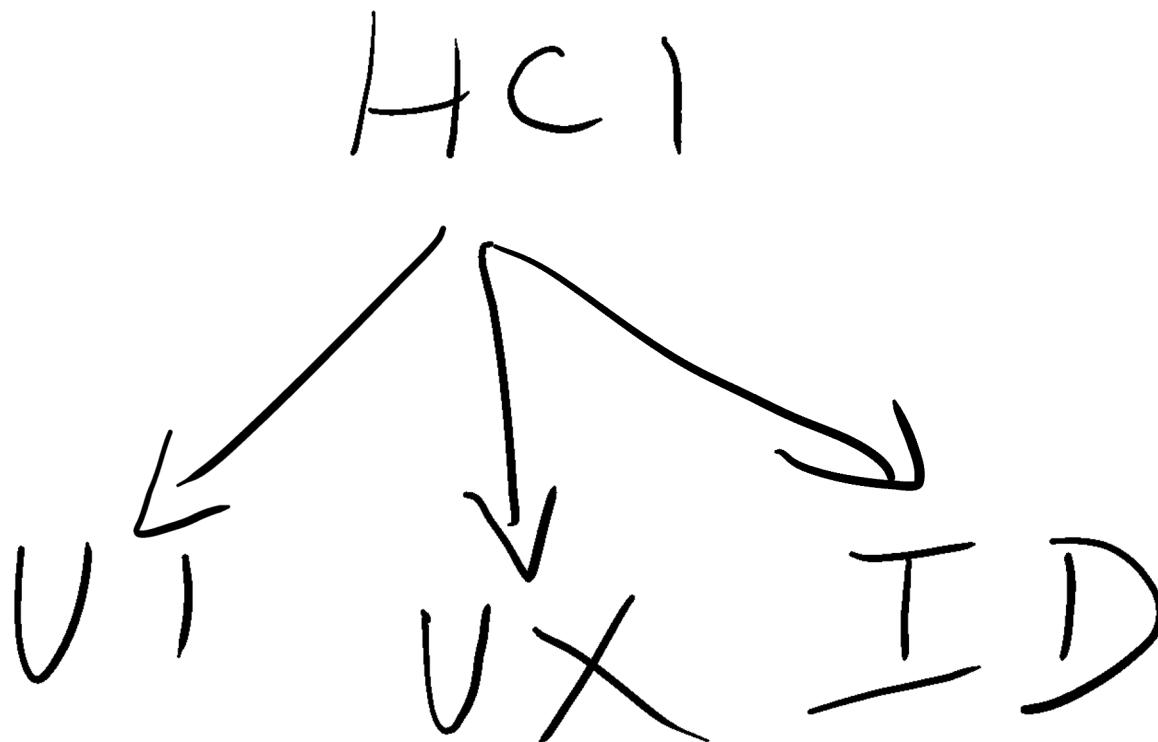
Finder

MacPaint

MacWrite

Hardware + software design





UI (User Interface) refers to the graphical layout and visual appearance of a software application. It includes the buttons, icons, colors, and overall look and feel of the application.

UX (User Experience) refers to the overall experience of a user when interacting with a software application, product or service. It encompasses a wide range of elements such as usability, accessibility, and emotions evoked by the interaction.

ID (Interaction Design) is a discipline concerned with the design of interactive products and services, with the goal of creating seamless, effective and satisfying experiences for users. Interaction design is often used synonymously with UX design.

HCI

- Human
 - The end-user of a program
 - Other people in the organization
 - The surrounding cultural context
- Computer
 - The hardware and the software
 - Microwaves, mobile phones, cars
- Interaction
 - The user tells the computer what they want
 - The computer communicates results



HCI is made up of..

- Theories – learn and apply
- Models – create and use
- Methods – master and apply
- Guidelines – learn and use
- Principles – understand and apply
- Techniques – master and use

Design Goals of the class

- Everything designed has some explicit criteria
 - Attractive
 - Cost effective to manufacture
 - Durable
 - Water tight
 - Can hold hot water effectively
 - Separate tea leaves from rest



But is it usable?

And is it useful to people?

USABILITY

Design and Goals of this class

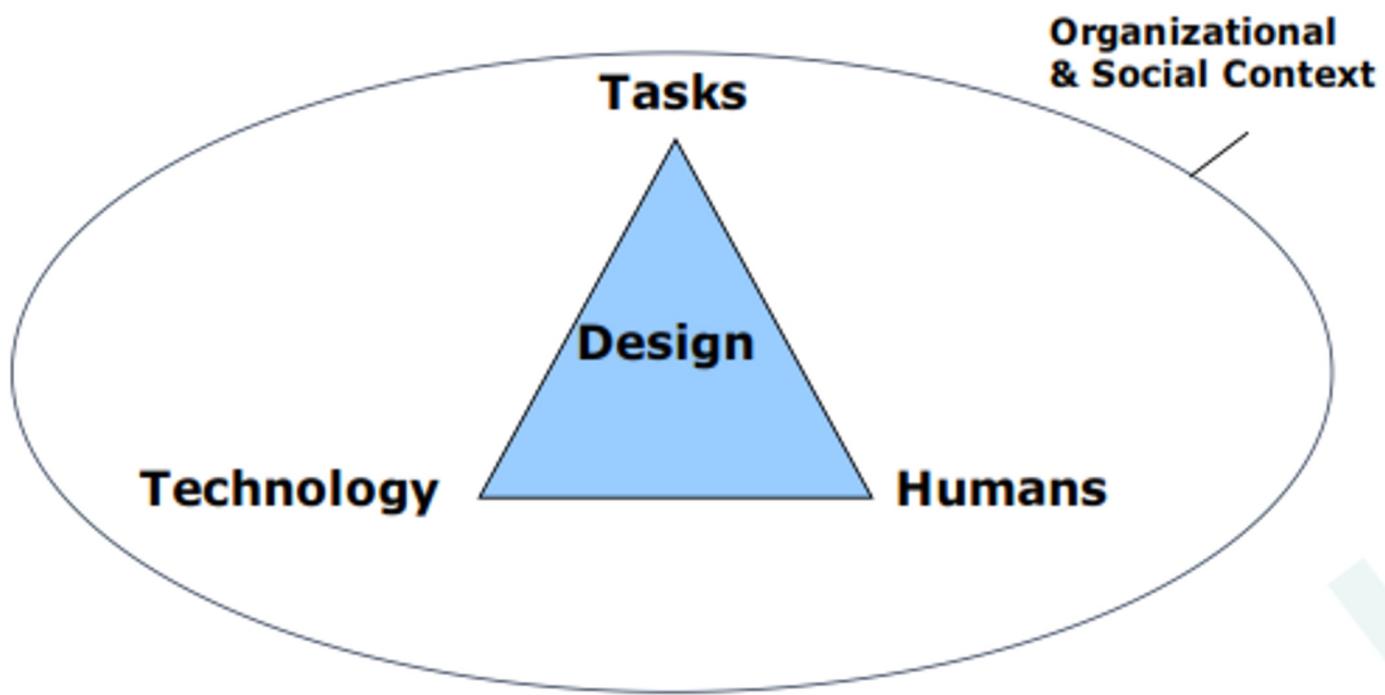
- Everything designed is done so within a specific context
- Training required
- Conventions
- Laws and regulation
- Competing products
- Human abilities and limitations



Understanding these influencing factors also a key part of this course

Goals of HCI

- Allow users to carry out tasks
 - Safely
 - Effectively
 - Efficiently
 - Enjoyably



- HCI draws computer science, psychology, and design together
- Main focus is on the people using system

To make better Interactive technology... We need to

- Know about how people **interact with things**
- Know about what people **can and can't do**
- Know about the **situations in which people**
- **do things**
- Know about the **basics of good design**
- Understand people's **goals**

HCI is changing...

- Physical things
- GUI interfaces
- Collaborative interfaces
- Internet technologies
- Social technologies
- Ubiquitous technologies
- **What next??**



System Centered Design

- What can I easily build on this platform?
- What can I create from the available tools?
- What do I as a programmer find interesting?



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User Centered Design

Design is based upon a user's

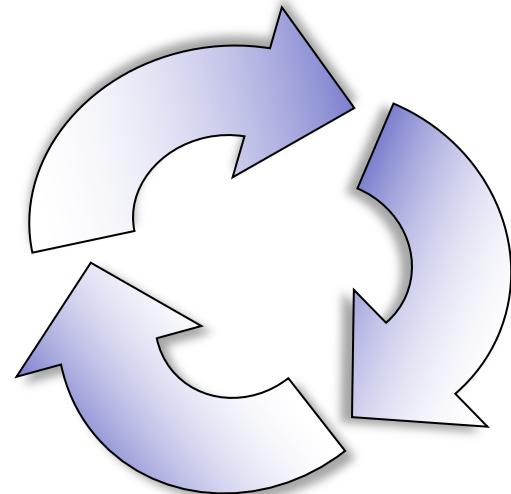
- abilities and real needs
- context
- work
- tasks
- values

User Centered Design

- Focus on the people who will use the system, on their preferences and their requirements
- Building models of the users, tasks and systems
- Iterative process
- Prototyping and Evaluation by users

UI Design/Develop Process

- Analyze user's goals & tasks
- Create design alternatives
- Evaluate options
- Implement prototype
- Test
- Refine



Two Fatal Mistakes

- Assume all users are alike
- Assume all users are like the designer

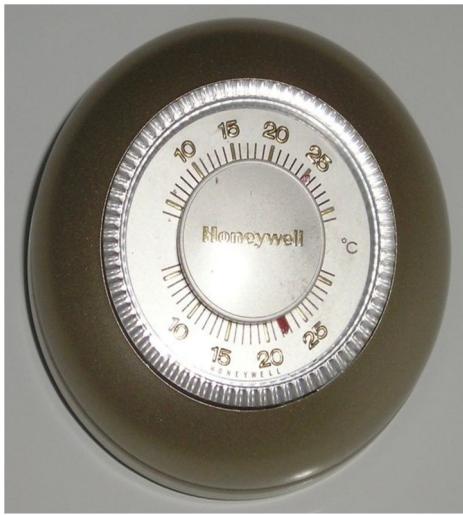
But Who are the Users?

**When you try to teach
your parents how to use
technology**



How do we improve interfaces?

1. Educate software professionals
2. Draw upon fast accumulating body of knowledge regarding H-C interface design
3. Integrate UI design methods & techniques into standard software development methodologies



Group Project

Semester-long team effort

Group Project

- Design and evaluate an interface
 - 0 - Team formation & topic choice
 - 1 - Understand the problem space
 - 2 - Exploring the design space
 - 3 - Prototype
 - 4 - Evaluation
- Main 4 parts worth ~10% each
- Presentation, documentation ~ 10%

Group Project Details

- Part 0 - Topic definition
 - Identify team & general topic
 - Create web notebook
 - Suggestion: Pick a population and pick a technology; check out intersection
- Part 1 - Understanding the problem
 - Describe tasks, users, environment, social context
 - What are implications for design?

Group Project Details

- Part 2 - Design alternatives
 - Storyboards, mock-ups for multiple different designs
 - Explore, push boundaries of design space
 - Explain decisions
- Part 3 - System prototype & eval plan
 - More detailed prototype (semi-working ok)
 - Plan for conducting evaluation

Group Project Details

- Part 4 - Evaluation
 - Conduct formal evaluation with example users
 - Use appropriate methods
 - Analyze results of evaluation
 - Characterize what's working and what's not

Project Teams

- K people
 - You decide (or I will!)
 - Diverse is best!
 - Consider schedules
 - Create a web space:
 - Immediately post ideas for general topics, populations, technologies, etc.
- Cool project and team name

Project Topics

Semester theme: “Innovative and Usable
Interfaces in Everyday Life”

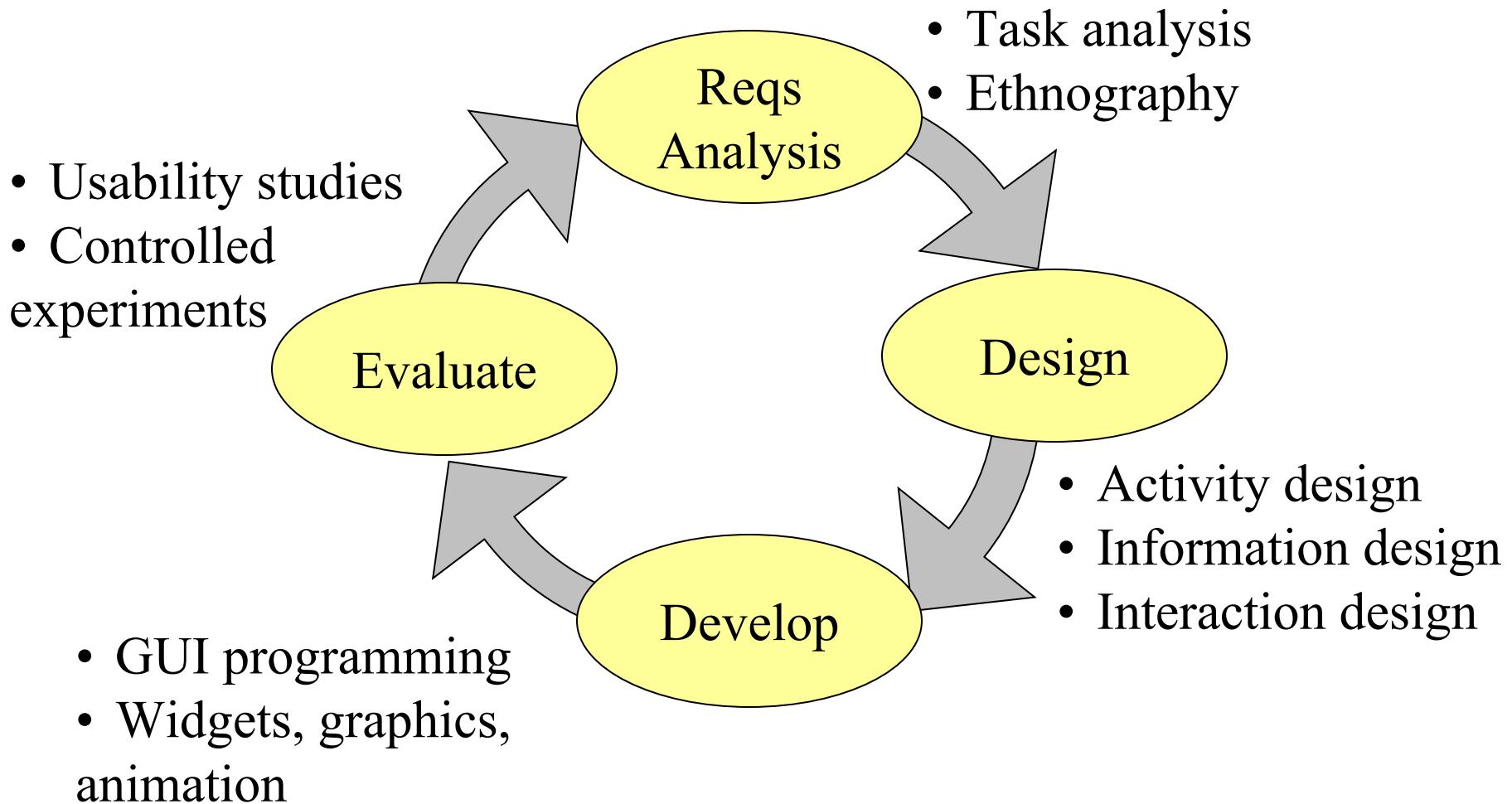
What Makes a Good Project

- Typically:
 - Access to domain experts & users
 - “Real” clients
 - Interesting human issues
 - Rich domain for design

Design Evaluation

- “Looks good to me” isn’t good enough!
- Both subjective and objective metrics
- Some things we can measure
 - Time to learn
 - Speed of performance
 - Rate of errors by user
 - Retention over time
 - Subjective satisfaction

The Learning Cycle

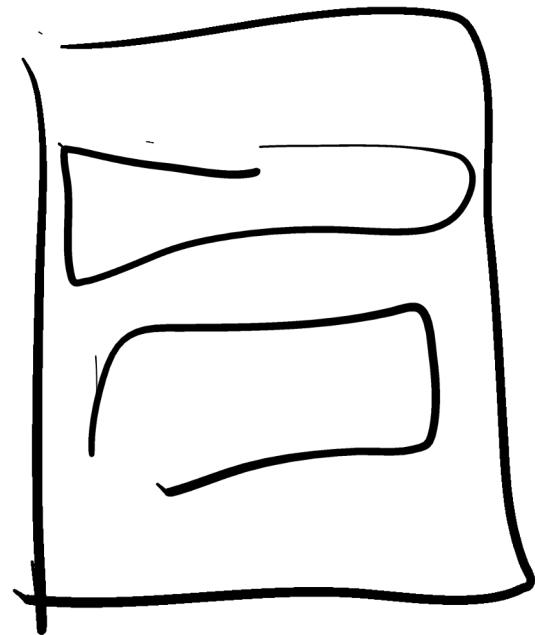
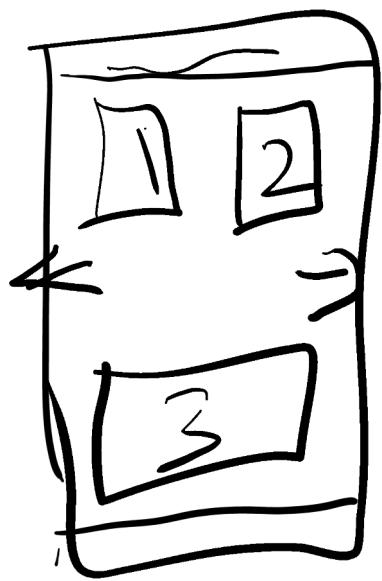


Case Study sample topics

- Virtual keyboards
- Existing websites and their design patterns, usage behavior, commonalities and differences, improvements
- Mobile applications
- Technology for Senior citizens
 - Usage behavior
 - Problems, difficulties,
 - Usability factors
 - Improvements
- Wearable interfaces
 - smartwatches

Case Study Method

- Objective
- Design Process Followed
 - Requirement Gathering
 - Problem Identification
 - Requirement Specification
- Concept Generation
 - Synthesis
- Prototype Development
- Documentation



IE 403-Winter 2023

Human-Computer Interaction

Week 2-Lec1

Topics for this week's classes

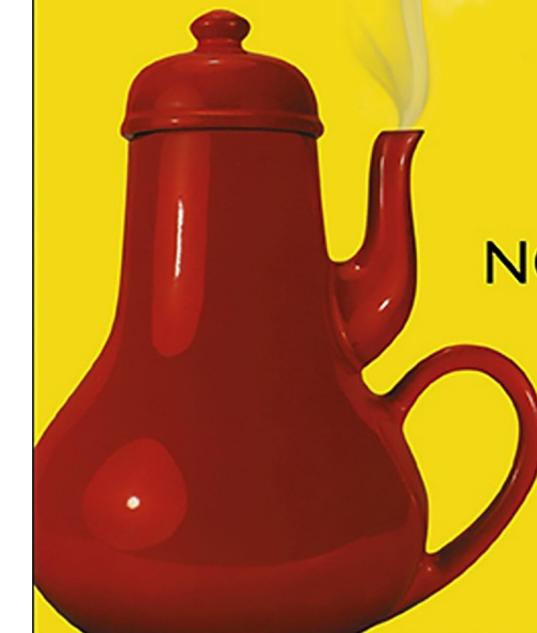
- Discussion on Don Norman's principles

- Conceptual Models



REVISED & EXPANDED EDITION

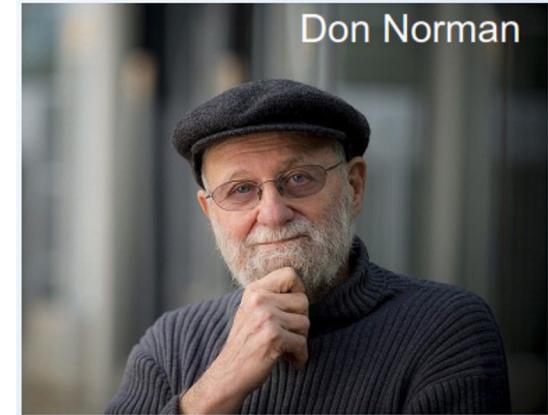
The DESIGN of EVERYDAY THINGS



DON
NORMAN

Overview

- Why are some everyday things difficult to understand and use?
- What are Don Norman's principles and how do they apply to the design of everyday things?
- How can we apply Norman's principles to the design of computer interfaces?



Psychopathology of Everyday Things

- We are surrounded by many everyday things that have poor *usability*
 - Programming a VCR
 - Telephone features we can't remember how to use
 - How to change the remote access code?
 - Photocopiers and fax machines
 - Face down or face up?
- Many of these things can be difficult to interpret and frustrating to use if they provide no clues or false clues as to how they operate

Norman's Principles of Design

- Make things visible
- Provide a good conceptual model
 - Affordance
 - Mapping
 - Constraints
 - Feedback

Norman's philosophy

“...things are designed to be used by people, and without a deep understanding of people, the designs are apt to be faulty, difficult to use, difficult to understand.”

Understanding

- *What does it all mean?*
- *How is the product supposed to be used?*
- *What do all the different controls and settings mean?*

Many products defy understanding simply because they have too many functions and controls.

User/Human Centered Design

Human-centered design (HCD), is an approach that puts human needs, capabilities, and behavior first, then designs to accommodate those needs, capabilities, and ways of behaving.

- Empathize: Understanding **YOUR USER** and design
 - Human needs, capabilities and behaviour
- Communication: Indicate what actions are possible, what is happening, and what is about to happen.

What is a good User Centered design?

- Has affordances - makes each operation visible;
- Offers obvious mappings - makes the relationship between the actual action of the device and the action of the user obvious;
- Provides feedback on the user's action;
- Provides a good mental model of the underlying behaviour of the device;
- Provides forcing functions - prevents a user from making bad errors;
- Supports automatic learning -- offers consistencies and practice that help the user acquire interface skills.

ma-af-fe-fo-meau

Fundamental Principles of Interaction



Discoverability

Is it possible to even figure out what actions are possible and where and how to perform them?

- Discoverability results by applying 6 fundamental psychological concepts

Affordances

(coined by psychologist James J. Gibson and applied to HCI by Don Norman)

- Affordances determine what actions are possible with an object by an agent(user) □ Relationship
- Exist even if they are not visible.
- For designers, their visibility is critical
 - visible affordances provide strong clues to the operations of things
- Perceived affordances
 - *Can I figure out what actions are possible ?*
 - If NO,
 - Presence of some **SIGNALS** is required.

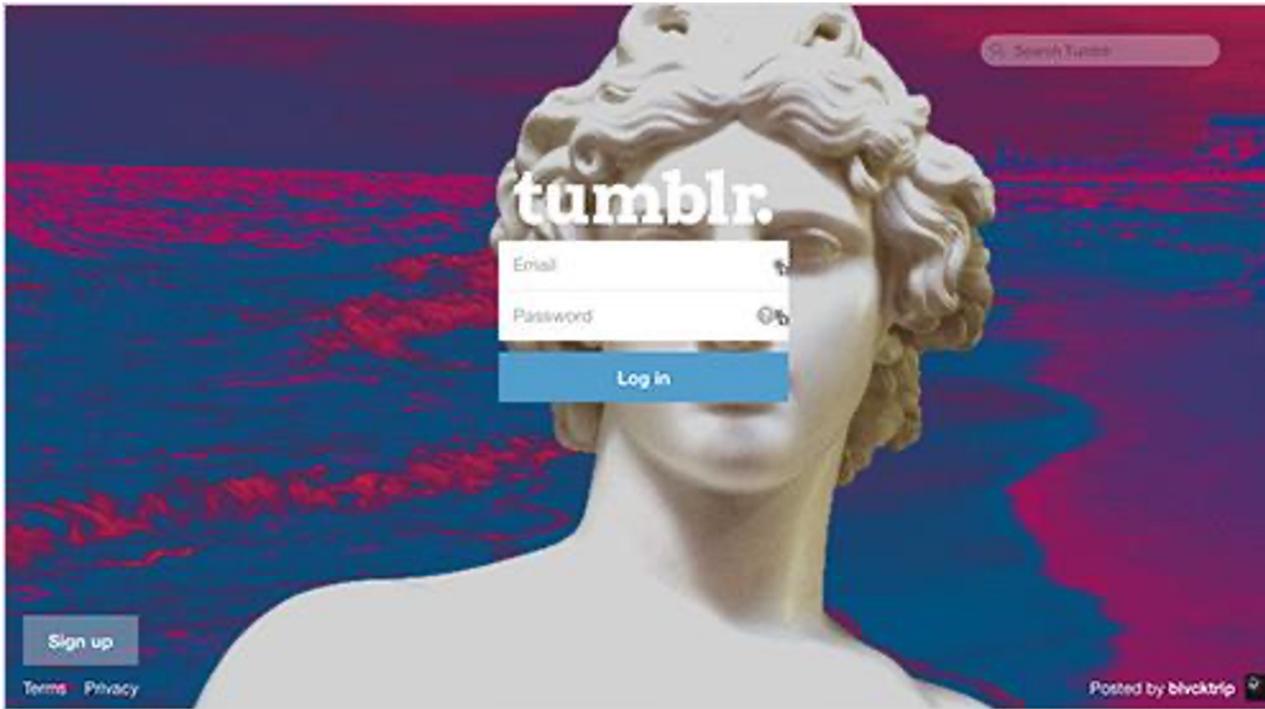


Affordance property
Visible, Discoverable



Glass: AntiAffordance property
Invisible, Not Discoverable

Affordances in Web Interfaces

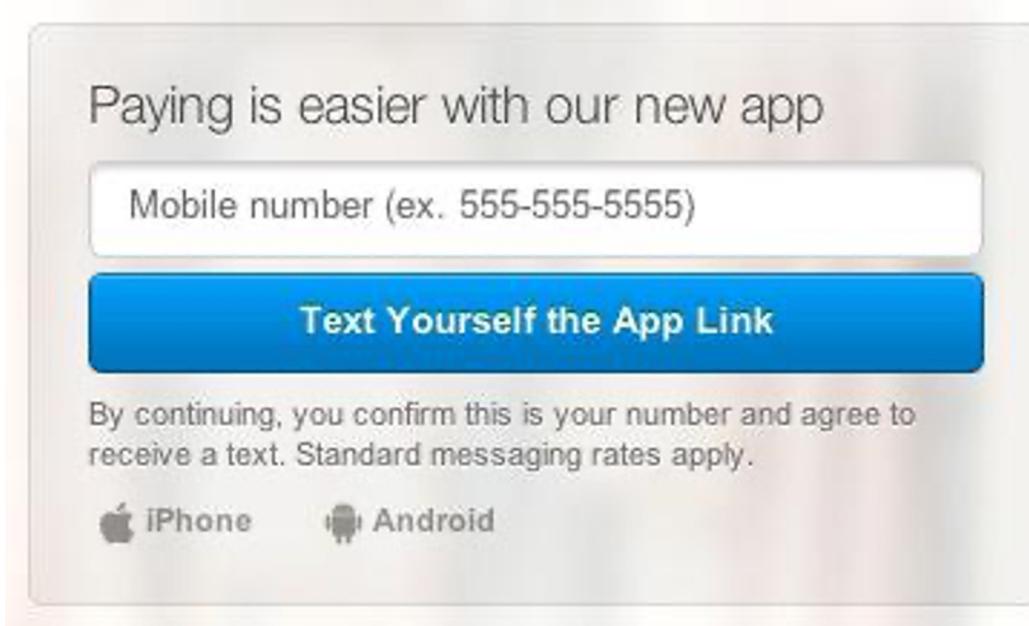


- What actions does the webpage provide to the user explicitly?

