Human-Computer Interaction

Research Frameworks in HCI

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Today's Agenda

- Topic overview: *Research Frameworks*
- Discussion
- Project Q&A, partner-matching

Topic overview: *Research Frameworks*

What is HCI theory? Does HCI have foundational theories? What is theory anyway?

...theory is the answer to queries of why. Theory is about the connections among phenomena, a story about why acts, events, structure, and thoughts occur. Theory emphasizes the nature of causal relationships, identifying what comes first as well as the timing of such events.

— **Sutton & Staw, 1995**

Strong theory … delves into underlying processes so as to understand the systematic reasons for a particular occurrence or nonoccurrence.

— **Sutton & Staw, 1995**

A good theory explains, predicts, and delights.

— Weick, 1995

Some Preliminaries

1. HCI research is a process by which we develop, test, and refine theory about how to design computer systems and social phenomena around them.
2. Theory should guide design, predict outcomes, and serve as an educational tool about the field—it should be informative, predictive, and prescriptive (Rogers, 2004).
3. To clarify, theory is not *references*, *data*, *variables*, *diagrams*, or *hypotheses*. These are resources we use in *theorizing*.
4. Theory-building, or theorizing, is an *iterative*, *slow*, and *collective* process.

So, what are some HCI theories?

GOMS

Definition: GOMS is a family of predictive models of human performance that can be used to improve the efficiency of human-machine interaction by identifying and eliminating unnecessary user actions.

» Four variations: *KLM*, *CMN-GOMS*, *NGOMSL*, *CPM-GOMS*.

» GOMS represents *goals*, *operators*, *methods*, and *selection rules*.

» KLM is constructed using four operators: keystroking, pointing, homing, drawing.

» New variations include TLM with new operators such as gestue, pinch, zoom, swipe, etc.

Model Human Processor[1]

Definition: A model that represents human cognition as an information-processing system made up of set of memories and processors and a set of principles and that can approximate processing times for a given user action.

