Conceptual Framework

Seven Stages of Action Model

Cognitive Engineering

Direct Manipulation

Notes

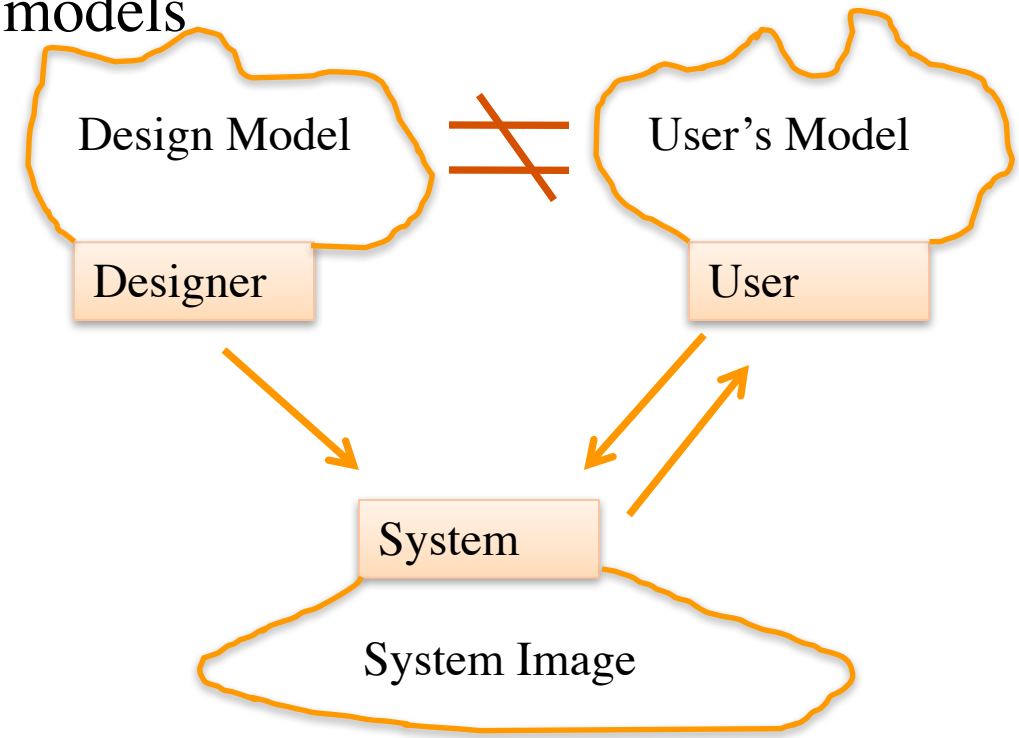
- No Class, 6/6 (Tuesday)
- Final Exam, 6/8(Thursday)
  - Contents covered after mid term exam

- Project review day, 6/13(Tuesday)
- Project presentation, 6/15(Thursday)
  - Demo (slides and demo website)

- Project submission deadline, 6/15

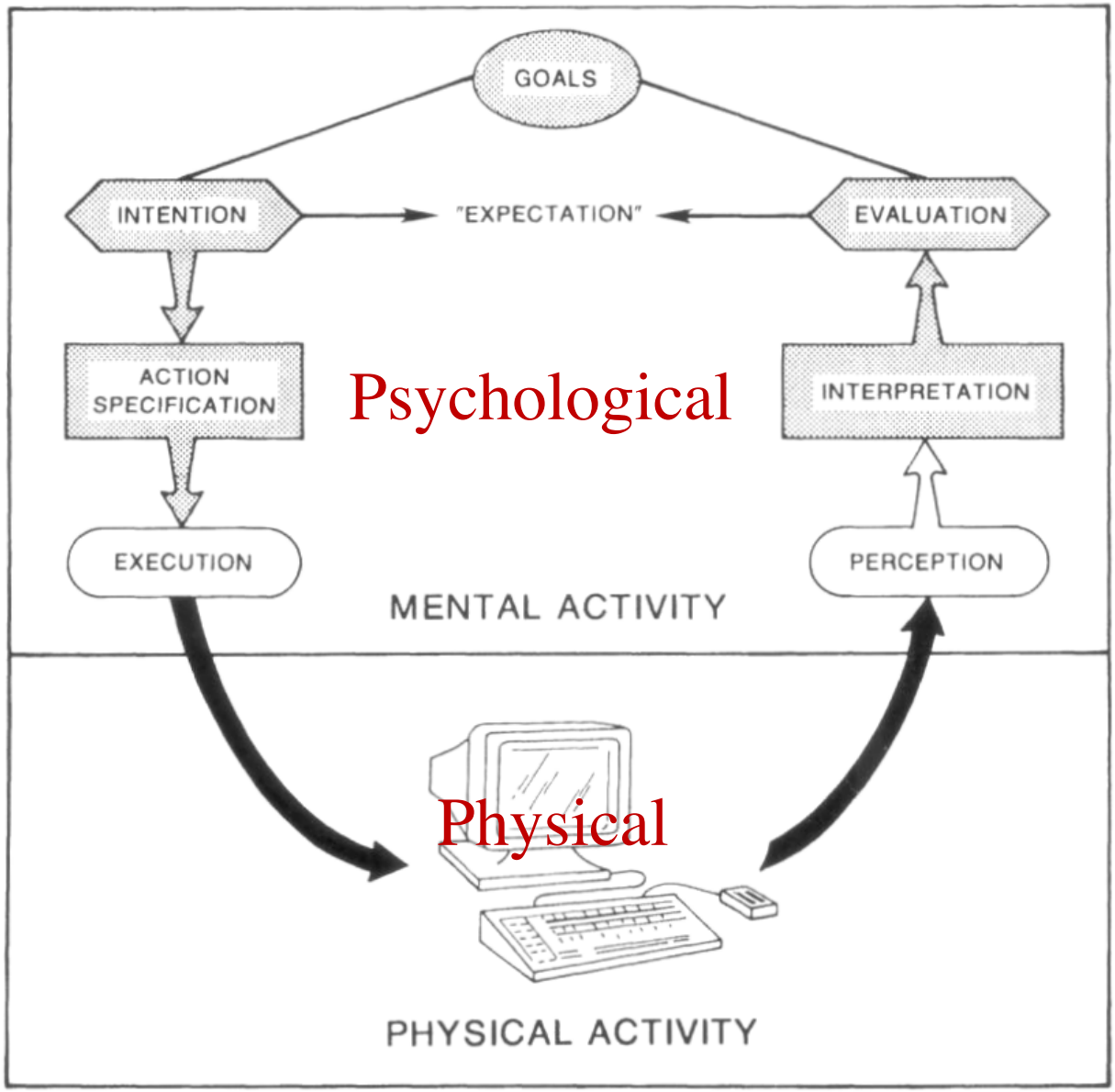
Three Conceptual Models

- Three aspects of mental models
  - Design model
  - User's model
  - System image



- conceptual frameworks
  - explain and predict user behavior based on theories of **cognition**

The Seven Stages of Action (Aspects of a Task)



Norman, 2002

Design Questions to Ask

How Easily Can One:

Determine The **Function** of the Device?