Or

- What does the interface afford to the user?

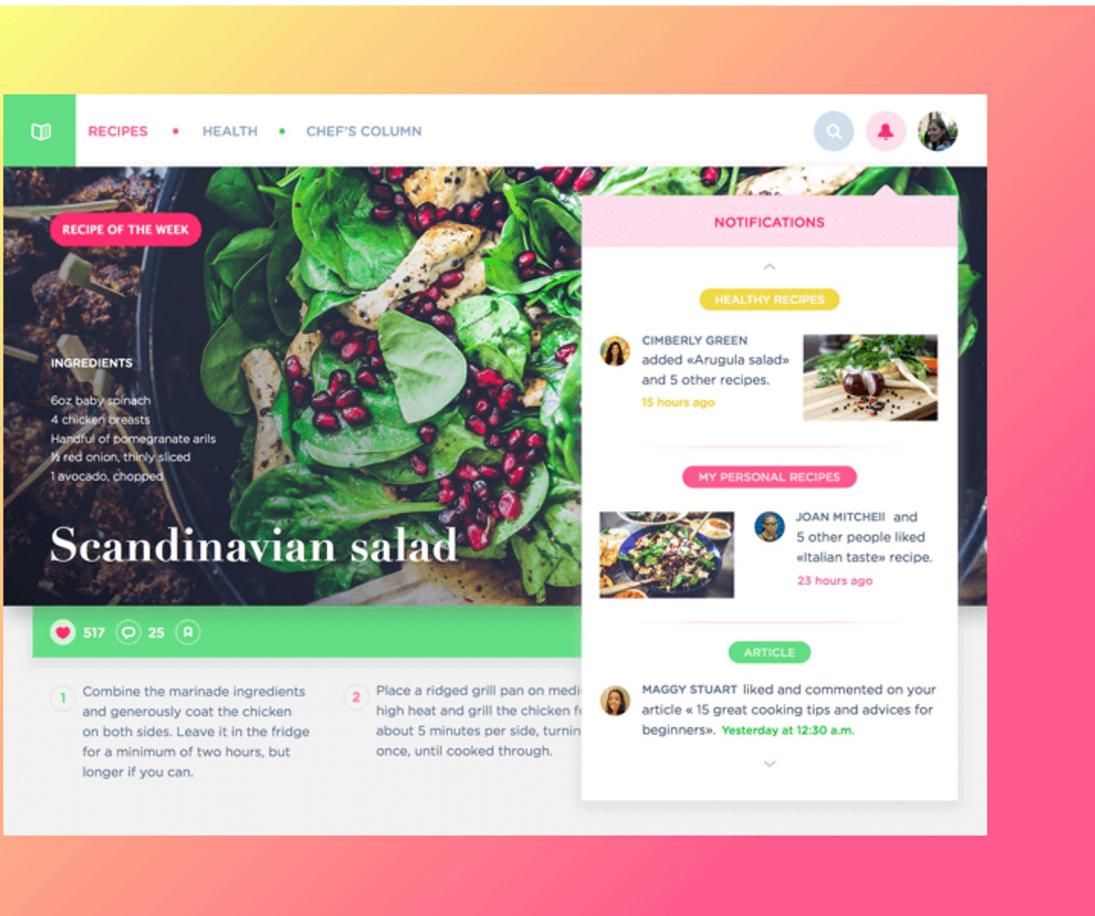
Affordances in Apps



- What Explicit affordance does the interface provide?
 - The raised appearance of the button affords pushing down. The text explicitly signals the result of the action.

Other types of Affordances

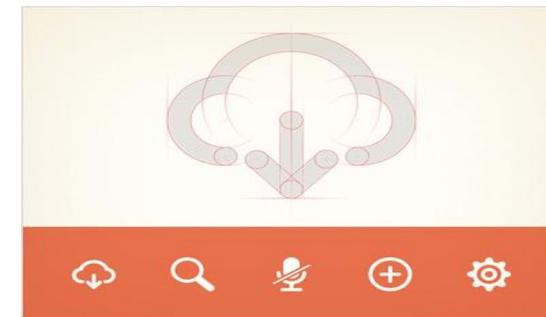
Pattern



Hidden



Metaphorical
(Contextual)

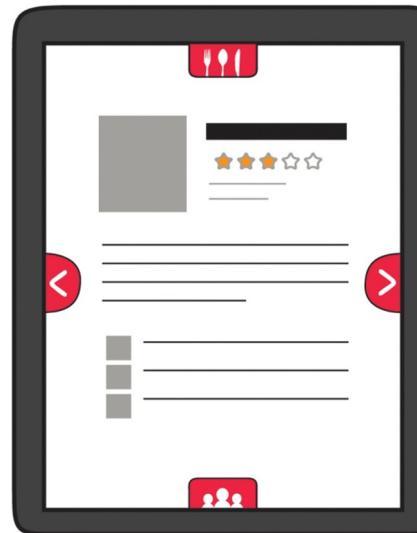


Signifiers

- Communicate where the action should take place
- Signifiers refers to *any mark of sounds, any perceivable indicator that communicates appropriate behaviour to a person*
- Signifiers are signals.
 - signs, labels, and drawings placed in the world



Fig 1. If a door needs a signifier, then it's a bad design



- Fig 2. The arrows are signifiers:
- Swiping left or right brings up new restaurant recommendations.
 - Swiping up reveals the menu for the restaurant being displayed
 - Swiping down, friends who recommend the restaurant

Mapping

- The relationship between the elements of two sets of things
 - Controls and Displays
- Groupings and proximity are map controls to function
 - Controls should be close to the item being controlled.



Fig 1

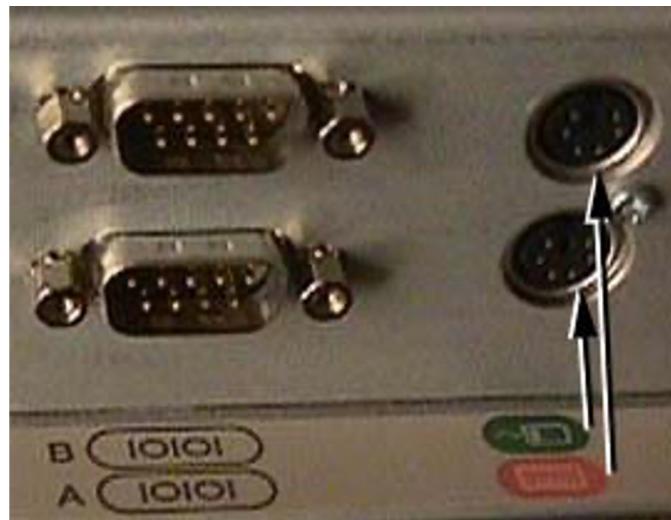


Fig 2

What Knob Goes Where?

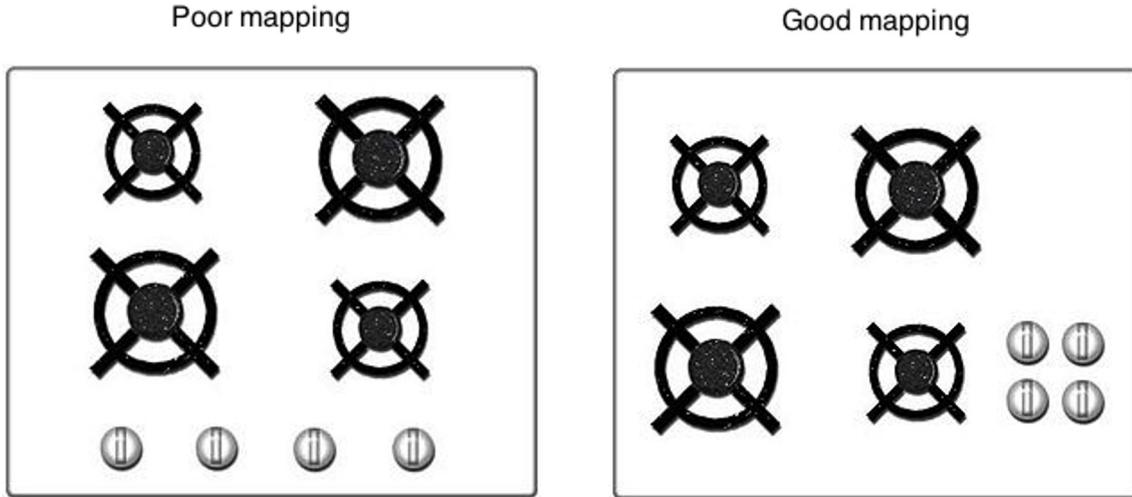


Fig 1

Best mapping: Controls are mounted directly on the item to be controlled.

Second-best mapping: Controls are as close as possible to the object to be controlled.

Third-best mapping: Controls are arranged in the same spatial configuration as the objects to be controlled



Exploiting Natural Mapping

Fig 2

Feedback

- Feedback — communicating the results of an action
 - *must be immediate*
 - *must be informative*
 - *Poor feedback can be worse than no feedback at all*



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Fig 1

Poor/No Feedback: Pressing elevator buttons repeatedly. Reason: No feedback of lift movement?

Norman's Principles in Software

- Visibility
 - Visibility of the tasks the interface supports : Can I see it?
 - Communication of system state / mode
- Affordance
 - **Button** Pressed
 - Here Click (web)
- Mapping
 - Where am I and where can I go?
 - Clicking on a particular interface element produces expected effect (under F)ile should be O)pen)

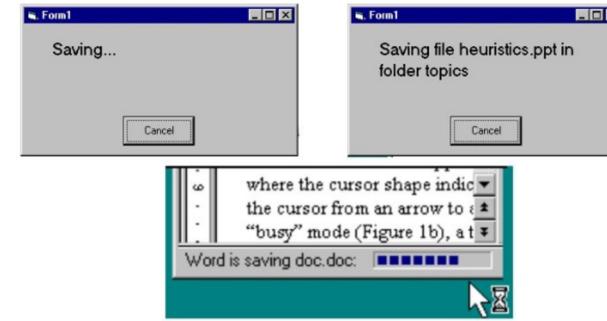


Fig 1



Fig 2

Norman's Principles in Software

- Constraints
 - Why can't I do that?
 - Constraining search criteria, graying out menu items that don't apply in a particular context
- Feedback
 - What is it doing now?
 - Providing clear and immediate feedback for each user action

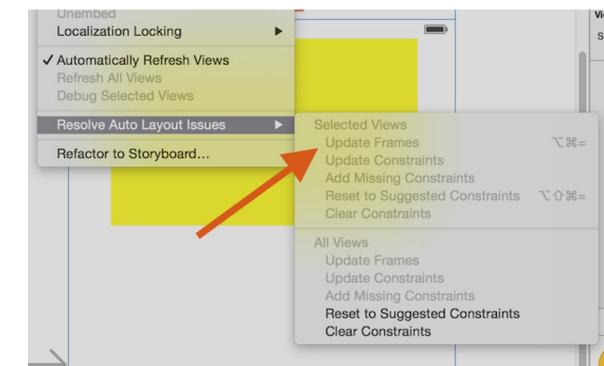


Fig 1

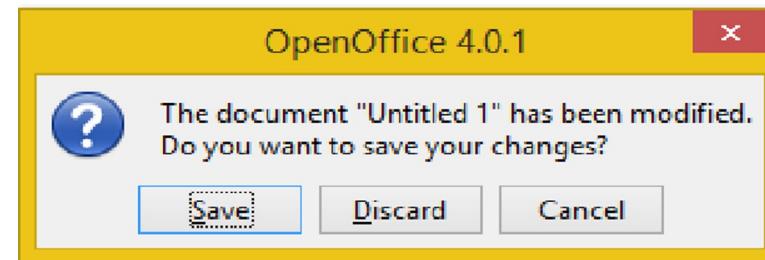


Fig 2

Assignment

- I. Major differences between Desktop and Mobile environments
- II. Take one real world website or app and start finding affordances, signifiers, mapping and constraints

RECALL OUR DESIGN CONCEPTS:

the basics:

(elements of these in
many of the others)

- affordance
- signifiers
- mapping
- constraints
- feedback

other concepts:

- findability
- transfer effects
- cultural associations
- individual differences

→ all inform a user' mental model

THE DESIGNER'S MODEL, THE USER'S MODEL, AND THE SYSTEM IMAGE.

the **user** also has a **mental model**.
they don't necessarily match.

(No connection)



CONCEPTUAL MODELS & CONCEPTUAL DESIGN:

- **conceptual models** describe how an interactive system is organized
 - the **user** also has a **mental model**. they don't necessarily match.
- conceptual model = the **foundation** of the interface.
 - different user interfaces could be built upon it
 - there are **many ways to represent** a conceptual model
- **goal of conceptual design**, how do conceptual models fit?
- **interface design translates the CM** into things we can see and interact with. It involves design choices, but must stay faithful to the concepts and terminology of the CM.

WHAT DOES A CONCEPTUAL MODEL LOOK LIKE?

however best helps you describe and understand its components:

- lists and tables
- diagrams
- storyboards and sketches
- written descriptions
- mood boards
- physical ‘sketches’

different methods might capture different parts of more effectively than others

→ you’ll likely use a combination of more than one!

A CONCEPTUAL MODEL CAN INCLUDE:

co-re-ma-te-fa-ac

- any central design **metaphors** and analogies
e.g. the “desktop metaphor”
- **concepts** – objects, actions you can do to them; user roles; attributes of both.
e.g., files and folders; both can be opened, have names;
- **relationships** among concepts
e.g., files are *contained* in folders
- **mappings** from concepts to the user experience envisioned;
e.g., the users can *browse* files, and *mark favorites*
- **terminology** that will be used (consistently) to tie it all together
- **interaction** types; how will they interact with it?
e.g. give commands, perform operations, explore
- **interface** types; is it/should it be constrained? how would different interfaces affect result?

A CONCEPTUAL MODEL EXCLUDES

- low level presentation
- implementation details
- menu and screen designs
- widgets
- etc.

if you started here,
you will probably get into trouble



METAPHORS

well known concepts you can rely on to help users understand and interact with the system

many kinds, e.g.,

interactions

- *swipe to turn page* in an ebook
- *move backwards through time* to explore file backups

ecological, contextual, broader system structure, e.g.

- dropbox: *a box you drop everything into*
- iCloud: *central mother ship to which everything connects*

personal relationships, e.g.,

- siri as a *personal assistant*

EXAMPLE: THE DESKTOP METAPHOR

unifying set of concepts employed in graphical user interfaces to help users understand and easily interact with a computer

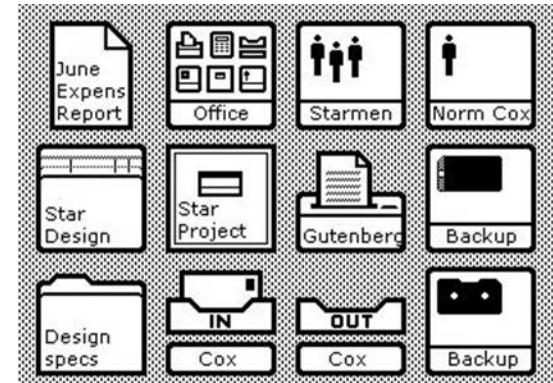
computer monitor → user's desktop

objects → documents, folders

you can do things with these objects:

- place documents upon desktop
- open documents into a window → paper copy
- organize in folders

extend desktop with desk accessories → calculator, notepad



RELATIONSHIPS AMONG CONCEPTS

what actions or attributes are shared between objects?

- e.g. song, podcast, audiobook all have timelines that users want to navigate (i.e. fast forward, rewind, etc.)

containment and hierarchy

- e.g., a song is contained by an album

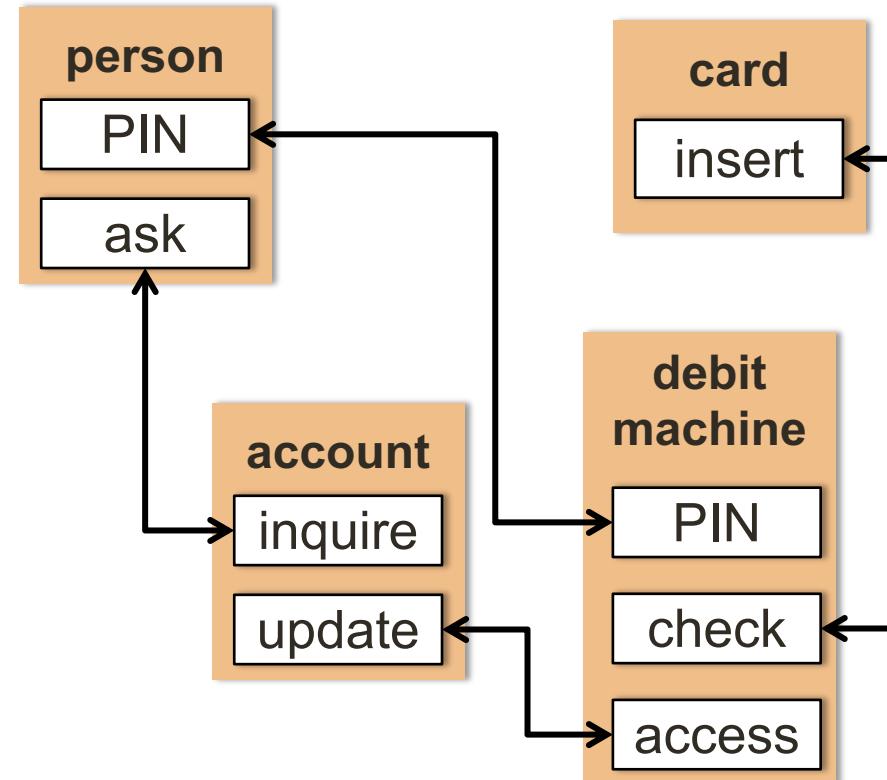
MAPPING OF CONCEPTS TO ACTUAL ACTIVITIES

How do the concepts **map** to what people will actually do?

one easy way to tell:
“run” a task example on it

learn:

- are these the right objects?
- can I do all the operations?
- do they match what people want to do?
- can I do them in a consistent way?



example: debit machine

TERMINOLOGY

What terms will you use to communicate concepts?

terminology should match your concepts

choose your terminology and stick to it!

easy to go from planning to interface and minimize confusion

Please login entering your username or email address.

username or email address

.....

[Forgot password?](#)

Login now

does your user login to a system with a user-id? a username? a member id? or an email address?

CONCEPTUAL MODELS: INTERACTION AND INTERFACE

Interaction type:

what the user is doing when interacting with a system.

- e.g., command line (how you talk to it), intelligent (function),
gestural (hardware), touch (both hardware and interaction type)

Interface type:

the kind of interface used to support the mode.

- e.g. speech, menu-based, gesture

INTERACTION TYPES

Instructing

instruct a system and tell it what to do; issuing commands and selecting options (e.g. print a file, save a file)

Conversing

interacting with a system as if having a conversation (e.g. search engines, advice-giving systems, help systems, virtual agents)

Manipulating

interacting with objects in a virtual or physical space by manipulating them (e.g. dragging, selecting, opening, closing and zooming actions on virtual objects)

Exploring

moving through a virtual environment or a physical space (e.g. google maps, GPS)

INTERFACE TYPES

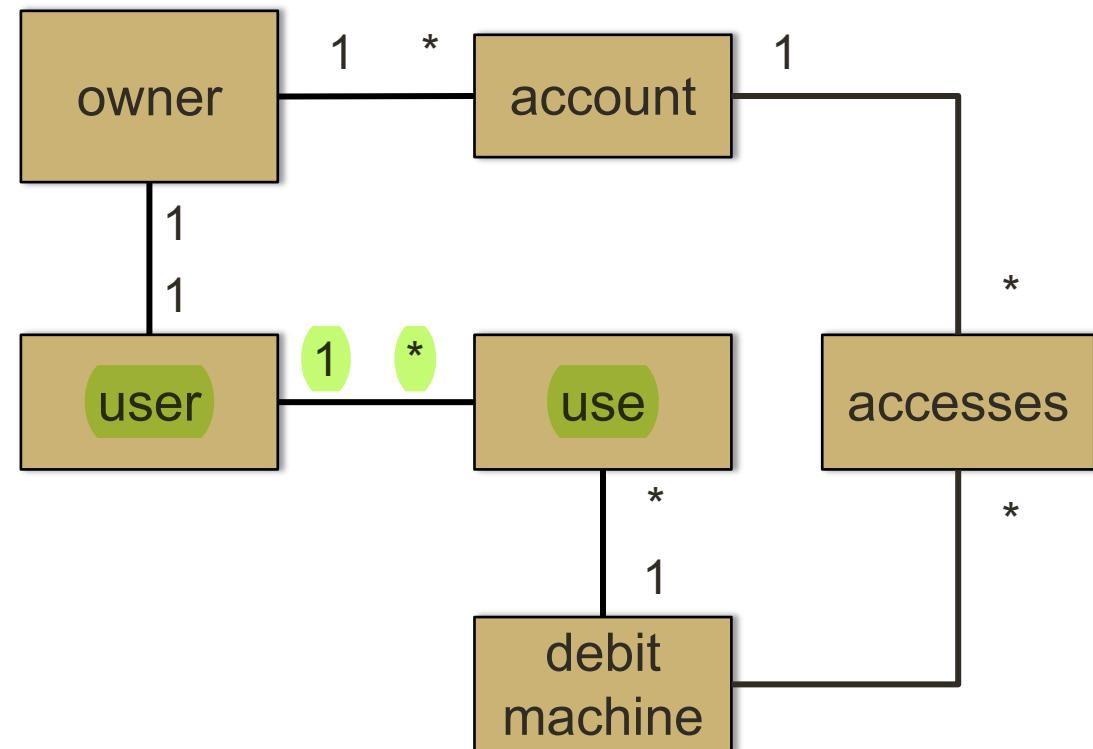
many different kinds (we won't examine each in detail)

- includes: mobile, GUI, touch, tangible, haptic, desktop, command line, data visualizations...

Interface type	See also
1. Command-based	
2. WIMP and GUI	
3. Multimedia	
4. Virtual reality	
5. Information visualization	
6. Web	
7. Consumer electronics and appliances	
8. Mobile	
9. Speech	
10. Pen	Shareable, touch
11. Touch	Shareable, air-based gesture
12. Air-based gesture	Tangible
13. Haptic	Multimodal
14. Multimodal	Speech, pen, touch, gesture, and haptic
15. Shareable	Touch
16. Tangible	
17. Augmented and mixed reality	Virtual reality
18. Wearable	
19. Robotic	
20. Brain-computer	

CONCEPTUAL MODEL FOR A DEBIT MACHINE

- using a *diagrammatic approach*
- shows concepts, relationships, terminology



IE 403/476

Human-Computer Interaction
Week 3-Lec2

Conceptual Models

- Need to first think about how the system will appear to users (i.e. how they will understand it)
- A high level description of
 - the proposed system with a set of integrated ideas and concepts about
 - what it should do
 - behave
 - look like
 - that will be understandable by the users in the manner intended

Understanding a Conceptual Model

- How will the user think about the system? Possibly based on:
 - Data or objects
 - Types of operations (activities) done
 - Metaphors (real world analogies/similarities)
- What kind of interface metaphor, if any, will be appropriate?
- What kinds of interaction modes and styles to use?



