Review

- What are modes?
- Why do they cause user errors?

Quasimodes

- **Quasimode (QM):** temporary mode maintained kinesthetically
  - Shift for uppercase (vs. Caps Lock), Mac menus
  - no mode errors, but don’t overuse them (max. 4..7 QMs)
  - bad: Control↓ Alt ↓ Shift ↓ Esc ↓ q↑ ↑ ↑ ↑
- *Habituating feature*: successfully operated by the blind
  - e.g., Canon Cat paragraph styles
- *Adaptive menu / palette*
  - place most (recently) used item at top of menu
  - 2 approaches: remove chosen item from list or duplicate it
  - e.g., Vellum (CAD program): adaptive palette *and* item at accustomed place
- 2 fundamental kinds of input to computer
  - *create content* or *control system*
  - rule of thumb: use quasimodes for control, but not for content
  - Why not the other way around?

Noun-Verb vs. Verb-Noun style

- Many commands apply an *action* to an *object*
  - e.g., change font of paragraph
- **Noun-verb** recommended by interface guidelines
  - command is locus of attention (no modes)
  - only one change of locus of attention
  - no cancel feature needed
- **Verb-noun** used for palettes
  - e.g., brush styles in paint programs
  - frequent mode errors but appearance is locus of attention
  - pure noun-verb model possible yet unnatural
- Case study: order form

Visibility and Affordances

- **Visible** interface feature
  - accessible to a human sense organ or in short-term memory
- **Invisible** feature
  - need to memorize that feature exists, use help system… (mapping problem)
- **Affordance** (DIS I, Norman)
  - "…indicate what parts to operate and how, how the user is to interact with the device…"
  - e.g., volume turning knob, push buttons, slots, balls
  - depends on user's experience and background, culture, context
- Optimize cognitive properties of interface
  - make all functions and the methods of operating them apparent by looking
  - visible feature should provide a recognizable affordance (icons?)
- Example: BART ticket system

Monotony

- Many methods execute the same command in today's UIs
  - e.g., menus & short-cuts, cut & paste vs. select & drag, autopilots
  - *backward* compatibility, appropriateness, managerial indecision
  - leads to complex products, errors, increased training time, costs…
- **Modeless** interface
  - gesture *g* always results in action *a*, but gesture *h* may too
- **Monotonous** interface
  - only one gesture for one particular command
  - monotony often happens spontaneously
- Modeless and monotonous interface
  - one-to-one correspondence between cause and effect
  - interface fades from user's consciousness (keep attention at task)
  - habitual and addictive product use

Beginner or Expert?

- “We’re humans first, beginners or experts second.”
  - consider cognitive capabilities and demands of task
- Common myth: different interfaces for user’s experience
  - only true for some systems, too many features to know
- Adapting to user’s level of expertise usually fails
  - How should system know your rate of learning or memory decay?
  - e.g., Windows 2000 changes order / set of menu items
- View interface through eyes of an individual
  - brief period of (conscious) learning: simplicity and visibility
  - long period of (automatic) routine: efficiency is important
- Satisfy all users’ needs with one mechanism

Quantitative analyses of interface designs

- **GOMS** (Card, Moran, and Newell 1983)
  - model of **g**oals, **o**perators, **m**ethods, **s**election rules
  - predict time an experienced worker needs to perform a task in a given interface design
- **Keystroke-level GOMS model** (simplified version)
  - comparative analyses of tasks that use GID and keyboard
  - correct ranking of performance times using different interface designs
- CPM-GOMS (critical path method)
  - computes accurate absolute times
  - considers overlapping time dependencies
- NGOMSL (natural GOMS language)
  - considers non-expert behavior (e.g., learning times)

