Review of key HCI concepts, theories, and models

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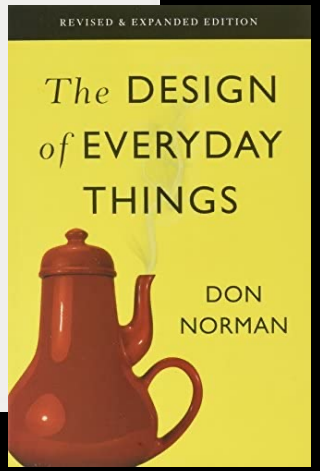
Interaction design

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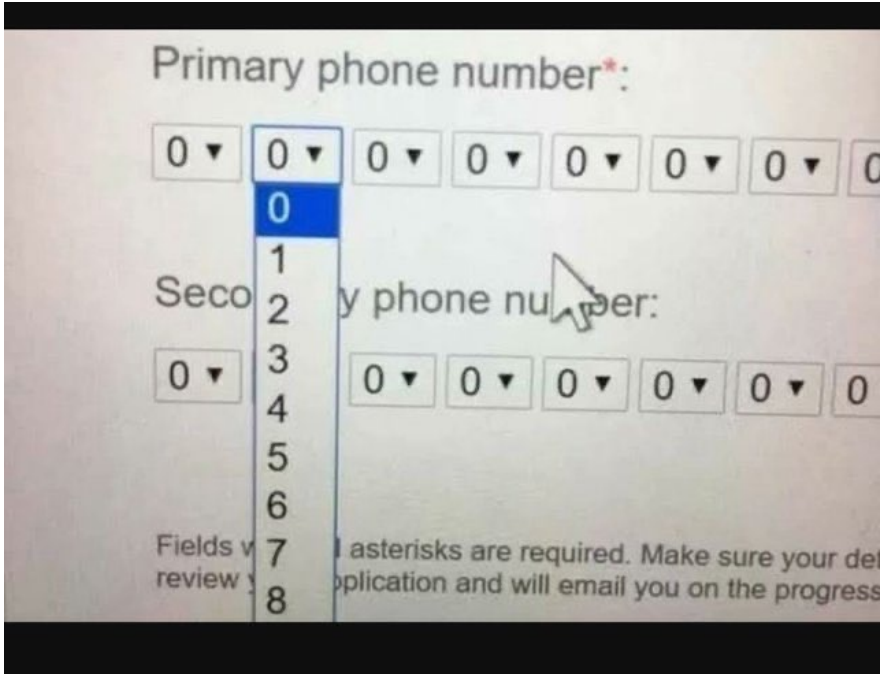
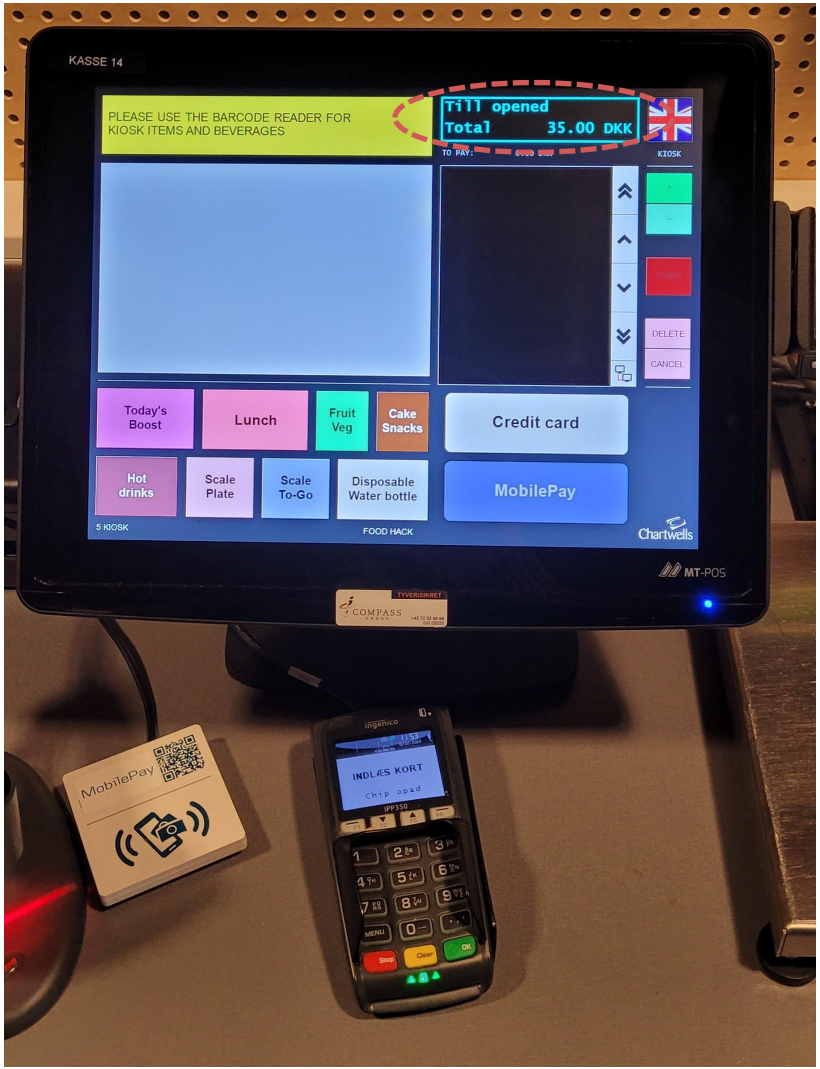
What we want to avoid





