Chapter 4.

Models of Human Behavior: Individuals

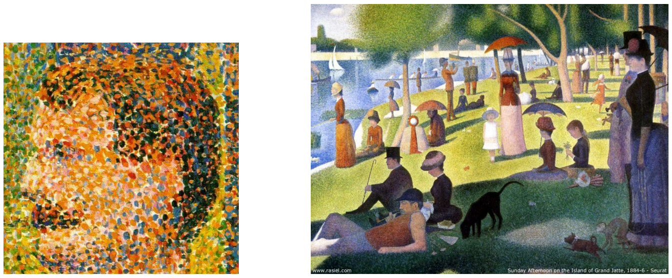


Figure 4.1: The human cognitive system fills in gaps. This occurs at both the perceptual level and for high-level expectations. Here we see examples of pointalist paintings. (check permission)

4.1. Describing Human Behavior

We have lots of ways of describing why people do things: For instance, We say that a person has knowledge, attitudes, beliefs, intentions, emotions, affective states, and personality. These approaches are sometime described as a "theory of mind" but the issues go beyond what is usually considered mind to cover all sorts of behavior. Folk Psychology. Constructs are often not consistent.

4.1.1. Cognition and Emotion

One on hand, people are very sophisticated information processors. On the other hand, the way they process information is very different from the processing of information by most computers and human information processing is frequently (if not always) affected by human emotion and needs. Emotion and cognition are two, sometimes competing, systems. Each with strengths.

It's clear that people process and make decisions based on information but what can we tell about what they are actually doing? People seem capable of the most amazing and sometimes he most perplexing actions. There's generally a simple connection between people's behavior and simple factors such as what's happening around them or the time of day. Obviously, social interaction is vital to people. In just about everything people do, information is vital. This approach has an emphasize the processes rather than the content. Later, we consider models of cohesion such as sense-making and attempting to reach consensus.

Integrated intelligent system. Many heuristics for approximate reasoning. Many capabilities. Learning, self-aware, collaborative. Principle of least effort to minimize energy. This even applies to cognitive effort. The person is part of a social group. Biological constraints (4.6.0).

While some behaviorists believe it is not productive to study the representations people use when reacting to their environment, most other psychologists do consider cognition and human information processing mechanisms. However, we can't see inside their heads to understand how that occurs. the mechanisms have to be inferred and many different models have been proposed. One such model, which is termed Human Information Processing, is based (roughly) on symbolic processing. People often process that information in what appears to a straightforward and sensible way. Many other times, that logical information processing appears to be biased by self interest or jumbled by emotion. People process information very differently from most computer-based information systems described earlier. Indeed, it is not clear whether the types of representations used by typical computer-based information systems are appropriate for human cognition. Symbolic and non-symbolic processing. The focus of the study of cognition is on mental processes rather than interaction with external information resources.

Qualitative models of causation (Fig. 4.19). Language is largely qualitative. Qualitative reasoning[35].

Here we focus on identifying general principles and then we will look at different styles of interaction with information systems. People acquire information from the environment encoded and stored in memory, and later recalled The human mind can itself be modeled as an information system (Fig. 4.2). This is essentially the same as a generic structure of an information system described earlier. Unlike information systems we build the cognitive system works must be inferred. However, this basic model is far too simple to give an accurate picture of how the human mind works; high-level cognition can affect perception, the context of our experiences may affect our memory of them, and our imagination can create situations that never existed. Cognition has implications for system design. In addition, learning is interwoven with social and emotional factors which we will consider in the next chapter.

Understanding the way humans process information can help in the design better ways for people and systems to interact: an understanding of sensory principles allows more fluid interfaces; analysis of motor control encourages easier interaction; knowledge of cognition allows more efficient information displays. In the end, the user is the most integral part of any information system. By seeking to find common principles across individual performance and behavior, we can develop guidelines to aid in the process of system design. Once we understand the commonalities across entire communities of users, we can direct attention to the creation of models focused on small groups and individuals. Understanding of the principles of human cognition and information processing will facilitate the development of user models that will support human-computer interaction. We will move from discussion of perception and pre-attentive processes to memory and cognition, and finally roughly following the levels of the basic model of human information processing (Fig. 4.2).

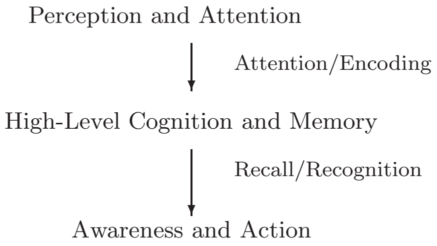


Figure 4.2: A simple model of human information processing.

However, human beings are clearly very different than current silicon information systems. Human beings have heterogeneous representations, complex motivations, and they are highly adaptive, They can reflect some of the contingencies of the environment. However, they are not perfectly adaptive. The human information processing model of human cognition is based on using information systems as an approach. This is effective in many ways, but it also reveals biases from imperfect information use.

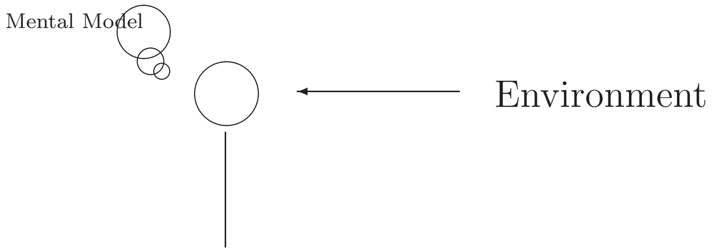


Figure 4.3: People actively interpret what is going on in the world based on their experiences.

Increasingly, we are understanding the details of brain structure (-A.12.2) and its relationship to cognition. This helps to inform models of human behavior.

Interaction with external sources of information. Considering the effort required for the information processing.

People detecting patterns. Static patterns. Patterns in motion.

4.1.2. About Cognitive Models

Theories about psychological processes rather than attempting to explain specific behavior. Mind and Brain. Information Processing in the Brain Modularity of brain processing systems.

Caution about Homunculus models.

Brain and mind as a self-organizing system. Cognitive systems[4]. Self-awareness. Increasing importance of Sensory processing, emotion, incentive, and brain science (-A.12.2).

Social Brain. Face recognition and empathy recognition regions in brain. Social signals. Mirror neurons and judging intention. Empathy (5.5.3). People generally have the sense that their experiences are coherent. However, there are may causes of which they are not aware[55]. Consciousness as an interpreter via narrative (-A.12.2). Neural simulations.

Cognitive architectures.

4.2. Perceptual Processing

4.2.1. Sensory and Pre-Attentive Processes

Hierarchical filtering to generate object comprehension. Everything we learn about the world is in some way derived from our senses. According to Fig. 4.2, a person senses and processes stimuli in a bottom-up fashion (10.1.5). Human sensors can be viewed as inputs to complex information processing system That is, our senses provide us with data about our environment, and we synthesize those pieces to create on overall sensation. Hubel and Wiesel. There may be interactions among the varying layers of mental processes; for instance, the human recognition element of cognition is probably an “up-down” process. indicating that there is no one formula for determining exactly how we interpret our environment. The interpretation of sensory stimuli is integrated with high-level cognition, The world around us assaults our senses, but our senses capture and refine those stimuli.

Before normal attention there is some pre-attentive processing. This intermediate stage gathers the information collected by the senses and performs a “quick-sort,” organizing the information into broad, spatial categories. While it is not fully understood how pre-attentive processing works, it is known that perceptual groupings, form segmentation, color categories, textures, and clustering are all examples of visual pre-attentive processing. The well-known vase/face illusion Fig. 4.4 illustrates pre-attentive processing and suggests that this is an emergent or gestalt process. Perceptual principles of similarity.

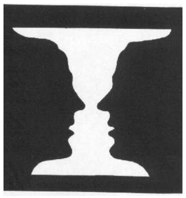


Figure 4.4: The vase/face figure-ground illusion is an example of emergent perception. Note how attention shifts between the faces and the vase. (redraw)

4.2.2. Attention

There is far too much information that exists in the world for our minds to capture and process all of it. People focus their attention on those areas of the environment that are likely to provide the most salient, or useful information. Attention is the direction of information processing resources to some part of the environment. We may miss information that is right in front of us if we are not attending to it. As we shall see later, planning presentations to manage the viewers’ attention is part of the design of digital objects. Attention can be as simple as turning toward an information source. Attention as information seeking. Attention and motivation/emotion.

Perception is often thought of as hidden — we cannot control the way that our mind and senses work together to process the stimuli of the world. In contrast, attention is dynamic — people are able to direct the focus of their attention. One example of this ability is the "cocktail-party effect," in which a person can attend to one specific conversation while filtering out all the other conversations that are taking place around them. Similarly, we can attend to one small part of a complex visual scene (Fig. 4.5); this is compared to a searchlight that emphasizes parts of the visual field. Attentional limitations are also seen in language processing.

Figure 4.5: Attention may be compared to a searchlight with which some objects are highlighted compared to their background. (check permission)

People pay attention to things that are meaningful to them. Orientating toward information sources.

Resource-limited models (4.3.3). There are many implications of losing attention. Texting while driving, when working with mobile devices, or air-traffic control. Task-switching.

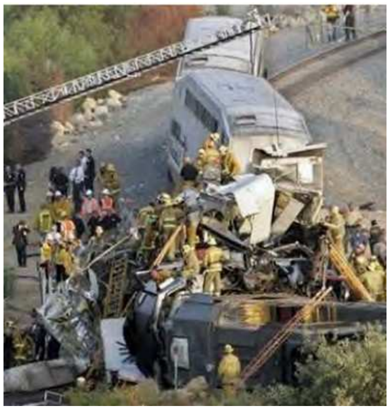


Figure 4.6: Texting requires has a high attentional load and multitasking. Texting by train engineers is the cause of many accidents such as this one near Los Angeles. (check permission)

Managing the attention of viewers improves effective information design. Authors may attempt to direct the attention of viewers using a variety of devices. Unusual features draw attention, as do changes in content. The advertising industry makes good use of these strategies to grab the attention of the public. Magicians manipulate attention. Attention and selective exposure to information.

Distraction from too little or too much information. Information overload. Attention and cognitive resources. Task stress. Fig. 4.7.

Eye movements seem to be a fairly reliable indicator of attention (Fig. 4.8). The pattern of the eye movement reflects the instructions to focus on the people in the picture[68]. As we shall see, eye movements have also been used to gauge attention during reading of text (10.2.0) and animations.

There are biases and distortions in attention[42]. Attention economy. Capturing eyeballs.

Figure 4.7: An airplane is a tightly coupled human-machine system. On one hand, in an emergency there can be too much information and the pilot may be overwhelmed. In other cases, such as when the airplane is on auto-pilot the human pilot may become distracted. (check permission)

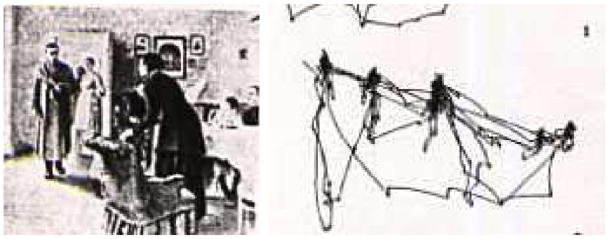


Figure 4.8: A person's eye movements while looking at an image provide clues as to what they are thinking The observer of the image on the left spent most of the time on people's faces as indicated by the eye tracks (right)[68]. (check permission)

Risk Aversion

Even simple statistical decision rules can be more effective than subjective human judgment. A simple statistical model using SAT scores and high-school grades is often more successful at predicting graduation rates than human judgment about the likelihood of student success[51]. This may, in part, be due to attentional biases (4.3.4) but also to the difficulties people have in doing accurate calculations with probabilities. However, there is some evidence that expert decisions in natural environments do not show bias. Use heuristics for decisions. Challenge to rationality (8.8.3); for instance, people tend to avoid risk.

4.2.3. Sensory Modalities: From Sensation to Cognition

Human senses allow us to receive information about the world. Indeed, our senses have implications for the selection of representations and for user interface design. People can often work around the limitations of modalities. We focus now on visual processing as we move from general principles of perception to principles related to the senses and vision in particular. Objects and images have visual properties such as size, brightness, color, texture, orientation, and shape. These visual elements are particularly relevant to the design of visual displays, and in developing visual effects in multimedia.

How do we understand and represent the world is also be a significant issue for image processing and virtual environments. As we described earlier (4.2.1), "pre-attentive" visual processing occurs prior to attention, as the name suggests. One example is the detection of regularities in texture which show how objects can be perceived against a textured background.

Furthermore, pre-attentive object perception seems to involve three different levels of representation. a primal sketch, a two and a half dimensional view, and a three-dimensional view that we perceive as our world view. These are similar to the stages which are often employed for machine vision. The $2\frac{1}{2}$-D sketch is like an artist's use of perspective in a drawing or painting.