Tell what actions are possible?

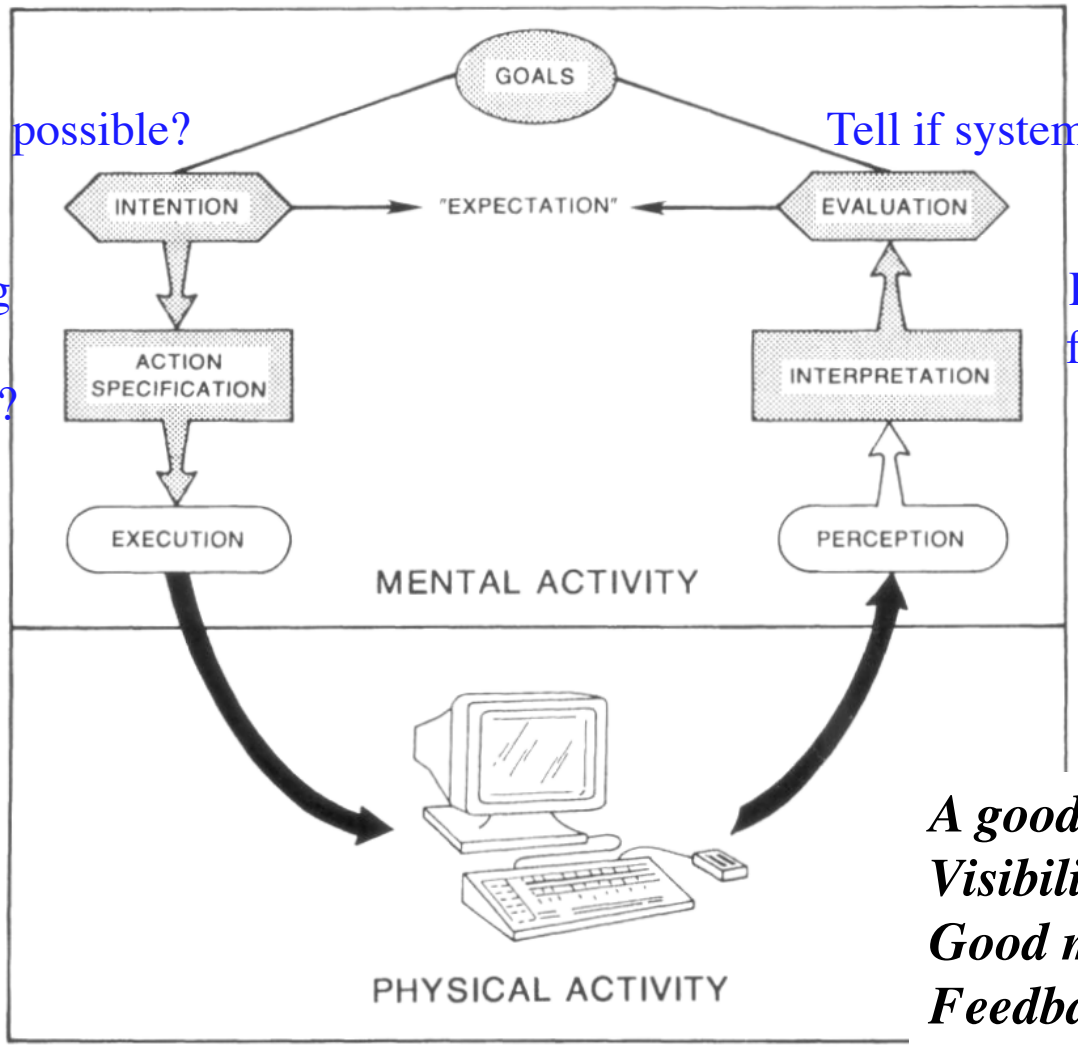
Tell if system is in desired state?

Determine mapping from intention to physical movement?

Determine mapping from system state to interpretation?

Perform the action?

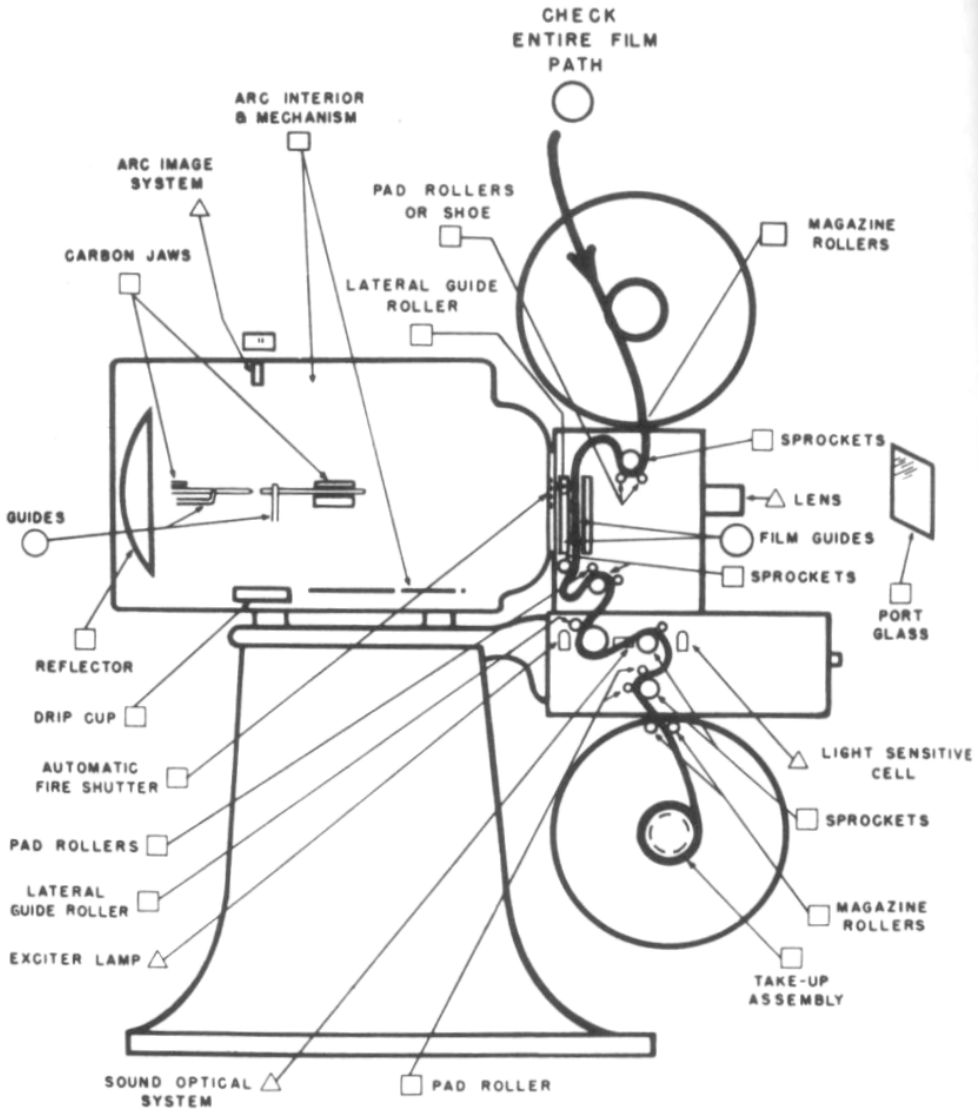
Tell what state the system is in?

