Psychological Basis for UI Design Rules

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Many HCI researchers and practitioners have offered UI Design Guidelines
UI Design Guidelines
(Nielsen & Molich, 1993)

- Visibility of system status
- Match between system & real world
- User control & freedom
- Consistency & standards
- Error prevention
- Recognition rather than recall
- Flexibility & efficiency of use
- Aesthetic & minimalist design
- Help users recognize, diagnose, & recover from errors
- Provide online documentation & help

UI Design Guidelines
(Stone et al, 2005)

- **Visibility**: First step to goal should be clear
- **Affordance**: Control suggests how to use it
- **Feedback**: Should be clear what happened or is happening
- **Simplicity**: as simple as possible & task-focused
- **Structure**: content organized sensibly
- **Consistency**: similarity for predictability
- **Tolerance**: prevent errors, help recovery
- **Accessibility**: usable by all intended users, despite handicap, access device, or environmental conditions
UI Design Guidelines
(Shneiderman & Plaisant, 2005)

- Strive for consistency
- Cater to universal usability
- Offer informative feedback
- Design task-flows to yield closure
- Prevent errors
- Permit easy reversal of actions
- Make users feel they are in control
- Minimize short-term memory load

Applying Usability Guidelines

- UI Guidelines are based on how people perceive, think, learn, act
- UI designers want reasons for rules
- UI guidelines are not rote recipes
- Applying them effectively requires understanding their scientific basis
  - Determining rule applicability & precedence
  - Balancing trade-offs between competing rules
Facts about Human Perception & Cognition

- We perceive what we expect
- Our vision is optimized to see structure
- Our color vision is limited
- Our peripheral vision is poor
- Our attention is limited
- Our memory is imperfect
- Recognition is easy; recall is hard
- We think mostly about our tasks, not our tools
- We seek and use structure
- Inductive reasoning is easy; deduction is hard
- Human thought-cycle: goal, execute, evaluate
- We have real-time requirements

We Perceive What We Expect

Our perception is biased by:
- Our experience
- The context
- Our goals
We Perceive What We Expect

THE CHT
We Perceive What We Expect

- Adults’ perception & attention focuses almost totally on our goals
- Tend not to notice things unrelated to goal
We Perceive What We Expect

Our Vision is Optimized to See Structure

Gestalt Principles of Visual Perception
- Proximity
- Similarity
- Continuity
- Closure
- Symmetry
- Common fate
- Figure/ground
Gestalt Principle: Proximity

- Items that are closer appear grouped

- **Left**: rows  
  **Right**: columns

Gestalt Principle: Similarity

- Items that look similar appear grouped

- Larger circles appear as a group
Gestalt Principle: Continuity

- We tend to see continuous forms
- Blue line and orange line; not blue-and-orange > and <
- Even if cross-point is covered

Gestalt Principle: Closure

- We tend to see whole, closed objects, not collections of fragments
- Overlapping circles & triangles, not odd fragments
Gestalt Principle: Symmetry

- We tend to see whole figures in relationship, rather than parts
- E.g., two overlapping diamonds; not inverted V standing on V

Gestalt Principle: Common Fate

- Items that move together are grouped
Gestalt Principle: Figure/Ground

- When objects overlap, we see smaller as figure on ground (larger)

- Escher exploited figure/ground ambiguity

Our Color Vision is Limited

- We have trouble discriminating:
  - pale colors
  - small color patches
  - separated patches
Our Color Vision is Limited

Federal Reserve Bank (Minn)

- Housing Units Authorized, Percent Change October 2003 vs Year-to-Date Compared With a Year Earlier
- Electricity Consumption per Capita, 2001
- Drinking and Wastewater Needs per Capita, 2003 Dollars
- Manufactured Homes as a Percent of Total Homes, 2000
- Percent of Occupied Housing Units That Are Owner Occupied
- Percent Change in Private Employment Due to Growth/Decline in Establishments, 2000-2001
- Labor-Force Participation Rate, 2002
- Number of Bank Offices per 10,000 People, 2003
- Total Foreign-Born, 2000
- Retail Gasoline Prices, May 17, 2004
- Total Manufacturing Exports per Capita, 2003
- House Price Index, Percent Change—Third Quarter 2002 to Third Quarter 2003
- State and Local Governments Per Capita General Fund Expenditures, 1977-2001

ITN.net

Our Color Vision is Limited

- Some people have color-blindness
  - ~ 8% of males
  - ~ 0.5% of females
- E.g., colors that would be hard for red-green colorblind people to distinguish
Our Color Vision is Limited

- MoneyDance

Our Color Vision is Limited, so

- Don’t rely solely on color
  - Use redundantly with other cues
- E.g., Let’s improve ITN.net

How *they* improved it:
Our Color Vision is Limited, so

- Avoid subtle color differences
  - Make colors differ in saturation as well as hue
  - Should still look different in gray scale
- E.g., FRB.org

Our Peripheral Vision is Poor

- Client internal Web-app
  
  Login

  For best results, Netscape Navigator 3.x or higher is recommended.
  