Keystroke-level model

- Execution time for a task = sum of times required to perform the serial elementary gestures of the task
- Typical gesture timings
  - **Keying** K = 0.2 sec (tap key on keyboard, includes immediate corrections)
  - **Pointing** P = 1.1 sec (point to a position on display)
  - **Homing** H = 0.4 sec (move hand from keyboard to GID or v.v.)
  - **Mentally preparing** M = 1.35 sec (prepare for next step, routine thinking)
  - **Responding** R (time a user waits for the system to respond to input)
- Responding time R effects user actions
  - causality breakdown after 250 ms
  - give feedback that input received & recognized

Keystroke-level calculation

1. List required gestures
   - e.g., HK = move hand from GID to keyboard and type a letter
2. Compute mental preparation times Ms
   - difficult: user stops to perform unconscious mental operations
   - placing of Ms described by rules
3. Add gesture timings
   - e.g., HMPK = H + M + P + K = 0.4 + 1.35 + 1.1 + 0.2 = 3.05 sec

- Rule terminology
  - **string:** sequence of characters
  - **delimiter:** character marking beginning (end) of meaningful unit
  - **operators:** K, P, and H
  - **argument:** information supplied to a command

Rules for placing Ms

- Rule 0, initial insertion for candidate Ms
  - insert Ms in front of all Ks
  - place Ms in front of Ps that select commands, but not Ps that select arguments for the commands

- Rule 1, deletion of anticipated Ms
  - delete M between two operators if the second operator is fully anticipated in the previous one (e.g., PMK → PK)

- Rule 2, deletion of Ms within cognitive units
  - in a string of MKs that form a cognitive unit, delete all Ms except the first (e.g., "Helen of Troy", 745.8)

Rules for placing Ms

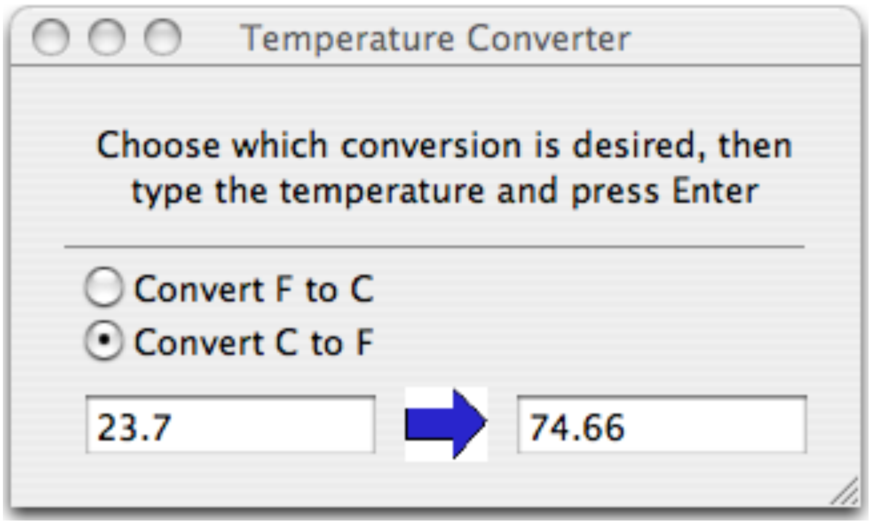
- Rule 3, deletion of Ms before consecutive terminators
  - if K is redundant delimiter at end of a cognitive unit, delete the M in front of it, e.g.,)'
- Rule 4, deletion of Ms that are terminators of commands
  - if K is a delimiter that follows a constant string then delete the M in front of it (not for arguments or varying strings)
- Rule 5, deletion of overlapped Ms
  - do not count any M that overlaps an R (e.g., user waiting for computer response)

Exercise: temperature converter

- Convert from degrees Fahrenheit (F) to Celsius (C) or v.v., requests equally distributed
- Use keyboard or GID to enter temperature
- Assume active window awaiting input, an average of four typed characters (including point and sign), and no typing errors

- Task: create and analyze your own interface!

