# User Interfaces

**EECS 3461 – Sections A & B**
**Fall 2021**

Resource Pack: Interaction II
Evaluation and Testing

# Intellectual Property Notice

# Dependencies

This resource pack assumes that you are already familiar with:

- R-Humans-I

- R-Design-V (and all previous)

- R-Interaction I

# Inquiry

Break down this resource pack into smaller pieces

1. What is meant by *evaluation*?

2. Recap of the position of evaluation in the design process.

3. What is heuristic evaluation?

4. How do we evaluate *usefulness*?

5. What is meant by an *affordance*?

6. What is *usability* and how do we evaluate it?

1. What is meant by *evaluation*?

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For instance…
- design outcomes (e.g., the interactive system, the user experience)
- knowledge outcomes (e.g., research results)
- educational design outcomes (e.g., course designs, assessment activities)
- social interventions (e.g., public health campaigns)
- …

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- critical analyses (e.g., applying sociological and other concepts in a line of argumentation)
- empirical, quantitative approaches (e.g., scientific experiments)
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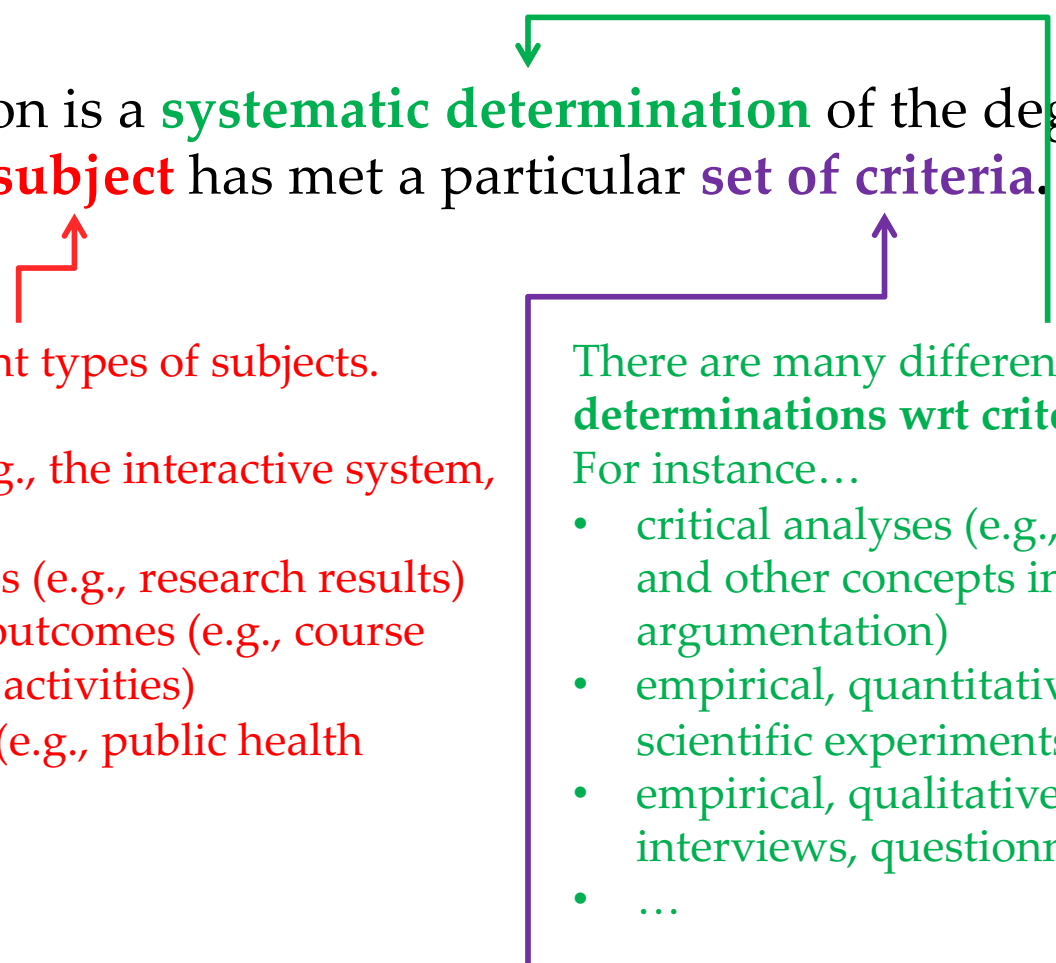There are many different systems for **making determinations wrt criteria.** For instance…
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There are different types of criteria… and operationalized concepts

# Criteria for Abstract Concepts

- much of what we want to study concerns **abstract concepts** that are not directly measurable

- Examples:
  - the concept of an interactive system being effective, efficient, safe, having utility, learnable, having memorability
  - the concept of user experience being pleasant, fun, inspirational, …
  - the concept of an interactive system being useful, helpful, providing value, perpetuating marginalization, …
  - the concept of an interactive system being market dominant, being an instrument of a regime, being a vehicle for propoganda