Depth perception is also an element of visual perception. At the sensory level, our binocular vision — having two eyes — is one factor that gives us depth perception, by means of which we can tell whether an object is near or far. The mind uses many cues for depth perception, however. Some of these cues include relative motion, linear perspective, and familiar size (Fig. 4.9). Depth perception may also include high-level inferences based on perceptual models of the world[48], such as the understanding that

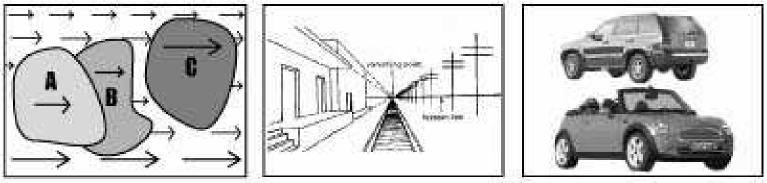


Figure 4.9: Some cues that people use in interpreting depth. (a) objects in the background seem to move more slowly than those in the foreground (b) objects in the distance appear smaller than those in the foreground, (c) apply world knowledge about the relative sizes of objects. Note that these involve relatively high levels of cognitive processing. (redraw)

Other Sensory Modalities

The traditional notion of five senses — sight, hearing, touch, taste, and smell — is highly simplified. A much larger range of sensors contribute to our perception of the world. Taste itself is composed of four different types of receptors (salt, sweet, bitter, acid) located on different parts of our tongue. The varying levels at which different food or drink stimulate each of these receptor types determine what we perceive to be the taste of that substance. Touch also provides vast amounts of information: touch reveals distinctive shapes and can indicate spatial and temporal patterns. Touch is also related to the sensation of temperature and pain. Although it is not widely recognized as a sense, the vestibular sense, or sense of balance, is mediated by the cochlea in the inner ear. Without it, we would be unable to stay upright. Proprioception is yet another type of sensory perception is which is the awareness of one's body in space. Touch and working in the world.

Even at a low-level, sensations are overlaid with cognition. Our understanding of the information provided by one sense will affect (often enhancing) our understanding of another. Smell and taste interact; we can imagine the taste of a substance from its smell, and something that tastes terrible becomes much more palatable with a pinched nose. Much of hearing is influenced by what we see, from the reading of lips to the reading of body language.

A well-designed Web site applies many cognitive principles. uses stimulating colors and sounds to help guide its use. Notice the small bumps on the "F" and "J" keys of your keyboard? They are a tactile orientation for touch typing. A system's use of sensation can even mean the difference between a person's using it or not.

Perception of Motion and Change

Action and behavior (11.4.1). Causation (4.4.2). Parsing events. Events.

Multimodal Integration

Synergistic senses.

4.2.4. Effectors and Physical User Actions

Ultimately, people make things happen with physical action. We will focus on motor behavior and the implications that this can have on the design of information systems. In normal life, people have many ways of interacting with their environments; in the world of computers, that has not been the case. Increasingly, however, interaction with a computer through a single stylized interface is disappearing. Almost any intentional behavior can now be captured and used as computer input. The term "multimodal" is applied to input devices beyond the keyboard, mouse, and joystick. Multimodal input devices allow input by speech, gestures, or handwriting. This revolution, though, has not altered the fact that human interaction with computers comes down to physical motion. Understanding human motor coordination might help us to predict the efficacy of interaction.

For those devices, requiring physical interaction, we can consider principles of motor behavior. We can distinguish “ballistic” motor behavior from motor behavior tuned by sensory feedback. Ballistic motor behavior assumes a fixed action pattern — like swinging a baseball bat or a golf club. However, with sensory feedback motor behavior the input is modified. Increasingly, sensors as interfaces. They are cheap and widely deployed. Wii and gestures (Fig. 4.10). Recognizing actions (11.4.1) and gestures. Location technologies for wireless (-A.15.1). Touch screens.

Figure 4.10: The Wii remote does motion recognition. (check permission)

Coordinated Motor Actions

It is often, but not always, easy for people to coordinate multiple actions. People interact with their environments with simultaneous, multiple modalities. Driving a car takes many coordinated physical actions and the input of several senses, and yet it is easily learned by most people. We often use both of our hands at the same time, fluidly coordinating their actions. Swiping touch screens. Multimodal interaction.

More subtly, we also see frequent coordination or reference between multiple inputs, such as when speaking people use facial expressions or hands gestures to amplify their words. This coordination between multiple inputs may be thought of as a type of referential semantics (6.2.3) in which the meaning of one set of actions (facial expressions or hand gestures) are dependent upon the meaning of the set of actions to which they refer (the words of the speaker). It is difficult for a computer to determine the meaning of referential semantics; meanings are contextual, cultural, and often ambiguous. Multimodal interaction and gesture input.

Skilled Motor Performance

Many complex activities, such as driving a car, involve feedback from the environment that allow adjustments to be made. But others activities, such as piano playing, tennis, and typing may not allow time for feedback. Procedures. The time required for nerve impulses to be sent from the brain to an extremity signaling for an action to be taken and for another signal to be sent from extremity back to the brain with the information that the action was completed, means that the instructions for a second action must be on the way before the first action is executed[44]. When signing your signature, you are moving your hand much more quickly than you could if you were consciously controlling it with feedback. This difference can be seen between hunt-and-peck typing and touch typing. Brain science (-A.12.2).

Sensorimotor Control (Haptics)

Simulated naturalistic systems should combine motor responses with appropriate sensory feedback. This interaction of sensory-motor control is also called “haptics”. A surgeon in training in an augmented reality environment (11.10.1) experiences the feel of cutting simulated tissue before working on a live patient; a participant in a game might want to feel one light saber hitting another; a musician playing a virtual instrument might benefit from feeling the responsiveness of the instrument. Additional sensations such as tactile vibration could thus improve the performance of motor tasks in a virtual environment[23] and, haptics could, for instance, support the experience of an interactive virtual museum. Force feedback.

Complex Decisions and Taking Action

Planning.

4.3. Cognitive Structures and Processes

Earlier, in this chapter we considered perception and attention, which are the first stages of human information processing. We discuss categories, memory and decisions, and emotion, which are later stages of human information processing. From cognition to affect. One topic in psychology focuses on examining cognitive structures. Motivation, learning. Matching to brain structures and cognitive function (-A.12.2).

4.3.1. Cognitive Representations

Human beings can be viewed as information processing systems, albeit complex ones. Start with very basic models.

What representations do people use when thinking? How do people recognize and use categories? As we noted earlier, it is common to analyze complex processes in terms of either structure of function (1.6.1).

The default approach to cognition is that the human mind is like a symbol-processing computer. Cognitive representations. Indeed, there are many ways in which that's not accurate but it still permeates a lot of thinking. Moreover, there are many indirect implications of that approach. Many models are based on rationalistic information processing. the models of human cognition are inferred and, in many cases, they seem likely to be approximations.

Natural-level categories.

Cognitive models are sometimes inspired by traditional computational models. In the models, cognitive processing is thought to work like a computer's CPU. There is a notion of fixed processing capacity with regard to human cognition. That is, the processing capacity of the mind is static, and that in order to store more information (i.e., memory), the new information and the already-stored information must be organized and nested in such a way as to reduce the demand on the finite powers of the brain.

Symbolic representations and frame. Cognition and categorization (2.1.2).

4.3.2. Human Memory Processes

Memory is the cognitive representation for stored information (1.1.2). There are many models for the structure of memory and how it works. Categories, discussed in the previous section, are believed to play a large role, helping to organize information and reduce the processing power necessary to retrieve memories. In some cases, memory by humans appears to follow hierarchies and simple inheritance[26], such as those we considered for knowledgebases (2.2.2). However, experimental data does not confirm this. Searching memory as a fundamental cognitive activity. Multiple memories.

Memory biases.

Models of human memory often divide it into working memory or short-term memory, and long-term memory (Fig. 4.11). We may remember some telephone numbers for only a short while we may remember others indefinitely. Even if they have an explanation, it often seems more like a story than a systematic explanation.

Models of human lexical-semantic memory, that is, memory for words.

Two types of retrieval processes from human memory are often considered. "Recognition" (1.4.4) involves identifying a stimulus that is presented, such as recognizing the correct answer on a multiple choice question. "Recall" is recovering items from memory without prompting, such as answering a fill-in-the-blank question. For user interfaces, a menu system involves recognition processes, while a command language generally requires recall of the correct command. Recognition is usually easier than recall.

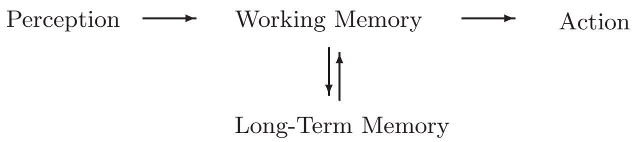


Figure 4.11: A very simple le traditional model of human information processing structure is based on the analog to a CPU. It has a working memory which manages processing and interacts with the long-term memory. This model needs to be expanded by considering the importance of context.

More Complex Models for Memory

Episodic memory is the memory for events. Autobiographical memory. Indeed, there may be a connection between episodic memory and semantic memory. The memories of multiple contexts eventually becomes meaningful.

Parallel Distributed Processing (-A.11.4). Visual and auditory relationships are very different from verbal semantics. Indeed, there is evidence of the existence of separate cognitive processing channels for verbal and non-symbolic (often multimedia) information [57]; This is a type of poly-representation. That is, there are multiple, sometimes overlapping, representations.

Memory for narrative and conceptually structured information. Transactive memory. Relying on association to help memory.

Errors and Forgetting. Retrieval failure. Errors in human inference. Overlay a memory trace. Distributed memory traces.

4.3.3. Architecture of Cognition and Resource-Based Models

We need to consider not only individual components but also how the individual pieces work together to form an overall architecture. Here we consider some basic cognitive architectures which have been proposed for human cognition and later we will consider architectures for intelligent agents which may include approaches such as machine learning (-A.11.0). While we can recall events from years past with seeming perfect detail, others remain hazy, indistinct, or even absent. What then are the limitations to accessing information that has been stored in human memory?

Architecture of cognition. The most successful of these models is ACT-R [**?**]. It has been applied to student models for tutoring systems (5.11.3) and, as we describe below, for multi-tasking.

Managing and allocating cognitive resources. Make good use of available mental energy (-A.12.2).

General model of cognitive resources. Cognitive-load.

Human information processing capability is finite – clearly, a person cannot process all the information in the environment. We often find it difficult to do two things at once because our attentional and cognitive resources are limited. The effort required to perform cognitive processing is known as the "cognitive load". Accidents associated with cellphone use while driving may be the result of a high cognitive load brought on by trying to carry on a conversation while trying to control a car. Furthermore, people manage their cognitive load, indeed, they generally minimize effort.

Multi-Tasking

Multi-tasking. Attention and use of resources.

Talk and walk at the same time. Activity production.

Declarative and procedural memories.

Problem-state block [**?**]

The amount of attention a person devotes to stimuli generally determines the "depth" to which those events are processed; that is, it affects the extent to which they are associated with other facts and the likelihood that they will be remembered. Because of this searchlight property, computing resources can be directed to the parts of a highly interactive interface that affect the user [1]. Attention and orientation towards.

4.3.4. Human Reasoning, Inference, and Decisions

Beyond the basic cognitive representations and processes, additional phenomena are of interest. Inference. The descriptions thus far have generally focused on cognitive structure. The "priming" effect in human cognition suggests that if a word such as "bird" is mentioned, then related concepts, such as "robin," will be activated and therefore more likely to be retrieved. Syntactic priming.

Expectations are intertwined with inferences. We should consider how people make inferences from the information they collect. not just logical inference (-A.7.0) such as deduction and induction. But there, may also be systematic probabilistic inference. Representation interacts with inference.

Everyday inference. Reasoning by logic versus reasoning by analogy. Abduction. Heuristics. Causal narratives. Social inference. Case-based reasoning.

Expertise and decision support systems help people to base their inferences on the most relevant factors. Economic rationality (8.8.3). Rationalizations. Age of Reason. Institutions to support reason.

Information Availability and Bias in Inference and Decision Making

Another non-rational pattern is based on the cognitive "availability" and salience of information. People often focus too much on information that is readily available in their memory. They may make a judgment based on the "availability" and "accessibility" of information in their memory (Fig. 4.13). We have already discussed that individual memory is fallible. In addition, people are often poor at predicting true probabilities of events. People often buy into the "gambler's fallacy," which is the belief that winning on one trial predicts future success. Even when allowing for such limitations, people often do not seem to act rationally. They may be self-indulgent or let their emotions control their choices. This illustrates the danger of relying on a "gut reaction". Often the probabilities of highly visible, but infrequent events are overestimated. This also implies that framing a problem is critical. That is, the context in which the problem occurs needs to be carefully described. Since human reasoning may be biased, systematic attempts to de-bias the analysis may be useful [66]. Subjective probabilities.

