AM+A

California

Aaron Marcus and Associates, Inc.
California and New York

1144 65th Street, Suite F
Emeryville, CA 94608-1053 USA

Tel: 510-601-0994
Fax: 510-547-6125
E-mail: Mail@AMandA.com
Web: www.AMandA.com

Lecture Notes for the Tutorial

User-Interface Design for Work, Home, and On the Way

Aaron Marcus, President, Ext. 19
Eugene Chen, Director of Design and Analysis and AM+A California, Ext. 23
Luke Ball, Designer/Analyst, Ext. 32
Larry Guan, Designer/Analyst, Ext. 17
Aaron Marcus and Associates, Inc., (AM+A)
1144 65th Street, Suite F
Emeryville, CA 94608-1053 USA
Tel: +1-510-601-0994
Fax: +1-510-547-6125
Email: Aaron@AMandA.com
Eugene@AMandA.com
Larry@AMandA.com
Luke@AMandA.com

Uri Kochavi, Senior Designer/Analyst
Aaron Marcus and Associates, Inc, (AM+A)
9 Desbrosses Street, Suite 306
New York, NY 10013-1701 USA
Tel: +1-212-625-1813, Ext. 102
Fax: +1-212-625-1815
Email: Uri@AMandA.com

Web: http: //www.AMandA.com

SIGGRAPH 2001
Los Angeles, CA, USA
12-17 August 2001

© Copyright 2001 by Aaron Marcus and Associates, Inc.
All Rights reserved

Intelligent Design

User Interfaces

Information Visualization

Contents

Section	Item
Intro 1	Cover Page
Intro 2	Table of Contents
Intro 3	Tutorial Abstract
Intro 4	Instructor Biography
Intro 5	Agenda
Lecture 1	Principles of Visual Design
Lecture 2	Grid Systems in UI Design
Lecture 3	Icon Design and Semiotics
Lecture 4	Mental Model and Navigation: Dialogue Design
Lecture 5	Interactivity in Web Applications
Lecture 6	Baby Faces: Extreme Design for Mobile Computing
Lecture 7	Metaphor Design
Article 1	Cultural Dimensions and Global Web User-Interface Design
Article 2	Principals of Effective Visual Communication for Graphical User Interface Design
Article 3	User Interface Issues in Web Design
Article 4	Metaphor Design in User Interfaces

© Copyright 2001 by AM+A. All Rights Reserved.

Tutorial Abstract

The use of graphical user interfaces (GUIs), the incorporation of multimedia, and the combination of computation with communication functions, e.g., fax, telephone, television, pagers, the Web, and CD-audio are enabling computer-based communication to occur in a wider array of environments beyond the office. Consequently, effective visual design techniques can assist users by making products easier to learn and use. They can also make products more appealing, not only for business-office, productivity-oriented, desktop work-devices of clerical, managerial, or engineering staff, but also for mobile and/or hand-held consumer communication devices used in leisure-time as well as work-time activities. There is a resultant need for more effective visual design to communicate clearly the content being portrayed for an ever more diverse range of viewers or users of computer-based displays.

Information-oriented visual design comprises the techniques of selecting typography, grids, layout, color, animation, symbolism, and sequencing applied to components of GUIs in order to improve productivity (in particular, to communicate structure and process more effectively) and to increase the appeal of the displays. Skillful visual design of GUIs for performance (productivity) tools, multimedia, and the Web is mission-critical to the success of innovative computer-based products, especially as computers become absorbed into consumer products intended for diverse, international user communities. Analyzing GUIs from a visual design perspective can also make products easier to produce, sell, learn, use, and maintain. Useful concepts that help professionals to design more effectively are these:

User Analysis: Specification of user demographics, task analysis, use-environment, and business objectives
Metaphors: Easy recognition and memorability of fundamental concepts conveyed through words, signs, and images
Mental models: Appropriate organization of data, functions, tasks, roles, and people
Navigation of mental model: Efficient movement within the mental model via windows, menus, dialogue boxes, or control panels
Appearance: Quality visual, acoustic, and touch characteristics
Interaction: Effective input and output-feedback sequencing
Information Visualization: Tables, charts, maps, and diagrams
Basic design: Scale, proportion, rhythm, symmetry, and balance.

In this tutorial, participants will learn how visual design affects user interface design; how effective visual communication benefits usability, productivity, and preference; and how to use typography, layout, and

© Copyright 2001 by AM+A. All Rights Reserved.

color more effectively. Illustrated lectures will introduce terminology, principles, and guidelines for current and future products that make them more intelligible, functional, aesthetic, and marketable. Case study analyses of icons, dialogue, and window layouts from performance (productivity) tools, multimedia, and the Web will illustrate how to analyze and design screens based on analysis of users and their tasks, semantic content, and established aesthetic principles. Pen-and-paper design projects will give participants experience in applying the principles. Participants will learn practical principles that are immediately useful, become familiar with many existing techniques, and discover potential new research topics.

© Copyright 2001 by AM+A. All Rights Reserved.

Instructor Biographies

Aaron Marcus, President

Mr. Marcus received a BA in Physics from Princeton University (1965) and a BFA and MFA in Graphic Design from Yale University Art School (1968). He is an internationally recognized authority on the design of user interfaces, interactive multimedia, and printing/publishing documents. Mr. Marcus has given tutorials at SIGGRAPH and SIGCHI conferences, and at seminars for businesses and academic institutions around the world. He co-authored *Human Factors and Typography for More Readable Programs* (1990), *The Cross-GUI Handbook* (1994), and authored *Graphic Design for Electronic Documents and User Interfaces* (1992), all published by Addison-Wesley.

Mr. Marcus was the world's first professional graphic designer to be involved full-time in computer graphics (1967), to program a desktop publishing system (for the AT&T Picturephone, 1969-71), to design virtual realities (1971-73), and to establish an independent computer-based graphic design firm (1982). In 1992, he received the National Computer Graphics Association Industry Achievement Award for contributions to computer graphics.

Eugene Chen, Director of Design and Analysis and AM+A California

Mr. Eugene Chen received his BS degree in Computer Science and Engineering from the University of Pennsylvania in 1987 and has also worked as a professional composer, audio engineer, and sound designer. Since joining AM+A and becoming Senior Designer and Director of the CA office, Mr. Chen has led and/or worked on most of AM+A's web-based, information-oriented projects, including those for Banter, the Getty Museum, Gigabeat.com, Kanisa.com, the US Federal Reserve Bank, the US Treasury Department, Samsung, and Visa.

Uri Kochavi, Senior Designer/Analyst

Mr. Kochavi received a Diploma in Professional Photography at Hadassah WIZO College of Design, Haifa and an MA in Interactive Media at the Royal College of Arts, London and is involved with a variety of Web, mobile device, and productivity tool user-interface design projects.

Mr. Luke Ball and **Mr. Larry Guan** are both Designer/Analysts with Aaron Marcus and Associates and are involved with a variety of Web, mobile device, and productivity tool user-interface design projects.

© Copyright 2001 by AM+A. All Rights Reserved.

Agenda for the Tutorial

Morning Session

Time	**Topic**
8:30-9:30	Lecture 1: Principles of Visual Design
9:30-10:00	Lecture 2: Grid Systems in UI Design Case Studies: Grid Systems in UI Design
10:00-10:15	Break
10:15-12:00	Lecture 3: Icon Design and Semiotics Case Studies: Icon Design Exercise: Icon Design
12:00-1:30	Lunch

Afternoon Session

Time	**Topic**
1:30-3:00	Lecture 4: Mental Model and Navigation: Dialogue Design Case Studies: Mental Model and Navigation: Dialogue Design Exercise: Mental Model and Navigation: Dialogue Design
3:00-3:15	Break
3:15-4:00	Lecture 5: Interactivity in Web Based Applications
4:00-4:30	Lecture 6.1: Baby Faces: Extreme Design for Mobile Computing Lecture 6.2: Baby Faces: Tour of Recent Products
4:30-5:00	Lecture 8: Metaphor Design

© Copyright 2001 by AM+A. All Rights Reserved.

Tutorial:
UI Design for Work, Home, and On the Way

Lecture:
Principles of Visual Design

User-Interface Design for Work, Home, and On the Way

Aaron Marcus, President, CA Ext. 19
Eugene Chen, Director of AM+A California, CA Ext. 23
Uri Kochavi, Senior Designer/Analyst, NY Ext. 102
Luke Ball, Designer/Analyst, CA Ext. 32

Aaron Marcus and Associates, Inc. (**AM+A**)
Emeryville, California and New York City, New York
California Tel: 510-601-0994, Fax: 510-547-6125
New York Tel: 212-625-1813,Fax: 212-625-1815
Web: www.AMandA.com
Email, [FirstName]@AMandA.com

Table of Contents

- Principles of Visual Design
- Layout and Grid Systems
- Icons and Semiotics
- Dialogue Design
- Web-based Applications
- Baby Faces for Mobile Computing
- Metaphor Design

Principles of Visual Design Introduction

Aaron Marcus and Associates, Inc.
1144 65th Street, Suite F
Emeryville, CA 94608-1053 USA
Tel: 510-601-0994

Aaron Marcus and Associates, Inc.
9 Desbrosses Street, Suite 306
New York, NY 10013-1701 USA
Tel: 212-625-1813

Web: www.AMandA.com

 © 2001 Aaron Marcus and Associates, Inc.

Aaron Marcus And Associates, Inc. 4

What Is a User Interface?

- **Metaphors:** Basic concepts via words, images
- **Mental Model:** Organization of data, functions, tasks, roles, and people
- **Navigation:** Movement through mental model
- **Interaction:** Input/output techniques, feedback
- **Appearance:** perceptual characteristics

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus And Associates, Inc. 5

Who are the Users?

- Demographics: age, education, gender
- Tasks: personal, group, professional
- Cognitive preferences, abilities
- Socio-cultural characteristics

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus And Associates, Inc. 6

User-Interface Development Process

- Plan
- Research
- Analyze
- Design
- Evaluate
- Implement
- Document
- Train

AM+A Experience Intelligent Design: www.AMandA.com

 © 2001 Aaron Marcus and Associates, Inc.

Aaron Marcus And Associates, Inc. 7

Challenges: User-Interface Design for Performance Tools and the Web

- Mixed technologies
- Multiple subject matter
- Multiple user groups
- Multiple communication goals
- Focus: Knowledge Design

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus And Associates, Inc. 8

Knowledge Design

- **Wisdom:** Significant knowledge with tested experience
- **Knowledge:** Significant patterns of information with action plan(s)
- **Information:** Significant patterns of data
- **Data:** Simple perceptual or conceptual input

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus And Associates, Inc. 9

What Is Visually-Oriented Knowledge Design?

- Information-oriented visual design, or graphic design, is the systematic use of typography, symbols, color, and other static and dynamic graphics, in two, three, or four dimensions, to communicate knowledge: facts, concepts, and emotions that enable people to make effective decisions about their or others' lives.

AM+A Experience Intelligent Design: www.AMandA.com

 © 2001 Aaron Marcus and Associates, Inc.

Aaron Marcus And Associates, Inc. 10

How Can Visual Design Help User-Interface Design?

- Users
- Subject matter
- Software applications
- Operating systems
- Hardware and networks
- Graphical user interfaces (GUIs)

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus And Associates, Inc. 11

Graphical User Interfaces

- Screens and windows
- Menus
- Dialogue boxes and control panels
- Icons and cursors
- Forms, charts, maps, and diagrams

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus And Associates, Inc. 12

User-Interface Design Objectives

- Simple, clear, consistent content
- Simple, clear, consistent form
- Effective visible language

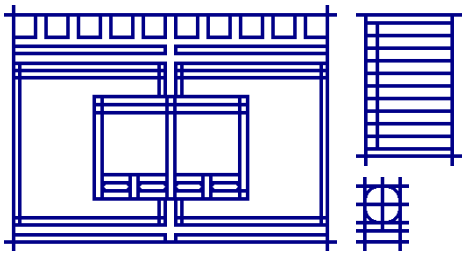
AM+A Experience Intelligent Design: www.AMandA.com

 © 2001 Aaron Marcus and Associates, Inc.

Visible Language

- Layout
- Typography
- Color and texture
- Imagery: Signs, icons, and symbols
- Animation
- Sequencing
- Sound
- Visual identity

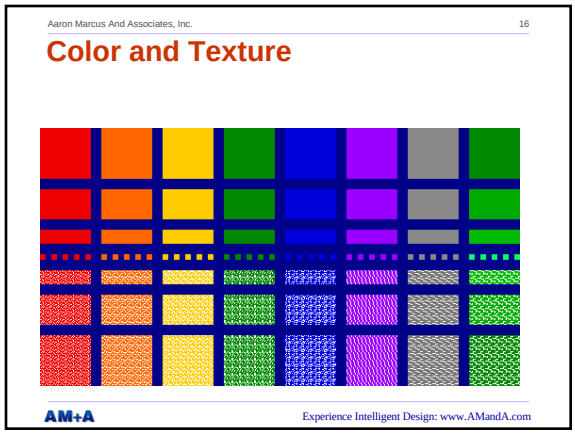
Layout

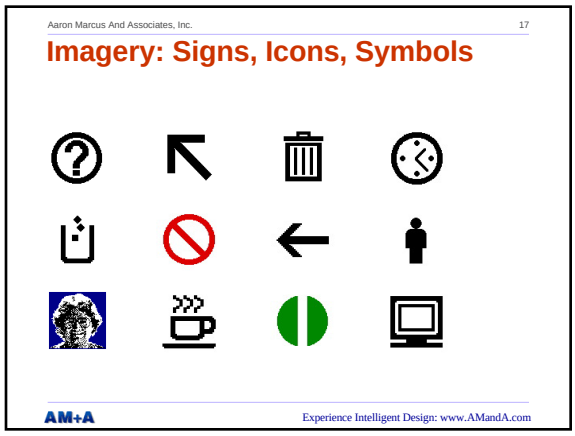


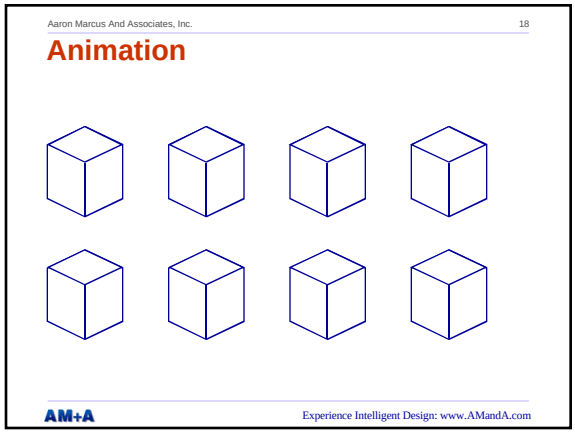
Typography

Abc	Xyz	123
Abc	Xyz	123
Abcdefghi	Mnopqrstu	12345678
Abcdefghi	Mnopqrstu	12345678
Abcdefghi	Mnopqrstu	12345678

 © 2001 Aaron Marcus and Associates, Inc.

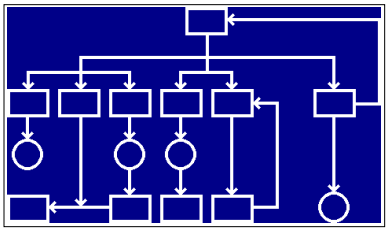




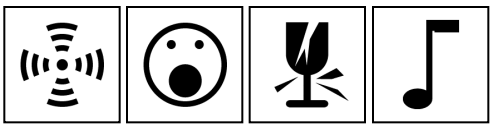


 © 2001 Aaron Marcus and Associates, Inc.

Sequencing

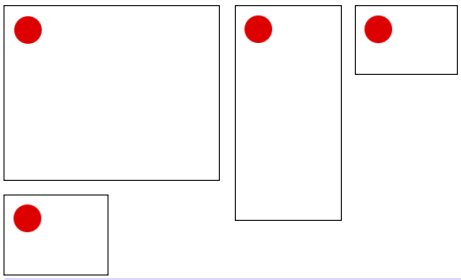


Sound



Abstract Voice Concrete Music

Visual Identity (Corporate and Product)



 © 2001 Aaron Marcus and Associates, Inc.

Aaron Marcus And Associates, Inc. 22

Three Principles of Visual Design

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus And Associates, Inc. 23

Three Principles of Design

- Goal: Effective visual communication

1. Organize: Provide the user with a simple, clear, and consistent conceptual structure.
2. Economize: Maximize the effectiveness of a minimal set of cues.
3. Communicate: Match the presentation to the capabilities of the user.

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus And Associates, Inc. 24

Principle 1: Organize

"To design is to plan and organize, to order, to relate, and to control. In short, it embraces all means opposing disorder and accident. Therefore, it signifies a human need and qualifies man's thinking and doing."

Josef Albers

AM+A Experience Intelligent Design: www.AMandA.com

 © 2001 Aaron Marcus and Associates, Inc.

Aaron Marcus And Associates, Inc. 25

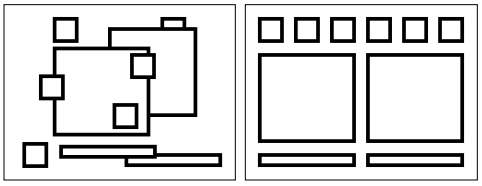
Organize

- Consistency
- Screen layout
- Visual relationships
- Movement

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus And Associates, Inc. 26

Chaotic Screen Ordered Screen



AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus And Associates, Inc. 27

Consistency

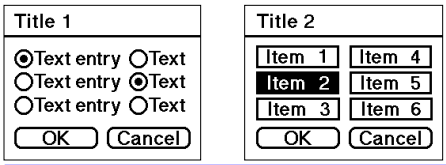
- Internal consistency
- External consistency
- Real world consistency
- Innovation

AM+A Experience Intelligent Design: www.AMandA.com

 © 2001 Aaron Marcus and Associates, Inc.

Internal Consistency

- Observe the same conventions and rules for all elements of the user interface.
- Example: Dialogue boxes

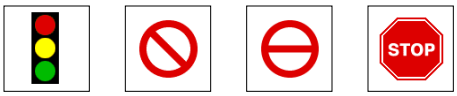


External Consistency

- Following existing platform and application conventions across user interfaces.
- Example: Text tool icons

Real World Consistency

- Make the conventions consistent with real-world experience.
- Example: Traffic signage



 © 2001 Aaron Marcus and Associates, Inc.

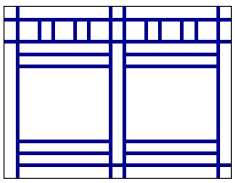
Innovation

- Deviate from existing conventions only when doing so provides a clear benefit to the user.

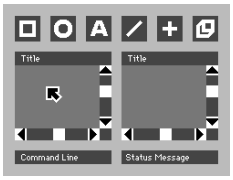
Screen Layout

- Use a grid structure.
- Standardize the screen layout.
- Group the related elements.

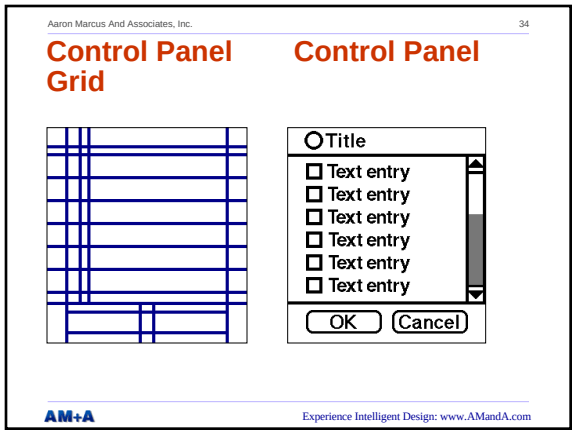
Screen Grid

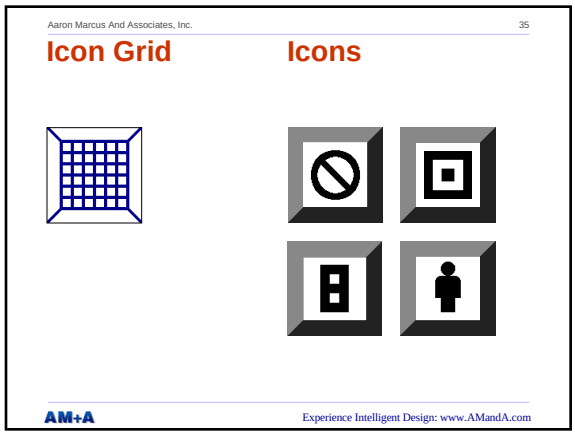


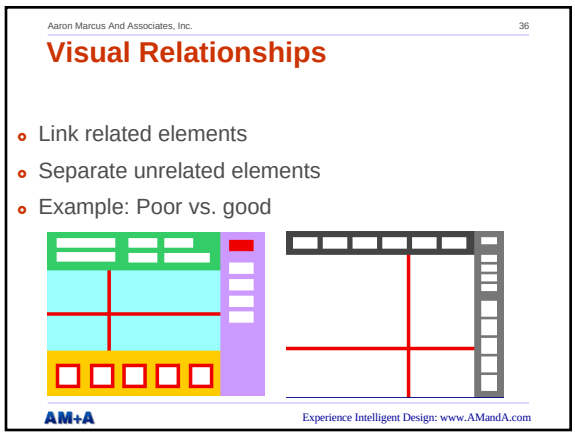
Screen



 © 2001 Aaron Marcus and Associates, Inc.





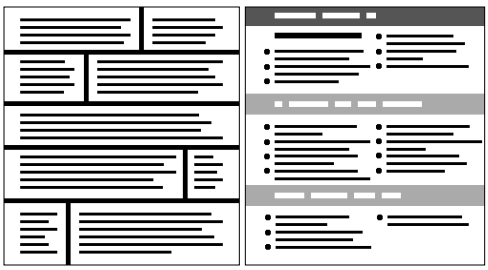


 © 2001 Aaron Marcus and Associates, Inc.

Movement

- Provide an initial focus for the viewer's attention.
- Direct attention to important peripheral items.
- Assist in movement or navigation throughout the content.

Poor Good



Principle 2: Economize

"How many controls does a device need? The fewer the controls, the easier it looks to use and the easier it is to find the relevant controls... To make something look easy, minimize the number of controls."

Don Norman

 © 2001 Aaron Marcus and Associates, Inc.

Aaron Marcus And Associates, Inc. 40

The Secret of Success

- Hide complexity
- Reveal content at the right time in the right form to the right people

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus And Associates, Inc. 41

Economize

- Simplicity
- Clarity
- Distinctiveness
- Emphasis

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus And Associates, Inc. 42

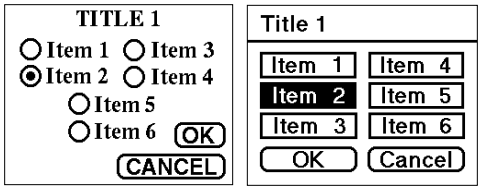
Simplicity

- Include only elements essential for communication.
- Be as unobtrusive as possible.

AM+A Experience Intelligent Design: www.AMandA.com

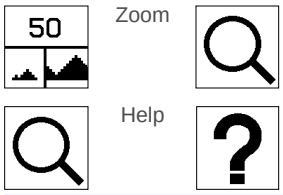
 © 2001 Aaron Marcus and Associates, Inc.

Complicated Simple



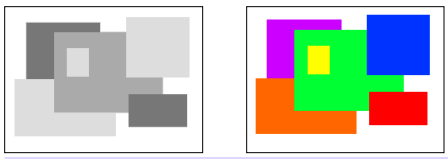
Clarity

- Design unambiguous components.
- Examples: Ambiguous vs. clear icons



Distinctiveness

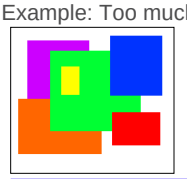
- Distinguish important properties of essential elements
- Example: Too little vs. too much



 © 2001 Aaron Marcus and Associates, Inc.

Emphasis

- Make the most important elements salient.
- De-emphasize non-critical elements.
- Minimize clutter to avoid hiding information
- Example: Too much vs. better



Principle 3: Communicate

"Communication...is...a social process, within a specified context, in which signs are produced and transmitted, perceived, and treated as messages from which meaning can be inferred."

Sol Worth

Communicate

- Legibility
- Readability
- Typography
- Symbolism
- Multiple views
- Color and texture

 © 2001 Aaron Marcus and Associates, Inc.

Legibility

- Design characters, symbols, and graphics to be easily noticed and distinguished.
- Examples: Illegible vs. legible

Text Set in Old English	Text Set in Univers
Large	**Large**
Small	Small

Readability

- Design text and graphics to be easy to identify and interpret.
- Design displays to be inviting and attractive.

Example: Low Readability

Unreadable: Design components to be easy

to interpret and understand.

Design components to be inviting

and attractive.

 © 2001 Aaron Marcus and Associates, Inc.

Example: High Readability

Readable

Design components to be easy to interpret and understand.

Design components to be inviting and attractive.

Typography

- **Typefaces:** Use a small number of typefaces of suitable legibility, clarity, and distinctiveness to distinguish all classes of information.
- **Typestyles:** Select appropriate alphanumerics, punctuation, and symbols for each typeface.
- **Typesetting:** Adjust character-, word-, and line-spacing, and paragraphing, to enhance readability of critical information.

Typefaces	Typestyles
Univers	ABCDEfghijkl123
Helvetica	*ABCDEfghijkl123*
Times Roman	AAaBBbCCcDDd
Garamond	
Courier	

 © 2001 Aaron Marcus and Associates, Inc.

Aaron Marcus And Associates, Inc. 55

Typesetting

- Use 1-3 sizes.
- Lines should have a maximum of 40-60 characters.
- Space words correctly.
- Do not space words incorrectly.

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus And Associates, Inc. 56

Typesetting

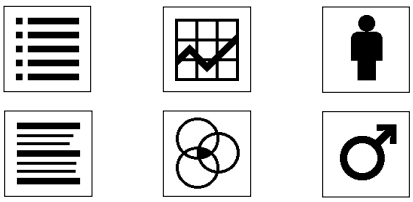
- Set text in appropriate formats.
- Set text flush left — Set numbers flush right — Avoid Centered text in lists — A v o i d S h o r t justified t e x t
- Use upper- and lowercase characters.
- AVOID ALL CAPITALIZED LINES OF TEXT.

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus And Associates, Inc. 57

Symbolism

- Use appropriate bullets, rules, charts, maps, diagrams, pictograms, and ideograms to communicate clearly the intended meaning.



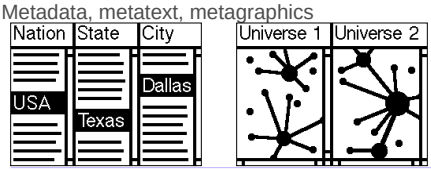
AM+A Experience Intelligent Design: www.AMandA.com

 © 2001 Aaron Marcus and Associates, Inc.

Aaron Marcus And Associates, Inc. 58

Multiple Views

- Multiple forms of representation
- Multiple levels of abstraction
- Simultaneous alternative views
- Links and cross references
- Metadata, metatext, metagraphics

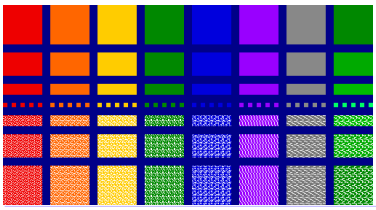


AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus And Associates, Inc. 59

Color and Texture

- Use appropriate highlighting and de-emphasis techniques to convey meaningful semantic distinctions.



AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus And Associates, Inc. 60

Color: A Tool for Communication

"Color can be a powerful tool to improve the usefulness of an information display in a wide variety of areas if color is used properly. Conversely, the inappropriate use of color can seriously reduce the functionality of a display system."

Gerald Murch

AM+A Experience Intelligent Design: www.AMandA.com

 © 2001 Aaron Marcus and Associates, Inc.

Aaron Marcus And Associates, Inc. 61

What is Color?