# Abstract Concepts, Measurability

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# The Micro, Meso, and Macro Levels

Sociologists investigate and understand human interaction at these different analytical levels:

- micro-level: looking at the interactions of an individual in their social setting

- meso-level: looking at the interactions within a group setting (e.g., workplaces, clubs, communities)

- macro-level: looking at the effects and traces of interaction at the scale of a large population, such as a nation or globally

# What is meant by *operationalize*?

- *operationalize* means to express or define an abstract concept in terms of the operations used to determine it

- operationalization is a concept in research design (among other domains)

- we operationalize **abstract concepts** that are not directly measurable (and the concept becomes defined in terms of how it is measured)

- *the core concepts and their operationalizations vary among different research and design teams, there are different approaches*

# Example of *operationalization*

- for instance…

- the concept of *efficiency* may be the operationalized as number of operations required to complete a particular task
    - recall: motivations $\rightarrow$ goals $\rightarrow$ activities $\rightarrow$ tasks $\rightarrow$ operations
    - e.g., in a word processor, the number of keystrokes required to search and replace all instances of a string

- if efficiency gets operationalized in this way, and if efficiency is important in the design domain, then this impacts the criteria for evaluation
    - e.g., "number of operations per task" gets used as an outcome measure, it becomes a criterion in evaluation

2. What is the position of evaluation in the design process?

# Four Core Activities

the output of one activity generally feeds into the next activity

Research (Observing/Establishing requirements)