Interactive systems are all about user-system interactions

Interaction design

- Need to take into account:
  - ❖ Who the **users** are
  - ❖ What **activities** are being carried out
  - ❖ Where **interaction** is taking place
- Need to optimize the **interactions** users have with a **product**:
  - ❖ So that they match the users' activities and needs

Interaction design

*"**Designing** interactive **products** to support the way people communicate and interact in their everyday and working lives."*

Sharp, Rogers, and Preece (2019)

Interactive Systems Engineering

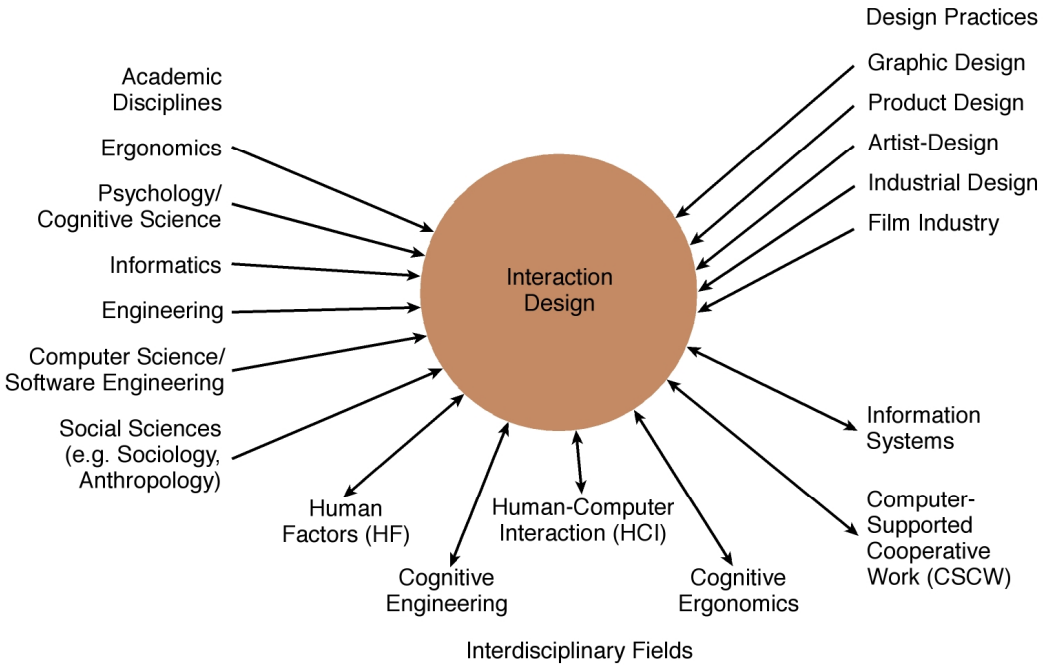
Engineering ***systems***

*"~~**Designing**~~ **interactive** ~~**products**~~ to support the way people communicate and interact in their everyday and working lives."*

Goals of interaction design

- Develop **usable ~~products~~ systems**
  - ❖ **Usability** means easy to learn, effective to use, and provides an enjoyable experience.
- Involve **users** in the design process.