The dialog box solution with radio buttons…



…and its keystroke-level model

- Case 1: select conversion direction
  - move hand to GID, point to desired button, click on radio button (HPK)
  - move hands back to keyboard, type four characters, tap enter (HPKHKKKKK)
  - Rule 0 (HMPMKHMKMKMKMKMK)
  - Rule 1, 2, 4 (HMPKHMKKKKMK)
  - Estimated time = 7.15 sec
- Case 2: correct conversion direction already selected
  - MKKKKMK = 3.7 sec

- Average time = (7.15 + 3.7) / 2 = 5.4 sec

Measuring interface efficiency

- How fast can you expect an interface to be?
- *Information* as quantification of amount of data conveyed by a communication (Information theory)
  - e.g., speech, messages sent upon click…
- Lower bound on amount of information required for task is independent of interface design
- **Information (theoretic) efficiency E =** min. amount of information required for task / amount of information supplied by user
  - E = 0..1 (e.g., E = 0 for providing unnecessary information)
- **Character efficiency =** min. number of characters required for task / number of characters entered in interface

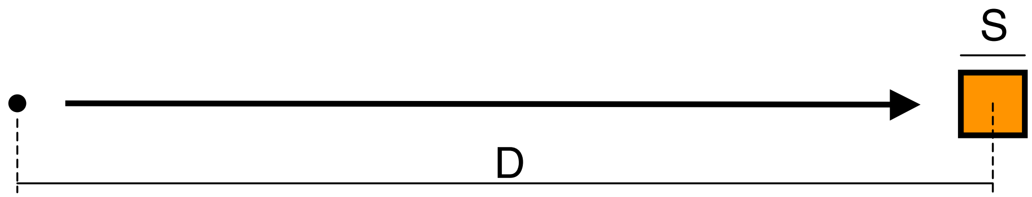
Quantify amount of data

- Information is measured in bits
  - 1 bit represents choice between 2 alternatives
- n equally likely alternatives
  - total information amount: $\log_2(n)$
  - information per alternative: $(1/n)\log_2(n)$
- n alternatives with different probabilities $p(i)$
  - information per alternative: $p(i)\log_2(1/p(i))$
  - total amount = sum over all alternatives
- Consider situation as a whole
  - probability of messages required
  - information measures freedom of choice (information $\neq$ meaning)

Example: temp. converter

- Average of 4 typed float chars, 25% negative values
  - -.dd and -d.d (each 12.5% and 100 values)
  - .ddd, d.dd, dd.d (each 25% and 1000 values)
  - Þ 11.4 bits/message, simple approach: 4 $\log_2(12) \approx 14$ bits
- Information efficiency
  - 128 keys standard keyboard (5 bits/key): $E \approx 55\%$ (11/20)
  - 16 keys numeric keypad: $E \approx 60\%$
  - 12 keys dedicated keypad: $E \approx 70\%$
- Keystroke efficiency
  - type C or F, value, enter: M K K K K K M K $\Rightarrow$ 3.9 sec (char. eff. 67 %)
  - type value, then C or F: M K K K K M K $\Rightarrow$ 3.7 sec (char. eff. 80%)
  - bifurcated: M K K K K = 2.15 sec (char. eff. 100 %)

Fitts' law



- Time to acquire a target is a function of distance (D) and size (S)
  - one dimensional, rapid movement

- Movement time MT = a + b $\log_2(D/S + 1)$ in ms
  - empirical constants a, b (e.g., a=50, b=150)
  - $\log_2(D/S + 1)$ measures difficulty of task in bits

Hick's law

- Predict choosing time of one among *n* alternative actions
- Actions equally distributed
  - $T = a + b \log_2 (n + 1)$ in ms
- Actions with different probabilities
  - $T = a + b \sum p(i) \log_2 (1/p(i) + 1)$
- Coefficients a and b as for Fitts' law
  - influenced by habituation and other factors
- Example: choosing from a menu with 8 items is faster than choosing from two menus with 4 items each
  - $a + b \log_2(9) < 2 (a + b \log_2(5))$