User Capabilities 2
Cognitive Frameworks

CSU4051 Human Factors

Cognitive frameworks

These are used to explain and predict user behavior at the interface

- Based on theories of behavior
- Focus is on mental processes that take place
- Also use of artifacts and representations

Cognitive frameworks

1. **Mental models**
2. Gulfs of execution and evaluation
3. Information Processing
4. Distributed cognition
5. External and embodied cognition

Mental models

- Users develop an understanding of a system through learning and using it
- Knowledge is often described as a *mental model*
  - How to use the system (what to do next)
  - What to do with unfamiliar systems or unexpected situations (how the system works)
- People make inferences using mental models of how to carry out tasks

Image: UX collective

Mental models

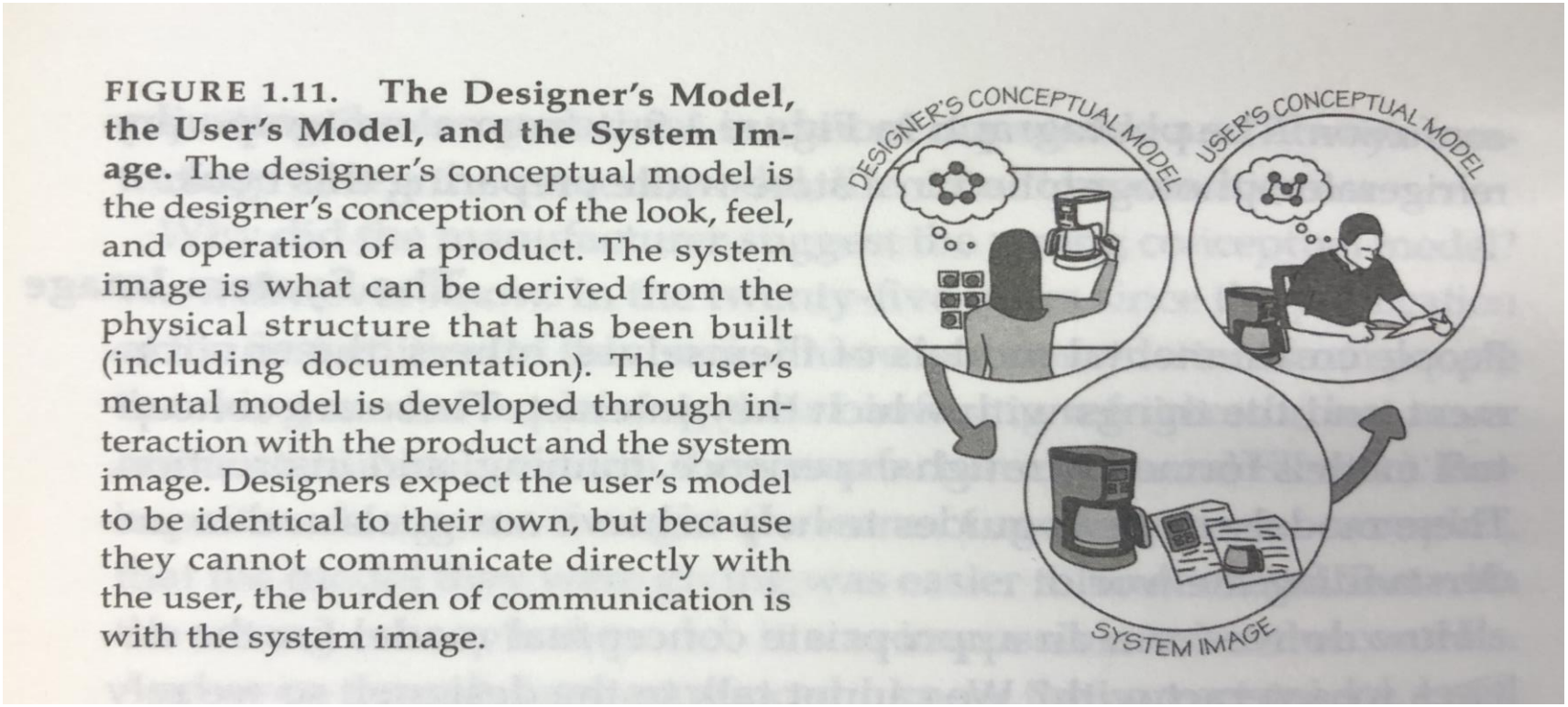

FIGURE 1.11. The Designer's Model, the User's Model, and the System Image. The designer's conceptual model is the designer's conception of the look, feel, and operation of a product. The system image is what can be derived from the physical structure that has been built (including documentation). The user's mental model is developed through interaction with the product and the system image. Designers expect the user's model to be identical to their own, but because they cannot communicate directly with the user, the burden of communication is with the system image.