Generating Ideas/Designing alternatives

Prototyping

Evaluating/Testing
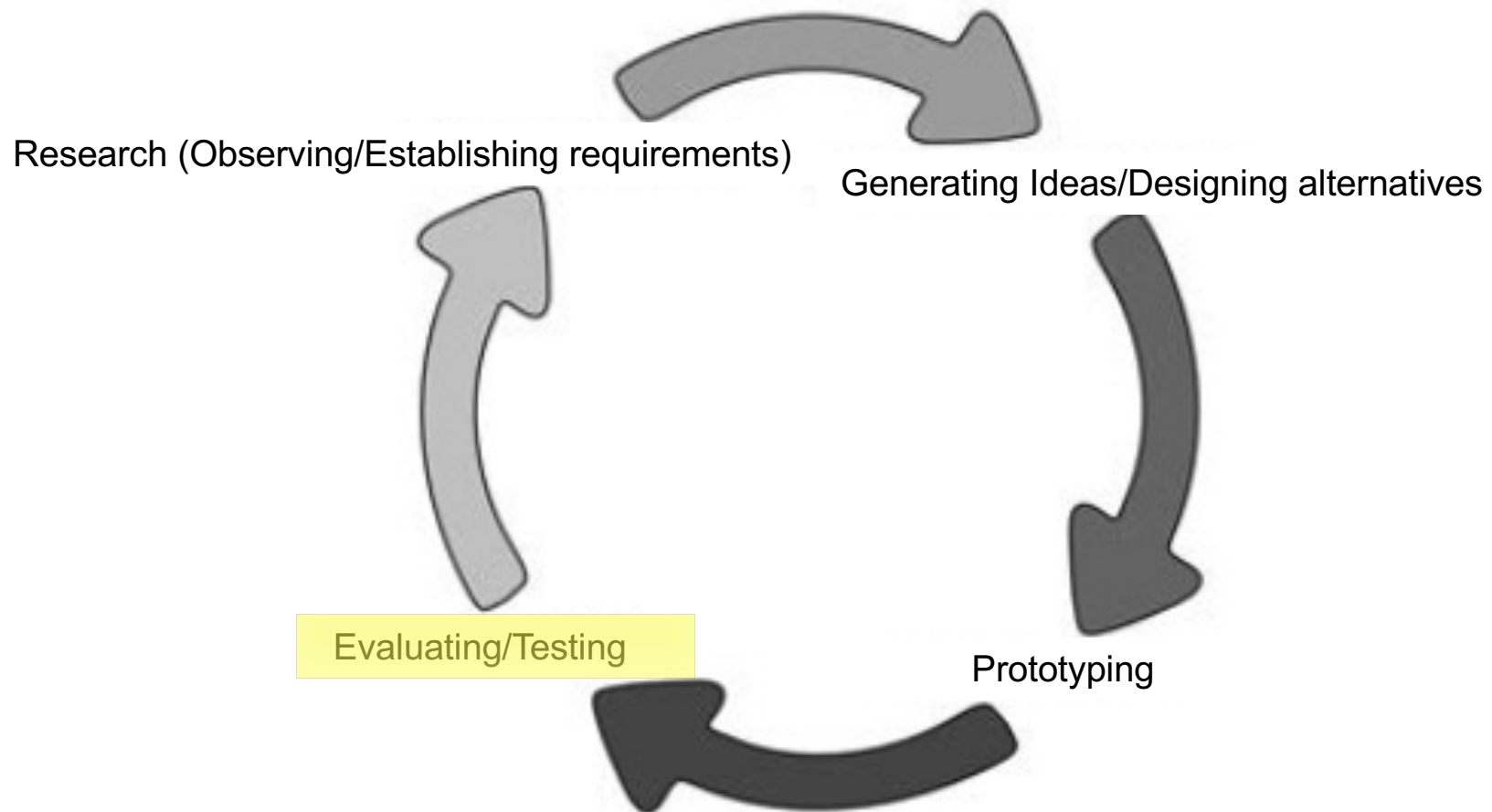
# The Double Diamond design process model
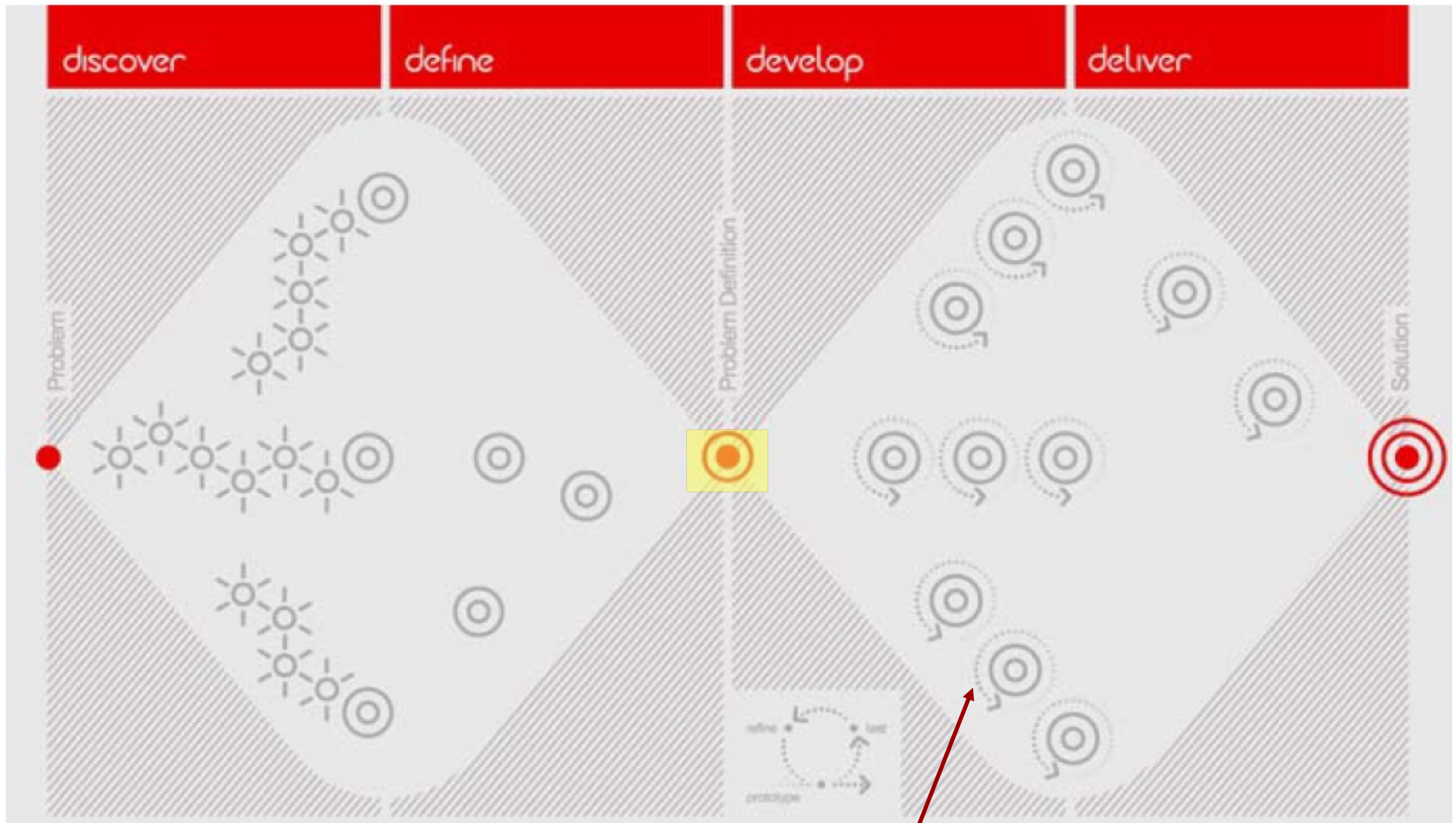


successive iterations of core activities

# Position of Evaluation in the Design Process

- Evaluation is one of the four core activities in the design process

- It is an activity carried out repeatedly (on prototypes that evolve and are successively refined)