Fig 1. Word processor Vs a typewriter



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A desktop Conceptual Model

- Interface metaphor
- Items on a desk – Desktop
 - Files, notepad,
- Trash can below the table –
 - Recycle bin (windows)
 - Trash Can in Mac → Easier metaphor
- Files in folders with labels

Developing a CM

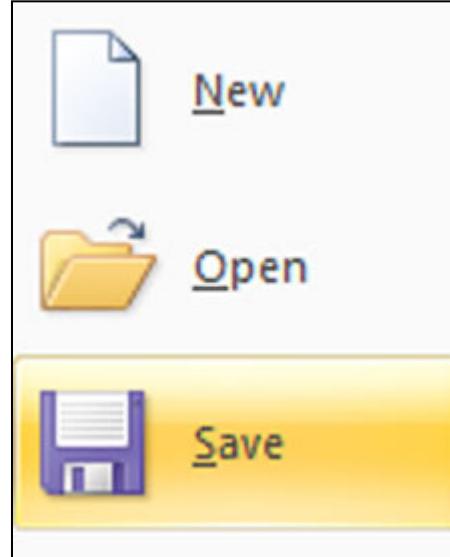
A CM is developed from three perspectives

- Interaction mode
- Interface metaphor
- Interface Paradigms

Interaction Modes

>ping ics.uci.edu

- Activity-based
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 - Conversing
 - Manipulating & Navigating
 - Exploring & Browsing



- Users instruct the system and tell it what to do e.g. tell the time, print a file, save a file
- Implementations: typing, pressing buttons, etc.
- Quick and efficient interaction

Interaction Modes

- Activity-based
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Interaction Modes

- Activity-based
 - Instructing
 - Conversing
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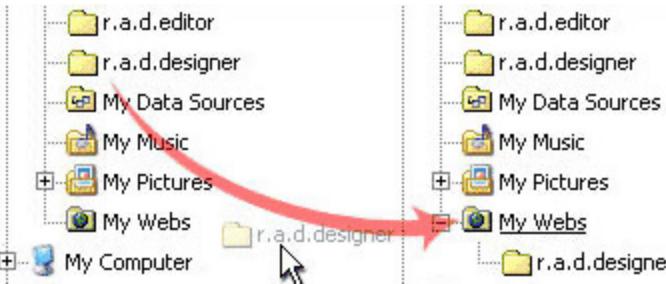


Fig 1. Navigate folders/files similar to real world set up



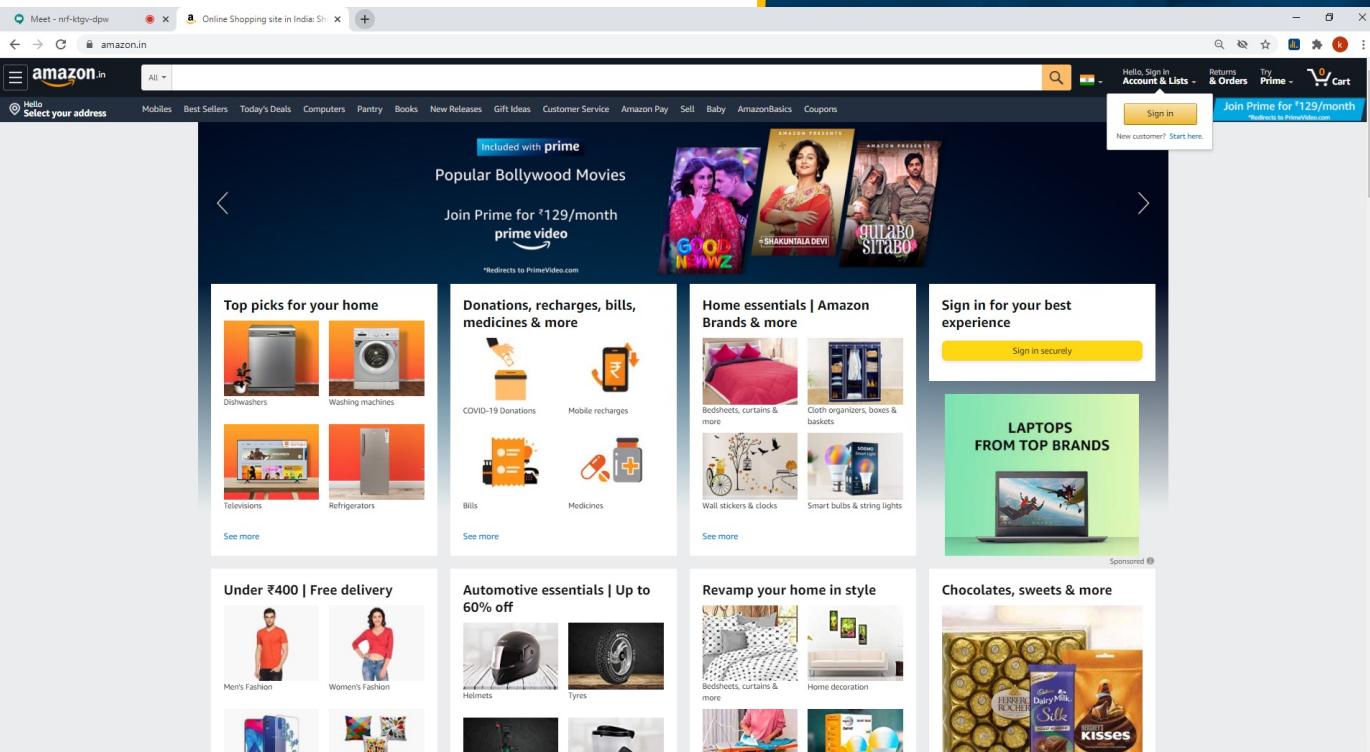
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Drag, zoom, pinch etc



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Interaction Modes

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Interface Metaphors

- Conceptual model similar to some aspects of a physical entity
- Need to be evaluated
 - Structure
 - Relevance
 - Representation
 - Clarity
 - Extensibility

Interface Paradigms

- Desktop
- Ubiquitous
- Pervasive
- Wearable
- ...
- Consider user tasks & environmental requirements

What should a CM consist of ?

Object/Action relationships

- Metaphors or analogies
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 - Functions performed and by whom
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 - Relationship between functions
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Example 1: Online Library

- ❖ **Metaphors** → Physical card catalogue
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Understand

- Problem space
- Task domains
- Create story like Scenarios

Mental models

- Users “**see**” the system through mental models
- Users “**rely**” on mental models during usage
- Reason about a sys
 - Interact with
 - Infer how it works
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Why are mental models important?

2016, Chrysler automobiles recalled over 100K vehicles



- Gear shows P, R, N, D/S
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100

crashes

40

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Classic Design
Flaw

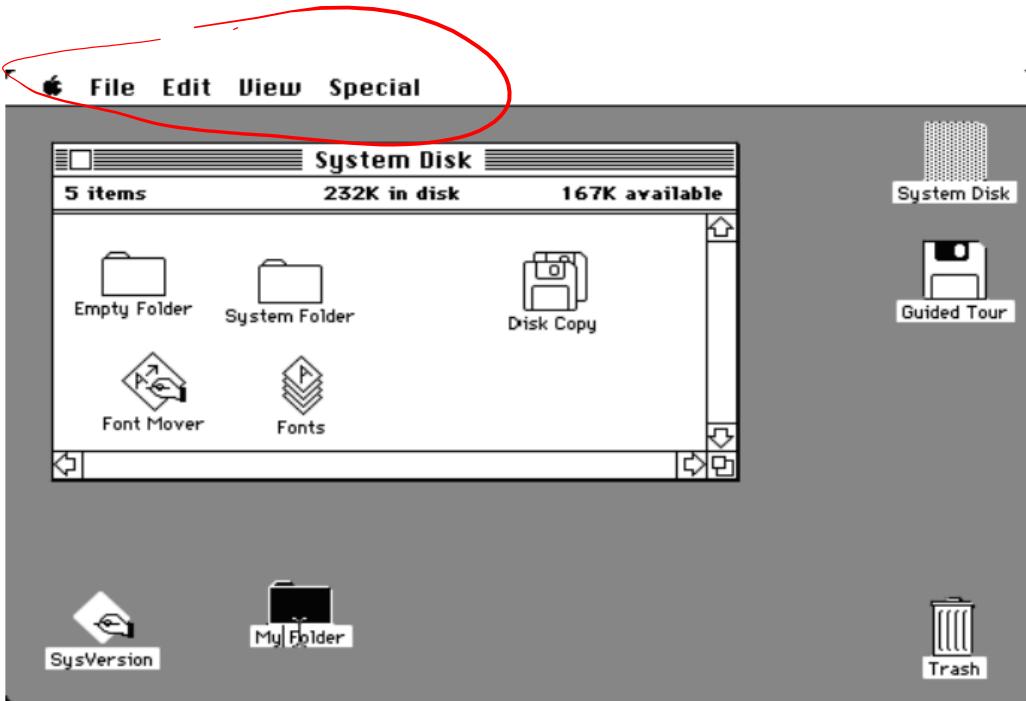


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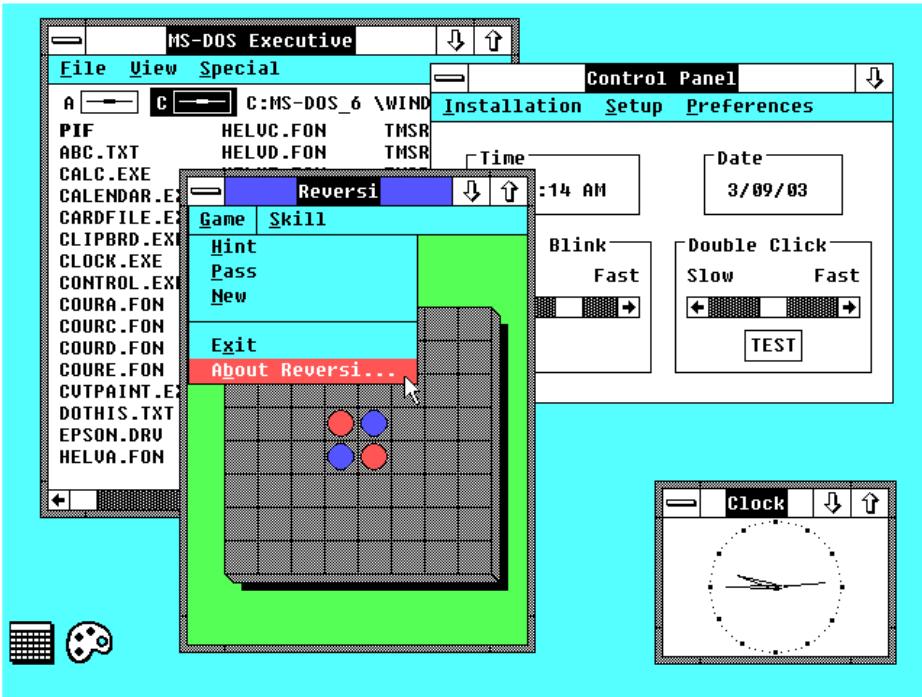
<https://www.carcomplaints.com/news/2017/lawsuit-chrysler-gear-shift-confusing.shtml>

Evolution of OS interface design - Examples

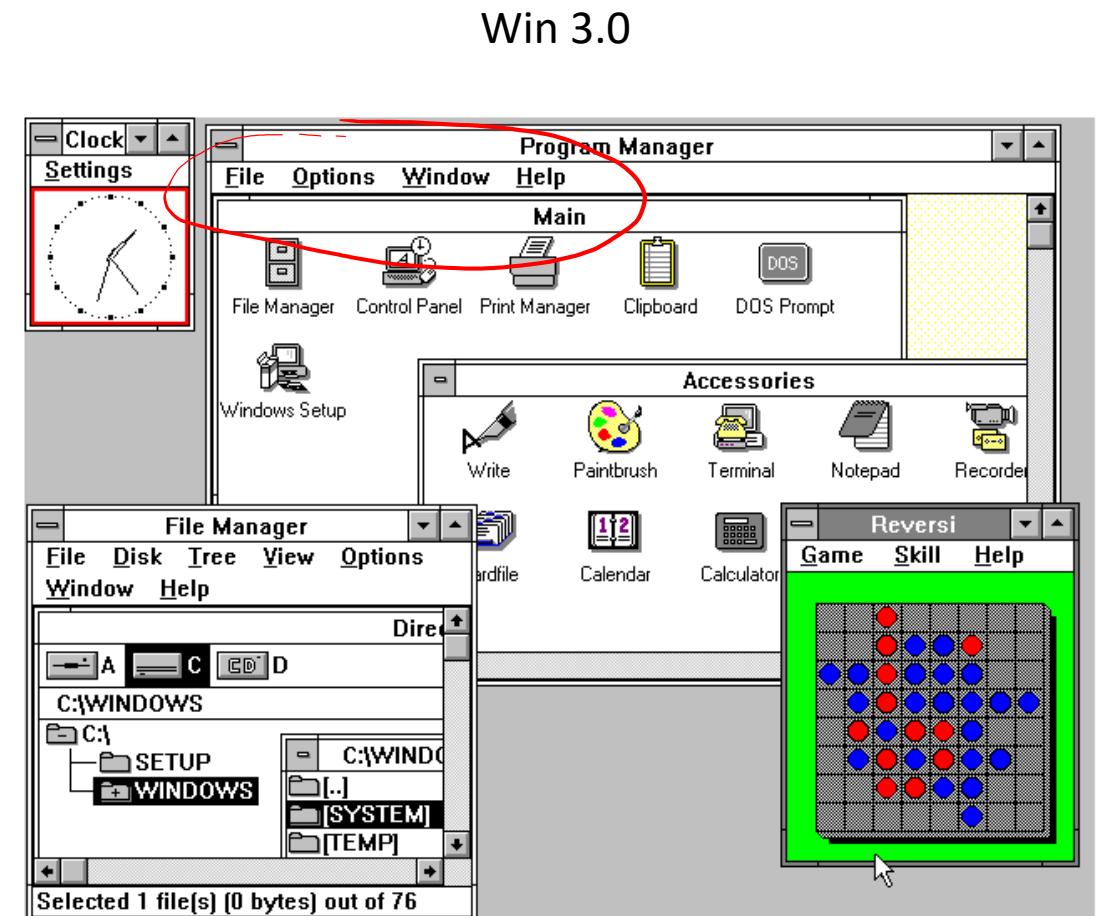
Mac OS



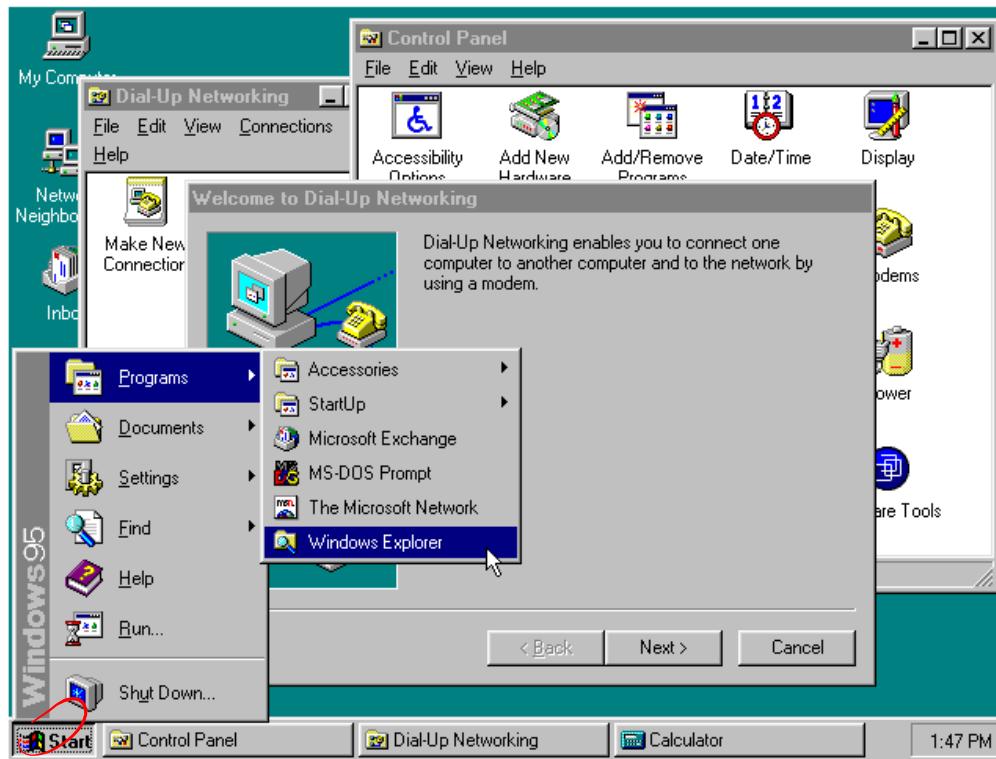
Windows



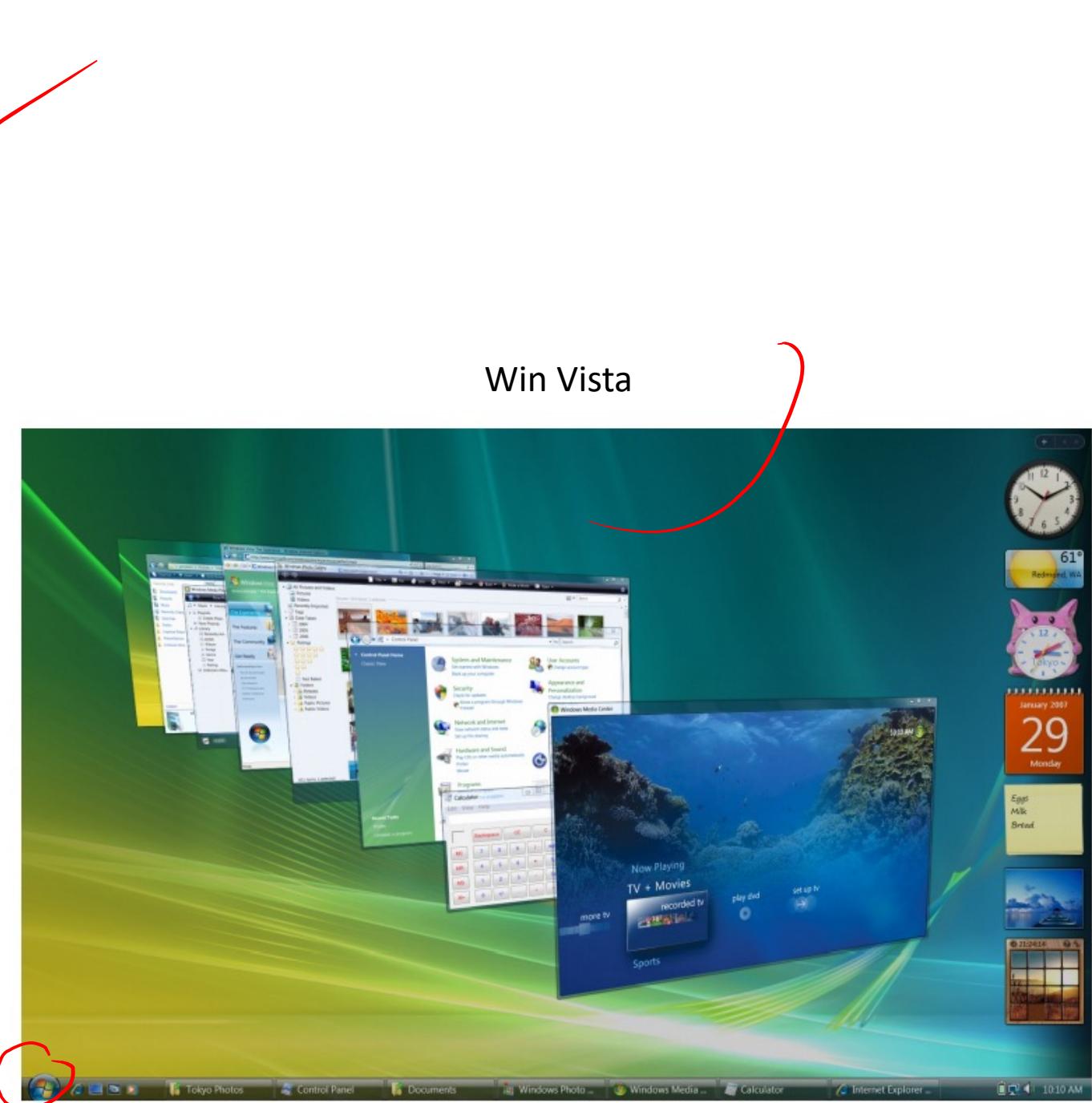
Win 1.0



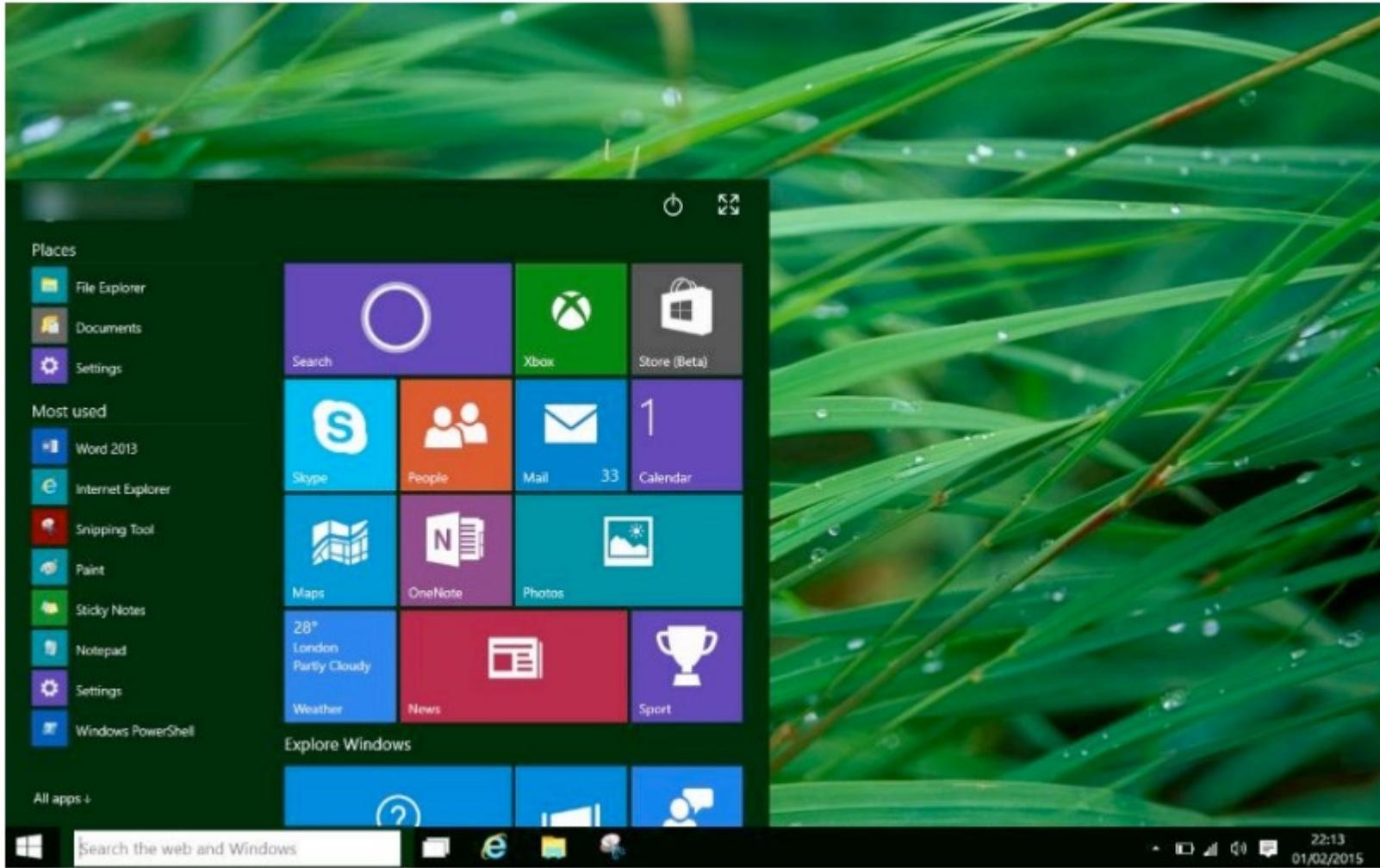
Win 3.0



Win 95



Win Vista



Win 10

Assignment 3

- Write down your own mental model of how a cash machine (ATM) works
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Human-Computer Interaction
Conceptual Models-II

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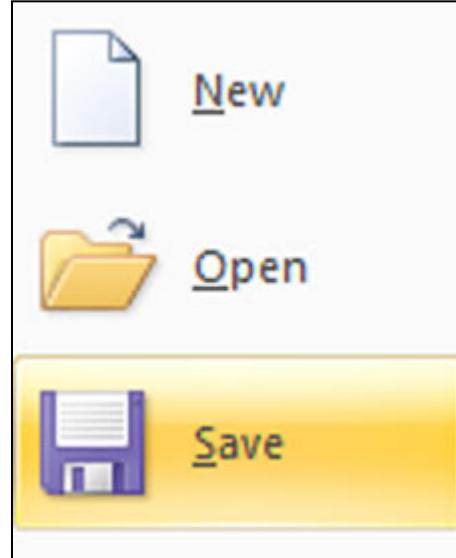
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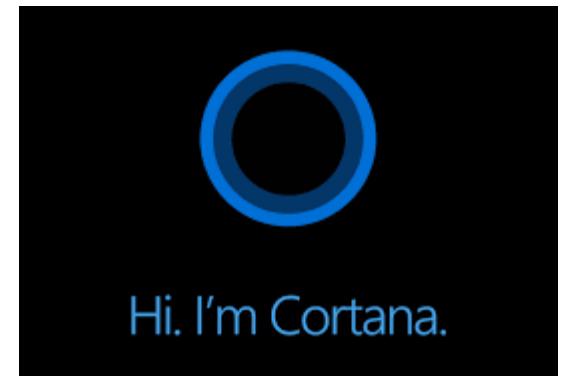
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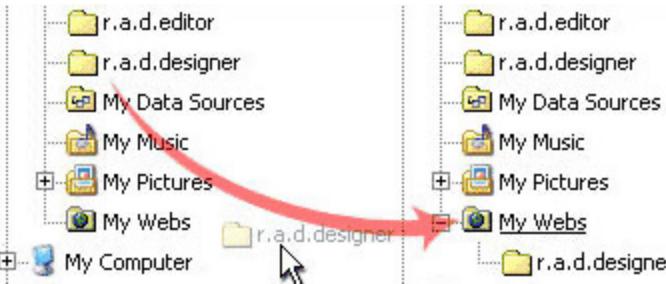


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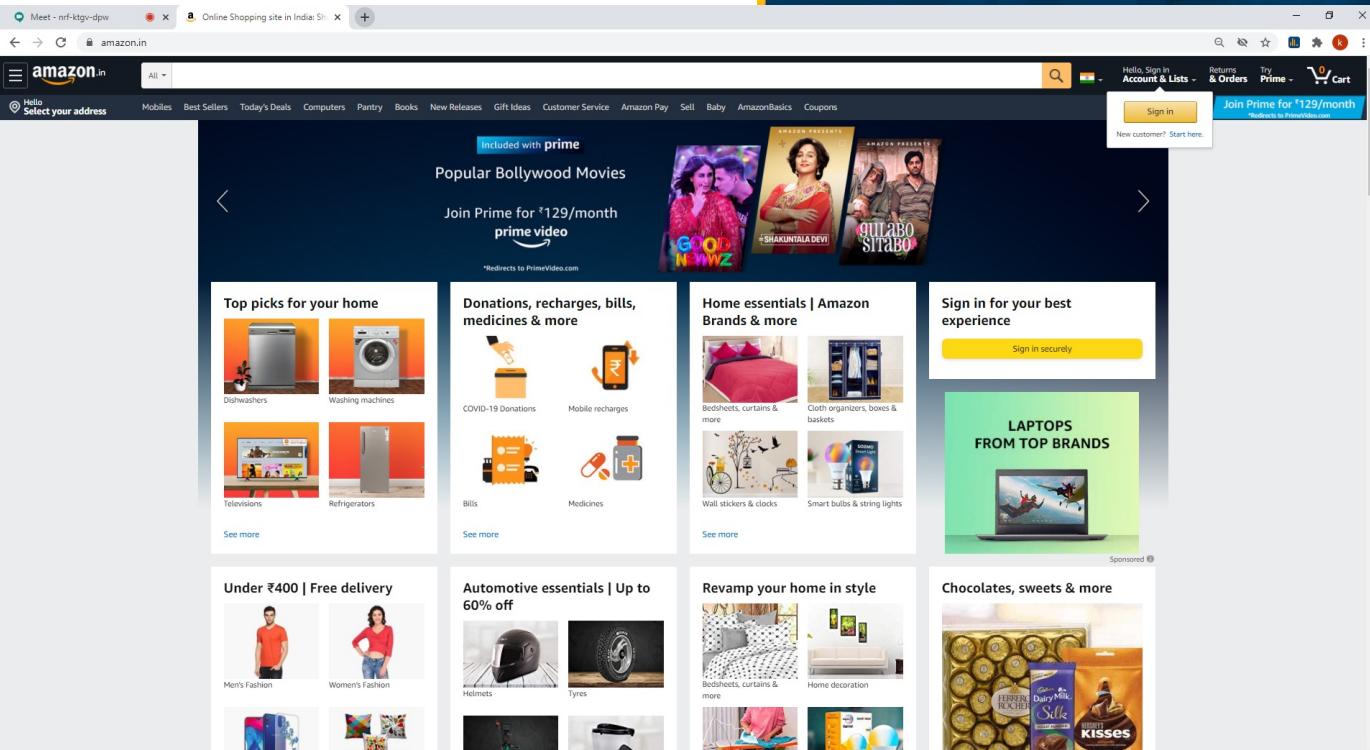
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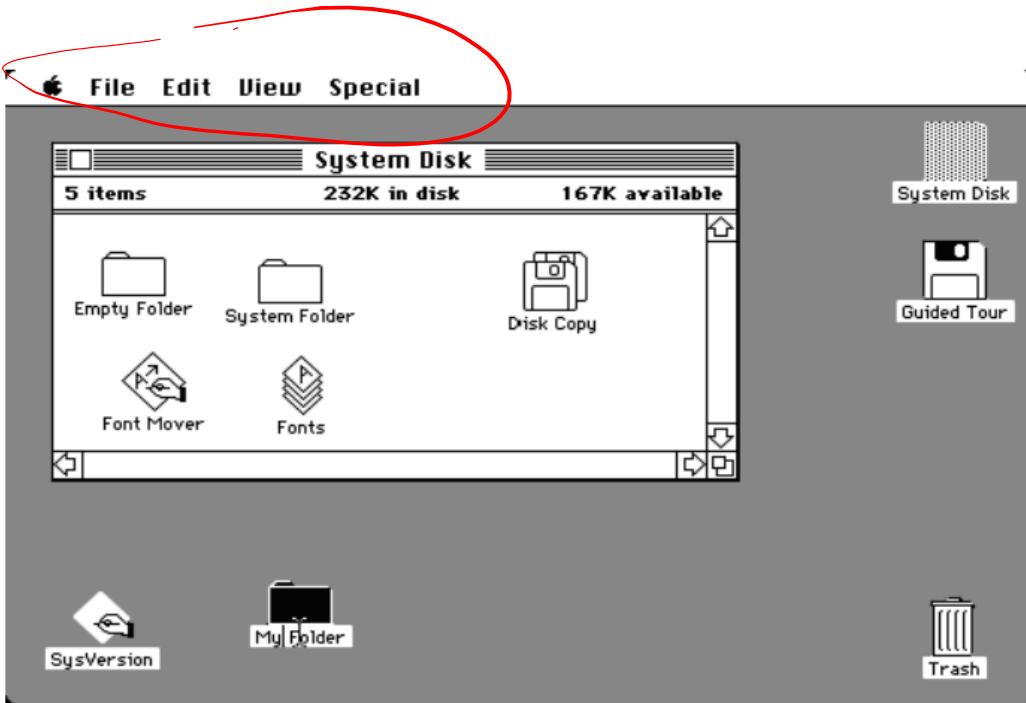