- **Hue:** Wavelengths of light perceived as color
- **Value:** Lightness or darkness of the color in a range from white to black
- **Chroma:** Purity of the color in a range from dull to vivid

AM+A Experience Intelligent Design: www.AMandA.com

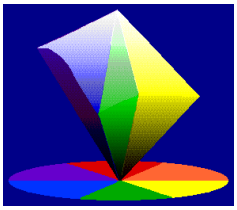
Aaron Marcus And Associates, Inc. 62

Dimensions

Light

Value

Dark



Hue

Chroma Low High

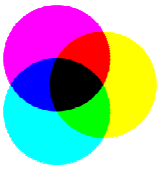
AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus And Associates, Inc. 63

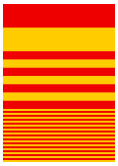
Mixtures

Additive

Subtractive



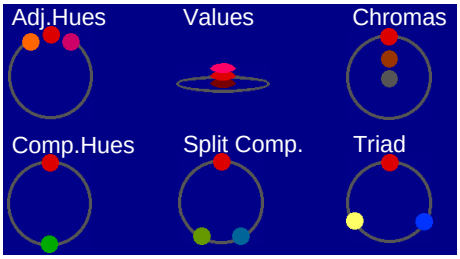
Optical



AM+A Experience Intelligent Design: www.AMandA.com

 © 2001 Aaron Marcus and Associates, Inc.

Harmonies



Advantages of Color

- Emphasize important information
- Identify subsystems or structures
- Portray time and progress
- Portray natural objects realistically
- Reduce errors of interpretation
- Add coding dimensions
- Increase comprehensibility
- Increase believability and appeal

Disadvantages of Color

- More expensive display hardware
- More expensive display software
- Color-deficient viewers
- Unintended associations
- Visual discomfort and afterimages
- Visual noise and confusion

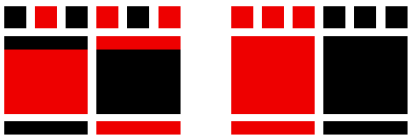
 © 2001 Aaron Marcus and Associates, Inc.

Applying Color to the Three Principles

- Color organization
- Color economy
- Color communication

Color Consistency

- Use color to group related items.

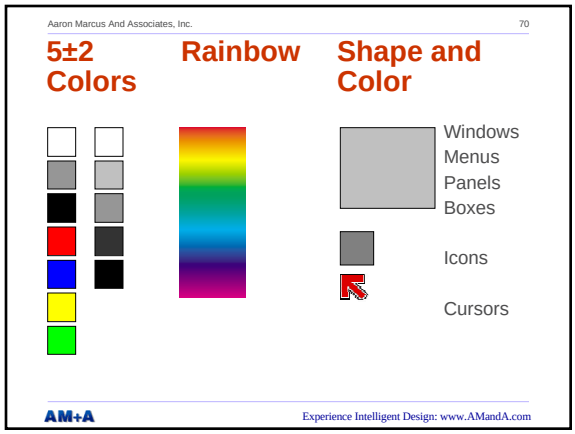


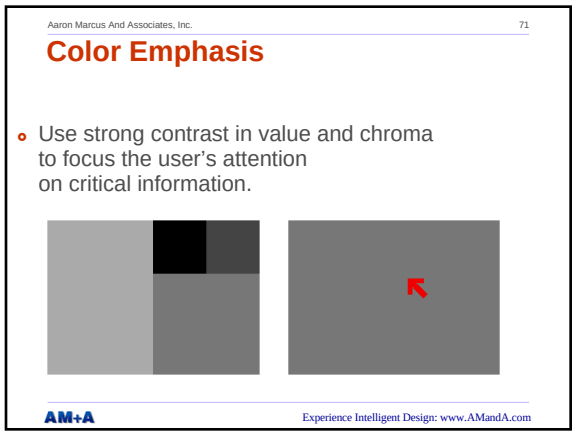
- Use a consistent color code for screen displays, documentation, and training materials.

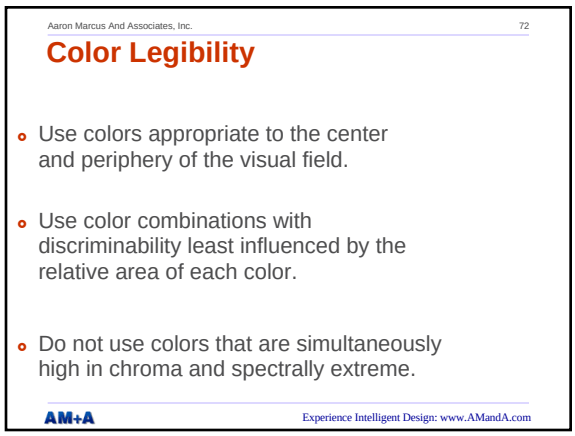
Color Simplicity

- Use a maximum of 5±2 colors where the meaning must be remembered.
- If appropriate, use redundant coding based on shape as well as color.
- Use color to enhance black-and-white information.

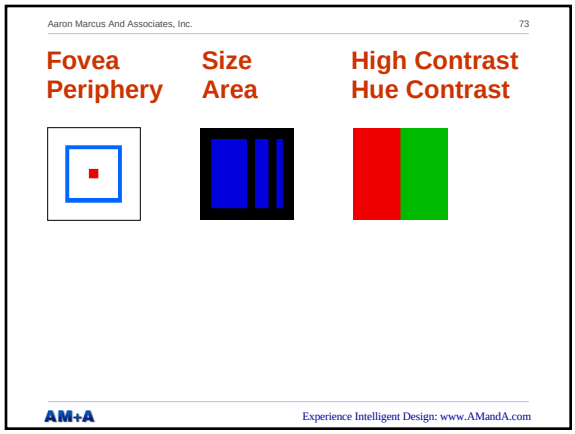
 © 2001 Aaron Marcus and Associates, Inc.

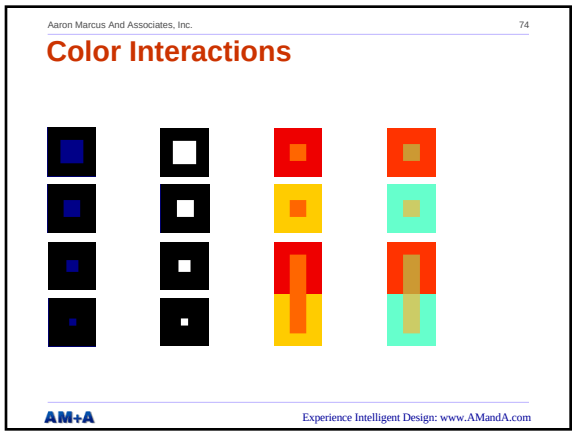


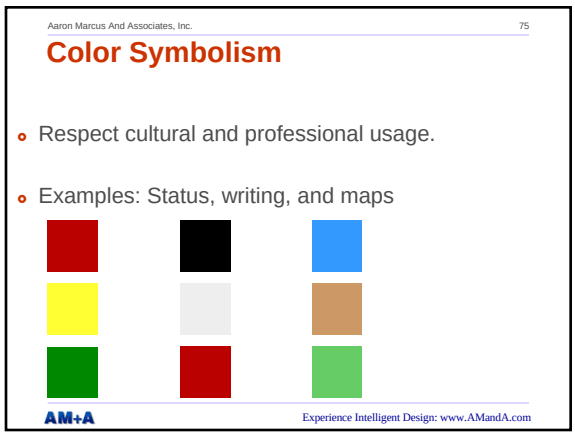




 © 2001 Aaron Marcus and Associates, Inc.







 © 2001 Aaron Marcus and Associates, Inc.

Conclusion: Three Basic Principles

- Organize
- Economize
- Communicate

 © 2001 Aaron Marcus and Associates, Inc.

Tutorial:
UI Design for Work, Home, and On the Way

Lecture:
Grid Systems in GUI Design

Grid Systems in GUI Design: Philosophy, Principles, and Guidelines

AM+A

Aaron Marcus and Associates, Inc.
Web: www.AMandA.com

California Tel: 510-601-0994
Email: Aaron@AMandA.com
Eugene@AMandA.com

New York Tel: 212-625-1813
Email: Melanie@AMandA.com

Why Are Grids Needed?

- Grids unify design by imposing structure.
- Grids provide a basis for controlled variation in layout components.
- Grids simplify development by reducing uncertainty about object location, extent, and orientation.

Where Are Grids Used?

- Icons
- Menus
- Dialogue boxes
- Control panels
- Windows
- Screens

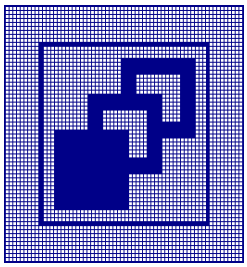
 © 2001 Aaron Marcus and Associates, Inc.

Tutorial:
UI Design for Work, Home, and On the Way

Lecture:
Grid Systems in GUI Design

Aaron Marcus and Associates, Inc. 4

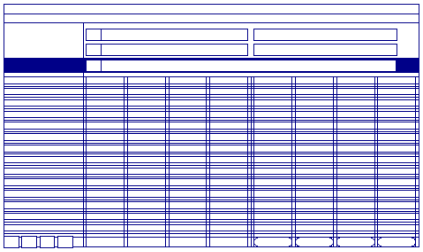
Simple Grid



AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 5

Complex Grid



AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 6

How Are Grids Used?

- Grids are not graph paper.
- Grids incorporate complex rhythms and indicate spaces between objects.
- Grids define how objects are related, but their constraints may be violated to handle special cases.

AM+A Experience Intelligent Design: www.AMandA.com

 © 2001 Aaron Marcus and Associates, Inc.

Aaron Marcus and Associates, Inc. 7

How Are Grids Used? (Continued)

- Grids ensure that comparable objects are placed consistently across displays.
- Primary objects align visually with the grid lines so that key items always begin in the same location.
- Where possible, major object groups align with major grid subdivisions.

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 8

General Algorithm for Grid Development

- Identify objects to be arranged.
- Identify display space constraints.
- Explore interrelation of objects.
- Develop single basic layout scheme.
- Determine measuring units (e.g., text size).
- Determine horizontal subdivisions.
- Determine vertical subdivisions.
- Determine oblique orientation lines.

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 9

Goals of Screen Layout

- Structure the display by clarifying the relation of windows, menus, dialogue boxes, and control panels.
- Isolate control, data, and status or feedback regions within the display.
- Ensure that frequent but transient objects appear in predictable locations.

AM+A Experience Intelligent Design: www.AMandA.com

 © 2001 Aaron Marcus and Associates, Inc.

Aaron Marcus and Associates, Inc. 10

Specify Algorithm for Screen Layout

- List major functional display objects.
- Identify object sizes and location needs.
- Determine size limit of display.
- Rank objects by importance.
- Sketch visual relation of objects.
- Establish positions for major objects.

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 11

Summary

- Grids are complex
- Grids take time to develop
- Grids are good for you and your users:
  They benefit both production and consumption of information

AM+A Experience Intelligent Design: www.AMandA.com

 © 2001 Aaron Marcus and Associates, Inc.

Grid Systems in GUI Design: Case Studies

AM+A

Aaron Marcus and Associates, Inc.
Web: www.AMandA.com

California Tel: 510-601-0994
Email: Aaron@AMandA.com
Eugene@AMandA.com

New York Tel: 212-625-1813
Email: Melanie@AMandA.com

Grids: Case Studies

- Scitex
- Kodak
- Crowley Maritime
- Charles Schwab
- Kaiser
- STIN
- AM+A

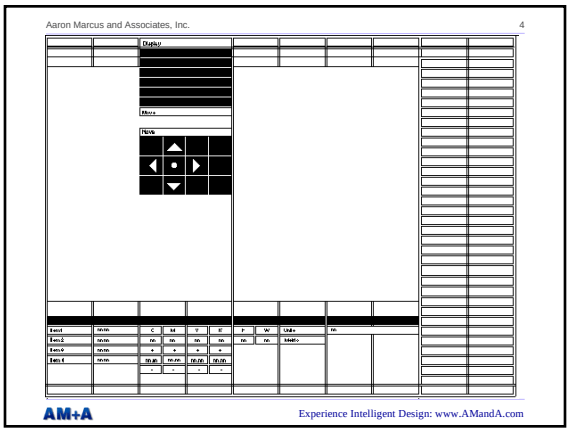
Scitex: Grid-Based Screen Design for Graphic Arts Workstation

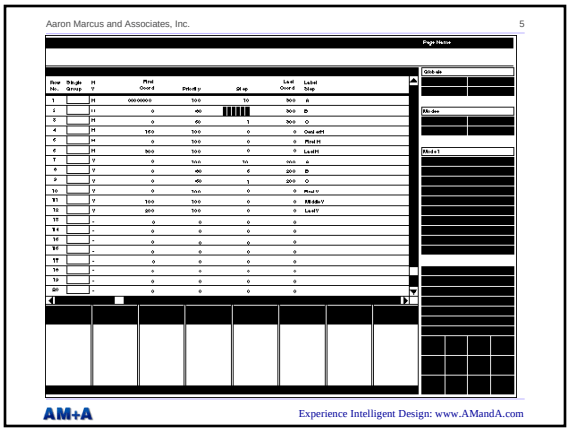
- Applications must show large images and controls in one screen, not two, as previously
- 9-Letter legible English-only menu commands determined column widths
- Legible typography x-heights determined minimum row height
- Grid determined most window, pane layouts

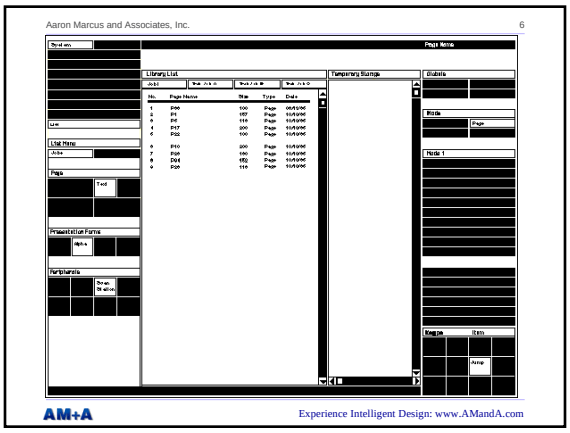
 © 2001 Aaron Marcus and Associates, Inc.

Tutorial:
UI Design for Work, Home, and On the Way

Case Studies:
Grid Systems in GUI Design



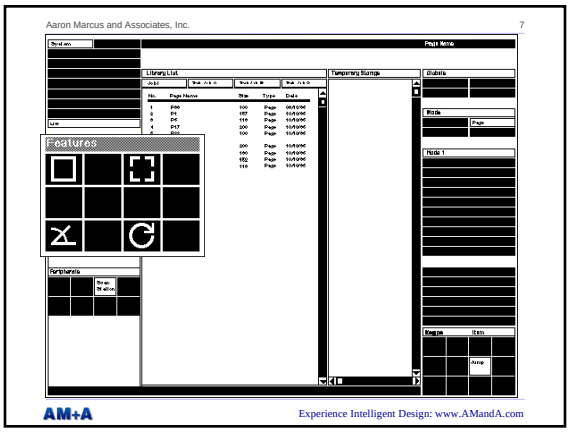


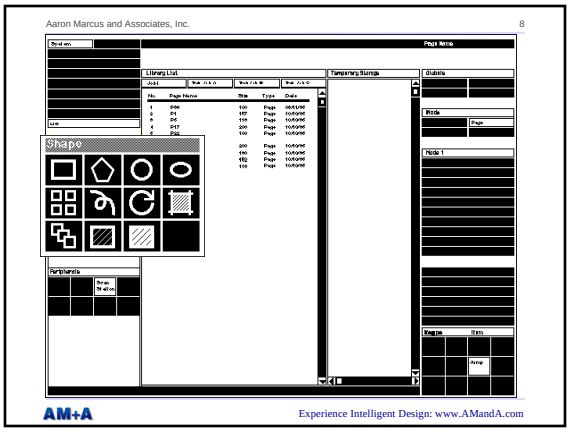


 © 2001 Aaron Marcus and Associates, Inc.

Tutorial:
UI Design for Work, Home, and On the Way

Case Studies:
Grid Systems in GUI Design





Aaron Marcus and Associates, Inc. 9

Kodak: Grid for Consistent Screen Layout Across Multiple Products

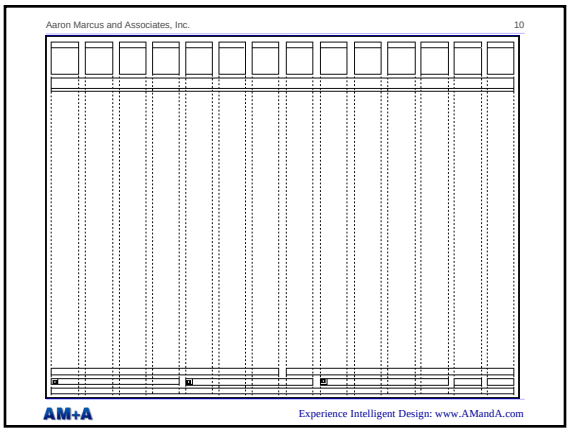
- Grid served common user-interface design for four different document editing applications
- Grid accommodated all functions and date, and all window layouts with minor exceptions
- Grid occasionally ignored for special circumstances, e.g., large-format document display

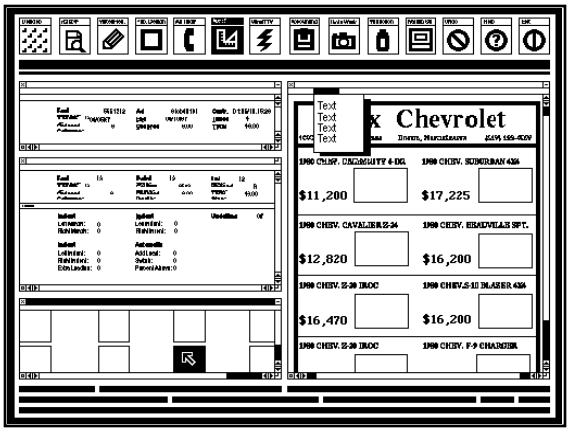
AM+A Experience Intelligent Design: www.AMandA.com

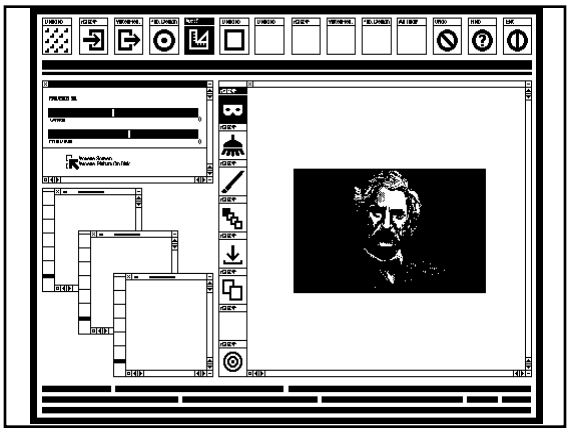
 © 2001 Aaron Marcus and Associates, Inc.

Tutorial:
UI Design for Work, Home, and On the Way

Case Studies:
Grid Systems in GUI Design



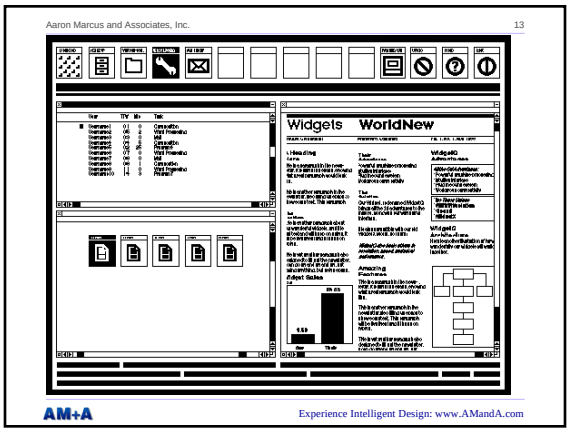


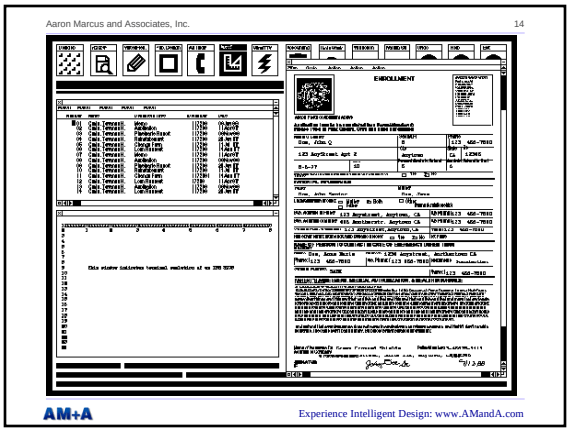


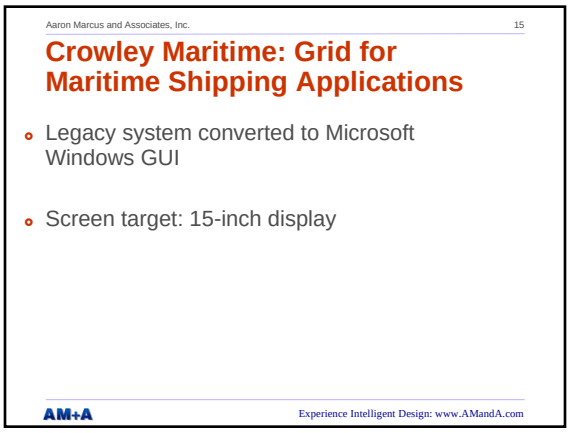
© 2001 Aaron Marcus and Associates, Inc.

Tutorial:
UI Design for Work, Home, and On the Way

Case Studies:
Grid Systems in GUI Design



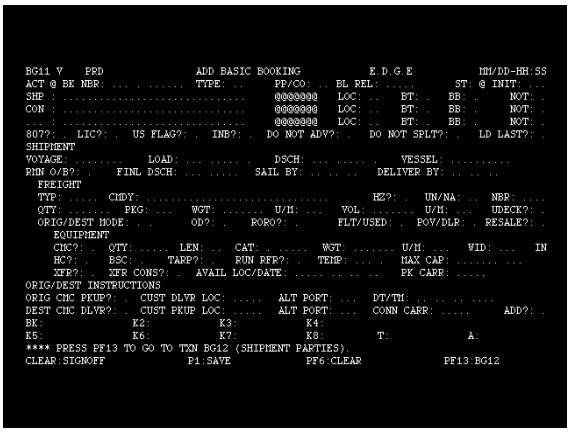


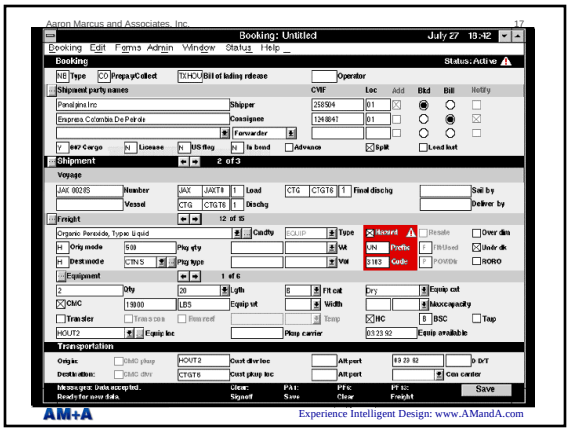


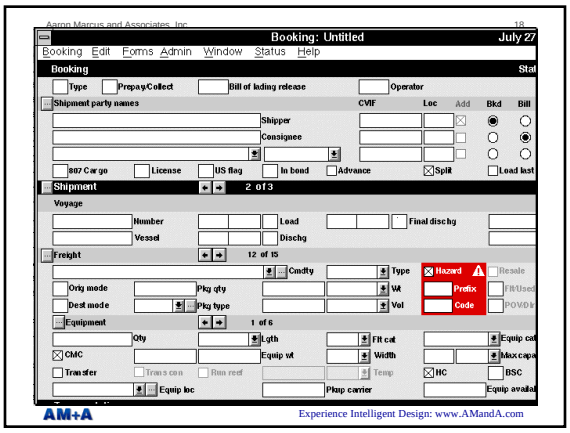
 © 2001 Aaron Marcus and Associates, Inc.

Tutorial:
UI Design for Work, Home, and On the Way

Case Studies:
Grid Systems in GUI Design



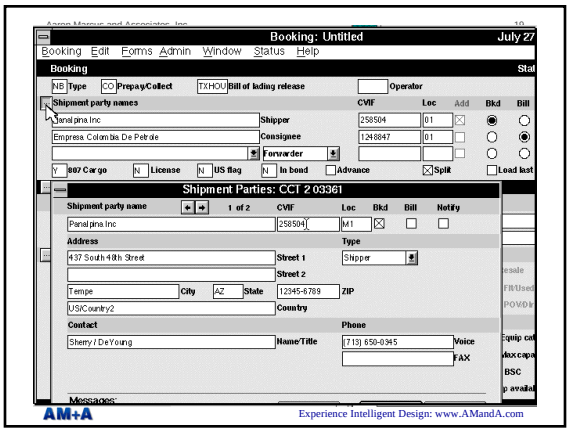


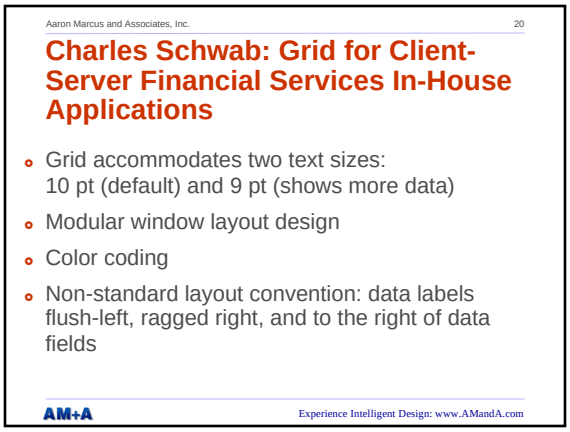


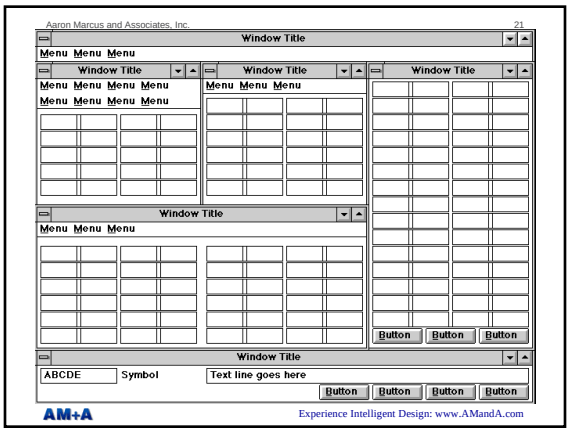
 © 2001 Aaron Marcus and Associates, Inc.