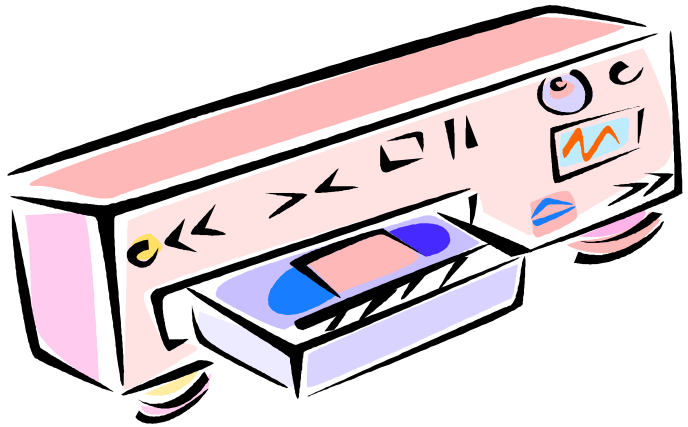


A good conceptual model
Visibility
Good mappings
Feedback

Norman, 2002

I want to watch a movie…





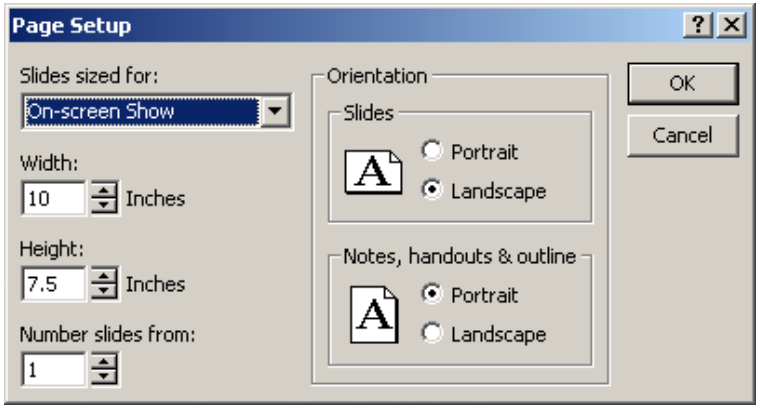
Norman, 2002

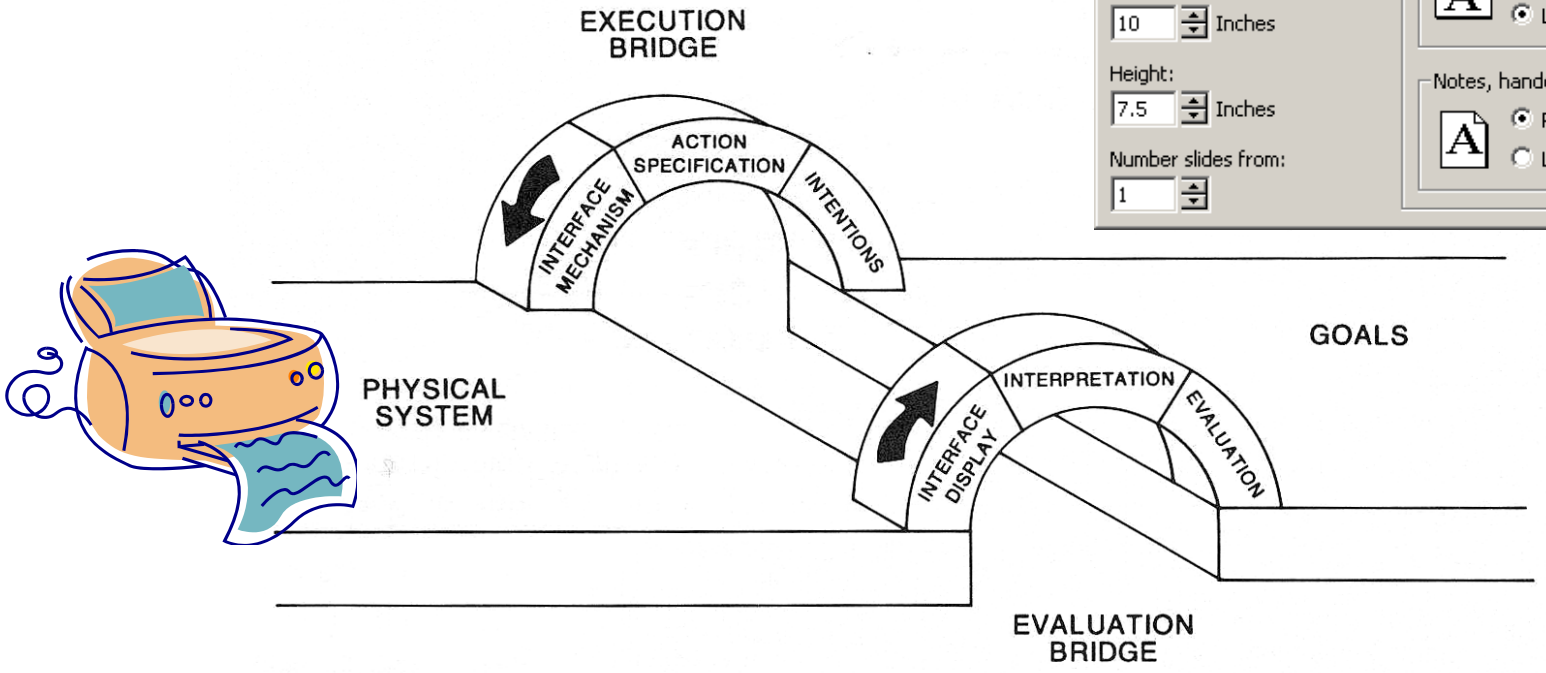
Cognitive Engineering (Norman, 1986)

