Chapter 5 – Cognitive Engineering

HCI: Developing Effective Organizational Information Systems
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Additional Context

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Introduction

- **Cognitive engineering** using cognitive psychology to design & develop systems to support the cognitive processes of users.
- Simplified human information processing model explains utilization of resources such as memory and attention.
- Other models also help in design:
  - Norman’s model
  - GOMS model
- Complexity uses up scarce cognitive resources
  - Reducing complexity is one of the goals of cognitive engineering.

A Simplified View of Human Information Processing (HIP)

- Figure 5.3 presents a simplified model of Human Information Processing which includes processors and memories that interact in order to process information.
- There are three types of processors:
  - Perceptual,
  - Cognitive, and
  - Motor processors.
- Two types of memory:
  - Working memory
  - Long-term memory
A Simplified View of Human Information Processing (HIP)

- **Performance**: speed & accuracy of the information-processing task.
- **Automatic behavior**: uses cognitive processes that are fast and cognitively undemanding.
- **Controlled behavior**: uses cognitive processes that are relatively slow and cognitively demanding.

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A Simplified View of Human Information Processing (HIP)

- **Processing of Images**: spatial, graphic, and holistic.
- **Processing of verbal information**: sequential, linguistic, and procedural.

**Memory Aids**
- **Heuristics**: rules of thumb that depend heavily on the content and context of the task.
- **Metaphor**: a cognitive process in which an experience is related to an already familiar concept.
- **Mental model**: a representation of the conceptual structure of a device or a system.

Complexity in HCI

- **Complexity in HCI**: the human resources needed for interacting with the computer to accomplish the task.

Figure 5.4 HCI as a Bridge between Human and Computer
Gulfs of Execution and Evaluation

- **Gulf of execution**: the gap between the user’s goal and its computerized implementation.
- **Gulf of evaluation**: the gap between the computerized implementation of the user’s goal and its evaluation by the user.

Bridging the gaps using Norman’s Model

- Establish a goal that needs to be accomplished.
- Form the intention (or hierarchy of intentions) that will accomplish the goal.
- Specify the action sequence to implement the intentions.
- Execute the action.
- Perceive the state of system resulting from the action.
- Interpret the system state.
- Evaluate your interpretation against the expectation based on your intentions.

Figure 5.6 Norman’s seven stage model of user activity
Fit and Complexity

- The fit between the user’s mental model and the actual model of the system affects complexity, too.
- The greater the fit, the easier it is to determine how to translate goals into action.
- The greater the misfit, the more difficult and error-prone is the process of bridging the execution and evaluation gulfs.

User Activity with Multiple Intentions

- Users in organizational settings usually interact with computers to achieve complex goals.
- Norman’s model of user activity can be useful
  - Describe the user activity involved in more complex tasks by modelling multiple intentions to accomplish a single goal,
  - e.g. checking a new sales forecast and summing the corresponding revenues
    - Each of these two intentions describes how the seven stages are organized to bridge the gulfs between the computer and the user.
The GOMS Model for Describing HCI

- **GOMS**: Goals, Operators, Methods, and Selection rules are the elements of a model that describes purposeful HCI.
  - **Goals** specify what the user wants and intends to achieve.
  - **Operators** are the building blocks for describing human-computer interaction at the concrete level.
  - **Methods** are programs built with operators that are designed to accomplish goals.
  - **Selection rules** predict which method will be used.
    - For example, “If the mouse is working, select ‘point to an item on screen’, if not select ‘choose OPEN option in file menu’.”

Using GOMS

![Flow chart for building GOMS](image-url)

*Figure 5.9 A flow chart for building GOMS*
Using GOMS for text editing

- **Operators**
  - Mental primitives for flow of control:
    - Accomplish the goal of <goal description>
    - Report goal accomplished
    - Decision: if<operator> then<operator> else<operator>
    - Goto step <number>
- **Memory stage and retrieval**
  - Recall that <working memory object>
  - Retain that <working memory object>
  - Forget that <working memory object>
  - Retrieve LTM that <long-term-memory object>
- **Primitive external operators**
  - Move mouse
  - Press key <key name>
  - Type in <string of characters>
  - Move-cursor to <target coordinates>

Example – Method to select text

- Determine position of beginning of text
- Move cursor to beginning of text
- Press mouse button
- Determine position of end of text
- Move cursor to end of text
- Verify that correct text is selected
- Release mouse button
- Report goal accomplished
Errors

- **Errors**: deviations from intentional behavior that is either skill, rule or knowledge based.

Classification of errors based on behavior type:

- **Skill based behavior**: automatic behavior that is predefined and requires minimal cognitive resources.
- **Rule based behavior**: controlled behavior that relies on predefined rules of behavior that are contingent on particular situation encountered.
- **Knowledge based behavior**: highly controlled behavior that requires assessment and generation of new rules of behavior, and is demanding of cognitive resources.

