CHAPTER 3:
Guidelines, Principles, and Theories

Designing the User Interface:
Strategies for Effective Human-Computer Interaction

Sixth Edition

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Introduction to Guidelines, Principles, and Theories

- **Guidelines:** Low-level focused advice about good practices and cautions against dangers.
- **Principles:** Mid-level strategies or rules to analyze and compare design alternatives.
- **Theories:** High-level widely applicable frameworks to draw on during design and evaluation, as well as to support communication and teaching.
  - Theories can also be predictive, such as those for pointing times by individuals or posting rates for community discussions.

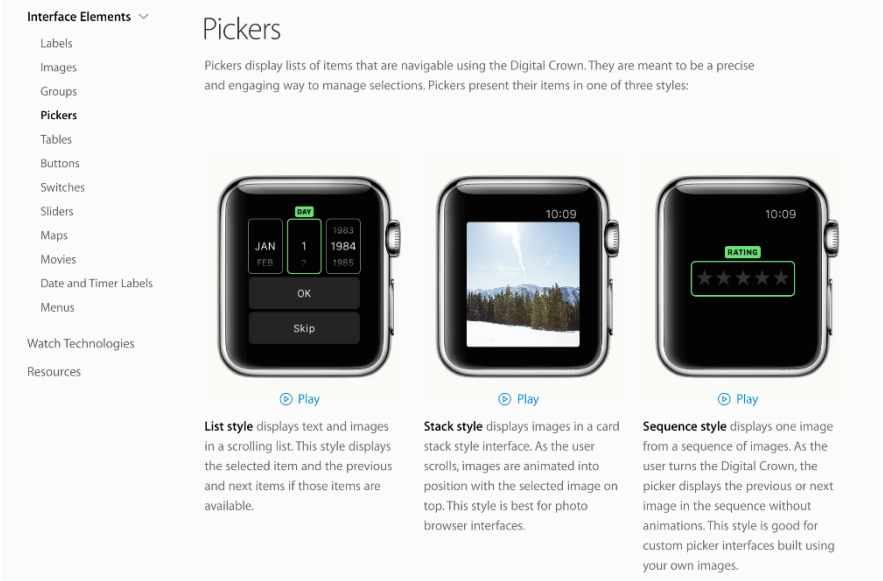
Guidelines

- Shared language to promote consistency among multiple designers in terminology usage, appearance, and action sequences
- Based on best practices
- Critics
  - Too specific, incomplete, hard to apply, and sometimes wrong
- Proponents
  - Encapsulate experience

Guidelines (continued)

- The early Apple and Microsoft guidelines, which were influential for desktop-interface designers, have been followed by dozens of guidelines documents for the Web and mobile devices

  Example of Apple guidelines for designing menus for the iWatch:



Navigating the interface

- Sample of the National Cancer Institute's guidelines (see www.usability.gov):
  - 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 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
- References:
  - U.S. Access Board
    - http://www.access-board.gov/508.htm
  - World Wide Web Consortium (W3C)
    - http://www.w3.org/TR/WCAG20/

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

Mobile HCI Design Constraints/ Guidelines

Design constraints

- Smaller screen size
- Touch data entry can cause errors
- Battery-power limitations
- Data download speed or access

Design Guidelines

- Spatial consistency
- Show high-level information
- Minimize number of steps (taps)
- Minimize data entry
- Focus on goals and optimize tasks
- Emerging standards from manufacturers

