Lecture 9: Graphical User Interfaces

- Elements of GUI Interaction Style
  - Menus
    - Depth versus Breath
  - Icons
  - Windowing Systems
  - Direct Manipulation
    - Cognitive Account of Direction Manipulation
      - Gulf of Execution / Gulf of Evaluation

Menus

Menus

- "A set of options displayed on the screen where the selection and execution of one (or more) of the options results in a change in the state of the interface." (Paap & Roske-Hofstrand, 1988 via Preece et al.)
- Users read a list of items, select most appropriate to task
- Menus need not be graphical
- Pull-down menus
  - menu appears from clicking title at top of screen or window
- Pop-up menus
  - menu appears when clicking on screen area (e.g. an icon)
- Some objects are logically menus even though not always thought of as such
  - pull-down box of fonts
  - toolbars

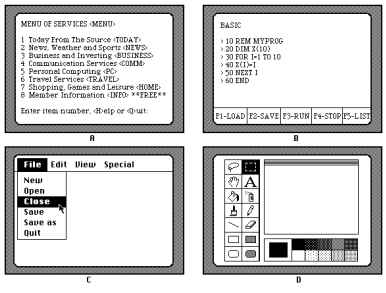


Figure 1.1 Examples of the current variety of menu selection types. Portions of menus from (a) The Source time-sharing network, (b) a Basic interpreter on the IBM-PC, (c) the Finder menu on the Apple Macintosh, and (d) the MacPaint tool palette.

From Kent Norman (1991) *The Psychology of Menu Selection*

Advantages of Menus

- Requires user only to recognize what they need or term
  - users do not have to recall command or term
- If terminology is understandable and distinct, user can accomplish task with little learning or memorization
- Menus need not be graphical
- Even if choices are not clear, menus can allow users to discover their function by trial-and-error, unlike command systems, which require reference to a manual

Organization of Options (1)

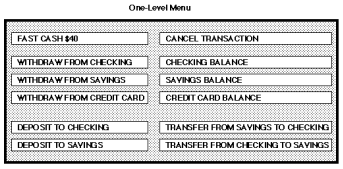
- Alternatives for organizing menu options
  - Alphabetical, Numerical
  - Categorical (Logical)
    - Select appropriate logical categories for organization
    - If logical grouping can be unambiguous and easily learned
  - Conventional (Natural Grouping)
    - Arrange into groups known to users by convention or specific task domain knowledge
    - Example: Months of the year
  - Frequency
    - more commonly chosen options appear prior to less commonly chosen options
    - Effective if number of options is small
  - Arbitrary

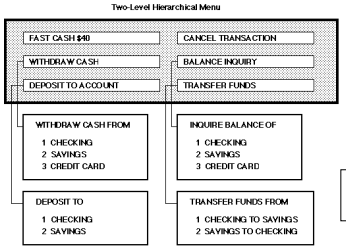
Organization of Options (2)

- ISO 9241-14 Recommendation for priority of organizing principles
  - Organization should reflect user expectations and work organization and should facilitate search
  - Conventional - first priority
    - if order of use is know, use that
  - Logical (Categorical)
    - If no conventional / natural grouping is available
    - Example: Months of the year
  - Frequency
    - if frequency is known and options or option groups number less than 8
    - In any case, if an option or options have great importance, they may be put first in priority over other ordering

Depth vs. Breath of Menus

- Hierarchical menu organization
  - Depth: increase number of menus, decrease number of options per menu
  - Breath: increase number of options per menu, decrease number of menus (or just one huge menu)
  - Design question for an application: present on one screen or divide up?
- Depth vs. Breath Tradeoff
  - Visual search time becomes a problem with broad menus
    - eye is required to search among option list, extra time from search itself
  - Navigating a large menu causes problems
    - increase cursor movement time, run out of mnemonics, etc.
  - With deep menus, more choices are required (more “mouse clicks”)
    - each choice requires search, decision, selection (motor movement)
  - Greater depth increases the uncertainty of location of an item
  - Depth is highly dependent on the organization and usability of the grouping strategy used in the hierarchical menu structure





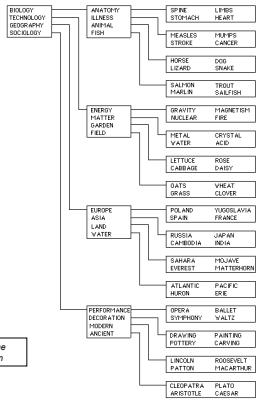
From Kent Norman (1991) *The Psychology of Menu Selection*

Figure 8.2. Two menu arrangements for automatic teller machines.