Norman, 2013, p32

Mental models

- Craik (1943) described mental models a:
  - internal constructions of some aspect of the external world enabling predictions to be made
- Involves unconscious and conscious processes
  - images and analogies are activated
- Deep versus shallow models
  - how to drive a car and how it works

Everyday reasoning and mental models

(a) You arrive home on a cold winter's night to a cold house. How do you get the house to warm up as quickly as possible? Set the thermostat to be at its highest or to the desired temperature?

(b) You arrive home very hungry. You look in the fridge and find all that is left is an uncooked pizza. You have an electric oven. Do you warm it up to 175 degrees first and then put it in (as specified by the instructions) or turn the oven up higher to try to warm it up quicker?

Heating up a room or oven that is thermostat-controlled

- Many people have erroneous mental models (Kempton, 1996)
- Why?
  - General valve theory, where ‘more is more’ principle is generalised to different settings (e.g. car accelerator, gas cooker, tap, radio volume)
  - Thermostats based on model of on-off switch

Heating up a room or oven that is thermostat-controlled

- Same is often true for understanding how interactive devices and computers work:
  - Poor, often incomplete, easily confusable, based on inappropriate analogies and superstition (Norman, 1983)
  - e.g. elevators and pedestrian crossings - lot of people hit the button at least twice
  - Why? Think it will make the lights change faster or ensure the elevator arrives!