Tutorial:
UI Design for Work, Home, and On the Way

Case Studies:
Grid Systems in GUI Design



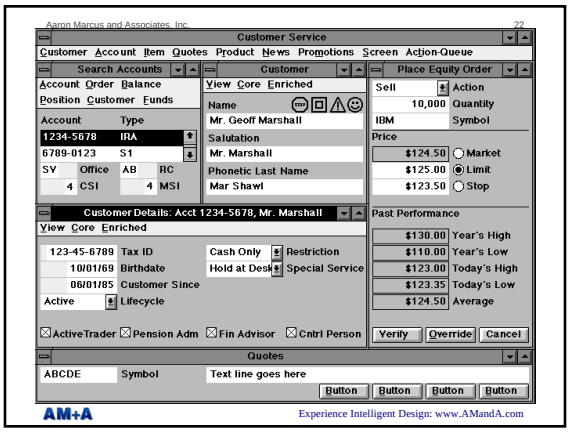


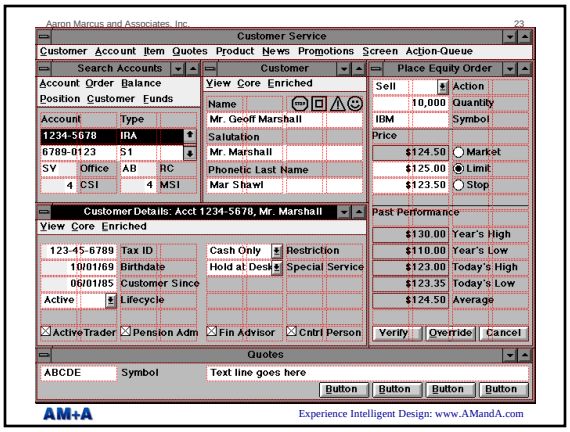


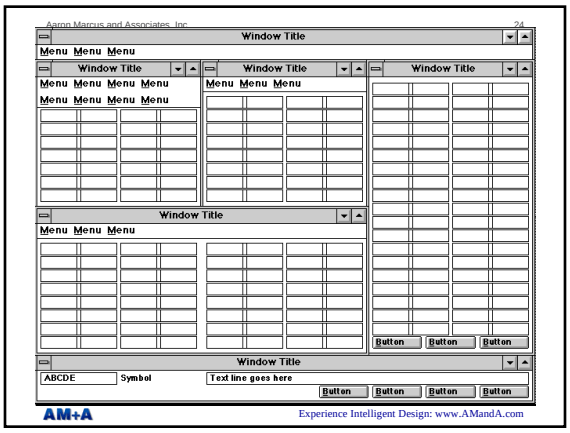
 © 2001 Aaron Marcus and Associates, Inc.

Tutorial:
UI Design for Work, Home, and On the Way

Case Studies:
Grid Systems in GUI Design



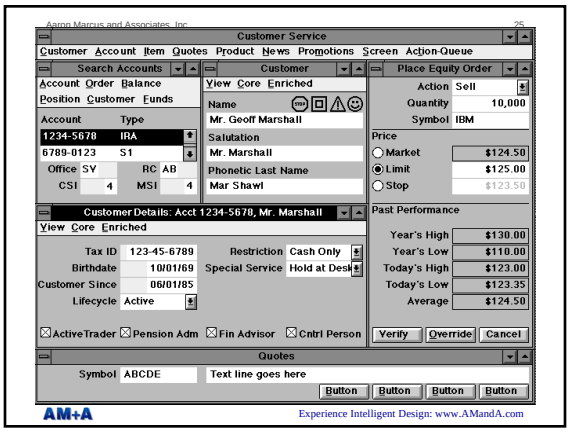


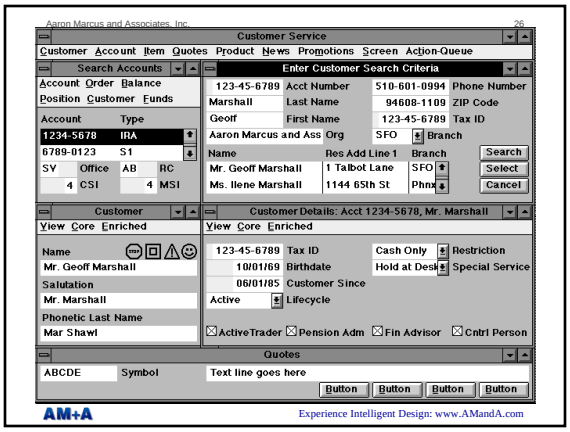


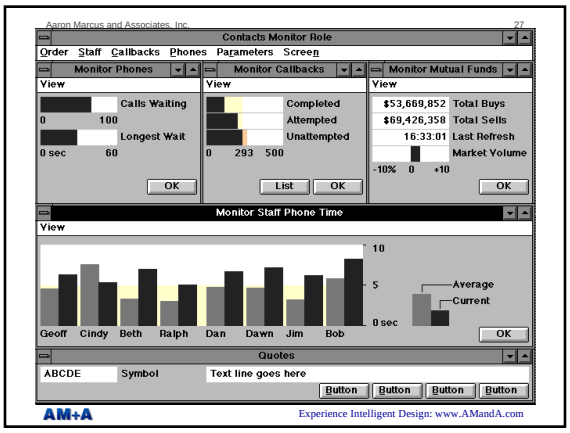
 © 2001 Aaron Marcus and Associates, Inc.

Tutorial:
UI Design for Work, Home, and On the Way

Case Studies:
Grid Systems in GUI Design



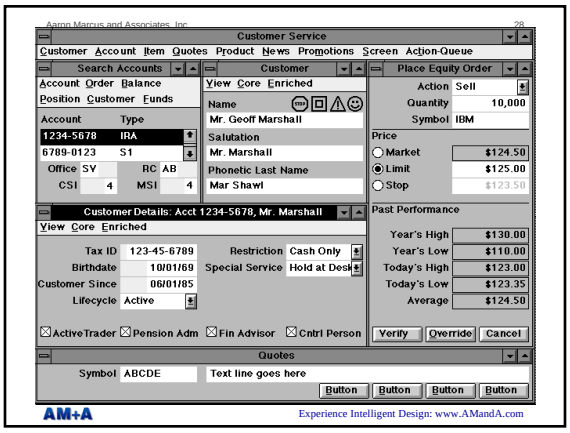


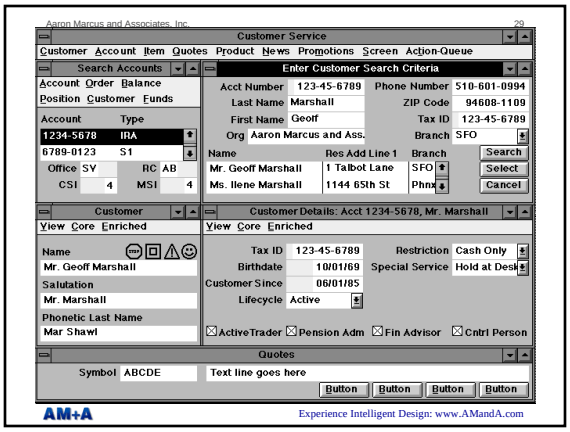


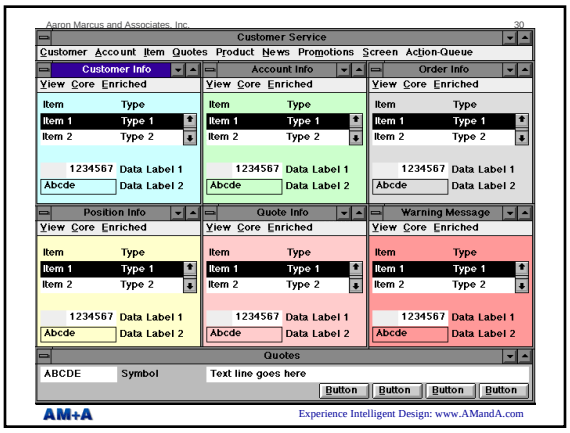
 © 2001 Aaron Marcus and Associates, Inc.

Tutorial:
UI Design for Work, Home, and On the Way

Case Studies:
Grid Systems in GUI Design







 © 2001 Aaron Marcus and Associates, Inc.

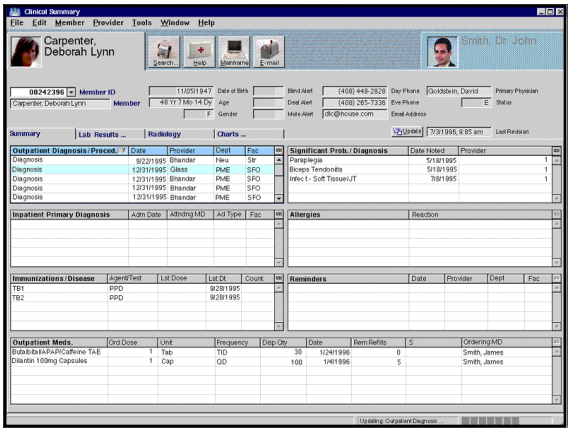
Kaiser: Grid for Client-Server Clinical Information System

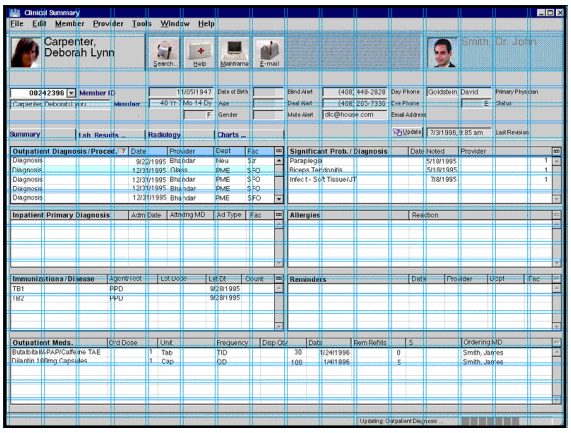
- Grid accommodates most information with varying contents, density, and size

 © 2001 Aaron Marcus and Associates, Inc.

Tutorial:
UI Design for Work, Home, and On the Way

Case Studies:
Grid Systems in GUI Design

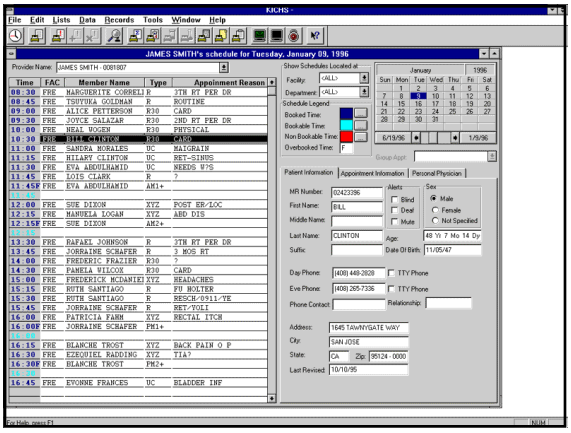


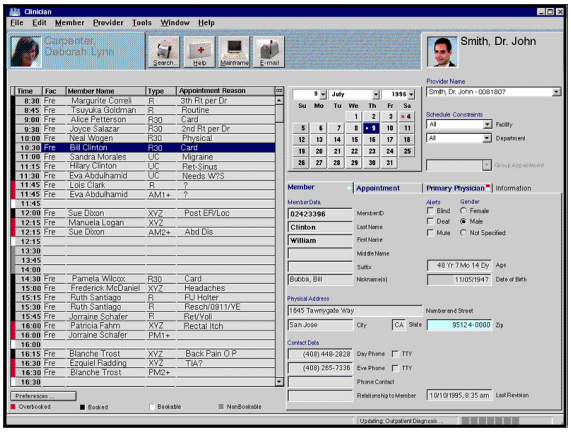


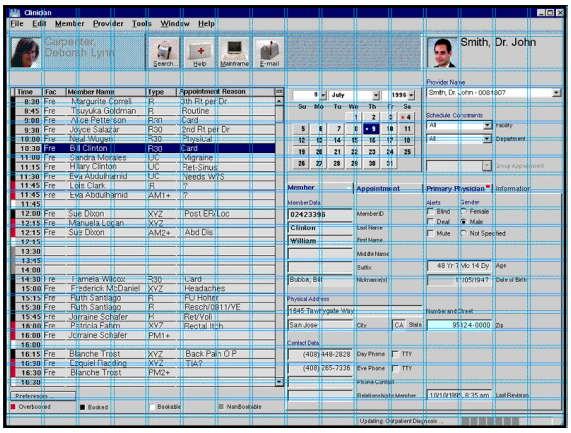
 © 2001 Aaron Marcus and Associates, Inc.

Tutorial:
UI Design for Work, Home, and On the Way

Case Studies:
Grid Systems in GUI Design







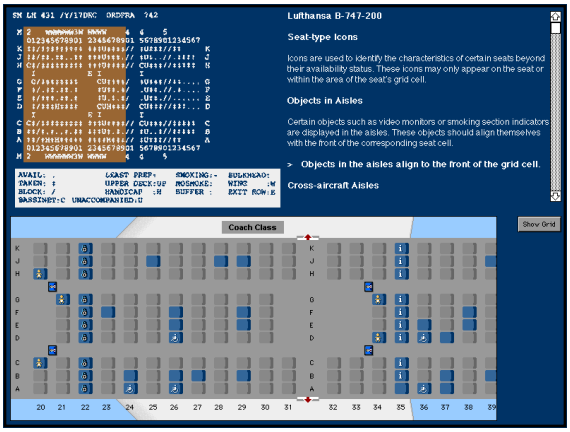
 © 2001 Aaron Marcus and Associates, Inc.

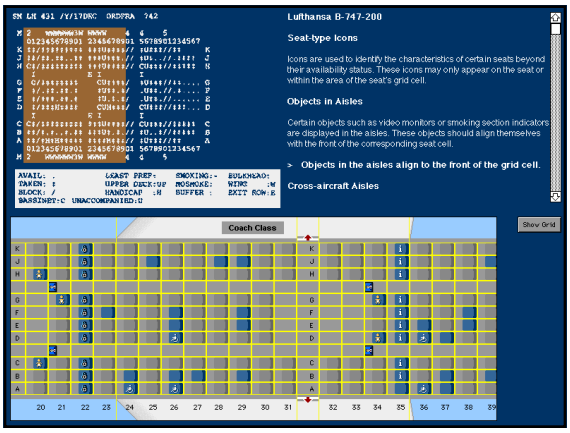
Tutorial:
UI Design for Work, Home, and On the Way

Case Studies:
Grid Systems in GUI Design

SABRE: Grids for Seat Maps in Planet SABRE Air Booking Application

- Grids defined layouts of cabin displays
- Grids defined bitmaps required to dynamically generate displays
- Grids for smaller coach-cabin seats differed from first-class seats

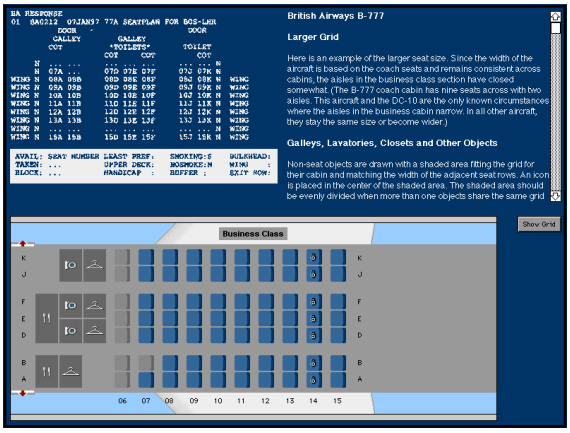


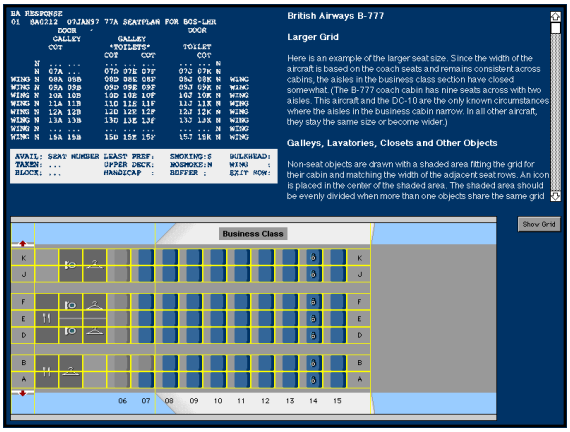


 © 2001 Aaron Marcus and Associates, Inc.

Tutorial:
UI Design for Work, Home, and On the Way

Case Studies:
Grid Systems in GUI Design





Aaron Marcus and Associates, Inc. 45

AM+A Website: Grid for All Layouts

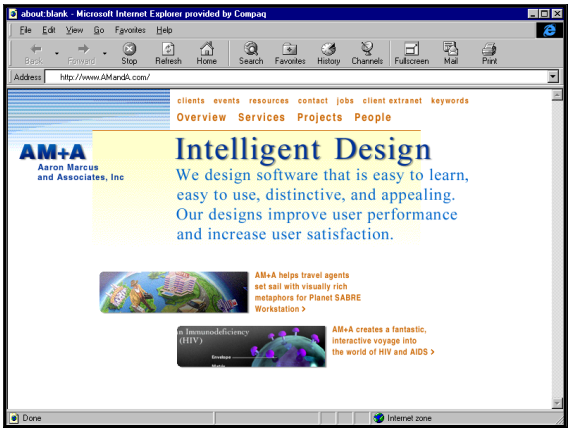
- Designed for 800 x 600 resolution for target market of users
- Design strategy for 640 x 480 resolution and smaller screens
- Design strategy for higher resolution and larger screens

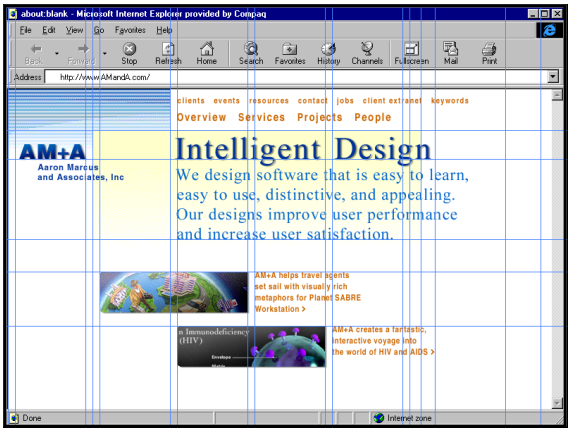
AM+A Experience Intelligent Design: www.AMandA.com

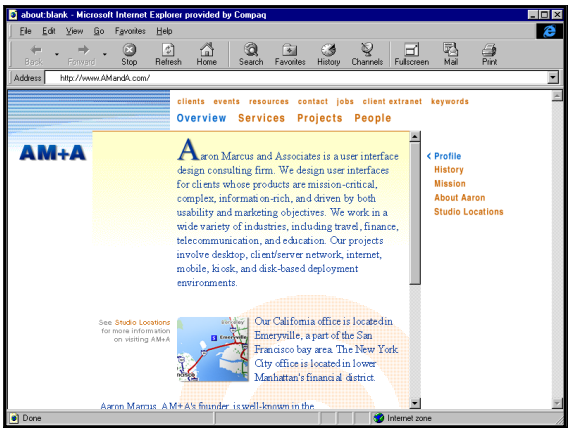
 © 2001 Aaron Marcus and Associates, Inc.

Tutorial:
UI Design for Work, Home, and On the Way

Case Studies:
Grid Systems in GUI Design



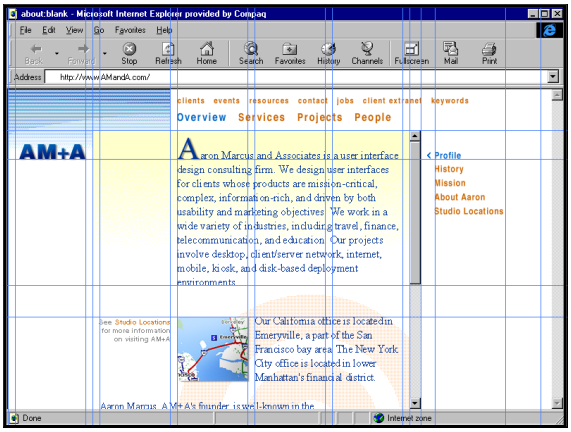




 © 2001 Aaron Marcus and Associates, Inc.

Tutorial:
UI Design for Work, Home, and On the Way

Case Studies:
Grid Systems in GUI Design



 © 2001 Aaron Marcus and Associates, Inc.

Icon Design

AM+A

Aaron Marcus and Associates, Inc.
Web: www.AMandA.com

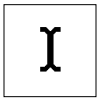
California Tel: 510-601-0994
Email: Aaron@AMandA.com
Eugene@AMandA.com

New York Tel: 212-625-1813
Email: Melanie@AMandA.com

Visual Semiotics: The Science of Signs

Icon

Symbol



Index

Pictogram

Ideogram

Semiotic Dimensions

- Lexical: Production
- Syntactic: Combination
- Semantic: Reference
- Pragmatic: Consumption

 © 2001 Aaron Marcus and Associates, Inc.

Aaron Marcus and Associates, Inc. 4

Visual Semiotics: Case Study

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 5

Analyzing Money via Semiotics

- Lexical: Printing process, paper, ink
- Syntactic: Size, layout, symmetry, borders, color, sides
- Semantic: Text, symbols, imagery
- Pragmatic: Size, portability, economic value, display requirements

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 6

Static/Dynamic Visual Features of GUI Icons

- Shape
- Size
- Location
- Color (value/hue coding)
- Line attributes
- Rotation/flipping
- Attached text
- Combinatorial ability

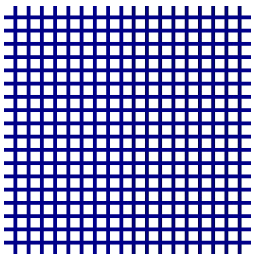
AM+A Experience Intelligent Design: www.AMandA.com

 © 2001 Aaron Marcus and Associates, Inc.

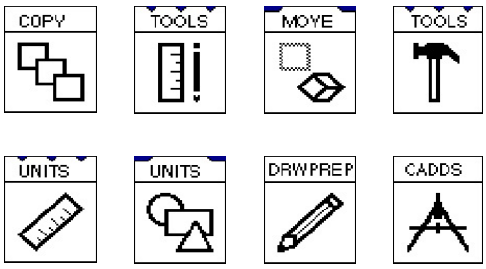
Syntactic Design Principles

- Use simple, clear unitary imagery.
- Use large objects and bold lines.
- Match the icon to display limitations.
- Strive for dark/light balance and symmetry.
- Keep signs stylistically consistent.
- Limit variation in sizes, shapes, angles, line thickness, color, and empty space.
- Design icons according to a grid

Icon Design Grid: Example

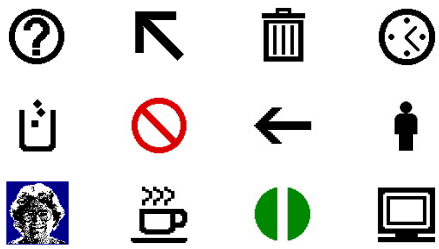


Grid-based Icon Design: Examples

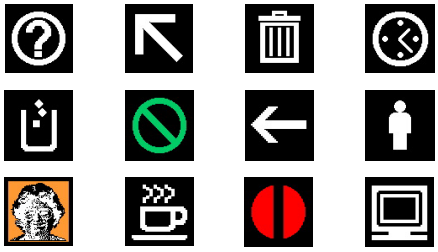


 © 2001 Aaron Marcus and Associates, Inc.

Normal Icon Set



Reversed Value Icon Set



Semantic Design Principles

- Select a distinctive point of view.
- Emphasize archetypal features.
- Exploit user's knowledge of the world.
- Respect established conventions.
- Use rhetorical techniques effectively.

 © 2001 Aaron Marcus and Associates, Inc.

Aaron Marcus and Associates, Inc. 13

Icon Rhetorical Techniques: 1/2

- Allude to the familiar: Trash can, folders
- Repeat signs for emphasis: Tool kits
- Exaggerate/understate: Trash can = destroy
- Provide contrast: Selection value-reversal
- Repeat sign parts: Kinds of documents

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 14

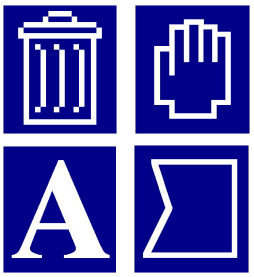
Icon Rhetorical Techniques: 2/2

- Repeat same sign: Multiple documents
- Substitute: Skull for dangerous action
- Associate: Pen for graphics editing
- Part for a whole: Calculator keypad
- Imitate style: Brush-like signs

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 15

Two Bases for Sign Semantics



Real-World Knowledge

AM+A Experience Intelligent Design: www.AMandA.com

 © 2001 Aaron Marcus and Associates, Inc.

Aaron Marcus and Associates, Inc. 16

Pragmatic Design Principles

- Make distinctive features prominent.
- Make the icon readable at a glance.
- Avoid obscure visual puns.
- Make the icon appealing.

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 17

Algorithm for Designing an Icon Set

- Identify objects to be represented.
- Generate quick conceptual sketches.
- Sort sketches by visual style.
- Select most promising sketches.
- Integrate style.
- Create layout grid for undefined style.
- Refine icons based on grid.

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 18

Summary

- Icon design is complex, requiring analysis, skill, and time.
- Semiotics principles can assist.
- All UI development steps may be relevant.

AM+A Experience Intelligent Design: www.AMandA.com

 © 2001 Aaron Marcus and Associates, Inc.

Icon Design: Case Studies

AM+A

Aaron Marcus and Associates, Inc.
Web: www.AMandA.com

California Tel: 510-601-0994
Email: Aaron@AMandA.com
Eugene@AMandA.com

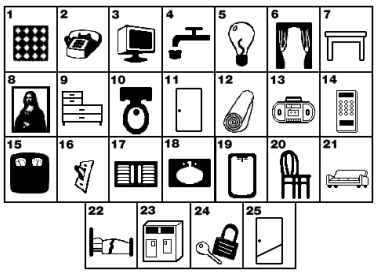
New York Tel: 212-625-1813
Email: Melanie@AMandA.com

Case Studies

- Symbol Examples
- East-West Center Audio-Visual Narrative
- Motorola
- InFocus Systems
- Arcland
- 3Com
- Nellcor
- ShareData
- SABRE: Air, Cars, Hotels; SBS

Hotel Signs to Report Problems, 1/2

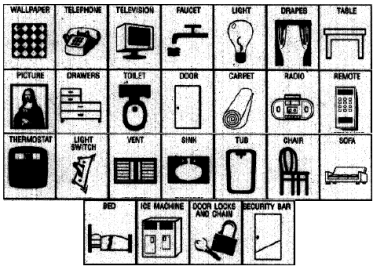
Can you identify the problems?



 © 2001 Aaron Marcus and Associates, Inc.

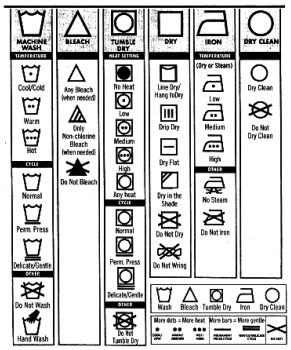
Hotel Icons to Report Problems, 2/2

Actual signs
and references



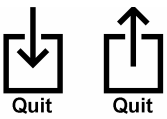
US Fabric Care Symbols

- Abstract
- Learning required



Ambiguity in Icon Design: Which Quit is "Correct"?

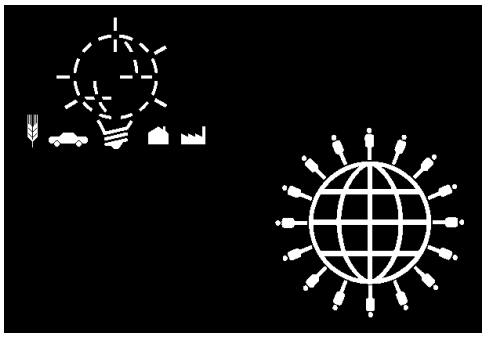
- 1: Finish and put away, like book or tool
- 2: Inside software, then leave environment
- Which direction to move: up, down, left, right?
- Ambiguity: Apple's Trash and Microsoft's Start



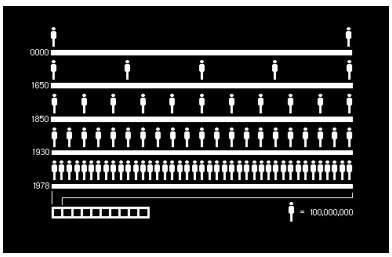
 © 2001 Aaron Marcus and Associates, Inc.