- The criteria for evaluation are derived from (informed by) the **design brief** (or other such artefact, such as problem definition)

- The design brief is central, it informs the entire process:
  - Ideation and Prototyping involve the use of design principles that are applied *prospectively*
  - Evaluation involves criteria that are applied *retrospectively*

**3.** What is heuristic evaluation?

# Human-Centered Design, Philosophy

Recall the three core principles in HCD:

1.  employ an iterative approach

2.  the focus on users must come in the early, not late, iterations

3.  <mark>decisions should be made empirically</mark>

- Thus, evaluation should involve:
  - interaction with users, and/or
  - direct observation of users

# What is Heuristic Evaluation?

- In HCD, evaluation should involve:
    - interaction with users, or
    - direct observation of users

- However, <mark>there are some approaches to evaluation do not require users to be present during the evaluation</mark>

- **These methods are based on knowledge of users**

- this knowledge is then **codified into heuristics** that are used as the basis for predicting user outcome
    - given a prototype, apply heuristics *retrospectively* to obtain evaluation

# Linked: Heuristic Evaluation and Design Principles

Notice the linkage…

- knowledge of users **codified into heuristics**
  - given a prototype, apply heuristics *retrospectively* to obtain evaluation

- knowledge of users **codified in design principles**
  - given an ideation and/or prototyping scenario, apply design principles *prospectively* to propel design process forward

# Status of Heuristic Evaluation

- if a design processes employs **only** heuristic evaluation, then it is not HCD
  - Human Centered Design (HCD) means, among other things, that design decisions are being made on the basis of empirical data

- However…
  - heuristic evaluation approaches can be useful
  - knowledge of heuristic evaluation approaches also connected to design principles

**4.** How do we evaluate *usefulness*?

What is the difference between *useful* and *usable*?  (conceptual foundation of usefulness)
Does the designer determine usefulness?

# Useful vs Usable

- can an interactive system be *useful* but not *usable?*

- can an interactive system be *usable* but not *useful?*


- to what extent do the actions of the designer determine usefulness?

**Case #1**

Is this useful?

# The Tyg



- a tyg is a multi-handled drinking cup

- popular in 18th century England

- a tyg makes it possible to not share a drinking surface
  - if multiple people drink from the same tyg, and each uses a different handle to hold it, each persons lips touch a different segment of the rim

- a tyg makes it easy to pass a hot cup from one person to another
  - both the giver and the receiver will have conveniently placed handles to hold, so that neither party will burn themselves

- so a tyg is clearly utilitarian and very practical, even if we didn't recognize it (from our own lived experiences)

# Product 'Scripts'

- Madeleine Akrich (1992) developed the concept of the "script" as a metaphor for the "instruction manual" that is "inscribed" in an artifact

    - Any artifact contains a "message" (the script) from the *producer/designer* to the *user* describing the product's intended use and meaning

- the product script might be legible to some people, but not others, depends on social factors

# Inscription

- dominant interests get reflected in the form and functioning of the technology, a process referred to as "inscription" (Latour 1992).

  Designers thus define actors with specific tastes, competences, motives, aspirations, political prejudices, and the rest, and they assume that morality, technology, science, and economy will evolve in particular ways, A large part of the work of innovators is that of "inscribing" this vision of (or prediction about) the world in the technical content of the new object.

  Akrich (1992, p. 208)

# The Tyg: Take-Aways

- The tyg is useful, even if we didn't recognize it as such…

- We may even find a use for a tyg that is different from its original intention (e.g., vase, pen holder)

- the designer is not the sole determinant of an artefact's usefulness

- the extent to which something is *useful* depends to a large extent on the user, irrespective of the 'script'

Is this useful?

# Antimalarial Mosquito Netting



Zabibu Athumani and her son Abirai Mbaraka Sultani rest under an insecticide-treated bed net at their home. (Bagamoyo, Tanzania, 2011). Gates Foundation, CC BY-NC-ND

# Antimalarial Mosquito Netting

- More than 3 billion people around the world are at risk of malaria.

- Aid agencies (Gates Foundation, others) distribute insecticide-treated bed nets for people to use in their homes.

- These bed nets repel the mosquitoes that transmit the malaria infection. (Mosquitos are the vectors that Plasmodium parasite.)

- These bed nets have played a huge role in cutting the toll of malaria (e.g., malaria incidence falling by almost 40% over a decade)…

- BUT…

# Antimalarial Mosquito Netting

- Antimalarial mosquito netting was found to be useful for many other purposes

- Examples:
  - for fishing nets (using one or more), to protect crops, to make chicken coops

- these other uses are now known to be harmful
  - e.g., fishing practices that are destructive to food security and coastal ecosystems.