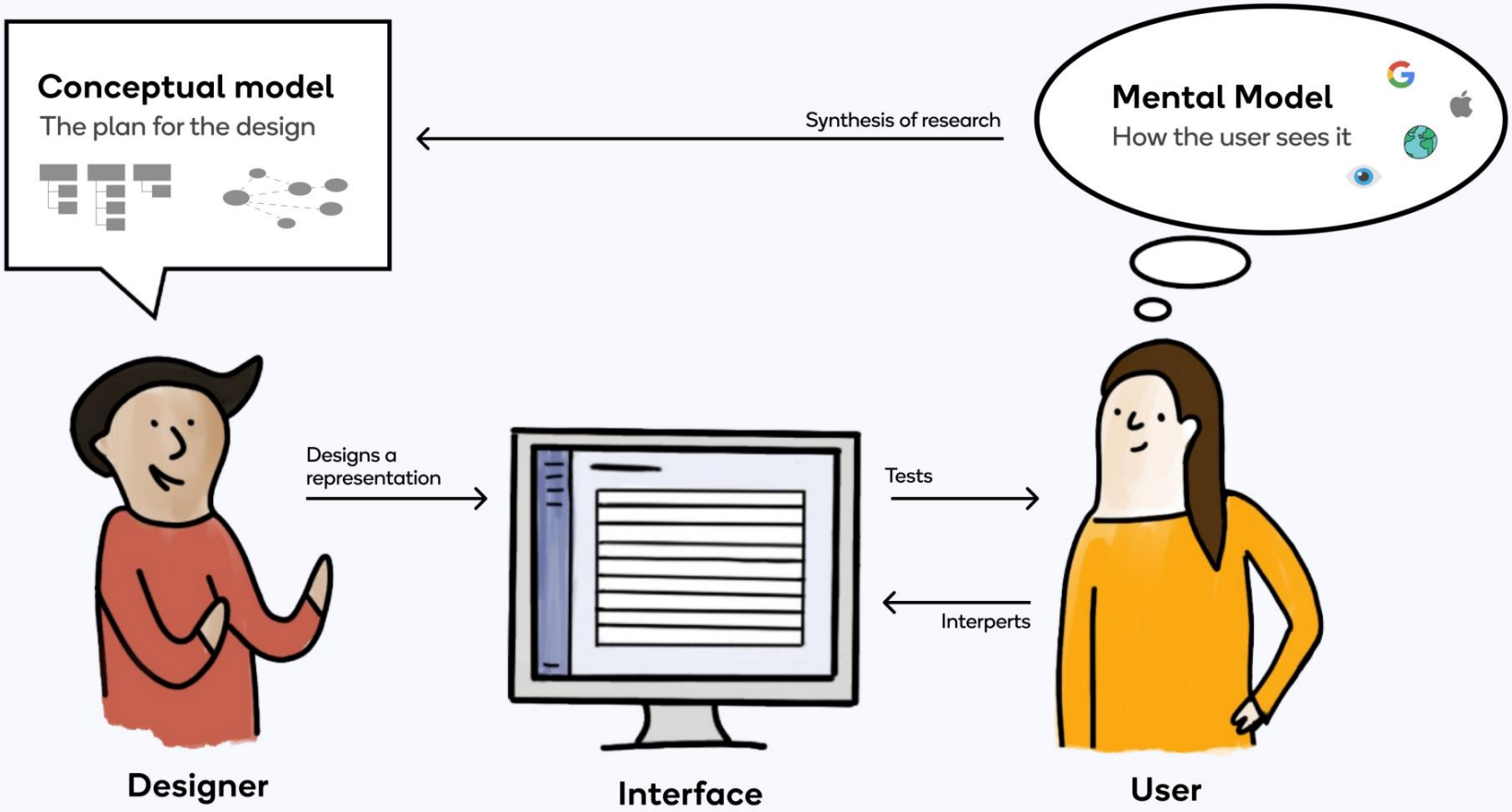

Image: UX Collective

How can UX be designed to help people build better mental models?

- Clear and easy to use instructions
- Appropriate tutorials and contextual sensitive guidance
- Provide online videos and chatbot windows when needing help
- Transparency: to make interfaces intuitive to use
- Affordances of what actions an interface allows
  - For example, swiping, clicking, or selecting

Cognitive frameworks

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2. **Gulfs of execution and evaluation**

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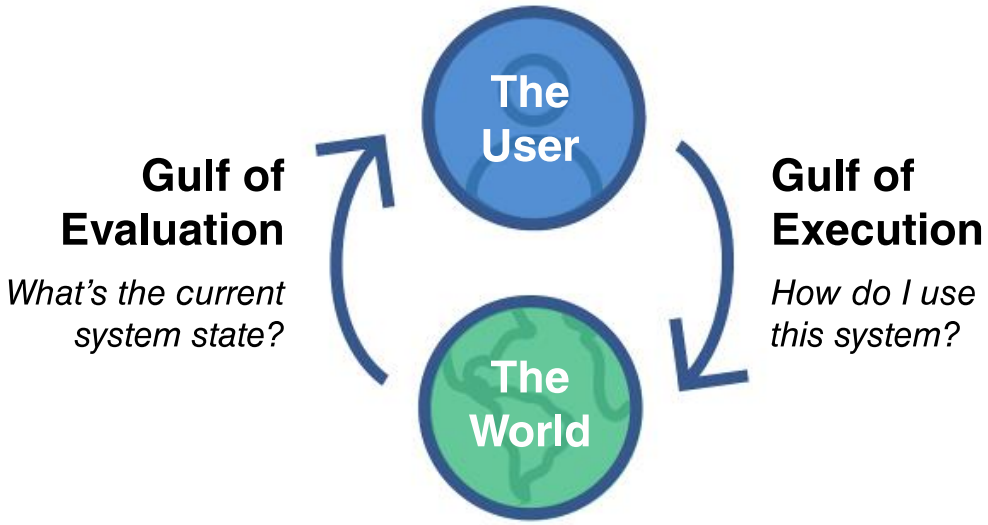
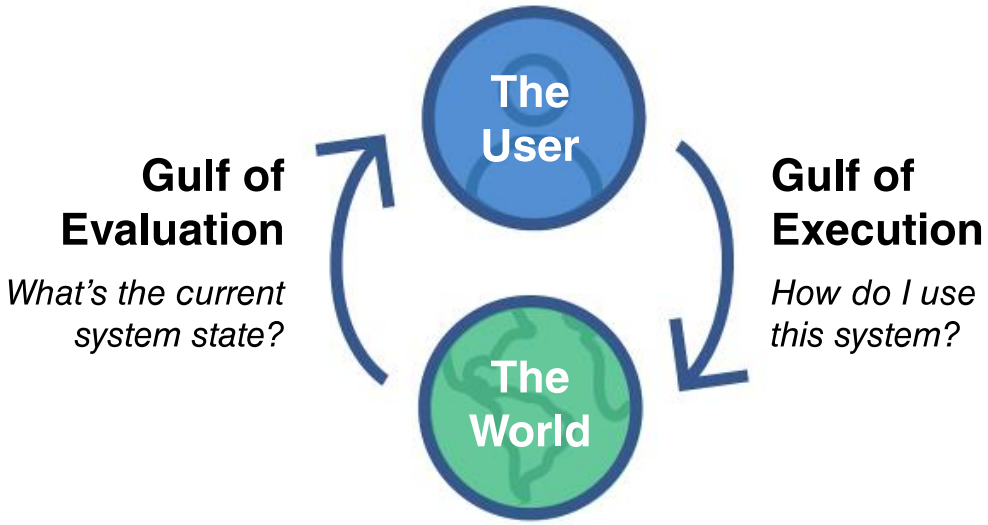
Bridging the gulfs