  ID
  
  Pin No
  
  Change your PIN

  Login  Cancel
Our Peripheral Vision is Poor

- Airborne.com

![Image of login form]

Our Peripheral Vision is Poor, so

- Common methods of getting seen
  - Put where users are looking
  - Put near the error
  - Use red for errors
  - Use error symbol

- Heavy artillery: use sparingly
  - *Popup* in error dialog box
  - *Audio*: beep
  - *Flash* or wiggle *briefly* (not continuously)
Our Peripheral Vision is Poor, so

- Client internal web-app, improved

Login

For best results, Netscape Navigator 3.x or higher is recommended.

ID

Pin No

Change your PIN

Login | Cancel

Our Attention is Limited; Our Memory is Imperfect

- Short-term memory (STM)
- Long-term memory (LTM)
Our Attention is Limited; Our Memory is Imperfect

**Short-term memory (STM)**
- Represents conscious mind
  - *Attention*: what we’re attending to **NOW**
- Holds 3-7 unrelated items
  - Goals, numbers, words, images, other info
- New items can “bump” old ones out
- Easy to forget goals or info

**Short-term memory (STM) test:**
- Memorize: 3 8 4 7 5 3 9
- Say your phone number backwards
- Memorize: 3 1 4 1 5 9 2
- Memorize: 1 3 5 7 9 11 13
- Memorize: town river corn string car shovel
- Memorize: what is the meaning of life
Our Attention is Limited; Our Memory is Imperfect

- Slate.com

- Blooper: Search terms not shown (short-term memory)

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Our Attention is Limited; Our Memory is Imperfect

- Microsoft Windows

- Blooper: Instructions go away too soon
Our Memory is Imperfect

Long-term memory (LTM)
- Stores a lifetime of experience, but…
  - error-prone, impressionist, free-associative, idiosyncratic, easily biased
- Seldom-followed routines hard to recall
  - Reason for food recipes, pilot checklists, etc.
- Even often-recalled memories change
  - See whale-shark, remember whale

Our Memory is Imperfect

Long-term memory (LTM) test:
- Was there a roll of tape in the toolbox?
- What was your previous phone number?
- In list? stream city corn auto twine spade
- The list: river town corn car string shovel
- What website doesn’t show search terms?
Our Memory is Imperfect

Long-term memory (LTM) & UI Design

- Which UI will be easiest to remember?
- Which one will be hardest?

<table>
<thead>
<tr>
<th>Object</th>
<th>Design A</th>
<th>Design B</th>
<th>Design C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table</td>
<td>insert, delete</td>
<td>insert, delete</td>
<td>insert, delete</td>
</tr>
<tr>
<td>Column</td>
<td>insert, delete</td>
<td>remove, add</td>
<td>insert, remove</td>
</tr>
<tr>
<td>Row</td>
<td>insert, delete</td>
<td>create, destroy</td>
<td>insert, delete</td>
</tr>
<tr>
<td>Border</td>
<td>insert, delete</td>
<td>draw, erase</td>
<td>insert, delete</td>
</tr>
</tbody>
</table>

Recognition is Easy; Recall is Hard

- We evolved to recognize things quickly
  - We assess situations very fast
  - We recognize faces so fast it’s a mystery
  - We recognize complex patterns
Recognition is Easy; Recall is Hard

- We did *not* evolve to recall arbitrary facts
  - Tricks for memorizing use *recognition* to stimulate recall, e.g., Greek “method of loci”
  - Developed writing to *avoid* memorizing
  - We rely on external memory aids, e.g., PDAs

- Implication for UI design:
  - *See & choose* easier to learn than *remember & type*

We Think Mostly About Our *Tasks*; Not Our Tools

- Barely pay attention to computer tools
  - Focus attention on own goals, data
- Think about computer, UI only superficially
- Very *literal* in following “scent” toward goal
We Think Mostly About Our Tasks; Not Our Tools

- Users don’t like to think
  - Krug: *Don’t Make Me Think*
- Willing to type *more* to think *less*
  - Focused on achieving goal
  - Prefer familiar paths over exploration
  - User: “I’m in a hurry, so I’ll do it the long way.”

We Seek & Use Structure

Structured info is easier to perceive

- Unstructured:
  
  You are booked on United flight 237, which departs from Auckland at 14:30 and arrives at San Francisco at 11:40 the same day.

- Structured:
  
  Flight: UA 237, Auckland => San Francisco
  Depart: 14:30
  Arrive: 11:40 (same day)
We Seek & Use Structure

Structured info is easier to perceive

<table>
<thead>
<tr>
<th>Mortgage Summary</th>
<th>Monthly</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1,840.59</td>
<td>$662,611.22</td>
</tr>
<tr>
<td>Monthly Payment</td>
<td>Payment</td>
</tr>
<tr>
<td>$318,861.22</td>
<td>$1,944.75</td>
</tr>
<tr>
<td>Total Interest Paid</td>
<td>Total Payments</td>
</tr>
<tr>
<td>$93,750.00</td>
<td>$700,111.22</td>
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<tr>
<td>Total Tax Paid</td>
<td>Total Interest</td>
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<td>$0.00</td>
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<td>Total PMI</td>
<td>Total Tax</td>
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<tr>
<td></td>
<td>$93,750.00</td>
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<tr>
<td>Payoff Date</td>
<td>Total PMI Paid</td>
</tr>
<tr>
<td></td>
<td>$37,500.00</td>
</tr>
</tbody>
</table>