Getting the user's attention

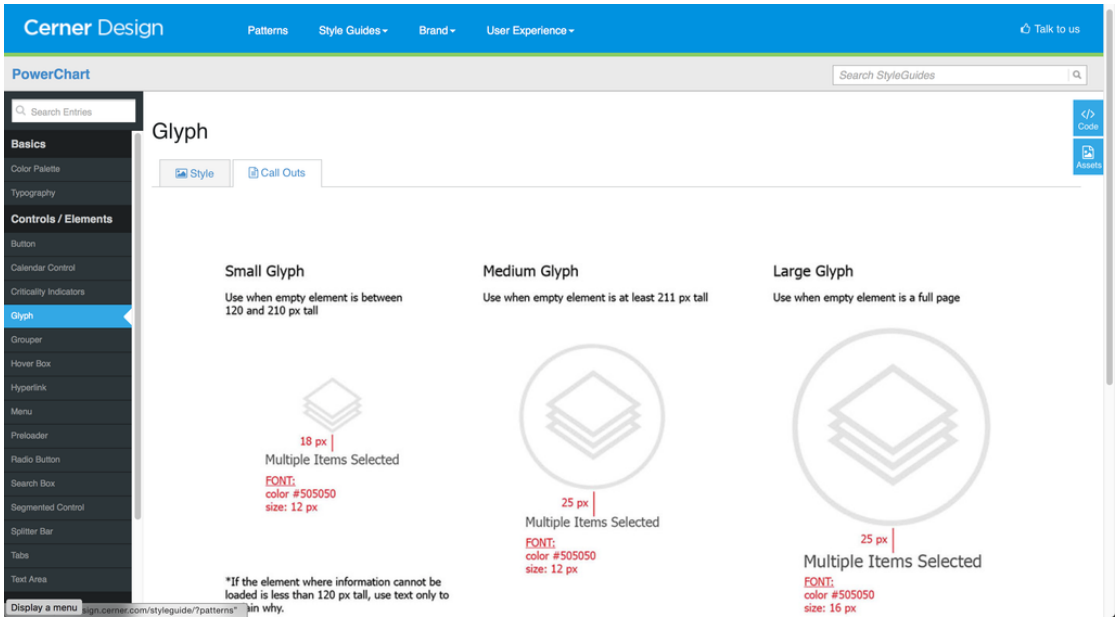
- Intensity
- Marking
- Size
- Choice of fonts
- Inverse video
- Blinking
- Color
- Audio

Facilitate data entry

- Similar sequences of actions speed learning
- Fewer input actions mean greater operator productivity, and usually less error
- Users should not be required to remember lengthy lists of codes
- The format of data-entry information should be linked closely to the format of displayed information, such as dashes in telephone numbers
- Experienced users prefer to enter information in a sequence that they can control, such as selecting the color first or size first, when clothes shopping

Facilitate data entry (concluded)

- The guidelines website for Cerner designers and developers
- This particular guideline describes the three sizes of icons or glyph that should be used in all electronic health record products (each consisting of hundreds of screens) (https://design.cerner.com/)



Principles

- More fundamental, widely applicable, and enduring than guidelines
- Need more clarification
- Fundamental principles
  - Determine user's skill levels
  - Identify the tasks
- 5 primary interaction styles
- 8 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 intermittent 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	**	**			
Physician	**	*			
Supervisor	*	*	**		
Appointment personnel	****				
Medical-record maintainer	**	**	*	*	
Clinical researcher			***		*
Database programmer		*	**	**	*

FIGURE 3.3

Frequency of Task By Job Title

Hypothetical frequency-of-use of data for a medical clinic information system. Answering queries from appointment personnel about individual patients is the highest-frequency task (****), and lower-frequency use is shown with ***, **, or *.

Choose an interaction style

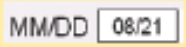
- Direct manipulation
- Menu selection
- Form fill-in
- Command language
- Natural language

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

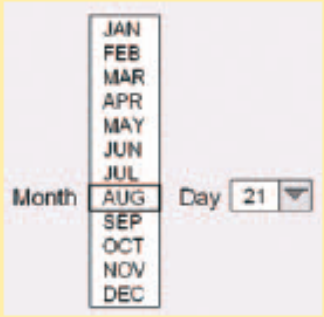
An example of progression towards more direct manipulation: less recall/more recognition, fewer keystrokes/fewer clicks, less capability to make errors, and more visible context.