The notions of gulfs provided a discourse to explore potential mappings and mismatches between how a system was designed to work and how a person understands how to do a task using it

Bridging the gulfs



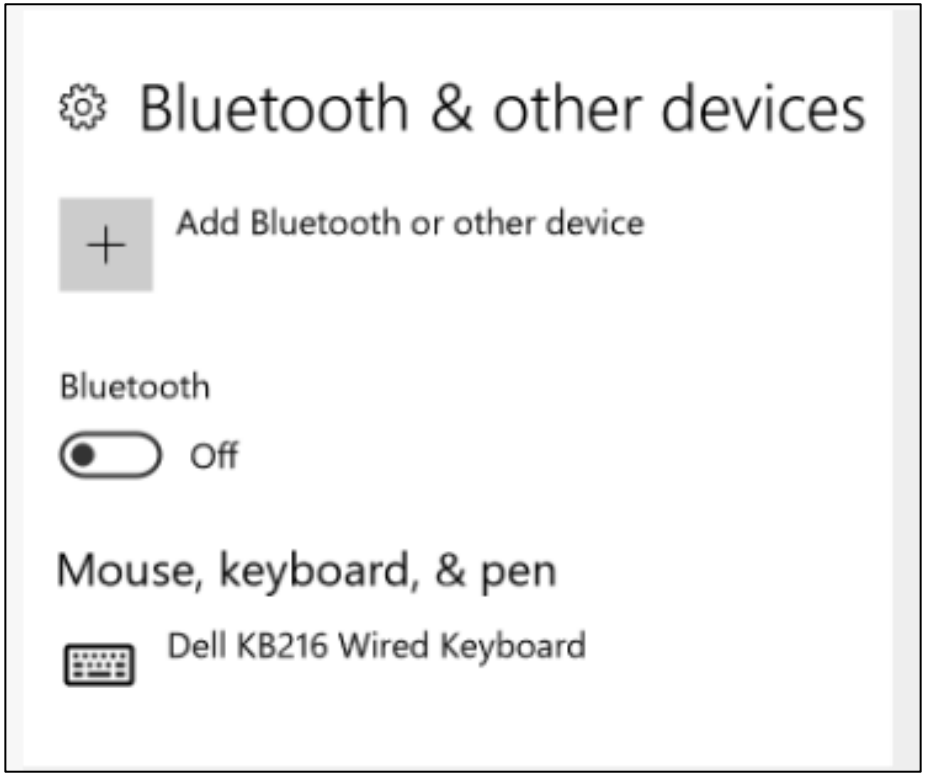
The gulf of **execution**

- The distance from the user to the physical system

The gulf of **evaluation**

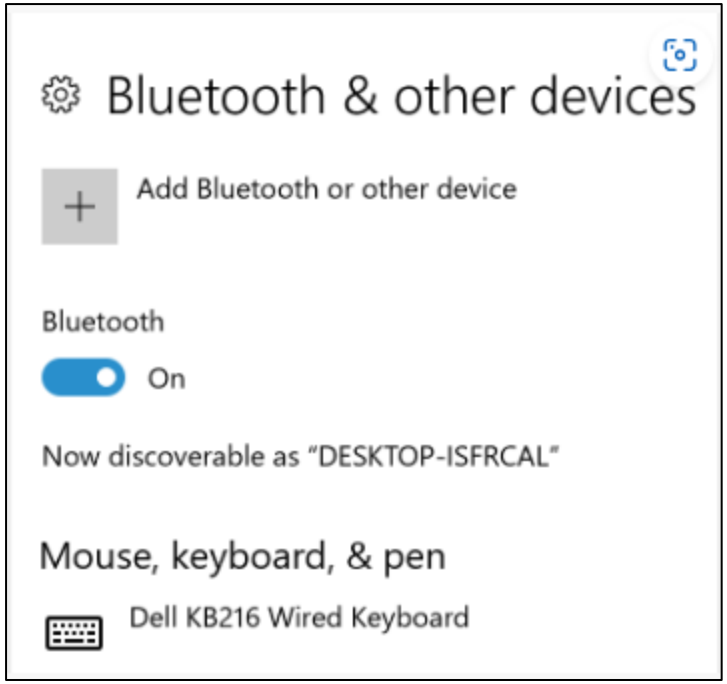
- The distance from the physical system to the user

Gulfs Example



https://www.nngroup.com/articles/two-ux-gulfs-evaluation-execution/

Gulfs Example



Unsuccessful evaluation, preventing successful execution

https://www.nngroup.com/articles/two-ux-gulfs-evaluation-execution/


amazon

"Like Having a Really bad PA": The Gulf between User Expectation and Experience of Conversational Agents

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ABSTRACT
The past four years have seen the rise of conversational agents (CAs) in everyday life. Apple, Microsoft, Amazon, Google and Facebook have all embedded proprietary CAs within their software and, increasingly, conversation is becoming a key mode of human-computer interaction. Whilst we have long been familiar with the notion of computers that speak, the investigative concern within HCI has been upon multimodality rather than dialogue alone, and there is no sense of how such interfaces are used in everyday life. This paper reports the findings of interviews with 14 users of CAs in an effort to understand the current interactional factors affecting everyday use. We find user expectations dramatically out of step with the operation of the systems, particularly in terms of known machine intelligence, system capability and goals. Using Norman's 'gulfs of execution and evaluation' [30] we consider the implications of these findings for the design of future systems.

Author Keywords
Conversational Agents; mental models; evaluation

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous

INTRODUCTION