Example Study: Miller (1981)

- D. P. Miller (1981) "The depth/breath tradeoff in hierarchical computer menus" HFES Proceedings (Reported in Kent Norman, 1991)
- Experiments in which depth and breath of menu system varied while holding number of terminal nodes (final choices) constant
- Conditions: Options-per-menu by Number-of-Levels: 2^6, 4^3, 8^2, 64^1
- Procedure
  - Subjects studied hierarchy of word prior to task to familiarize
  - Goal word presented
  - Screen blanked, then menu presented
  - Menus separated by 4 second rest period
- Total response time and time per menu recorded, errors recorded

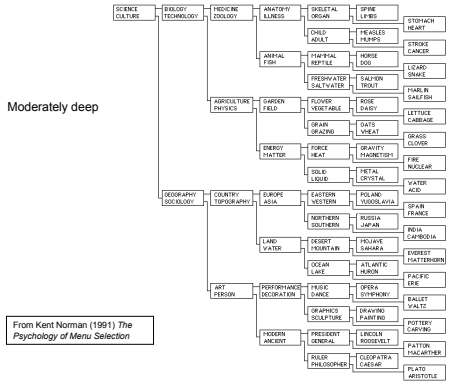
Moderately broad



From Kent Norman (1991) *The Psychology of Menu Selection*

Figure 8.7. Word hierarchy for the 4^3 condition in the study by Miller (1981).

Moderately deep



From Kent Norman (1991) *The Psychology of Menu Selection*

Figure 8.6. Word hierarchy for the 2^6 condition in the study by Miller (1981).

Miller (1981) Results

- Fastest response times for 4^3, 8^2
- Extreme versions slowest: 2^6, 64^1
- Errors: 1% in 8^2, 2.9% in 64^1, 7.6 % in 2^6, 6.6% in 4^3
- Conclude: Two-level menu hierarchy is the best
- Some methodological problems, later studies should better results for broad menus

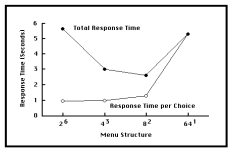


Figure 8.8. Mean total response time and response time per choice as function of menu structure. (After Miller, 1981)

From Kent Norman (1991) *The Psychology of Menu Selection*

Snowberry, Parkinson, & Sisson, 1983
Organization Makes a Difference

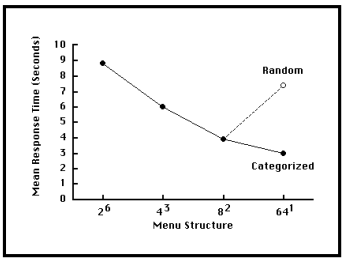


Figure 8.9 Mean response time as a function of menu tree structure.
(After Snowberry, Parkinson, & Sisson, 1983)

Conclusions: Depth vs. Breath

- Kent Norman (1991) literature review
  - Study results are mixed as to optimal trade-off of depth vs. breath
  - Generally speaking, all studies replicate result that deep menu hierarchies are more difficult to traverse
  - Concludes that should increase breath to the extent possible

> "It may very well be that the depth vs. breadth trade-off issue is really misplaced and that the transcending issue is that of effectively revealing menu organization to users, while reducing the number of frames and responses required to locate target items. …"

Paap & Roske-Hofstrand (1988) Factors Favoring Depth vs. Breadth: Quantitative Approach