Interaction design



Human-Computer Interaction (HCI) over time

Early 1980s

HCI: Narrow focus on the *design* and *usability* of **computing systems**.

2000s

Interaction Design: Broader focus, concerned with *desigining* **user experiences** for all manner of technologies, systems, and products.

Nowadays

HCI: Far-reaching, *"from helping save the planet to encouraging world peace"* (Rogers, 2012).

3-wave HCI

- **First wave:** Framing design for the user at a **desktop primarily in an office setting**.
- **Second wave:** Broadening to include **group working**, **situated and social action**, and **participatory design**.
- **Third wave:** Expanding further into quite **new use contexts and application types**, that emphasize non-work, non-spaces and non-purposeful engagements, and where **notions of culture, emotion, reflexivity and multiple mediation** have entered center stage**.**

Important concepts

The user experience (UX)

- How a product behaves and is used by people in the real world:
  - The way people **feel** about it and their **pleasure** and **satisfaction** when using it, looking at it, holding it, and opening or closing it.
  - *"Every product that is used by someone has a user experience: newspapers, ketchup bottles, reclining armchairs, cardigan sweaters."* (Garrett, 2010)
  - *"All aspects of the end-user's interaction with the company, its services, and its products."* (Nielsen and Norman, 2014)
- One cannot design a user experience − can only design ***for*** a user experience.

Defining user experience

*"How users perceive a product, such as whether a smartwatch is seen as sleek or chunky, and their **emotional** reaction to it, such as whether people have a **positive** **experience** when using it."*
(Hornbæk and Hertzum, 2017)

- Hassenzahl's (2010) model of the **user experience**:
  - **Pragmatic**: how simple, practical, and obvious it is for the user to achieve their goals.
  - **Hedonic**: how evocative and stimulating the interaction is to users.

Core characteristics of interaction design

- **Users** should be **involved** throughout the development of the project.
- Specific **usability and user experience goals** need to be identified, clearly documented, and agreed to at the beginning of the project.
- **Iteration** is needed through the core activities.

Why?

- Help designers:
  - ❖ Understand how to design interactive products that fit with **what people want**, **need**, and may **desire**.
  - ❖ Appreciate that **one size does not fit all** (for example, teenagers are very different to grown-ups).
  - ❖ **Identify any incorrect assumptions** they may have about particular user groups (for example, not all old people want or need big fonts).
  - ❖ Be aware of both **people's sensitivities** and their **capabilities**.

Usability goals

- Effective to use
- Efficient to use
- Safe to use
- Have good utility
- Easy to learn
- Easy to remember how to use

User experience goals

- **Desirable** aspects:

Satisfying	Engaging	Exciting
Helpful	Challenging	Supporting creativity
Fun	Surprising	Emotionally fulfilling
Enjoyable	Pleasurable	Entertaining
Motivating	Enhancing sociability	Cognitively stimulating
Provocative	Rewarding	Experiencing flow

- **Undesirable** aspects:

Boring	Making one feel guilty	Childish
Unpleasant	Making one feel stupid	Gimmicky
Frustrating	Annoying	
Patronizing	Cutesy	

Usability and user experience goals

- Selecting terms to convey a person's feelings, emotions, and so forth can help designers understand the **multifaceted nature of the user experience**.
- How do usability goals differ from user experience goals?
- Are there trade-offs between the two kinds of goals? (for example, *can a product be both fun and safe?*)
- How easy is it to measure usability versus user experience goals?

Design principles

- Generalizable **abstractions** for thinking about different aspects of design.
- The **do's and don'ts** of interaction design.
- What to provide and what not to provide at the interface.
- Derived from a mix of theory-based knowledge, experience, and common-sense.

Design principles

1. **Visibility**: the more visible functions are, the more likely it is that users will be able to know what to do next.
2. **Feedback**: sending information back to the user about what has been done. Includes sound, highlighting, animation, and combinations of these.
3. **Constraints**: restricting the possible actions that can be performed. It helps prevent users from selecting incorrect options.
4. **Consistency**: design interfaces to have similar operations and use similar elements for similar tasks. Consistent interfaces are easier to learn and use.