# Antimalarial Mosquito Netting: Take-Aways

• an artifact may get used in a way that was not intended by the designer

• an artifact may get used in a way that was not inscribed in the product's script... a kind of *subversive use*

• the designer is not the sole determinant of an artefact's usefulness

• the extent to which something is *useful* depends to a large extent on the user, irrespective of the 'script'

Is this useful?

**Case #3**

Is this useful?

**Case #3**

# 'Manufrance'

- these two examples are from Jacques Carelman (1929-2012), an artist and designer, who developed *Catalogue d'objets introuvables* (1969) – a parody of catalog of the French mail order company 'Manufrance'
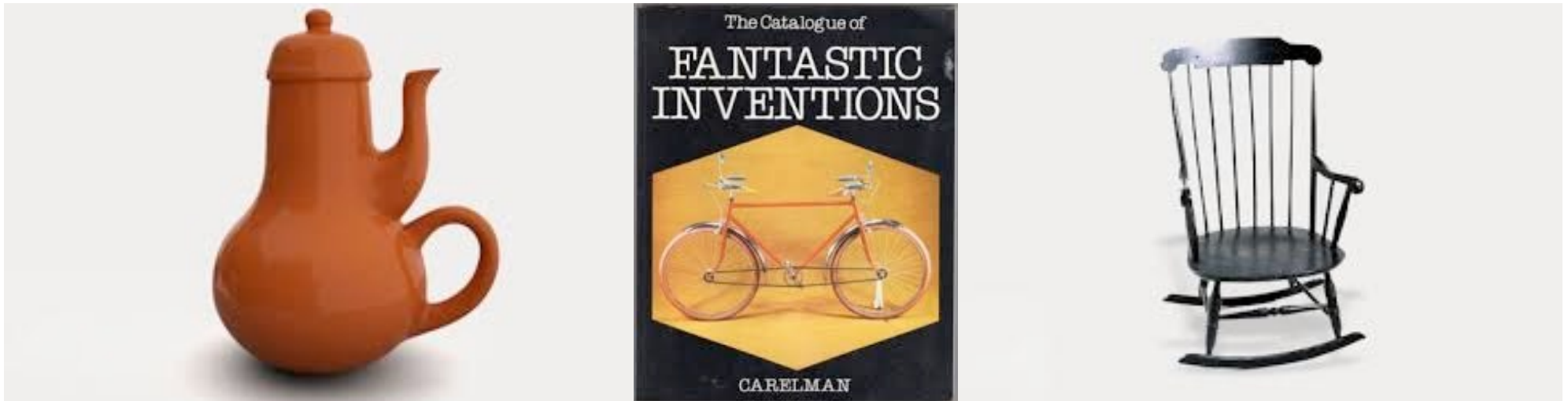
**Case #3**

# Parody

r/UnnecessaryInventions
u/rightcoastguy

The Breakfast Machine
Simone Gertz





https://www.youtube.com/watch?v=E2evC2xTNWg

# Parody Design

- the designer may deliberately inscribe a 'subversive' script

- a subversive script can be one that:
  - deliberately invokes 'non use'
  - makes some kind of other point
  - engages in a social commentary (e.g., wastefulness, laziness)

# Parody Design: Take-Aways

- the designer may deliberately inscribe a 'subversive' script, and yet is received by the user, where it then serves its purpose

- the degree to which something is *useful* can depend to a large extent on the user, even with a subversive script

- the designer is not the sole determinant of an artefact's usefulness

- the extent to which something is *useful* depends to a large extent on the user, irrespective of the 'script'

# Does the Designer Determine Usefulness?

- In sum, usefulness is <mark>relational</mark> – usefulness is constructed between the artefact's script and the user

- the designer is not the sole determinant of an artefact's usefulness

- the extent to which something is *useful* depends to a large extent on the user

# Does 'Useful' Imply Purpose or Goal?

- are we assuming a **task-oriented context**?

- not all interactive systems are **task-oriented**

- think of systems used for pleasure and enjoyment, for entertainment, for being social, for emoting, etc
    - would we say these are useful systems?

- there is a much broader context of *user experience*

# Earlier Concepts of 'Use'

- in the early 1980's, the first PC's started to emerge

- up to the 1990's, digital interactive systems were not yet well established as mainstream consumer products

- up until this point, the predominant concept of the 'use' of digital technology was:
    - individualistic
    - tightly connected to workplace settings
    - tightly connected to specialized equipment (as opposed to mainstream consumer products)
    - tightly connected to 'instrumental' motivations
        - 'instrumental' meaning use the program to get the job done as quickly, efficiently and correctly as possible

- the concept of usability connected to this concept of use, and became strongly established

# Shifting Concept of 'Use'

- starting about the mid 1990's, digital technology grew into the form of consumer products, the WWW started to be established and then commercialized