[1] Image source: Card, Moran, Newell, 1985

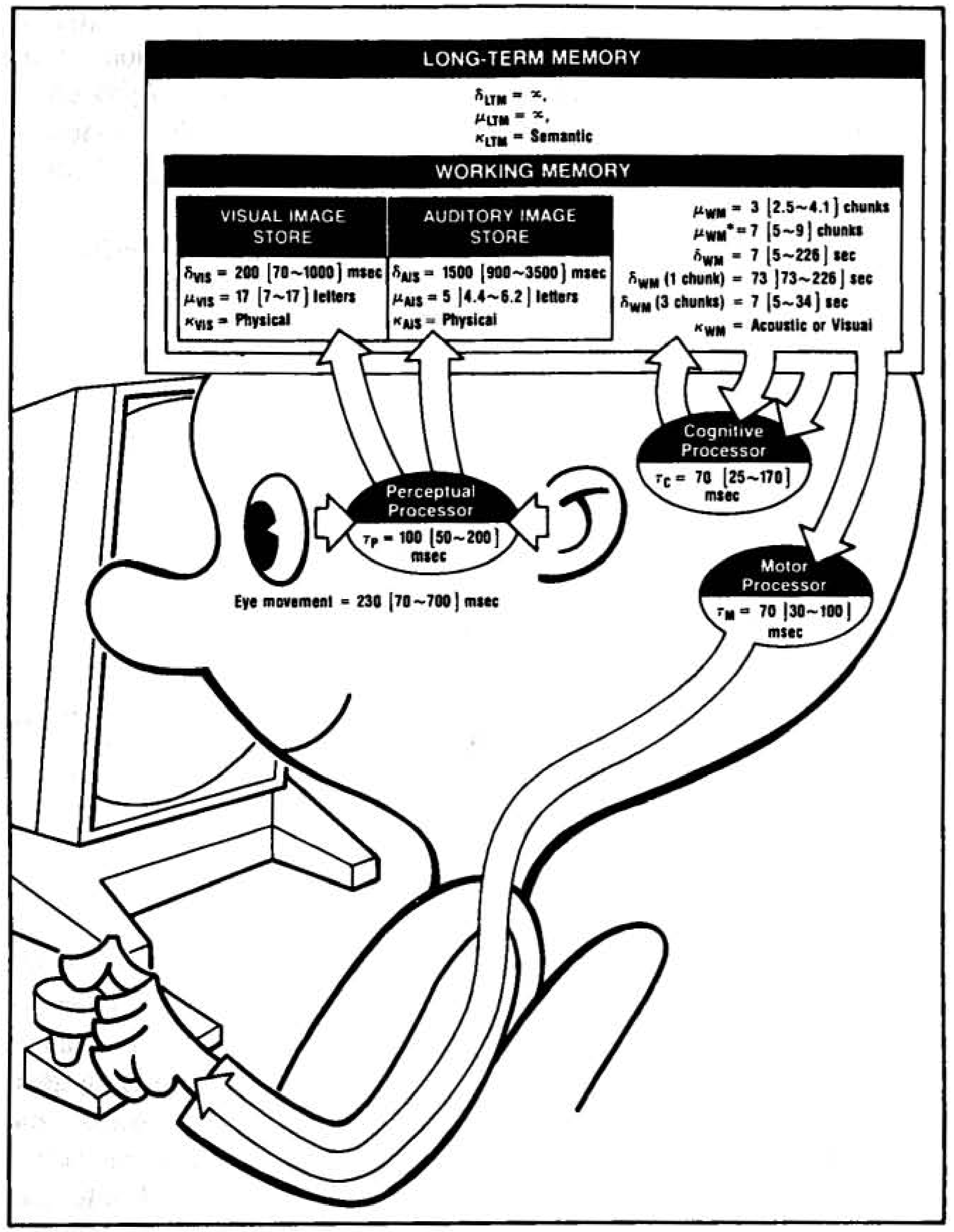

Figure 2.1. The Model Human Processor—memories and processors.

Sensory information flows into Working Memory through the Perceptual Processor. Working Memory consists of activated chunks in Long-Term Memory. The basic principle of operation of the Model Human Processor is the *Recognize-Act Cycle of the Cognitive Processor* (P0 in Figure 2.2). The Motor Processor is set in motion through activation of chunks in Working Memory.

P0. ***Recognize-Act Cycle of the Cognitive Processor.*** On each cycle of the Cognitive Processor, the contents of Working Memory initiate actions associatively linked to them in Long-Term Memory; these actions in turn modify the contents of Working Memory.

P1. ***Variable Perceptual Processor Rate Principle.*** The Perceptual Processor cycle time τ_P varies inversely with stimulus intensity.

P2. ***Encoding Specificity Principle.*** Specific encoding operations performed on what is perceived determine what is stored, and what is stored determines what retrieval cues are effective in providing access to what is stored.

P3. ***Discrimination Principle.*** The difficulty of memory retrieval is determined by the candidates that exist in the memory, relative to the retrieval clues.

P4. ***Variable Cognitive Processor Rate Principle.*** The Cognitive Processor cycle time τ_c is shorter when greater effort is induced by increased task demands or information loads; it also diminishes with practice.

P5. ***Fitts's Law.*** The time T_{pos} to move the hand to a target of size S which lies a distance D away is given by:

$$T_{pos} = I_M \log_2 (D/S + .5), \qquad (2.3)$$

where I_M = 100 [70~120] msec/bit.

P6. ***Power Law of Practice.*** The time T_n to perform a task on the nth trial follows a power law:

$$T_n = T_1 n^{-\alpha}, \qquad (2.4)$$

where α = .4 [.2~.6].

P7. ***Uncertainty Principle.*** Decision time T increases with uncertainty about the judgement or decision to be made:

$$T = I_C H,$$

where H is the information-theoretic entropy of the decision and I_C = 150 [0~157] msec/bit. For n equally probable alternatives (called Hick's Law),

$$H = \log_2 (n + 1). \qquad (2.8)$$

For n alternatives with different probabilities, p_i, of occurence,

$$H = \Sigma_i p_i \log_2 (1/p_i + 1). \qquad (2.9)$$

P8. ***Rationality Principle.*** A person acts so as to attain his goals through rational action, given the structure of the task and his inputs of information and bounded by limitations on his knowledge and processing ability:

Goals + Task + Operators + Inputs
+ Knowledge + Process-limits → Behavior

P9. ***Problem Space Principle.*** The rational activity in which people engage to solve a problem can be described in terms of (1) a set of states of knowledge, (2) operators for changing one state into another, (3) constraints on applying operators, and (4) control knowledge for deciding which operator to apply next.

Figure 2.2. The Model Human Processor—principles of operation.