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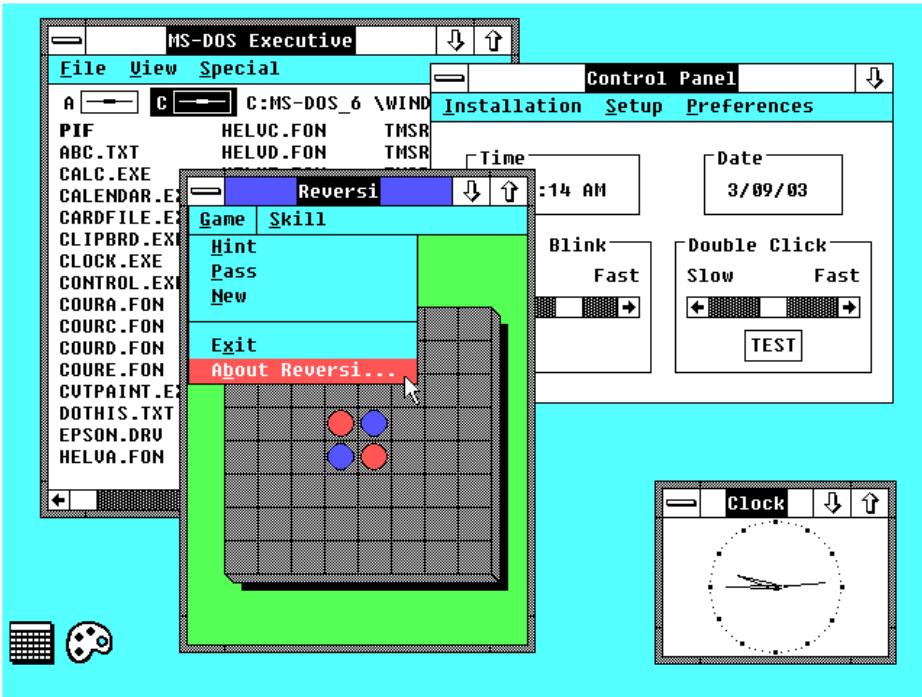
<https://www.carcomplaints.com/news/2017/lawsuit-chrysler-gear-shift-confusing.shtml>

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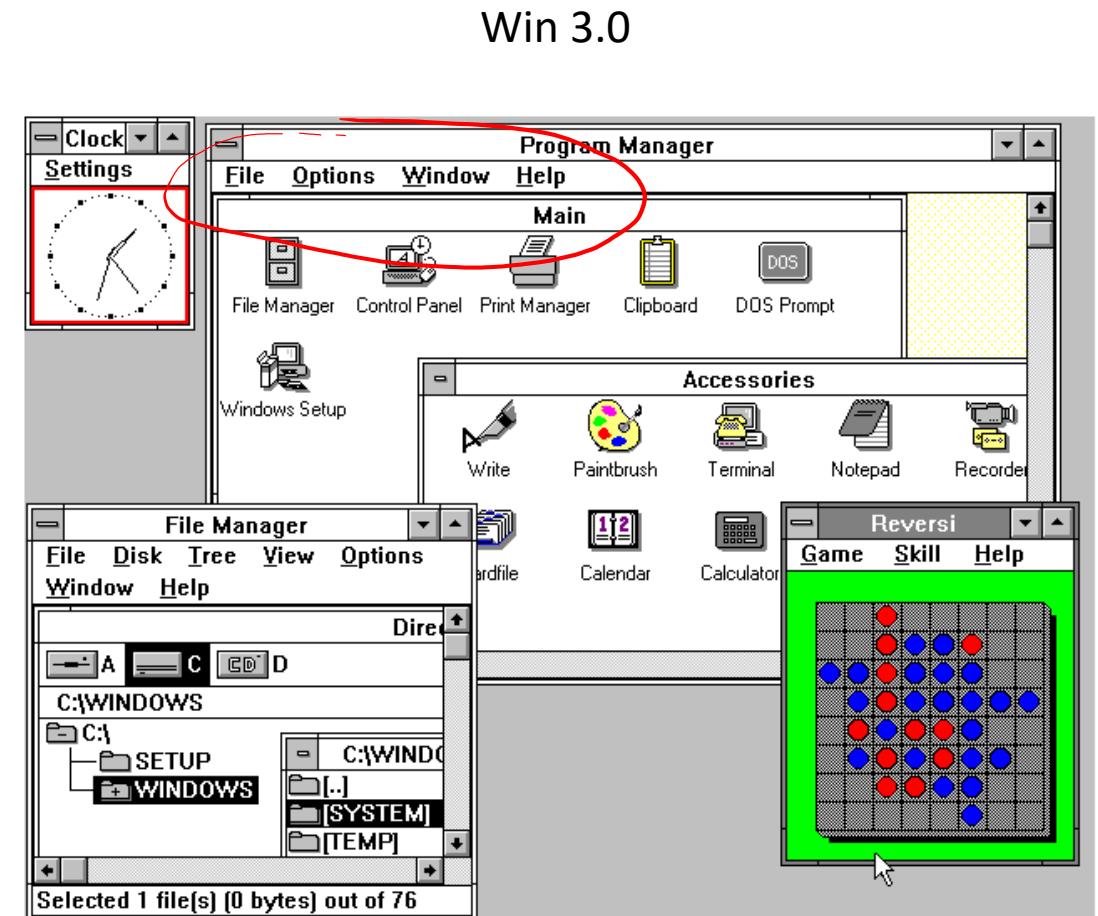
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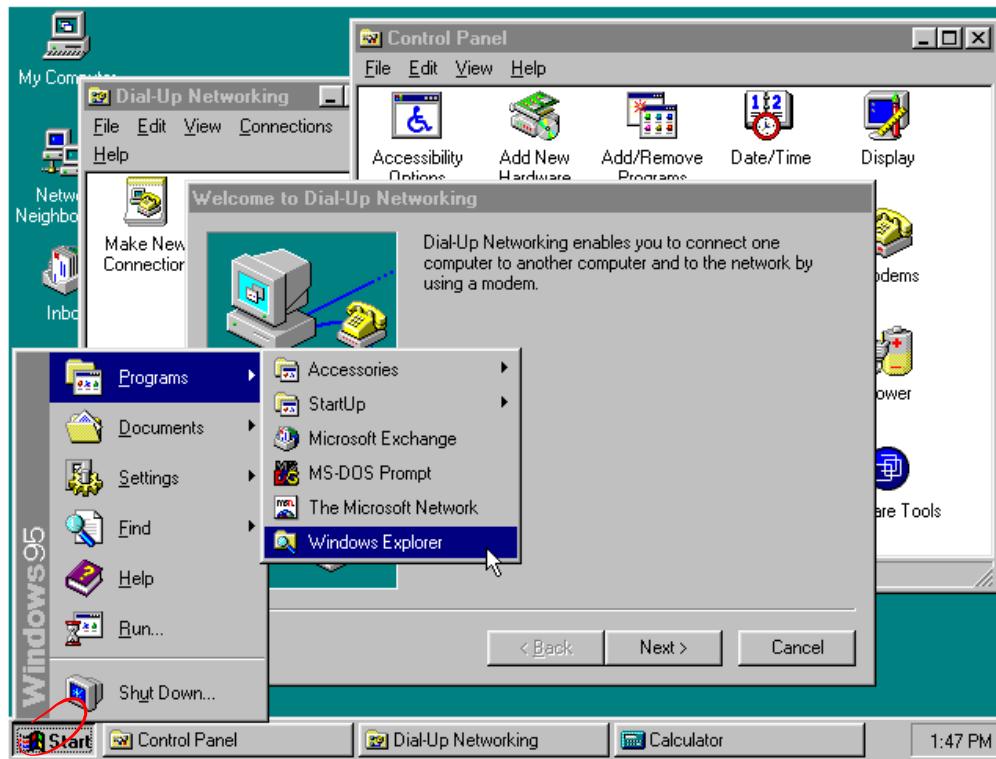
Windows



Win 1.0



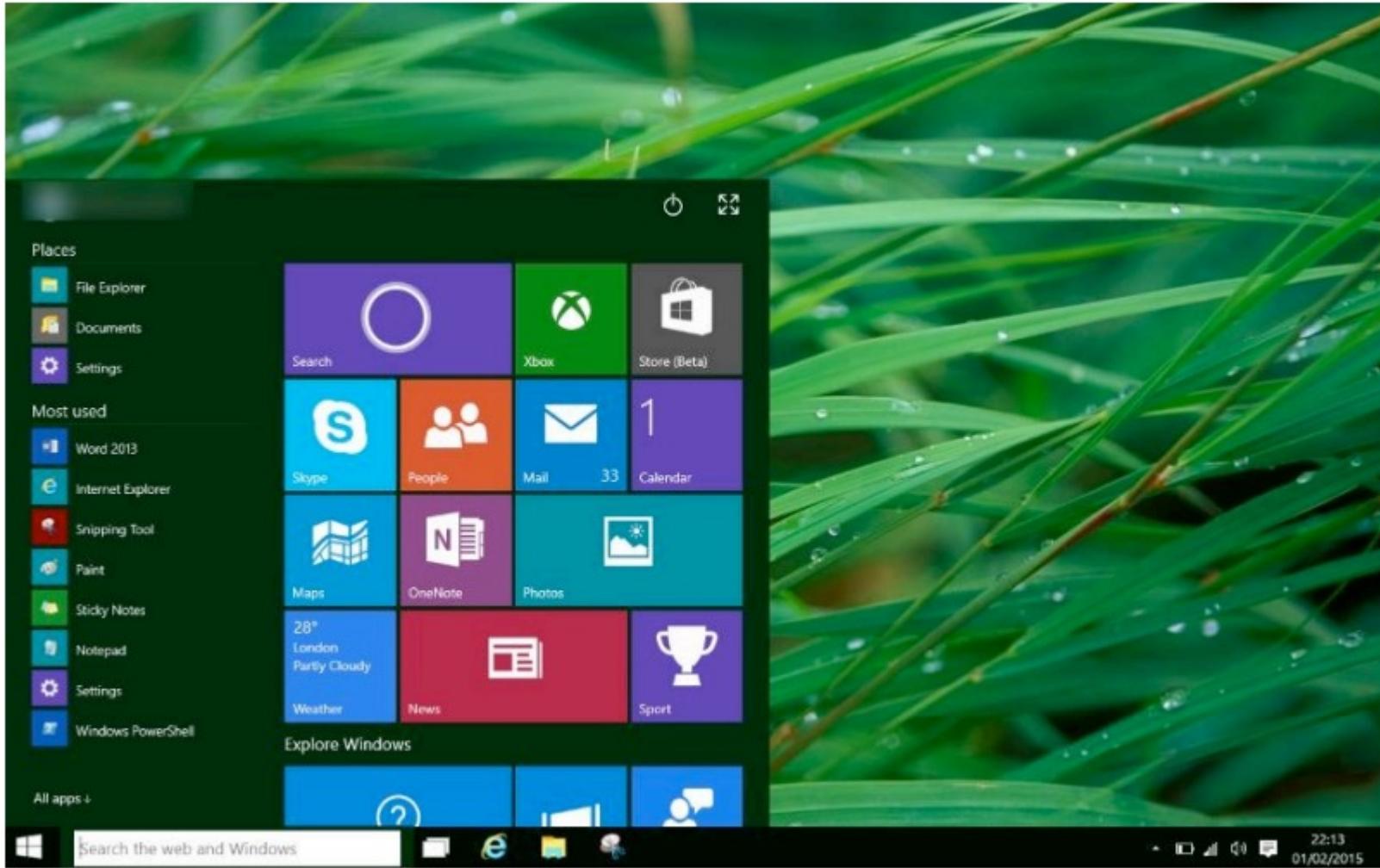
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Human-Computer Interaction
GoEx and GoEv

Usability

- ISO 9241 defines usability as effectiveness, efficiency and satisfaction with which users accomplish tasks
- The ability of a User to **Use** the product/ system / environment as **desired**
- Usability Engineering: The '**affordance**' offered by a product that makes it useable

Dimensions of Usability

- **Learnability:** Easy to learn
- **Efficiency:** Once learned, is it fast to use?
- **Errors:** Are errors few and recoverable?
- **Visibility:** Is the state of the system visible?
- **Effectiveness:** Can it do the job well and correctly?
- **Satisfaction:** Is the user happy with the interface?



Building all these dimensions into a product is called Usability Engineering

Rate the usability of each on a scale of 5





Fig 1: Microwave model I



Fig 2: Microwave model 2

Conceptual models



Fig 1. Scissors

- describe how an interactive system is organized
- Is the foundation of the interface.
- Ask:
 - what users will be able to do
 - what concepts or knowledge users will need, in order to interact
 - how they will interact with system (at a very high level)

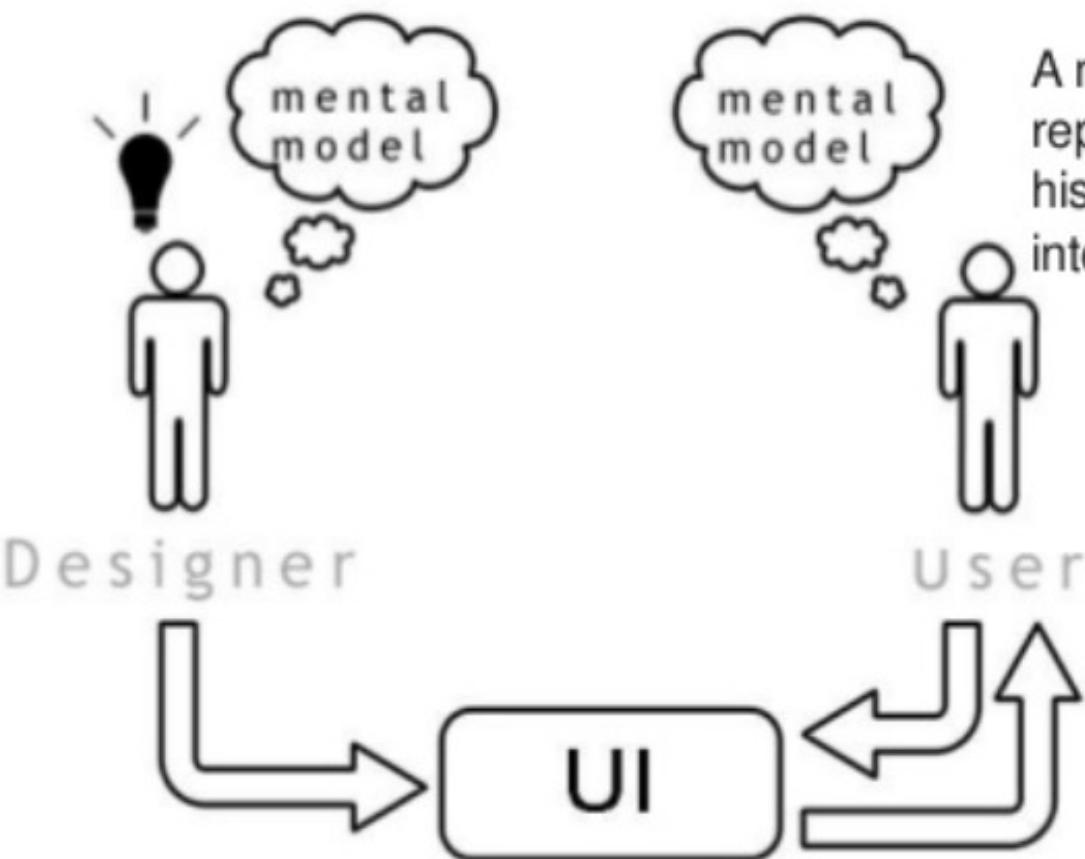


Fig 2. Files in folders Icon

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Mental Model vs Conceptual Model



A mental model is the representation that a person has in his mind about the object he is interacting with.

A conceptual model is the actual model that is given to the person through the design and interface of the actual product.

System Image

- The designer's conceptual model
 - How do I want it to be, work and operate?
- The system Model:
 - Actual physical structure, documentation
- User's mental model
 - How is it supposed to be or work?
- DESIGN FLAW
 - Designer's model = User's model

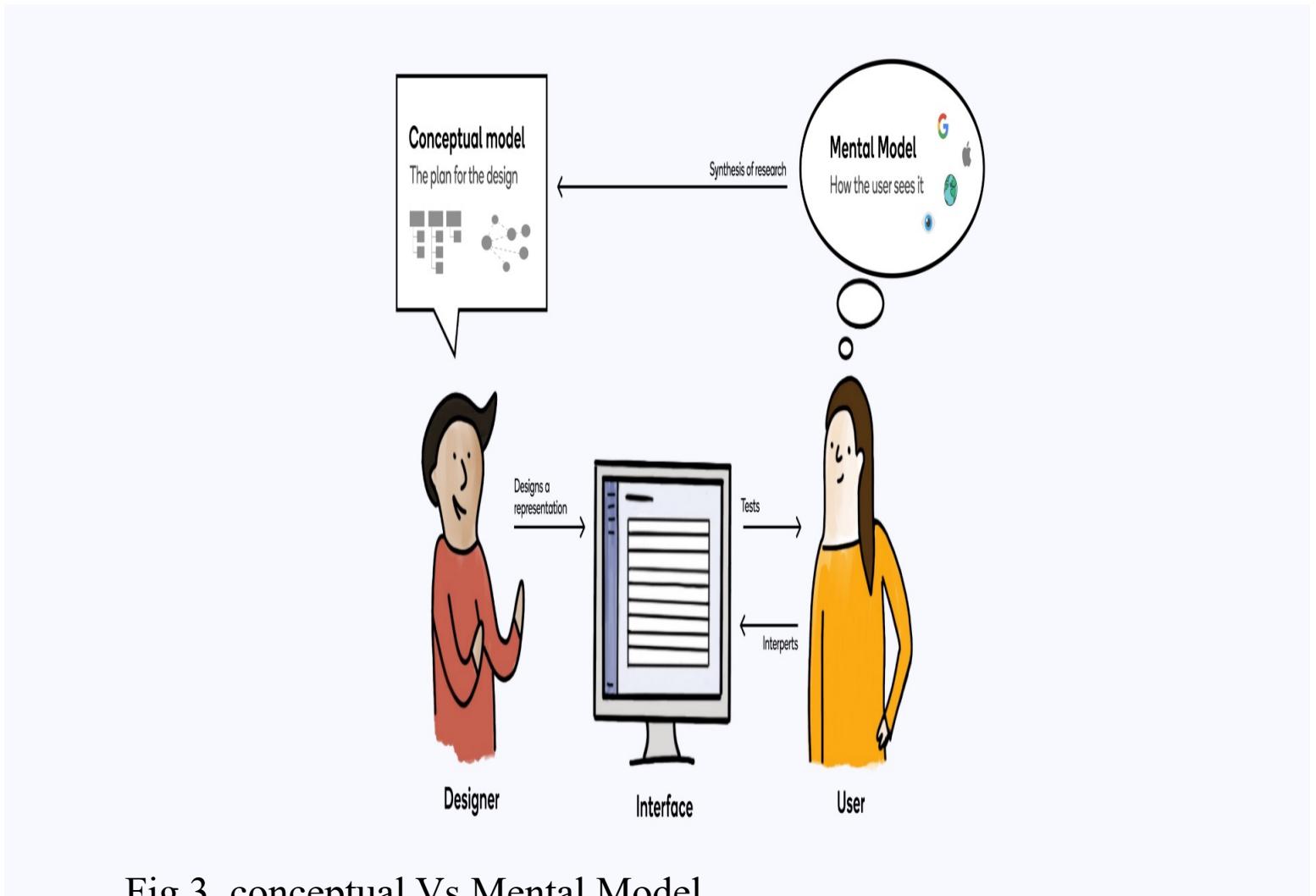


Fig 3. conceptual Vs Mental Model

<https://uxdesign.cc/understanding-mental-and-conceptual-models-in-product-design-7d69de3cae26>

Learnability & Memorability

Making interfaces easier for

- *new users to learn*
- *casual users to remember.*

Recognition Vs Recall

Recognition:

- remembering with the help of a **clue**
 - “using knowledge in or of the world”

Recall:

- Remembering with **no help**
 - “using knowledge in the head”
 - How much do we remember?

I hear and I forget.

I see and I remember.

I do and I understand.

Confucius



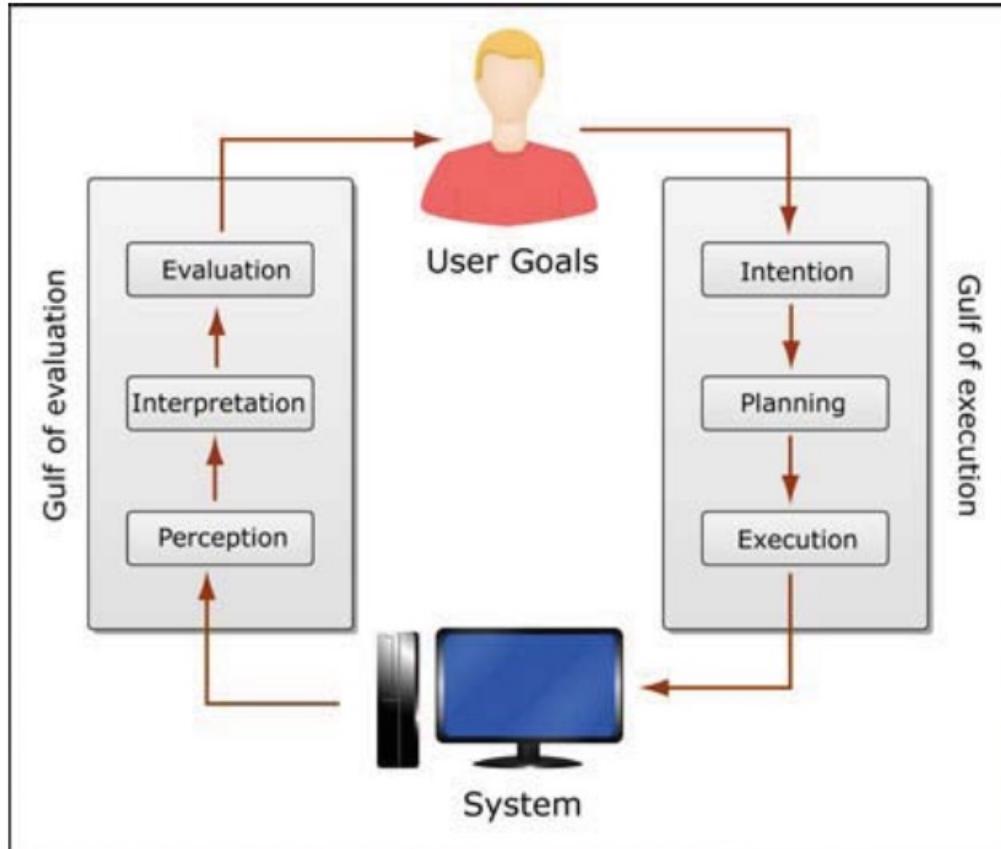
The weather.com website features a complex layout with various sections. On the left, there's a sidebar for "Customize My Weather" with a "Local Weather" search bar. The main content area includes a "BREAKING WEATHER" section with a "Winter" banner, a "NEWS CENTER" with "TOP STORIES" about winter storms, and a "Current U.S. Weather" map. There are also sections for "Featured Maps" and "Browse all cities/countries". A "FEATURED SECTIONS" bar at the bottom lists "Thursday, Mar 9" with small images.



VS



A generalized Cognitive Model



- Learnability: Execution side
- Visibility & Feedback : Evaluation side
- Efficiency: Measure of whole cycle, speed of execution and perception
 - What I did Vs What just happened Vs What is it I am going to see/experience?