Framed as "dialogue systems often endowed with 'humanlike' behaviour" [43 p.357], conversational agents (CA) are their respective operating systems and Alexa finds its home in the form of Amazon Echo, giving us every reason to believe that spoken dialogue interfaces will become the future gateways to many key services.

Whilst the past 4 years have clearly seen a reinvigoration of such systems, this is very much a return to an old idea; that conversation is the next natural form of HCI. It has also long been argued that "when speech and language interfaces become more conversational, they will take their place along with direct manipulation in the interface" [6]. Moreover, they will have the potential to enhance both the system usability and user experience [43]. However, despite these expectations, the weight of research has veered away from such single modalities and tended towards multimodal developments, with a focus upon embodiment and anthropomorphism rather than voice alone. Indeed, our fascination with computers that converse can be traced back as far as 1964 when, seeking to create the illusion of human interaction, Joseph Weizenbaum of MIT created Eliza [10], a computer program that responded on the basis of data gleaned only from human respondents' typed input. Whilst script-based, it is considered the first convincing attempt to simulate natural human interactions between a user and a computer. This chatterbot, rudimentary by today's standards, was designed in the form of a Rogerian psychotherapist and, due to the high level of emotional involvement exhibited by users, was hailed as the beginnings of an automated form of

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Cognitive frameworks

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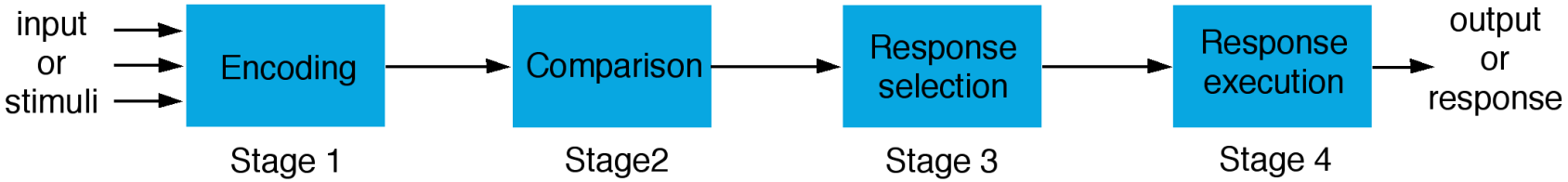
3. **Information Processing**
4. Distributed cognition
5. External and embodied cognition

Information processing

- Conceptualises human performance in metaphorical terms of information processing stages.