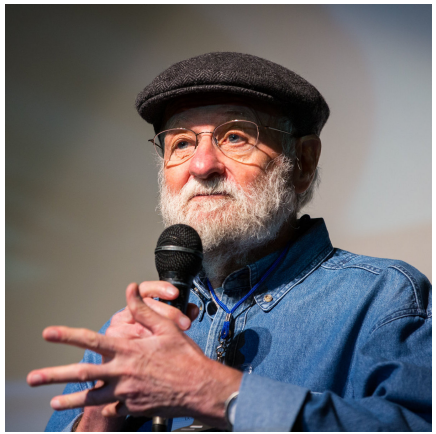
5. Affordances

- Refers to an attribute of an object that allows people to **know how to use it**. (For example, a mouse button invites pushing, a door handle affords pulling).
- Norman (1988) used the term to discuss the design of everyday objects.
- Has since been popularized in interaction design to discuss how to design interface objects (for example, scrollbars to enable moving up and down; icons to click on).

Affordances

*“An **affordance** is a relationship between the properties of an object and the capabilities of the agent that determine just how the object could possibly be used.”*

Dan Norman (1988)



What does “affordance” have to offer interaction design?

- Interfaces are *virtual* and **do not** have affordances like physical objects.
- Norman argues that it does not make sense to talk about interfaces in terms of ‘real’ affordances.
- Instead, interfaces are better conceptualized as ‘**perceived**’ **affordances**:
  - ❖ Learned conventions of arbitrary mappings between action and effect at the interface.
  - ❖ Some mappings are better than others.

Paradigms, theory, models and frameworks

Paradigm

- A paradigm provides a **set of practices** that a community has agreed upon (Rogers et al., 2011). These include:
  - ❖ questions to be asked and how they should be framed;
  - ❖ phenomena to be observed;
  - ❖ how findings from studies are to be analyzed and interpreted.

Examples of paradigms in HCI

- Windows, Icons, Menus and Pointer (WIMP)
- Graphical User Interfaces (GUIs)
- Ubiquitous Computing
- Wearable Computing
- Internet of Things (IoT)
- …

Theory

- **Explanation** of a phenomenon.
  - ❖ For example, information processing that explains how the mind, or some aspect of it, is assumed to work.
- Can help **identify factors** relevant to the design and evaluation of interactive products .
  - ❖ Such as cognitive, social, and affective.
- Can be used to **predict** what users will do with different interfaces.

Models

- A **simplification** of an HCI phenomenon.
- Enables designers to **predict and evaluate** alternative designs.
- **Abstracted from a theory** coming from a contributing discipline, for example:
  - ❖ Don Norman's (1996) model of the Seven Stages of Action.
  - ❖ Marc Hassenzahl's (2010) model of the user experience.

Frameworks

- Set of interrelated concepts and/or specific questions for '**what to look for**'.
- Provide **advice** on how to design user experiences:
  - ❖ Helping designers think about how to conceptualize learning, working, socializing, fun, and emotion.
- Focus on **how to** design particular kinds of interfaces to evoke certain responses.
- Come in various forms:
  - ❖ Such as steps, questions, concepts, challenges, principles, tactics, and dimensions.

The role of theory in HCI

“Theories demonstrate what humans are good and bad at and, based on this knowledge, can inform the design of technologies that both extend human capabilities and compensate for their weaknesses.”
(Rogers, 2012)

Most important theories imported to HCI

- **Cognitive theories** about human memory:
  - Have informed the **design of interface elements**, such as icons, command names and the location of menu items, to make them easy to remember.
- **Social psychology** theories:
  - Have informed the **design of social experiments** which investigate how people communicate and work together in groups when using computer-based collaborative tools and social media.
- **Organizational** theories:
  - Have been developed in CSCW to systematically **conceptualize how** people interact and process information, make decisions, behave towards others and operate in their work and other social settings.

Cognitive engineering

Example: Fitt's Law

- Used to predict the **best placement** of buttons and keys on mobile devices and elements on a GUI.
- **Objective**: reducing error rate based on the observation of how users aim for targets using their fingers or pointing devices.
- Fast movements and small targets result in **greater error rates**, due to the speed-accuracy trade-off.

Example: Recognition is better than recall!

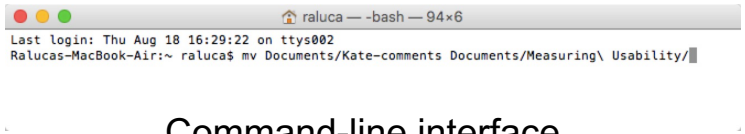
- People find it easier to **recognize** things shown to them than to have to recall them from memory.
- Most graphical interfaces have been designed to provide visual ways of presenting information, that **enable the user to scan and recognize an item** like a command, rather than require them to recall what command to issue next at the interface.