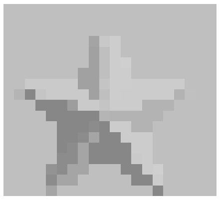


Figure 4.12: Framing affects decision outcomes.

One source of bias results from people trying to minimize cognitive effort (4.3.3) in decision making. A person who is engaged in many complex cognitive activities may use simple cognitive processing strategies – a jet fighter pilot needs to make decisions under pressure. The decisions that fighter pilots often face are formalized with algorithms (-A.9.3), which although simple, don't always accurately reflect all the variable present in a given situation. Because the use of information in decision making is so obviously important, the decision to seek more information may seem the most rational act in almost every situation. However, even this principle must be weighed against other factors, such as the required immediacy of action (as with fighter pilots), the actual existence of a truly "correct" course of action, or the simple ability to comprehend the various possibilities. Indeed, cognitive effort may be a factor in the willingness of people to carefully analyze a situation. When an exact solution is too difficult to calculate, people may be rules of thumb or "heuristics' but even then they are susceptible to bias. Even

The frequency of appearance of letters in the English language was studied. A typical text was selected, and the relative frequency with which various letters of the alphabet appeared in the first and third positions in words was recorded. Words of less than three letters were excluded from the count.

You will be given several letters of the alphabet, and you will be asked to judge whether these letters appear more often in the first or in the third position, and to estimate the ratio of the frequency with which they appear in these positions.

Consider the letter R.
Is R more likely to appear in the
_ the first position?
_ the third position? (check one)?
My estimate for the ratio of these two values is ________ :1.

Figure 4.13: Most people stated that the letter “R” is more common in the first position than in the third position of a word. Actually, the opposite is true. Their confusion may be explained by the “availability” hypothesis because people more easily think of examples of words that begin with “R” than those that have “R” in the third position ([42], p167).

professionals seem to be affected by cognitive biases in perception[27]. And even experts judgments may be clouded especially outside their area of expertise.

Heuristic and Analogical Reasoning

A lot of human reasoning is informal. In some cases, it is based on heuristic reasoning or simply on stories (6.3.6). Family resemblance categories. Metaphor versus analogy. Analogical models (Fig. 4.14). Analogies at several levels. Reasoning by analogy often leave a lot out. If we say that one situation is like another and therefore should do again what worked before, the similarities may be apparent but the differences may not. Culture (5.8.2). [39]

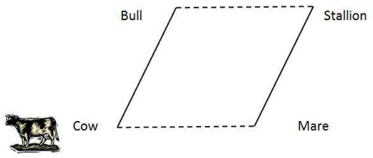


Figure 4.14: A simple model for analogy involves shifts on two attribute dimensions. In this case: gender and species. (redraw)

Verbal analogies. Analogy in science. Mental models. Reasoning by analogy and heuristics to save cognitive energy.

Sembl game. Network thinking. Less obvious links between objects.

Do People Use Plans?

We have seen that plans are fundamental for most AI models of interaction. However, it’s not clear that people actually use plans. This may affect many sorts of interaction which is based on intentional actions. An alternative model is situated action.

4.3.5. Cognition and Learning

Adapting to the environment. People are highly adaptable. Learning is ubiquitous. Learning a skill. Leaning by doing. Learning by association. Here, we consider cognitive mechanisms of human learning, but later we will consider social aspects of learning (5.5.4). Implications for education (5.11.0) and machine learning (-A.11.0). Rather, people come into new situations with processes and expectations on which to build. Habit formation. Indeed, language learning seems to be neurologically fixed (-A.12.2). Human learning vs machine learning.

Representations are interrelated with learning. Indeed, learning may be considered as changing a representation.

One simple way to learn would be to remember patterns and sequences of actions which have proven useful. This reflects the structural approach. This idea fits some evidence from cognitive psychology that people “chunk” information into conceptual units. Expert chess players learn the relationships among the pieces on a chess board so well that that they immediately analyze a configuration of pieces in terms of those relationships. They “chunk” the positions differently than do novice players, who tend to view each piece independently of the others.

A lot of human learning seems to come simply from associations and correlations. A child may learn the sound of a key turning in the lock is followed by the entrance of his/her mother. After a few occurrences (associations) the child learns that one things leads to the other.

Generalization. A second principle of learning is known as “transfer of training”. That is, learning one thing may facilitate learning a second thing. Learning Spanish may help a person to learn Portuguese. The learning of one thing may inhibit the learning of a second thing (negative transfer); learning Spanish may make it more difficult to learn Mandarin. Another example, could be the keys on a calculator pad; there are competing ideas regarding their design (Fig. 4.15). Transfer components of the design to other tasks.

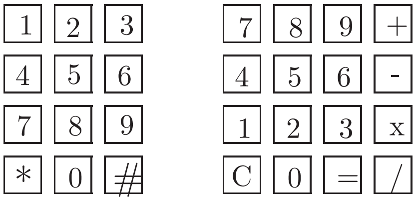


Figure 4.15: Alternative keypad layouts: a telephone keypad and calculator layout. Office workers with both types of keypads sometimes have difficulty transferring when switching from one to the other.

4.4. Complex Cognition

Coherence and constraint satisfaction. Cognition applied to problem solving (3.7.1) and planning (3.7.2).

4.4.1. Concepts, Concept Networks, and Conceptual Models

Concepts

Concepts are basic units of thought. As suggested earlier (1.1.4), concepts are abstract ideas. They are related to but separate from the words used to describe them.

Earlier, we described the notion of entities (3.9.1)and we examined formal systems for presenting them in databases. However, the notion of a entities as building blocks for complex conceptual systems is quite general. We might apply it for descriptions of concepts in human cognition since concepts have a relatively stable structure of attributes. When entity-like structures are applied in modeling concepts, they are termrf frames. These are essentially the same as the notion of schema ((sec:data schema)(. The attributes are said to fill slots in the frame (Fig. 4.16). More complex structures based on frames are also possible. For instance, frames may be arranged hierarchically.

Concept Schemas, Maps, and Networks

In any system, several components need to work together. Thus, we need to move from individual concepts to sets of concepts and from there to the description of interoperating components. We might like to understand the relationship among concepts for

so we might make a map. Relationship of a set of concepts. Data diagrams are one example of schemas. Document description. Topic maps. Concept maps can be cognitive organizers when presented to people who want to find out about a new domain. That is, they would be a type of conceptual model as described below. They can direct attention to important sections of the text, and make readers

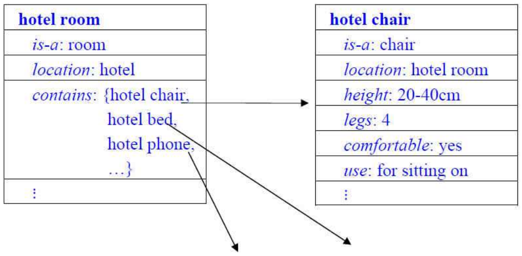


Figure 4.16: Frames and slots. (redraw)

aware of important connections between ideas. However, the presentation of a concept map before a reading can influence what is remembered about that reading by creating an expectation, which sometimes serves as a substitute for actual memory. After the fact of reading, a person my remember what they were told a particular passage said, as opposed to what it actually did. There are simple type of hypertext map (2.6.2). NASA library of concept maps. Mind map.

Fig. 4.17 shows a map obtained from a student after that student had read an essay. The student has drawn an illustration of how she thinks the concepts are related. These are like semantic networks (2.1.4).

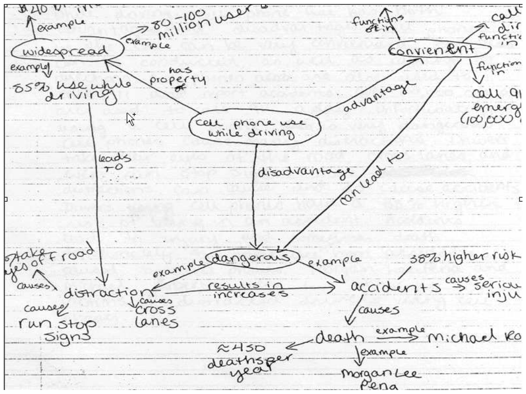


Figure 4.17: A subjective concept map was generated by a student to show how they believe concepts in this domain are connected to other concepts[24]. (redraw)

Conceptual Models for Explanation and Description

Models of a specific concept. Informal and Formal Conceptual Models.

4.4.2. Events and Causation

Events. From events to narrative (6.3.6).

Causation as a type of inference people make. Inference of causation often depends on models. Understanding causation in physical systems is often relatively straightforward. As illustrated by Fig. 4.18 we can confidently say that when a rolling pool ball hits a stopped one, that the impact starts the second one rolling. Is causation anything more than correlation[41]? Just because the sun has always up in the morning, are we sure that it will come up tomorrow morning? Causation is essential to narrative. Causation and agency. Determinis, causation, and free will.

The language of causation. “The cause” versus “A cause”. When can we infer that there has been a cause? Understanding of causation is often associated with developing models. Scientific models can help provide confidence about these assertions, but even those are still simply confirmed from cumulated observations. Judgments about causation of social activities is trickier than judgments of physical causation. Causation in attribution (5.5.2) and in science ((sec:sciencecausation)). Reasoning about causation. Necessary and sufficient conditions. Causation as a state change. Covariation and temporal sequence. Multiple causation: INUS [?]. Causation versus means-to-an-end.

Causation also affects mental models and expectations (4.4.4) as well as decision making ((sec:decide)).

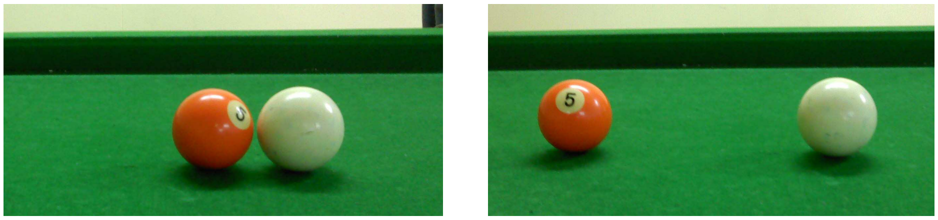


Figure 4.18: When one billiard balls hits another one which is at rest, the second one then starts moving. So long as there is not a long delay, we conclude that the collision caused the second ball to start moving.

Causation of the behavior of complex systems is hard to asses. Complex causes: Multiple causes and causal chains. Indeed, for complex systems, causation is often indirect and difficult to isolate. In cases where the rate of adaptation is slow, it is useful to understand the relationships.

Social causation is based on intentions and is far different from physical causation. Multiple factors to combine for any event but usually we identify just one or two as the cause. Minimal set of sufficient causes. More on causation (-A.10.2).

Complex causes: Multiple causes and causal chains. Indeed, for complex systems, causation is often indirect and very difficult to isolate. Because of the complexities there dangers in inferring causation. Our expectations about causes will bias perception and understanding. Informal causal models. Causal misconceptions and credit assignment (-A.11.3)(Fig. 4.20). Some of the problem nay be the mental models (4.4.4) and even the category systems.

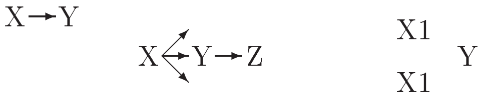


Figure 4.19: Qualitative causal graph. (not finished)

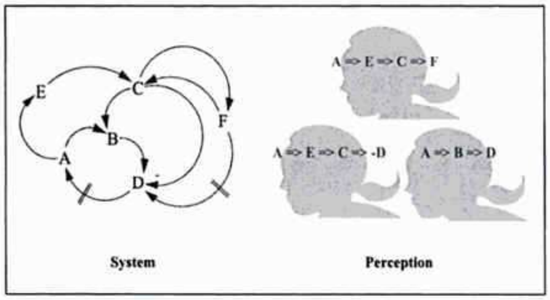


Figure 4.20: People interpret the causation of complex systems very differently. These interpretations also affect later decisions and memories. (check permission), (redraw)

Discourse (6.3.2). Narrative and plot (6.3.6).

Causal relationships in complex systems (-A.10.2) may be model with system dynamics models (Fig. 4.21). These are composed on stocks and flows (Fig. 4.22). Stocks are reservoirs which store values and can create delays in processes and flows link stocks.