- This view can be criticised for ignoring the fact that cognition (and action) is always situated in a particular context.

Cognitive frameworks

1. ~~Mental models~~
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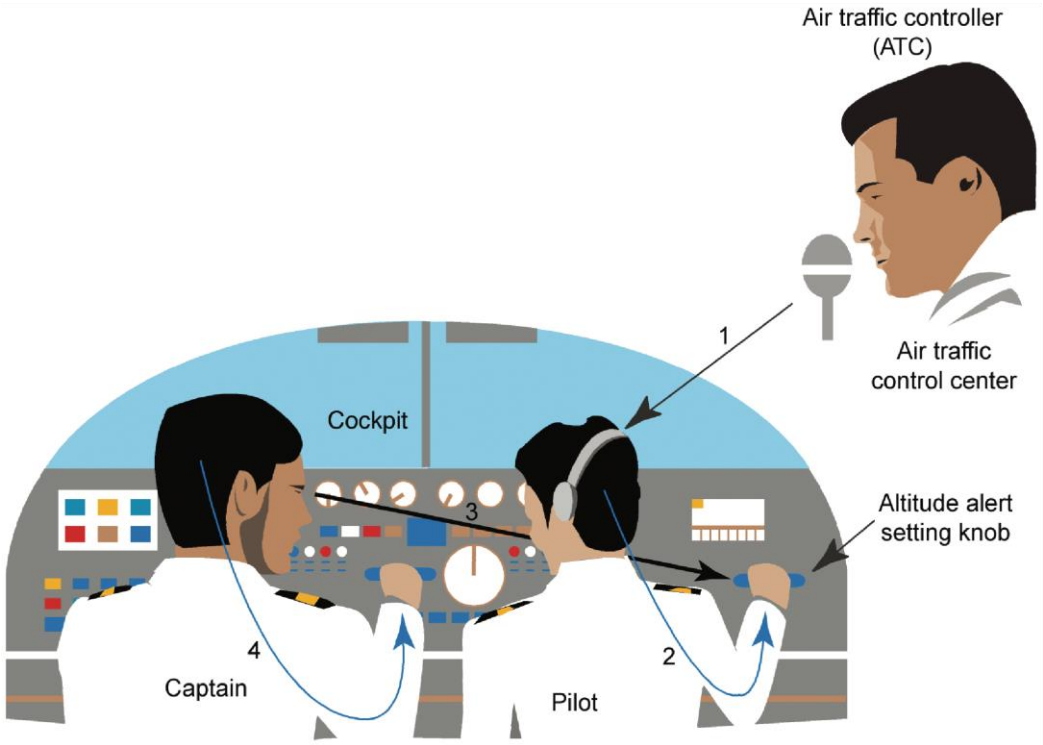
4. **Distributed cognition**
5. External and Embodied cognition

Distributed cognition

- Concerned with the nature of cognitive phenomena across individuals, artifacts, and internal and external representations (Hutchins, 1995)
- Describes these in terms of propagation across representational state
- Information is transformed through different media (computers, displays, paper, heads)

A cognitive system for ATC



Propagation of representational states:

1 ATC gives clearance to pilot to fly to higher altitude (verbal)

2 Pilot changes altitude meter (mental and physical)

3 Captain observes pilot (visual)

4 Captain flies to higher altitude (mental and physical)

What's involved

- The distributed problem-solving that takes place
- The role of verbal and non-verbal behavior
- The various coordinating mechanisms that are used (for example, rules and procedures)
- The communication that takes place as the collaborative activity progresses
- How knowledge is shared and accessed

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Externalising to reduce memory load

- Diaries, reminders, calendars, notes, shopping lists, to-do lists
  - Written to remind us of what to do
- Post-its, piles, marked emails
  - Where placed indicates priority of what to do
- External representations:
  - Remind us that we need to do something (e.g. to buy something for mother's day)
  - Remind us of what to do (e.g. buy a card)
  - Remind us when to do something (e.g. send a card by a certain date)