East-West Center, Honolulu

- Design goal: communicate global energy interdependence to multi-lingual, multi-cultural professionals and citizens
- Multi-disciplinary team developed, over five months, a non-verbal, pictographic-ideographic visual narrative
- Approximately 100 final signs from about 1000 initial sketches



Example of Diagram Using Signs



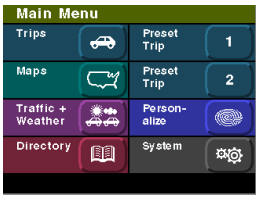
 © 2001 Aaron Marcus and Associates, Inc.

Motorola: Icons for Prototype In-Car Vehicle Navigation System

- Icons for touch-screen LCD display
- Suitable for general consumer
- Used with text in four languages

Motorola: Main Screen with Icons

- Default novice (left) and optional expert (right) icons



Motorola: Navigation Icons

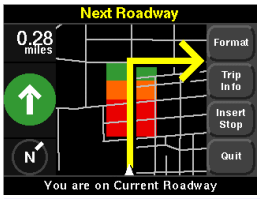
- Large icon assists driver's peripheral viewing, with optional speech and acoustic cues

 © 2001 Aaron Marcus and Associates, Inc.

Aaron Marcus and Associates, Inc. 13

Motorola: Navigation Map

- Optional map view with smaller icons



AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 14

Motorola: Traffic Status Map with Icons

- Map icons show roads, traffic, geography, and political boundaries

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 15

InFocus Systems Icons

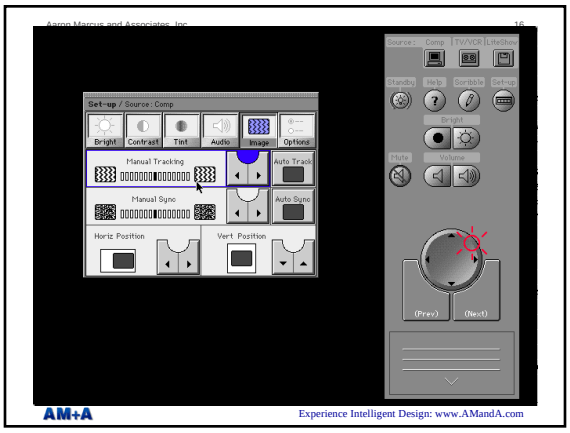
- Input device: Remote control for video projector
- Buttons enable interaction with on-screen device dialogue boxes and computer's operating system
- Special interaction techniques for selection with limited number of buttons

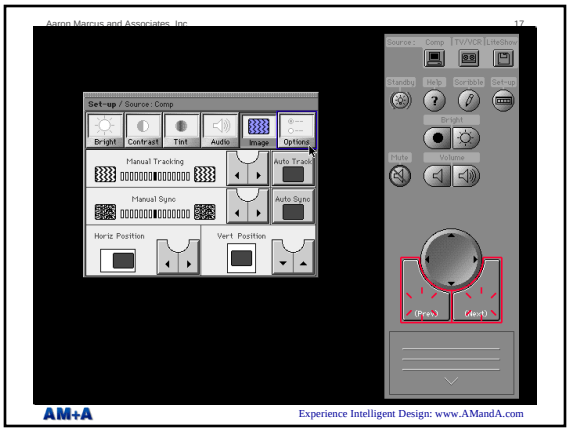
AM+A Experience Intelligent Design: www.AMandA.com

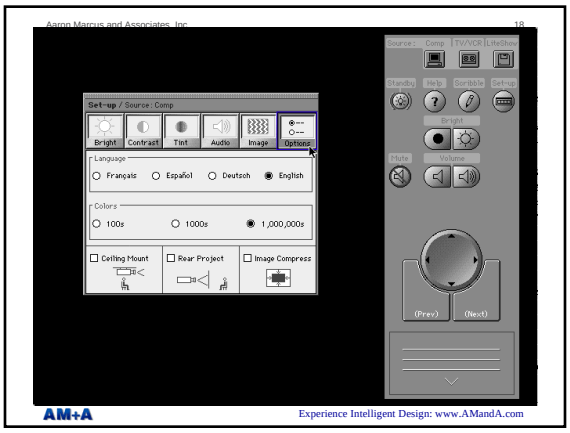
 © 2001 Aaron Marcus and Associates, Inc.

Tutorial:
UI Design for Work, Home, and On the Way

Case Studies:
Icon Design



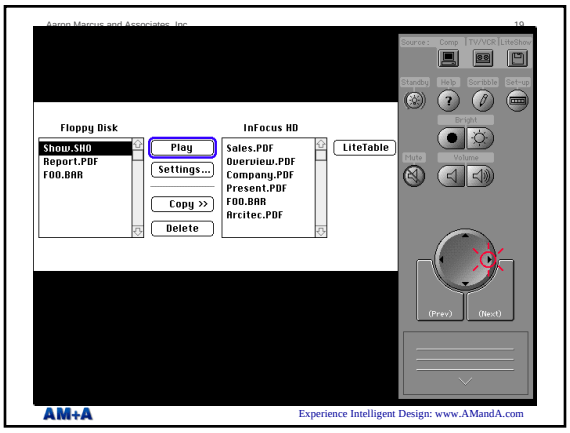




 © 2001 Aaron Marcus and Associates, Inc.

Tutorial:
UI Design for Work, Home, and On the Way

Case Studies:
Icon Design



Aaron Marcus and Associates, Inc. 20

Arcland

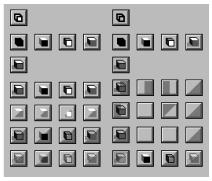
- Abstract icons for complex diagram editing application
- Designed many variations of visual style (syntax) and reference (semantics) to achieve suitable legibility and comprehension (pragmatics)

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 21

Arcland: Icons

- Variations in style of objects depicted (nodes and links) and icon background

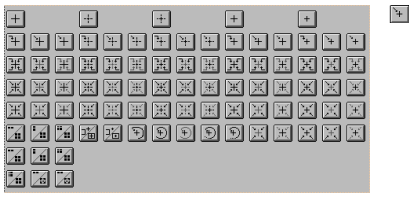


AM+A Experience Intelligent Design: www.AMandA.com

 © 2001 Aaron Marcus and Associates, Inc.

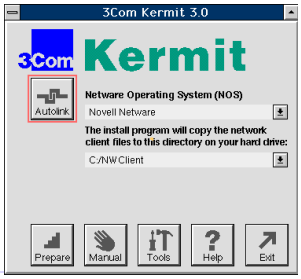
Arcland: Icons

- Return-to-Center icon and “winner”



3Com: Icons, Variation 1/2

- Prototype icons for network installer software
- Uses simple, conventional pictographic signs



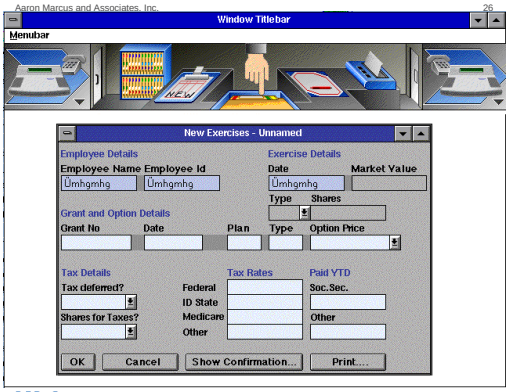
3Com: Icons, Variation 2/2

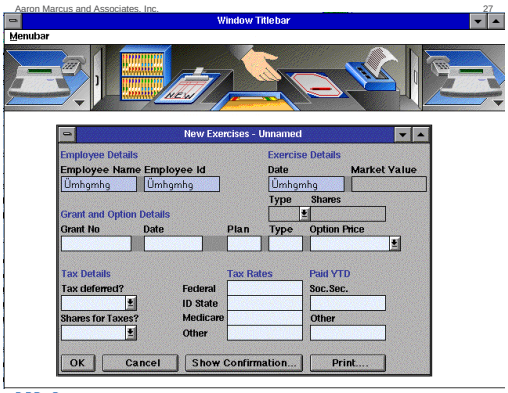
- Prototypes for initial dialogue box
- Builds on corporate identity
- Uses words

 © 2001 Aaron Marcus and Associates, Inc.

Nellcor: Icons for Medical Device

- Product for medical office assistants to input and edit data from device used in the field
- Icons are illustrational and narrative
- Hand represents “guide” to process step

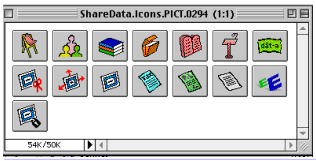




 © 2001 Aaron Marcus and Associates, Inc.

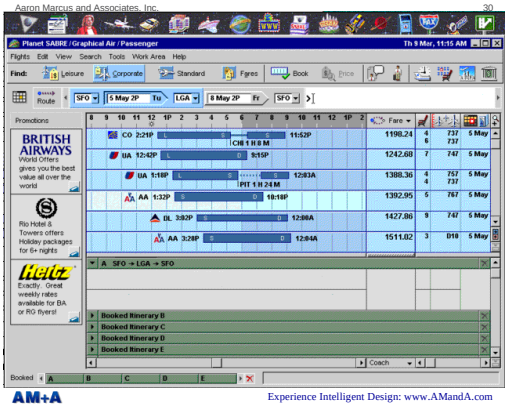
ShareData: Icons for Stock-OptionsManagement Software

- Illustrational icons influenced by printed marketing literature
- Icons needed to be greatly simplified for screen display



SABRE Graphical Air Booking: Icons

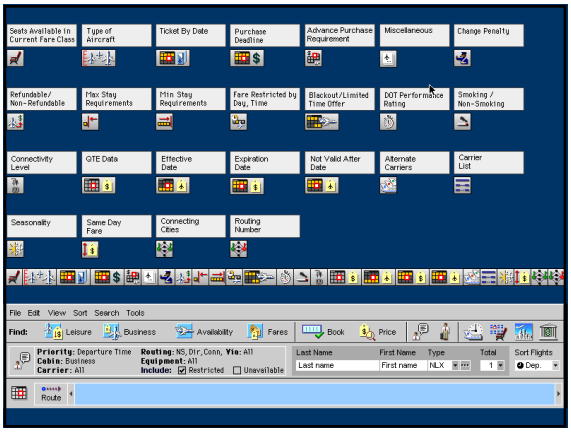
- Complex extranet transactions by dedicated users: travel agents
- Complex references required for many functions and types of data
- Icons evaluated repeatedly during GUI testing
- Designs influenced other SABRE applications and products

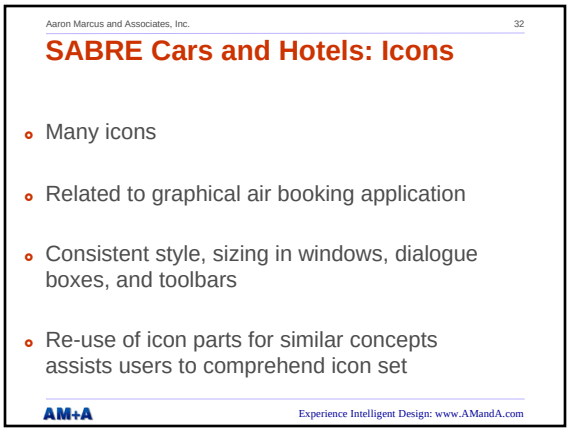


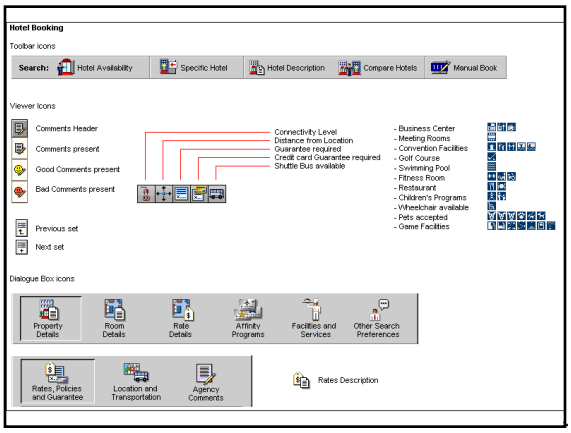
 © 2001 Aaron Marcus and Associates, Inc.

Tutorial:
UI Design for Work, Home, and On the Way

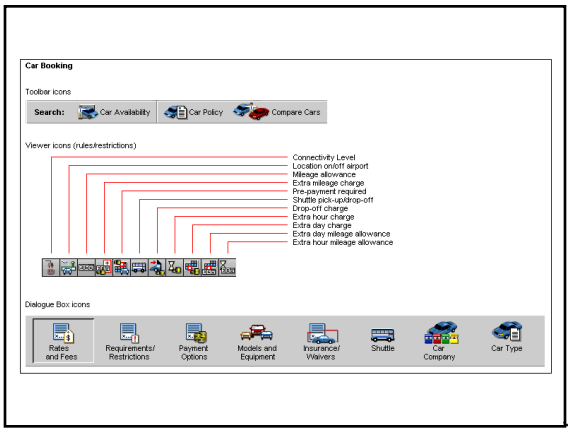
Case Studies:
Icon Design

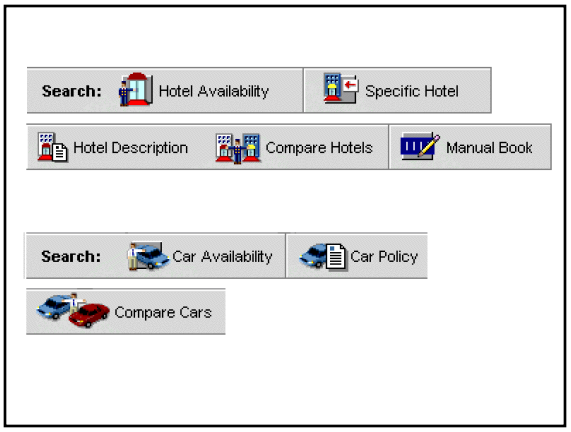


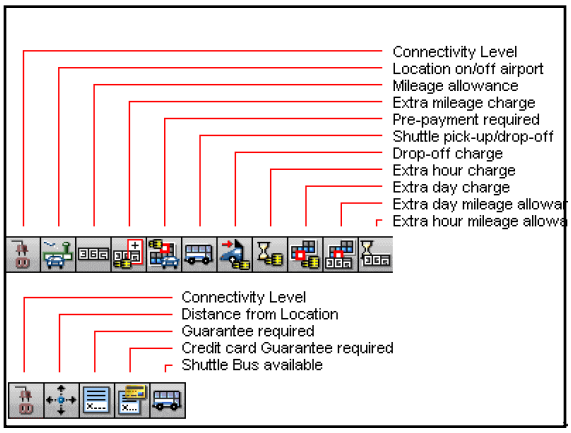




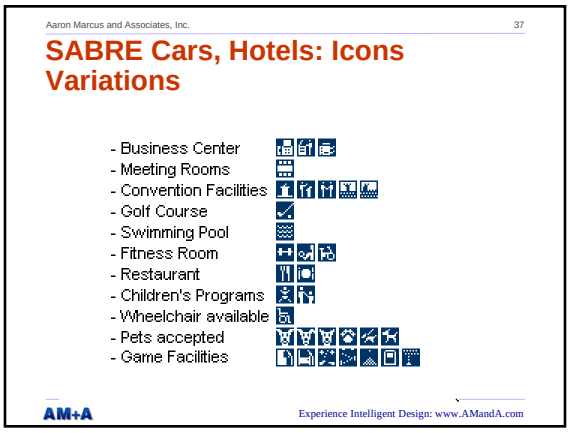
 © 2001 Aaron Marcus and Associates, Inc.

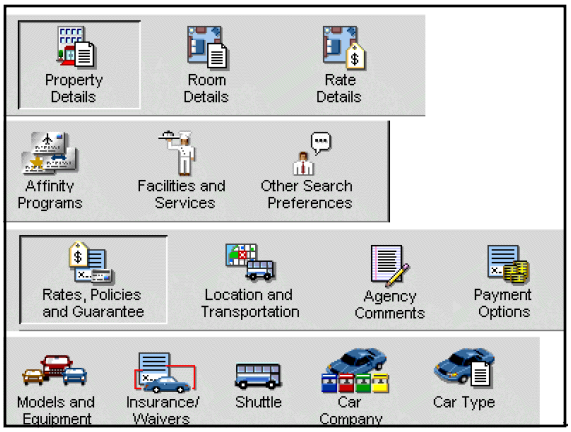


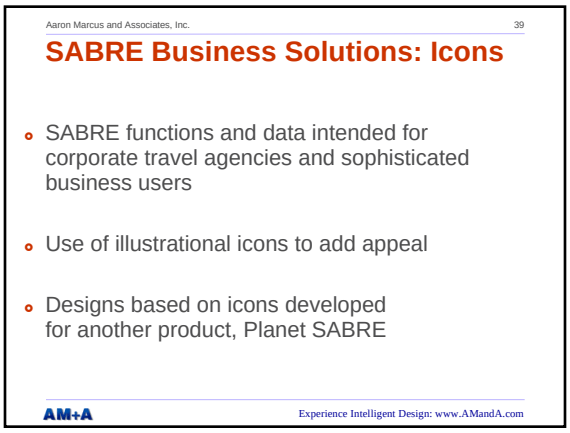




 © 2001 Aaron Marcus and Associates, Inc.

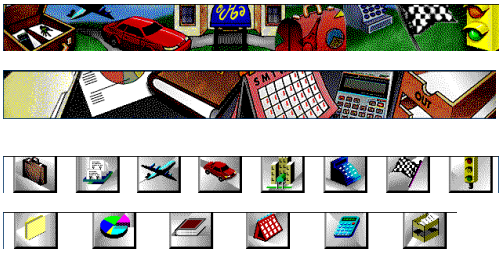






 © 2001 Aaron Marcus and Associates, Inc.

SABRE SBS: Icons



Summary

- Icon design is both challenging and complex.
- Good design benefits both developers and users.
- Assign money and time for good icon design.

 © 2001 Aaron Marcus and Associates, Inc.

Icon Design Exercise

AM+A

Aaron Marcus and Associates, Inc.
Web: www.AMandA.com

California Tel: 510-601-0994
Email: Aaron@AMandA.com
Eugene@AMandA.com

New York Tel: 212-625-1813
Email: Melanie@AMandA.com

Icon Design Project

- Allows participants to develop skills in planning, designing, implementing, and evaluating a system of signs for a specific context to represent objects, relationships, structures, and processes.

Project Assignment

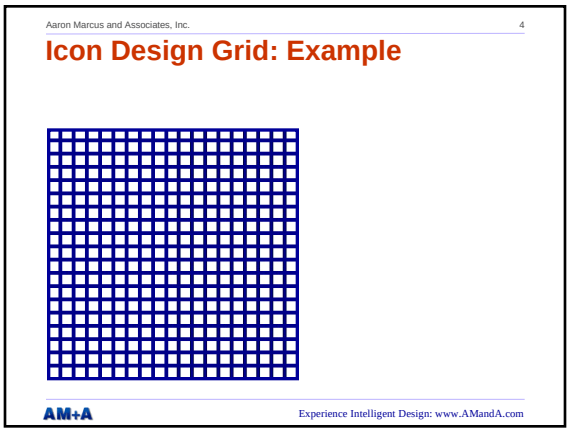
- Use 32 x 32 grid as framework to develop iconic and/or symbolic signs that communicate these functions:

  Text Editing tool
  Texture/Pattern editing tool
  Zoom-in/Zoom-out tool
  Undo tool

 © 2001 Aaron Marcus and Associates, Inc.

Tutorial:
UI Design for Work, Home, and On the Way

Exercise:
Icon Design



 © 2001 Aaron Marcus and Associates, Inc.

Tutorial:
UI Design for Work, Home, and On the Way

Lecture:
Mental Model and Navigation: Dialogue Design

Mental Model, Navigation, Interaction: Philosophy, Principles, Guidelines

AM+A

Aaron Marcus and Associates, Inc.
Web: www.AMandA.com

California Tel: 510-601-0994
Email: Aaron@AMandA.com
Eugene@AMandA.com

New York Tel: 212-625-1813
Email: Melanie@AMandA.com

Mental Model + Navigation + Interaction = Dialogue Design

- Significant challenge in GUI design.
- Enables navigation of mental model.
- Enables command and control.
- Menus: Lists of verbs, nouns, adjectives,and adverbs.
- Windows and dialogue boxes: Layouts of verbs, nouns, adjectives, and adverbs.

Goals for Menu Design

- Group menu items according to easily recognizable logical relations to make them more easily learned.
- Group menu items to be clearly distinguishable perceptually.
- Position most likely selections (given the current context) for easy access.
- Use good terminology.

 © 2001 Aaron Marcus and Associates, Inc.

Aaron Marcus and Associates, Inc. 4

Location Tradeoff for Tool Palettes and Pop-up Menus

- Extreme positions are easier to learn, remember, and locate.
- Interior positions are faster and easier to reach.

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 5

Rules for Menu Appearance

- Left-justify all textual menu lists.
- Capitalize only initial letters of items.
- Separate groups of text, icons, and hotkey codes.
- Attempt to limit groups to 7±2 items.
- Carefully select and use consistent terms (Verbal appearance).

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 6

Algorithm for Menu Design

- Identify top-level menus.
- List full item set (commands, objects, etc.).
- Identify groups of related items.
- Identify sets of groups.
- Sort groups by top-level menus.
- Order groups by frequency of use.
- Order items by logical relation: (e.g. alphabet, numerical order, geography, size, time, color).
- Clarify items and groups with visible language.
- Check efficiency, consistency of terms.

AM+A Experience Intelligent Design: www.AMandA.com

 © 2001 Aaron Marcus and Associates, Inc.

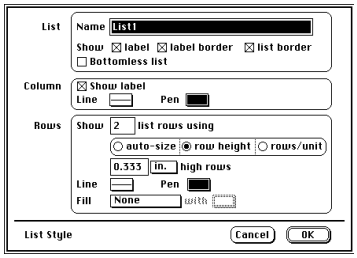
Goals for Dialogue Layout, 1/2

- Display all parameters within the layout according to task groups.
- Present all controls required to complete the task or tasks.
- Make most frequently used controls easy to locate and manipulate.

Goals for Dialogue Layout, 2/2

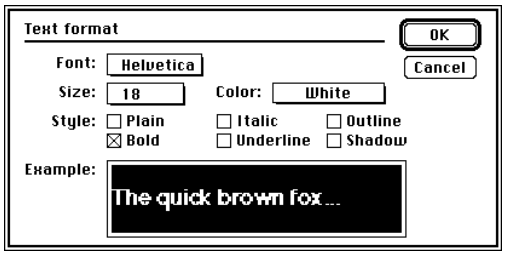
- Spatial order of controls should reflect typical interaction sequences.
- Establish clear context for each dialogue area with prominent and consistently located titles.
- Use simple, clear, consistent terms, labels.

Disorganized Dialogue Box



 © 2001 Aaron Marcus and Associates, Inc.

Organized Dialogue Box



Dialogue Analysis Process, 1/2

- Analyze the contents.
- Create a conceptual diagram.
- Sort the area into information zones.
- Tell a story visually.
- Let the typography tell the story.
- Make any instructions clear.

Dialogue Analysis Process, 2/2

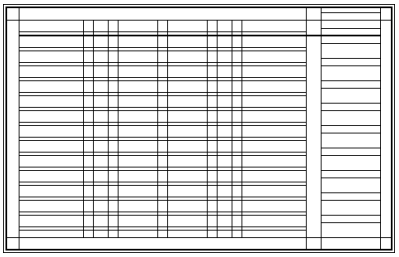
- Use a short, clear title.
- Minimize variations in lengths and widths.
- Establish a layout grid.
- Leave enough space for date entry.
- Use color with discretion.
- Use simple, clear, consistent terms, labels.
- Evaluate the design with users.

 © 2001 Aaron Marcus and Associates, Inc.

Algorithm for Dialogue Design

- Identity parameters to be included.
- Match parameters to control types.
- Group related items in logical order.
- Rank control groups by importance.
- Determine appropriate size for panes.
- Sketch spatial layout of groups.
- Position required response buttons.
- Place control groups according to a grid.

Example of Dialogue Layout Grid



Summary

- Design of mental model and navigation is challenging and complex.
- Good design requires time, skill, and experience.
- Subject-matter and task knowledge is crucial.
- Terminology and titling are also important.
- Dialogue should be evaluated with users.

 © 2001 Aaron Marcus and Associates, Inc.

Dialogue Design: Mental Model, Navigation, and Interaction Case Studies

AM+A

Aaron Marcus and Associates, Inc.
Web: www.AMandA.com

California Tel: 510-601-0994
Email: Aaron@AMandA.com
Eugene@AMandA.com

New York Tel: 212-625-1813
Email: Melanie@AMandA.com

Dialogue Design Case Studies

- Sabre Graphical Air
- Sabre Hotels
- Unigraphics
- Xerox

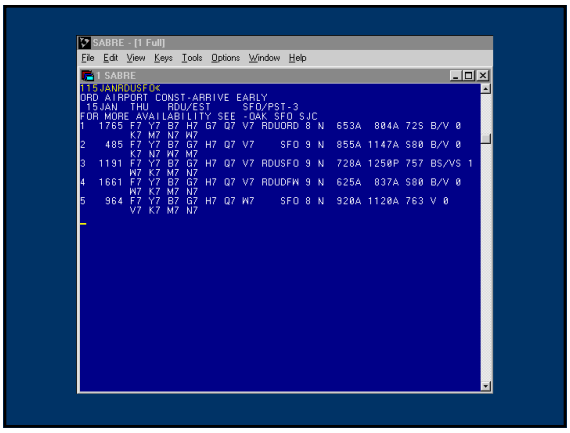
STIN Graphical Air Booking: Evolution of Mental Model and Navigation

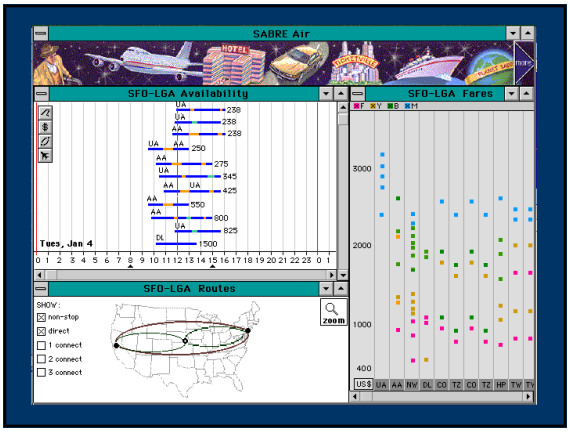
- Primary application in new Planet SABRE GUI
- Complex functions, large database
- Large extranet used by professional travel agents worldwide
- Early designs showed too much of the wrong content

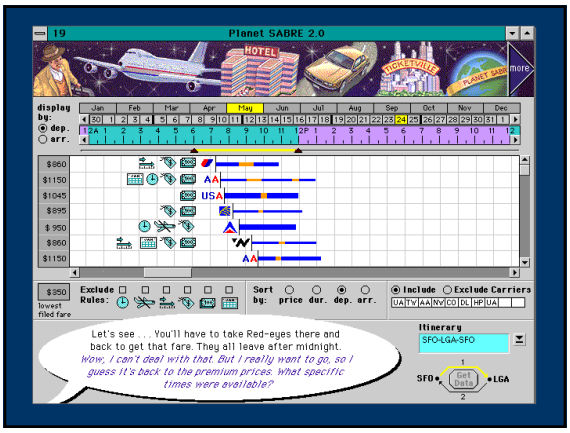
 © 2001 Aaron Marcus and Associates, Inc.