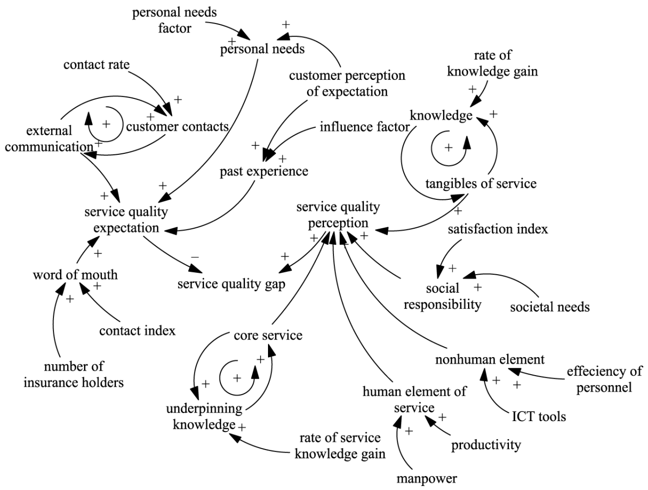


Figure 4.21: Causal loop models as developed in the field of Systems Dynamics provide approximations to complex systems. (redraw)(check permission)

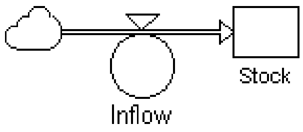


Figure 4.22: The basic components of system dynamics models are stocks and flows. Stocks are reservoirs and flows control the rate of flow into the stock. (redraw)(check permission)

4.4.3. Expectations and Memory

We rely on expectations all the time. Mental models are what are in a person's mind. They are the expectations or causal narratives people have about situations. Whereas a conceptual model is external to a person, the mental model is internal; but, they are closely related. Expectations as preconceptions.

Expectations seem to affect memory. Retrieval failure or changed memory. Human memory is very different from representations housed by traditional databases; it is not exact and the memory itself can be affected by expectations, prejudices, or stress. If a person is asked to recall a story, there are often omissions and intrusions of new material (Fig. 4.23). These are story schemas. Distortions may be amplified because a story does not conform to expectations. Similarly, our memory of the events we observe may be flawed by expectations. Narrative and human experience (6.3.6). For human cognition, the representation is confounded with the cognitive processes so they may not be distinguishable. Social expectations based on culture and norms.

4.4.4. Mental Models

Mental models are one model for how expectation arise. People may develop mental models to represent their understanding of procedures (3.5.1). Procedural knowledge, however, varies greatly in its complexity, function, and type. Automobile mechanics need to understand cars at a different level than do auto drivers. In cognitive terms, people need a mental model of an appropriate level for whatever task they need to complete. Computer users generally need to know more about the options in the interface than about the internal workings of the computer, whereas a computer technician needs a detailed knowledge of both.

Mental models are a way of storing expectations. Engaging with mental models is sense-making. Mental models for social action.

The representationsused by mental models are unknown. Observations of the way people interact with simulations of complex systems suggest that they often understand those systems in qualitative, rather

> ... So the canoes went back to Egulac, and the young man went ashore to his house, and made a fire. And he told everybody and said “Behold I have accompanied the ghosts, and we went to fight. Many of our fellow warriors were killed, and many of those we attacked were killed. They said I was hit, and I did not feel sick”.
> He told it all, and then he became quiet. When the sun rose he fell down. Something black came out of his mouth. His face became contorted. The people jumped up and cried.
> He was dead.

> ... He did not know he was wounded and returned to Etishu. The people collected round him and bathed his wounds, and he said he had fought with the Ghosts. But in the night he was convulsed and something black came out of his mouth.
> And the people cried: “He is dead”.

Figure 4.23: A Native American story called “The War of the Ghosts” (fragment in top panel) was recalled two weeks later (bottom panel) with many confusions[16]. The difference seems to show the simplification of the original passage and the intrusion of expectations. (check permission)

than quantitative terms. A wine-maker might simply know that adding more sugar to a fermenting bottle of wine will increase the alcohol content without knowing the chemistry involved. Collaborative mental models. From static mental models to dynamic mental models which represent actions. We might even say that a person’s reality is the sum of all their mental models. People may also have mental models for social interaction.

Mental simulations. Structure building framework.

4.4.5. Diagnosis and Troubleshooting

Diagnosis and troubleshooting attempt to understand the causes of difficulties with a complex system. Many examples from medicine to IT to auto repair. Medical reasoning (9.9.2). Debugging computer programs. Reasoning for scientific information. (Fig. 4.24). Indeed, a great many activities ranging from tutoring to answering reference questions and providing customer service involve some type of diagnosis.

Diagnostic categories.

Diganosis can rely simply on a rote decision tree ((sec:decisiontree)). Or, if human judgement is used it involves matching the behavior of a system to a mental model ((sec:mentalmodel)) of that system. However, as with many inference tasks, there prior assumptions or reliance on misleading information can lead to errors.

The initial presentation of symptoms can be explored by additional observation and testing. Such tests allow the systematic decomposition of problems and elimination of alternative. Testing and problem solving to rule out alternatives. Experience in selecting effective tests. (4.1.1) such as generate and test. Critical thinking (5.12.0).

Diagnosis is more challenging when there are multiple faults and especially when the symptoms of those faults interact with each other.

Qualitative reasoning models for automating diagnosis.

4.5. Beliefs and Attitudes

We make a broad range of attributions about the mental states such as beliefs, goals, attitudes, opinions, and values. These are informal, and often contradictory, descriptions.

While some models of human cognition assume that the representations of information is based on Aristotelian categories, other representations have also been considered. Models of beliefs and attitudes often seem to assume fuzzier representations. In a sense, they are like prototypes. Moreover, in some

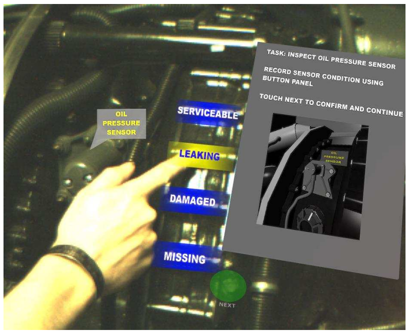


Figure 4.24: Support for diagnosis and repair with an augmented reality overlay[32]. (check permission)

cases, all of these terms sometimes refer to a general orientation and at other times to more specific issues. Beliefs often reflect expectations about social interaction. Opinions, which are generally thought not to have a strong affective component, are covered elsewhere. Attitudes are related to beliefs but include some emotion. Values. Opinions.

Inferences about future events. Optimism bias [**?**] relative to an objective view.

4.5.1. Beliefs and Belief Systems

Beliefs

Beliefs are the expectations about the state of the world upon which a person act. Belief is intertwined with the confidence. Beliefs may reflect expectations and inferences. Some beliefs may be the result of extensive inference from other knowledge or beliefs.

Beliefs for conceptual organizations and beliefs about the state of the world.

Two senses of beliefs: "I believe it is raining today." versus "I believe in you."

Framing a debate to emphasize certain beliefs. Reasoning about beliefs.

Beliefs and what is considered to be valid evidence. Beliefs from a trusted source. In modern society, many beliefs are based on scientific principles. Beliefs and science. Mental models as beliefs about actions and outcomes.

However, many intutions are simply incorrect. A simple example is the gambler's fallacy described above.b

People's misconceptions. Complex narrative. True believers. World views. Handling contradictory evidence.

The beliefs of one person can seem tenuous. What should we make of claims about UFO? Even when a claim is disproven, some people may continue to believe in it and just modify it slightly[33]. [63]. But, it's also true that everyone accepted some things on faith. Beliefs apply particularly to social attribution and categorization (5.5.2) of social motives since we have little confidence about them. Pseudo-science (9.2.2).

Figure 4.25: Some people believe that UFOs are staged; some people do not. (check permission)

Given the ambiguity, people's beliefs may often reflect positions that benefit them. But what is the cause-effect.

Accepting the accuracy of a fortune cookie. Horoscopes (Fig. 4.26). Conspiracy theories. People may use narratives to make inferences about beliefs. Conformity and beliefs.

> It won't be one of your greatest days. If you've been on a roll at work or school, then today may introduce a slight slump, thanks to pesky influences. Take a leaf out of Gemini's book and take it slowly: don't rely on it all working out: a plodding, measured pace will ensure fewer mistakes!

Figure 4.26: Horoscope example. People believe such statements apply to them even if they are entirely generic. (check permission)

Belief Systems

Belief systems are networks of inter-connected beliefs. They are coherent to a point. Beliefs and cultural values (5.8.2). Core beliefs. Ideology. Cultural origins of belief systems.

Many belief systems are internally coherent and are readily accepted when accompanied by social pressure. Shifting from one framework to another under extended subtle pressure is sometimes termed "brainwashing".

Belief systems are often not based on logic; rather they are often based on culture (5.8.2) and self-interest. Many belief systems are internally coherent and are readily accepted especially when accompanied by social pressure.

Stories of causal relationships. This is sometimes described as "creating a narrative".

Representing Beliefs

Some efforts have been made to model such beliefs (-A.7.4)[58]. It's unclear whether the detailed beliefs are stored or whether there is a continual process of interpretation from the core beliefs. Indeed, sometimes elaborate belief systems may be constructed based on just a few core beliefs. These are often associated with culture.

How do people make inferences based on belief systems. Beliefs vs conceptual systems (1.1.4).

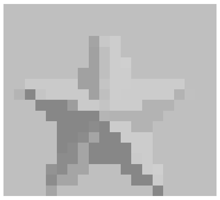


Figure 4.27: Belief network.

4.5.2. Attitudes

An attitude is an orientation toward an object or concept. As such it, it more than a purely cognitive connection. An attitude incorporates a context which makes them fuzzier than concepts. It may be viewed as emotion inflected cognition. The term is sometimes used interchangeably with beliefs but more generally, attitudes include an affective component (4.6.2). Attitudes are widely used to explain behavior. For instance, attitudes are considered useful predictors in determining adoption of a new technology (7.9.6).

Unlike models of inference discussed earlier, inference involving attitudes is more like constraint satisfaction. This is also sometimes described as field theory which can be thought of a a type of constraint processing.

Attitudes are inter-related and generally coherent. Theory of Reasoned Actions. Among other factors attitudes and beliefs often reflect a person's self-interest[9]. Conformity is a tendency for the opinions of members of a group to converge. High-status individuals often can be opinion leaders. Relationship to norms (5.3.1).

People are usually attracted to people with similar values and they also tend to adopt additional values from those other people. Thus, values tend to cluster within a group and may be polarized from other groups [**?**].

Figure 4.28: "Well Heck, If all of you smart cookies agree, who am I to dissent?" As an illustration of conformity in conflict with an expectation for independent judgment. (redraw-K) (check permission)

Selective Exposure Theory (Confirmation Bias)

Attitudes seem to affect the willingness with which people accept new information. People tend to seek out opinion statements that are consistent with their beliefs and avoid opinion statements that are inconsistent with their beliefs. We may have a certain attitude toward one political party or another, and even a great deal of rational evidence may not convince us to change that opinion. However, there are also times when people will seek out perspectives which are contrary to their own.

Not only are attitudes correlated with actions, but attitudes seem to affect the selection of information sources. A person from given political party may prefer literature consistent with that party's message. Though, of course, there are also some times when individuals will seek on opinions and facts which do not support their own beliefs.

From Attitudes to Intentions and Actions

Attitudes generally seem to predict behavior. When they do not predict behavior we may look for other constraints. A person many not act on their attitudes if are being paid to do something else. We might get a better indication of a person's likely behavior by asking them about their intentions (Fig. 4.29). Even a decision to act may not result in a completed action if, the person is physically blocked from being able to do that. While attitudes are generally predictive of behavior, and the usual assumption is that attitudes actually cause behavior (e.g., Fig. 4.29) an alternative model suggests that in some cases, behavior causes attitudes[18]. This difference has implications for attitude change.

Intention versus practical action. BDI model for plan recognition (3.7.2) and agents (6.5.3). Propositional attitudes.

Forming and expressing a plan makes it more likely for that plan to be acted on.

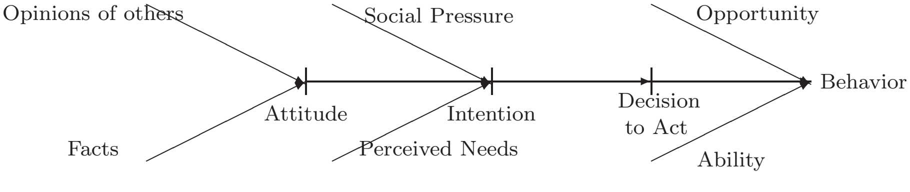


Figure 4.29: The usual model for attitudes proposes that attitudes lead to intentions and eventually to actions. We may have an attitude about voting. That is carried into an intention, a decision to act, and ultimately actual behavior. [9].

Attitude Formation and Change

Attitude change can be hard. While attitudes are resistant to change, we can explore the situations in

Figure 4.30: An alternate model of the relationship between behavior and attitudes, behavior may be used to infer as attitude: Behavior may be determined by past experiences and not by attitude. The same logic could also be applied to the origin of beliefs.

which do change. Information plays a part in the development of attitudes, but other emotional factors also contribute. One of the most important factors is source credibility. Indeed, this is consistent with sensible information literacies (5.12.2). There is a relationship to argumentation and rhetoric (6.3.5) through the presentation of reasoned arguments.