Example: “7+−2”

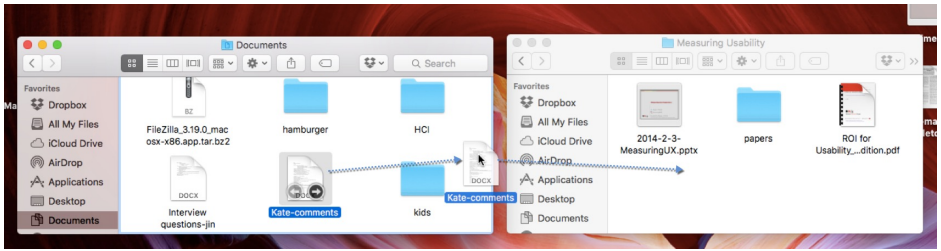
- George Miller’s theory about memory.
- Only “7+−2” **chunks of information**, such as words or numbers, can ever be held in short-term memory at any one time.
- GUIs are designed to comply with this rule.
- Has been **misused**:
  - ❖ No more than “7+−2” of a category (e.g., number of colors, number of icons on a menu bar, number of tabs at the top of a web page, and number of bullets in list).

Cognitive Modeling

- Shneiderman's (1983) framework of **direct manipulation** (DM):
  - ❖ Unlike in command-line interfaces, DM is an interaction style in which users act on **displayed objects** of interest using **physical**, **incremental**, **reversible actions** whose effects are **immediately** visible on the screen.



Command-line interface



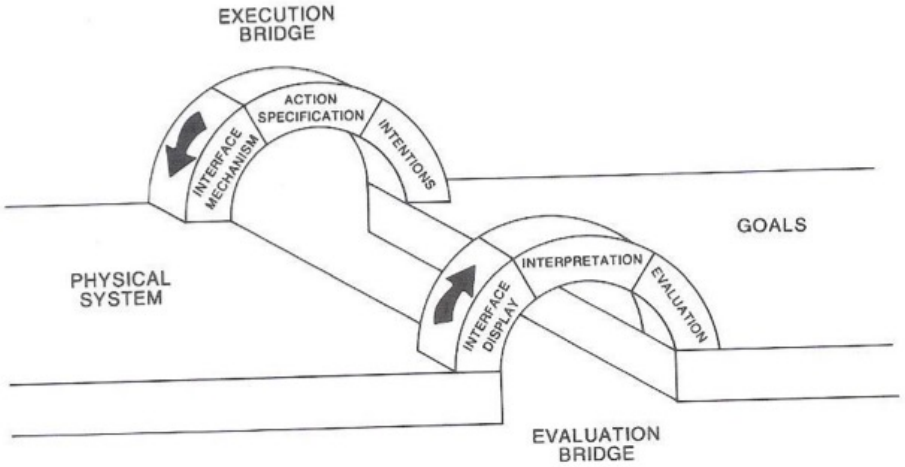
Direct manipulation

Source: nngroup.com/articles/direct-manipulation/

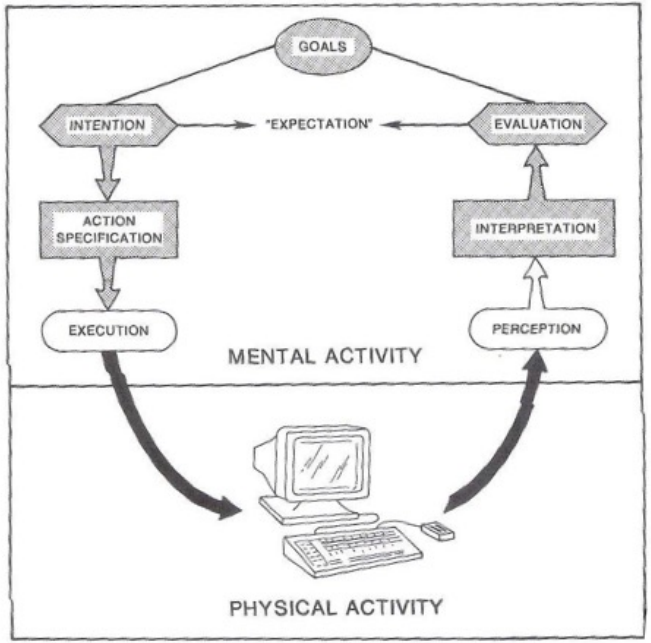
Cognitive Modeling

- Hutchins et al.’s (1986) **conceptual framework of directness**:
  - ❖ Describes the gap between the **user’s goals** and the way a system works in terms of **gulfs of execution and evaluation**.
- Norman’s (1986) **theory of action**:
  - ❖ Models the **putative mental and physical stages** involved in carrying out an action when using a system.