External cognition

- Annotation involves modifying existing representations through making marks
  - e.g. crossing off, ticking, underlining
- Cognitive tracing involves externally manipulating items into different orders or structures
  - e.g. playing scrabble, playing cards, scrum board
- Computational offloading: using a tool or device in conjunction with an external representation to help carry out a computation
  - eg. using a pen and paper to do a mathematical problem

Design implications

- Provide external representations at the interface that reduce memory load and facilitate computational offloading

e.g. Information visualizations have been designed to allow people to make sense and rapid decisions about masses of data

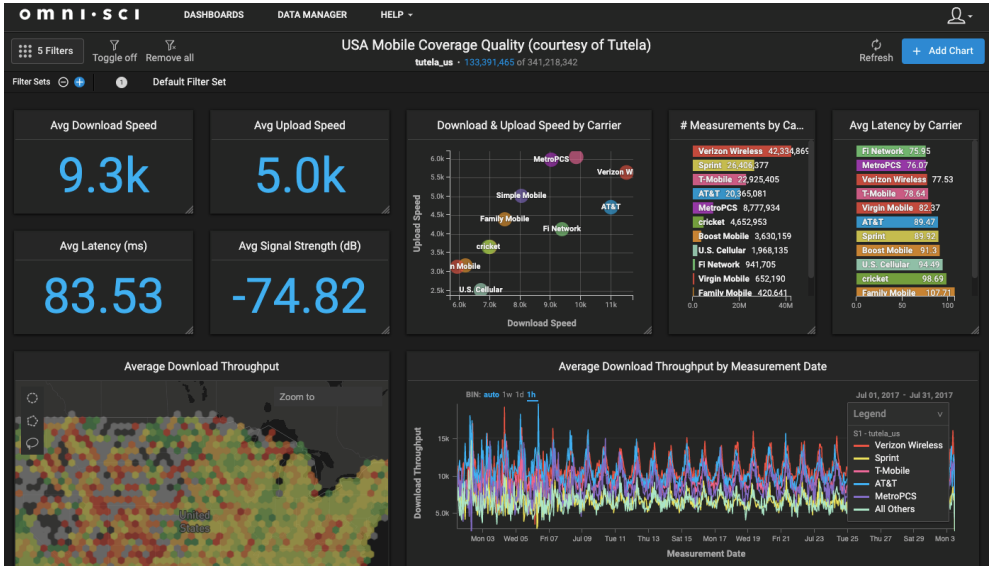

Image: Omnisci

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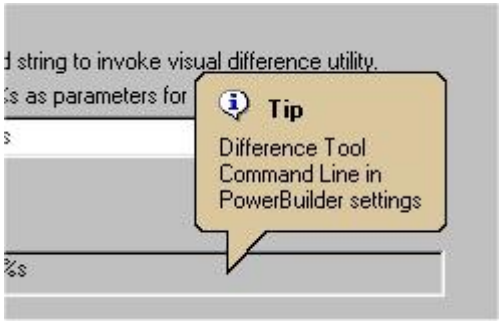
Levels of experience

- As users gain experience with a system their style of use will change, from novice to expert.
- For novices, the main concern is ease of learning.
- For experts the main concern is ease of use.
- Systems used on a daily basis by many people are more likely to have a majority of expert users. Thus ease of use must be the main concern, allowing expert users to perform their tasks quickly.

Novice and expert users



- Other systems, such as decision support systems are likely to have only occasional users, thus greater emphasis must be placed on ease of learning.
- Some features for novices may distract or inconvenience expert users.

Key points

- Cognition involves several processes including attention, memory, perception and learning
- The way an interface is designed can greatly affect how well users can perceive, attend, learn and remember how to do their tasks
- Theoretical frameworks such as mental models and external cognition provide ways of understanding how and why people interact with products, which can lead to thinking about how to design better products

In-depth activity

Write down how you think a contactless card or smartphone app like Apple Pay works

- What information is sent between the card/smartphone and the card reader when it is placed in front of it?
- What is the maximum amount you can pay for something using a contactless card, Apple Pay or Google Pay?
- Why is there an upper limit?
- How many times can you use a contactless card or Apple/Google Pay in a day?
- What happens if you have two contactless cards in the same wallet/purse?
- What happens when your contactless card is stolen and you report it to the bank? What does the bank do?