Persuasion includes both attitude change and ultimately changes in behavior. Advertising is an everyday example of persuasive speech. Some advertising is primarily informational, in that it simply tells you about a product, but advertisers also use other, more subtly persuasive tactics. Persuasion and belief revision.

A new car may be advertised as making you likely to catch the attention of attractive members of the opposite sex. Other techniques include an appeal from a person of apparent high status, or grabbing a person's attention and goodwill with images of dogs or children, which has the halo effect of generating goodwill toward the product. Fear can facilitate attitude change. For instance, in showing the health consequences of cigarette smoking. However, many people eventually learn to ignore that message. Dual processing models are information processing models for how persuasion might work.

Social media, data mining and persuasion.

Persuasive technologies. Persuasive games.

Attitude Change Simply makeing specific plans may enhance the likelihood of action.

4.6. Emotion, Affect, and Motivation

While we have focused on information systems; human being, of course, also depend on a biological system – their bodies. People have biological needs for air, food, water, minerals, and moderate temperature. People are not just neutral information processing machines, but there is a close connection of information processing and decisions with their biological needs. Social interaction has a strong aspect of emotion and affect. Brain science (-A.12.2). Social affect and the social brain (-A.12.2). For instance, there is a distinct part of the brain devoted to face recognition. Relationship of cognition to emotion. Emotion is more automatic. Embodied Action.

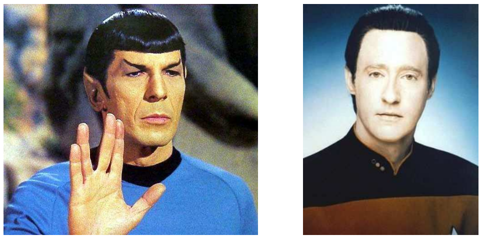


Figure 4.31: The conflict between human reason and human emotion is a common theme of science fiction as illustrated by the characters Spock and Data in *StarTrek*. (check permission)

4.6.1. Physiological Arousal and Emotion

It turns out to be important to distinguish physiological around from emotion. Unlike learning, emotion is transitory and generally does not change a person's mental representation. However, there is research to the contrary. Regardless, we may also judge emotions in others by observing individuals and drawing conclusions about their situations (5.5.2).

An individual may experience dissonance — a discrepancy between the expected and actual outcomes of events and a generalized physiological reaction. Simple physiological arousal is a strong component of emotion. Indeed, one theory even asserts that emotion *is* simple generalized physiological arousal, to which the individual applies a label consistent with the situation. This is a type of social categorization (Fig. -A.115). Interaction with cognition, such that the "fight or flight" reaction can be minimized if it the cause of the noise is benign. A violation of expectations often leads to at least a mild emotional reaction and to learning. It is accompanied by a surge of dopamine which is a potent neurotransmitter (-A.12.2).

Emotion affects cognition and decision making presumably because it reduces cognitive processing capacity[46]. Emotions can be too immediate and powerful to allow much analysis outside of them, yet these very same emotions demand immediate action. Emotions affect memory and attention. Emotion reduces human information processing capacity (Fig. 4.32).

Figure 4.32: Emotion reduces cognitive processing capacity.

Humor and surprise.

Fear and aggression. Violence and arousal and video games[13] (5.9.4), (11.7.0). Bio-sensors can also be used for health monitoring.

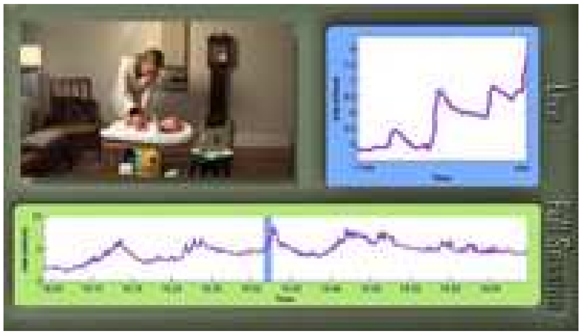


Figure 4.33: Designing for affect. Wearable bio-sensor[7]. (check permission)

Two models: imitation and catharsis. Increasingly, interfaces attempt to monitor and adapt to human emotion; this is an example of expressive and affective computing (4.6.2).

Determining Emotions in Ourselves and Others

Important to know the reactions of others. Emotion as signaling to others. While emotions serve a biological function such as spurring us to action in the face of danger, or bonding us to another to aid in the propagation of our species, the expression of emotions also serves a social function. We have a rich vocabulary for describing emotions, from "hate" to "love," and we freely apply those terms to ourselves and to other people. Emotions perform various functions in society, primarily serving as a basic means of communication between individuals. Guilt, for instance, is a fairly specific reaction and does not have specific correlates. Attribution (5.5.2). Emotions demonstrated by gestures. Social significance of smiling[65].

Facial displays. Identifying the different types of emotions. Perhaps emotions can be explained as a type of social categorization[56]. One theory suggests that individuals cannot accurately sense their own emotional states, and so use external cues in their environments (such as the reaction of other individuals) to help them determine their own emotions[62]. When we observe emotions in other people, we may depend on biological signals such as extremes of facial expression (Fig. 4.34). However, there is much research indicating that these extreme facial expressions are not culture specific; rather that they are understood by everyone, regardless of the culture in which they were raised.

Avatars generating appropriate facial expressions.

Figure 4.34: Expressions which are at the extremes of the Facial Affect Coding system: Anger, fear, surprise, disgust, happiness, and sadness[31]. (redraw-k) (check permission)

4.6.2. Affect and Aesthetics

Affect

Affect is a weak form of emotion. Affect and communication of social intent. Regulation of affect and self (5.5.1). Affect is interwoven with attention (4.2.2) and higher-level cognitive processing. Affect from social interaction. Mining affective texts and speech (10.5.3).

Experience management. Entertainment (1.6.1). Group interaction. Affect and tutoring. Affect is integral to almost all human action. This is it natural to incorporate it into under interfaces. Games (11.7.0). Affective design. This may include designing to induce and manage affect. Or designing to develop a meaningful interaction with an artifact. Gamification supporting user engagement.

Pleasure and Aesthetics

Some objects and environments give people pleasure. This is often by blurring conceptual or emotional boundaries.

Interest and engagement. Aesthetic responses, such as the pleasure from a piece of music, are weak types of emotion.

Mere familiarity can have a big effect on preference. Remarkably, mere exposure to stimuli leads to preference for them[69]. Similarly, as suggested by so called "hidden profiles", people prefer positions with which they are familiar[6].

Pain. Anger.

What is beauty? Mood. Engagement. Music selection systems.

Rap. Poetry. Trope such as a turn of phrase or allegory.

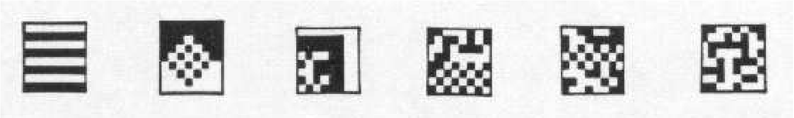


Figure 4.35: People show more interest in patterns with a moderate level of complexity such as those in the middle of the diagram as compared to the ones on either end (adapted from[19]). (check permission)

Entertainments provide an emotional ride.

Interaction with Emotion Inducing Information Resources

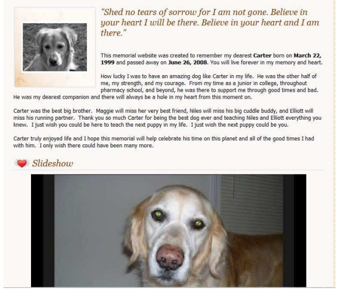
Comparable to information behavior which we discussed earlier. Aesthetics. Everyday aesthetics. Art:

Visual (11.1.1), music (11.3.2), and dance (11.5.1). Presumably, horror movies are popular because they provide an emotional jag. Self-management of aesthetic material. That is in some cases, people clearly enjoy strong emotions.

People also sometimes prefer visual novelty and complexity [20]. When viewing artwork, often the greatest preference is for objects with moderate levels of complexity (Fig. 4.35); complexity seems to affect interest and attention. People manage their moods; they generally avoid boredom and often seek excitement [12] [70].

Increasing difficulty of video game levels. Anger management.

Memorials. Reconciliation. Commemoration. This can also be seen as a type of cultural record (5.9.3).



"Shed no tears of sorrow for I am not gone. Believe in your heart I will be there. Believe in your heart and I am there."

This memorial website was created to remember my dearest **Carter** born on **March 22, 1999** and passed away on **June 26, 2008**. You will live forever in my memory and heart.

How lucky I was to have an amazing dog like Carter in my life. He was the other half of me, my strength, and my courage. From my time as a junior in college, throughout pharmacy school, and beyond, he was there to support me through good times and bad. He was my dearest companion and there will always be a hole in my heart from this moment on.

Carter was the best big brother. Maggie will miss her very best friend, Niles will miss his big cuddle buddy, and Elliott will miss his running partner. Thank you so much Carter for being the best dog ever and teaching Niles and Elliott everything you knew. I just wish you could be here to teach the next puppy in my life. I just wish the next puppy could be you.

Carter truly enjoyed life and I hope this memorial will help celebrate his time on this planet and all of the good times I had with him. I only wish there could have been many more.

Figure 4.36: Pet memorial Web site. (check permission)

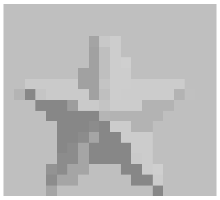


Figure 4.37: Attachment to objects. (check permission)

4.6.3. Motivation

The basis of motivation is survival needs such as food, shelter, reproduction, and related needs such as sleep. People will also work to avoid things which hurt them some of which are indicated with the painful stimuli. People often prefer novelty. There are advantages for people to explore and know about their environment.

Maslow's needs. This could be considered a motivation ontology. There are also many types of social motivation. Sociability, social recognition, and social engagement are often highly motivating. Social factors, such as fear, shame, or anger also play a role in an individual's decision-making process. Social approval and status can also be highly motivating. Social pressure. (5.0.0).

Pure information processing does not focus on motivation. Indeed, in Western culture there is a long tradition of considering the mind as something separate from the body. The expression "The mind is willing but the flesh is weak" echoes this belief. Because these two components are often thought to act independently, this notion is called "dualism". However, there are many reasons to dispute this traditional separation. Models of emotion and information processing. This is also related to other dualisms such as intention vs action, and belief vs conduct. The physiological system can be seen as complex system that seeks homeostasis although this can be complicated by addiction (-A.12.2).

Intrinsic motivation for, instance, in games. Mediated intimacy. Emotional health. Empathy (5.5.3). Motivation and brain science. Motivation and addiction.

SIMS modeling motivation.

Incentives and Rewards

People will clearly work for rewards. Extrinsic and intrinsic rewards. Setting up contingencies and incentives. As noted in the following section, money for rewards adds complications. User engagement as an incentive. How should we structure incentives?

Gamification points and explitic rewards. Resistance to explicit rewards (4.7.0).

Incentive can have a negative effect. For instance, a person who is paid to read a statement with a controversial opinion may later change his/her own opinion toward the controversial opinion later if paid a small amount but that change is less is the person is paid more. Sense-making is derived from dissonance. People make inferences not only from what they say but also from the conditions in which they say it. Complexity of actual motivation but also the perception of motivation.

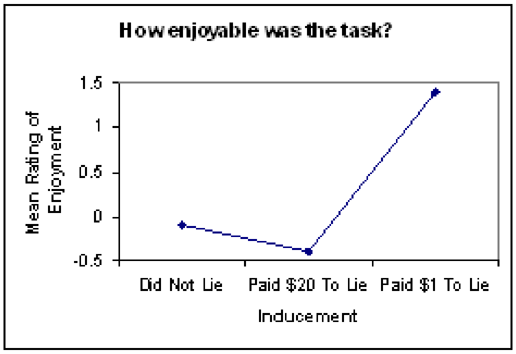


Figure 4.38: Dissonance illustration. (check permission) (redraw)

Learning, Affect, and Motivation

There are many reasons we learn but one of strongest is learning based on motivation. However, motivation is essential for instrumental learning. That is, for learning how to do things which fulfill goals. Attaining motivators is rewarding. Motivation and working for rewards. Motivation seems directly tied to learning. We are more likely to learn something if there is a clear motive for doing so. Biological systems also show adaption and a kind of learning. The human body stores excess food in the form of fat to protect against times when food is not available.

Social interaction is itself a strong motivation. Because they are essential to human life, the basic human needs are interwoven with human social organization, family, and culture. Social motivation and altruism. Social isolation reduces social control mechanisms. [34].

Cognition, Social Factors, and Motivation

Cognition can affect the perceived value of rewards. For instance, a person may discount value of an actions if the reward is perceived as being too large. Activities in the real world have multiple tradeoffs. Contingencies and incentive. People may not take an immediately-available alternative and to wait for another one. While this “delay of gratification” may be beneficial, it is difficult to learn[54]. Internal monitors. Internalized motivation. Self-efficacy[15]. Self-regulated learning. People’s judgment of their capabilities.

