CHAPTER 2:
Guidelines, Principles, and Theories

Designing the User Interface:

Strategies for Effective Human-Computer Interaction

Fifth Edition

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Addison Wesley
is an imprint of

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Guidelines

Guidelines

- Shared language
- Best practices
- Critics
  - Too specific, incomplete, hard to apply, and sometimes wrong
- Proponents
  - Encapsulate experience

Navigating the interface

- Sample of the National Cancer Institutes guidelines:
  - Standardize task sequences
  - Ensure that embedded links are descriptive
  - Use unique and descriptive headings
  - Use check boxes for binary choices
  - Develop pages that will print properly
  - Use thumbnail images to preview larger images

Accessibility guidelines

- Sample of Access Board guidelines
  - Provide a text equivalent for every non-text element
  - For any time-based multimedia presentation synchronize equivalent alternatives
  - Information conveyed with color should also be conveyed without it
  - Title each frame to facilitate identification and navigation

Organizing the display

- Smith and Mosier (1986) offer five high-level goals
  - Consistency of data display
  - Efficient information assimilation by the user
  - Minimal memory load on the user
  - Compatibility of data display with data entry
  - Flexibility for user control of data display

Organizing the display cont'd

- Sample: Design of control rooms for electric-power utilities
  - Be consistent in labelling and graphic conventions
  - Standardize abbr.
  - Use consistent formatting in all displays (headers/footers, paging, etc.)
  - Present data only if they assist the operator (necessary data)
  - Present info graphically
  - Present digital values only when knowledge of numerical values is necessary and useful
  - Use high-resolution monitors and maintain them to provide maximum display quality
  - Design a display in monochromatic for using space and arrangement for organization and then judiciously add color where it will aid the operator
  - Involve users in the development of new displays and procrdures

Getting the user's attention

- Intensity
- Marking
- Size
- Choice of fonts
- Inverse video
- Blinking
- Color
- Audio

Data entry

- Sample of Smith and Mosier guidelines for data entry
  - Consistency of data-entry transactions
  - Minimal input actions by user
  - Minimal memory load on users
  - Compatibility of data entry with data display
  - Flexibility for user control of data entry

Principles

Principles

- More fundamental, widely applicable, and enduring than guidelines
- Need more clarification
- Fundamental principles
  - Determine user's skill levels
  - Identify the tasks
  - …
- Five primary interaction styles
- Eight golden rules of interface design
- Prevent errors
- Automation and human control

Determine user's skill levels

- "Know thy user"
- Age, gender, physical and cognitive abilities, education, cultural or ethnic background, training, motivation, goals and personality
- Design goals based on skill level
  - Novice or first-time users
  - Knowledgeable intermediate users
  - Expert frequent users
- Multi-layer designs

Identify the tasks

- Task Analysis usually involve long hours observing and interviewing users
- Decomposition of high level tasks
- Relative task frequencies

	TASK				
Job Title	Query by Patient	Update Data	Query Across Patients	Add Relations	Evaluate System
Nurse	0.14	0.11			
Physician	0.06	0.04			
Supervisor	0.01	0.01	0.04		
Appointment personnel	0.26				
Medical-record maintainer	0.07	0.04	0.04	0.01	
Clinical researcher			0.08		
Database programmer		0.02	0.02	0.05	

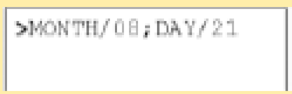
Choose an interaction style

- Direct Manipulation
- Menu selection
- Form fill-in
- Command language
- Natural language

Advantages	Disadvantages
Direct manipulation	
Visually presents task concepts	May be hard to program
Allows easy learning	May require graphics display and pointing devices
Allows easy retention	
Allows errors to be avoided	
Encourages exploration	
Affords high subjective satisfaction	
Menu selection	
Shortens learning	Presents danger of many menus
Reduces keystrokes	May slow frequent users
Structures decision making	Consumes screen space
Permits use of dialog-management tools	Requires rapid display rate
Allows easy support of error handling	
Form fill-in	
Simplifies data entry	Consumes screen space
Requires modest training	
Gives convenient assistance	
Permits use of form-management tools	
Command language	
Flexible	Poor error handling
Appeals to "power" users	Requires substantial training and memorization
Supports user initiative	
Allows convenient creation of user-defined macros	
Natural language	
Relieves burden of learning syntax	Requires clarification dialog
	May not show context
	May require more keystrokes
	Unpredictable