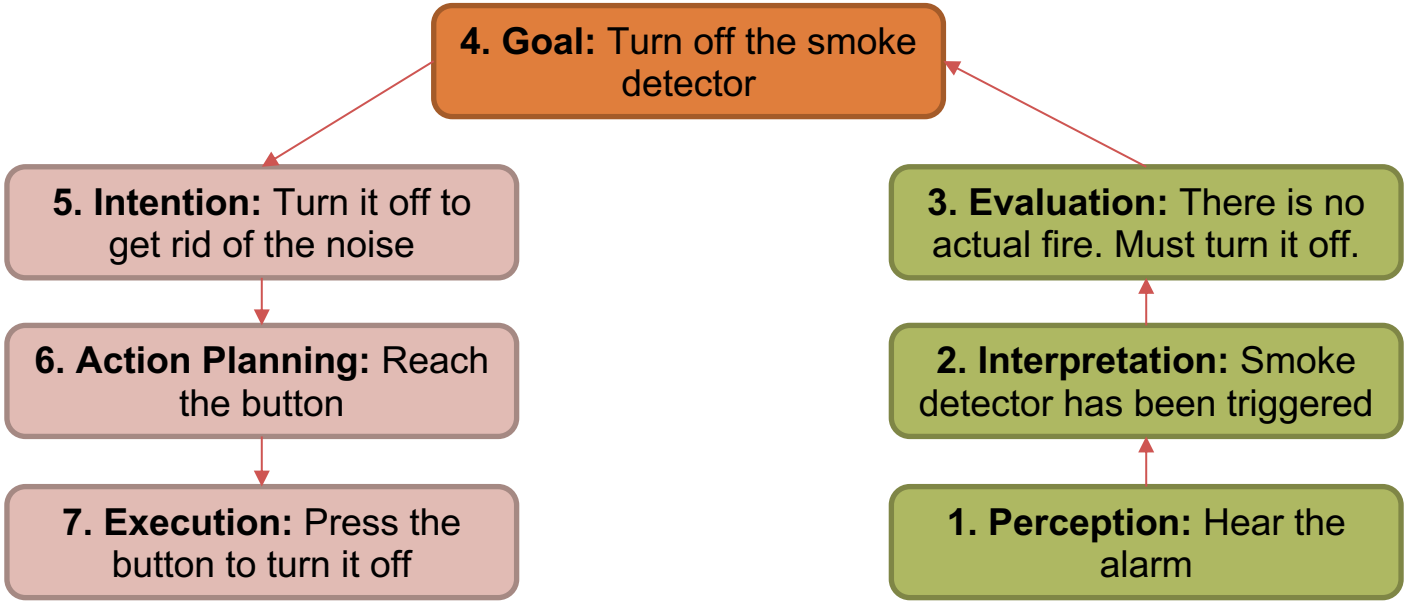
Interface Gulfs



Norman’s model of the Seven Stages of Action



Example: Smoke detector triggered

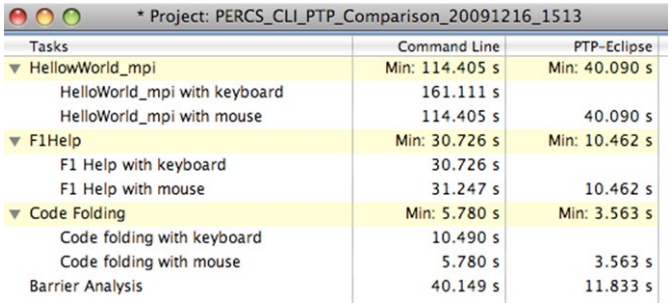


Interface Gulfs

- Designers and users need to concern themselves with how to **bridge the gulfs** in order to **reduce the cognitive effort required to perform a task**.
- This could be achieved:
  i. by designing **usable interfaces that match the psychological characteristics of the user**, e.g., taking into account their memory limitations (**system adapted to the user**);
  ii. by the **user** learning to create goals, plans and action sequences that **fit with how the interface works** (**user adapted to the system**).