Tutorial:
UI Design for Work, Home, and On the Way

Case Studies:
Mental Model and Navigation: Dialogue Design



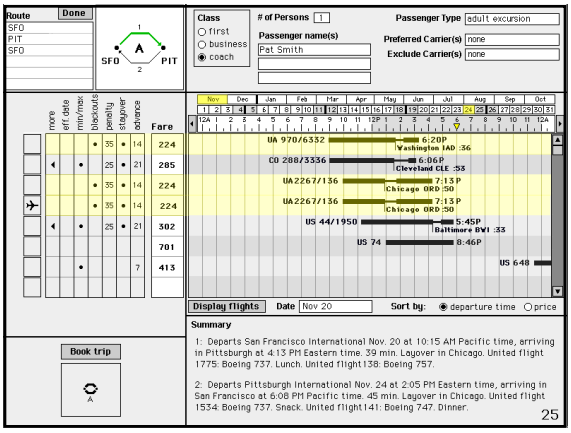


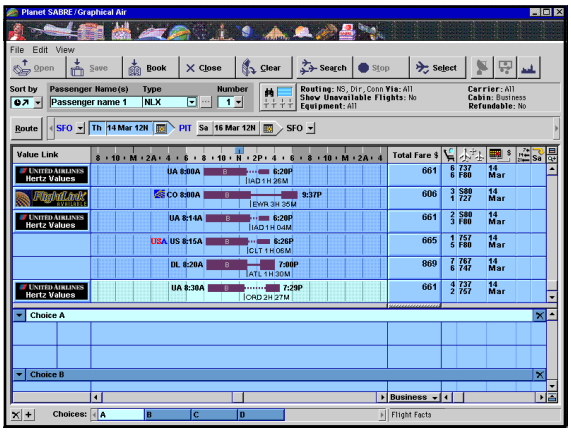


 © 2001 Aaron Marcus and Associates, Inc.

Tutorial:
UI Design for Work, Home, and On the Way

Case Studies:
Mental Model and Navigation: Dialogue Design

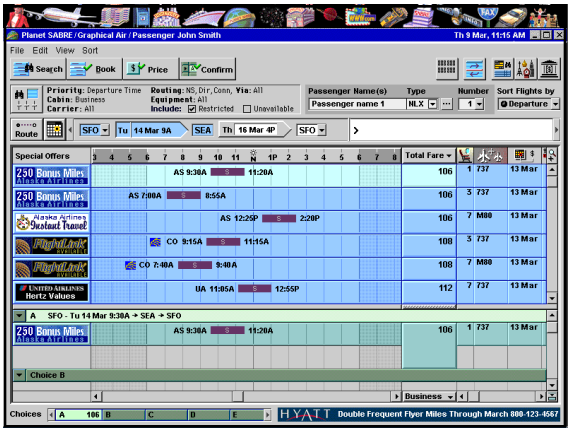


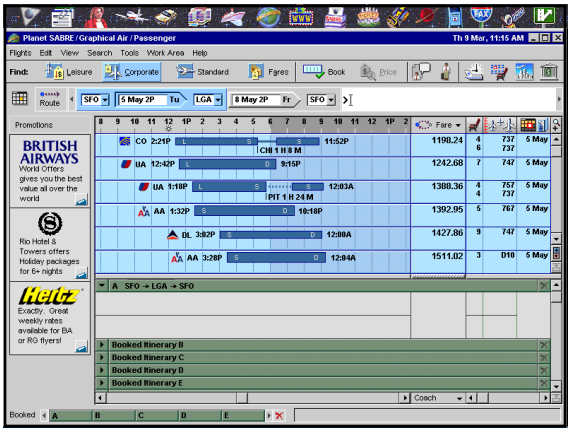


 © 2001 Aaron Marcus and Associates, Inc.

Tutorial:
UI Design for Work, Home, and On the Way

Case Studies:
Mental Model and Navigation: Dialogue Design

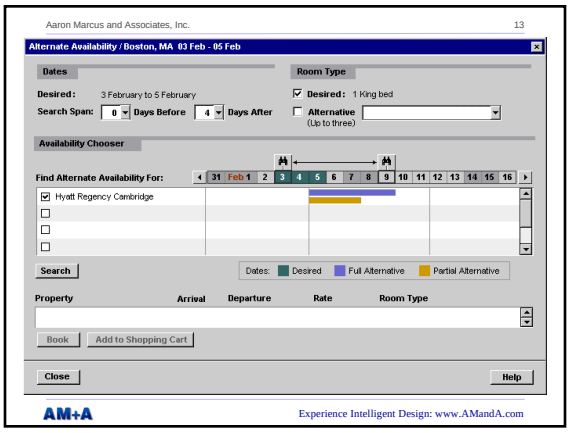


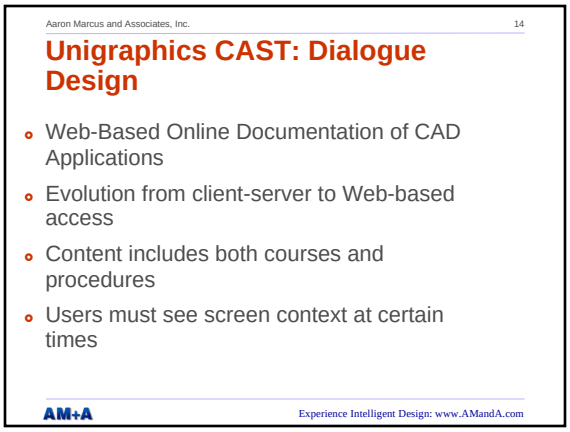


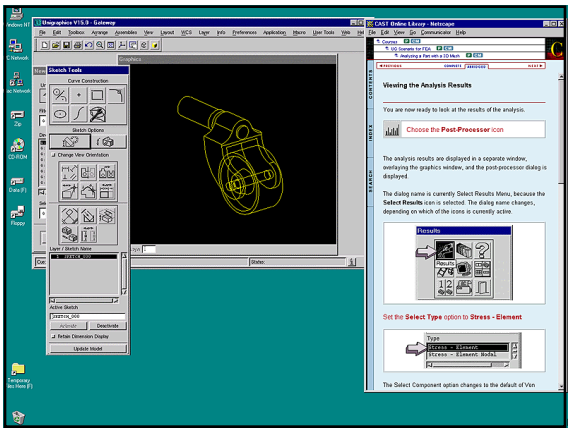
 © 2001 Aaron Marcus and Associates, Inc.

Tutorial:
UI Design for Work, Home, and On the Way

Case Studies:
Mental Model and Navigation: Dialogue Design



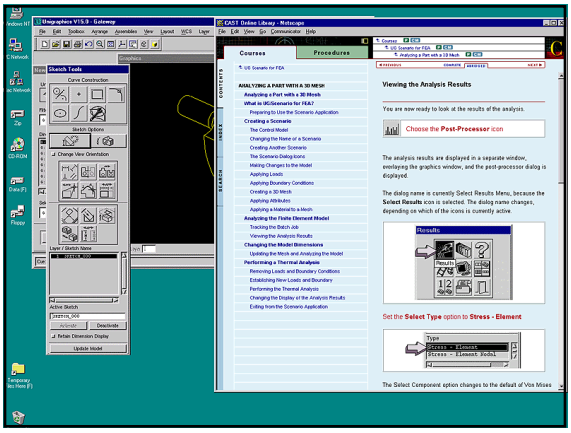


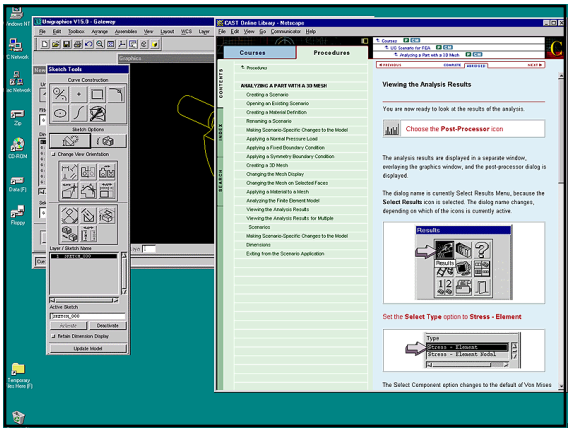


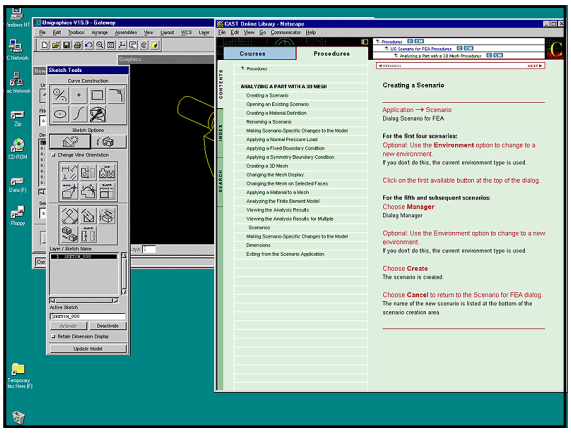
 © 2001 Aaron Marcus and Associates, Inc.

Tutorial:
UI Design for Work, Home, and On the Way

Case Studies:
Mental Model and Navigation: Dialogue Design



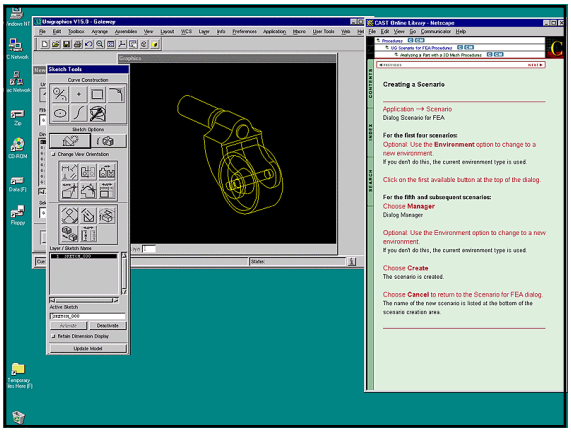


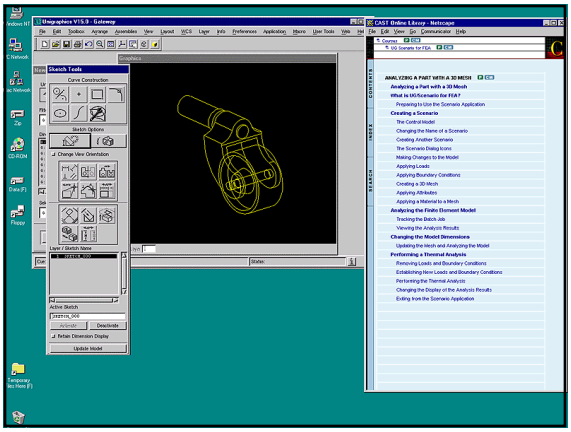


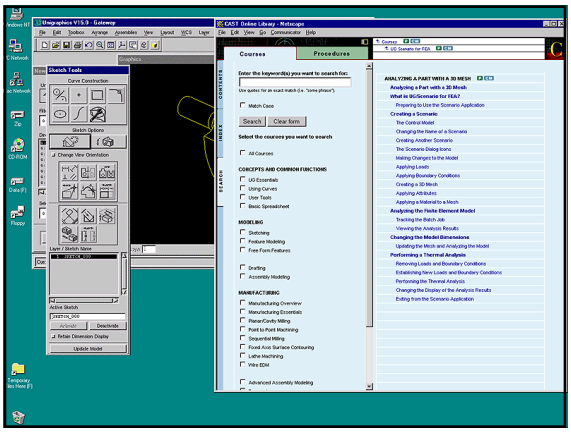
 © 2001 Aaron Marcus and Associates, Inc.

Tutorial:
UI Design for Work, Home, and On the Way

Case Studies:
Mental Model and Navigation: Dialogue Design



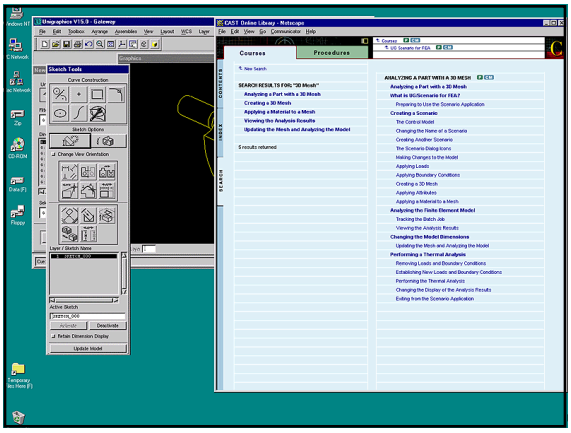


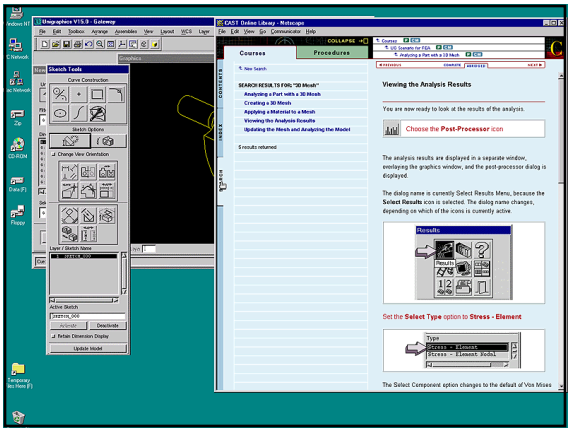


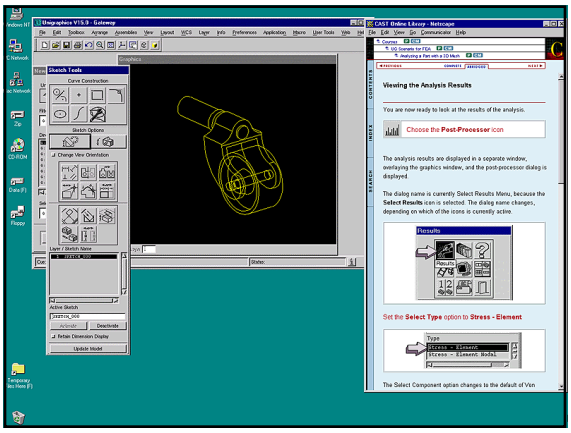
 © 2001 Aaron Marcus and Associates, Inc.

Tutorial:
UI Design for Work, Home, and On the Way

Case Studies:
Mental Model and Navigation: Dialogue Design



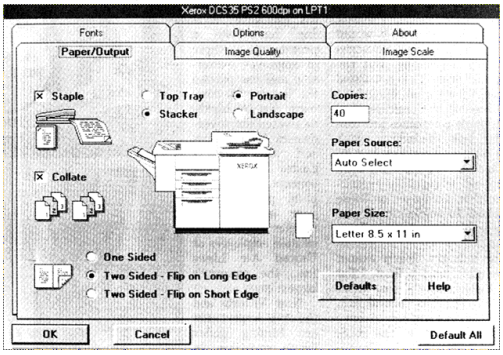


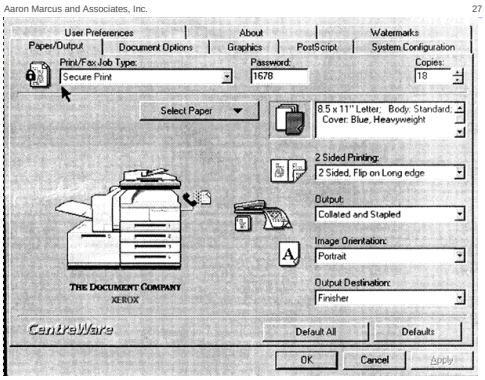


 © 2001 Aaron Marcus and Associates, Inc.

Xerox: Dialogue Boxes for Printers

- Two dialogue boxes for printers as shown in published advertisements
- Mixture of verbal and visual content





 © 2001 Aaron Marcus and Associates, Inc.

Mental Model and Navigation (Dialogue) Design: Exercise

AM+A

Aaron Marcus and Associates, Inc.
Web: www.AMandA.com

California Tel: 510-601-0994
Email: Aaron@AMandA.com
Eugene@AMandA.com

New York Tel: 212-625-1813
Email: Melanie@AMandA.com

Dialogue Box Design Project

- Enable users to determine the parameters of a “Print Document” dialogue box.
- Participants must determine the most appropriate and effective representation for each element.
- Consider how to brand the “user experience.”

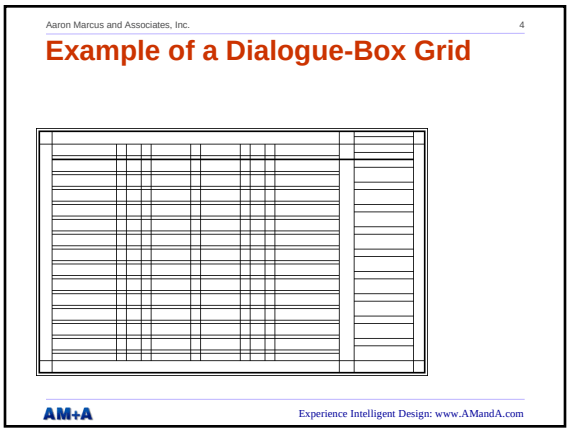
Print-Document Dialogue Box Contents

- Print back to front, or front to back
- Print both sides or a single-side
- Beginning/ending page numbers
- Print “thumbnails” or miniatures
- Number of copies
- Reduction or enlargement percentage
- Paper orientation (portrait/landscape)
- OK
- Cancel
- Help

 © 2001 Aaron Marcus and Associates, Inc.

Tutorial:
UI Design for Work, Home, and On the Way

Exercise:
Mental Model and Navigation: Dialogue Design



 © 2001 Aaron Marcus and Associates, Inc.

Tutorial:
UI Design for Work, Home and on the Way

Lecture:
Interactivity in Web Applications

Thick to Thin: Interactivity in Web Applications

AM+A

Aaron Marcus and Associates, Inc.
Web: www.AMandA.com

California Tel: 510-601-0994
Email: Aaron@AMandA.com
Eugene@AMandA.com

New York Tel: 212-625-1813
Email: Melanie@AMandA.com

AM+A

- 20 years of innovation in user interface and information visualization
- Across all vertical markets
- Offices in California and New York
- Across all deployment platforms and environments
  - Desktop, cd-rom, web, in-car, info appliance, handhelds

Introduction

Audience:

- Developers familiar with desktop applications, but not web
- Web site developers new to application design

Covers:

- Strategic, design, and engineering issues in creating and porting applications to the web

 © 2001 Aaron Marcus and Associates, Inc.

Aaron Marcus and Associates, Inc. 4

Topics

Thick Client to Thin Client

Browser as UI Platform

Tools vs. Pages

Choice of Active Technologies

Requirements for a Usable Interface

Likely Changes

Deployment Strategies

Case Study

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 5

Questions We Hear From Clients:

- Will I have to dumb down my app?
- What technology should I use to build this?
- What UI can we get with a given active technology?
- Who's using it?
- What questions should we ask when researching a given active technology?

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 6

Where does the interactivity go?

- Desired UI influences selection of technology
- Technology constrains the UI
- Active Technologies (dHTML, Java, JavaScript, ActiveX, Flash etc.) create a more modern usable (and useful) interface, but incur costs in bandwidth, audience, development effort.
- Issues intertwined: design, user experience, development costs, feasibility

AM+A Experience Intelligent Design: www.AMandA.com

 © 2001 Aaron Marcus and Associates, Inc.

Motivations for creating a Web App

- **Broaden Audience**: customers accessing internal systems, end-point sales people
  - Requires lowest common denominator solution
- **Soft Releases:** No installation, update control, centralized administration
  - Thicker technologies ok
- **Remote Access:** Managers from home, trainees and contractors, Access from the field, factory or office
  - Standalone IP enabled possible

Topics

Thick Client to Thin Client

Browser as UI Platform

Tools vs. Pages

Choice of Active Technologies

Requirements for a Usable Interface

Likely Changes

Deployment Strategies

Case Study

What Is a User Interface?

- **Metaphors**: Basic concepts via words, images
- **Mental Model**: Organization of data, functions, tasks, roles, people
- **Navigation**: Movement through mental model
- **Interaction** (Feel): User input, system response
- **Appearance** (Look): Sensory elements

 © 2001 Aaron Marcus and Associates, Inc.

Aaron Marcus and Associates, Inc. 10

Interaction Design

- Define around usage rather than objects
- Organization of verbs is less obvious than nouns
- Everyone does something different

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 11

Interaction Design Fundamentals

- User Roles/Persona
- Use Cases/Scenario
- Concrete Use Case vs. Essential Use Case
- Essential Use Case does not change based on platform
- Get as close to essential use case as possible

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 12

Concrete Use Case Narrative

- Written as conversation between user and system [Wirfs-Brock]
- For a call on a cell phone:

Make Phone Call

User Action	**System Response**
Activate Phone	
Enter Address Book	
	Show Contacts
Select Party	
	Connect to Party

AM+A Experience Intelligent Design: www.AMandA.com

 © 2001 Aaron Marcus and Associates, Inc.

Aaron Marcus and Associates, Inc. 13

Essential Use Cases Narrative

- Anything non-essential ("excise") is target for removal

Make Phone Call

User Intent	System Responsibility
Activate phone	
Identify party	
	Connect to party

- Star Trek gets it right
  - Tap wearable communicator, "Captain to Doctor", talking begins

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 14

Interaction Vocabulary

- Level of interactivity = Granularity/variety of input/output

Descending order:

- Multimedia CD-Rom
- Desktop Application
- Browser based
- Handheld "Babyface" Device

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 15

Standard Desktop Application Interface Elements

- Menus
- Window
- Controls
- Icons
- Always a tension between standardization and innovation

AM+A Experience Intelligent Design: www.AMandA.com

 © 2001 Aaron Marcus and Associates, Inc.

Aaron Marcus and Associates, Inc. 16

A Menu of Menus

- Types
  - Pull down
  - Pop up
  - Hierarchical
- Attributes
  - Tear-off
  - Auto Scrolling
- Elements
  - Icons
  - Accelerator Keys
  - Toggle Items
  - Exclusive-select Items
  - Dividers

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 17

Windows

- SDI vs. MDI (Multiple Document Interface)
- Multi-tasking vs. Full Immersion

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 18

Dialog Boxes

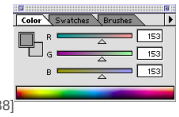
- Modeless
- Movable Modal
- Modal
- System Modal
- Alert

AM+A Experience Intelligent Design: www.AMandA.com

 © 2001 Aaron Marcus and Associates, Inc.

Controls

- *Affordance* – the perceived properties of the thing that determine usage
  - E.g. hammer, beveled button, metal bar on door 'means' pull, cursor hinting
  - Invisible features have the least affordance. E.g. modifier key sequences
- *Constraint* – limits to possible use
  - E.g. slider



[Norman, Psychology of Everyday Things, 1988]

Controls 2/2

Buttons
Radio buttons
Check boxes
Disclosure triangles
Text boxes
Spinner boxes
Tab controls
Sliders
Custom Widgets (Kai's Power Tools)

What Is "Web Design"?

- User Interface Design
- Content Design
- Information Design
- Information Architecture
- Graphic Design
- User Experience

 © 2001 Aaron Marcus and Associates, Inc.

Tutorial:
UI Design for Work, Home and on the Way

Lecture:
Interactivity in Web Applications

Aaron Marcus and Associates, Inc. 22

What Is “Web Design”?

- Different than software
- Different than print design
- Different than CD-Rom
- Different than publishing
- Different than broadcasting
- Web Design is its own discipline

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 23

Metaphors on the Web

- **Place**: Visitors, Site, Chat Rooms, Home
- **Publishing**: Readers, Magazines, Books, Subscriptions, Chapters, Storytelling, Online Documents
- **Broadcasting**: Viewers, TV, Radio, Channels
- **Software**: Users, Applications, Toolbar, Control Panel, Saved Data and Preferences
  (awkward)

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 24

Mental Models on the Web

- Home Page and global navigation bar can form the main mental model
  - E.g. Tabs

- Mental model vs. Sense model
- Sense model ➡ persuasion, manipulation
- App vs. Site

AM+A Experience Intelligent Design: www.AMandA.com

© 2001 Aaron Marcus and Associates, Inc.

Aaron Marcus and Associates, Inc. 25

Mental Model Vs. Sense Model

"In software applications, users form mental models of the product--how it works and where the functionality is located.

"Users of web sites...navigate forward, 'in the moment'. We didn't see any evidence that users ever attempted to understand the layout of the site. Users apparently don't think about site structure at all" -- Jared Spool

Users retrace known steps

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 26

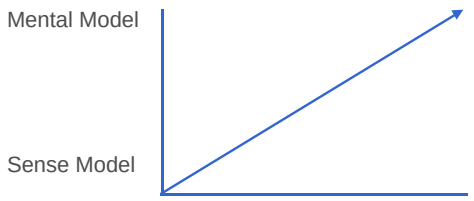
Mental Model vs. Sense Model

- Tools are finite/Sites are indefinite
- Mental model means understanding structure, logic, patterns
  - Mental model takes time to form, gain power through mastery
  - We spend time learning tools, but not books, galleries
- Mental models are rational/Sense models involve qualitative values
  - Attractiveness, persuasion, manipulation
  - Links at top get more clicks; Links with icons get more clicks
  - Features need to first sell themselves

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 27

Mental Model Vs. Sense Model



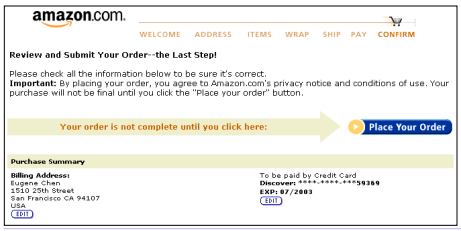
AM+A Experience Intelligent Design: www.AMandA.com

 © 2001 Aaron Marcus and Associates, Inc.

Aaron Marcus and Associates, Inc. 28

Formation of mental model?

- Lack of standard structures, consistent behavior
- Apparently we can't "read" the affordance of web pages



AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 29

Mental Model vs. Sense Model

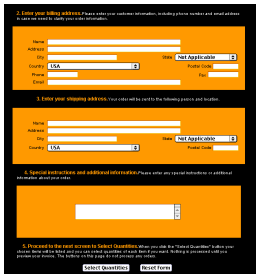
- This doesn't mean you shouldn't have internal logic--just don't count on users to comprehend it
- Navigation standards are emerging (About Us, Jobs, Site Map, Footer links)

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 30

Mental Model: Wizards

- Wizards and step by step instructions avoid a mental model



AM+A Experience Intelligent Design: www.AMandA.com

 © 2001 Aaron Marcus and Associates, Inc.

Explain this Structure

Interaction on the Web

- Most interactivity is through <FORM> input widgets
  - Button, Pop-Up Menu, List Box, Input Box, Password Field, Text Area, Checkbox, Labeled Checkbox
- All widgets are about some selection/indication of intent
- The hyperlink (selector) is a generalized widget
  - Difficult to predict effects other new page load

Interaction: Scrolling

- Lack of layout control increases need for scrolling
- Popular Wisdom: Users don't like to scroll
- User Testing: Users do scroll if led to believe information lies below ("scroll affordance")
- Keep important content "above the fold"
- Lots of short pages vs. fewer long pages?
  - Lots of pages require more clicks/decisions
  - Shorter, navigation oriented pages at the top (3 clicks)
  - Longer, content rich pages/sections at the bottom

 © 2001 Aaron Marcus and Associates, Inc.

UI Design vs. Web Design 1/2

- **User Interface is larger:** it covers more platforms
  - Web + Desktop, CD-Rom, PDA, Games etc.
  - User Interface centers around the design of interaction
  - User based
- **Web Design is larger:** integrates more design disciplines:
  - User Experience = Business Design + Branding + Content + User Interface. Also production-oriented.
  - Web Design centers around the design of information
  - Web Design serves publisher and reader: dialectic of two needs

UI Design vs. Web Design 2/2

- Information design is newer and more complex, involving rhetoric
- Communication: a two-sided goal
- Designing for Power (clear goals, clear design) vs. Pleasure (more ambiguous goal)
- Testing for Performance vs. Preference
- Distinctions will blur

Web Applications

- Web Applications “Webplications”
- Require skills/knowledge of Web Designer + User Interface Designer

 © 2001 Aaron Marcus and Associates, Inc.