Spectrum of Directness

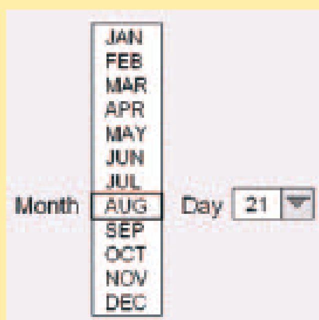
An example of progression towards more direct manipulation: less recall/more recognition, fewer keystrokes/fewer clicks, less capability to make errors, and more visible context.



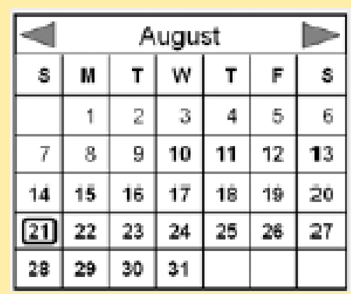
a. Command line

b. Form fill-in to reduce typing

c. Improved form fill-in to clarify and reduce errors



d. Pull-down menus offer meaningful names and eliminate invalid values



e. 2-D menus to provide context, show valid dates, and enable rapid single selection

The eight golden rules of interface design

1. Strive for consistency
2. Cater to universal usability
3. Offer informative feedback
4. Design dialogs to yield closure
5. Prevent errors
6. Permit easy reversal of actions
7. Support internal locus of control
8. Reduce short term memory load

Prevent errors

- Make error messages specific, positive in tone, and constructive
- Mistakes and slips (Norman, 1983)
- Correct actions
  - Grey out inappropriate actions
  - Selection rather than freestyle typing
  - Automatic completion
- Complete sequences
  - Single abstract commands
  - Macros and subroutines

Automation and human control

Humans Generally Better	Machines Generally Better
Sense low-level stimuli	Sense stimuli outside human's range
Detect stimuli in noisy background	Count or measure physical quantities
Recognize constant patterns in varying situations	Store quantities of coded information accurately
Sense unusual and unexpected events	Monitor prespecified events, especially infrequent ones
Remember principles and strategies	Make rapid and consistent responses to input signals
Retrieve pertinent details without *a priori* connection	Recall quantities of detailed information accurately
Draw on experience and adapt decisions to situation	Process quantitative data in prespecified ways
Select alternatives if original approach fails	Reason deductively: infer from a general principle
Reason inductively: generalize from observations	Perform repetitive preprogrammed actions reliably
Act in unanticipated emergencies and novel situations	Exert great, highly controlled physical force
Apply principles to solve varied problems	Perform several activities simultaneously
Make subjective evaluations	Maintain operations under heavy information load
Develop new solutions	Maintain performance over extended periods of time
Concentrate on important tasks when overload occurs	
Adapt physical response to changes in situation	

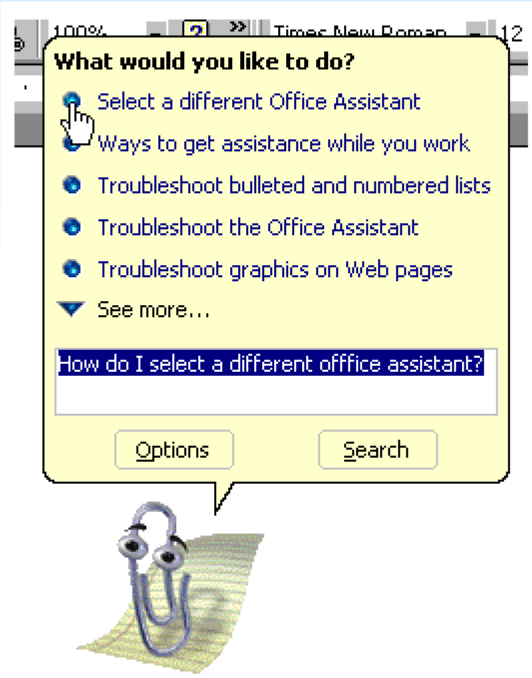
Automation and human control (cont.)