The Model Human Processor

- Card et al.'s (1983) cognitive model of the user.
- **Quantitative predictions** about **user performance**.
- GOMS (Goals, Operators, Methods and Selection).
- CogTool (Teo and John, 2008):
  - ❖ Enables non-psychologists to create **cognitive models of user tasks** from which reliable **estimates of skilled user task times** can be derived.



Tasks	Command Line	PTP-Eclipse
HellowWorld_mpi	Min: 114.405 s	Min: 40.090 s
HelloWorld_mpi with keyboard	161.111 s	
HelloWorld_mpi with mouse	114.405 s	40.090 s
F1Help	Min: 30.726 s	Min: 10.462 s
F1 Help with keyboard	30.726 s	
F1 Help with mouse	31.247 s	10.462 s
Code Folding	Min: 5.780 s	Min: 3.563 s
Code folding with keyboard	10.490 s	
Code folding with mouse	5.780 s	3.563 s
Barrier Analysis	40.149 s	11.833 s

Source: Bonnie E. John, "CogTool: A tool for interface design and ACT-R research"

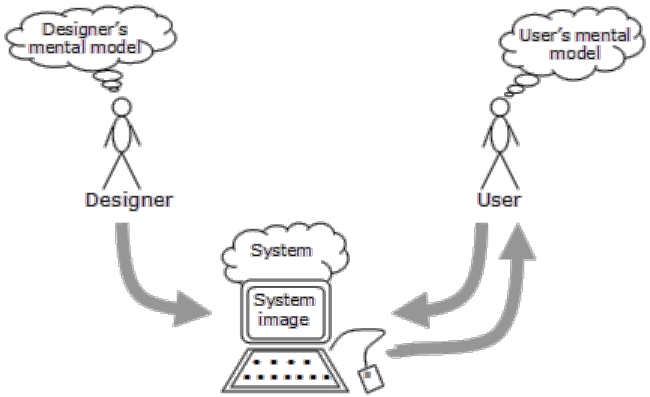
Mental Models

- Characterizing the **knowledge that people are assumed to have** when interacting with a system.
  - ❖ How that enables them to understand how a system works and to know what to do next.
- Norman (1983) argues that people's mental models are often incomplete, easily confusable, based on inappropriate analogies and superstition.
- Ideally, users should be able to develop a mental model that **matched the designer's conceptual model of how they had envisioned the system working** (=> **semiotic engineering**).

A classic HCI framework

- Don Norman's (1988) framework of the relationship between the design of a conceptual model and a user's understanding of it.
- Consists of three interacting components:
  - **The Designer's Model**
    - The model the designer has of how the system should work.
  - **System Image**
    - How the system actually works, which is portrayed to the user through the interface, manuals, help facilities, and so on.
  - **The User's Model**
    - How the user understands how the system works.

Don Norman's (1988) framework



- **Challenge**: ensuring that the user's mental model corresponds to the designer's model.
  - The designer **does not** talk directly with the user.
  - The designer **can only** talk to the user through the "**system image**" (the designer's materialised mental model). The system image is, like a text, open to interpretation.

One of the problems with cognitive engineering

- In cognitive engineering, the agent of all seven actions defined for traversing the execution and evaluation gulfs (Norman's model) is the ***user***.
- Cognitive engineering theory does not account for what ***designers*** are doing, why, and how.
- The theory can only be used to **verify if** or **explain why** certain design choices lead to "an appropriate system image" (Norman, 1986).
- The theory itself **cannot directly** describe and explain the process of **generating** such choices, because the cognitive engineering model of HCI is only about the ***users' actions*** - **not the designers'**.

Other problems with cognitive engineering

- Cognitive theories focus on the individual.
- The cognition that happens during human-computer interaction is **much more messy**:
  - ❖ Many interdependent processes are involved for any given activity:
    - ➢ People rarely perform a task **in isolation**.
    - ➢ They are **constantly interrupted or interrupt** their own activities, by talking to others, taking breaks, starting new activities, resuming others, and so on.
  - ❖ The **context of use** and **external resources and representations** play an important role on the usability of different interfaces.