- Breath
  - Hierarchical menus provide a navigation problem
- Depth
  - Crowding
    - Insufficient space to present all options
  - Insulation
    - Menus provide the ability to not offer unlikely or irrelevant options
  - Funneling
    - Reduce the total number of "options processed"
      - Efficiency gained from hierarchical menus
      - Don't have to look thru and think about as many options
    - Most advantageous when processing time per option is high

Lee & MacGregor (1985)
Depth--Breadth Tradeoff Function (1)

- Assume exhaustive search

  $$ST = ((bt + k + c) / (\ln b)(\ln n)$$

  - ST = Total Search Time
  - b = breath
  - t = processing time per option
  - k = human response time
  - n = size of database (no. of options)
  - c = computer response time
- Options per page (b) that minimizes ST
  - Set derivative with respect to b = 0

    $$b(\ln b - 1) = (k + c) / t$$

Lee & MacGregor (1985)
Depth--Breadth Tradeoff Function (2)

Conclusions from functions

- Optimal breath: 3-8 options per menu
- Benefits of depth most apparent when
  - response times per options are fast, and
  - Processing time per option is slow
- If search is *self-terminating*
  - Optimal breath is 4 – 13 options
  - Assume search terminated halfway thru list on average
  - Advantages of funneling is mitigated (i.e. less savings in options processed)
- Extended by Paap & Roske-Hofstand (1986)
  - User can restrict scope of search from
    - Experience, or
    - organization of menus

Example -- Optimal breath based upon Lee & MacGregor model = dip in curve

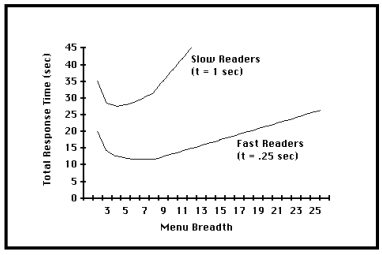


Figure 8.3. Total response time as function of the number of alternatives per menu frame using exhaustive search (k = 1, c = .50, After Lee & MacGregor, 1985).

Zaphiris & Mtei (1997)

Depth vs. Breath in Menu Applies to Web Site Navigation as Well

2 → 2 → 2 → 2 → 2 → 2

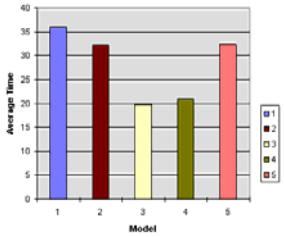
4 → 4 → 4

8 → 8

4 → 16

16 → 4

Zaphiris & Mtei (1997) – Search Time Results



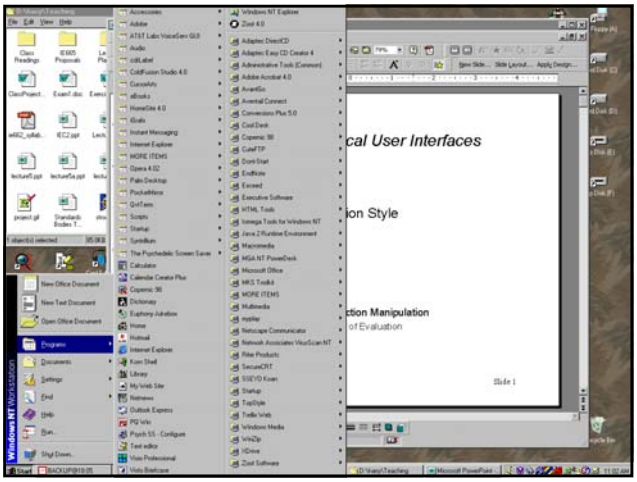
- [1] 2x6 , breadth = 2, depth = 6
- [2] 4x3, breadth = 4, depth = 3
- [3] 8x2, breadth = 8, depth = 2
- [4] 4x1 16x1 first page breadth = 4, second page breadth = 16
- [5] 16x1 4x1 first page breadth = 16, second page breadth = 4.