Tutorial:
UI Design for Work, Home and on the Way

Lecture:
Interactivity in Web Applications

Aaron Marcus and Associates, Inc. 37

Topics

Thick Client to Thin Client

Browser as UI Platform

Tools vs. Pages

Choice of Active Technologies

Requirements for a Usable Interface

Likely Changes

Deployment Strategies

Case Study

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 38

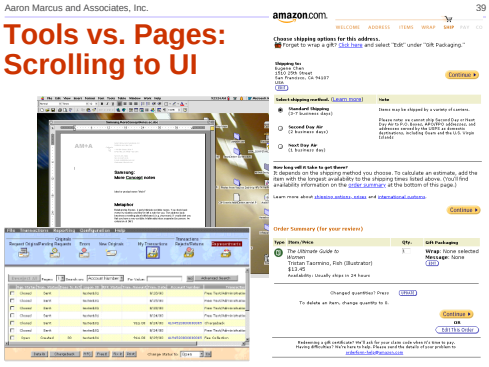
Tools vs. Pages, 1/2

Tools	Pages/Forms
Dynamic/Interactive	Static
Mental model	Sense model
One primary area	Series of areas
Finite set of controls	Hypertext → anything can be UI control
Stable main menu	Changeable nav bar
Scrolling content only	Scrolling to UI
Info inside UI	UI inside info

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 39

Tools vs. Pages: Scrolling to UI



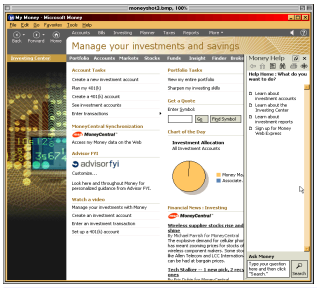
AM+A Experience Intelligent Design: www.AMandA.com

 © 2001 Aaron Marcus and Associates, Inc.

Tools vs. Pages, 2/2

Tools	Pages/Forms
Use full window	Use negative space
All of the area "pliant"	Non-click background
Appearance directed to function	Branding, "experience"
Appearance determined by system	Varied typography, imagery, color
Coordination between windows	Little window control

Page Approach on Desktop



Fast moving world of conventions

- Adoption of technology: Frames, dHTML, Flash
- Acceptance of idioms: Portals, shopping cart, personalization
- Anticipate "Tool" and "Page" approaches blending
- These conventions build expectations

 © 2001 Aaron Marcus and Associates, Inc.

Aaron Marcus and Associates, Inc. 43

Building/Porting Applications to the Web

- Choose appropriate active technologies
- Support requirements for a usable interface
- Anticipate likely interface changes
- Consider deployment strategies

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 44

Topics

Thick Client to Thin Client
Browser as UI Platform
Tools vs. Pages
Choice of Active Technologies
Requirements for a Usable Interface
Likely Changes
Deployment Strategies
Case Study

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 45

Choice of Active Technologies 1/1

Thin Client:

- Straight HTML
- Dynamic HTML
  - dHTML = JavaScript + Document Object Model + Cascading Style Sheets
  - Good technology, but difficult to develop cross-browser
- JavaScript

AM+A Experience Intelligent Design: www.AMandA.com

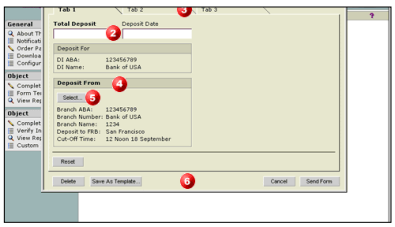
 © 2001 Aaron Marcus and Associates, Inc.

Choice of Active Technologies 2/2

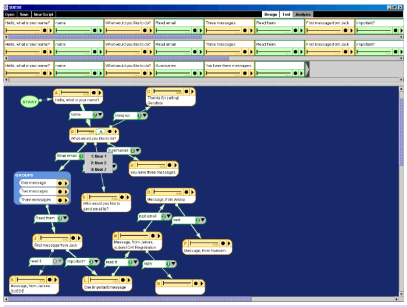
Thicker Client:

- Java
  - Start up time performance hit
- ActiveX
- Flash
  - Loading time can be made interesting
- Data Driven Graphics
  - Allow you to "draw" complex screen objects
  - Macromedia Generator
- Seagate Crystal Reports

Layered Functionality: HTML + Java Applet

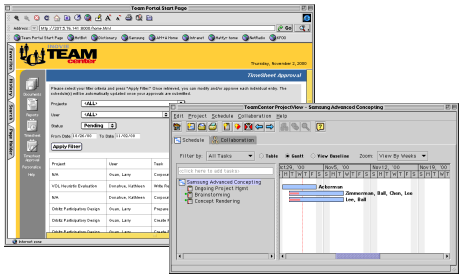


Java Standalone

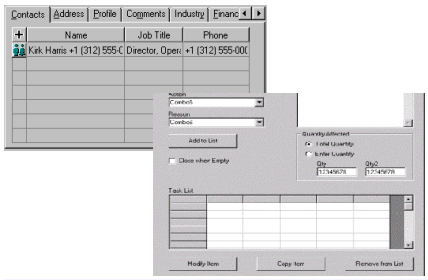


 © 2001 Aaron Marcus and Associates, Inc.

Layered Funcationality: HTML and Java Standalone



Active X Control



Flash

 © 2001 Aaron Marcus and Associates, Inc.

Tutorial:
UI Design for Work, Home and on the Way

Lecture:
Interactivity in Web Applications

Topics

Thick Client to Think Client

Browser as UI Platform

Tools vs. Pages

Choice of Active Technologies

Requirements for a Usable Interface

Likely Changes

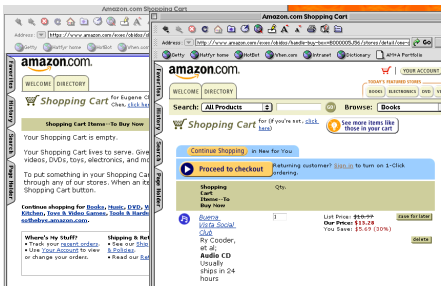
Deployment Strategies

Case Study

Support Requirements for a Usable Interface

- Appropriately enable buttons according to state
  - Field-level validation on client side
  - Don't enable Submit button
- Support dependent fields
  - Selection in one widget affects another
  - May require background trips to server
- Look for modal dialog support
  - Dialogs become sequence of pages

Modality Problem Example



 © 2001 Aaron Marcus and Associates, Inc.

Aaron Marcus and Associates, Inc. 55

Requirements for a Usable Interface (continued)

- Consider productivity support
  - TABINDEX
  - Accelerator Keys
  - Typeahead fields
- Remember printing
  - Frames don't print WYSIWYG
  - Special formatting is out
- Review needs for push technologies
  - Real-time monitoring
  - Manual refresh w/ last update timestamp

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 56

Topics

Thick Client to Thin Client

Browser as UI Platform

Tools vs. Pages

Choice of Active Technologies

Requirements for a Usable Interface

Likely Changes

Deployment Strategies

Case Study

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 57

Anticipate Likely Changes (1/5)

- HTML has a limited set of controls
  - Missing: combo boxes, sliders, hierarchical menus
- HTML supports a limited number of events
  - Missing: double-click, right-click
- HTML does not provide a main menu
  - The browser owns it
  - Where will yours go?

AM+A Experience Intelligent Design: www.AMandA.com

 © 2001 Aaron Marcus and Associates, Inc.

Likely Changes (2/5)

- Non standard scrollbars
  - Outlook bars
  - Scrollbar widgets
- Loss of screen space
  - 100 vertical pixels go to browser toolbar

Likely Changes (3/5)

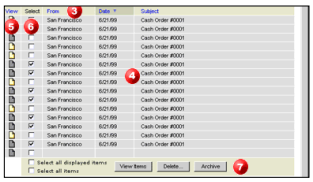
- HTML weakly supports split views
  - Positions aren't remembered
  - Splitting is not optional
- HTML has no direct support for a tree view
  - Easily done with JavaScript and dHTML layers
- Plan for a dynamic layout
  - UI personalizes depending on login
- Allocate space for branding

Likely Changes (4/5)

- HTML Tables do not support input
  - Matrix of input cells
  - No spreadsheet features
- Redesign special windows (e.g. tool palettes)
- Consider tab design alternatives
  - dHTML can reduce refresh
- Multiple-selection is difficult

 © 2001 Aaron Marcus and Associates, Inc.

Multiple Selection Example



Likely Changes (5/5)

- A browsers navigation capabilities wreak havoc with usability
  - Back, forward, bookmarks, history, URL field
  - Capture the page leaving event
- Consider Refresh frequency
  - Cached pages can show old data
- Remember Web specific interaction Issues
  - E.g. Announcing new features
- Drag and Drop features require redesign

Topics

Thick Client to Thin Client

Browser as UI Platform

Tools vs. Pages

Choice of Active Technologies

Requirements for a Usable Interface

Likely Changes

Deployment Strategies

Case Study

 © 2001 Aaron Marcus and Associates, Inc.

Aaron Marcus and Associates, Inc. 64

Consider Deployment Strategies

- Target different platforms in layers
  - Public and captive, private, intranet audience
- Target different functionality in layers
  - E.g. MS Project and Project Central
- Deploy dHTML for MSIE initially
- Web- or IP-enabled program with intelligent installation
  - Save to Web, Save to Desktop
  - Connect HTML and Standalone components

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 65

Topics

Thick Client to Think Client

Browser as UI Platform

Tools vs. Pages

Choice of Active Technologies

Requirements for a Usable Interface

Likely Changes

Deployment Strategies

Case Study

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 66

Case Study: a Manufacturing Shop Floor

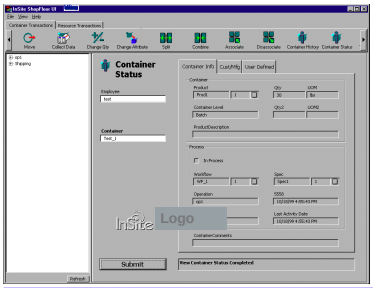
- Objective 1: Convert client-server LAN GUI to Web-based client version to avoid hard-to-maintain NT workstations on the shop floor
- Objective 2: Allow outside manufacturers to track progress of activities on the shop floor
- Components: Queries, resource transactions, container transactions

AM+A Experience Intelligent Design: www.AMandA.com

 © 2001 Aaron Marcus and Associates, Inc.

Aaron Marcus and Associates, Inc. 67

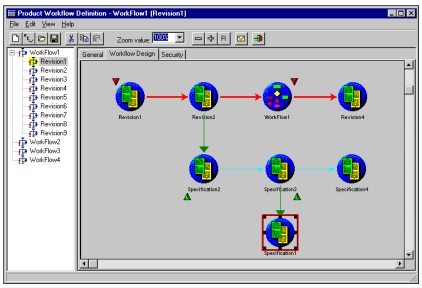
Shop Floor Screen 1: Thick UI for LAN



AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 68

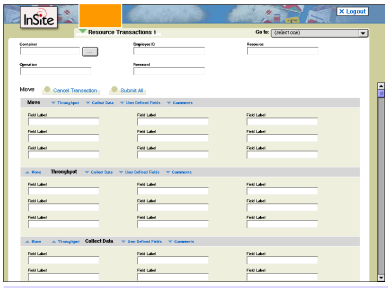
Shop Floor Screen 2: Thick UI for LAN



AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 69

Shop Floor Screen 4: Thin UI for Web

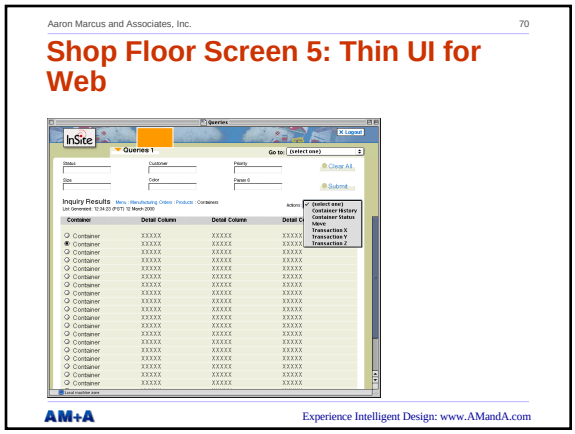


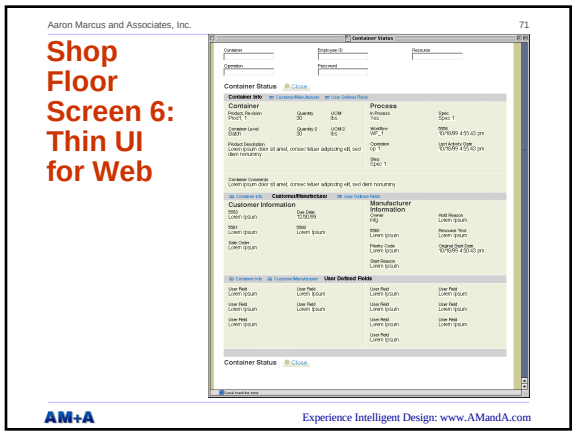
AM+A Experience Intelligent Design: www.AMandA.com

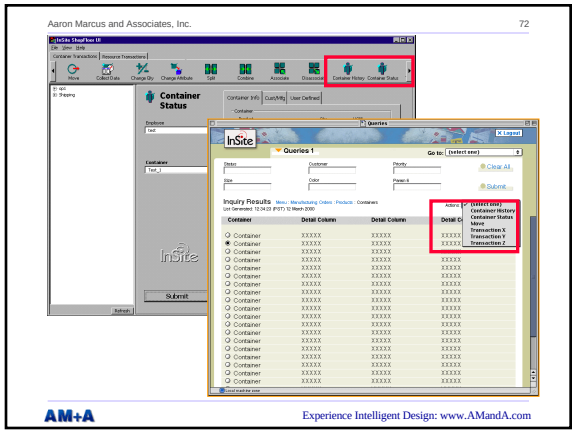
 © 2001 Aaron Marcus and Associates, Inc.

Tutorial:
UI Design for Work, Home and on the Way

Lecture:
Interactivity in Web Applications



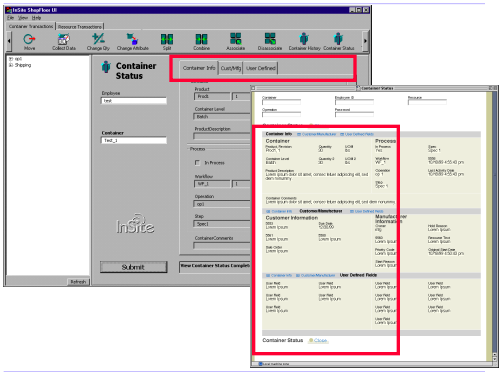




 © 2001 Aaron Marcus and Associates, Inc.

Tutorial:
UI Design for Work, Home and on the Way

Lecture:
Interactivity in Web Applications



Web Application Issues: Summary

- The Webplication is an offspring of both the tool and the page
- HTML interaction is a step backward
- Use active technologies to increase productivity and usability

Questions and Discussion

Aaron Marcus, President
Eugene Chen, Director of Design and Analysis
and AM+A California

Aaron Marcus and Associates, Inc.
California and New York, USA
California Tel: 510-601-0994, Ext. 23
California Fax: 510-547-6125
Email: [FirstName]@AMandA.com
Web: www.AMandA.com

 © 2001 Aaron Marcus and Associates, Inc.

Advanced Developments in User-Interface Design for Web and Mobile Computing

Aaron Marcus and Associates, Inc.
California and New York, USA
Web: www.AMandA.com

Part 1: Baby Faces: Extreme Design for Mobile Computing

Aaron Marcus and Associates, Inc.
California and New York, USA
Web: www.AMandA.com

Types of Baby Faces: Good Things in Small Packages

- Telephones, videophones, pagers
- Organizers, palm PCs, PDAs, memo devices
- Navigators : vehicles or person (compasses)
- Watches, weather instruments (time, weather)
- Cameras, rulers, other leisure/work devices
- Appliances: kitchen, den, office, vehicle
- Games, toys
- PCs that are personal!

 © 2001 Aaron Marcus and Associates, Inc.

Aaron Marcus and Associates, Inc. 4

Why Baby Face Design? Part 1: Extreme Variety of Users!

- Global distribution of technology
- Global cultural differences in use of technology!
- Novice vs. expert in subject matter vs. technology!
- Extreme variety of use context in work, leisure
- Extremely small area in which to display content!

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 5

Why Baby Face Design? Part 2: Extreme Wants/Desires of Users!

- Portable devices for the pocket
- Low cost for consumers
- Expectation of new features: Web access, messaging, email, fax, video, radio
- Merging concepts of phone, organizer, pc, Internet device
- Emergence of fashion: Jewelry, accessory

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 6

What's Extreme about Baby Faces?

- Users: 37 languages and growing
- Tasks: Work, leisure, mobile
- Physical environment: Static, mobile
- Technology environment: GPS, SMS, WAP
- No cross-device, cross-application, cross-content global UI standards, including information-visualization!
- Need for cross-delivery platform agents

AM+A Experience Intelligent Design: www.AMandA.com

 © 2001 Aaron Marcus and Associates, Inc.

Aaron Marcus and Associates, Inc. 7

What are Baby Face UI Components?

- **Metaphors**: Concepts via words, images, sounds, tactile experience
- **Mental models:** Organization of data, functions, tasks, roles, people
- **Navigation:** Movement through content and tools, dialogue
- **Interaction:** Input/output techniques, feedback
- **Appearance:** Visual, auditory, tactile

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 8

Extreme Challenges of Baby Face. UI Design, 1/4

- Ubiquitous, portable products with small displays (1/6 -1/8 normal area or smaller): 100 x 100 to 320 x 240 pixels
- Special interaction with physical input devices: Buttons, pens, fingers, voice
- Possibly limited color
- Possibly limited spatial resolution
- Possibly limited use of sound input/output, vibration output

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 9

Extreme Challenges of Baby Face. UI Design, 2/4

- Visual Design
  - Legible, readable displays with minimum documentation/help
  - Systematic use of visible language
  - Accounting for cognitive, cultural preferences
- Content: accurate, timely, complete, useful
  - Navigation in physical space
  - Navigation in abstract spaces: content, tools
  - Points of interest: quick access to memorable locations
- Low Cost: under $500 for mass market
  - Goal: $19.99 or free

AM+A Experience Intelligent Design: www.AMandA.com

 © 2001 Aaron Marcus and Associates, Inc.

Aaron Marcus and Associates, Inc. 10

Extreme Challenges of Baby Face. UI Design, 3/4

- **Metaphors:** New, different, maps, dashboards, not computers
- **Mental model:** Needs to be simplified
- **Interaction:** Innovation needed for selection keyboard and keypad; expert/novice; text entry
- **Appearance:** Simple grid, limited fonts, limited colors; multimodal with voice
- **Users:** Account for novice/expert, cultures
- **Easy:** learning, use, performance, productivity

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 11

Extreme Challenges of Baby Face . UI Design, 4/4

- Opportunities to differentiate products, brands
- Flexible interaction, searching, results reviews
- Reduce need for detailed info

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 12

How are Current Products Doing? Part 1/3

- Displays are sometimes too verbose
- Graphic images not simple enough for rapid comprehension
- Organization of contents not suitable for mobile user
- Colors, fonts, symbols, layout not suitable
- Limited legibility and readability limitations
- Interaction paradigms not optimum for detailed target selection

AM+A Experience Intelligent Design: www.AMandA.com

 © 2001 Aaron Marcus and Associates, Inc.

Aaron Marcus and Associates, Inc. 13

How are Current Products Doing? Part 2/3

- Low Contrast -> limited use of graphics, icons, color, and grayscales (e.g. no 3D effects)
- Large characters and symbols for reading, but...
  - Small characters to fit a whole menu item

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 14

How are Current Products Doing? Part 3/3: Dialogue Design Problems

- No standard UI components
- Small screen and many functions increases navigation
  - No visual stability, 4 lines of text can be overwhelming
  - Recall rather than Recognition
  - Good terminology is 80% of the challenge
- On-line Help
  - Often limited by memory and screen size
- Text input via phone keypad

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 15

How are Current Products Doing? Part 4/4: Nokia Guidelines

- Nokia: Consistent menu navigation via soft keys and hard keys

  Left soft key for forwarding, selecting, and confirming
  Right soft key for stepping back, exiting and clearing
  Scroll keys for moving to other menu items and options

- Capability/flexibility for adding new features
- Guide novice users: often limited

AM+A Experience Intelligent Design: www.AMandA.com

 © 2001 Aaron Marcus and Associates, Inc.

Aaron Marcus and Associates, Inc. 16

Tour of Products

- Navigation Products
- Phone, Pager,Organizer Products
- Wristwatch-Sized Products

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 17

Navigation Products

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 18

Example Project: Motorola

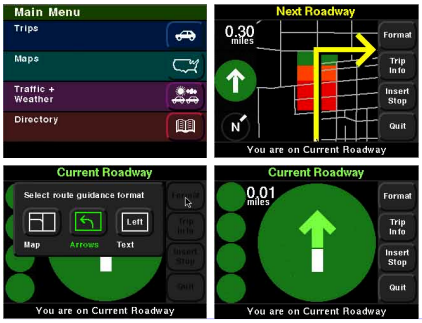
- In-vehicle GPS navigation solution
- Government/private 4-year project
- Extensive prototyping, evaluation
- Touch-screen, voice output
- Display variations per cognitive preferences

AM+A Experience Intelligent Design: www.AMandA.com

 © 2001 Aaron Marcus and Associates, Inc.

Aaron Marcus and Associates, Inc. 19

Motorola Sample Scenes, 1/2



AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 20

Motorola Sample Scenes, 2/2

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 21

Garmin StreetPilot GPS

AM+A Experience Intelligent Design: www.AMandA.com

 © 2001 Aaron Marcus and Associates, Inc.

Aaron Marcus and Associates, Inc. 22

Hertz NeverLost

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 23

Sharp Auto Diagnosis: Internal Vehicle Navigation

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 24

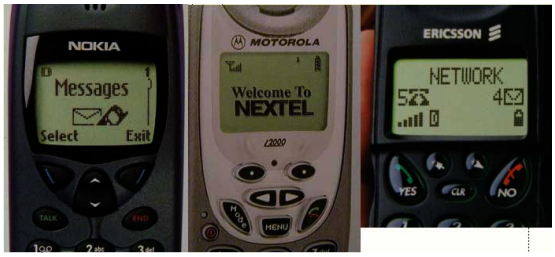
Phone, Pager, Organizer Products

AM+A Experience Intelligent Design: www.AMandA.com

 © 2001 Aaron Marcus and Associates, Inc.

Aaron Marcus and Associates, Inc. 25

Inconsistent Screen, Button Standards



AM+A Experience Intelligent Design: www.AMandA.com

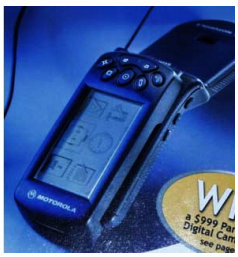
Aaron Marcus and Associates, Inc. 26

Kyocera Videophone: Kyocera.co.jp

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 27

Motorola Web Phone/Organizer



AM+A Experience Intelligent Design: www.AMandA.com

 © 2001 Aaron Marcus and Associates, Inc.

Aaron Marcus and Associates, Inc. 28

Motorola Pager with Keyboard

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 29

Nokia Co-Branding of Phone "Skins"

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 30

Hammacher Schlemmer Pen Recorder

AM+A Experience Intelligent Design: www.AMandA.com

 © 2001 Aaron Marcus and Associates, Inc.

Aaron Marcus and Associates, Inc. 31

NeoPoint Web Phone

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 32

Sanyo Web-Ready? Phone

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 33

Ideo Prototype

AM+A Experience Intelligent Design: www.AMandA.com

 © 2001 Aaron Marcus and Associates, Inc.

Aaron Marcus and Associates, Inc. 34

Ericsson R380 and Prototype

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 35

Palm-Sized PDAs: Varieties of UIs, 1/2

3Com Palm Pilot

Casio Cassiopeia

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 36

Palm-Sized PDAs: Varieties of UIs, 2/2

Compaq Aero

Oregon Scientific

AM+A Experience Intelligent Design: www.AMandA.com

 © 2001 Aaron Marcus and Associates, Inc.

Aaron Marcus and Associates, Inc. 37

Wristwatch-Sized Products

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 38

OnHand.com: World's Smallest PC/PDA

- www.onHandpc.com
- IBM announces Linux in a wristwatch device: http://www.wired.com/news/technology/0,1282,38050,00.html

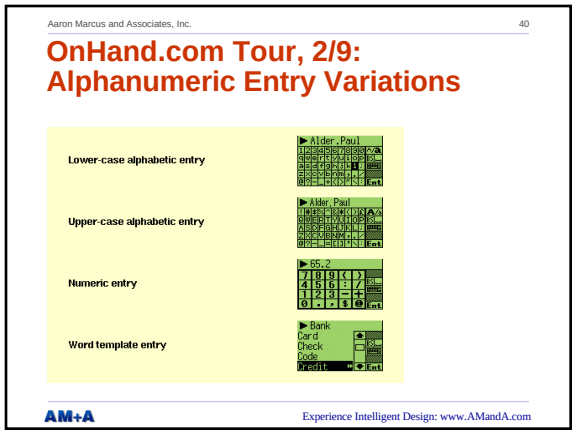
AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 39

OnHand.com Tour, 1/9: Data Entry Keyboard

AM+A Experience Intelligent Design: www.AMandA.com

 © 2001 Aaron Marcus and Associates, Inc.



 © 2001 Aaron Marcus and Associates, Inc.

 © 2001 Aaron Marcus and Associates, Inc.

OnHand.com Tour, 8/9: Filer View/Preferences

OnHand.com Tour, 9/9: File Attributes

Samsung AnyCall WristPhone

 © 2001 Aaron Marcus and Associates, Inc.

Aaron Marcus and Associates, Inc. 49

Other Wrist Devices

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 50

AM+A Prototype Wrist All-In-One

- Powerful PC
- Email, voicemail, message management
- Web access
- Videophone
- Used with minimal headset
- Fashion/jewelry ready
- Meets challenge of miniatures, info viz

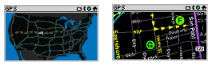
AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 51

AM+A Wrist-All-In-One Tour, 1/5: Examples of Essential Functions

Message Management

GPS Navigation



Email Enlarged

Videophone

AM+A Experience Intelligent Design: www.AMandA.com

 © 2001 Aaron Marcus and Associates, Inc.

Aaron Marcus and Associates, Inc. 52

AM+A Wrist-All-In-One Tour, 2/5: View of Email Messages

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 53

AM+A Wrist-All-In-One Tour, 3/5: View of GPS Navigation

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 54

AM+A Wrist-All-In-One Tour, 4/5: Videophone Number Selection

AM+A Experience Intelligent Design: www.AMandA.com

 © 2001 Aaron Marcus and Associates, Inc.

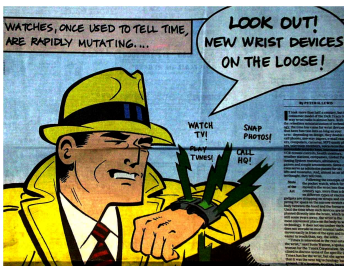
Aaron Marcus and Associates, Inc. 55

AM+A Wrist-All-In-One Tour, 5/5: Videophone Operation

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 56

Achieving Dick Tracy's 50-Year Dream: Requires UI + Info-Viz Extreme Design



AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 57

Future Issues, 1/2

- Managing engineering and marketing requirements
- Developing special tools to facilitate rapid prototyping
- Better planning for business case and usability evaluation
- Better design strategies to keep UI designers in the loop of hardware-oriented product development

AM+A Experience Intelligent Design: www.AMandA.com

 © 2001 Aaron Marcus and Associates, Inc.