- Successful integration:
  - Users can avoid:
    - Routine, tedious, and error prone tasks
  - Users can concentrate on:
    - Making critical decisions, coping with unexpected situations, and planning future actions

Automation and human control (cont.)

- Supervisory control needed to deal with real world open systems
  - E.g. air-traffic controllers with low frequency, but high consequences of failure
  - FAA: design should place the user in control, and automate only to improve system performance, without reducing human involvement

Automation and human control (cont.)



- Goals for autonomous agents
  - knows user's likes and dislikes
  - makes proper inferences
  - responds to novel situations
  - performs competently with little guidance
- Tool like interfaces versus anthropomorphic autonomous agents

Automation and human control (cont.)

"Team America: World Police"

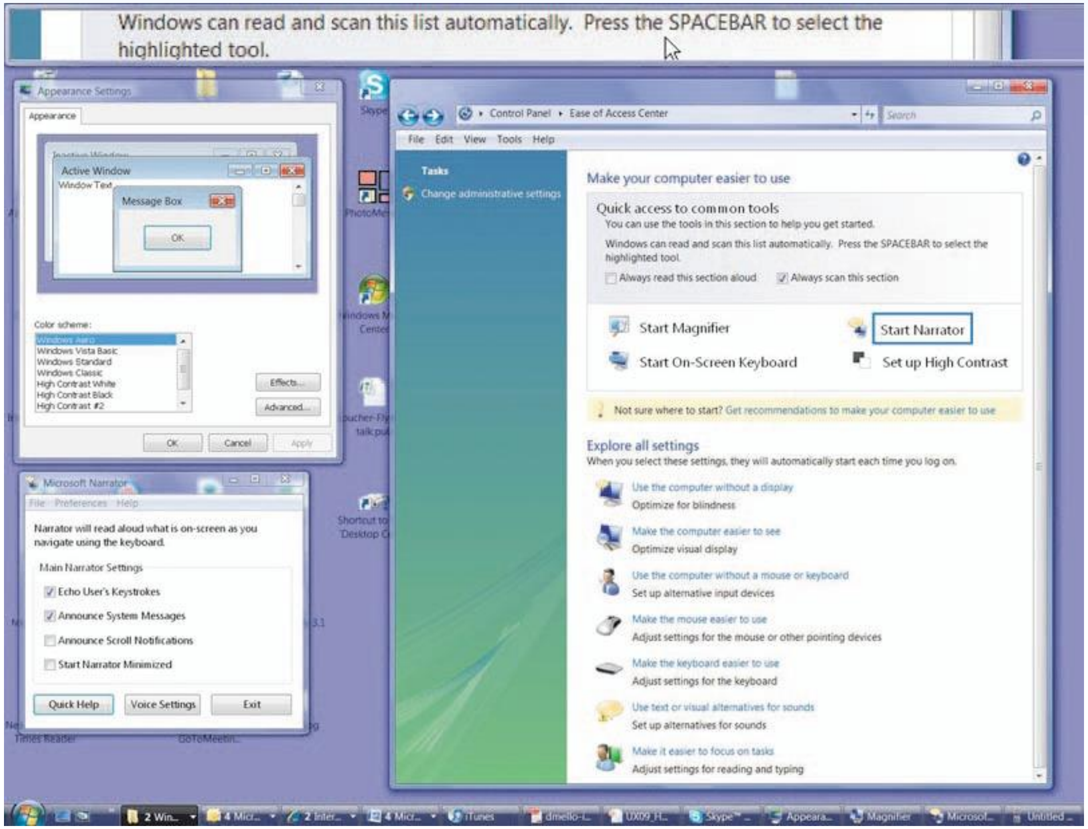
Automation and human control (cont.)