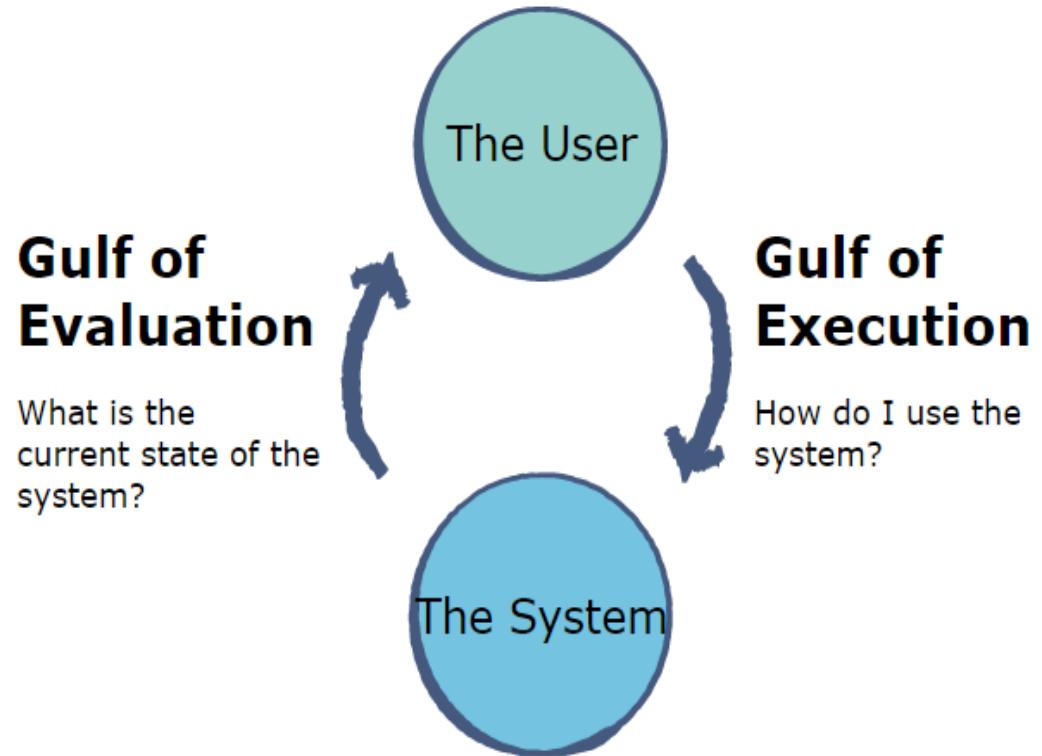
GoEv Vs GoEx

The Gulf of Execution (GoEx) is

- *the difference between the intentions of the users and what the system allows them to do*
- *how well the system supports those actions*

The Gulf of Evaluation (GoEv) is

- *the level of difficulty in assessing the state of a system*
- *how well the artifact supports the discovery and interpretation of that state*



<https://www.educative.io/edpresso/gulf-of-execution-and-gulf-of-evaluation>

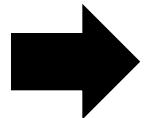
Norman's 7 stages of Actions

Questions	GOAL	EXECUTION	EVALUATION
<i>What do I want to accomplish?</i>	✓	-	
<i>What are my alternatives?</i>		✓	
<i>What can I do now?</i>		✓	
<i>How do I do it?</i>		✓	
<i>What happened?</i>			✓
<i>What does it mean?</i>			✓
<i>Is it OK? Have I accomplished my goal?</i>			✓

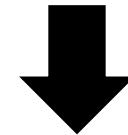
Making Coffee in a Brewer

Questions	GOAL	EXECUTION	EVALUATION
<i>What do I want to accomplish?</i>	<i>Coffee</i>		
<i>What are my alternatives?</i>			
<i>What can I do now?</i>		—	
<i>How do I do it?</i>		—	
<i>What happened?</i>		—	—
<i>What does it mean?</i>		—	<i>Coffee</i>
<i>Is it OK? Have I accomplished my goal?</i>			<i>Coffee!</i>

*Learnable
Interface*



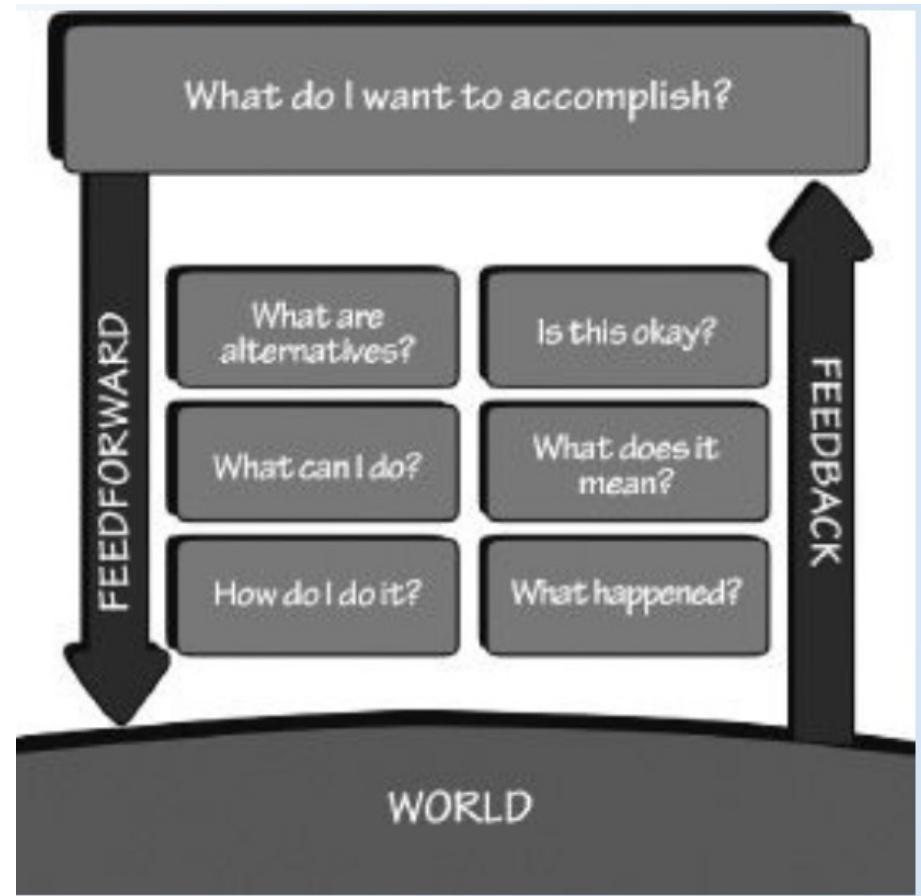
Smaller GoEx & GoEva



Easier to execute

How designers can bridge the Gulf?

- Bridge gulf of execution by:
- ○ Signifiers, constraints,
- mapping, conceptual model
- ● Bridge gulf of evaluation by:
- ○ Feedback, conceptual model
- ● Help users answer these →
- questions
- ○ 7 questions; 7 stages



IE 403/476

Human-Computer Interaction
Week 4-Lec1

Agenda

- Jacob Nielsen's 10 point rules of thumb
- Discussion on a research paper

Recap

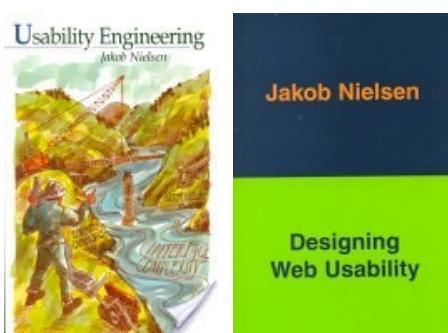
- Cognitive Model
- Gulf of execution and Gulf of evaluation
- 7 stages of actions By Norman
- Mental Vs Conceptual Model



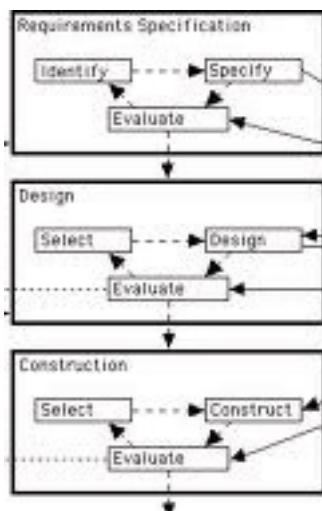
Jakob Nielsen

Usability consultant

Jakob Nielsen is a leading web usability consultant. He holds a Ph.D. in human–computer interaction from the Technical University of Denmark in Copenhagen.



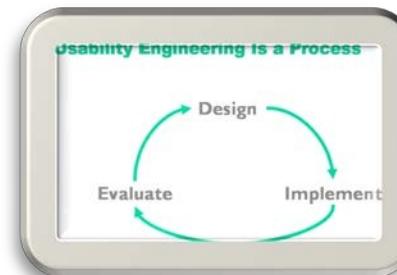
He has authored many books in Usability, HCI, & Experience design. His book titled “ Usability Engineering” 1993 is a textbook on methods to make interfaces easier to use.



Usability Engineering

Usability Engineering involves User Research; Design Research and Validation of Design through Construction & User Testing.

In some institutions it is taught as an independent discipline while in others it is part of HCI discipline.



History of the Heuristics

- Derived
 - Factor analysis of 249 usability problems
- Method are empirically based derivations.
 - Through experiments and observations
- Method suggested by Nielsen is popular because of its
 - simplicity and low cost.
 - It is preferred evaluation technique at the preliminary design stages

The Ten Heuristics as put forth by Nielsen.

- 1. Visibility of system status**
- 2. Match between system and the real world**
- 3. User control and freedom**
- 4. Consistency and standards**
- 5. Error prevention**
- 6. Recognition rather than recall**
- 7. Flexibility and efficiency of use**
- 8. Aesthetic and minimalist design**
- 9. Help users recognize, diagnose, and recover from errors**
- 10. Provision of Help and documentation**

Visibility of system status

Users need to be kept informed by the system about what is going on, through appropriate feedback within reasonable time.

Elaboration

constantly made aware of his/her interaction with the interface while interacting.

The control response ratio (input – output time) need to be as small as possible.

Any interface needs to communicate that it is in a ready state to be operated upon

Most important
to users is to know
"Where am I?" and
'Where can I go next?"
Internal reference is a
must to feel in control.



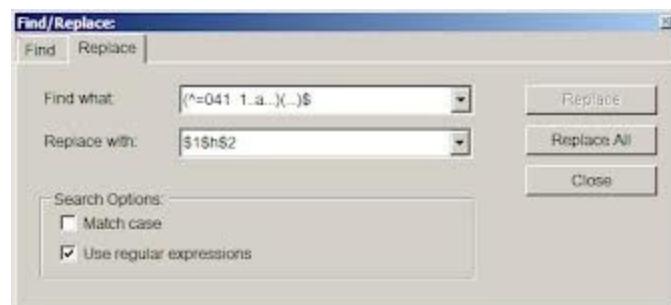
Match between system and the real world

The system should speak the users' language, with words, phrases and concepts familiar to the user, rather than system-oriented terms. Follow real-world conventions, making information appear in a natural and logical order.

Elaboration: Technical jargon or using terms like 'Initiate' or 'Load' in place of 'Start' contributes to initial mismatch between the users cognitive process and machines feed back dialogue.

An interface need to allow smooth transition from contextual 'reality' world to artificial machine world.in other words from 'reality' to 'digitality'.

Tendency to use programming language and syntax on the display, while understandable to the software programmer, will certainly be a mismatch to the user.



Users can come from different backgrounds, skills levels , specializations & culture.
The context on the screen needs to match with the context of the user's mental model

User control and freedom

Users often choose system functions which they did not want . (Mouse click due to haste) . This calls for Support undo and redo.

A user need to have to go through tracing too many steps back to regain control.

Elaboration: Sequential thought process in a user that follows a simple everyday human habit need to be reflected in the dialogue between the device and the user. A good interface facilitates this.

Being in control implies that one can choose to stop interacting at time rather than be forced or trapped by the interface into inaction.

Feeling in the user that he/she is in control at all times must be created.

If the user attempts to gain control and if a message like 404 error occurs the system is unfriendly & unhelpful !



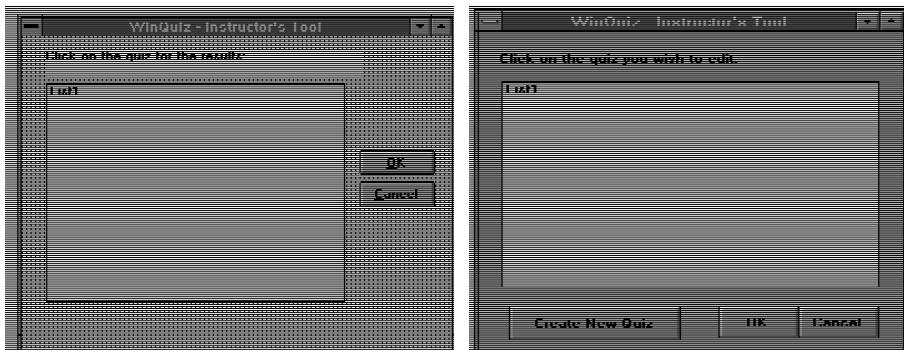
Can users select and sequence tasks? Can they easily re-turn to where they were if they choose an inappropriate /action path? The first example “accuses” them of committing an error. The second one is much better but does not tell the user what to do next ! The third example is inappropriate !

Consistency and standards

Using different words to mean the same action or using different symbols on different pages can be confusing to the user. Users should not have to wonder whether different words, situations, or actions mean the same thing. They should not be in doubt as to what to do next.

Elaboration: Within an interface if multiple words or actions are used to mean the same thing , it only leads to confusion in the user due to perceived lack of consistency. Interaction pattern gets disrupted. When pattern becomes complex, user's cognitive load increases.

Consistency in dialogue as well as in visual elements is achieved by specifying and adhering to a dictionary of words / labels/ symbols/ colors which together form a 'standard' – a prescribed set – compulsorily to be followed.

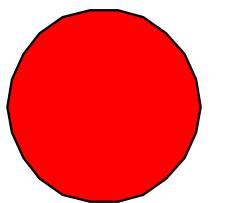


Inconsistent wording & windows / buttons can confuse users when the destination page has a different title from the link. The two screens belong to the same software but appear differently at different places within the website.

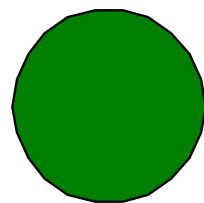
Strive for Consistency

- There are many form of consistency

Example:



Start



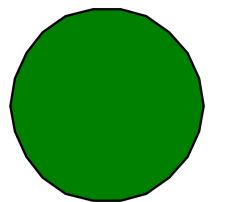
Stop

Inconsistent Interface Design

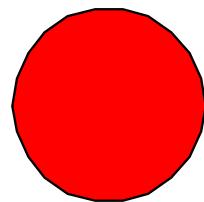
Strive for Consistency

- There are many form of consistency

Example:



Start



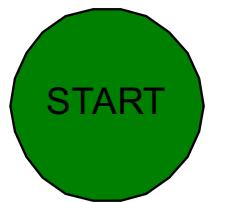
Stop

Consistent interface design

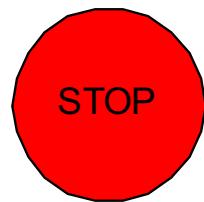
Strive for Consistency

- There are many form of consistency

Example :



Start



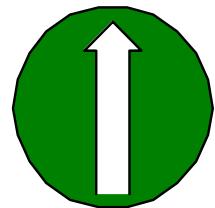
Stop

Better consistency in an interface design

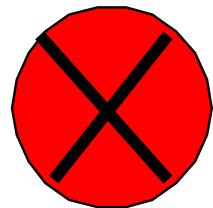
Strive for Consistency

- There are many form of consistency

Example :



Start



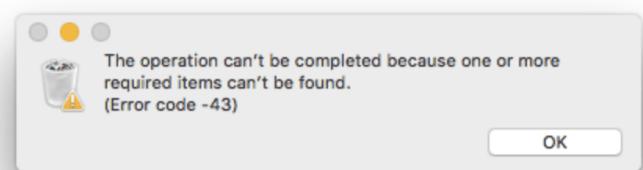
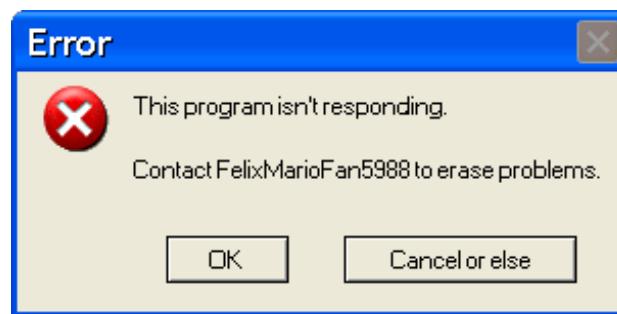
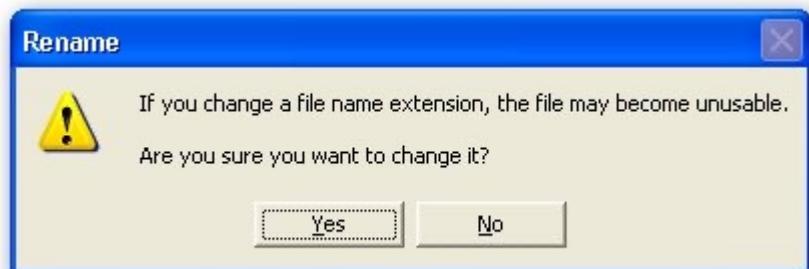
Stop

Another better consistency in an interface design

Error prevention

Prevention of error is best approach. However recovery from error prone actions through a well designed error message should be adopted.

Elaboration : To err is human. Errors can happen regardless the level of expertise of the user or familiarity of the interface. A good principle of design is to seek out error prone interactions , build in error prevention within the dialogue. Forewarning, restricting , prompting , retracing or recovery routes , etc are means of addressing errors. Errors lead to a situation wherein users feel subdued by a machine. Anticipating for errors and incorporating preventive measures ensures fear free and ego free user there importance to 'H' in HCI through 'I'



GUI-style windows cut down on the errors but may still have to be double checked before confirmation

Recognition rather than recall

*Loading the STM- short term memory of the user beyond a limit has negative consequences. Given a navigation path, a user need not have to remember or recall all the instructions. Users are better at **recognising** things they have previously experienced. **Prompts , visibility , sequential direction, pop-ups etc** should come to the aid of the user. Help needs to be easily retrievable.*



Good labels and descriptive links are crucial for recognition.
The first two icons are difficult to recognise or to recall.

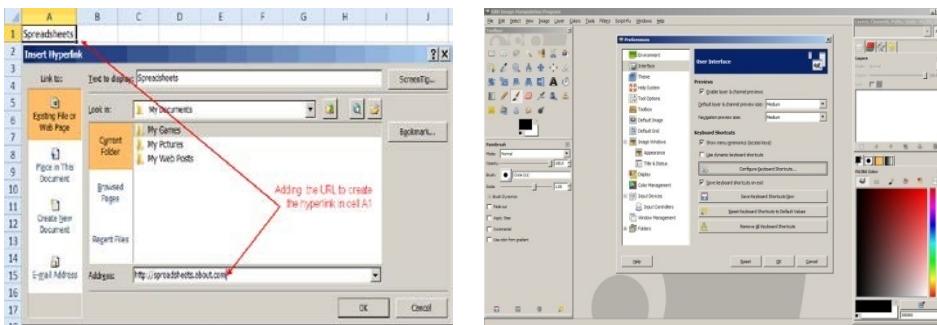
Elaboration : Reduction on cognitive load during the interaction ensures that the user is not asked to rely on means and methods that extract human cost. If an interface requires specialised training and use of memory to operate - it will be quickly abandoned by the user.

Analogy, metaphor, symbols, sounds, etc are used as design elements in an interface to ease recall thereby eliminating the need for 'thinking while interacting' and memory loads for the user.

Flexibility and efficiency of use

The system can cater to both *inexperienced and experienced* users. As the user becomes proficient - shortcuts can be encouraged. Thereby increasing the efficiency. Allowing the rearranging of the screen elements by the user can also be adopted.

Elaboration : Once a user becomes adept at using an interface , he/she upgrades into a higher level user from a novice. Such users will always seek to complete the task faster . Such users seek out shortcuts. An interface need to allow this. It needs to be flexible and make it possible for the user to adopt quicker dialogues through shortcuts. The user feels efficient as well as proficient. The feeling of having mastered the software is a flexible sign of being in control thereby.



Advanced users can opt for shortcuts in the spreadsheet example in the first picture.

Flexibility of keeping the required buttons / sections in view or hiding them gives the option to the user to rearrange GUI as needed as shown in the second picture.

Aesthetic and minimalist design

Relevancy, simplicity, minimum amount of labels, un cluttered graphics result in efficient communication dialogue between the user and the interface unnecessary superfluous elements need to be dropped.

Elaboration : Visual clutter in the interface only adds to inefficiency however impressive it is visually.

Simplicity is equal to efficiency is equal to elegance is equal to beauty is the aesthetic algorithm in minimalism. Use of least number of elements (minimalism) is more 'scientific' rather than 'artistic'.

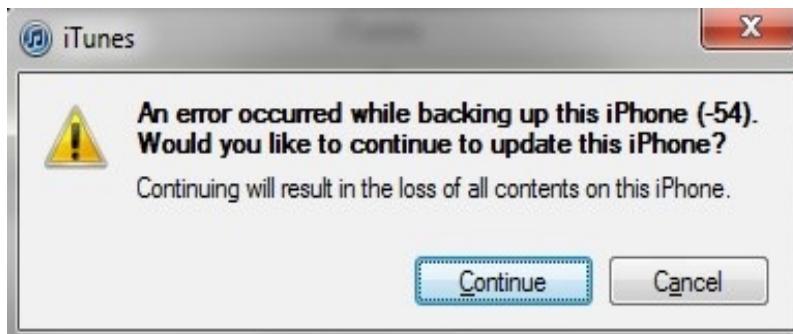
Visual noise needs to be completely eliminated.



Help users recognize, diagnose & recover from errors

Preventing a user who is about to make a error would be a good approach. Gentle wording of error messages, constructive suggestions, reeducating the user- all can contribute to a happy self confident user who is not afraid of being caught unawares or penalized.

Elaboration : No body likes to be loudly informed that he/ she has erred. Error messages need to be disused as suggestions / prompts and precise instructions so as to be able to correct the error and recover. The learning component in errors so that the user recognizes the error as it is being made, or recognizes the reason why the error happened in the first place – helps the user learn.



There is no way to understand the consequences of canceling. The onus seems to be on the user who will be held responsible for what ever is opted for. proper diagnosis & how to possibly recover is not clear. Very unfriendly interface./

Help and documentation

Even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation. Help queries need to be answered promptly without the user having to go through an elaborate eliminating list.

Elaboration : This again is to assist the user learn and understand the dialogue between the user and the machine or understand - where what went wrong - or aid recall during memory-lapses due to long usage time gaps. Adequate 'Help' support system when the user wants and at the point where the user wants it - is a good principle of Interface design.



The screen shots (1&2) attempt to Train the user by offering information on the consequences of their decision

Conclusions:

- These ten heuristics of usability help in refining a potential design into a good design. They ensure that interfaces evolve in the right direction.
- These rules of the thumb act a check list to evaluate a design.
- They also can be used as check list while evaluating any GUI.

Paper discussion

What If Conversational Agents Became Invisible? Comparing Users' Mental Models According to Physical Entity of AI Speaker

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Proceedings of ACM Interactive Mobile, Wearable Ubiquitous Technology, ver 4, issue 3, Article 88 (September 2020),

Context of the problem

- Invisible intelligence
 - Physical disappearance of computers from users' view
 - Miniaturization of devices and their integration into other everyday artifacts or the home environment
 - to act as intelligent agents that use prediction algorithms to predict behaviors
- How can people perceive and interact with invisible devices?
- What other advantages do invisible CAs have compared to CAs with physical entities?
- How can sensor-based, invisible interfaces be designed for implicit interaction with humans?

Identify users' mental models and determine the design direction of the invisible CA.

Method

- Conducted a drawing study
 - to understand the differences between the two CAs with different physical entities
 - how their physical visibility affects users' mental models and interactions.
- 30 participants interacted with CAs with a physical presence and an invisible CA
- Differences :
 - Mental models and interactions
- Aim to
 - Understand users' perceptions
 - Expectations of the role of the agent

Visible CA with physical entity



Invisible CA without physical entity



Fig. 1. Equipment used Clova

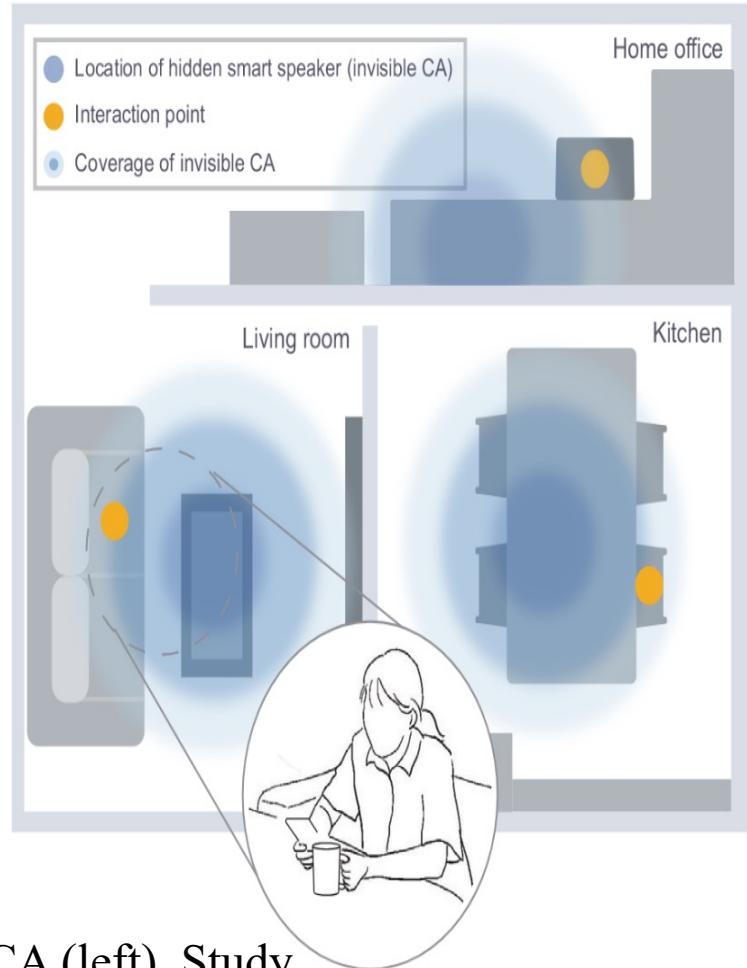
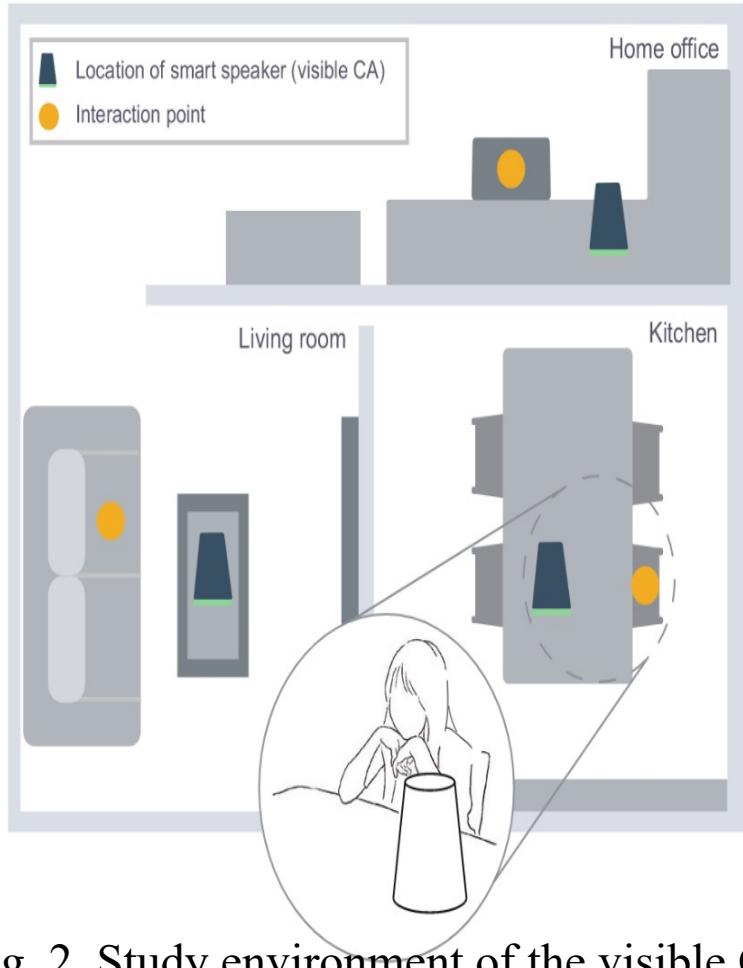


Fig. 2. Study environment of the visible CA (left). Study environment of the invisible CA (right).