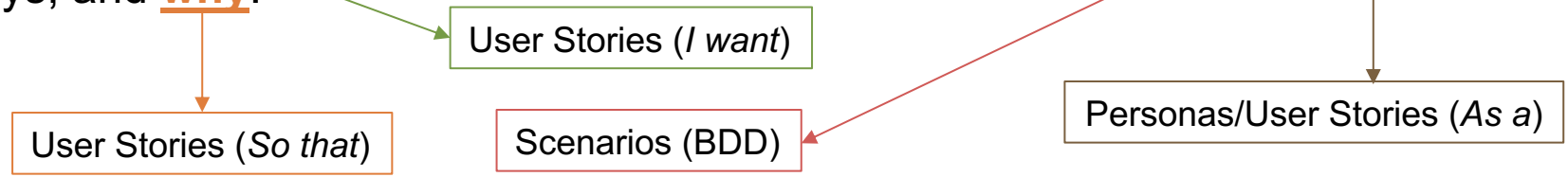
An alternative: Semiotic engineering

Semiotic theory of HCI (de Souza, 2005)

- Based on Eco's *Theory of Semiotics* (Eco, 1976).
- Views HCI as **computer-mediated communication between designers and users at interaction time**.
- The system **speaks** for its designers in various types of **conversations** specified **at design time**.
- These conversations **communicate** the designers' understanding of **who** the users are, **what** they know the users want or need to do, in **which** preferred ways, and **why**.
- *Communication about communication*, or **metacommunication**.

Semiotic theory of HCI (de Souza, 2005)

- These conversations **communicate** the designers' understanding of **who** the users are, **what** they know the users want or need to do, in **which** preferred ways, and **why**.



Metacommunication Template

- Designers *talk* to the users in **first person**:

*"Here is **my** understanding of **who** you are, **what** **I**'ve learned you want or need to do, in **which** preferred ways, and **why**. This is the system that **I** have therefore designed for you, and this is the way you can or should use it in order to fulfill a range of purposes that fall within this vision."*

Metacommunication

- The foundational distinction proposed by the theory is that HCI **is not** about *how users interact with computers*, but rather about **how users communicate with computer system designers and developers through their proxy at interaction time** (the *designers' deputy*).
- The system's interface **mediates** the designer–user communication process.
- This communication **is not** natural. It's replaced with **signs** like interface buttons, menus, images, sounds, used in combination with various sorts of input/output (I/O) devices.

Metacommunication

- Metacommunication happens **regardless of** the designers' or the users' **degree of awareness** that they are actually communicating with each other through computer systems interfaces.
- A system is then designed and evaluated in regard to its **communicability**, i.e., how well the designers' message is communicated to the user through the system's interface.
- Methods to **evaluate the quality of metacommunication** in HCI:
  - ❖ Semiotic inspection method (SIM)
  - ❖ Communicability evaluation method (CEM)

Signs

- Semiotic engineering relies on **sign production** and **sign interpretation** in computer-mediated communication.
- Unlike in natural face-to-face conversations, computer-mediated conversations require that HCI designers have a very broad view of the **conversational context** and that they ***anticipate all conversational turns*** that are necessary for smooth interaction.
- According to semiotic engineering, this *anticipation and subsequent encoding of solutions and possibilities* in various sorts of **computational interface signs** is what HCI design is about.

Signs: consequences

1. Along the process of metacommunication, human signification is **narrowed down** to computational symbol processing.
   - ❖ Challenge: **simplification**. How to accurately represent complex human signification into a limited set of signs?
2. Although human meanings cannot be strictly predicted or fully inspected because they are constantly evolving, **computer meanings can**.
   - ❖ Computer meanings are limited to what has been pre-programmed.

In-Depth Activity

- **In groups**: Find an interactive system (webpage, game, mobile app, etc.) and examine how it has been designed, paying particular attention to how the user is meant to interact with it.
  1) From your first impressions, write down what is **good and bad** about the way the device works.
  2) Give a **description of the user experience** resulting from interacting with it.
  3) Outline some of the core **micro-interactions** that are supported by it. Are they pleasurable, easy, and obvious?
  4) Based on what you've learned, compile a set of **usability and user experience goals** that you think will be most relevant in evaluating this system. Decide which are the most important ones and explain why.
  5) Reflect about whether (and how) the **design principles** have been applied to this system, and how this resonates with the HCI **theories, frameworks, and models**.
  6) Finally, discuss possible **improvements** to the interface based on what you've discussed.

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