- User modeling for adaptive interfaces
  - keeps track of user performance
  - adapts behavior to suit user's needs
  - allows for automatically adapting system
    - response time, length of messages, density of feedback, content of menus, order of menu items, type of feedback, content of help screens
  - can be problematic
    - system may make surprising changes
    - user must pause to see what has happened
    - user may not be able to
      - predict next change
      - interpret what has happened
      - restore system to previous state

Automation and human control (cont.)

- Alternative to agents:
  - user control, responsibility, accomplishment
  - expand use of control panels
    - style sheets for word processors
    - specification boxes of query facilities
    - information-visualization tools

Automation and human control (concluded)



Features to aid in universal access

Above: Mac OS X system preference settings

Right: Windows Vista Control Panel

Theories

Theories

- Beyond the specifics of guidelines
- Principles are used to develop theories
- Theories can be categorized:
  - Descriptive, explanatory, prescriptive or predictive
  - Motor task, perceptual, or cognitive

Explanatory and predictive theories

- **Explanatory theories:**
  - Observing behavior
  - Describing activity
  - Conceiving of designs
  - Comparing high-level concepts of two designs
  - Training
- **Predictive theories:**
  - Enable designers to compare proposed designs for execution time or error rates

Perceptual, Cognitive, & Motor tasks

- **Perceptual or Cognitive subtasks theories**
  - Predicting reading times for free text, lists, or formatted displays
- **Motor-task performance times theories:**
  - Predicting keystroking or pointing times

Taxonomy (explanatory theory)

- Order on a complex set of phenomena
- Facilitate useful comparisons
- Organize a topic for newcomers
- Guide designers
- Indicate opportunities for novel products.

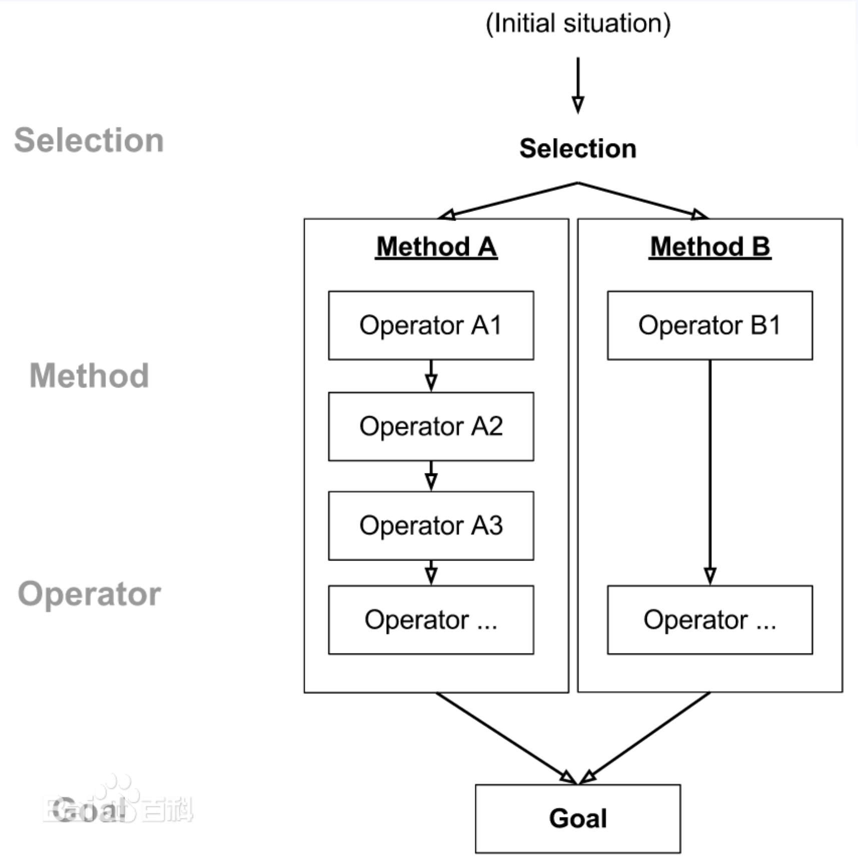
Theories

- Some more about theories
  - Theories should be more central to research and practice
  - Theories should lead rather than lag behind practice