4.7. Psychology in the Wild

In one sense, this whole chapter is about psychology. In the sense here, psychology describe decisions and tradeoffs of the whole organism. Bias toward stability.

Many apparently common-sense expectations about behavior such as the response to policy mandates are wrong.

Frequency of exposure effect.

Judgment of responsibility. Internalization of trust.

Saving face. Information avoidance. Self-expression. Interaction of concepts, beliefs, attributes, emotions, and motivation.

Information overload. It often isn't possible to access all information about a topic. So, there has to be triage. That is, picking and choosing the most promising sources. Information phobias. Psychological disorders.

Interacting with other people. Social incentives. Karma points.

In some cases, human behavior can be easy to understand. We have seen that aggregate crowd behavior can be predicted reasonably well. Similarly, behavior in constrained situations can often be predicted well. Human behavior in more complex situations is very difficult but would be very useful to predict. Similarly, developing intelligence agents with plausible human behavior would be of great interest for interactive environments such as games and teaching. Artificial Psychology. Application to avatars and video games (11.10.3). Conversational agents (11.10.4). Parallel to artificial intelligence. Affordances. Modeling attributions. Modeling and predicting human behavior.

4.8. Human-Computer Interaction

The field of HCI deals with the design and development of interactive user interfaces. There are many dimensions to the interaction of people with information systems. Some of the interaction depends on the task, some of the structure of the information, and some on the cognitive processes and affective responses of the person, or perhaps of a team working on a project. Thus, human-computer interaction can deal with very narrow tasks and very specific interaction techniques and on the other hand, it can deal with relatively complex sequences of actions as people complete tasks. The emphasis on interaction broadens into considering the impact of activities than the interface design itself or the task activities employed and those issues are discussed later. Hierarchy of levels of interaction. Increasingly resembles social interaction rather than tool-based interaction.

Design process with prototyping.

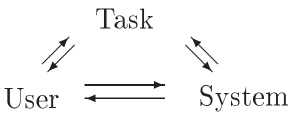


Figure 4.39: Task-Users-Systems. Here the focus on the interaction between the user and the system.

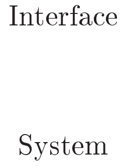


Figure 4.40: Hierarchy of levels of interaction.

Persuasion, simulation environments. Embodiment. Interaction with social agents.

Constraints for design can include technology, organization issues, user capabilities.

Specific application of cognitive issues in problem solving and task completion. We already explored some issues for supporting collaborative interaction. Detailed understanding of the tasks to be accomplished and the steps needed for completing them.. Activity theory (3.5.1). Applying design methodologies such as scenario-based design (3.8.0).

Technology both reflects and shapes organizations and society. In some cases, complex information systems are a poor fit and are rejected. Finding a balance between system needs and user needs and abilities. This is does with use cases and interface design principles (4.8.2). TAM (7.9.6). Agency and user control. How much should a user know about what a system is doing on their behalf. Markus' interaction theory.

When we consider interfaces for complex activities, we need to include understanding of the task the user is tying to accomplish. This, then, involves consideration of requirements; in particular use cases (3.10.2). Design (3.8.0)steps include: Goals, claims, assumptions, technologies[60].

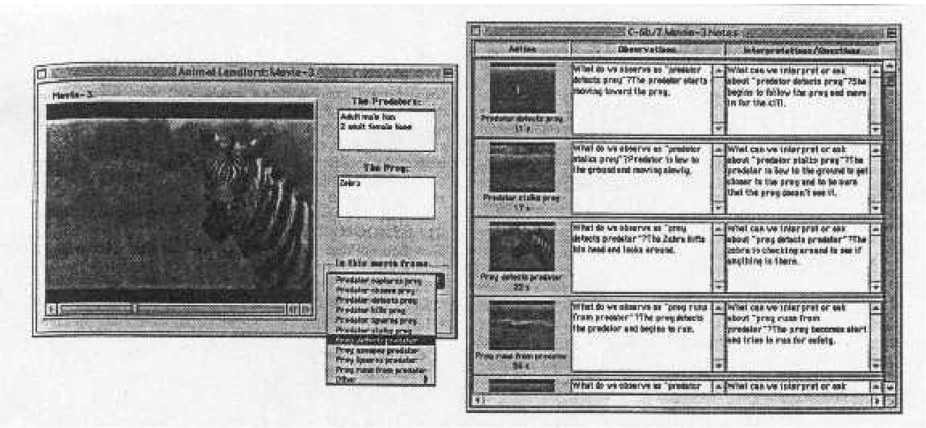


Figure 4.41: Structured input. (check permission)

Ergonomics and human factors.

Genres of interaction: command languages, WYSIWYG, mobile/social.

4.8.1. From Interface to Interaction

Both people and computers are very flexible. Both are able to adapt (or be adapted) to new situations, often in unlikely ways. Interactive systems limit and direct a user's behavior.

Confidence in estimates of utility (-A.9.4). Economic analysis (8.7.0).

One such heuristic claims that "an interface should strive for consistency". Consistency provides users with expectations of where to find things and facilitates the transfer of skills from one task to another. Consider the design of desktop interfaces — a person with no knowledge of a particular program is able to navigate through it fairly easily because of design consistency. However, all such heuristics are limited. There can be consistency within a single tool but may be inconsistent with the design decisions made for other tools.

Dimension	Description or Example
Internal	Within a single tool.
Desktop	Across a set of tools on a desktop.
Real-world	Virtual environments are consistent with the "real world".

Figure 4.42: Three dimensions of consistency for user interfaces (adapted from[36]).

Building applications based on user interface requirements (7.9.1) and designs (3.8.0)

Design and evaluation are closely intertwined but we will try to discuss them separately.

4.8.2. Interaction Design and Evaluation

Different levels of design – from task to action.

Applications versus environments. Desktops (3.5.4).

Interaction Design

Design for complex and interacting activities. Several strategies have been proposed for designing interfaces. Ultimately, design reflects cultural values.

Scenario-based design and activity scenarios [22]. Scenarios have: Actors, background, goals, and sequences of actions. Claims analysis provides explanations for some of the design decisions. Consider different types of users. Use cases (3.10.2).

Design of user interfaces and design of computer programs [?] or, of information systems. Interface design prototypes and as part of the design cycle (Fig. 4.43). Story-board and scenario-based design.

Design for engagement and sociability.

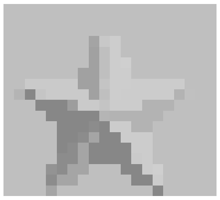


Figure 4.43: Lo-Fi vs Hi-Fi prototypes.

Interface Engineering

When the user behavior is highly predictable, systematic support can be developed. Perhaps, we could use them to engineer an interface, much the way that other engineers design a bridge or a rocket. Quantitative models focus on data and specifics to increase usability. Predictive models for interface design might be based on psychological principles. Specifically, we can apply models of perception (4.2.1) and motor behavior to predicting the time users spend making responses. However, the details of the predictions have not proven to be very insightful. State-based models (3.10.1) can describe interaction sequences (Fig. 4.44). This is also related to full use-case diagrams (3.10.2).

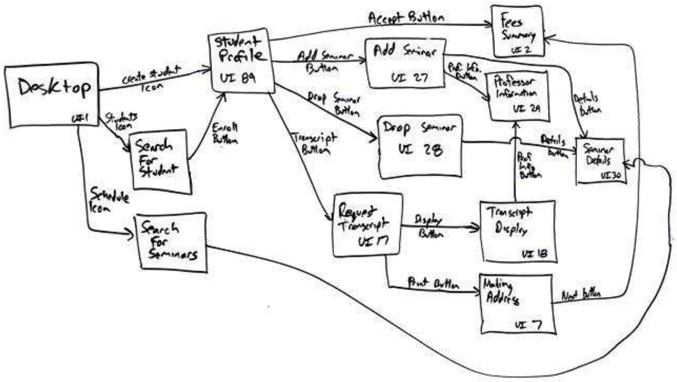


Figure 4.44: State diagrams for interaction with a user interface. (redraw) (check permission)

Eq. 4.3 suggests that a response is simply the sum of component activities (cf. [21]). Thus, we might expect the amount of time spent to move a mouse to a target would simply be the sum of the time for understanding the task (C), the time for finding the target (P), and the time for moving the mouse (M). We might estimate that a task would require 1.1 seconds of cognitive time, 0.3 seconds of perceptual time, and 1.0 seconds of motor time for a total of 2.4 seconds. While this approach works well, it may be limited by not allowing for the user to do two of these activities simultaneously.

$$response\ time \quad = \quad cognitive\ time + perceptual\ time + motor\ time \tag{4.1}$$

$$R = C + P + M \tag{4.2}$$

$$2.4\ sec = 1.1\ sec + 0.3\ sec + 1.0\ sec \tag{4.3}$$

Fig. 4.45 shows how formulas like Eq. 4.3 calculates the times of experienced users completing edits with two text editor deletion commands as a function of the number of characters being removed. A projected third command (dotted line, Method S) might save a few seconds in the region where it crosses the functions of the other two commands. To determine whether it is worthwile to add the new command, we need to compare the benefit of time saved with the difficulty involved for the user in having to remember the additional command. Multiple feedback mechanisms.

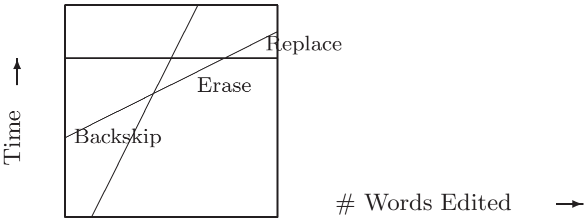


Figure 4.45: There are (at least) three ways that a word substitutions could be made with a text-based word processing system. This model attempts to predict the time for each of those options. Give such predictions, we might then be able to decide whether including all three commands was useful given the extra effort required to learn and remember the command[21].

There are many other factors which must be considered in any tool design such as the amount of time the user will spend with the tool and, thus, the number of features and options which that user will be able to remember. The physical characteristics such as display size, its "form factor", can affect the effectiveness of a device (Fig. 4.46). A large display gives a sense of physical presence and, indeed, of social presence (5.6.5). Protocols.

Figure 4.46: Small and very large display form factors give very different effects. Attempting to display complex information on a small screen. (check permission)

Minimizing errors.

Task and Job Analysis

This follows the workflow specification. Understanding what needs to be done versus re-designing the tasks. Representing tasks. Hierarchical task models. Task operators. Beyond workflows to include mental times and user knowledge. Indeed, a wide range of formalisms have been proposed. There is an ongoing debate about the relationship of these relatively formal task models compared to narrative-based approaches such as scenarios.

This specification can also be useful for documentation (7.9.6). At a deeper level, the task specification is also related to the user's cognition. GOMS. Cognitive task analysis (CTA) extends task analysis

(3.5.4). What do people actually do to complete a task[37]. Cognitive task analysis - what is the task from the user's viewpoint.

4.8.3. Evaluation Strategies

Expert reviews. Experiments. Discount usability: think aloud, heuristic evaluation.

In a cognitive walkthrough, the designer describe the features of the system to another person[67]. A similar technique can be used in evaluating complex multimedia productions[40]. Combine technological developments with human needs. Cognitive walkthrough for metadata.

4.9. Individual Differences

People differ from each other in many ways. There are physical differences such as height and behavioral traits such as handednesss. Presumably, these are based in physiology. There are also learned differences such language and culture as well as social role differences.

Rather than focusing on general principles of behavior and cognition, we could focus, instead, the ways in which individuals differ. They differ in the languages they speak, in their physical abilities, and in their preferences. The origins of these differences are widely debated; in some cases these differences may be biological and in other cases the differences may be due to experience or education. Representations can be built into applications

The origin of individual differences may be different experiences, cultures, and expectations or it may be more deep seated such as physiology and genetics predispositions. Knowledge work, or the process of obtaining or constructing new knowledge, is highly individualized. Every individual has a method of working that best suites them. While standard techniques and processes may be important and useful to know for virtually all people working within a given area, the ways in which these techniques are applied by individuals are too numerous to list. Information systems are applied differently by different users. The difference of adapting to the users and adapting to the tasks of the users is often confused.

Digital divide.

4.9.1. Cognitive Differences

These cognitive differences are intertwined with other differences among individuals, such as age. Fig. 4.47 shows a test for spatial ability. Spatial ability seems to be relatively consistent to be related to activities such as navigation, and it predicts the ease with which a person can use a graphical interface[8]. Spatial neurons (-A.12.2).

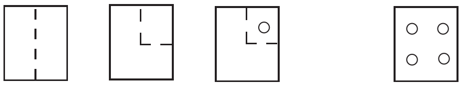


Figure 4.47: Paper folding test for measuring individual differences in spatial abilities[8]. The student is asked to decide if holes punched in a folded piece of paper, as shown in the sequence on the left would produce the pattern in the unfolded piece of paper shown on the right.

