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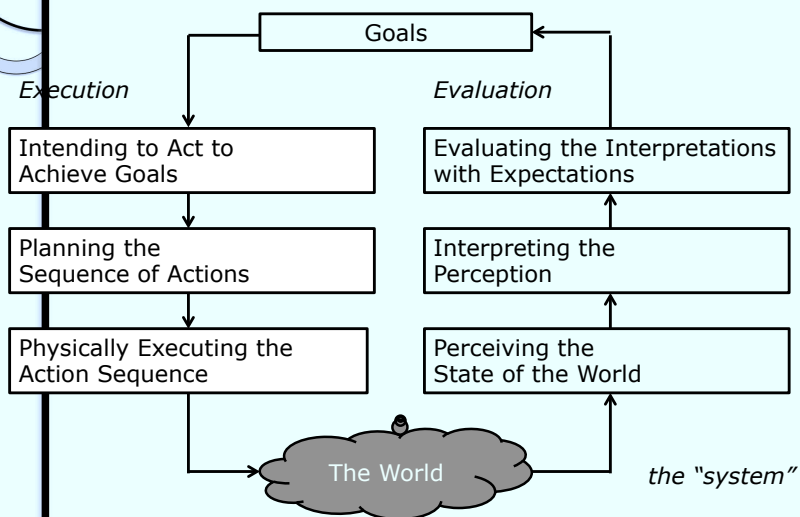
HUMAN ERROR

Human Error

- Goal:
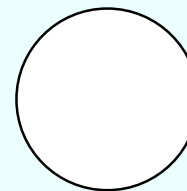 - could the designer have improved the user interface to reduce the chance of human error?

Norman's 7 Stages of Action

Goals

Execution

Evaluation

Intending to Act to Achieve Goals

Planning the Sequence of Actions

Physically Executing the Action Sequence

Evaluating the Interpretations with Expectations

Interpreting the Perception

Perceiving the State of the World

The World

the "system"

Interaction Problems

- Adobe Illustrator:
  - e.g., draw a 2-inch circle with a red boundary

Interaction Difficulties

- Gulfs of execution:
  - effort to turn intentions into actions

user's formulation of actions	? =	actions allowed by the system

- Gulfs of evaluation:
  - effort to interpret feedback

user's expectation of changed system state	? =	actual presentation of system state

to address these gulfs, need good visibility and feedback   7

Types of Human Error

- Mistake:
  - involves *conscious* thought

  - forming the wrong goal, decision, or judgment

  - e.g., deciding on the wrong version of file to delete

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Example Mistake

- USS Greeneville incident:
  - collided with and sank Japanese fishing vessel

  - *distracted* by the distinguished visitors
  - *rushed* visual checks
  - *disregarded* relevant data

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Example Mistake

- Space Shuttle Challenger incident:
  - disintegrated at 73 s into launch

  - *social pressure* to launch (teacher in space)
  - Morton Thiokol managers overrode engineers
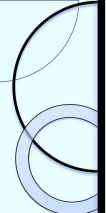 - Rockwell managers did not push their concerns

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Example Mistake

- American Airlines Flight 965:
  - crashed into a mountain on the approach to Cali, Colombia

  - erroneously cleared approach waypoints
  - entered R for waypoint (Rozo intended, but Romeo chosen)
  - lost situational awareness

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Types of Human Error

- Slip:
  - involves *everyday* thought

  - right goal formed, but doing something unintended during the performance

  - e.g., typing rn not rm to delete a file

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Example Slip

- Phobos I spacecraft:
  - lost contact

  - batteries drained
  - solar array misoriented
  - no navigational lock
  - attitude control turned off

  - single character omitted in software upload
  - no independent double-check

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Causes of Slips

- "Capture error":
  - when two different sequences of action begin similarly, and the familiar one *captures* the intended one

  - e.g., you get in your car on Saturday to go to the store, but end up at work instead

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Causes of Slips

- "Description error":
  - when the intended action has much in common with others that are possible

  - e.g., pouring juice on your breakfast cereal, rather than milk

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Causes of Slips

- "Loss-of-activation error":
  - when you forget what to do in the middle of an activity

  - e.g., you walk from the living room to the bedroom, but forget why you are there in the first place