- the concept of 'use' started to shift, additional concepts of `use` arose, such as:
    - 'using' for entertainment and for pleasure
    - 'using' for communication (interpersonal and within communities)

- *as digital technologies have evolved, so has the use of these technologies*

- the concept of 'use' became broadened from the initial concept

- the concept of usability didn't connect well to this broadened concept of `use`, instead the concept of user experience came into use

# Usefulness, In Sum

- the usefulness of an interactive system emerges jointly from the user, their environment, and the affordances of the interactive system

5. What is meant by an *affordance*?

# Systems and Their Elements

- We already discussed the sociotechnical systems view: the elements in the sociotechnical system include the computational interactive systems and the humans (users), the system provides the context in which interaction takes place

- Computational interactive systems:
  - Have articulators and sensors
  - Have 'inner state' (as determined via computational processes)
  - Are hardware-software systems

- Humans:
  - Are biological systems
  - Have bodies with sensory-perceptual pathways
  - Have bodies with motor systems (and other systems for effecting action upon the world)
  - Have senses which are not passive (not solely in "inputs") but rather active
  - Have cognition
  - Are meaning makers
  - Are social creatures

# Human Action Within Their Environment

- We want to delve further into the questions like:
    - why do humans do what they do when interacting with digital technologies?
    - how can we apply this knowledge towards the design of interfaces that will give rise to certain (desirable) outcomes and that will not give rise to other (undesirable) outcomes?

- In investigating questions like this, a very useful concept is often employed – the concept of *an affordance*

- This concept of an affordance is also important since it is foundational to our definition of *interactive systems*
    - an interactive system is a digital technology that *affords* interactivity to human users

- So now we will discuss this concept

# What is an affordance?

- Before providing the characterization…

- the concept of *affordance* is often misunderstood and misused (especially in the fields of HCI, UI, UX, IxD, etc)

- we will cover the correct characterization here and distinguish the correct characterization from the mischaracterizations

# Gibson

- Gibson, a researcher in the field of psychology, originally defined the term affordance as follows:

    Affordances are all "action possibilities" latent in the environment, objectively measurable and independent of the individual's ability to recognize them

James J. Gibson (1977), The Theory of Affordances. In Perceiving, Acting, and Knowing, edited by Robert Shaw and John Bransford, ISBN 0-470-99014-7.

# Re: Gibson's concept

- Gibson's concept of an affordance implies a separation of **performability** and **perception**

- **performability** is the key factor
    - **performability**: whether or not a feature of the environment provides an "action possibility" to a particular individual
    - performability depends on the individual's embodiment **in relationship to** the environment
    - different embodiments, different relationships
    - thus, performability is a <mark>*relational*</mark> term

- perception is not part of establishing the action possibility
    - even in the individual fails to recognize an action possibility, if the action is performable by the individual, then that action possibility exists
    - the perceptibility of features is also <mark>*relational*</mark>

# The Design of Everyday Things, Norman (2002)

- About 25 years later (in 2002), Norman took core concepts from cognitive psychology and applied them to the domain of design

- He took Gibson's concept of an affordance and applied it to the practice of design:

  "the term affordance refers to the perceived and actual properties of the thing, primarily those fundamental properties that determine just how the thing could possibly be used" (p. 9, 2002)

- While this restatement is entirely incorrect, it is written in a way that led to many misunderstandings…

# Mass Misuse of the Concept of Affordance

- upon its publication in 2002, Norman's book became hugely popular in fields such as HCI, UI, UX, IxD, etc

- many practitioners took up the term 'affordance', but they misused and misunderstood the concept
  - instead of focusing on *performability*, the focus shifted to *perception*
  - instead of focusing on **relational properties**, the focus stayed on **properties of the interactive system**

- Here is an example of the misuse
  - Preece (2002): affordance "is a term used to refer to **an attribute of an object that allows people to know how to use it**"

- in all fairness, Norman could have been more careful (looking retrospectively)

# The Design of Everyday Things (2nd Ed), Norman (2013)

- Norman tried to correct the misunderstanding in the book's second edition (2013)

- In 2013, Norman noted:
  - the term affordance "created much confusion in the world of design"
  - "… the term became used in ways that had nothing to do with the original"
  - "Many people find affordances difficult to understand because they are relationships, not properties."
  - "Designers deal with fixed properties, so there is a temptation to say that the property is an affordance"

- In the second edition (2013), he worked on correcting the misuse and clarifying

# Ongoing misuse…

- Despite Norman's efforts to correct the misuse of the term affordance, the misuse continues

- The mischaracterization is deeply entrenched

- E.g. Preece (p. 30, 2019), still has in the section "Affordance" "This is a term used to refer to an attribute of an object that allows people to know how to use it."

# Door Example (I)

- Say a door has a pull handle (and it is positioned at the chest level of a person of average height)

- Person A
  - approaches on foot and perceives the pull handle visually.
  - knows that pulling on the pull handle will cause the door to swing on its hinges towards them (knowledge).