- Cognitive Psychology/Cognitive Science/Human Factors
- Apply what is known from science to design of machines
- The way that people interact with machines
  - (Cognitive) Principles behind human action and performance
  - Systems that are pleasant to use (direct manipulation/engagement)
- Emphasis on users and tasks → User-centered Design

Cognitive Engineering

- Gulfs of execution and evaluation [Norman 86]
  - We **interact** on the left side of the drawing
  - We **solve problems and generate goals** in the right side of the drawings





  - **Neither gulf is under the control of the designer.** It depends on each individual's the cultural convention or technical knowledge

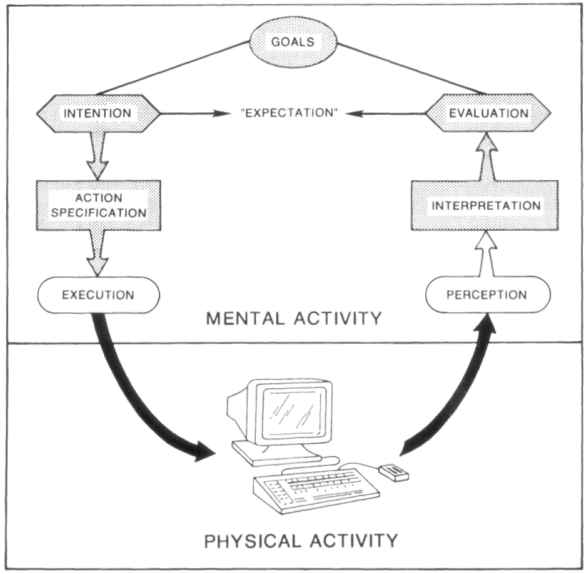
Norman, 2002

The Gulf of Execution

- The difference between the intentions and the allowable actions in the system

- Measure the size of gulf
  - How well the system allows the person to do the intended actions directly, without extra effort?
  - Do the actions match those intended by the person?

- Related to **functionality**, **usability**



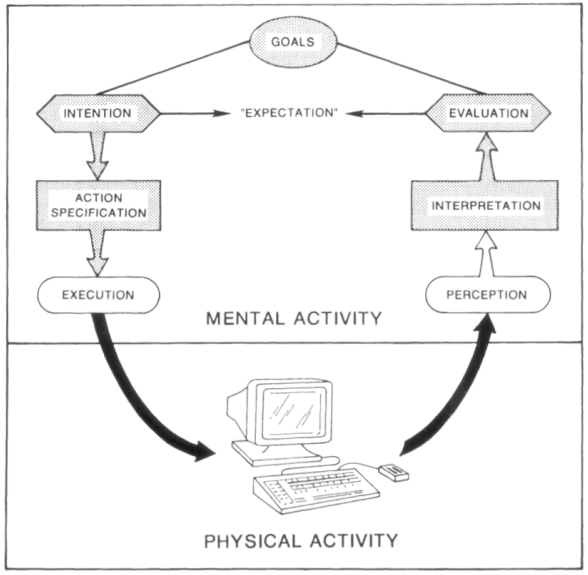
Norman, 2002

The Gulf of Evaluation

- The difference between
  - the physical representation provided by the system
  - users' interpretation (in terms of the intentions and expectations)

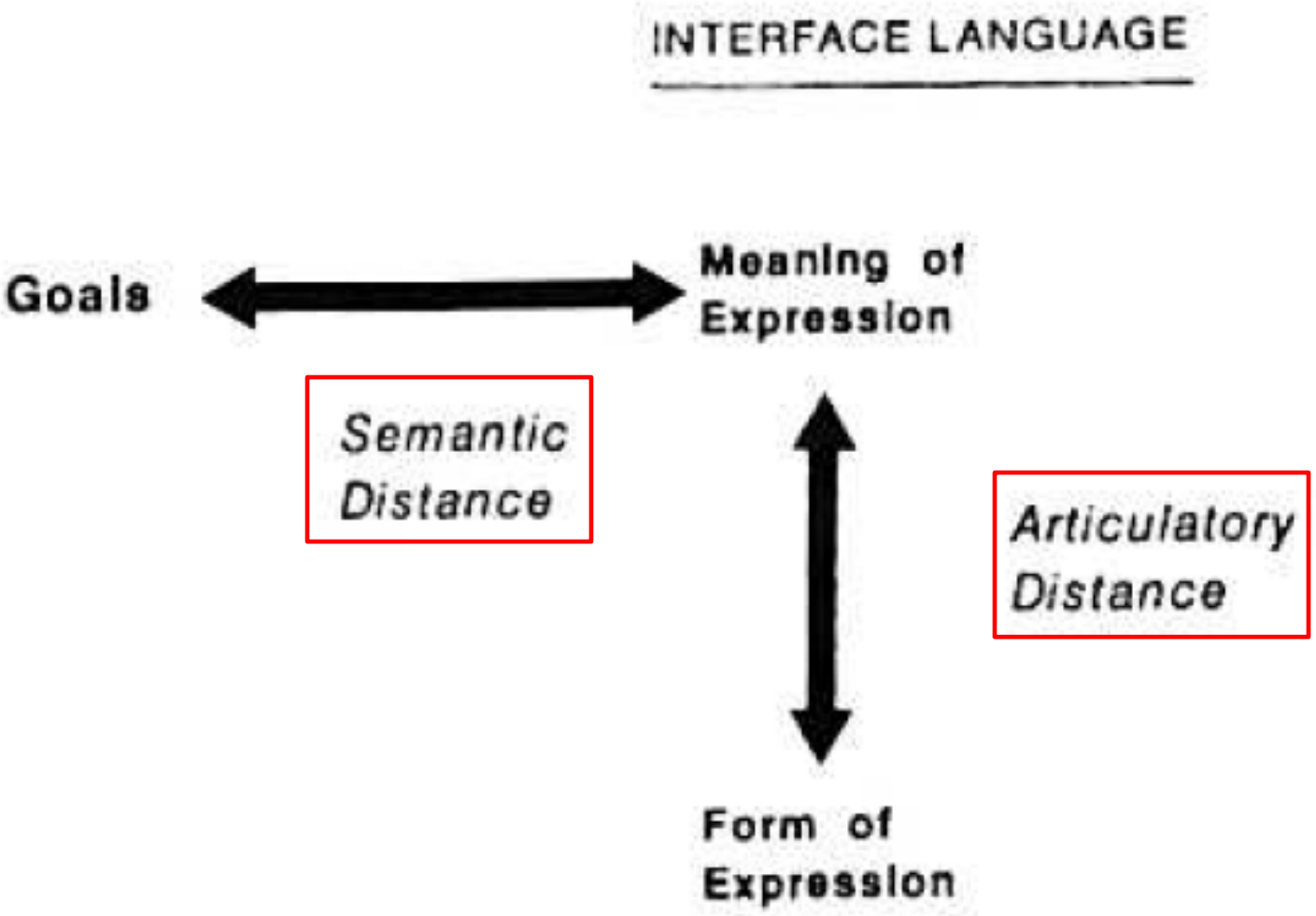
- Reflects the amount of effort that the person must exert
  - to interpret the physical state of the system
  - to determine how well the expectations and intentions have been met