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GOAL: EDIT-MANUSCRIPT
.  GOAL: EDIT-UNIT-TASK ...repeat until no more unit tasks
.  .  GOAL: ACQUIRE UNIT-TASK ...if task not remembered
.  .  .  GOAL: TURN-PAGE ...if at end of manuscript page
.  .  .  GOAL: GET-FROM-MANUSCRIPT
.  .  GOAL:EXECUTE-UNIT-TASK ...if a unit task was found
.  .  .  GOAL: MODIFY-TEXT
.  .  .  .  [select: GOAL:  MOVE-TEXT* ...if text is to be moved
.  .  .  .               GOAL:  DELETE-PHRASE ...if a phrase is to be deleted
.  .  .  .               GOAL:  INSERT-WORD] ...if a word is to be inserted
.  .  .  .     VERIFY-EDIT

*Expansion of MOVE-TEXT goal
GOAL: MOVE-TEXT
.  GOAL: CUT-TEXT
.  .  GOAL: HIGHLIGHT-TEXT
.  .  .  [select**:  GOAL: HIGHLIGHT-WORD
.  .  .                 .  MOVE-CURSOR-TO-WORD
.  .  .                 .  DOUBLE-CLICK-MOUSE-BUTTON
.  .  .                 .  VERIFY-HIGHLIGHT
.  .  .              GOAL: HIGHLIGHT-ARBITRARY-TEXT
.  .  .                 .  MOVE-CURSOR-TO-BEGINNING                 1.10
.  .  .                 .  CLICK-MOUSE-BUTTON                       0.20
.  .  .                 .  MOVE-CURSOR-TO-END                       1.10
.  .  .                 .  SHIFT-CLICK-MOUSE-BUTTON                 0.48
.  .  .                 .  VERIFY-HIGHLIGHT]                        1.35
.  .  GOAL: ISSUE-CUT-COMMAND
.  .  .  MOVE-CURSOR-TO-EDIT-MENU                                    1.10
.  .  .  PRESS-MOUSE-BUTTON                                          0.10
.  .  .  MOVE-MOUSE-TO-CUT-ITEM                                      1.10
.  .  .  VERIFY-HIGHLIGHT                                            1.35
.  .  .  RELEASE-MOUSE-BUTTON                                        0.10
.  GOAL: PASTE-TEXT
.  .  GOAL: POSITION-CURSOR-AT-INSERTION-POINT
.  .  .  MOVE-CURSOR-TO-INSERTION-POINT                              1.10
.  .  .  CLICK-MOUSE-BUTTON                                          0.20
.  .  .  VERIFY-POSITION                                             1.35
.  .  GOAL: ISSUE-PASTE-COMMAND
.  .  .  MOVE-CURSOR-TO-EDIT-MENU                                    1.10
.  .  .  PRESS-MOUSE-BUTTON                                          0.10
.  .  .  MOVE-MOUSE-TO-PASTE-ITEM                                    1.10
.  .  .  VERIFY-HIGHLIGHT                                            1.35
.  .  .  RELEASE-MOUSE-BUTTON                                        0.10
                                         TOTAL TIME PREDICTED (SEC)  14.38

  **Selection Rule for GOAL: HIGHLIGHT-TEXT:
    If the text to be highlighted is a single word, use the
    HIGHLIGHT-WORD method, else use the HIGHLIGHT-ARBITRARY-TEXT method.
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Moving text with the *MENU-METHOD*

Description	Operator	Duration (sec)
Mentally prepare by Heuristic Rule 0	M	1.35
Move cursor to beginning of phrase (no M by Heuristic Rule 1)	P	1.10
Click mouse button (no M by Heuristic Rule 0)	K	0.20
Move cursor to end of phrase (no M by Heuristic Rule 1)	P	1.10
Shift-click mouse button		
(one average typing K)	K	0.28
(one mouse button click K)	K	0.20
Mentally prepare by Heuristic Rule 0	M	1.35
Move cursor to Edit menu (no M by Heuristic Rule 1)	P	1.10
Press mouse button	K	0.10
Move cursor to Cut menu item (no M by Heuristic Rule 1)	P	1.10
Release mouse button	K	0.10
Mentally prepare by Heuristic Rule 0	M	1.35
Move cursor to insertion point	P	1.10
Click mouse button	K	0.20
Mentally prepare by Heuristic Rule 0	M	1.35
Move cursor to Edit menu (no M by Heuristic Rule 1)	P	1.10
Press mouse button	K	0.10
Move cursor to Paste menu item (no M by Heuristic Rule 1)	P	1.10
Release mouse button	K	0.10
TOTAL PREDICTED TIME		14.38

[2] John & Kieras, 1996

Activity Theory

Definition: A hierarchical model of activity that frames consciousness at the levels of *operations*, *actions*, and *activities* and a set of principles.