4.9.2. Age

Passages. Stages of life. Individual differences in information needs. Youth services (7.2.1). Role in proving community information.

Children

At one extreme of the age spectrum, children have limited knowledge and cognitive processing skills. Children learn differently from adults. While strict developmental categories has proven to be too simplistic[59], Classification systems to help children locate materials may need simplified categories. Young people generally have more difficulty finding facts than complex information. Difficulties of young people in formulating queries for search engines and then in understanding the results of search engines. Cognitive abilities by age. Working with children in developing user interfaces[43]. Language and age (6.1.3).

Older Adults

At the other extreme, elder users, who make up an increasingly large segment of the population, often have limited perceptual motor abilities, or they may have age-related diseases. As we discuss when considering differently-abled users, age affects us all. Eyesight deterioration is a common consequence of aging. Management of chronic pain.

Figure 4.48: Big buttons can help the elderly. However, even if the buttons are large the functionality can still be a challenge. (check permission)

Age limitations.

4.9.3. Disabled Users

Human beings are fragile. Varying degrees of abilities. As a result of accident or birth, people differ from one another in their abilities to perform certain tasks. Some of these differences are based on physicality, while others are based on cognition. Impairments may affect one or the other of these components. How do we compensate for these differences? Often this just means that a response for a given action takes longer. However, if a system were designed to better meet the needs of a differently-abled user with more thorough interface engineering, this response-time delay could become negligible. Impairments due to health-conditions.

Everybody is “differently-abled” in some sense. People can be color-blind, very tall, very short, unable to hear, to smell, to see, unable to walk, unable to run fast, uncoordinated, bad at math, bad at art, or even temporarily “differently-abled” such as being unable to use their hands when driving. Allowing systems to be tailored to suit individual needs would allow more people to participate in more tasks more effectively. Ideally, we would have tools which are usable by everyone – that is they should have universal usability. Substituting modalities and motor capabilities. We might support brain damaged patients or senior citizens.

Disabilities research to provide compensation for the disabilities.

Assistive technologies. Stakeholders for assistive technologies.

Sensory Disabilities

There are many ways for people to acquire information about their environment. Some modalities are better than others for imparting certain types of information. Music is obviously best delivered using an audio modality. Some modalities may be substituted for other modalities.

Visual impairments range from poor sight to color blindness, to complete blindness. There is a correspondingly large range of visual enhancements that can to overcome a visual deficit. These include providing descriptions of actions to support interactivity; magnifying text using video; touch screens that also involve speech for developing a mental map of a Web site; speech versions of text documents or descriptive videos. However, vision may even be replaced in some circumstances. Speaker characteristics can be controlled in text-speaking programs so that a different inflections can represent links, for example. Menu options can be spoken rather than displayed, and Braille generators are getting cheaper, though there remains the difficulty of representing images in Braille. Reading disabled and automated text-to-speech reading programs. Adoption of assistive technologies - who are the stakeholders.

Ebooks for the blind. Labeling graphics. Mobile phone apps for blind. Color identification. Sceen identification.

Screen-readers. Closed-captioning can be used for people with hearing loss to allow them to read what is being said. An avatar (11.10.3) can train students who want to learn lip reading[25] (Fig. 4.49). Alternatively, automatic lip reading systems might be developed.

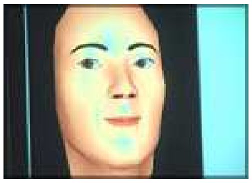


Figure 4.49: An avatar can help teach lip reading[25]. (check permission)

Motor Disabilities

Until recently, computer effectors have been primarily limited to keyboards and mice. These have proven very effective for the majority of users, but some people may have difficulty with these devices. Some motor-impaired users can simply switch to standard devices such as track-balls. Other options are typing via head motions, or using speech control for a Web interface. In some cases, one can enter text by blinking, or control a keyboard by blowing into a tube (Fig. 4.50). More fundamentally, if a task can be decomposed and reduced to its most fundamental and necessary elements, it can then be optimized for different modalities.

Figure 4.50: The physicist Steven Hawking has Amyotrophic Lateral Sclerosis (ALS), also known as Lou Gehrig's Disease, a neuromuscular disease. He often uses a speech synthesizer that is controlled by eye and mouth movements. (check permission)

Cognitive and Learning Disabilities.

Cognitive and learning disabilities are often neurological. Whether present from birth or brought on by trauma or disease, people suffering from a cognitive or learning disability may find it difficult to utilize many common programs and systems. However, information systems can be designed to better suit their needs (Fig. 4.51)[61]. Aphasia is the loss of the ability to understand spoken or written words, and it can be caused by an injury or disease that targets the language centers of the brain. Image-oriented design can help those with aphasia to use information systems. Brain science (-A.12.2).

Type	Description
Autism	Difficulty in social interaction
Aphasia	Language disorder. Difficulty with understanding.
AD/HD	Lack of continuity in attention.

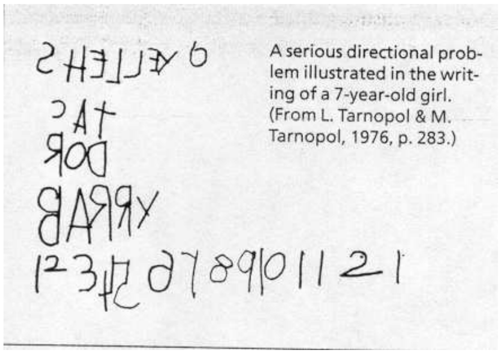
Figure 4.51: A few examples of cognitive and learning disabilities.

Computational behavioral science (Fig. 4.52). Analysis of autistic behaviors. Automated behavioral analysis. Diagnosis (4.4.5, 9.9.2). Interactive environments for teaching autistic individual skills to cope.

Another major group of disabilities is learning disabilities. Dyslexia is a cognitive impairment which affects the use of language This can include difficulties in both reading and writing (Fig. 4.53). It is

Figure 4.52: Detecting autistic behaviors from multimodal analysis[2]. (check permission)

often typified by difficulty associating spoken words with the same word when it is written; letters in a word appear to be out of order. Design-based aids for dyslexia can often be relatively simple: font changes and re-readers can help people with dyslexia process information (10.2.0). Brain science and dyslexia (-A.12.2). Also, schizophrenia.



A serious directional problem illustrated in the writing of a 7-year-old girl. (From L. Tarnopol & M. Tarnopol, 1976, p. 283.)

Figure 4.53: Example of writing by a dyslexic[64]. (check permission).

Personality Traits?

A person's behavior is often determined by factors such as the immediate task they are trying to accomplish (3.0.0). A personality trait we ascribe to another person is a models for our predictions about that person. People tend to develop habits to engage in or deal with similar tasks or situations. In many cases, what is called "personality" may simply be a consistent reaction to a consistent environment[53]. Still, there seems to be a type of homeostasis by which people tend to revert to those environments in which they are most comfortable functioning. Individuals interact with their environment. Personality versus roles.

Indeed, it is vvery difficult to make any generalization about categories of people.

4.10. Personal Data, Personalization, and User Models

Big data in science ((sec:bigdatasci)). Medical data.

4.10.1. Application Usage Characterstics

Shopping data.

4.10.2. User Models

We would like to capture, represent, and apply distinctive characteristics of users such as preferences, affective state, needs, and history. In conversations, participants adapt to one other (6.4.0), making allowances for accent, vocabulary, or personality. Indeed, adaptation is a characteristic of many sorts of interaction. Information systems can be designed to adapt to the differences among users. It may often be easier for a system to adapt to the user than for the user to adapt to the system.

User models may be contrasted with mental models (4.4.4), which are expectations that the user has about the computer. Just as a user's behavior is often greatly affected by the tasks in which they are engaged, a user model might be coordinated with the computer's task model that is used for a particular job (7.9.3). Properly coordinated user and task models could allow the system to make routine decisions for people as opposed to allowing them to have an optimal set of choices; this would decrease the complexity of the system, and allow it to be utilized by a wider variety of people. The values of these independent variables can be obtained explicitly from the user. Or, they may be inferred indirectly (implicitly) from some aspects of the user's actions. This can be the basis of complex services such as personalized travel recommender systems. Privacy, data integration. Predicting online behavior.

Assessment to fill those models. Personal assistants that learn.

Affective user models. Adaptive hypertexts and drama management.

4.10.3. Personalization

Personalization can be based on user attributes. Personalization versus situational context. Personalized search (10.11.4). Explicit and implicit personalization. What information about users to capture? Algorithmic personalization may narrow a person's exposure to diverse viewpoints.

Meta-design and human crafters.

Cross-platform tracking and personalization.

Beyond personalization to prediction of a person's behavior. Anticipating and predicting what the person is doing.

Customizable technologies.

Type of Independent Variable	Examples
Tasks	homework assignments
Skills and knowledge	know a location, know how to program
Attitudes and transient personal characteristics	mood, hunger, interests
Stable personal characteristics	marital status, education, languages spoken
Culture and norms	
Demographics, group membership	age, political party

Figure 4.54: There are several levels of detail from predictions can be made about people (adapted from[11]).

Personalization often means specializing by tasks in which a user is engaged. Networking and new computational resources allow transactions to be personalized much more easily than used to be possible. When considered broadly, user models often include task models and even queries. An important factor in the effectiveness of the predictions is the stability of the behavior[52]. There are many applications of user models, such as a personal aerobics instructor moving at your optimal pace, a recommender system (5.5.5), or personalized language generation (6.4.0). Tutoring systems and statistical student (user) models (5.11.3) such as the geometry tutor[14].

Personalization has great commercial appeal as well. Advertisers would like their materials to be relevant to users; this is the idea behind targeted advertising. Advertisers look for user attributes that are most applicable to their particular advertising goals. This streamlines advertising and reduces costs for both the distributor and the consumer. Real-time targeted ads. How to pick the best-match advertisement to present given the fragmentary information about users. Auctioning impressions based on real-time web interaction.

Mass Personalization with Big Data.

4.10.4. End-User Programming

Programming allows the specification of complex constraints. Some programming languages such as Java and C++ are general-purpose. Other programming languages are specific. Among those, some are designed for the end user to do the programming. When programming a VCR, a person may specify the time recording should start and the channel to be recorded. Programming with command languages or by moded states. Spreadsheets. Automate repetitive web-based tasks such as gathering information from an ecommerce tasks. These are often involve lots of semantic structure. End-user communities which can share tools. This can also be used to set personal options – that is personalization. However, programming a VCR is notoriously confusing for some people (Fig. 4.55). End-user programming in the home.

Figure 4.55: VCRs allow users to do limited programming to set functions. However, doing that programming is notoriously difficult for many users. (screen-dump)

4.11. Personal Information Management

Personal information management (PIM) is often close to the tasks in which people are engaged. There are many kinds of personal information such as address books, photographs, voice mails, medical records, and letters. Some of these are digital and some not. And, probably all of us have lost track of some of our personal records.

Importance of family (5.1.1) for personal records. Mechanisms for family record keeping.

In some cases, PIM applies to everyday information but also information management for groups and teams. PIM versus group and team projects. Social Memory (5.13.3). Collecting material about separate individuals to form a picture of a larger group. Different styles of personal record keeping[50]. PIM and personal email (10.3.2) especially nearly complete searchable mail records.

Personalization and privacy.

Citizen archivists. Self archiving. Digital lives (10.3.1) of authors. Personal data. Coordination personal archives. Management of personal sensor data. Self-monitoring for self-improvement. Comparison to institutional archives.

Family bible. Chinese genealogy.

4.11.1. Personal Information Resources and Collections

Information management skills (5.12.0). Organizational work activities. Folders. Connection to social media preservation. Ultimately, this relates to questions of the self and identity (5.5.1) and the nature of archives.

Personal Collections

What a person collects for him/herself outside of a public or organized source. Personal collections of information resources Collections (7.1.3). Memories. Value. Amusement.

Diary. Personal reflections. Creation and use. Personal narratives (6.3.6).

PUT - Personal Unified Taxonomy. Personal ontologies. But, ultimately, these are primarily social creations.

Personal reference collections. Personal photos, Personal notes. Management of personal records (7.4.1).

Cognition (4.3.0) memory and PIM.

Personal search: search organized by personal relevance.

Project and team archives (5.6.4).

People often go back and search for something they had previously found; this is known as “refinding”. Landmarks can help people in finding information they have already seen[30]. However, personal information systems do not necessarily enhance personal productivity[5] (8.8.1). Personalization (4.10.2). Subjective importance. Retrieval by context.

Privacy and protection of personal infornation (8.3.1). Right to oblivion ((sec:oblivion)).

Information literacy (5.12.0). How do people learn that information resources are useful for answering their needs. Making the awareness of information needs a higher priority.