Causes of Errors

- Skill-based performance
  - Inattention
  - Habitual slips
  - Omissions following interruptions
  - Reduced inattention
  - Perceptual confusions
  - Inference errors
- Rule-based performance
  - Misapplication of good rules
    - First exceptions
    - Countercue
    - Information overload
    - Rule strength
    - General rules
    - Redundancy
    - Rigidity
  - Application of bad rules
    - Encoding deficiencies
    - Action deficiencies
    - Wrong rules
    - Ineligible rules
    - Inadmissible rules
- Knowledge-based performance
  - Selectivity
  - Work-space limitations
  - Availability
  - Confirmation bias
  - Overconfidence
  - Biased reviewing
  - Illusory correlation
  - Halls effect
  - Problem with causality
  - Problems with complexity
Scenario

- Denver, October 16, 1998: A large audience of Windows developers, filling an entire auditorium hall, witnessed the execution of “Clippy,” the Microsoft Office Assistant.

- Most developers disliked Clippy’s “cuteness” and complained gravely about its intrusiveness.

Figure 6.1 Clippy

- Devices are supposed to process information
  - No emotion, right?
  - Wrong!

- We have things today that we didn’t even know enough to dream about yesterday

- Is everything amazing but is nobody happy?
Introduction

- Affect is a general term for a set of psychological processes and states including emotions, moods, affective impressions and attitudes.
- The new psychological basis of HCI that balances and integrates affective and cognitive aspects view is rapidly gaining popularity.
- Cognition interprets and makes sense of the world.
- Affect evaluates and judges, modulating the operating parameters of cognition and providing warning of possible dangers.

What is affect?

- Core affect (or feeling) is a neuro-physical state that integrates two dimensions: pleasure - displeasure and activated - non-activated.
- Affective quality is the object’s ability to cause a change in the user’s core affect.
- An emotion is a core affect that is intentional and directed towards a certain object.
- Moods are non-intentional core affects that exist within a person independently of external objects.
Affect and Design

- An affective impression is the user's appraisal of the affective qualities of the HCI.
- In the design of HCI, we concentrate on affective qualities of HCI components (e.g., color and animation) and on affective impressions that are linked to core affect but are specific to the HCI domain.
- Recent studies have identified a large assortment of affective qualities in HCI.
- PC Marketers try to activate affective cues.
- Affective qualities of websites and screens include beauty, overview, title, shape, structure, texture, menu, main images, and color (Zhang and Li, 2004).
Affect and HCI

- An interesting study on affective qualities of homepages demonstrates well the link between design and affect.
- Kim, Lee, and Choi (2003) performed an elaborate study of the affective impressions evoked by a set of diverse homepage designs.
- In the first stage, affective impressions were determined from a survey of users.
- Thirteen affective impressions of homepages were identified: bright, tense, strong, static, deluxe, popular, adorable, colourful simple, classical, futuristic, mystic, and hopeful.

A. Classical

B. Futuristic

Figure 6.3 Affective impressions in homepages.
Adapted from (Kim, Lee and Choi, 2003)
User perceptions and affect

- Lavie and Tractinsky (2004) identified two dimensions in users’ perceptions: “classical aesthetics” and “expressive aesthetics”.
- The classical aesthetics dimension pertains to aesthetic notions that emphasize orderly and clear design.
- The expressive aesthetics dimension is manifested by the designers’ creativity and originality and by the ability to break design conventions.
- Thus, this study offers a reliable tool that can be used to capture the affective impressions of websites on these dimensions.
- Interestingly, the classical dimension is closely related to elements of perceived ease of use and usability (discussed in chapter 9), while the expressive dimension is not.

The relationship between HCI design factors, affective qualities and emotions

![Diagram showing design factors, affective qualities, and affective impressions.](image)

**Figure 6.4 Design impacts emotions – example design factors, affective qualities, impressions and affect in web-based design. These lists are tentative and partial.**
Affective engineering in HCI is a new and exciting area (see advanced reading by Hudlicka, 2003). Affect concerns four major roles in the design of HCI:

- modeling affect in the user and the computer;
- sensing and recognizing the user’s affective state;
- adapting the computer’s state to fit the user’s affective state; and
- generating on the computer (artificial) affective expressions.