- Related to **feedback** and **visibility**



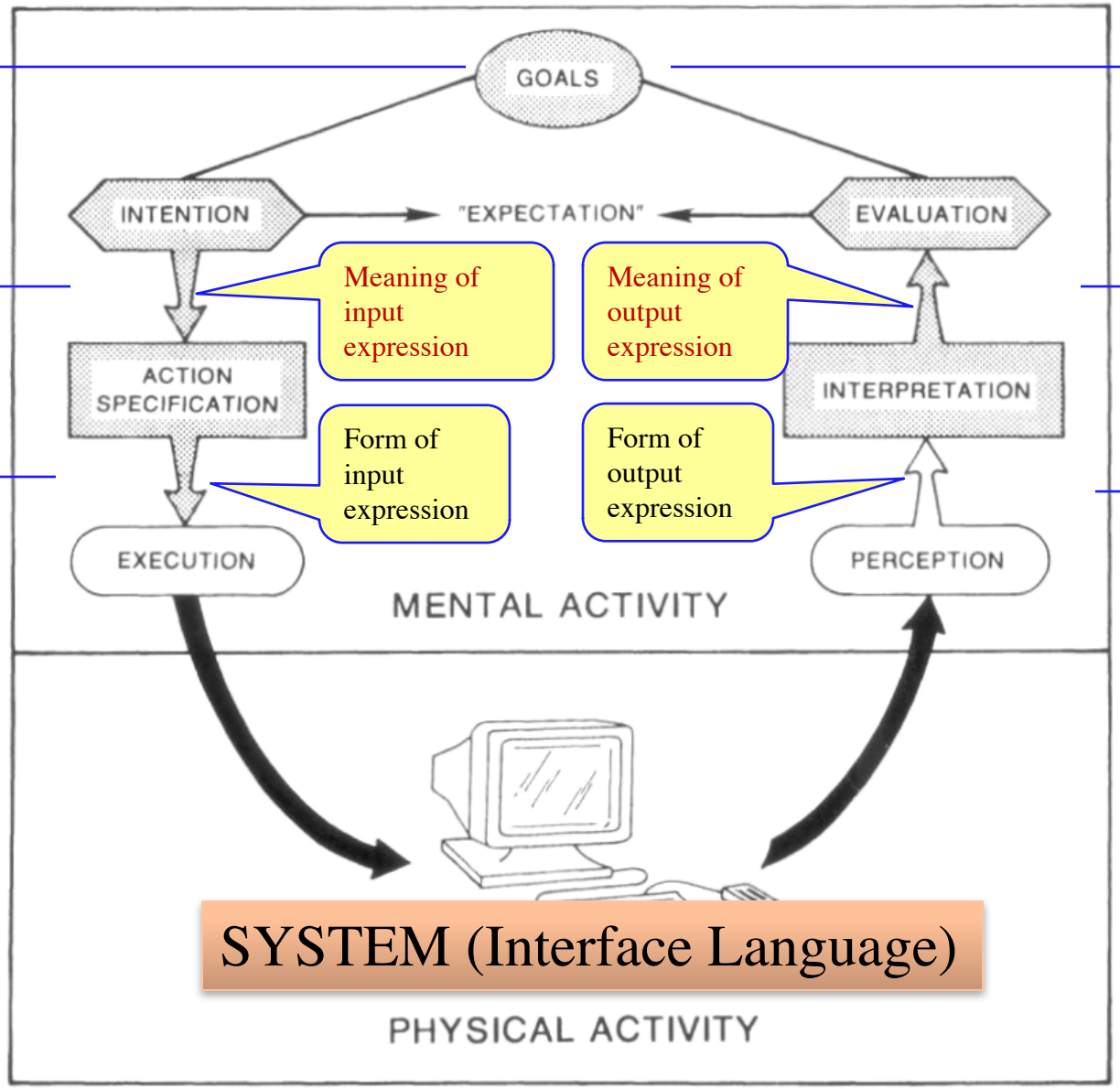
Norman, 2002

Meaning and Form of Expression



Norman, 2002

Gulfs and Distances



Semantic Distance

Articulatory Distance

Semantic Distance

Articulatory Distance

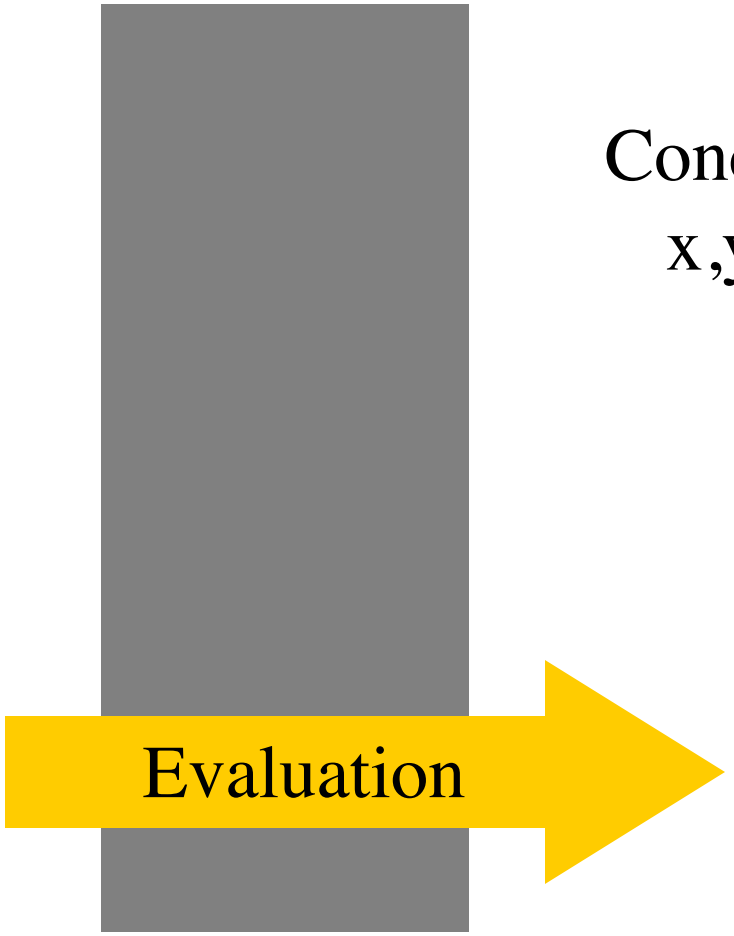
Norman, 2002

Gulf of evaluation: statistical analysis (1)