Storing and preserving personally created information such as blog postings personal Web pages.

Overlapping personal information spaces. Team and group information spaces.

For effective use, people need to manage their information artifacts. Some online records are easy to find, but others are only located after extensive searching, or perhaps stumbled upon accidentally. By keeping an archived record of important or useful websites, the Web itself becomes a more powerful information tool. Most Web browsers make this particularly easy by providing a “favorites” or “bookmark” function. Along the same lines, a personal bibliography[3] serves much the same purpose. This is a list of all the books that a person possesses, or has read, with useful metadata associated with each one. Within an individual book, a person may place a bookmark to indicate a passage to be remembered, or to mark their spot. An information environment can be further extended with “altering services”. These notify users of changes in their information environments and they include Email news alerts.

Lifelogging

While PIM focuses on materials that a person creates, Lifelogging has been proposed to passively record a person. This could be done, for instance, with audio or video camera they carried around all the time. Lifelogging tools could also support reminiscence. Personal image collections. Supporting reminiscence. Autobiography. Diary. (Fig. 4.56).

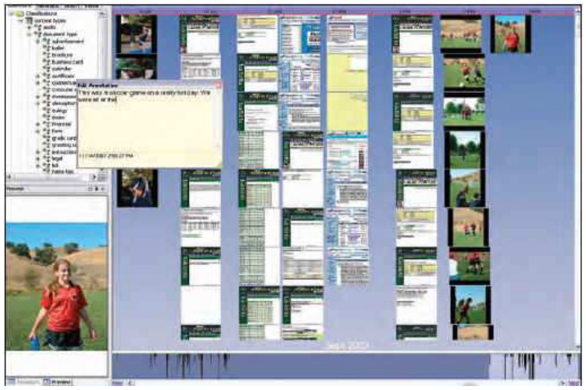


Figure 4.56: Interface for reflecting on Lifelogs (from[17]). (check permission)

There are several variations: Long-term personal information management. Personal information management[28]. Personal collections and digital libraries. Personal image preservation[49]. My Life bits. Sensors. People’s systems for information organization evolve.

4.11.2. Personal Task Environments and Workspaces

People develop personal information systems for personal information such as cooking recipes. Intensive personal information management. Cellphones to calendar systems[29]. Balancing effort and estimated benefit in organizing information. Allowing commercial organizations such as banks to keep personal information about you. Managing group information such as the information of your family. Some tools and some information sources (e.g., an appointment calendar) are used so frequently that they belong on the desktop Information management beyond personal workspaces. Preservation of personal information is related to archives which we will consider later (7.5.1). Preservation of personal and family photos. Desktop computers (3.5.4). Desktop searching. People often click on the same URL time many times. Searching personal media archives.

Personal Task Support

Individuals will have different strategies for completing the same tasks. various strategies for organizing their information and task environments. Some information environments are personal information spaces (Fig. 4.57). Offices and desks are perhaps the most traditional information workspaces. Often, they are dominated by collections of paper documents, sometimes in disarray. The way in which a person organizes his or her office or desk can be an indication of strategies facilitating access to the information needed to accomplish tasks (Fig. 4.58)[47]. Setting personal records such a calendars and contact lists. Personalization (4.10.2).

Figure 4.57: A refrigerator door can both store information and provide reminders.

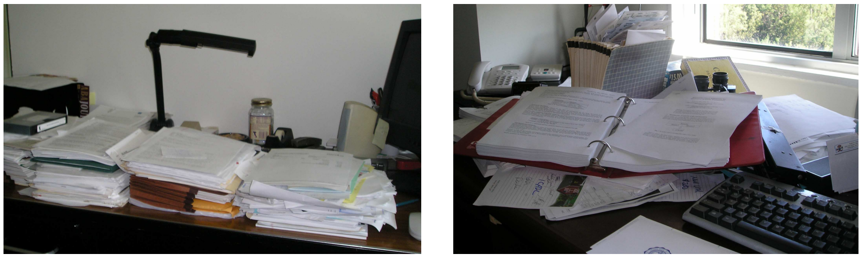


Figure 4.58: Examples of personal information management strategies: A neat office (left) and a messy office (right).

Task Interaction Histories

Many activities repeat with small changes. A person doing them may want to review the steps in a search or to modify the steps in it. Keeping track of the tasks in which a person is engaged. Tasks such as searching are often repetitive. A valuable question to ask is, what does a person believe about what he or she is doing; what do they expect? What data can be recorded about their actions? This may be useful for searches involving many components. The memory of task completion can be organized around task semantics; query histories can be maintained (10.7.1).

We can distinguish between individual user models and collective histories. Towards performance support and help systems (7.9.6).

People know a lot about themselves — their motivations, the approaches to tasks, and the tasks in which they have been involved. Keep track of what a person has done; a user's history can be helpful in planning future activity. "Bread crumbs" can provide a trail for the user to follow to show where they have visited previously. Coordinated with person's memory and current goals. Repeating previous searches. Making small changes as a complex search with parameters previously derived. Saving search histories. Characteristics of user searching behavior. Local web sites versus remote web sites.

Coordinating various tasks, and keeping records of search notes, strategies and plans, as well as of one's thoughts on the topic and navigation already performed, can all provide a context for continued use. Ad hoc search procedures.

Visualization of interaction histories could show what the user has done in a given session. The semantics of action sequences user's viewpoint; users have a unique perspective based on their own memories of what they have been doing, and the landmarks and salient events they have observed. Some activities are engaged in by many people. The cumulative traces left by various users could indicate areas of productive interaction for new users. Scroll bars are one way of representing user histories (Fig. 4.59).

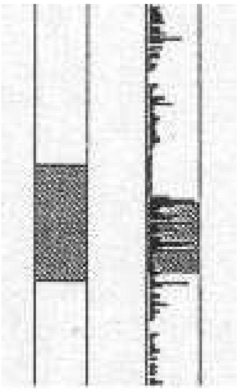


Figure 4.59: Rather than simply showing a slider (left) a history-enriched scrollbar (right) can show graphically which parts of a document have been accessed most frequently[38]. The users may find it useful to navigate to sections of a document which have been of interest to others. (redraw) (check permission)

Exercises

Short Definitions:

Assistive technology
Attention
Attitude
Autism
Categorical perception
Cognition
Cognitive load
Concept map
Conceptual model
Delay of gratification
Dyslexia
End-user programming
Emergent perception
Emotion
Episodic memory
Form factor (display)
Force feedback
Gestalt
Habitability
Individual differences
Mental model
Mixed-mode initiative
Personalization
Situated cognition
Short-term memory
User model

Review Questions:

1. Distinguish between "sensation," "attention," "perception," "cognition," and "emotion". (4.2.1, 4.2.2, 4.3.0)
2. Compare cognitive representations with database representations. (4.3.1)
3. Describe some types of visual impairments. (4.9.3)
4. Complete an interface usability calculation. If $C = 0.8\ sec$, $P = 1.4\ sec$, and $M = 1.2\ sec$ what is R? (4.8.2)
5. Distinguish between "user models" and "mental models". (4.4.4, 4.10.2)

Short-Essays and Hand-Worked Problems:

1. What are the limits of the searchlight metaphor of attention? (4.2.2)

2. Why are people likely to exaggerate the likelihood of highly visible or unusual risks while apparently underestimating the likelihood of more common risks? (4.2.2, 8.8.3)
3. Were the representations we use for electronic information systems are relevant to human cognitive representations of information? (4.3.1)
4. Have you ever heard a piece of music but not been able to remember its name? How could that be explained by the dual-coding model of memory? (4.3.2)
5. Give an example of attempted attitude change by an organization or politician. In what ways is it likely to be effective? (4.5.2)
6. Propose an advertising campaign to convince people to stop smoking. Describe why you feel it would be effective.(4.5.2)
7. How is "motivation" related to "goals"? (4.6.0)
8. How would you develop a user interface that would adapt to a user's information processing load? (4.3.3, 4.8.0)
9. Propose a cognitive explanation for why people so often fail to remember to add attachments to their email messages. (4.3.0, 4.8.0)
10. List the advantages and disadvantages of the two calculator designs in Fig. 4.15 (4.8.0)
11. Give some examples of the use of metaphor in human-computer interfaces. (4.8.0)
12. What are some of the ways visual interaction could be replaced with audio to support visually impaired users? What are some of the limitations of this approach. (4.9.3)
13. Describe what resources are available in your university library to support information access to students with disabilities. (4.9.3)
14. What are some difficulties that a person might have in learning to use a spreadsheet? (4.10.4)
15. Describe some techniques which might be useful for implicitly collecting data for a user model. (4.10.2)
16. What are the tradeoffs between individual systems for organizing information and common systems for organizing information? (4.11.2)
17. Describe your system for organizing your own desk or your online workspace. How could it be improved? (4.11.2)
18. Test the back button of a Web browser. Describe the algorithm the browser uses to move back. (4.11.2)

Practicum:

1. Interface design.
2. Device design.

Going Beyond:

1. Is there an objective "reality" by which we should measure the quality of a person's perceptions? (1.6.2, 4.2.1)
2. Information can be transmitted between people via different modalities? How could you quantify the information capacity of modalities? (4.2.1)
3. How feasible would it be to develop applications that are specifically independent of interaction modalities and then have them adapted to the user's modalities? (4.2.1)
4. Some animals have very sensitive sensory mechanisms. What is distinctive about the hearing of bats, the vision of owls, and the olfaction of dogs? Could artificial sensory organs be developed which modeled these? (4.2.1)
5. Is it possible to say that some sensory modalities allow people to acquire information faster than other sensory modalities? Give some examples. (4.2.1)
6. Do two people experience perception in the same way? Is your perception of the color green the same as your friend's perception of green? (4.2.1)
7. Develop a detailed model for how people coordinate multiple complex motor behaviors, such as singing and dancing. (4.2.4)
8. Compare the psychological notion of a "stimulus" with the concept of "information". (1.6.1, 4.3.0)
9. Our definition of "information" is related to the psychological notion of "stimulus". Explain this similarity. (1.6.1, 4.3.0)
10. How much confidence should we have in what people say about their own thought processes and motives? (4.3.0)
11. How reliable are people's statements about their own information processing? (4.3.0).
12. How accurate is introspection? How well can a person tell the mechanisms of their own thought processes? (4.3.1)
13. How do people know what they don't know? (4.3.1)
14. How is long-term memory related to mental models. (4.3.1)
15. What role does human memory and learning plan in attitude change? (4.3.2, 4.5.2)
16. Several noted psychologists such as George Miller and Herb Simon have argued that chunking is a fundamental process for organizing information in human memory. What is the evidence for that? Do you agree that it is a fundamental aspect of memory? (4.3.5)
17. How can we validate concept maps such as the one shown in Fig. 4.17 (4.4.1)

18. Do attitudes cause behavior or does behavior cause attitudes? (4.5.2)
19. Develop a cognitive model for the processing of attitudes? (4.5.2)
20. Describe some of the ways the principles of cognitive psychology are relevant to the design of user interfaces? (4.8.0)
21. What do we mean when we talk about a "computer user". What are some problems with that construct? How does it apply to embedded computing? (4.8.0)
22. How many bits of information are transmitted (a) by vision, (b) touch ? (4.9.3, -A.1.0)
23. What are the limits in the predictability of user behavior? (4.10.2)
24. Give some examples of representations that might be applied to user models. (4.10.2)
25. Interview professionals to determine how much time they spend searching for different types of information and what difficulties they have. (4.11.2)

Teaching Notes

Objectives and Skills: Be able to apply the principles of human perception and cognition in systems design.

Instructor Strategies: A course with practical orientation might emphasize user interface design, while a conceptually-oriented course might emphasize human information processing systems.

Related Books

- Hutchins, E. *Cognition in the Wild.* MIT Press, Cambridge MA 1996.
- Lamberts, K., and Shanks, D. R. (editors) *Knowledge, Concepts, and Categories.* MIT Press, Cambridge MA, 1997.
- Marr, D. *Vision: A Computational Investigation into the Human Representation and Processing of Visual Information.* Freeman, New York, 1982.
- Mates, B.T., Wakefield, D., and Dixon, J.M. *Adaptive Technology for the Internet: Making Electronic Resources Accessible to All.* American Library Association, Chicago, 2000.
- Norman, D.A. *The Psychology of Everyday Things.* Harper Collins, New York, 1998.
- Palmer, S.E., *Vision Science: Photons to Phenomenology.* MIT Press, Cambridge MA, 2002.
- Picard, R. *Affective Computing.* MIT Press, Cambridge MA, 2000.
- Rogers, T.T., and McClelland, J. *Semantic Cognition.* MIT Press, Cambridge MA, 2004.
- Rosson, M.B., and Carroll, J. *Usability Engineering: Scenario-Based Development of Human-Computer Interaction.*
- Solso, R.L. *Cognition and the Visual Arts.* MIT Press, Cambridge MA, 1997.