Generating artificial affective expressions

Figure 6.5 Generating affective expressions in a robot - Kismet from MIT Media Lab

Kismet's Range of emotions; being scolded
Next Generation: Nexi

- Full robot—not just head
- Mobile-Dexterous-Social
- Nexi video

Effects of emotions on cognition

<table>
<thead>
<tr>
<th>Table 6.1: Effects of emotions on cognition (adapted from Hudlicka, 2003)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anxiety and attention: Anxiety limits attention, predisposing attention to source of danger</td>
</tr>
<tr>
<td>Affect and memory: Mood biases memory recall (positive mood induces recall of positive information)</td>
</tr>
<tr>
<td>Obsessiveness and performance: Obsessiveness delays decision making, reduces recall of recent events, reduces confidence in ability to distinguish between real and imagined events.</td>
</tr>
<tr>
<td>Affect and judgment: Negative mood decreases and positive increases perception of self control, anxiety predisposes towards interpretation of ambiguous stimuli as threatening.</td>
</tr>
</tbody>
</table>
Attitudes

- Attitude represents a summary evaluation of an object.
- An attitude towards an object, such as a computer system, "represents a summary evaluation of a psychological object captured in such attribute dimensions as good-bad, harmful-beneficial, pleasant-unpleasant and likable-dislikeable" (Ajzen, 2001, p. 27).
- Attitudes are influenced by cognition (beliefs about the object) as well as affect (emotions towards the object) and result in a tendency to behave in a certain way towards the object (i.e., an intention to act).
- Tripartite view of attitudes (Allport 1956): Affective, Cognitive, Conative

Technology Acceptance Model

- The Technology Acceptance Model (Davis, 1989) is the leading model in IS to explain attitudes towards using a system.

Figure 6.6: The Technology Acceptance Model (TAM) adapted from Davis 1989 - 'attitude' was excluded from the model's application.
TAM

- **Perceived usefulness** is the users’ belief that using the system will enhance their performance.
- Perceived ease of use is the users’ belief that using a particular system would be free of effort.

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**Expanded view of affect and its impact on use**

**Attitude**

- Perceived Usefulness
- Perceived EoU
- Perceived Enjoyment

**Use**

- Intention to use
- Actual use; flow
- Satisfaction – EUCS: Content, accuracy, timing, Format, Ease of Use
- Satisfaction – User Interface
- Individual traits and states, e.g., Computer anxiety

*Figure 6.7: Expanded view of affect and its impact on use*
Expanded view of affect in HCI

- **Perceived enjoyment** is the extent to which fun can be derived from using the system as such.
- **Computer anxiety** is emotion about the implications of using a computer such as the loss of important data or other important errors.

Satisfaction

- Satisfaction is perhaps the most commonly used construct of affect in IS.
- Satisfaction is a positive affect resulting from the evaluation of the use of the computer system. Expectation-confirmation theory explains how satisfaction is formed (Bhattacherjee, 2001)
- Users have certain expectations, they then confirm (or disconfirm) these expectations and, as a result, form a feeling of satisfaction.
Many different measures of satisfaction are available to IS developers so it is important to first determine how to use it and accordingly select the appropriate measure.

One important purpose of measuring satisfaction is to evaluate a system (this is done in place or in addition to measuring system use).

One of the most popular measures of satisfaction is called End-User Computer Satisfaction (Doll and Torkzadeh, 1988).

This measure is built of five sub-factors, each measured with 2-4 questions:

1) content
2) accuracy
3) format
4) timeliness, and
5) ease of use

Galletta and Lederer’s (1989) cautions still apply!
Individual differences and training

- Attitudes towards computers are influenced by individual characteristics such as personality and background.
- Individual differences in these characteristics affect the user’s beliefs about use (perceived usefulness, ease of use and enjoyment)
  - Hence they affect user attitudes.
- These individual traits can be classified as general traits or as specific traits.

Computer Self-Efficacy

- Computer self-efficacy (CSE) refers to a person’s evaluation of his or her capabilities to use computers in diverse situations.
  - People high on CSE will tend to form more positive perceptions of the benefits from using computers
  - Therefore, according to TAM, tend to use computers more frequently than those lower in CSE.
Flow and Playfulness

- How can we characterize the user’s feeling during interaction with a computer? One of the most popular characterizations is the affective-cognitive concept of *flow*.
- Flow represents the user's perception of the medium as playful and engaging.

Flow

- Flow can be measured.
- It can be defined as a continuous variable, ranging from lack of flow to intense flow.
- Trevino and Webster (1992) defined four dimensions of Flow experience:
  - Control
  - Attention Focus
  - Curiosity and
  - Intrinsic Interest
HCI and Flow

- HCI design should be undertaken with the above dimensions of flow in mind.
- Interfaces should afford users with a perceived sense of control.
- The interface must also disappear into the background in order to give the user the perceived sense of interaction focus.

<table>
<thead>
<tr>
<th>Person and situation</th>
<th>Table 6.2 Attitude-related constructs in HCI</th>
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<tr>
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<td>People’s belief about their capabilities to use computers in diverse situations</td>
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<tr>
<td>Flow</td>
<td>Holistic sensation that people feel when they act with total involvement</td>
</tr>
<tr>
<td>Perceived usefulness</td>
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<td>The fulfillment of positive expectations of using a computer</td>
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