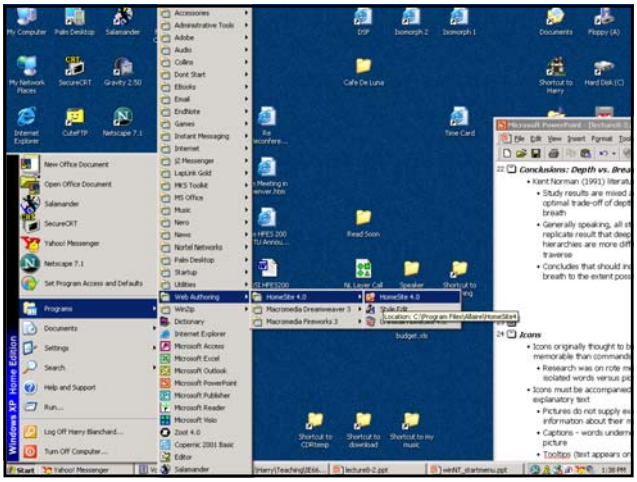
Further Conclusions

- Broader, shallow sites are better
  - Find info quicker
  - Understood better
- Later Research -- Zaphiris (2001)
  - Either extreme is bad (very broad / very deep)
  - This is particularly true for older users
- Summary of research: Straub & Weinschank (2003)
  - For web, first page of apx 16 items followed by 2-3 further menus (pages)

Discussion Exercise

- Windows Start Menu
  - Windows NT
  - Windows XP
- Issues
  - Organization
  - Depth vs. Breath
  - User control vs. System control



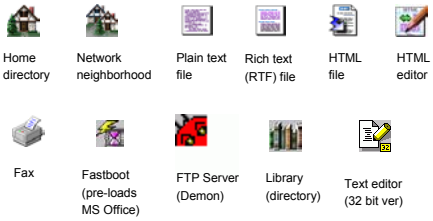


Icons

Icons

- Icons originally thought to be more memorable than commands
  - Research was on rote memory for isolated words versus pictures
- Icons must be accompanied by explanatory text
  - Pictures do not supply exact information about their meaning
  - Captions - words underneath picture
  - Tooltips (text appears on mouse “rollover”)
- Icons are important
  - … in their role of providing objects for direct manipulation
  - … in conveying the (desktop) metaphor to users
- Design of icons (Nolan, 1989)
  - test candidate designs on potential users
    - determine if icons suggest the function they represent
  - Mail survey showed users prefer
    - concrete icons to abstract ones
    - familiar icons
    - boxes around icons

What do these icons represent?



Windows

Windows

- Windows are (rectangular) area of visual display which shows several virtual displays within the physical display space
  - Individual windows can show different data or actions from different computers, different applications, different files
- Window working set
  - An individual application opens several windows with different information (palettes, menus)
- Microsoft MDI (Multiple document interface)
  - Nested windows: same application contains windows within its working window
- Window management
  - Windows have controls associated with them
    - close, minimize, menus, maximize, scroll
  - Operating system controls, e.g. shift focus to different windows

What do Users Need from Windows?

- Multitasking
  - Operating system can run more than one program (process) at a time.
  - Window systems allow user to view the input and output of processes on the same display
    - Compare old alterative: unix switching between separate shells in full character displays using a control key sequence
- Task switching
  - Move quickly from one application to another
    - Without having to take explicit user-initiated steps to start application each time
    - But, CPU does not (cannot) devote processing cycles to more than one application at a time
  - Older computers (e.g. Mac) actually did task switching
  - Modern example: Palm Pilot interface
- Multitasking comes for “free” in modern technology, but consider that in many circumstances users really just *need* rapid task switching

Windows Interoperability

- Windows from different platforms have different widgets (interface elements) which perform common functions (e.g. close window)
  - Mac - MS Windows - OSF Motif (Unix)
  - See Preece et al. Ch. 14 for comparison of widgets (From Marcus, 1992)
- Standards efforts failed
  - IEEE “Driveability”
  - Analogy:
    - Get into rental car, can drive it because steering, gas, clutch have common interface
    - Radio controls are not common and may be difficult to interpret, but are not vital to task of driving car
- Nearly obsolete issue today, due to market dominance of MS Windows