Interaction Tasks

- The study consisted of four sessions:
- 5-minute tutorial
- 30-min interaction
- 40-minute drawing,
- Debriefing interview

Catergory of instruction	Command examples
Music/Audio	"Play a song that suits on a rainy day" / "Read a book"
Daily information	"How's the weather today?" / "Tell me today's news"
Shopping / Delivery	"Please order paper towel" / "Please deliver pizza"
Schedule management	"Wake me up at 7 in the morning every day" / "Tell me about today's schedule of mine"
Search	"Give me your US country code" / "How old is the earth?"
Smart home	"Turn on or off the TV" / "What is the current temperature of the air conditioner?"
Others	"Hi!" / "Sing me a song"

Table 1. Printed instruction in seven categories

Findings from Drawings – visible CA

- Participants perceived that interacting with the three AI speakers
 - As talking to three individual agents
 - because even though the devices had the same form, wake-up words, and voice in the experimental setting, the users perceived each agent differently

D1 Three agents with different appearances for each space.



① The triplets are wearing different clothes depends on the each role.

② The triplets are connected to a box with a question mark.

D8 Three agents with different appearances for each space.



① Agent in the kitchen is singing bird in the kitchen

② Agent in home office is Mechanical robot

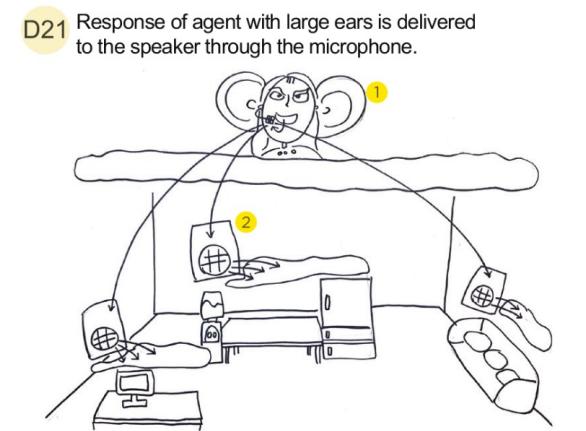
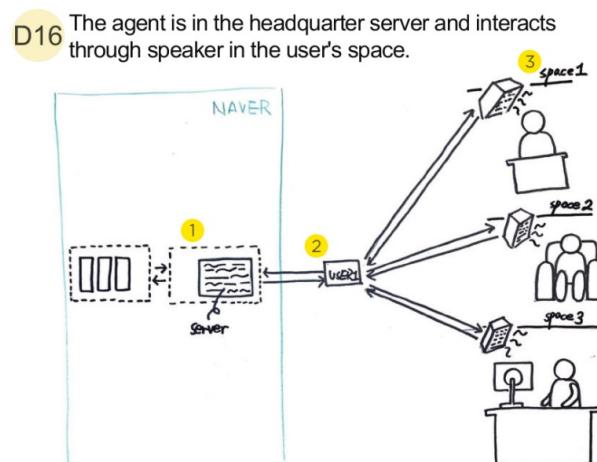
③ Agent in living room is a person who speaks happily

Although there are three devices of the same shape, each one seems to be different depending on where they are placed individually. (P8)

The devices were separate, so I perceived them as different beings. (P10)

Invisible CA

- Perception: Even though 3 diff agents as a single agent
- Drawings depicted One agent controlling the entire space.
 - Because the voice of the agent was the same everywhere
 - Device was not visible in any of the spaces
 - Focus was more on the consistency of the voice regardless of the number and location of the interactions.



I feel like there is a single agent connected to the server in the sky. Actually, rather than having three agents, I feel like one agent can go anywhere. (P17)

I think this is one person. Because it doesn't change the tone, it doesn't change the voice, and the personality is not different (...) The reason I drew the big ears is because I feel like she is listening to me very carefully with huge ears. (P21)

Mental Model – Visible CA

- Perceived three agents that each play a role with own expertise depending on the space
- Smart agents in the home office and as more active and bright agents in the living room.
- Users' perceptions of individual agents for each device were naturally connected to different personas, roles, or functionalities
- Negative impressions of interacting with multiple agents.
- If environment were a real home
 - a mental load would be required to talk to several agents in their private spaces.
 - Interaction was similar to communicating with people
 - where more effort is required to get to know several people than it is to know one person.

I feel like I have to try to get to know this [agent] through conversation, but if there are several of them, it is a huge burden that I have to try to get to know three or four people. (P8)

Even if different agents communicate with each other through something like a hub, it's likely to be creepy or less reliable because I'm afraid that these agents will communicate my private information that I don't want to share with other people.

Mental Model – Invisible CA

- Only one agent
 - No change in tone/voice
 - User's location of communication irrelevant
- Could detect a user's behavior and status
 - without space limitations
 - Expected the agent to provide the most appropriate information based on its awareness of the user's context
- Some Users took personalized responses from agents for granted.
 - Contrary to the mental model for the visible agent, where participants were concerned that their conversation records were shared with agents in other spaces.

On the sofa, when I said to the agent, “I was having a hard time today,” and then when I moved and sat at the desk and asked it to play music, the agent said, “I’ll play music that feels good.” That is so touching even though it was a brief moment, I felt like I was emotionally interacting with this agent. (P28)

This [agent] knows all of the things I do, but I don’t want my information to be shared with the next-door neighbor or headquarters like Google. Then, I will never believe this agent and will never use it

Interaction Styles

Visible CA

- Direct – eye contact
 - Device installation location
- Visual Cue – LED
 - Start of device , ready to listen
 - Learnability Increased
 - User knew when to speak
 - Discoverability of the Voice UI

Invisible CA

- ambient interaction without space constraints
- No physical presence
 - Only auditory cues
 - Less affordances
 - Initial interaction issues
- Did other tasks while communicating with agent – Talk and listen anywhere

I felt comfortable because I had someone to talk to. (P9)

This form makes me feel like I'm having a conversation with someone. If this disappears, it would be awkward because I would be talking to nothing, which would definitely not be a natural conversation (P10).

When the light comes on, I can see that the agent is listening to me, and if there is no visual feedback, I wouldn't be really sure. (P8)

Ambient Interaction

- Invisible agent has the advantage of
 - enabling parallel task execution,
 - because in the case of an agent without a device, it is not necessary to look at it, so subtasks can be carried out while the user continues to do his or her previous or main work.

When I can see it, I have to consciously stare and talk, and keep checking to see if the agent is listening to me or not, and I guess this will interfere with usability. But, if I don't need to see the agent, then I can do two things at the same time.

I felt uncomfortable and a sense of cognitive discrepancy with talking to an invisible agent because there's a sound, and something is coming from somewhere, but there is nothing—just empty space. (P21)

This is uncomfortable because Siri lights up but this one does not. I have no idea how loud I should speak and where to speak. If this is visible, I can know how I should talk to the agent, but I don't know where it is... (Is it under there or up there?) I don't know how loud I should speak. (P16)

Conclusions

- the physical entity's visibility influenced
 - the mental model of the user,
 - Played an important role in the User Experience.
- ambient interaction naturally connected to a user's perception
- expectation was
 - Interaction could be with personalized agents everywhere,
 - Similar to the goal of ambient intelligence
 - Example: JARVIS



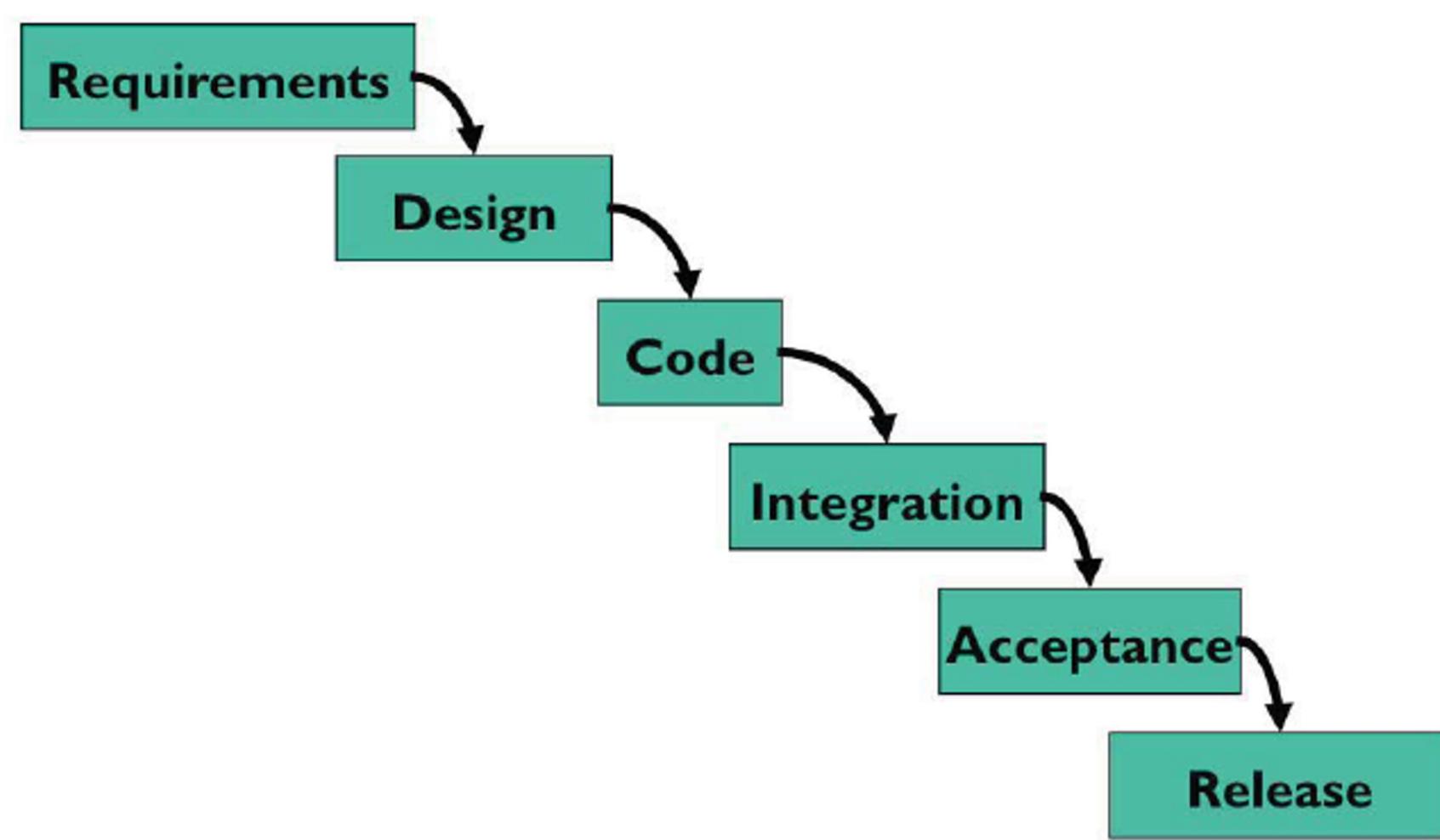
IE 403

Human-Computer Interaction
Week 4-Lec3

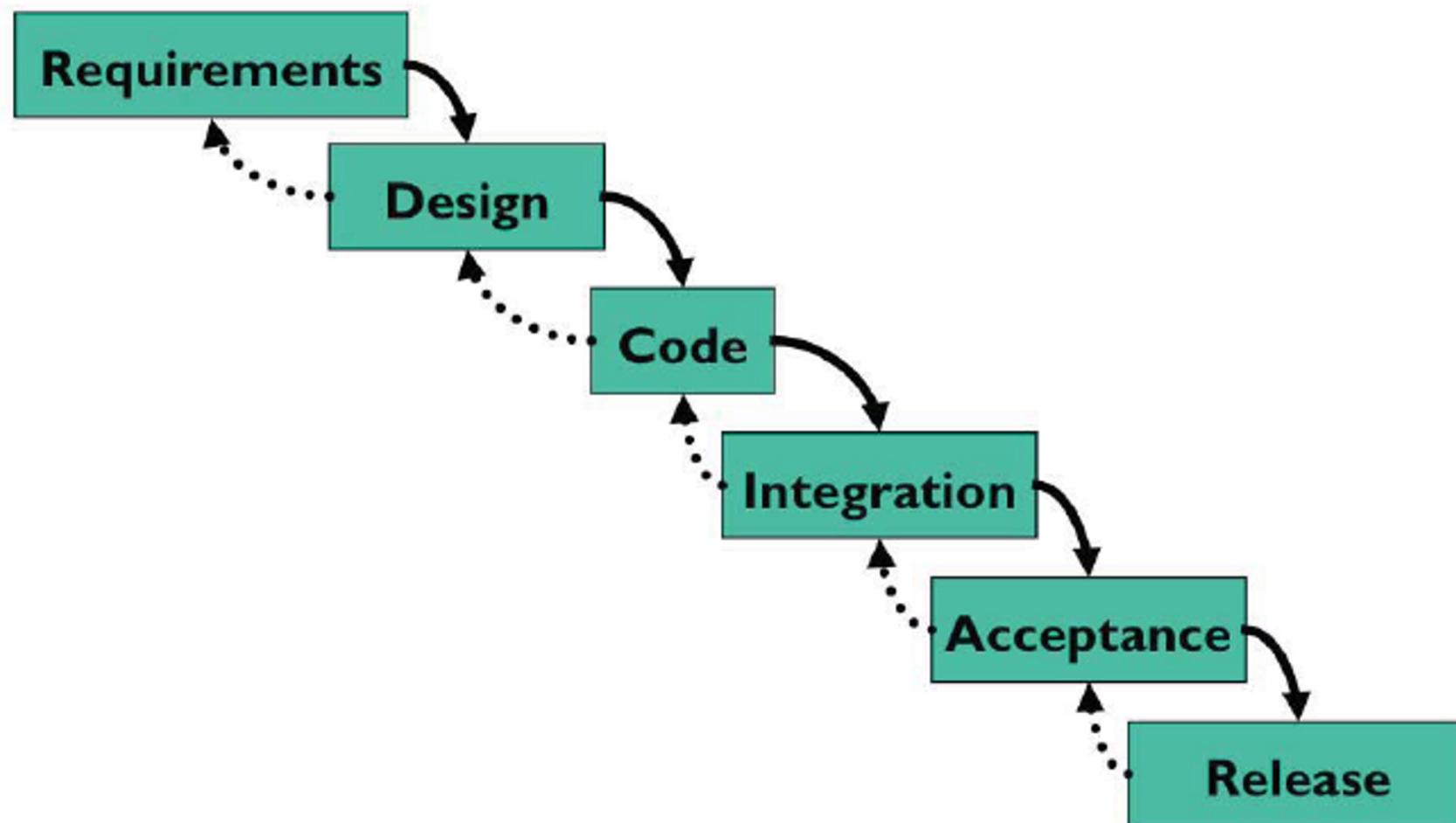
Agenda

- Iterative Design
- User centered Design

Waterfall model



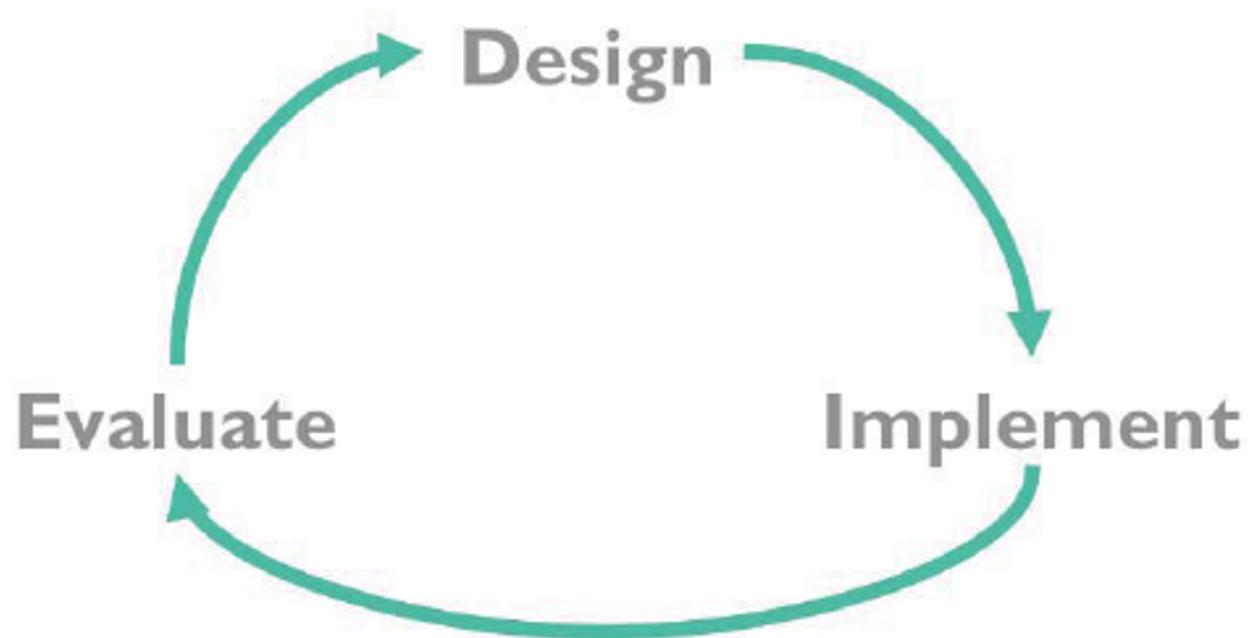
Feedback in Waterfall model



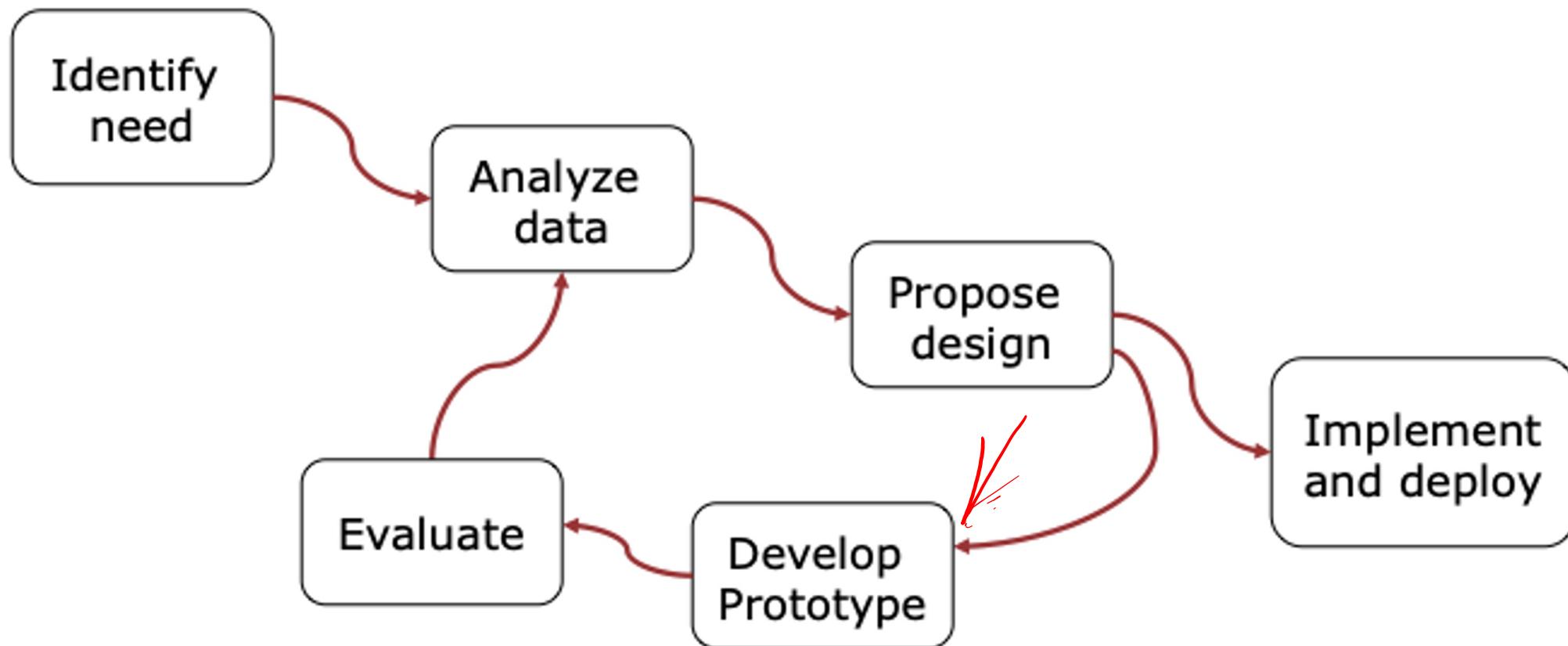
Why waterfall model bad for UI design

- UI is Risky - probability of getting wrong high
- No involvement of users till acceptance testing
- UI makes sudden changes in requirements and design

Usability engineering - Iterative Design



UCD Lifecycle



Identify Need

- Interview (structured, semi-structured, unstructured)
- Contextual inquiry
- Cultural probes
- Ethnography
- User models

Evaluate

- Heuristic
- Usability eval
- Full eval

Analyze Data

- Scenario analysis : User usage
- Task analysis : tasks reqd to be performed by user

Prototype dev

- Low Fidelity: paper based
- High Fidelity: Tools/software

Case Studies examples

Olympic Messaging system (1984)

- Iterative design
 - 200 Iterations for user guide
- Cheap prototypes
 - scenarios
 - user guides
- Absence of UCD
 - language barrier - telephone prompts

<https://www.youtube.com/watch?v=W6UYpXc4czM>

Microsoft Interactive Program Guide

- Embedded interactive TV application inside set top box
- Objective
 - Simple
 - Low level inputs
 - Familiar and usable interface
 - Accurate
 - Context based - what was entered

User Tasks listing

- Changing channels/channel surfing
- Finding out the name of the TV program currently being watched what it was about
- Searching for a specific TV program
- Setting a list of favorite channels
- Finding child-appropriate cartoons
- Setting parental controls

Procedure

- 13 core tasks to complete by users in lab
- Task performance for benchmarking
- Track progress of UI design over a year

STUDY #1 FINDINGS	ACTION TAKEN
<p>Expected to be able to specify a time rather than a timeframe in Search</p> <p>Three participants wanted the ability to specify specific times rather than a timeframe in the Search by Time feature.</p> <p>These participants also indicated that the labels Morning, Afternoon, Night and Late Night were ambiguous because they weren't certain if 11:00 pm constituted Night or Late Night.</p>	<p>Changed search capabilities from 4 generic categories to specific hours of the day to allow user to specify a specific time.</p> <p>Bug # A21B5</p>

STUDY #2 FINDINGS	FURTHER RECOMMENDATIONS
<p>Able to successfully search using By Day and Time label</p> <p>All participants were able to correctly search on a specific day (tomorrow) at a specific time for a specific program using the By Day and Time label. All participants easily picked out the day and time to complete the task.</p> <p>When asked to search for programs on today, six participants selected the Today label within search, while only one participant opted to use the Browse feature.</p>	<p>Continue to allow users to specify a specific day and time to complete a search.</p> <p>No recommendations are necessary.</p>

Usability Findings

Benchmark Study A

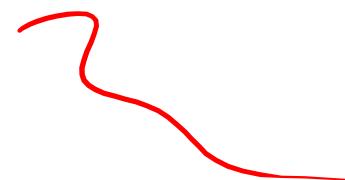
- 33 usability issues were discovered
- 30 of these issues were addressed through a redesign or UI change (to be verified in next study)
- Result – the team is addressing more than 90% of the usability issues found with the user experience