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Causes of Slips

- "Perceptual blindness":
  - when you do not see things that are in plain sight

  - e.g., you "lost" the stapler, but it is only oriented differently from the norm

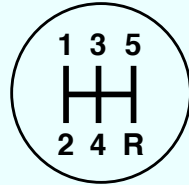 - more generally, inattentional blindness

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Causes of Slips

- "Saccadic masking":
  - when your visual perception is blocked during eye movement

  - e.g., not noticing the window content already scrolled because it happened during an eye movement
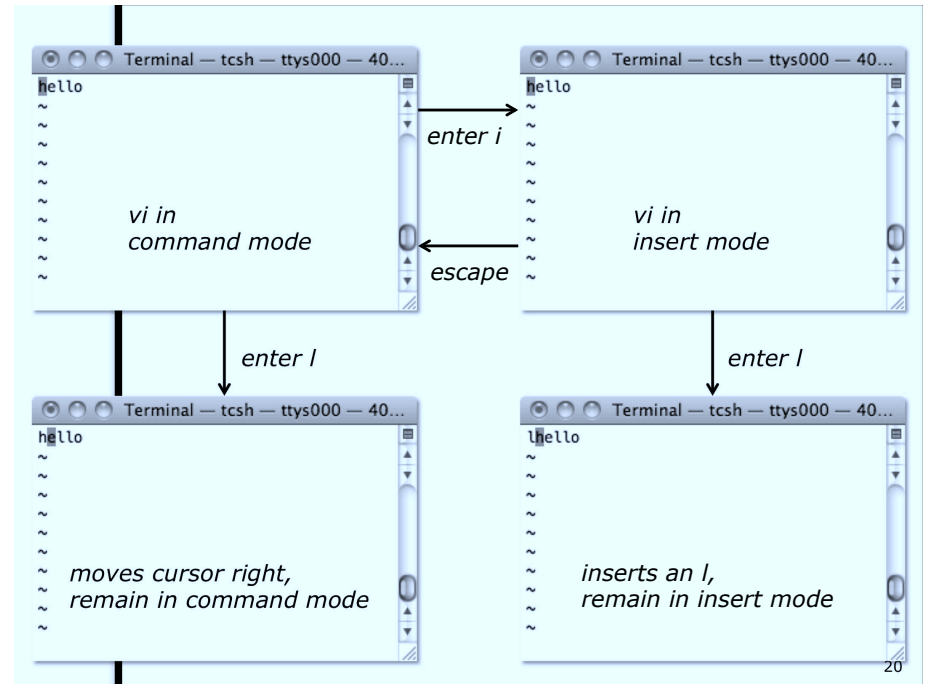
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Causes of Slips

- "Mode error":
  - when you think (or forget) something is in one state, but it is actually in another

  - e.g., car controls

  - e.g., caps lock key

---

vi in command mode — *enter i* → *vi in insert mode* — *escape* ←

enter l ↓ — *moves cursor right, remain in command mode*

enter l ↓ — *inserts an l, remain in insert mode*

Mode Error

- Three Mile Island nuclear plant:
  - partial core meltdown

  - secondary loop issues
  - reactor shutdown
  - stuck open relief valve

  - misinterpreted relief valve indicator light
  - off = powered off, not closed
  - not recognizing loss-of-coolant accident

Minimizing Human Errors

- Designing in the presence of error:
  - normal human behavior is not always direct, accurate, or rational
  - understand the causes of error and minimize those causes

  - how?

Minimizing Mode Error

- Approaches:
  - reduce the number of modes that the user needs to understand

  - make modes visible and distinctive
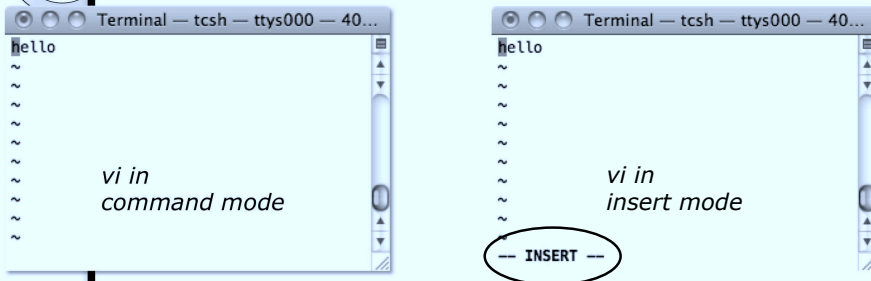
Make Modes Visible