Gulf

Real world:

X	Y
0.67	0.79
0.32	0.63
0.39	0.72
0.27	0.85
0.71	0.43
0.63	0.09
0.03	0.03
0.20	0.54
0.51	0.38
0.11	0.33
0.46	0.46

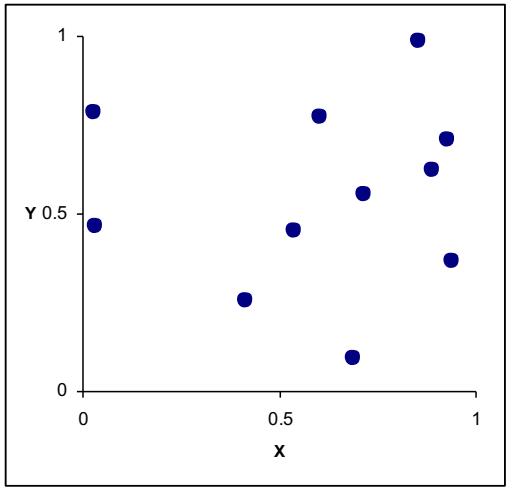


Conceptual model:
x,y correlated?

Gulf of evaluation: statistical analysis (2)

Gulf

Real world:



Conceptual model:
x,y correlated?

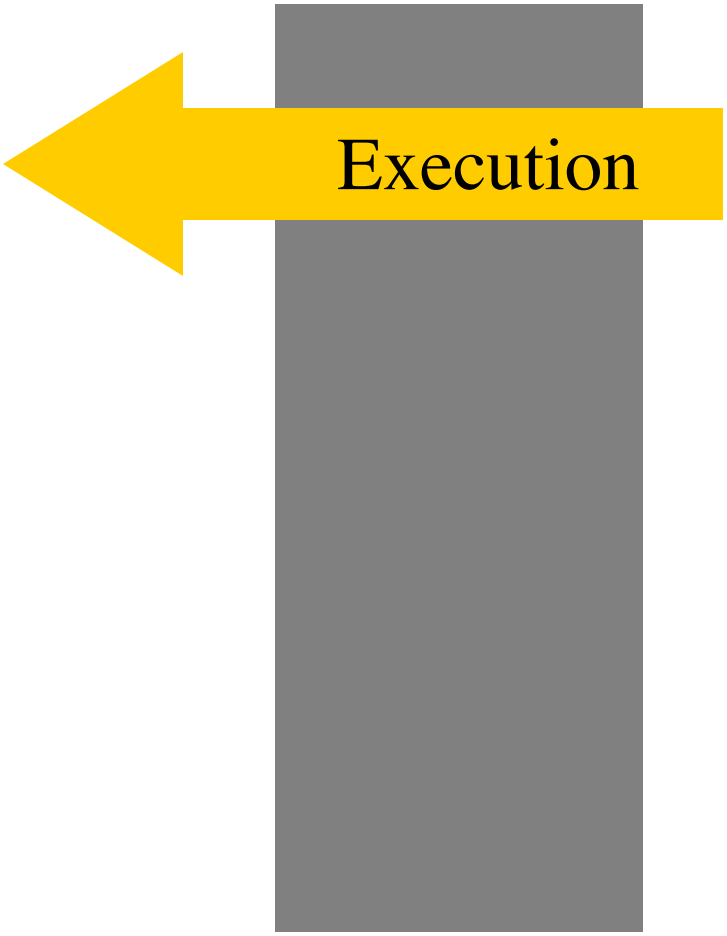
Evaluation

Gulf of execution: Drawing a rectangle (1)

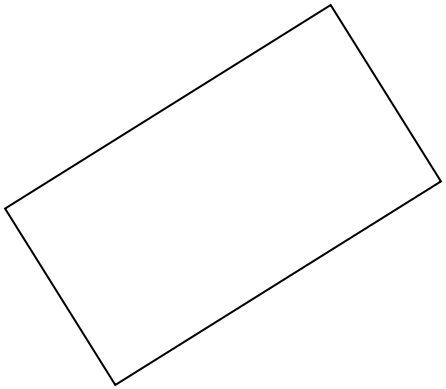
Real world

Gulf

Conceptual model:
Draw a rectangle



Move 90 30
Rotate 35
Pen down
…



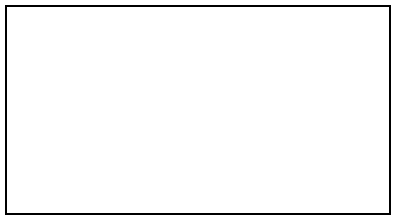
Gulf of execution: Drawing a rectangle (2)

Real world

Gulf

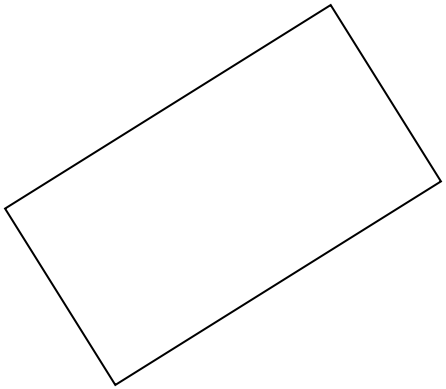
Conceptual model:
Draw a rectangle

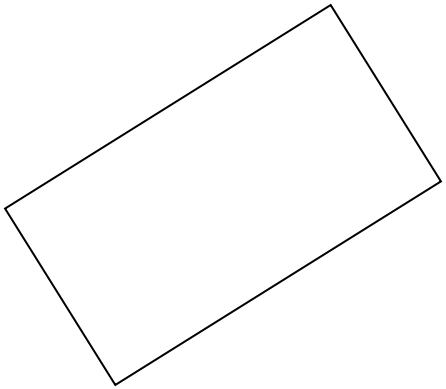
Draw a rectangle



Execution

Rotate the shape





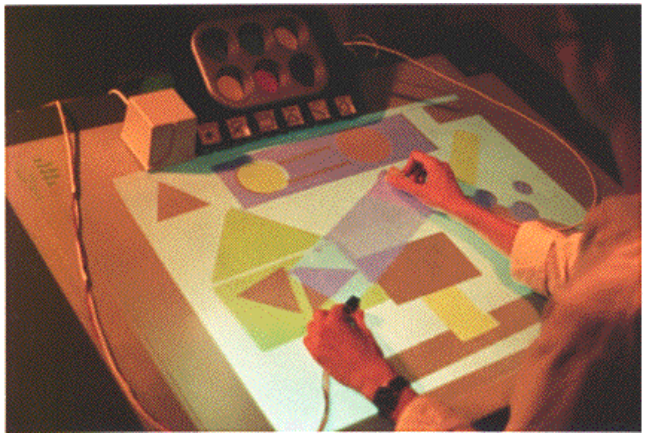
Gulf of execution: Drawing a rectangle (3)