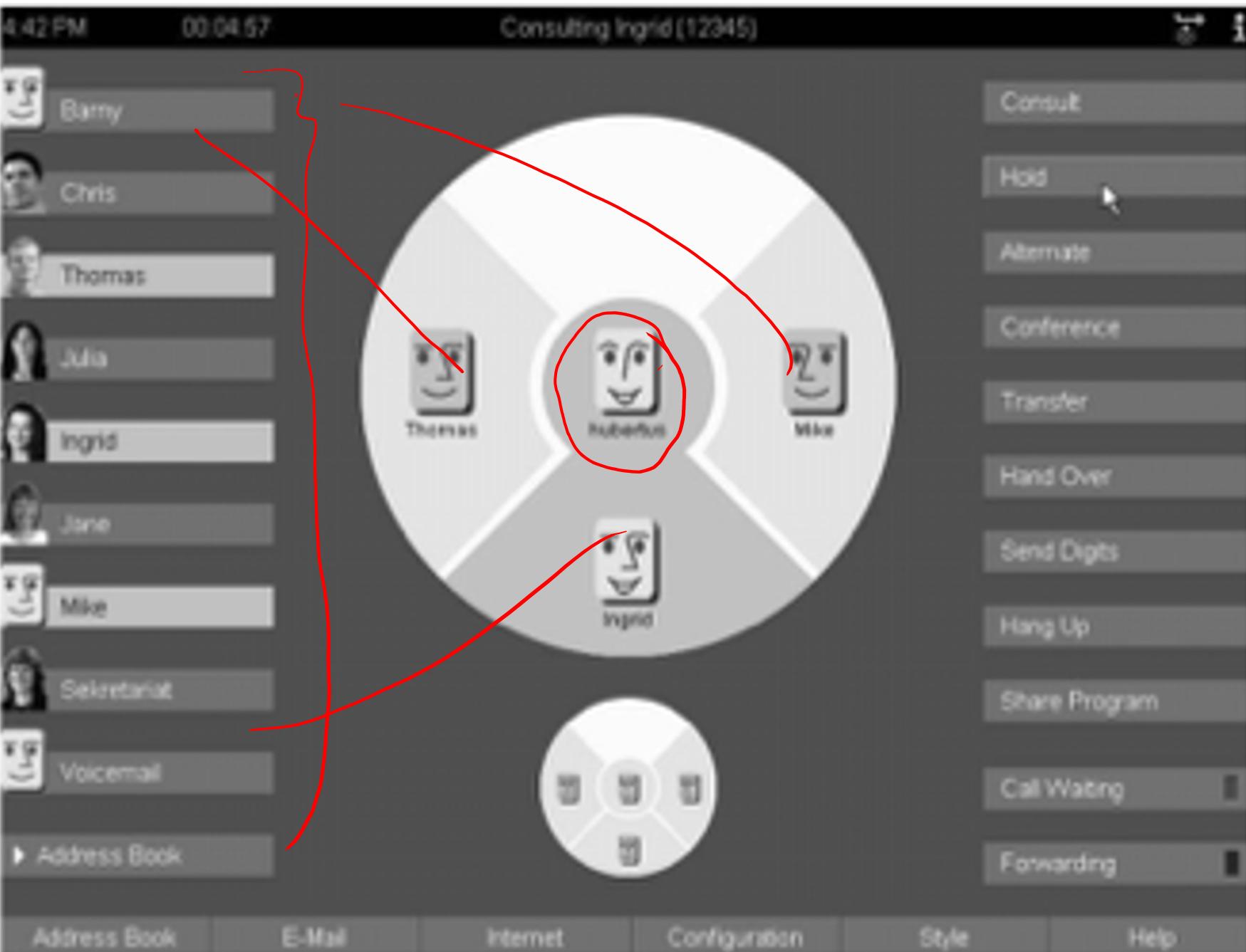
Benchmark Study B

- 15 usability issues were discovered
- 10 of these were new usability issues
- 5 were re-occurring issues – all had dropped in severity from previous study

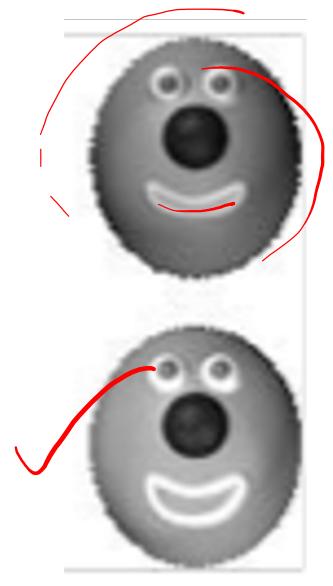
EASYCOM telephony design

- more supplementary features are supported
- the more difficult these phones are to operate
- integrating voice and data communication functions into a single PC-based user interface,
- Efficiency of employee workflows
- Conceptual model
- communication circle
- USer at the center
- drag, drop communication partners
- Direct manipulation





- improve the handling of complex synchronous communication processes by striving for ease of use
- designing for fun and emotion has become an equally important success factor
- observations are based on user feedback collected in internal and external field trials as well as interviews with customers and sales people.
- reduced Anxiety in making conference calls which were complex
- Pleasant UI
 - innovative
 - USP for Siemens VOIP products



GUI: avatars or talking heads

How to read a research paper

Abstract

What If Conversational Agents Became Invisible? Comparing Users' Mental Models According to Physical Entity of AI Speaker

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The popularity of conversational agents (CAs) in the form of AI speakers that support ubiquitous smart homes has increased because of their seamless interaction. However, recent studies have revealed that the use of AI speakers decreases over time, which shows that current agents do not fully support smart homes. Because of this problem, the possibility of unobtrusive, invisible intelligence without a physical device has been suggested. To explore CA design direction that enhances the user experience in smart homes, we aimed to understand each feature by comparing an invisible agent with visible ones embedded in stand-alone AI speakers. We conducted a drawing study to examine users' mental models formed through communicating with two different physical entities (i.e., visible and invisible CAs). From the drawings, interviews, and surveys, we identified how users' mental models and interactions differed depending on the presence of a physical entity. We found that a physical entity affected users' perceptions, expectations, and interactions toward the agent.

CCS Concepts: • Human-centered computing → User studies.

Additional Key Words and Phrases: Ubiquitous smart home, conversational agent, voice user interface, invisible intelligence, drawing study

ACM Reference Format:

Sunok Lee, Minji Cho, and Sangsu Lee. 2020. What If Conversational Agents Became Invisible? Comparing Users' Mental Models According to Physical Entity of AI Speaker. *Proc. ACM Interact. Mob. Wearable Ubiquitous Technol.* 4, 3, Article 88 (September 2020), 24 pages. <https://doi.org/10.1145/3411840>

1 INTRODUCTION

Introduction

1 INTRODUCTION

Due to its seamless and unobtrusive input method, the use of voice user interface (VUI) has increased in the form of AI speakers as hubs to control smart homes [11, 39, 45]. Because commercialized AI speakers consist of a physical device with a speaker and microphone, users need to face the device for better communication, as people do when they communicate face-to-face. Users interact with CAs in stand-alone devices, such as Alexa in Amazon Echo, which makes users look at where the device is installed and listen in the direction of the sound coming from the device. This means that the conversational agent (CA) in the physical device leads to visually and auditorily directed interaction. However, because the directed communication is based on where the device is installed, there are limitations in the agent's immediate interaction with the user, and it is difficult to notice the changing context of the user in real time at home [34].

To find answers of these questions, it is critical to identify users' mental models and determine the design direction of the invisible CA. Similar to previous studies on CAs embedded in AI speakers, we emphasized the importance of understanding users' mental models for designing CAs [7, 11, 16, 28, 30, 39]. These studies attempted to understand users' mental models mainly through verbal approaches [11, 30]. However, because it is unclear how each user will accept the new concept of invisible agents, when forming a mental model toward the unsubstantial system by comparing it with current CAs in physical devices, limitations can hinder discovering users' expectations for a new concept with only a verbal approach. For this reason, it is necessary to explore users' mental models of invisible agents and to find out the difference between existing CAs in physical entities—such as AI speakers—for future design possibilities and development directions combining visual and verbal approaches.

Thus, we conducted a drawing study to understand the differences between the two CAs with different physical entities, as well as how their physical visibility affects users' mental models and interactions. To achieve that goal, 30 participants interacted with CAs with a physical presence and an invisible CA, and we then identified the users' mental models through their drawings, in addition to interviews and a survey. We explored how users' mental models and interactions are different in directed interaction with a visible agent than they are in ambient interaction with an invisible agent. The findings describe users' perceptions, expectations of the role of the agent, and interaction in terms of physical entities to discover the potential of the invisible agent. Based on this finding, physical presence is an important element in CA design, and we found features of invisible agents compared with CAs in AI speakers that were not revealed in previous studies. Finally, this study suggests that invisible agents can be one design direction in VUI to enhance user experience in the ubiquitous environment.

Methodology

3 METHOD

3.1 Participants

To grasp users' first perceptions of visible and invisible CAs, we recruited 30 novice users (avg. age = 22.5 years old, SD = 3.32; 13 females and 17 males) who had never used an AI speaker. Half were to talk to a visible CA and the other half were to talk to an invisible CA. We posted in online communities, such as a university one, to recruit people who wanted to use an AI speaker for their homes. We tried to recruit relatively young participants, even if awareness of users of different ages is important, because 34% of U.S. 18–29-year-olds owned a smart speaker at the beginning of 2019 [51]. This is significantly higher compared to other age groups. Therefore, we thought that this age group would use this type of device in the future. We also focused on first-time users because the initial stage of CA use would affect users' mental models and later stages of use [12, 28, 36], and users in the initial stages of voice interaction need the most assistance to be led to proper use [11]. To compare clearly the new concept of invisible CA with that of the existing visible CA devices, users experienced with neither were more appropriate. Moreover, according to previous research, the first image of an agent rarely changes, being imprinted in users' minds as soon as they hear the agent's voice [36]. Therefore, we would be able to grasp the unbiased perceptions that users formed by the experimental setup we provided. All of our participants were Korean, and we conducted the study in Korean with native Korean speakers. Each participant was compensated with approximately U.S. \$20.

3.2 Apparatus

Because the goal of this study was to compare natural user experiences with visible and invisible CAs, we used three commercialized AI speakers and invisible agents in the study environment. Figure 1 shows the apparatus that our study used. A CA without a physical entity—that is, an invisible agent—has not yet been commercialized, so we hid a stand-alone AI speaker in the study environment to make it invisible. Because the goal of the invisible agent is to assist users without visually distracting them from a task, we adjusted the volume and position during the setup process so that the participants did not know where the sound was coming from, causing them to feel as though the invisible agent was ambient. The participants accordingly perceived the sound as coming from the ceiling, rather than from where the agent was actually installed. Three AI speakers were installed in the lab environment in the case of visible devices, and three devices were hidden in the case of invisible agents.

In terms of AI speaker types, we used AI speakers from Naver Clova [38] which are some of the most advanced

3.3 Study Environment

Figure 2 shows the study environment, which includes the location of each device and interaction point. We did not specify the interaction point clearly for the participants but had them interact at whichever point was comfortable in each space. The environment reflected a smart home in which people have multiple speakers dispersed to increase the coverage of a voice agent. Referring to prior research on common locations for Alexa devices [45], we configured the lab environment into three spaces: a kitchen, a living room, and a home office. To provide the sense of a comfortable home and typical environment for AI speaker usage, we placed a sofa and table in the private room, a table and TV in the living room, and a desk and computer in the home office. The

Results

4 FINDINGS

From the qualitative analysis, which mainly focused on comparing each agent, we found that participants perceived CAs with physical entities and invisible CAs differently. In particular, participants' drawings showed how the different physical entities of the CAs affected their perceptions (Figure 3 and 5). The data from observations and interviews allowed us to grasp the mental models and interactions linked to the users' perceptions. In addition, for the survey data, we analyzed the average of the overall CA experience trends for the two physical entities (Table 2). Through findings related to perception, the mental model, and interaction, we can discover the unexplored features of invisible CAs compared with CAs in the stand-alone device. In next section, we refer to each drawing as D and the participant who drew it as P. Both have the same number.

IE 403

Human-Computer Interaction
Week 5-Lec1

Recap

- Cognitive Model
- Gulf of execution and Gulf of evaluation
- 7 stages of actions By Norman
- Mental Vs Conceptual Model

Conceptual Models

- Need to first think about how the system will appear to users (i.e. how they will understand it)
- A high level description of
 - the proposed system with a set of integrated ideas and concepts about
 - what it should do
 - behave
 - look like
 - that will be understandable by the users in the manner intended

Understanding a Conceptual Model

- How will the user think about the system? Possibly based on:
 - Data or objects
 - Types of operations (activities) done
 - Metaphors (real world analogies/similarities)
- What kind of interface metaphor, if any, will be appropriate?
- What kinds of interaction modes and styles to use?



Fig 1. Word processor Vs a typewriter



Fig 2. iBooks flipping pages similar to physical books

Mental models

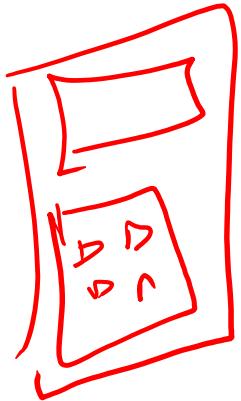
- Users “**see**” the system through mental models
- Users “**rely**” on mental models during usage
- Reason about a sys
 - Interact with
 - Infer how it works
 - Figure out how to correct when things do wrong

Why are mental models important?

2016, Chrysler automobiles recalled over 100K vehicles



- Gear shows P, R, N, D/S
- Shift through the gear options
- But returns to center position
- What is the problem ?



People were getting out of their cars thinking the gear was in Park mode
But it wasn't, so the car drove off without them!!!

→ 100 (5 mins)
315

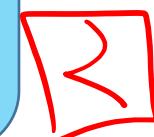
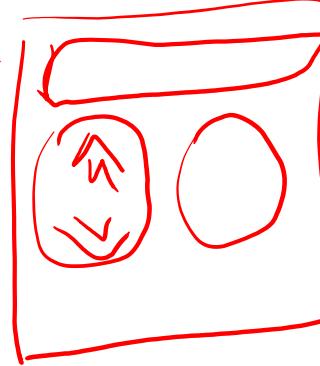
crashes

40 (9+) x (3+5)

injuries

Classic Design Flaw

Designing something that people don't understand or making something which is totally NEW & Expecting USERS to figure out
User's mental model is not the same as what was designed



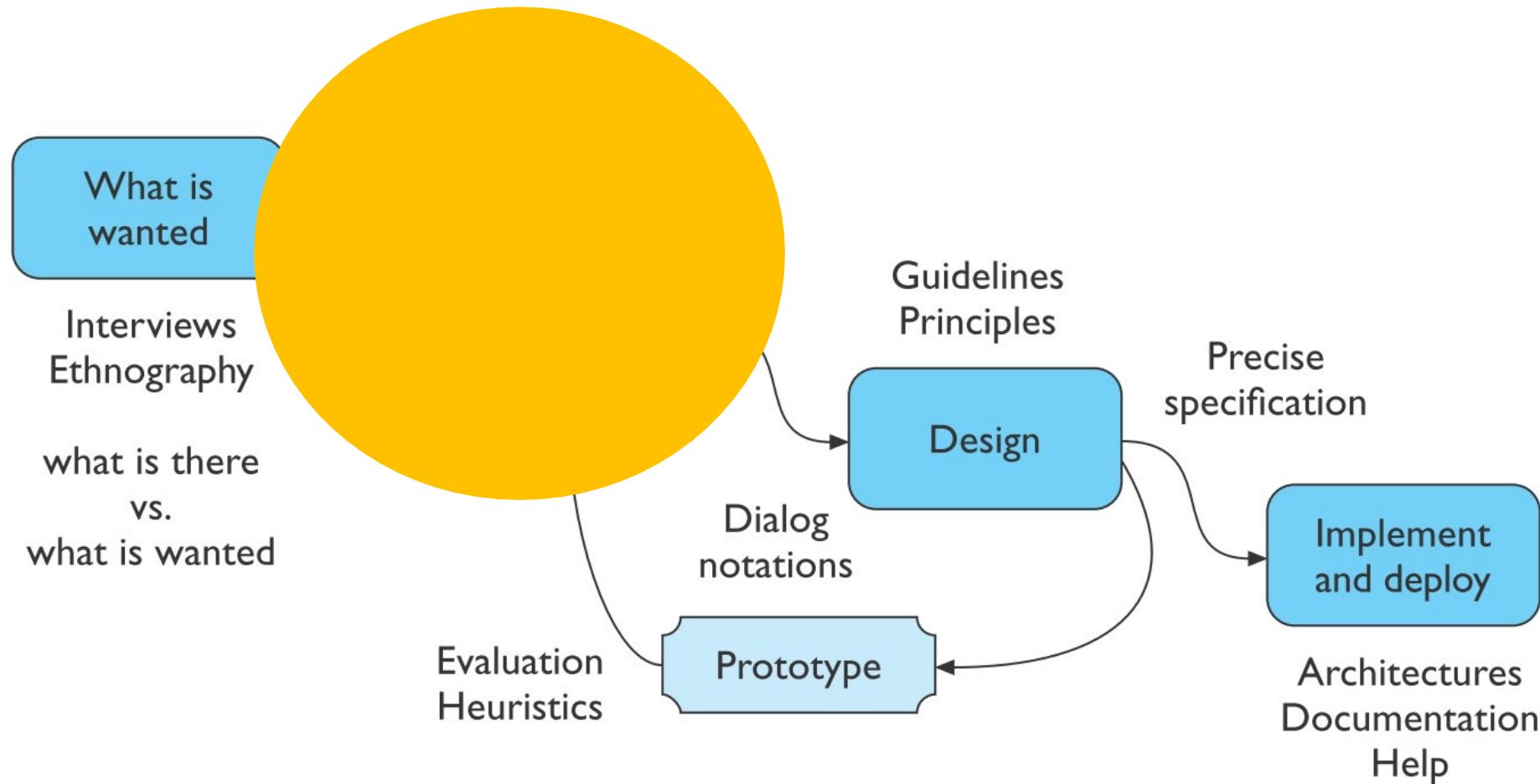
"(+ 100%)"

Task Analysis

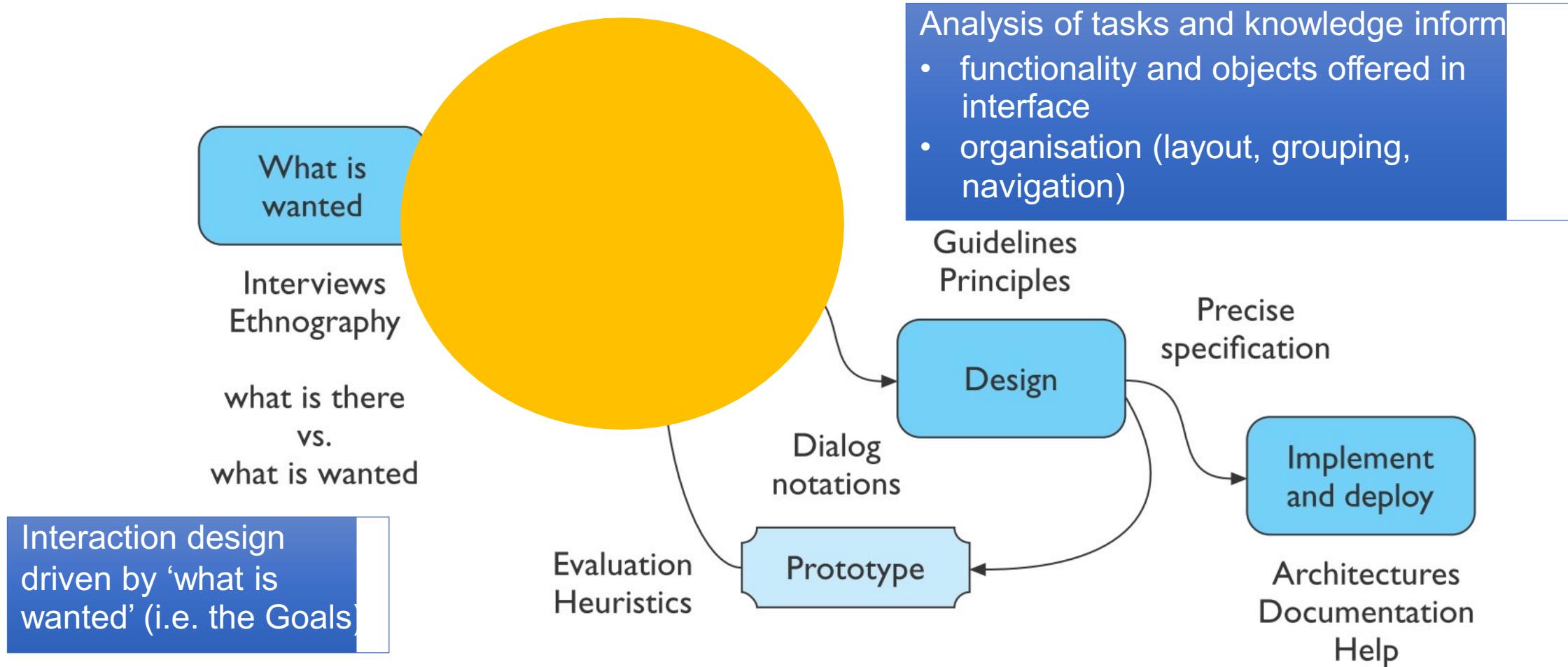
Summary

- Task Analysis
 - Purpose and structure
 - Goals, Tasks, Actions
- Hierarchical Task Analysis (HTA)
- Knowledge-based Analysis

Human-Centered Design Process



Human-Centered Design Process



Task Analysis

- Task Analysis is the study of the way people perform their jobs.
- Aim is to determine:
 - what they **do**
 - what things they **use**
 - what they must **know**

USER: 1. Clicks button labelled "Start"	SYSTEM RESPONSE: 2. Menu pops up
3. Clicks "shut down"	4. Greys screen and presents dialogue box describing shut down and offering "OK" "cancel" and "Help" options
5. Clicks "OK"	5. Screen blanks and "Please wait" message shown 6. Computer turns off

Example

- Task: to clean the house
 - get the vacuum cleaner out
 - fix the appropriate attachments
 - clean the rooms
 - when the dust bag gets full, empty it
 - put the vacuum cleaner and tools away
- Must **know** about:
 - vacuum cleaners, their attachments, dust bags,
 - cupboards, rooms etc.

Example

- For example, a person preparing an overhead projector for use would be seen to carry out the following actions :
 1. Plug in to main and switch on supply.
 2. Locate on/off switch on projector
 3. Discover which way to press the switch
 4. Press the switch for power
 5. Put on the slide and orientate correctly
 6. Align the projector on the screen
 7. Focus the slide

What is a Tasks?

- «A **task** is a **goal** together with some ordered set of **actions**.» (Benyon)

Goal

- A state of the application domain that a work system (user+technology) wishes to achieve
- Specified at particular levels of abstraction

Task

- A structured set of activities required, used, or believed to be necessary by an agent (human, machine) to achieve a goal using a particular technology
- The task is broken down into more and more detailed levels of description until it is defined in terms of actions

Action

- An action is a task that has no problem solving associated with it and which does not include any control structure
- Actions are ‘simple tasks’

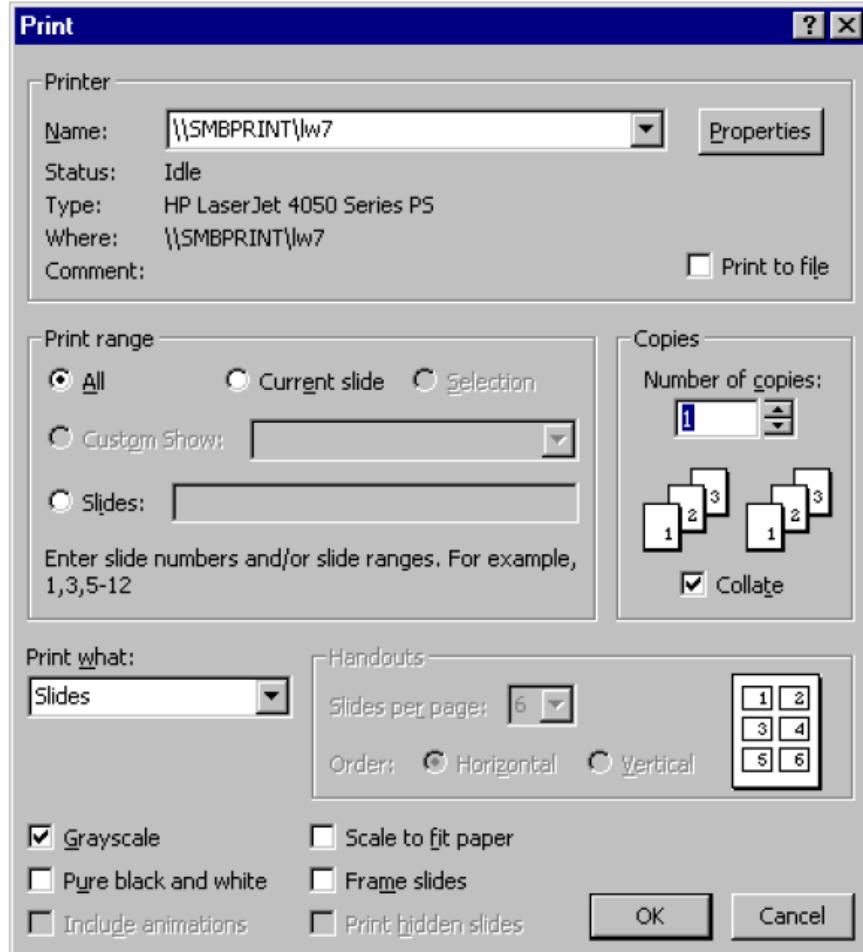
What you learn with Task Analysis

- What your users' goals are; what they are trying to achieve
- What users actually do to achieve those goals
- What experiences (personal, social, and cultural) users bring to the tasks
- How users are influenced by their physical environment
- How users' previous knowledge and experience influence:
 - How they think about their work
 - The workflow they follow to perform their tasks

Why is it useful?

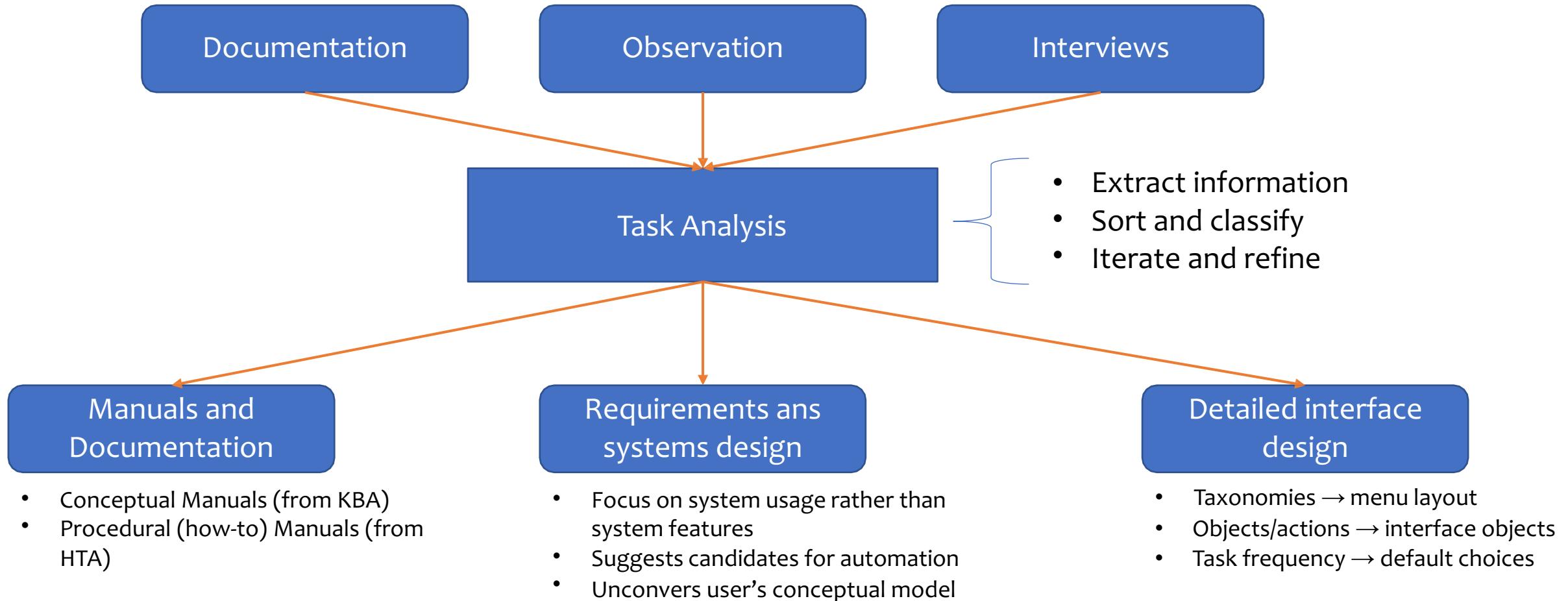
- Task analysis is the process of learning about ordinary users by observing them in action to understand in detail how they perform their **tasks** and achieve their intended **goals**.
- Tasks analysis helps in
 - Identifying the tasks that your website and applications **must support**
 - Refining or re-defining your site's **navigation** or **search**
 - Website requirements gathering
 - Developing your content strategy and **site structure**
 - **Wireframing** and **Prototyping**
 - Performing **usability testing**

Example



- Tasks are used to plan for the layout of the application window
- Proximity and Boundaries reflect the decomposition of tasks
- Order of tasks is not mandatory

Where it fits



[Some] Techniques for Analysis

- ▶ **Task decomposition** – Splitting tasks into sub-tasks and their ordering.
- ▶ **Knowledge-based techniques** – Any information and instructions that users need to know, and how that knowledge is organized
- ▶ **Entity-relationship-based analysis** – identify actors, objects, relationships and their actions
- ▶ **Ethnography** – Observation of users' behavior in the use context.
- ▶ **Protocol analysis** – Observation and documentation of actions of the user. This is achieved by authenticating the user's thinking. The user is made to think aloud so that the user's mental logic can be understood.