caps lock on

Make Modes Visible

vi in command mode

vi in insert mode

-- INSERT --
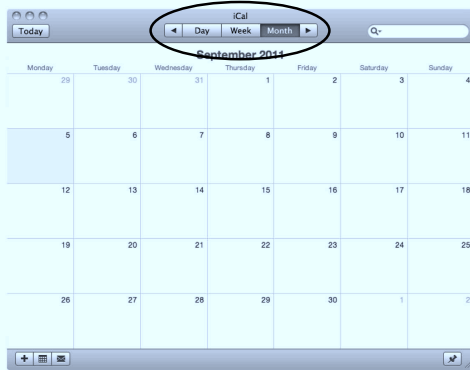
Make Modes Visible

each tool is a different mode

how else is the current tool shown?

Make Modes Distinctive

Confirm "Dangerous" Actions

- Confirm:
  - but do not overdo it

  - user: remove file "masterpiece"
  - system: are you sure?
  - user: yes
  - system: really?
  - user: yes!
  - system: file "masterpiece" removed
  - user: oops

Confirm "Dangerous" Actions

- Annoying confirmation:

  - user: quit
  - system: quit without saving?
  - user: yes
  - system: are you sure?
  - user: yes
  - system: return to application?
  - user: no!

Constraining Actions

- Constraints:
  - limitations on actions to prevent problems
  - but could become annoying in actual usage

  - e.g., clutch down and turn key to start car
  - e.g., press brake before shifting out of park

  - e.g., pressing brake disengages the accelerator

Constraining Actions

- Limiting options:
  - choose only from valid options
    - e.g., use combo boxes, sliders, spinners, etc.
  - gray out options not available in current state

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Improve Feedback

- Detection and correction:
  - improve feedback to more easily detect errors
  - give feedback on progress of slow operations
  - make actions reversible
  - validate user data
  - in an application crash,
    system suggests corrective actions

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Simplify

- Reconsider complex mental models:
  - explicit saving can create complications
  - determining a destination
  - user forgetting to save
  - auto-save feature
  - save before quit alert
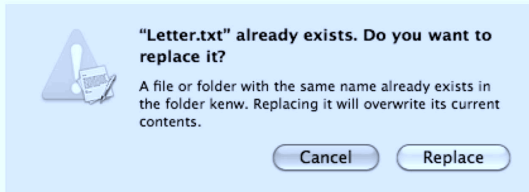 - save replace alert

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Reduce Human Actions

- Autonomic computing:
  - system manages itself
  - self-configuring, -healing, -optimizing, -protecting

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Alert Messages

clear statement of issue and question

distinctive warning icon

"Letter.txt" already exists. Do you want to replace it?

A file or folder with the same name already exists in the folder kenw. Replacing it will overwrite its current contents.

Cancel   Replace

situation and consequences

default choice is safe

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Alert Messages

- Guidelines:
  - tell the truth in plain terms

  - don't SHOUT!
  - don't be rude
  - don't use the word "error"
  - don't highlight dangerous buttons in red

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Alert Messages

- Avoid "violent" language:
  - hit
  - strike
  - punch
  - kill
  - purge
  - execute
  - destroy
  - boot

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Alert Messages

- Avoid "violent" metaphors:
  - … of death!
  - system bomb, hang, crash, freeze

  - killer applications
  - viruses, worms, bugs
  - hacking, cracking
  - ripping, burning

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Alert Messages

- Avoid cryptic messages:
  - fatal error
  - segmentation fault
  - process killed
  - core dumped
  - kernel panic

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Reducing Choices

- Approach:
  - reduce too many choices

  - analysis paralysis
    - overanalyzing a situation to the point of not making a decision

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Human Efficiency

- Hick's Law:
  - time to make a decision from a set of choices (if subdivision applies)

  - average choice reaction time
    - $T \approx b \log_2(n + 1)$
    - n equally probable choices
    - constant b determined by experiment

    - $T \approx b \sum p_i \log_2(1/p_i + 1) = b \bullet$ entropy
    - each choice with probability p_i
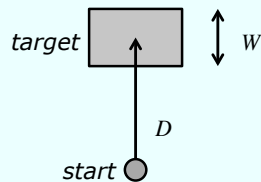
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Human Efficiency