Aaron Marcus and Associates, Inc. 58

Future Issues, 2/2

- Tactics to globalize/localize products
- Solving miniature information-display and interaction
- Sources of research, innovation
- Relation of visual to voice input/out
- Need for BabyFace Mark-up Language
- Accounting for differently abled people

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 59

Conclusions for Extreme Design of Baby Faces for Mobile Computing

- Compromises may be necessary for business, engineering, marketing requirements, but...
- Keep design quality high via effective planning, innovative approaches to metaphors, mental models, navigation, interaction, and appearance that lead to break-throughs in usability and acceptance via user experience

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 60

URL References

- www.onhandpc.com, Guinness Book of Records: “world's smallest computer/PDA”
- www.tol.oulu.fi/projects/hci/babyfaces/: BabyFaces Website
- /www.samsungelectronics.com/products/mobilephone/mobilephone.html: Samsung AnyCall
- www.dsi-inc.net/: Intelligent Vehicle Info
- www.nhtsa.dot.gov/people/injury/research/wireless/index.html: Cellphone Injury Report

AM+A Experience Intelligent Design: www.AMandA.com

 © 2001 Aaron Marcus and Associates, Inc.

Bibliographic References, 1/4

- Abrams, M., C. Phanouriou, A.L.Batlongbacal, S. Williams, and J.E.Schuster. (1999) UIML: an appliance independent XML user interface language. Proceedings of the WWW8 Conference, Toronto, Canada. May 11-14. p. 617-30.
- D.Clark Preparing for a new generation of wireless data. IEEE Computer 32(8): 8-11.
- A. Dillon, J.Richardson, and C.McKnight. 1990. The effect of display size and text splitting on reading lengthy text from the screen. Behavior and Information Technology, 9(3) 215-227.

Bibliographic References, 2/4

- R.L.Duchnicky and J.Kwahk. Readability of text scrolled on visual display terminals as a function of window size. *Human Factors* 25. 683-92.
- S.H.Han and J.Kwahk. 1994. Design of a menu for small displays presenting a single item at a time. *Proc. Human factors and Ergonomics Society 38th Annual Meeting*. 360-364.
- Jones, M., G. Marsden, N. Mohd-Nasir, K.Boone, and G. Buchanan. 1999. Improving Web interaction on small displays. Proceedings of the WWW8 Conference, Toronto, Canada. May 11-14. 51-59.
- T.Kamba, S.Elson, T.harpold, T.Stamper, and N.Piyawadee. 1996. Using small screen space more efficiently. *Proc. CHI'96*. 383-390.

Bibliographic References, 3/4

- Marcus, Aaron, "Designing the User Interface for a Vehicle Navigation System: A Case Study," in Bergman, Eric, editor, *Information Appliances and Beyond: Interaction Design for Consumer Products*, Morgan Kaufmann, San Francisco, in press, approx. p. 210-260.
- Marcus, Aaron, *Graphic Design for Electronic Documents and User Interfaces*, Addison-Wesley, Reading MA, 1992 (available in Japanese).
- Marcus, Aaron, "Chapter 19: Graphical User Interfaces," in Helander, M., Landauer, T.K., and P. Prabhu, P., Eds., *Handbook of Human-Computer Interaction*, Elsevier Science, B.V., The Hague, Netherlands, 1997, ISBN 0-444-4828-626, pp. 423-440.

 © 2001 Aaron Marcus and Associates, Inc.

Bibliographic References, 4/4

- J.F.Resiel and B. Shneiderman. 1987. Is bigger better? The effects of display size on program reading. In G.Salvendy (Ed.) *Social, Ergonomic and Stress Aspects of Work with Computers.* Elsevier, Amsterdam. 113-122.
- S.J.Swierenga. 1990. Menuing and scrolling as alternative information access techniques for computer systems; interfacing with the user. *Proc. Human Factors Society 34th Annual Meeting.* 356-359.
- Watters and Shepherd. Adaptive Medical Portals. *ACM SIGIR Customized Information Delivery Workshop Proceedings.* San Franscisco. August 19, 1999.
- C. Watters and D. Comeau. 1999. Adaptive Portals with Wireless Components. Conference Proceedings.

Baby Faces: Extreme Design for Mobile Computing

Aaron Marcus, President
Aaron Marcus and Associates, Inc.
California and New York, USA
CA Tel: 510-601-0994, CA Fax: 510-547-6125
Email: Aaron@AMandA.com, Web: www.AMandA.com

 © 2001 Aaron Marcus and Associates, Inc.

Aaron Marcus and Associates, Inc. 1

Baby Faces: Tour of Recent Products

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 2

Types of Baby Faces: Good Things in Small Packages

- Telephones, videophones, pagers
- Organizers, palm PCs, PDAs, memo devices
- Navigators : vehicles or person (compasses)
- Watches, weather instruments (time, weather)
- Cameras, rulers, other leisure/work devices
- Appliances: kitchen, den, office, vehicle
- Games, toys
- PCs that are personal!

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 3

Telephones

AM+A Experience Intelligent Design: www.AMandA.com

 © 2001 Aaron Marcus and Associates, Inc.

Aaron Marcus and Associates, Inc. 4

Japanese Miniature Phone Websites

Japan Is Bringing Miniaturization to the Internet

Host of Minisites May Be Accessible By Cellular Phones

By Robert A. Guth
Staff Reporter of The Wall Street Journal

TOKYO—Japan is applying its miniaturization expertise to Web sites, and it could change the way people view the Internet.

Furious growth of Japan's cell-phone market is spurring a universe of Web sites that can be displayed on phones with tiny screens. At the center of the action are services like NTT DoCoMo's i-mode, which connects a handset to the Internet, and have enticed Japanese content provid-

its U.S. wireless phone subscribers access to Yahoo, Amazon.com and CNN.com over their cell phones.

The Japanese services solve some of the stickiest problems preventing broader use of the Internet. "They're making the Internet accessible to people who don't have an interest in PCs, or the budget or space in their homes," says Tim Clark, Tokyo-based president of consultancy TKAI Inc. Plus, using Japan's cell-phone Web sites, he says, is "bonehead simple."

All that adds up to big business for service providers and the Web sites. Among the sites offered through NTT DoCoMo's i-mode:

• Bandai Co., the toy maker of Tamagotchi digital-pet fame, ships a different animated character every day to subscribers' i-mode phones. Silly? Maybe, but this service and others that Bandai offers over i-mode boast 1,148,000 subscribers, each paying about $1 a month.

Japanese cell-phone users are decorating their LCD screens with animated Bandai characters, which can be downloaded from the Internet daily for a subscription fee of $1 a month.

Wall Street Journal, 29 March 2000, A17

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 5

cdma1 Phones

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 6

DoCoMo + HP

3 Phones in comparison to a wrist watch

AM+A Experience Intelligent Design: www.AMandA.com

 © 2001 Aaron Marcus and Associates, Inc.

Aaron Marcus and Associates, Inc. 7

Phone with GPS and Compass Strap

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 8

Woman's Phone with Make-Up Kit

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 9

Mobile Phone and Strap Decorating Kits

AM+A Experience Intelligent Design: www.AMandA.com

 © 2001 Aaron Marcus and Associates, Inc.

Aaron Marcus and Associates, Inc. 10

Mobile Phone Straps and Flashers

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 11

Variety of Mobile Phone Display Areas

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 12

ISDN in Public Phones

AM+A Experience Intelligent Design: www.AMandA.com

 © 2001 Aaron Marcus and Associates, Inc.

Aaron Marcus and Associates, Inc. 13

Vehicle Navigation

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 14

AddZest Auto Radio

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 15

Casio Navigator, 1

AM+A Experience Intelligent Design: www.AMandA.com

 © 2001 Aaron Marcus and Associates, Inc.

Aaron Marcus and Associates, Inc. 16

Casio Navigator, 2

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 17

Casio Navigator, 3

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 18

Casio Navigator, 4

AM+A Experience Intelligent Design: www.AMandA.com

 © 2001 Aaron Marcus and Associates, Inc.

Aaron Marcus and Associates, Inc. 19

Eclipse Navigator E8809 DVZ

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 20

Fujitsu-Ten Navigator

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 21

Information Appliances, Wrist-Tops, and Finger-Tops

AM+A Experience Intelligent Design: www.AMandA.com

 © 2001 Aaron Marcus and Associates, Inc.

Aaron Marcus and Associates, Inc. 22

Blood Pressure Device

AM+A Experience Intelligent Design: www.AMandA.com

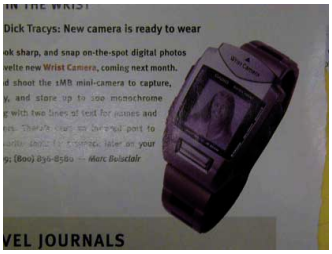
Aaron Marcus and Associates, Inc. 23

Casio ProTrek GPS Watch

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 24

Casio Camera Watch



AM+A Experience Intelligent Design: www.AMandA.com

 © 2001 Aaron Marcus and Associates, Inc.

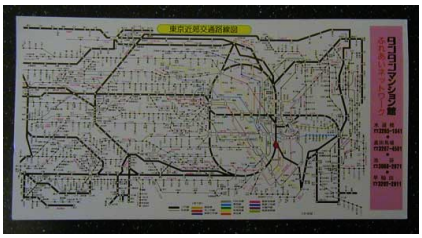
Aaron Marcus and Associates, Inc. 25

Mickey Mouse Finger Watch

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 26

Extreme Challenge: Subway Diagram



AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 27

Summary

- Many competing products
- Great variety of design philosophies and styles
- Lack of cross-technology standards
- Miniaturization suitable for Japanese culture
- Issue: Suitability for Europe, USA?

AM+A Experience Intelligent Design: www.AMandA.com

 © 2001 Aaron Marcus and Associates, Inc.

Baby Faces: Tour of Recent Products

Aaron Marcus, President
Aaron Marcus and Associates, Inc.
California and New York, USA
CA Tel: 510-601-0994, CA Fax: 510-547-6125
Email: Aaron@AMandA.com,Web: www.AMandA.com

 © 2001 Aaron Marcus and Associates, Inc.

Metaphor Design: Philosophy, Principles, and Guidelines

AM+A

Aaron Marcus and Associates, Inc.
Web: www.AMandA.com

California Tel: 510-601-0994
Email: Aaron@AMandA.com
Eugene@AMandA.com

New York Tel: 212-625-1813
Email: Melanie@AMandA.com

Metaphor Design: Metaphor Management

- " ...the way we think, what we experience, is very much a matter of metaphor."

  George Lakoff and Mark Johnson
  Metaphors We Live By, 1980
- Examined metaphors in English
- They assert: Spatial metaphors are basic

Dimensions of Pure and Applied Visual Semiotics

- Lexical
- Syntactic
- Semantic (product semantics)
  - Rhetoric (tropes)
  - ...
  - Metaphor
  - ...
- Pragmatic

 © 2001 Aaron Marcus and Associates, Inc.

Aaron Marcus and Associates, Inc. 4

Rhetorical Tropes

- Synonomy: Synonym repetition for emphasis
- Erotesis: Questioning the viewer
- Hyperbole: Exaggeration
- Antithesis: Strong, contrasted ideas
- Comparison: Extended, balanced, matching
- Anaphora: Successive repetition of symbols
- **Metaphor:** Substitution of one for another
- **Metonymy:** Use of an associated symbol
- **Synecdoche:** Part for a whole; vice-versa

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 5

User-Interface Metaphor Changes: Overarching and Specific, 1/2

- Character (CUI) uses typewriter:

  Highlighting, alphanumeric selection, deletion, scrolling
- Graphical (GUI) uses desktop:

  Folders, documents, scrolling in windows, drag-and-drop deletion to trash can (recall window scrollbar debate circa 1981)

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 6

User-Interface Metaphors Changes: Overarching and Specific, 2/2

- Pen-based (PUI) uses pen-and-paper:

  Drawing, handwriting, gestures of tapping, circling, crossing-out
- Virtual reality (VRUI) uses flying:

  Pointing, touching, 3D orientation

AM+A Experience Intelligent Design: www.AMandA.com

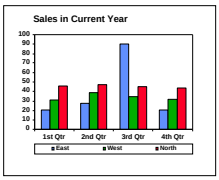
 © 2001 Aaron Marcus and Associates, Inc.

Information Visualization Metaphors: Depictions of Structure and Process

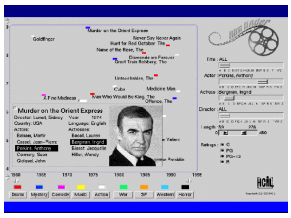
- Charts: quantities, lists, tables vs. 2D, 3D, 4D
- Maps: Globe vs. projections
- Diagrams: Abstractions vs. representations
- Example: “Temperature” thought of in terms of thermometer readings
- Example: Shift of scientific paradigms, e.g. particle and wave theories

Info-Viz Metaphor Example

Bar Chart



Star Chart, U of Maryland



Noun-Object Metaphors of Collection

- Desk: Drawers, files, folders, papers
- Books, newspapers: Articles, figures
- Photo album: Photographs
- Television set: Programs
- Disk, phonograph: Tracks, records
- Deck of cards: Cards
- Film: Rolls, slide trays, shows, reels, movie
- Tree: Branches, leaves

 © 2001 Aaron Marcus and Associates, Inc.

Aaron Marcus and Associates, Inc. 10

Verb-Object Metaphors

- Browse: Rapid replacement, scanning lines, window shopping
- Select: Touch item, peel back plastic, place finger and slide
- Delete: Trash can, garbage can, black hole, recycling, shredder
- Valuate: Rotate knob, slide pointer

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 11

Benefits of Metaphors

- Capture primary attributes, relationships
- Enable discovery of new attributes, relationships
- Assist learning, comprehension, memory, interaction, appeal

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 12

Example of Substituting to Discover: If GUIs = Movies, Then...

- Subject, genre: Western, documentary, comedy
- Place of Origin: Hollywood, India, France
- Creator: Director, star
- Use: Buy, rent
- Color: Black-and-white, color
- Culture: Star personalities, society attitudes
- Roles: Star, gaffer, ticket taker, ticket seller
- Reviewers: Functional service, critics

AM+A Experience Intelligent Design: www.AMandA.com

 © 2001 Aaron Marcus and Associates, Inc.

Example of Substituting to Discover: Desktop Metaphor Allusions

- Background (shallow) = Desktop: folders
- Background (deep) = Ocean:
  folders = fish, catching fish
- Background (deep) = Space:
  folders = planets, landing on planets
- Background (deep) = Sky:
  folders = clouds, rain, dancing for rain

Cultural Diversity of Metaphors

- Clerical staff: Desktop, kitchen counter
- Engineers, scientists: Scientific workbench
- Middle class: Pocketbook, library, VCR control
- Homeowner: Closet, kitchen counter, workbench
- Stockbroker: Trading room floor
- Shopper: Market, bazaar, mall

Culturally Diversity of Users

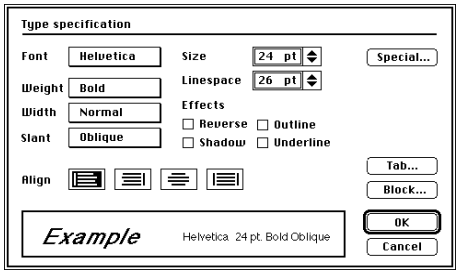
- Default standard: White, well-educated,
  20- to 40-year old, male engineer
- Geography: European, Asian, USA
- Gender: Women, men
- Consumer market-specific: African-Americans,
  consumers of international-style design
- Age: Children, teenagers, seniors
- Profession: Designers, doctors, plumbers

 © 2001 Aaron Marcus and Associates, Inc.

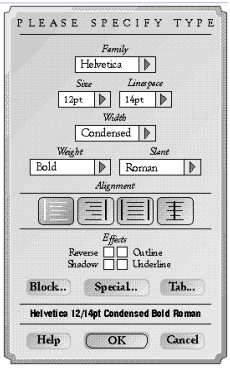
Cultural Diversity can Affect GUI Design: Examples

- Standard
- European
- Gender-specific
- Children

Standard Dialogue Box



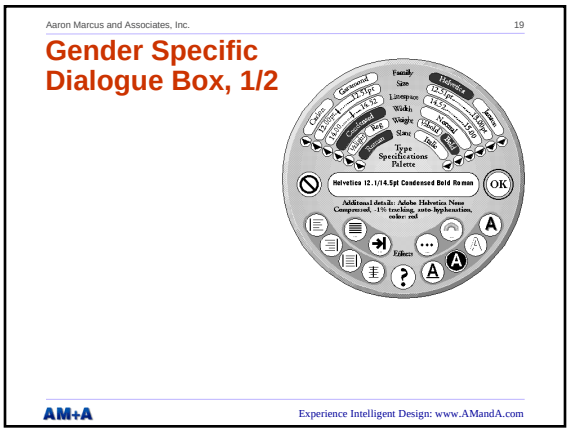
European Dialogue Box

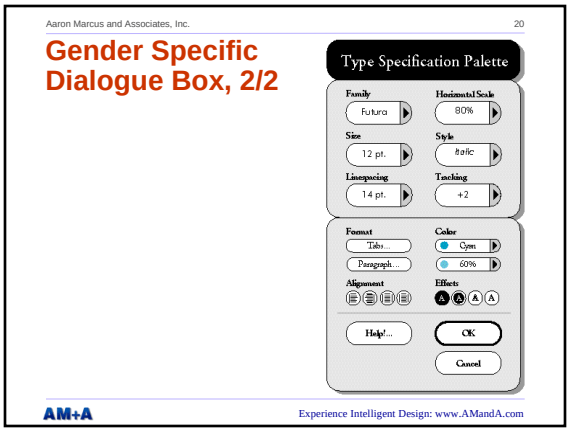


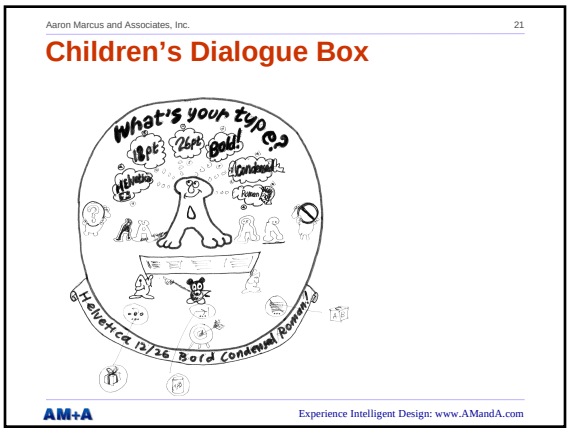
 © 2001 Aaron Marcus and Associates, Inc.

Tutorial:
UI Design for Work, Home, and On the Way

Lecture:
Metaphor Design







 © 2001 Aaron Marcus and Associates, Inc.

Aaron Marcus and Associates, Inc. 22

New Computer Metaphors

- Emerging constantly
- Faster pace with technology, social change

AM+A Experience Intelligent Design: www.AMandA.com

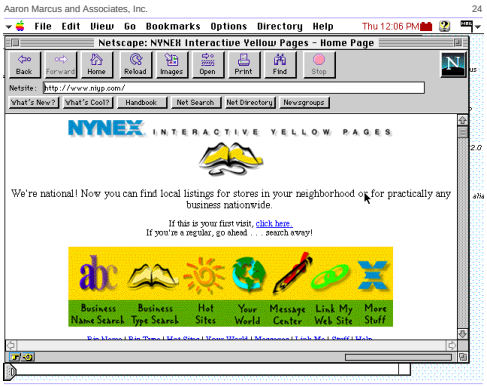
Aaron Marcus and Associates, Inc. 23

Mixed Metaphors in Early Internet/Web

- Nynex Yellow Pages: Database
- Hotwired: Publication, channels

AM+A Experience Intelligent Design: www.AMandA.com

Aaron Marcus and Associates, Inc. 24



AM+A Experience Intelligent Design: www.AMandA.com

 © 2001 Aaron Marcus and Associates, Inc.

Examples of Technologies Spawning New Metaphors

- Personal digital assistants, portable devices
- Information appliances
- Web, Internet
- Wearable computers
- Virtual reality

Metaphor Development

- Requires similar steps to complete GUI development process
- Emphasis on design creativity, but also user evaluation
- Increased importance with technology changing quickly
- Example: Planet SABRE took one year and considerable resources

 © 2001 Aaron Marcus and Associates, Inc.

Summary

- Metaphors are necessary, not optional, components of communication
- Metaphor design is complex and challenging
- Development process is a “fractal” version of the GUI development process

 © 2001 Aaron Marcus and Associates, Inc.

AM+A

Aaron Marcus and Associates, Inc.
California and New York

California

1144 65th Street, Suite F
Emeryville, CA 94608-1053 USA

Tel: 510-601-0994
Fax: 510-547-6125
E-mail: Mail@AMandA.com
Web: www.AMandA.com

Reprints

The following article reprints are included as supplementary material for the lectures of this tutorial.

This article appeared as part of the Proceedings of the6th Conference on Human Factors and the Web in Austin, Texas, 19 June2000.

Cultural Dimensions and Global Web User-Interface Design: What? So What? Now What?

Aaron Marcus, President
Aaron Marcus and Asociates, Inc.
1144 65th Street, Suite F
Emeryville, CA 94608 USA
Tel: 510-601-0994, Ext. 19
Fax: 510-547-6125
Email: Aaron@AmandA.com
Web: www.Amanda.com

Emilie West Gould, Adjunct
Lally School of Management
Rensselaer Polytechnic Institute (RPI)
110 8th St.
Troy, NY 12180-3590
Email: goulde@rpi.edu

Abstract

This paper introduces dimensions of culture, as analyzedby Geert Hofstedein his classic study of cultures in organizations,and considers how theymight affect user-interface designs. Examples fromthe Web illustratethe cultural dimensions.

Introduction

The Web enables global distribution of products and services throughInternet Websites, intranets, and extranets. Professional analysts anddesigners generally agree that well-designed user interfaces improve theperformance and appeal of the Web, helping to convert "tourists" or "browsers"to "residents" and "customers." The user-interface development processfocuses attention on understanding users and acknowledging demographicdiversity. But in a global economy, these differences may reflect world-widecultures. Companies that want to do international business on the webshould consider the impact of culture on the understanding and use ofWeb-based communication, content, and tools. This paper contributes tothe study of this complex and challenging issue by analyzing some of theneeds, wants, preferences, and expectations of different cultures throughreference to a cross-cultural theory developed by Geert Hofstede.

A few simple questions illustrate the depth ofthe issues.

Consider your favorite Website. How might thisWebsite be understoodand used in New York, Paris, London, Beijing, NewDelhi, or Tokyo, assumingthat adequate verbal translation were accomplished?Might something inits metaphors, mental model, navigation, interaction,or appearance confuse,or even offend and alienate, a user?

Consider what year this is. Is it 2000? In some other countingsystems, it is 4698, 5760, or 1420. Even to refer to the counting systemof another culture might confuse or alienate people used to their ownnative system. Let us not forget that Hindu-Arabic numerals, which Westernsociety now takes for granted, were once viewed as the work of the devilby Christian Europe, and educated people for hundreds of years blockedtheir introduction into European society. Whether people view importsfrom other cultures as delightful gifts or poisonous viruses is oftena matter of socio-political context.

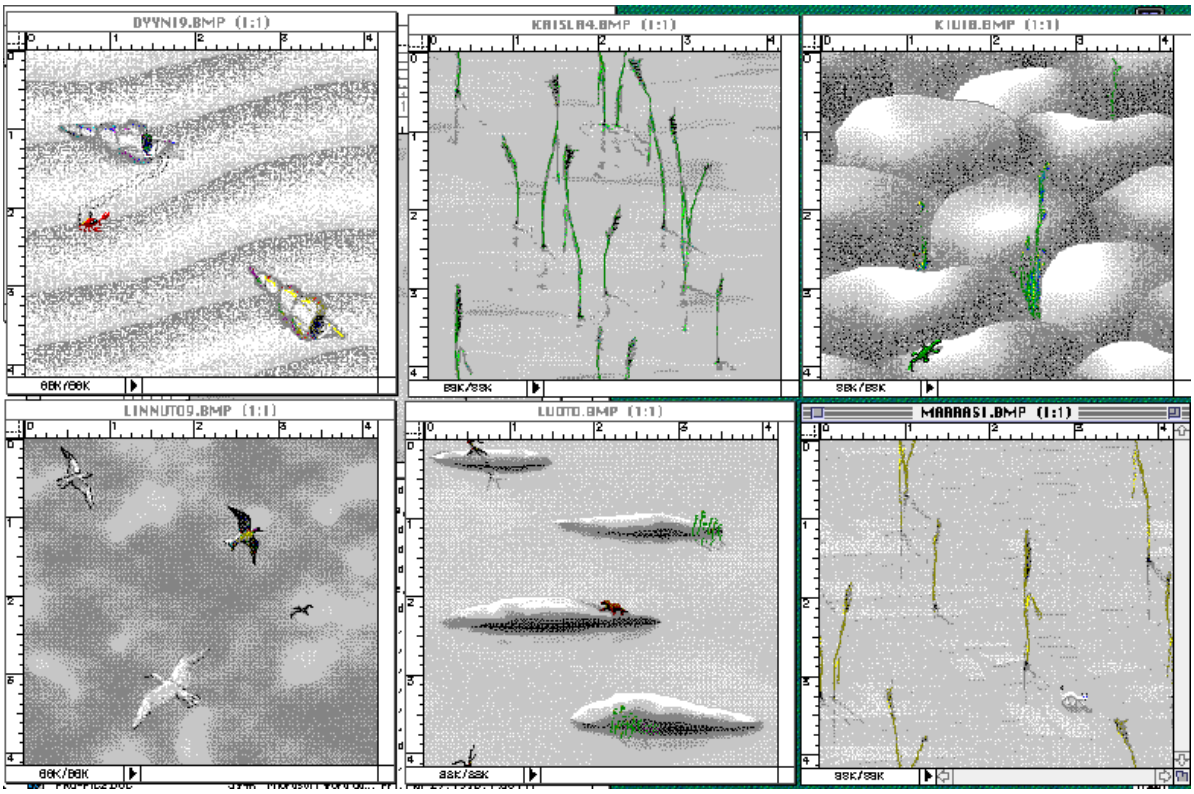
Consider the order in which you prefer to find information. Ifyou are planning a trip by train, do you want to see the schedule informationfirst or read about the organization and assess its credibility? Differentcultures look for different data to make decisions.

A New Issue for User-Interface Designers

In most projects, the complex interplay of user, business, marketing,and engineering requirements needs to be resolved by Web user-interfaceand information visualization designers. Their development process includesiterative steps of planning, research, analysis, design, evaluation, documentation,and training. As they carry out all of these tasks, however, they wouldo well to consider their own cultural orientation and to understand thepreferred structures and processes of other cultures. This attention wouldhelp them to achieve more desirable global solutions or to determine towhat extent localized, customized designs might be better than internationalor universal ones.

Cultures, even within some countries, are very different. Sacredcolors in the Judeo-Christian West (e.g., red, blue, white, gold) are different from Buddhist saffron yellow or Islamic green. Subdued Finnishdesigns for background screen patterns (see Figure 1) might not be equallysuitable in Mediterranean climates, in Hollywood, USA, or Bollywood, India.These differences go deeper than mere appearance; they reflect strongcultural values. How might these cultural differences be understood withoutfalling into the trap of stereotyping other cultures?

Figure 1. TeamWare Finnish screen patterns



Many analysts in organizational communication have studied culturesthoroughly and published classic theories; other authors have appliedthese theories to analyze the impact of culture on business relationsand commerce (see Bibliography). Few of these works are well known tothe user-interface design community. This paper introduces the well-respectedwork of one theorist, Geert Hofstede, and applies some of his culturaldimensions to Web user interfaces. Edward T. Hall, David Victor, and Fons Trompenaars would have been equally valuable in illuminating the problemsof cross-cultural communication on the Web, but our application of Hofstedewill demonstrate the value of this body of research for our field.