- The handle **affords** pulling for person A.
  - Opening the door **is an action possibility** for person A.
  - The door affords 'pullability' for person A.
  - The possibility **was latent** in the environment (for Person A), independent of Person A's ability to recognize it.
  - *Perception of the possibility was visual, likely as the door designer envisioned*

# Door Example (II)

- Say a door has a pull handle (and it is positioned at the chest level of a person of average height)

- Person B
    - has a visual impairment and is not able to see the handle.
    - reaches out anyway, feels the handle, and then pulls on it.

- The handle **affords** pulling for person B.
    - Opening the door **is an action possibility** for this person B.
    - The door affords 'pullability' for person B.
    - The possibility **was latent** in the environment (for Person B), independent of Person B's ability to recognize it.
    - *Perception of the possibility need not be visual and can be any manner of perception or discovery, even if the door designer did not anticipate it*

# Door Example (III)

- Say a door has a pull handle (and it is positioned at the chest level of a person of average height)

- Person C
  - uses a wheel chair and approaches the door, perceives the pull handle visually
  - reaches up but cannot reach it because it is too high
  - even it they could reach it, the door is too heavy and they can't move their chair back while simultaneously pulling.

- The handle **does not afford** pulling for person C.
  - Opening the door **is not an action possibility** for person C.
  - The door does not afford 'pullability' for person C.
  - The possibility **was not latent** in the environment (for Person C), irrespective of Person C's ability to recognize it.
  - *Activation of the action possibility will often be contingent on certain capabilities; designers often make implicit assumptions about the required capabilities*

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# Door Example (IV)

- Say a door has a pull handle (and it is positioned at the chest level of a person of average height)

- Person D
  - has a visual impairment and is not able to see the handle
  - reaches out anyway, and, despite feeling for the handle, does not locate it
  - turns around and leaves the doorway

- The handle **affords** pulling for person D.
  - Opening the door **is an action** possibility for this person D.
  - The door affords 'pullability' for person D.
  - The possibility **was latent** in the environment (for Person D), even though Person D did not recognize nor make use of the possibility.
  - *Perception of the possibility need not be visual and can be any manner of perception or discovery. The designer can provision for this by providing cues and signals that are not likely to be missed.*

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# Affording Interactivity

- Now we have characterized affordances

- This concept is important since it is foundational to our definition of *interactive systems*
    - an interactive system is a digital technology that *affords* interactivity to human users

- The next resource pack will discuss *interactivity* and will compare it to *reactivity*

# Affordance, In Sum

- The sociotechnical systems approach focuses on the interaction between people and technology

- In these systems, humans and computational interactive systems are the elements that stand in interaction with one another

- The concept of affordance is a relational property, it captures the aspect of performability

- The concept of affordance is different from the concept of perceptability

6. What is *usability* and how do we evaluate it?

# Usability

- the construct of *usability* in design is typically composed of several different *aspects of use*

- this construct has its roots in the application of cognitive psychology to Human-Computer Interaction

- there are many deconstructions, here is a common one
  [from Sharp et al 2019, §1.7.1 Usability Goals]
    - effectiveness
    - efficiency
    - safety
    - utility
    - learnability
    - memorability

# Utility

**Utility**: to what extent does the system provides the range of desired functionality?

- example of poor utility from the textbook
  - "a software drawing tool that does not allow users to draw freehand but forces them … to create their drawings using only polygon shapes"

- does this not overlap with useful?
  - yes, it does

- interpretive note:
  - utility makes sense in application domains where there is a sense of 'incremental' functionality for users in task-based activities (e.g., think of raster or vector graphics editing, photo editing, IDEs)

# Effectiveness

**Effectiveness**: to what degree does the system allow the users to do what it is they need to do?

- concerned with **outcome,** not effort or other attributes of the process

- can I accomplish what I need to do (even if it takes me quite a lot of time, energy, frustration, …) ?

# Does Effective Overlap with Useful?

yes, there is overlap…

- the term *usability* is an overarching concept developed in a scholarly research community
  - connected to the scholarly discipline of HCI, emerging in the 1980's
  - this discipline assumed a functional, task-based context of use

- the term *useful* is a word in everyday use
  - is now connected to the the UI/UX grey literature
  - often gets used within the 'contrasting trio' of "useful, usable, used"

# Efficiency

**Efficiency:** how much effort is required to derive the desired outcome?

- concerned with **process**: to achieve a particular outcome (effectiveness), how much time and/or energy goes into getting that outcome?