- Fitts's Law:
  - time to point to a target object
    - through pointing device or directly

  - what does the movement time depend on?
    - size of target and distance to it
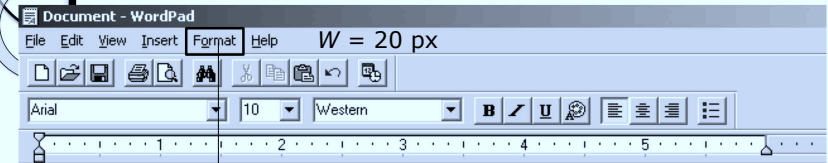
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Targeting

- Fitts's Law:
  - average movement time
    - $T \approx a + b \log_2(D/W + 1)$
    - constants a and b determined by experiment
    - distance D from start to center of target
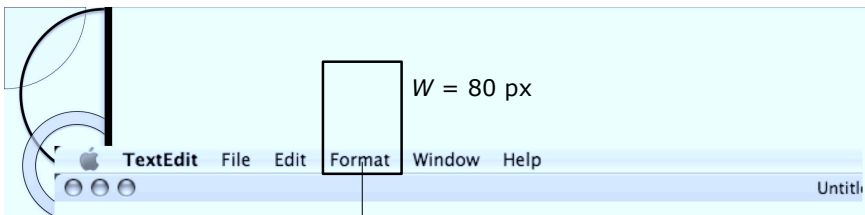   - width W of target along line of motion

target ▢ W

D

start ◯

to reduce T,
want D low
and W high

Menu Targeting Example

Document - WordPad
File Edit View Insert Format Help

$W = 20$ px

Arial 10 Western **B** / U 🖉 ≡ ≡ ≡ ⋮≡

· · · 1 · · · · 2 · · · 3 · · · 4 · · · 5 · · ·

$D = 200$ px

start ◯

top of window menus (Windows)

🍎 **TextEdit**   File   Edit   Format   Window   Help

$W = 80$ px

◯◯◯   Untitl

$D = 200$ px

start ◯

*pointer stops
automatically at the
edge of the screen*

*effective size is
larger because you
do not have to stop
precisely within
the menu bar*

top of screen menus (Mac)

Menu Targeting Example

- Top of window menus:
  - T = 50 + 150 log$_2$(200/20 + 1) = 569 ms

- Top of screen menus:
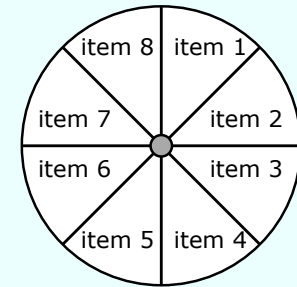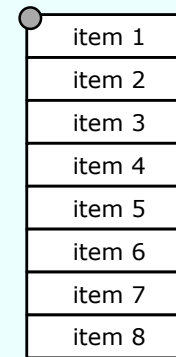 - T = 50 + 150 log$_2$(200/80 + 1) = 321 ms

Fitts's Law

- Question:
  - What are the best screen locations to place targets?

Fitts's Law

- Question:
  - Which is typically faster:
    linear popup menu or pie (radial) popup menu?

item 1
item 2
item 3
item 4
item 5
item 6
item 7
item 8

item 8 | item 1
item 7 | item 2
item 6 | item 3
item 5 | item 4

More Information

- Books:
  - The Design of Everyday Things
    - D. Norman
    - Doubleday, 1988

  - The Invisible Gorilla
    - C. Chabris and D. Simons
    - Broadway, 2011

More Information

- Books:
  - Fatal Defect
    - I. Peterson
    - Vintage, 1995

  - GUI Bloopers
    - J. Johnson
    - Morgan Kaufmann, 2000

More Information

- Links:
  - Human Error and the Design of Computer Systems
    - http://www.jnd.org/dn.mss/commentary_human_error_and_the_design_of_computer_systems.html

More Information

- Links:
  - The RISKS Digest
    - http://catless.ncl.ac.uk/risks

  - Interface Hall of Shame
    - http://homepage.mac.com/bradster/iarchitect/shame.htm

  - Magic and Software Design
    - http://www.asktog.com/papers/magic.html