Hierarchical Task Analysis

Hierarchical Task Analysis (HTA)

- One possible method for Task Decomposition
- Hierarchical Task Analysis is the procedure of **disintegrating tasks into subtasks** that could be analyzed using the logical sequence for execution. This would help in achieving the goal in the best possible way.

"A hierarchy is an organization of elements that, according to prerequisite relationships, describes the path of experiences a learner must take to achieve any single behavior that appears higher in the hierarchy.
(Seels & Glasgow, 1990, p. 94)".

Example HTA: How to clean a house

0. in order to clean the house
 1. get the vacuum cleaner out
 2. fix the appropriate attachment
 3. clean the rooms
 - 3.1. clean the hall
 - 3.2. clean the living rooms
 - 3.3. clean the bedrooms
 4. empty the dust bag
 5. put the vacuum cleaner and attachments away

Plan 0: do 1 – 2 – 3 – 5 in that order.
when the dust bag gets full do 4

Plan 3: do any of 3.1, 3.2 or 3.3 in any order
depending on which rooms need cleaning

- A hierarchy of tasks and sub-tasks
 - Indentation and numbering denote the levels
- A set of plans describing in what order and under what conditions subtasks are performed
 - Plans are labeled by the task they describe

Notes

0. in order to clean the house
 1. get the vacuum cleaner out
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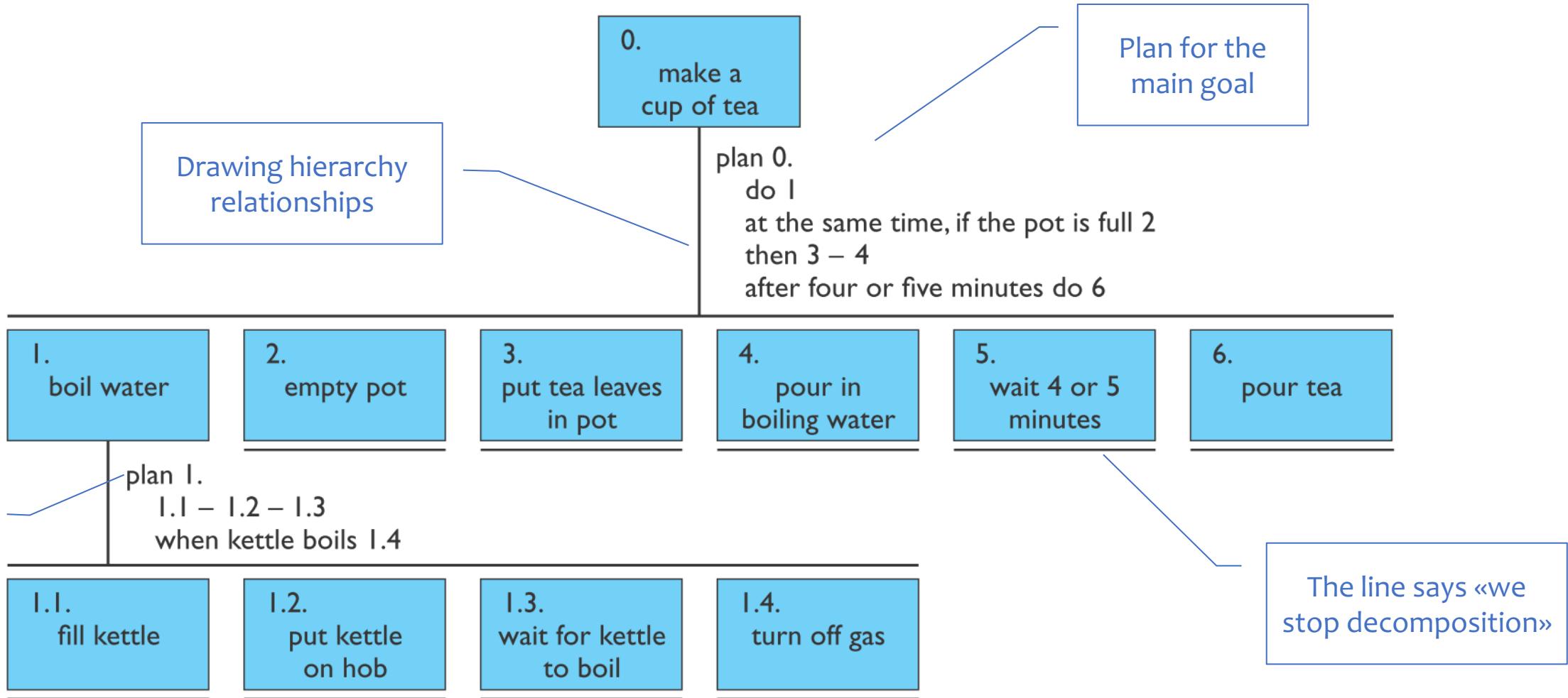
- Not all tasks are mandatory
 - E.g., task 4 is needed only if the bag is full.
- The order of operations may be free
 - E.g., the rooms may be cleaned in any order
- Could be further refined with additional knowledge or context
 - E.g., Plan 3: do 3.1 every day
3.2 once a week
when visitors are due 3.3

Expanding the hierarchy

- Each task is de-composed in sub-tasks, iteratively and recursively
 - Answer to the question: «what subtasks must be accomplished in order to perform the main task?»
 - The answer will come from direct observation, expert opinion, documentation, ...
- Procedural task knowledge elicitation techniques:
 - Observation, re-enactment
 - Ask about procedures and triggers (pre-conditions)
 - “What happens if X goes wrong?”
 - Sorting steps into appropriate orders

- When is this process stopped?
 - Depends on the intended usage of the HTA (design vs documentation vs troubleshooting vs ...)
 - Expand only **relevant** tasks
 - «Simple» tasks should be **obvious** to the users, and they should not contain hidden **risks** of failure
 - **Motor** actions are the lowest level (not always needed)

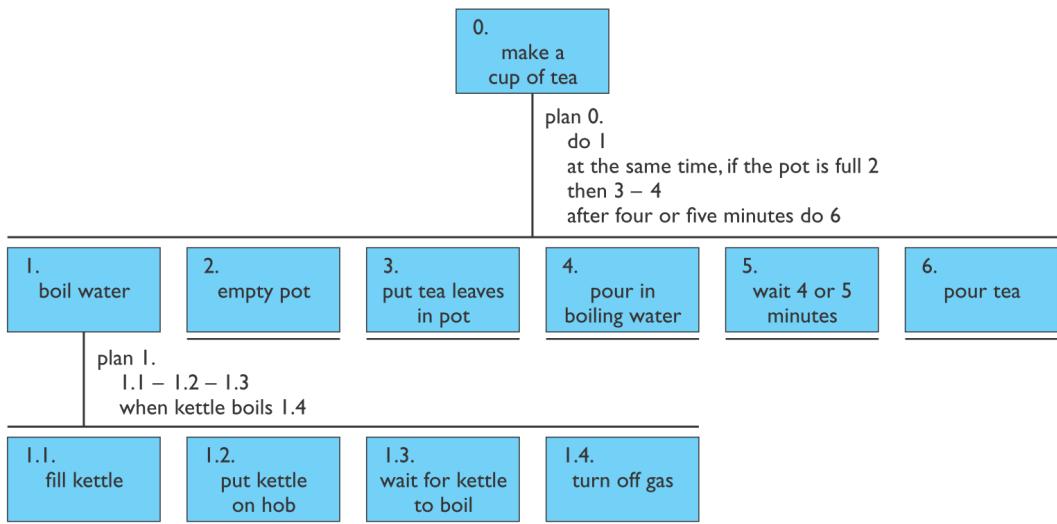
Example



Tasks as explanation

- Imagine asking the user the question:
 - **What are you doing now?**
- For the same action the answer may be:
 - typing ctrl-B
 - making a word bold
 - emphasising a word
 - editing a document
 - writing a letter
 - preparing a legal case

Refining the HTA



- Checking matched actions
 - Turn “off” without turning “on”?
- Restructuring
 - “Make pot” might be a meaningful task and group related actions
- Balancing complexity
 - Is “pour tea” simpler than “make pot”?
- Generalizing
 - If we want to make one or more cups?

References

- Alan Dix, Janet Finlay, Gregory Abowd, Russell Beale: Human Computer Interaction, 3rd Edition, Chapter 15 “Task Analysis”
- David Benyon: Designing Interactive Systems, Chapter 11 “Task Analysis”
- <http://www.usabilitybok.org/task-analysis>
- <https://www.usability.gov/how-to-and-tools/methods/task-analysis.html>

Acknowledgements

- Some icons from <https://icons8.com>
- Some material by
 - <http://www.inf.ed.ac.uk/teaching/courses/hci/0708/lecs/tasks.pdf>
 - https://www.tutorialspoint.com/human_computer_interface/design_processes_and_task_analysis.htm
 - <https://www.slideshare.net/alanjohndix/hci-3e-ch-15-task-analysis>



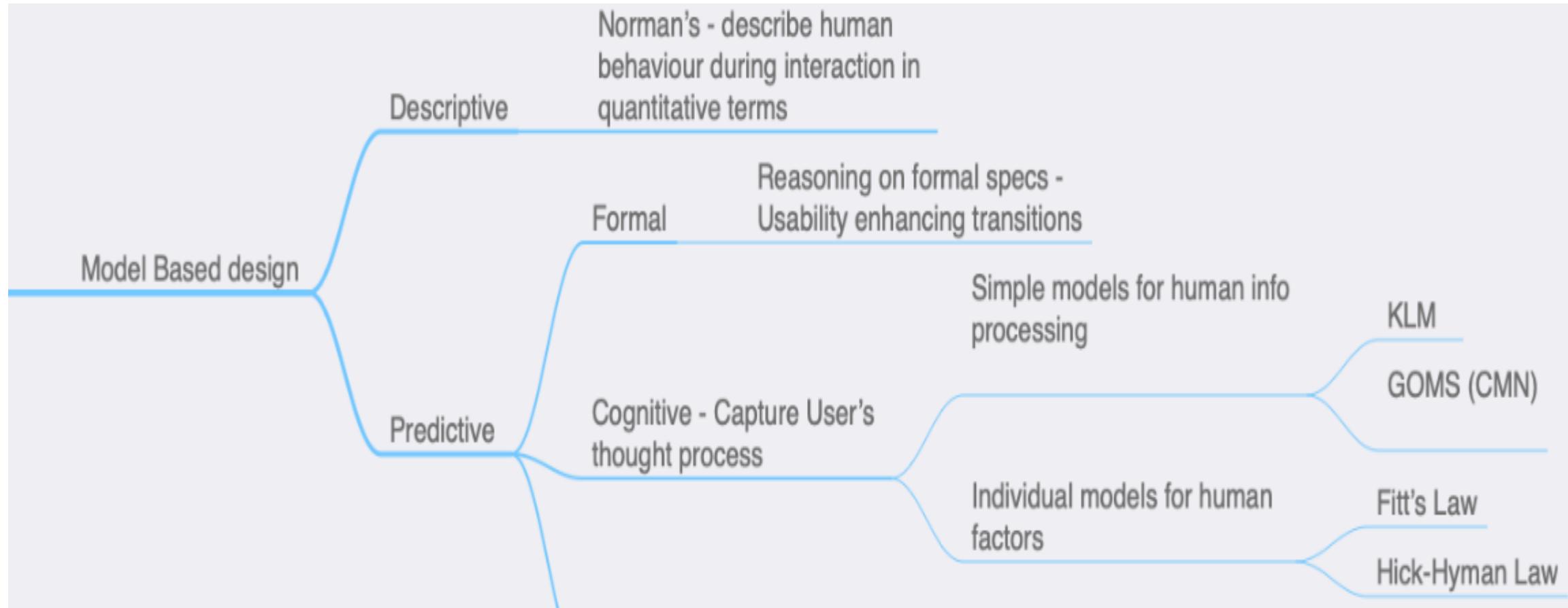
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Week 6-Lec 1

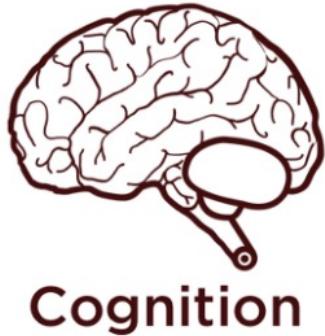
Human Information Processing(HIP) models

HIPs are used to understand and model how user interacts with an interface

Approaches to model cognition



Cognitive (User) models



Greater number of steps



Complex Cognitive activities

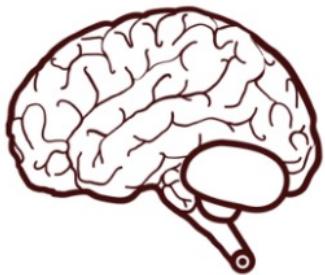
Higher complexity



Usability

Predict: how many cognitive steps required?

What do cognitive models actually model?



Cognition

Thinking



Perception



Touch



Sound

Perceiving the interface



Hand
movements

Keystroke Level Model (KLM)

- Predictive model
 - Time taken for avg user to execute through
 - Interface
 - Interaction method
 - Eg: close editor, save file, open document etc.,
- How it works?
 - Break down into simple steps
 - Operators
- How to use it?
 - Focus on task
 - Encode as sequence of steps
 - Calculate time
 - Using operators for each step
 - Sum all time values

Physical Motor Operators

Keystroke

Button press or release with mouse

Point with mouse

Draw line with mouse

Home hands between mouse and keyboard

Mental operator

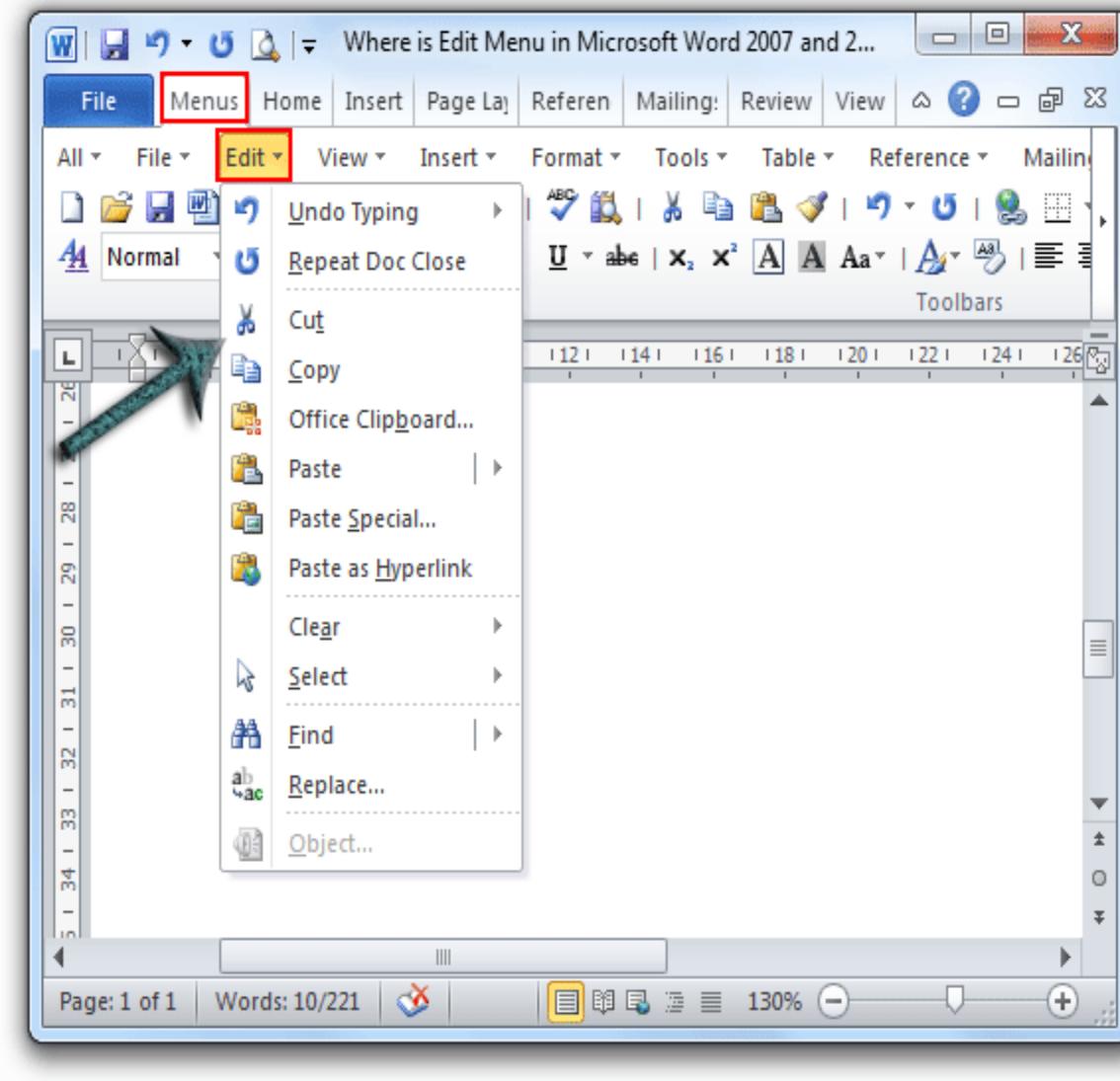
- Core thinking process (M)
- Decision making

Response operator

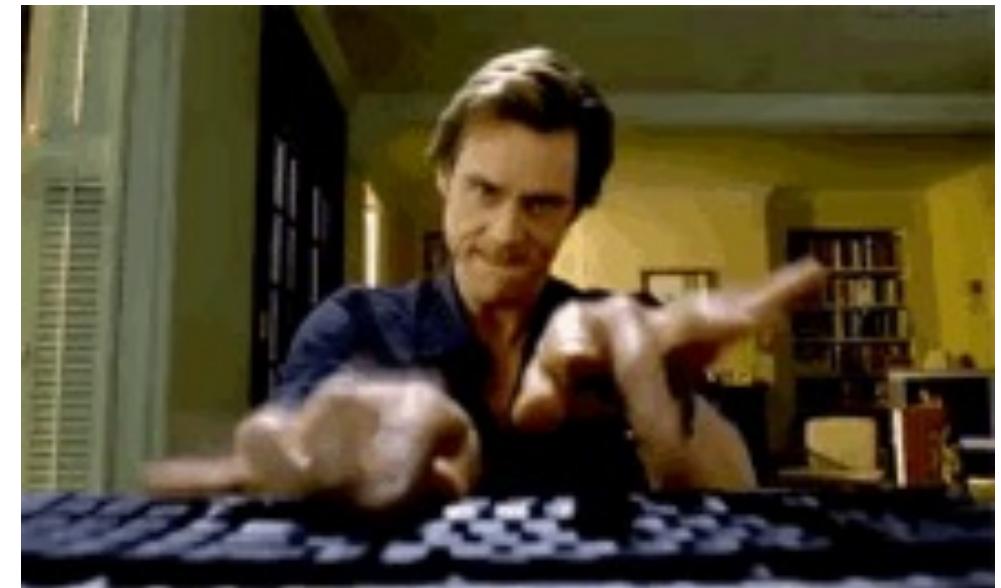
- Sys response time
 - Key press → output

How to use KLM

- Focus on task
 - Replace a word
 - Encode as sequence of steps
 - K, B, P, H, D (if any)
 - Mental operator time
 - Σ (Operator times)
 - Cognitive Task Analysis



Different styles of Keyboard typing



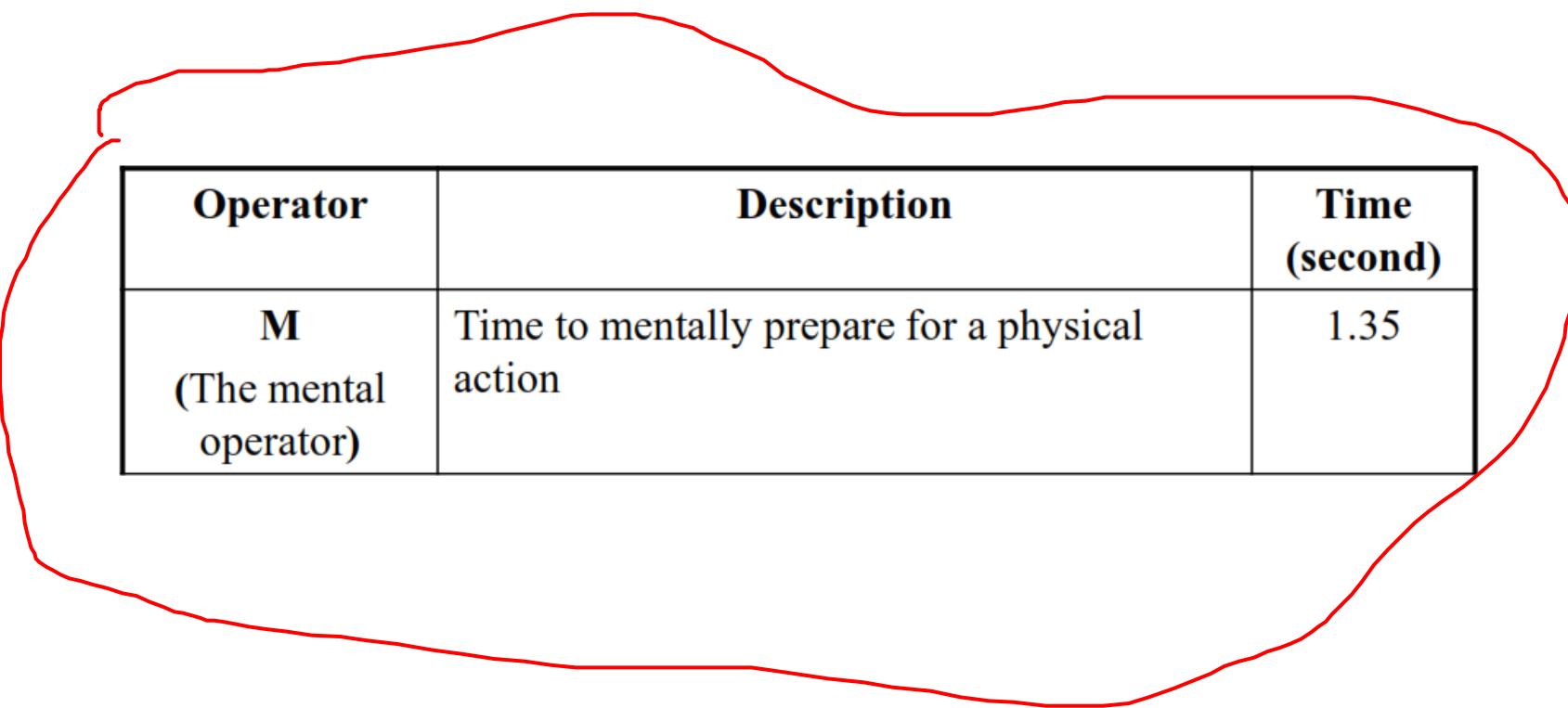
Avg Motor Operator times

Operator	Description	Time (second)
K (The key press operator)	Time to perform K for a good (expert) typist	0.12
	Time to perform K by a poor typist	0.28
	Time to perform K by a non-typist	1.20

Operator	Description	Time (second)
B (The mouse-button press/release operator)	Time to press or release a mouse-button	0.10
	Time to perform a mouse click (involving one press followed by one release)	$2 \times 0.10 = 0.20$

Operator	Description	Time (second)
P (The pointing operator)	Time to perform a pointing task with mouse	1.10
H (the homing operator)	Time to move hand from/to keyboard to/from mouse	0.40

Mental Operator time



Operator	Description	Time (second)
M (The mental operator)	Time to mentally prepare for a physical action	1.35

Example

Suppose a user is writing some text using a text editor program. At some instant, the user notices a single character error (i.e., a wrong character is typed) in the text. In order to rectify it, the user moves the cursor to the location of the character (using mouse), deletes the character and retypes the correct character. Afterwards, the user returns to the original typing position (by repositioning the cursor using mouse).

Calculate the time taken to perform this task (error rectification) following a KLM analysis.

Building KLM for the Task

- Step 1: user brings cursor to the error location
 - To carry out step 1, user moves mouse to the location and ‘clicks’ to place the cursor there
- Operator level task sequence

Description	Operator
Move hand to mouse	H
Point mouse to the location of the erroneous character	P
Place cursor at the pointed location with mouse click	BB

Building KLM for the Task

- Step 2: user deletes the erroneous character
 - Switches to keyboard (from mouse) and presses a key (say “Del” key)
- Operator level task sequence

Description	Operator
Return to keyboard	H
Press the “Del” key	K

Building KLM for the Task

- Step 3: user types the correct character
 - Presses the corresponding character key
- Operator level task sequence

Description	Operator
Press the correct character key	K

Building KLM for the Task

- Step 4: user returns to previous typing place
 - Moves hand to mouse (from keyboard), brings the mouse pointer to the previous point of typing and places the cursor there with mouse click
- Operator level task sequence

Description	Operator
Move hand to mouse	H
Point mouse to the previous point of typing	P
Place cursor at the pointed location with mouse click	BB

What Is missing ?

- What about M (mental operator) – where to place them in the list?