We Seek & Use Structure

Visual hierarchy gets people to goal faster

Create a Clear Visual Hierarchy

Organize and prioritize the contents of a page by using size, prominence and content relationships. Let’s look at these relationships more closely:

- **Size**: The more important a headline is, the larger its font size should be. Big bold headlines help to grab the user’s attention as they scan the Web page. The more important the headline or content, the higher up the page it should be placed. The most important or popular content should always be positioned prominently near the top of the page, so users can view it without having to scroll too far. Group similar content types by displaying the content in a similar visual style, or in a clearly defined area.

- **Prominence**: The more important the headline or content, the higher up the page it should be placed. The most important or popular content should always be positioned prominently near the top of the page, so users can view it without having to scroll too far.

- **Content Relationships**: Group similar content types by displaying the content in a similar visual style, or in a clearly defined area.
Inductive Reasoning is Easy; Deduction & Calculation are Hard

- Induce generalities from specifics: easy
- Deduce specifics from generalities: hard
  - A man built a four-sided house. All four walls faced south. A bear walked by. What color was the bear?

That’s one reason we invented computers
- They do calculation & deduction better than we do

Implications for UI design:
- Don’t make people deduce things
  - “It wants my ‘member ID’. Is that the same as my ‘username’? It must be.”
  - Tell them explicitly & exactly what to do, or explicitly & exactly what happened
- Don’t make people reason by elimination, e.g.,
  - Debug complex computer malfunctions, e.g., faulty Internet connection
  - Optimize combinations of many settings
- Don’t make people calculate things the computer can calculate
Requiring Calculation that Software Could Do

- EDD.CA.gov

Human Thought-Cycle

- Form goal
- Execute actions:
  - A goal can be achieved in different ways
- Evaluate: perceive results of actions
  - Did we achieve goal?
  - Are we closer to goal?
  - Are our actions working?
- Repeat (at many levels)
Human Thought-Cycle, e.g.

- **Goal: Buy airline ticket to Berlin.**
- Go to travel website.  
  *(First step)*
- Search for suitable flights.  
  *(Normal step)*
- Choose desired flight.  
  *(If none, back up)*
- Go to checkout.  
  *(Approaching goal)*
- Confirm flight details.  
  *(All correct?)*
- Purchase ticket w/credit card.  
  *(Looks OK)*
- Print ticket.  
  *(Goal achieved)*

Many Levels of Goals, Actions

- Send flowers to friend
  - Find flower delivery service
    - Type “flowers” into Google
      - Correct typo: “floowers”
    - Visit some of resulting links
  - Order flowers delivered to friend
    - Review service’s flower selection
    - Choose flowers
    - Specify delivery
    - Pay for flowers & delivery
Thought-Cycle Affects Short-Term Memory (STM)

- Keeping track of things in STM is work.
- When we reach a goal, we often let everything related to it fall out of STM.
- That’s why we often forget “loose ends” of tasks:
  - Last pages of documents are left on copiers.
  - Car headlights are left ON.
  - Device or software is left in the wrong mode.
- Therefore:
  - Systems should remind users of loose ends.
  - Modes should revert to “normal” automatically.

We Have Real-Time Requirements: 0.1 Second

- Governs human:
  - Perceptual-motor time-loop
  - Perception of cause-effect
  - Perceptual fusion
- Relevance to UI design:
  - Feedback for hand-eye coordination
  - Feedback for button click
  - Deadline for “busy” indicators
  - Minimum frame rate for smooth animation
We Have Real-Time Requirements: 1 Second

- Governs human:
  - Turn-taking in conversation
  - Minimum reaction time for unexpected events

- Relevance to UI Design:
  - Displaying progress indicators
  - Opening window
  - Finishing unrequested operations

We Have Real-Time Requirements: 10 Seconds

- Governs human:
  - Unbroken attention to a task
  - “Unit task”

- Relevance to UI Design:
  - Completing one “step” of task
  - Finishing input to operation (e.g., Print dialog)
  - Finishing one step in multi-step task (wizard)
Clicks Need Immediate Feedback

- Controls must react immediately (0.1 sec) to clicks or we assume we missed

Display “Whole” Quickly
Fill in Detail Later
Display “Whole” Quickly
Fill in Detail Later

Animation:
Preserve 16 frames/sec

- InXight Cone Tree
Applying Design Rules in Real UI Designs is Not Simple & Mindless

- Constraints happen; force tradeoffs
  - Sometimes we must violate one rule to follow another, more important one
  - That’s why UI design is a *skill*; not something anyone can do by following a recipe
- Designers learn to prioritize
  - Recognize which rules to follow in each design situation
  - Prototyping helps explore tradeoffs

Now, Maybe those UI Design Rules Make More Sense

Questions?