- need to factor out the effort that goes into learning, since this is a separate aspect of usability
  - thus, this question is typically posed as "how much effort is required to derive the desired outcome, *once users have already learned the system*?
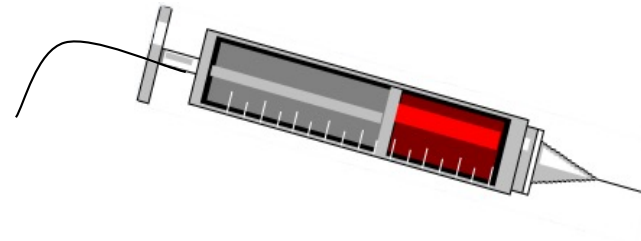
# What is "User Mistake"

- user did the 'wrong' thing … usually meaning 'different from what they intended' … an 'inadvertent error'

- users can make mistakes for many different reasons: incorrect assumptions, mistaken beliefs, inattention, motor error

- mistakes are connected to both effectiveness and efficiency
  - detecting and correcting mistake (assuming they can be corrected) takes time and energy … this is a detriment to **efficiency**
  - if errors cannot be corrected … this is a detriment to **effectiveness**

- mistakes are inevitable, it is difficult to imagine all of the mistakes that will happen…

# Safety

**Safety:** Is the user protected from negative consequences from user mistake?

- given all possible user actions at a point in time, what are the possible of outcomes and their consequences?
    - are there 'dangers' in some of these consequences
        - e.g., creation of hazards, loss of data and/or previous work, …
    - for these dangerous actions, are there means of recovery?

- this aspect is concerned with helping *any kind of user in any kind of situation* to avoid making mistakes and/or to recover from mistakes
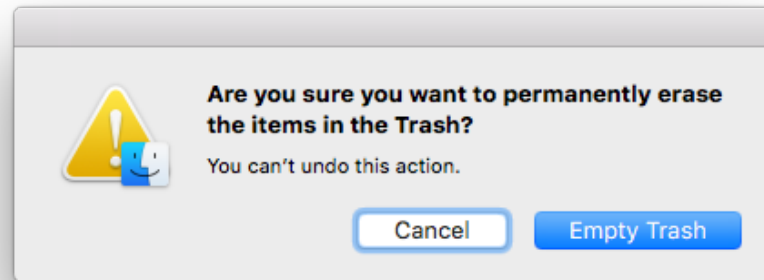
# Expensive Mistakes

- actions can be ambiguous – was this action a mistake or was it deliberate?

- if the consequence of the action is easily reversed…
    - then if it was a mistake, at least it wasn't an expensive mistake

- if the consequences that cannot be easily reversed…
    - it a mistake expensive or inexpensive?
    - expensive mistakes include:
        - operations that use up a lot of computing time
        - operations that use up a lot computing resources (bandwidth, fill up the disk space, etc)
        - operations that cause loss of data and/or previous work

# High-Stakes Actions

- if a user performs a high-stakes action (serious consequence)
    - this could mean an expensive mistake

- a good strategy is to verify…

- a common form of safeguard is a verification step
    - this can mitigate consequences of user actions made in error by requiring the user to confirm the action

# Example: Disk Operations



- for example, some file system operations can be non-recoverable

# Safeguards vs Efficiency

- the verification step is a "mixed blessing"
  - requiring the user to confirm the action is a small step to avoid an expensive mistake
  - requiring the user to confirm non-mistaken actions can cost unnecessary time and effort for actions not made in error

- thus, there can be a tradeoff with efficiency

- when is safety a good tradeoff with efficiency?
  - it really does depend on the tradeoff among the likelihood of the error, the magnitude of the consequence, and the frequency of the actions

- thus, safeguards improve safety, but safeguards can stand in tension with efficiency

# Learnability

- Learnability: the extent to which the users can easily figure out how to use the system from the outset
    - learnability is connected to the complexity of system

- can the user employ their own strategies?
    - most often, the user's strategy is exploration

- is a particular mode of learning enforced?
    - e.g., guided walk-throughs (wizards), documentation, tutorials, videos, exploration, …

- users are mostly* intolerant of time-intensive learning

- can learning be measured?
    - yes, learning can be operationalized
    - requires pre/post probes, and a retention probe as well

# Memorability

- Memorability: the extent to which users can remember how to use the system, particularly after a pause

- implies a context of use in which learning has already taken place

- the poorest memorability outcome would be a system that has to be relearned from scratch every time

- a system may provide some prompts to help users remember

# Useful vs Usable

think in terms of separating the 'what' from the 'how'

- useful: the 'what'
  - allows user to accomplish task or objective (the 'what')

- usable: the 'how'
  - characterizes things like…. and here it depends on how you define 'use':
  - objectively measurable things:
    - productive, low-effort, safe, easy to learn, easy to remember …
  - subjective aspects:
    - enjoyable, pleasurable, and so on…

# In Sum

- usable is different from useful

- usable and useful are connected to task-based contexts

- think of useful as the 'what', and usable as the 'how'

- an interactive system be *useful* but not *usable,* and an interactive system be *usable* but not *useful*