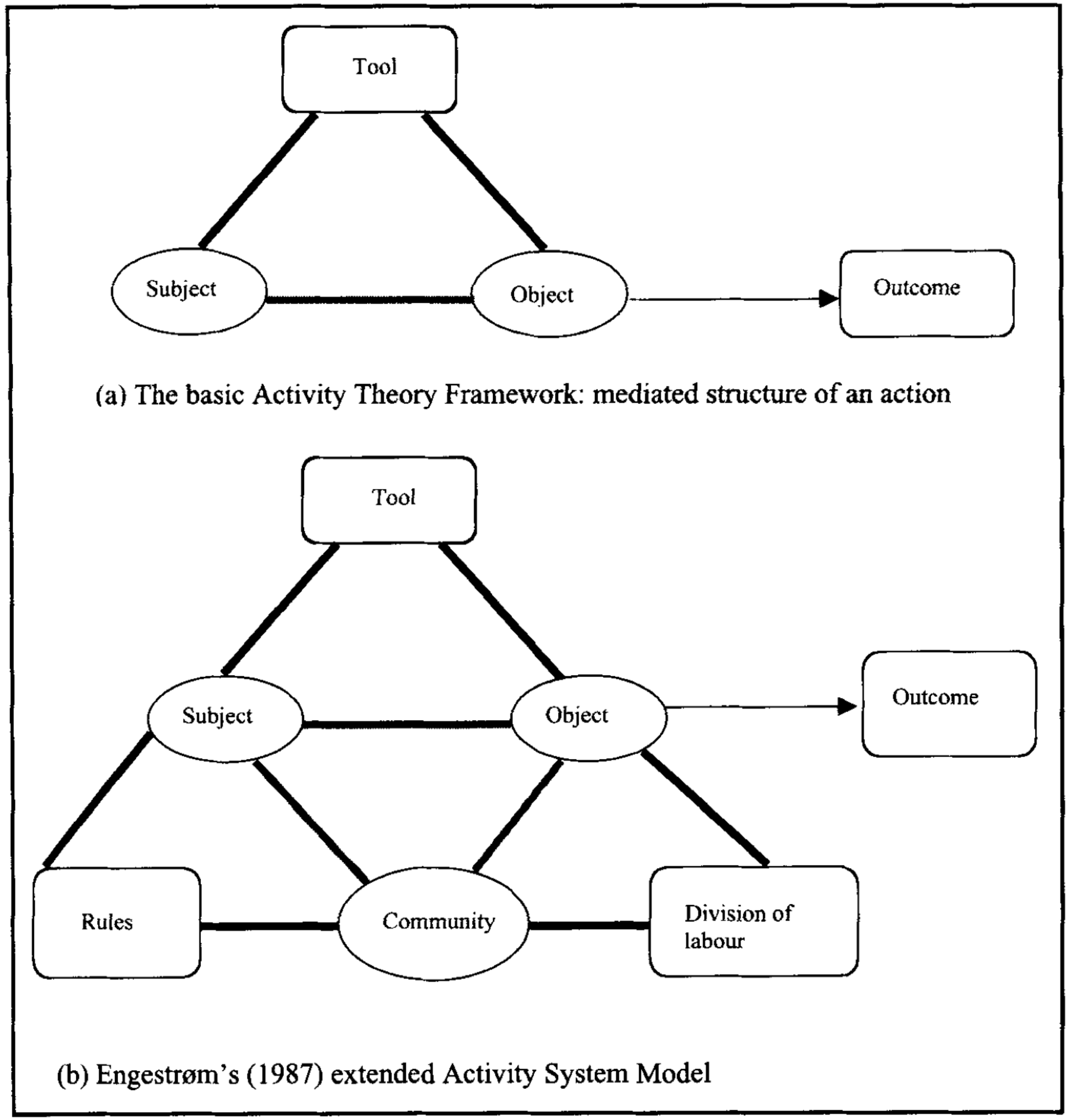

Figure 2.1 (a) The basic Activity Theory Framework and (b) Engestrøm's (1987) extended Activity System Model

Situated Action

Definition: A theory that focuses on the emergent, contingent nature of human activity and argues that activity grows directly out of practices in a given situation.

Distributed Cognition

Definition: In distributed cognition, the unit of analysis is extended beyond individual cognition to involve individuals and artifacts they use.

Cognitive processes are *distributed*:

» Over time

» Across a social network

» Across resources in an environment

Discussion Questions

» Consider an interaction you had with/via a computer today, which theory is most applicable to it?

» Are these theories compatible with each other?

» Where do you think theories would be most useful? Where would they fall short?

» What other theories and models did your external resources point to?

» …