Design by levels: Conceptual, semantic, syntactic, and lexical model

- Foley and van Dam four-level approach
  - *Conceptual level:*
    - User's mental model of the interactive system
  - *Semantic level:*
    - Describes the meanings conveyed by the user's command input and by the computer's output display
  - *Syntactic level:*
    - Defines how the units (words) that convey semantics are assembled into a complete sentence that instructs the computer to perform a certain task
  - *Lexical level:*
    - Deals with device dependencies and with the precise mechanisms by which a user specifies the syntax
- Approach is convenient for designers
  - Top-down nature is easy to explain
  - Matches the software architecture
  - Allows for useful modularity during design

Design by levels: GOMS



Stages of action models

- **Norman's seven stages of action**
  1. **Forming the goal**
  2. **Forming the intention**
  3. **Specifying the action**
  4. **Executing the action**
  5. **Perceiving the system state**
  6. **Interpreting the system state**
  7. **Evaluating the outcome**
- **Norman's contributions**
  - **Context of cycles of action and evaluation.**
  - ***Gulf of execution:* Mismatch between the user's intentions and the allowable actions**
  - ***Gulf of evaluation:* Mismatch between the system's representation and the users' expectations**

Stages of action models (cont.)

- **Four principles of good design**
  - State and the action alternatives should be visible
  - Should be a good conceptual model with a consistent system image
  - Interface should include good mappings that reveal the relationships between stages
  - User should receive continuous feedback
- **Four critical points where user failures can occur**
  - Users can form an inadequate goal
  - Might not find the correct interface object because of an incomprehensible label or icon
  - May not know how to specify or execute a desired action
  - May receive inappropriate or misleading feedback

Consistency through grammars

Consistent user interface goal

- Definition is elusive - multiple levels sometimes in conflict
- Sometimes advantageous to be inconsistent.

Consistent	**Inconsistent A**	**Inconsistent B**
delete/insert character	delete/insert character	delete/insert character
delete/insert word	remove/bring word	remove/insert word
delete/insert line	destroy/create line	delete/insert line
delete/insert paragraph	kill/birth paragraph	delete/insert paragraph

Consistency through grammars (cont.)

Inconsistent action verbs

- Take longer to learn
- Cause more errors
- Slow down users
- Harder for users to remember

The disappearance of syntax

- Users must maintain a profusion of device-dependent details in their human memory.
  - Which action erases a character
  - Which action inserts a new line after the third line of a text file
  - Which abbreviations are permissible
  - Which of the numbered function keys produces the previous screen.

The disappearance of syntax (cont.)

- Learning, use, and retention of this knowledge is hampered by two problems
  - Details vary across systems in an unpredictable manner
  - Greatly reduces the effectiveness of paired-associate learning
- Syntactic knowledge conveyed by example and repeated usage
- Syntactic knowledge is system dependent

The disappearance of syntax (concluded)

- Minimizing these burdens is the goal of most interface designers
  - Modern direct-manipulation systems
  - Familiar objects and actions representing their task objects and actions.
  - Modern user interface building tools
  - Standard widgets

Contextual Theories

- User actions are situated by time and place
  - You may not have time to deal with shortcuts or device dependent syntax, such as on mobile devices, when hurried
  - Physical space is important in ubiquitous, pervasive and embedded devices, e.g. a museum guide stating information about a nearby painting
- A taxonomy for mobile device application development could include:
  - Monitor and provide alerts, e.g. patient monitoring systems
  - Gather information
  - Participate in group collaboration
  - Locate and identify nearby object or site
  - Capture information about the object and share that information

The end