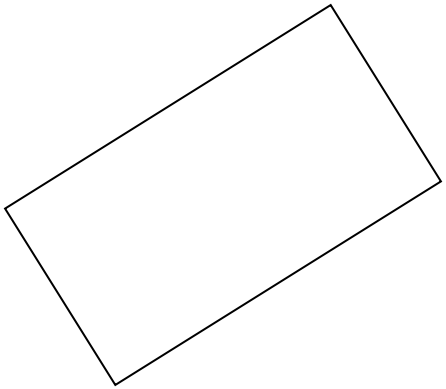
Real world

Gulf

Conceptual model:
Draw a rectangle

Execution





How to bridge the gulfs

- From system side by the interface
- From user side by developing appropriate conceptual models
  - Cognitive/mental burden on users

- **Minimize cognitive (mental) effort of users**

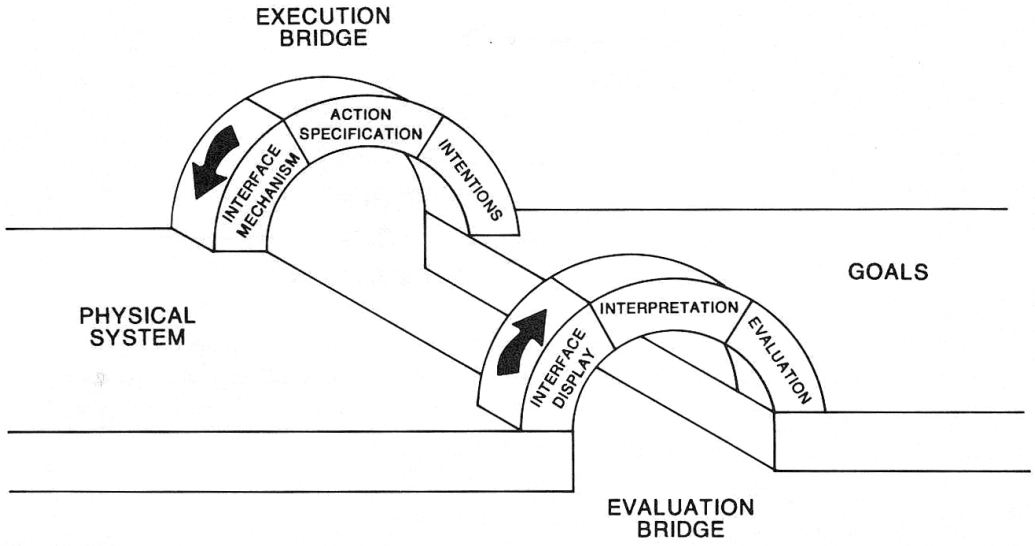
- Gulf of Execution
  - Make the commands and mechanisms of the system match the thoughts and goals of the users

- Gulf of Evaluation
  - Make the output displays present a good “Conceptual Model” of the system

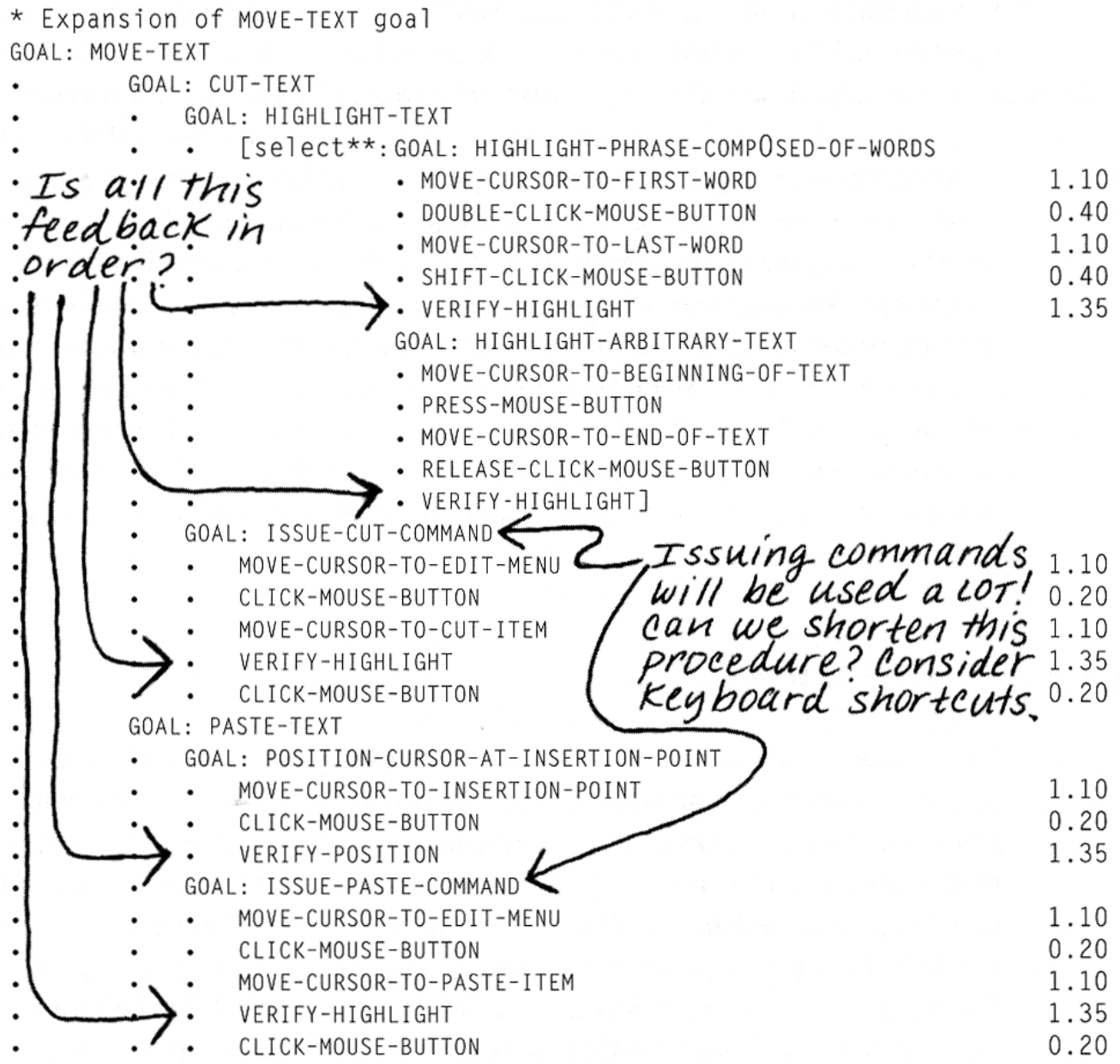
Cognitive engineering example

- Move “paper.tex” from ~/conferences/CHI_10
  to ~/conferences/UIST_10
  - Using a Unix shell (current directory is ~)
  - Using a GUI (starting from the desktop, no window open)

- What are the evaluation and execution gulfs?