a. Command line

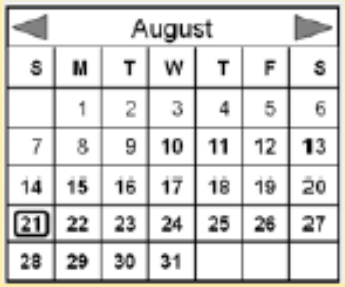


b. Form fill-in to reduce typing

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 8 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. Keep users in 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
  - Gray 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-making from hearing, sight, touch, etc.	• Sense stimuli outside human's range
• Detect familiar signals in noisy background	• Rapid consistent response for expected events
• Draw on experience and adapt to situations	• Retrieve detailed information accurately
• Select alternatives if original approach fails	• Process data with anticipated patterns
• Act in unanticipated situations	• Perform repetitive actions reliably
• Apply principles to solve varied problems	• Perform several activities simultaneously
• Make subjective value-based judgments	• Maintain performance over time
• Develop new solutions	
• Use information from external environment	
• Request help from other humans	

Automation and human control (continued)

- 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 (continued)

- 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 (continued)

- 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 autonomous agents

Automation and human control (continued)

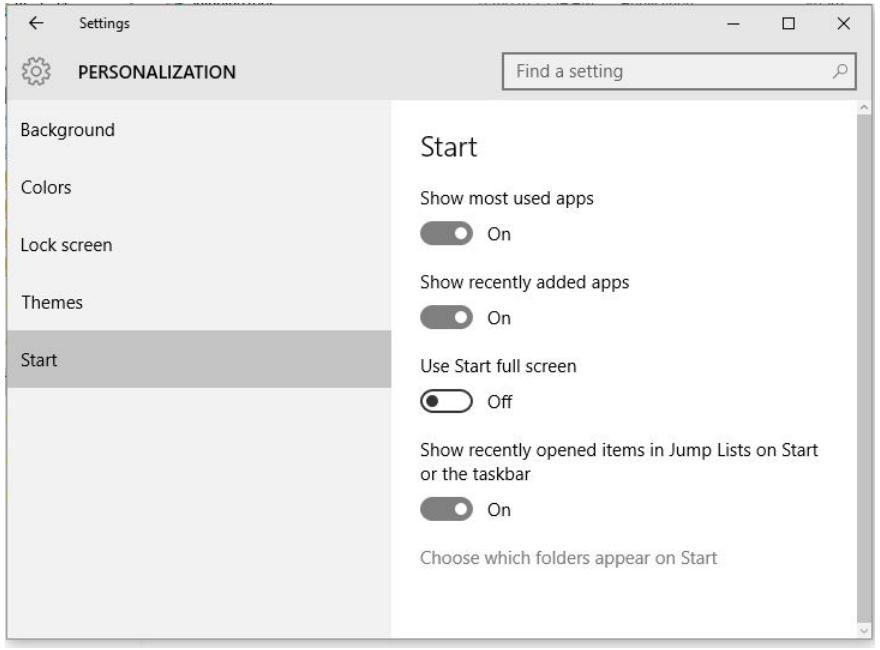
- User modeling for adaptive interfaces
  - keeps track of user performance
  - adapts behavior to suit user's needs
  - allows for automatically adapting system
    - response time, length of messages, density of feedback, content of menus, order of menu items, type of feedback, content of help screens
  - 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 (continued)

- 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)

- Users employ control panels to set physical parameters, such as the cursor blinking speed or speaker volume, and to establish personal preferences such as time/date formats, color schemes, or the content of start menus.



Theories

- Beyond the specifics of guidelines
- Principles are used to develop theories
- Some theories are descriptive
  - Explanatory
  - Prescriptive
  - Predictive
- Some theories are based on human capacity
  - Motor task
  - Perceptual
  - 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, and 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

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

**Computer Graphics: Principles and Practice, Third Edition*

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 user's expectations

Stages of action models (concluded)

- 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

Inconsistent action verbs

- Take longer to learn, cause more errors, slow down users, and are harder for users to remember

Contextual theories

- Micro-HCI Theories
  - Focus on measurable performance (such as speed and errors) on multiple standard tasks taking seconds or minutes in laboratory environments
    - Design-by-levels
    - Stages of action
    - Consistency
- Macro-HCI Theories
  - Focus on case studies of user experience over weeks and months, in realistic usage contexts with rich social engagement
    - Contextual
    - Dynamic

Contextual theories (concluded)

- 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