Cognitive engineering; Direct Manipulation Interfaces
Book: "User Centered System Design", by Donald Norman and Stephan Draper


* Expansion of MOVE-TEXT goal
GOAL: MOVE-TEXT
GOAL: CUT-TEXT
GOAL: HIGHLIGHT-TEXT
[select**: GOAL: HIGHLIGHT-PHRASE-COMPOSED-OF-WORDS
• MOVE-CURSOR-TO-FIRST-WORD 1.10
• DOUBLE-CLICK-MOUSE-BUTTON 0.40
• MOVE-CURSOR-TO-LAST-WORD 1.10
• SHIFT-CLICK-MOUSE-BUTTON 0.40
• VERIFY-HIGHLIGHT 1.35
GOAL: HIGHLIGHT-ARBITRARY-TEXT
• MOVE-CURSOR-TO-BEGINNING-OF-TEXT
• PRESS-MOUSE-BUTTON
• MOVE-CURSOR-TO-END-OF-TEXT
• RELEASE-CLICK-MOUSE-BUTTON
• VERIFY-HIGHLIGHT]
GOAL: ISSUE-CUT-COMMAND
• MOVE-CURSOR-TO-EDIT-MENU 1.10
• CLICK-MOUSE-BUTTON 0.20
• MOVE-CURSOR-TO-CUT-ITEM 1.10
• VERIFY-HIGHLIGHT 1.35
• CLICK-MOUSE-BUTTON 0.20
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
• CLICK-MOUSE-BUTTON 0.20
• MOVE-CURSOR-TO-PASTE-ITEM 1.10
• VERIFY-HIGHLIGHT 1.35
• CLICK-MOUSE-BUTTON 0.20
TOTAL TIME PREDICTED (SEC) 16.25
Is all this feedback in order?
Issuing commands will be used a LOT! Can we shorten this procedure? Consider keyboard shortcuts.

CMN-GOMS

Three Principles of Direct Manipulation

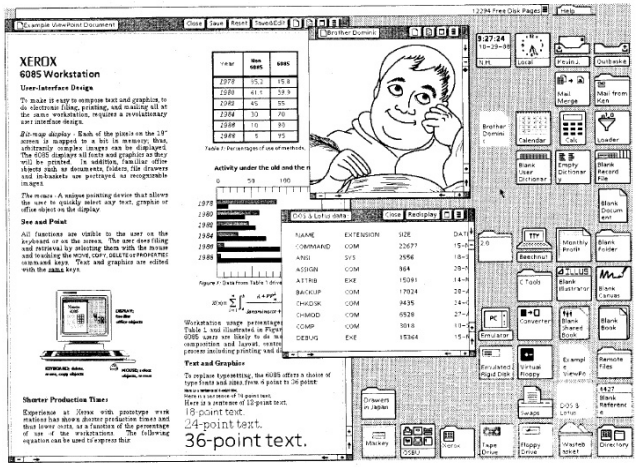
- **Continuous** representation of the objects and actions of interest with **meaningful visual metaphors**

- **Physical** actions or presses of labeled buttons, instead of complex syntax

- **Rapid**, **incremental**, **reversible** actions with **immediate visible feedback**

Direct manipulation (Shneiderman, 1974)

- Central ideas
  - Object understood by their visual characteristic
    - *Using good affordances*
    - *Using a good conceptual model and convincing metaphors*
  - Actions understood in term of their effects on the screen
    - ***Rapid*** *and* ***incremental***
    - ***Immediate*** *visual feedback*
    - *Easily* ***reversible***
- Outcome
  - Direct **engagement**
    - *the feeling of working* directly *on the task*
    - *No need to know the implementation details*
  - The display becomes reality: the WYSIWYG interface
  - Fewer error messages?



Xerox Star, Smith et al., 1982

Shneiderman, Direct manipulation: A step beyond programming language, IEEE Computer, 16(8), pp 57-69, 1983

Grammatical structure

- Object-action (Noun verb)
  - Modeless
  - Action always within the context of objects
  - Examples
    - *Drag and drop…*
    - *Select and delete*

- Action-Object (Verb noun)
  - Modal
    - ***Mode** can be dangerous*
  - Often more efficient
  - Examples
    - *Pick a tool, then use it…*

Interface metaphors

- Definition
  - Use of one kind of object or idea in place of another to suggest a likeness or analogy between them
- Purpose
  - Leverages our knowledge of familiar, concrete objects/experiences
  - Transfer this knowledge to abstract computer and task concepts
- Examples
  - Desktop, files, folders, trash can…
  - Paintbrush in a painting program

- Two Metaphors for HCI (Norman and Draper)
  - Conversation metaphor
    - *The interface is a language medium to express assumed implicit objects*
  - Model world metaphor
    - *The interface is itself a world where the user can act and get response*

Direct Engagement

- Model world metaphor
  - "Sensation in the user of acting upon the objects of the task domain themselves"

- Direct Manipulation
  - Qualitative feeling that we are directly "engaged" with **the control of the objects** (the semantic objects of our goals and intentions)
  - Not with the programs!

Metaphors caveats

- Too limited
  - The metaphor restricts interface possibility
- Too powerful
  - The metaphor makes believe that the system can do things it can’t
- Too literal or cute
  - Make it difficult (or tedious) to operate
- Mismatched
  - The metaphor makes it difficult to carry out the task

Direct manipulation: Good or Evil?

- Good for intermediate users
  - Recognition versus recall trade-off
  - What about expert? Fast?
  - Accuracy? (type exact coordinates vs. point)
- Explicit versus implicit command
  - How to automate, generalize tasks?
  - "rename each file by adding '_old' to its name"
- Metaphor might be too restrictive
  - WYSIAYG: What You See Is All You Get
- Applications mix
  - Direct manipulation
    - *Tools, drag and drop interactions…*
  - Abstraction
    - *Menus, dialog boxes, scripting, …*

Problems with direct manipulation

- Consume valuable screen space
- Must learn the meaning of visual representations
- Misleading visual representation
- For blind or vision-impaired users?
- For expert users?
- For small screens?

Shneiderman, Direct manipulation: A step beyond programming language, IEEE Computer, 16(8), pp 57-69, 1983