Hofstede's Dimensions of Culture

During 1978-83, the Dutch cultural anthropologist Geert Hofstede conducteddetailed interviews with hundreds of IBM employees in 53 countries. Throughstandard statistical analysis of fairly large data sets, he was able todetermine patterns of similarities and differences among the replies.From this data analysis, he formulated his theory that world culturesvary along consistent, fundamental dimensions. Since his subjects wereconstrained to one multinational corporation's world-wide employees, andthus to one company culture, he ascribed their differences to the effectsof their national cultures. (One weakness is that he maintained that eachcountry has just one dominant culture.)

In the 1990s, Hofstede published a more accessible version ofhis research publication in Cultures and Organizations: Software of theMind [Hofstede]. His focus was not on defining culture as refinement ofthe mind (or "highly civilized" attitudes and behavior) but rather onhighlighting essential patterns of thinking, feeling, and acting thatare well-established by late childhood. These cultural differences manifestthemselves in a culture's choices of symbols, heroes/heroines, rituals,and values.

Hofstede identified five dimensions and rated 53 countries onindices for each dimension, normalized to values (usually) of 0 to 100.His five dimensions of culture are the following:
•Power-distance
•Collectivism vs. individualism
•Femininity vs. masculinity
•Uncertainty avoidance
•Long- vs. short-term orientation

Each of Hofstede's terms appears below with our explanation ofimplications for user-interface and Web design, and illustrations of characteristicWebsites.

Power Distance

Power distance (PD) refers to the extent to which lesspowerful membersexpect and accept unequal power distribution within a culture.

Hofstede claims that high PD countries tend to have centralizedpolitical power and exhibit tall hierarchies in organizations with largedifferences in salary and status. Subordinates may view the "boss" asa benevolent dictator and are expected to do as they are told. Parentsteach obedience, and expect respect. Teachers possess wisdom and are automaticallyesteemed. Inequalities are expected, and may even be desired.

Low PD countries tend to view subordinates and supervisors ascloser together and more interchangeable, with flatter hierarchies inorganizations and less difference in salaries and status. Parents andchildren, and teachers and students, may view themselves more as equals(but not necessarily as identical.) Equality is expected and generallydesired. There are some interesting correlations for power distance: lowPD countries tend to have higher geographic latitude, smaller populations,and/or higher gross domestic product (GDP) per capita than high PD countries.

Hofstede notes that these differences are hundreds or even thousandsof years old. He does not believe they will disappear quickly from traditionalcultures, even with powerful global telecommunication systems. Recentresearch has shown that the dimensions have remained quite stable forthe last twenty years.

Based on this definition, we believe power distance may influencethe following aspects of user-interface and Web design:
•Access to information: highly (high PD) vs. less-highly (lowPD) structured.
•Hierarchies in mental models: tall vs. shallow.
•Emphasis on the social and moral order (e.g., nationalismor religion)and its symbols: significant/frequent vs. minor/infrequent use.
•Focus on expertise, authority, experts, certifications, officialstamps, or logos: strong vs. weak.
•Prominence given to leaders vs. citizens, customers, or employees.
•Importance of security and restrictions or barriers to access:explicit, enforced, frequent restrictions on users vs. transparent, integrated,implicit freedom to roam.
•Social roles used to organize information (e.g., a managers'section obvious to all but sealed off from non-managers): frequent vs. infrequent

These PD differences can be illustrated on theWeb by examining universityWeb sites from two countries with very different PD indices (Figures 2and 3). The Universiti Utara Malaysia (www.uum.edu.my)is located in Malaysia,a country with a PD index rating of 104, the highestin Hofstede's analysis.

Figure 2. High powerdistance: Malaysian UnversityWeb site.

The Website from the Ichthus Hogeschool (www.ichthus-rdam.nl) and the TechnischeUniversiteit Eindhoven (www.tue.nl)are located in the Netherlands, with a PD index rating of 38.

Figure 3a. Low power distance: Dutch Educational Website.

Figure 3b. Low power distance: Dutch Educational Website.

Note the differences in the two groups of Websites. The MalaysianWebsite features strong axial symmetry, a focus on the official

seal ofthe university, photographs of faculty or administration leaders conferringdegrees, and monumental buildings in which people play a small role. Atop-level menu selection provides a detailed explanation of the symbolismof the official seal and information about the leaders of the university.

The Dutch Websites feature an emphasis on students (not leaders),a stronger use of asymmetric layout, and photos of both genders in illustrations.These Websites emphasize the power of students as consumers and equals.Students even have the opportunity to operate a WebCam and take theirown tour of the Ichthus Hogeschool.

Individualism vs. Collectivism

Individualism in cultures implies loose ties; everyone is expected tolook after one's self or immediate family but no one else. Collectivismimplies that people are integrated from birth into strong, cohesive groupsthat protect them in exchange for unquestioning loyalty.

Hofstede found that individualistic cultures value personal time,freedom, challenge, and such extrinsic motivators as material rewardsat work. In family relations, they value honesty/truth, talking thingsout, using guilt to achieve behavioral goals, and maintaining self-respect.Their societies and governments place individual social-economic interestsover the group, maintain strong rights to privacy, nurture strong privateopinions (expected from everyone), restrain the power of the state inthe economy, emphasize the political power of voters, maintain strongfreedom of the press, and profess the ideologies of self-actualization,self-realization, self-government, and freedom.

At work, collectivist cultures value training, physical conditions,skills, and the intrinsic rewards of mastery. In family relations, they value harmony more than honesty/truth (and silence more than speech),use shame to achieve behavioral goals, and strive to maintain face. Theirsocieties and governments place collective social-economic interests overthe individual, may invade private life and regulate opinions, favor lawsand rights for groups over individuals, dominate the economy, controlthe press, and profess the ideologies of harmony, consensus, and equality.

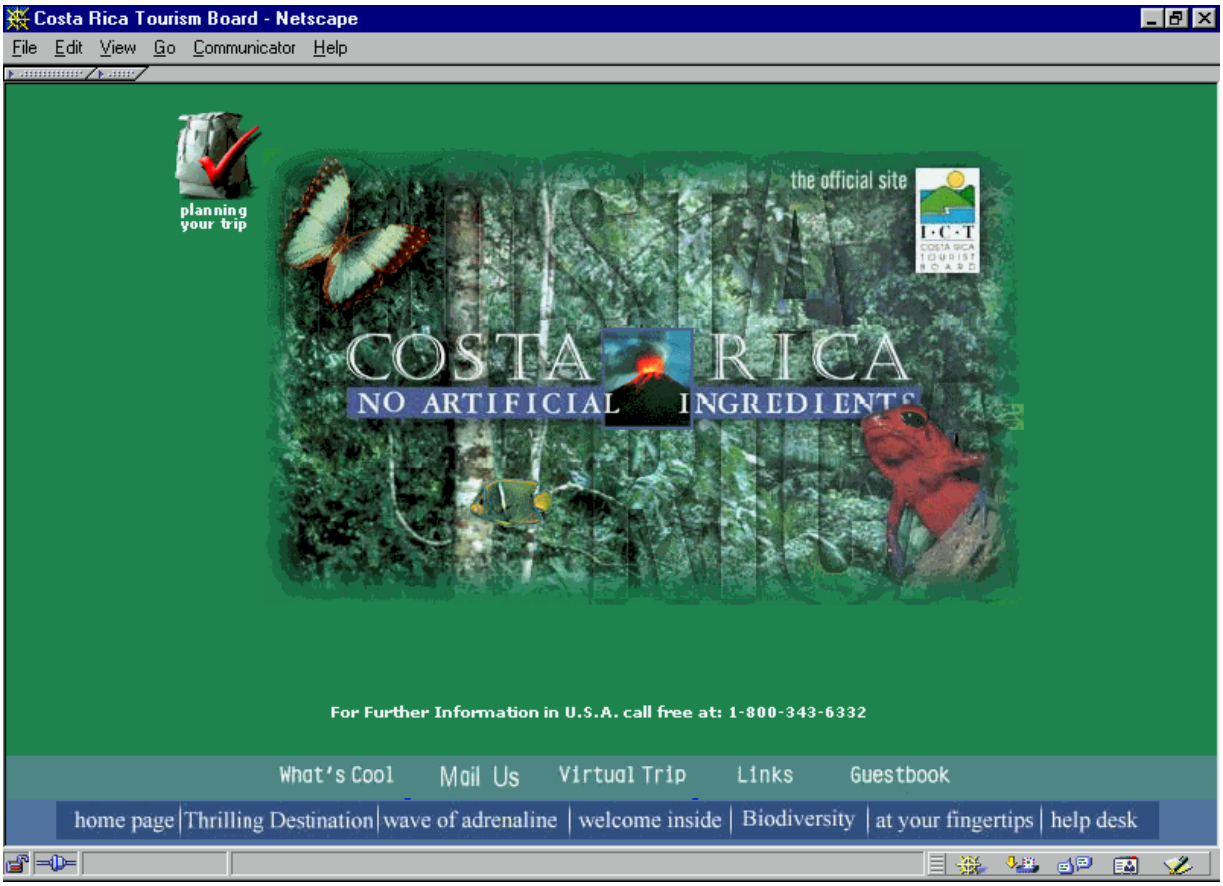
Based on this definition, we believe individualism and collectivismmay influence the following aspects of user-interface and Web design:
•Motivation based on personal achievement: maximized (expectthe extra-ordinary) for individualist cultures vs. underplayed (in favorof group achievement) for collectivist cultures.
•Images of success: demonstrated through materialism and consumerismvs. achievement of social-political agendas.
•Rhetorical style: controversial/argumentative speech andtolerance or encouragement of extreme claims vs. official slogans and subdued hyperbole and controversy.
•Prominence given youth and action vs. aged, experienced, wiseleaders and states of being
•Importance given individuals vs. products shown by themselvesor with groups.
•Underlying sense of social morality: emphasis on truth vs.relationships.
•Emphasis on change: what is new and unique vs. traditionand history.
•Willingness to provide personal information vs. protectionof personal data differentiating the individual from the group.

The effects of these differences can be illustrated on the Webby examining national park Web sites from two countries with very differentIC indices (Figures 4 and 5). The Glacier Bay National Park Website (www.nps.gov/glba/evc.htm is located in the USA, which has the highest IC index rating (91).

Figure 4. Highindividualist value: US NationalPark Website.

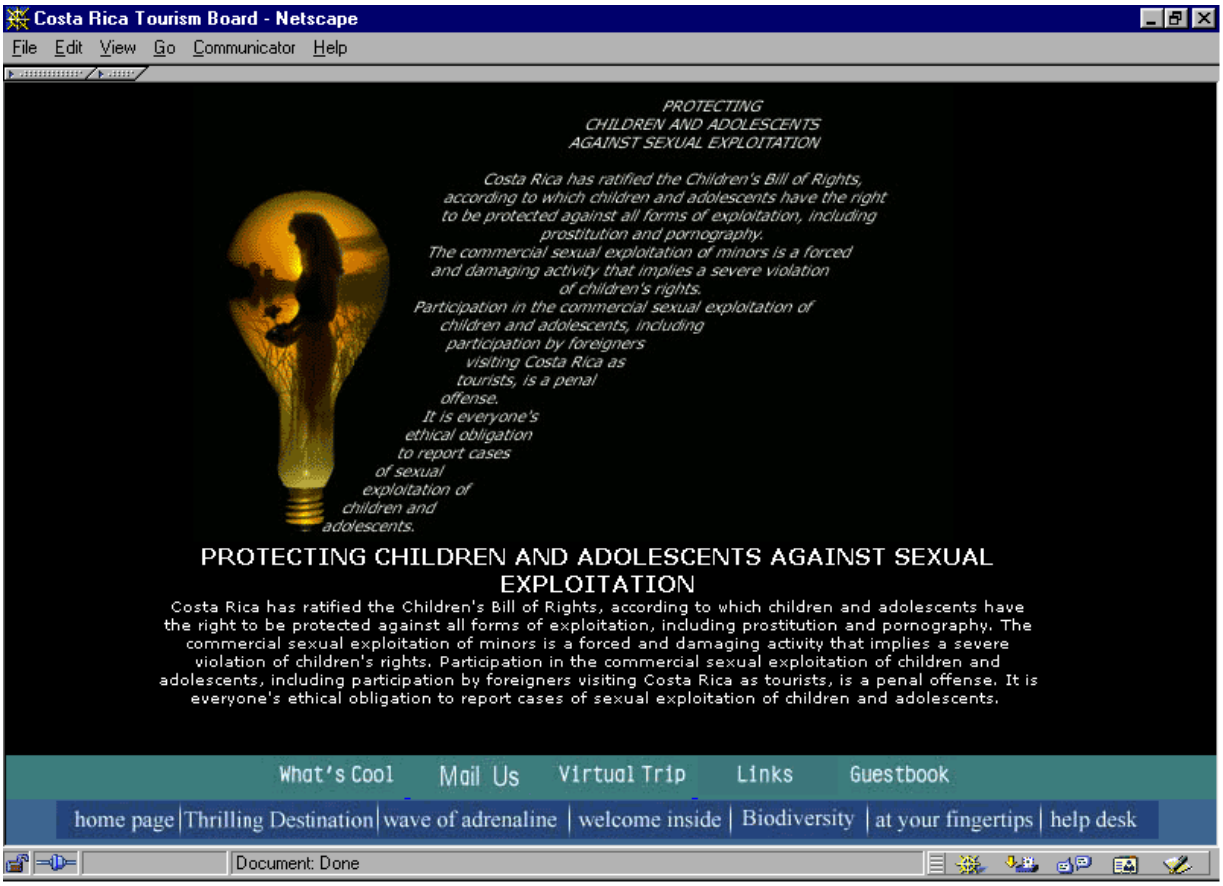
The Website from the National Parks of Costa Rica (www.tourism-costarica.com) is locatedin a country with an IC index rating of 15.

Figure 5. Lowindividualist value: Costa RicanNational Park Website.



The third image (Figure 6) shows a lower level of the Costa Rican Website.

Figure 6. Costa RicanWebsite What's Cool contents: Political message about exploitation of children.



Note the differences in the two groups of Websites. The USA Website features an emphasis on the visitor,his/her goals, and possible actions in coming to the park. The Costa Rican Website features an emphasis on nature, downplaysthe individual tourist, and uses a slogan to emphasize a national agenda.An even more startling difference lies below the What's Cool menu. Insteadof a typical Western display of new technology or experience to consume,the screen is filled with a massive political announcement that the CostaRican government has signed an international agreement against the exploitationof children and adolescents.

Masculinity vs. Femininity (MAS)

Masculinity and femininity refer to gender roles, not physical characteristics.Hofstede focuses on the traditional assignment to masculine roles of assertiveness,competition, and toughness, and to feminine roles of orientation to homeand children, people, and tenderness. He acknowledges that in differentcultures different professions are dominated by different genders. (Forexample, women dominate the medical profession in the Soviet Union, whilemen dominate in the USA.) But in masculine cultures, the traditional distinctionsare strongly maintained, while feminine cultures tend to collapse thedistinctions and overlap gender roles (both men and women can exhibitmodesty, tenderness, and a concern with both quality of life and materialsuccess.) Traditional masculine work goals include earnings, recognition,advancement, and challenge. Traditional feminine work goals include good relations with supervisors, peers, and subordinates; good living and workingconditions; and employment security

The following list shows some typical masculinity(MAS) index values,where a high value implies a strongly masculine culture:

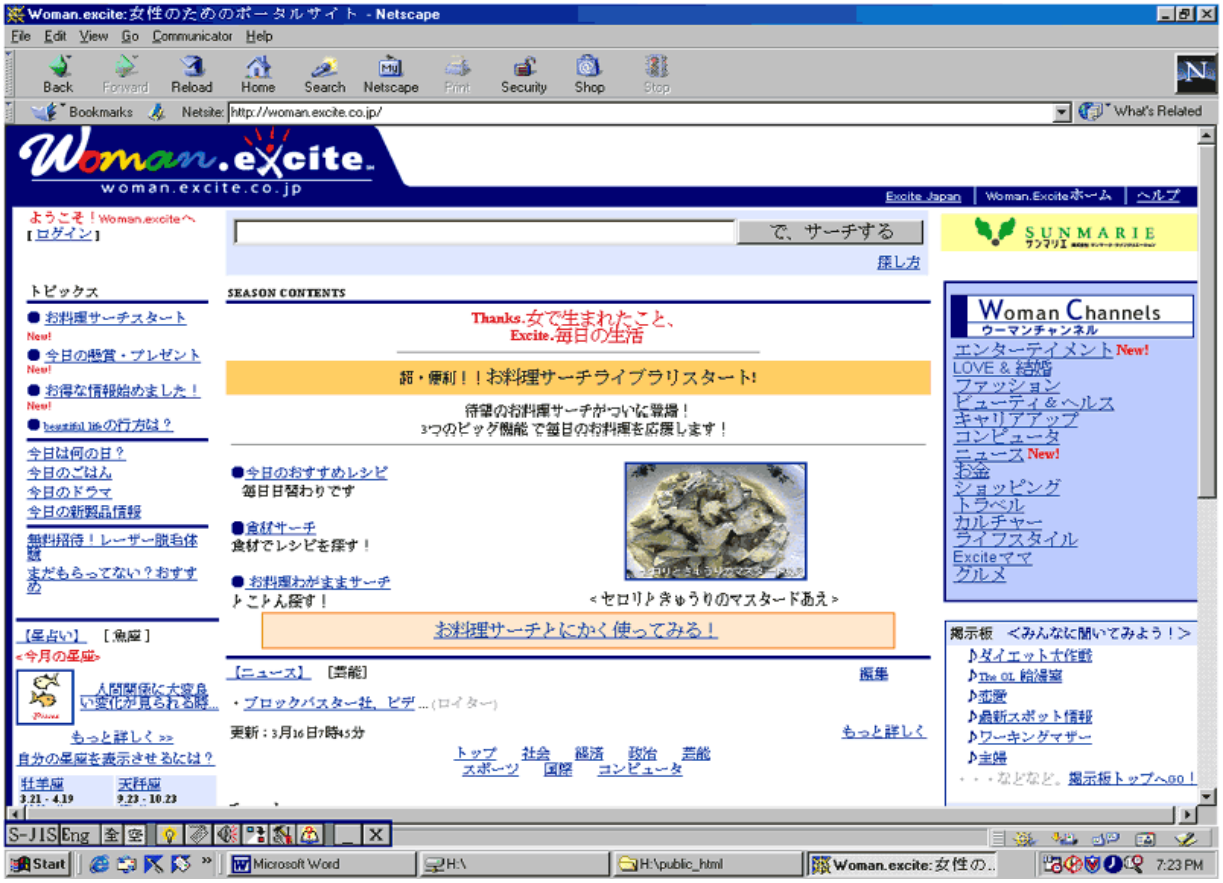
95 Japan
79 Austria
63 South Africa
62 USA
53 Arab countries
47 Israel
43 France
39 South Korea
05 Sweden

Since Hofstede's definition focuses on the balance between rolesand relationships, we believe masculinity and femininity may be expressedon the Web through different emphases. High-masculinity cultures wouldfocus on the following user-interface and design elements:
•Traditional gender/family/age distinctions
•Work tasks, roles, and mastery, with quick results for limitedtasks
•Navigation oriented to exploration and control
•Attention gained through games and competitions
•Graphics, sound, and animation used for utilitarian purposes

Feminine cultures would emphasize the following user-interfaceelements:
•Blurring of gender roles
•Mutual cooperation, exchange, and support, (rather than masteryand winning)
•Attention gained through poetry, visual aesthetics, and appealsto unifying values

Examples of MAS differences on the Web can be illustrated by examiningWebsites from countries with very different MAS indices (Figures 7, 8and 9). The Woman.Excite Website (woman.excite.co.jp) is located in Japan, which has the highest MAS value (95). The Websitenarrowly orients its search portal toward a specific gender, which thiscompany does not do in other countries.

Figure 7. High masculinityWebsite: Excite.comfor women in Japan



The ChickClick (www.chickclick.com)USA Website (MAS = 52) consciously promotes the autonomy of young women(although it leaves out later stages in a woman's life.)

Figure 8. Medium masculinity Website: ChickClick.comin the USA.

TheExcite Website (www.excite.com.se) from Sweden, with thelowest MF value 5, makes no distinction in gender or age. (With the exceptionof the Netherlands, another low MAS country, all other European Websitesprovide more pre-selected information.)

Figure 9. Low masculinityWebsite: Swedish Excite.com.

Uncertainty Avoidance (UA)

People vary in the extent that they feel anxiety about uncertain or unknownmatters, as opposed to the more universal feeling of fear caused by knownor understood threats. Cultures vary in their avoidance of uncertainty,creating different rituals and having different values regarding formality,punctuality, legal-religious-social requirements, and tolerance for ambiguity.

Hofstede notes that cultures with high uncertainty avoidance tendto have high rates of suicide, alcoholism, and accidental deaths, andhigh numbers of prisoners per capita. Businesses may have more formalrules, require longer career commitments, and focus on tactical operationsrather than strategy. These cultures tend to be expressive; people talkwith their hands, raise their voices, and show emotions. People seem active,emotional, even aggressive; shun ambiguous situations; and expect structurein organizations, institutions, and relationships to help make eventsclearly interpretable and predictable. Teachers are expected to be expertswho know the answers and may speak in cryptic language that excludes novices.In high UA cultures, what is different may be viewed as a threat, andwhat is "dirty" (unconventional) is often equated with what is dangerous.

By contrast, low UA cultures tend to have higher caffeine consumption,lower calorie intake, higher heart-disease death rates, and more chronicpsychosis per capita. Businesses may be more informal and focus more onlong-range strategic matters than day-to-day operations. These culturestend to be less expressive and less openly anxious; people behave quietlywithout showing aggression or strong emotions (though their caffeine consumptionmay be intended to combat depression from their inability to express theirfeelings.) People seem easy-going, even relaxed. Teachers may not knowall the answers (or there may be more than one correct answer), run moreopen-ended classes, and are expected to speak in plain language. In thesecultures, what is different may be viewed as simply curious, or perhapsridiculous.

Based on this definition, we believe uncertainty avoidance mayinfluence contrary aspects of user-interface and Web design. High-UA cultureswould emphasize the following:
•Simplicity, with clear metaphors, limited choices, and restrictedamounts of data
•Attempts to reveal or forecast the results or implicationsof actions before users act
•Navigation schemes intended to prevent users from becominglost
•Mental models and help systems that focus on reducing "usererrors"
•Redundant cues (color, typography, sound, etc.) to reduceambiguity.

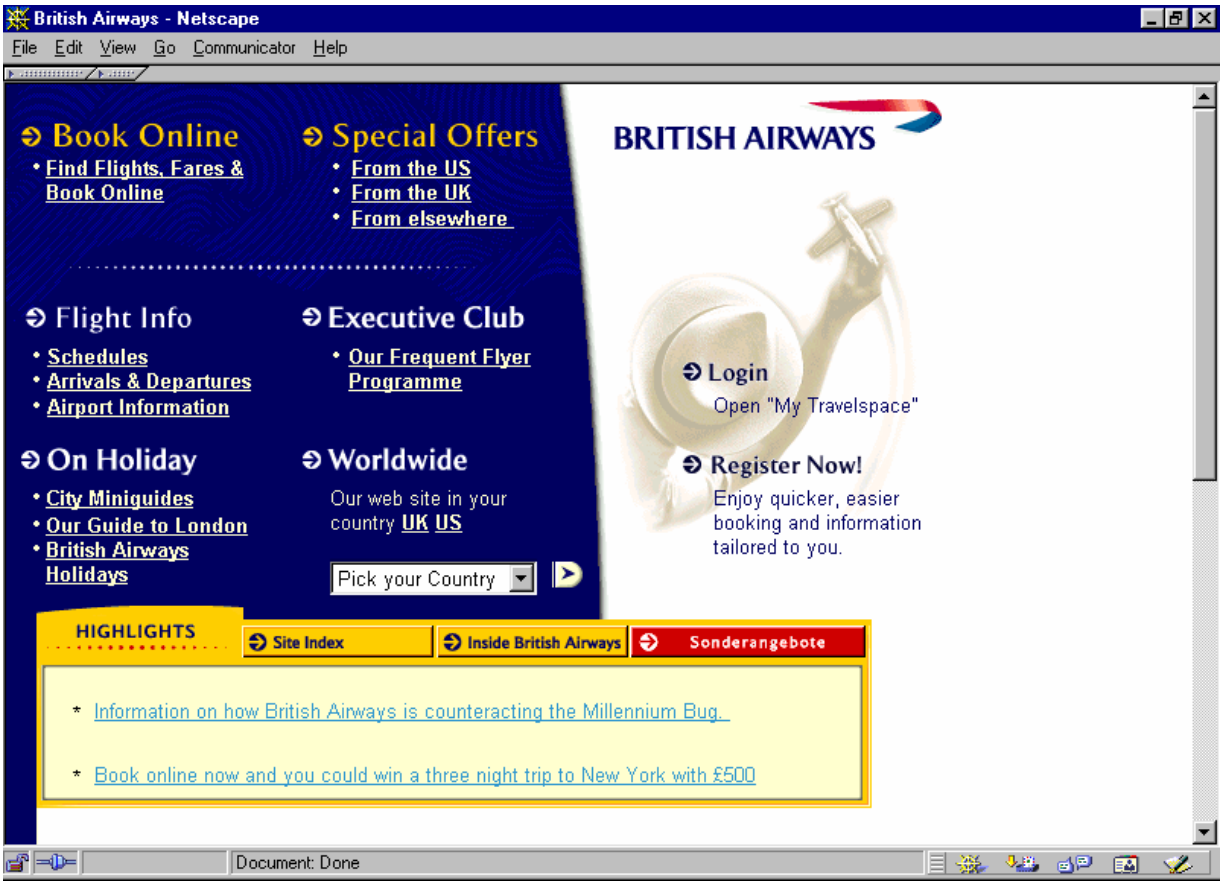
Low UA cultures would emphasize the reverse:
•Complexity with maximal content and choices
•Acceptance (even encouragement) of wandering and risk, witha stigma on "over-protection"
•Less control of navigation; for example, links might opennew windows leading away from the original location
•Mental models and help systems might focus on understandingunderlying concepts rather than narrow tasks
•Coding of color, typography, and sound to maximize information(multiple links without redundant cueing)

Examples of UA differences can be illustrated on the Web by examiningairline Websites from two countries with very different UA indices (Figures10 and 11). The Sabena Airlines Website (www.sabena.com) is located in Belgium, a country with a UA of 94, the highest ofthe cultures studied. This Website shows a home page with very simple,clear imagery and limited choices.

Figure 10. High uncertainty avoidance: Sabema AirlinesWebsite from Belgium.

The British AirwaysWebsite (www.britishairways.com) from the UnitedKingdom (UA = 35) shows much more complexity of content and choices withpopup windows, multiple types of interface controls, and "hidden"content that must be displayed by scrolling.

Figure 11. Low uncertaintyavoidance: British AirwaysWebsite from United Kingdom.



Long- vs. Short-Term Time Orientation

In the early 1980s, shortly after Hofstede first formulated his culturaldimensions, work by Michael Bond convinced him that a fifth dimensionneeded to be defined. Long-Term Orientation seemed to play an importantrole in Asian countries that had been influenced by Confucian philosophyover many thousands of years. Hofstede and Bond found such countries sharedthese beliefs:
•A stable society requires unequal relations.
•The family is the prototype of all social organizations;consequently, older people (parents) have more authority than younger people (and men more than women)
•Virtuous behavior to others means not treating them as onewould not like to be treated
•Virtuous behavior in work means trying to acquire skillsand education, working hard, and being frugal, patient, and persevering

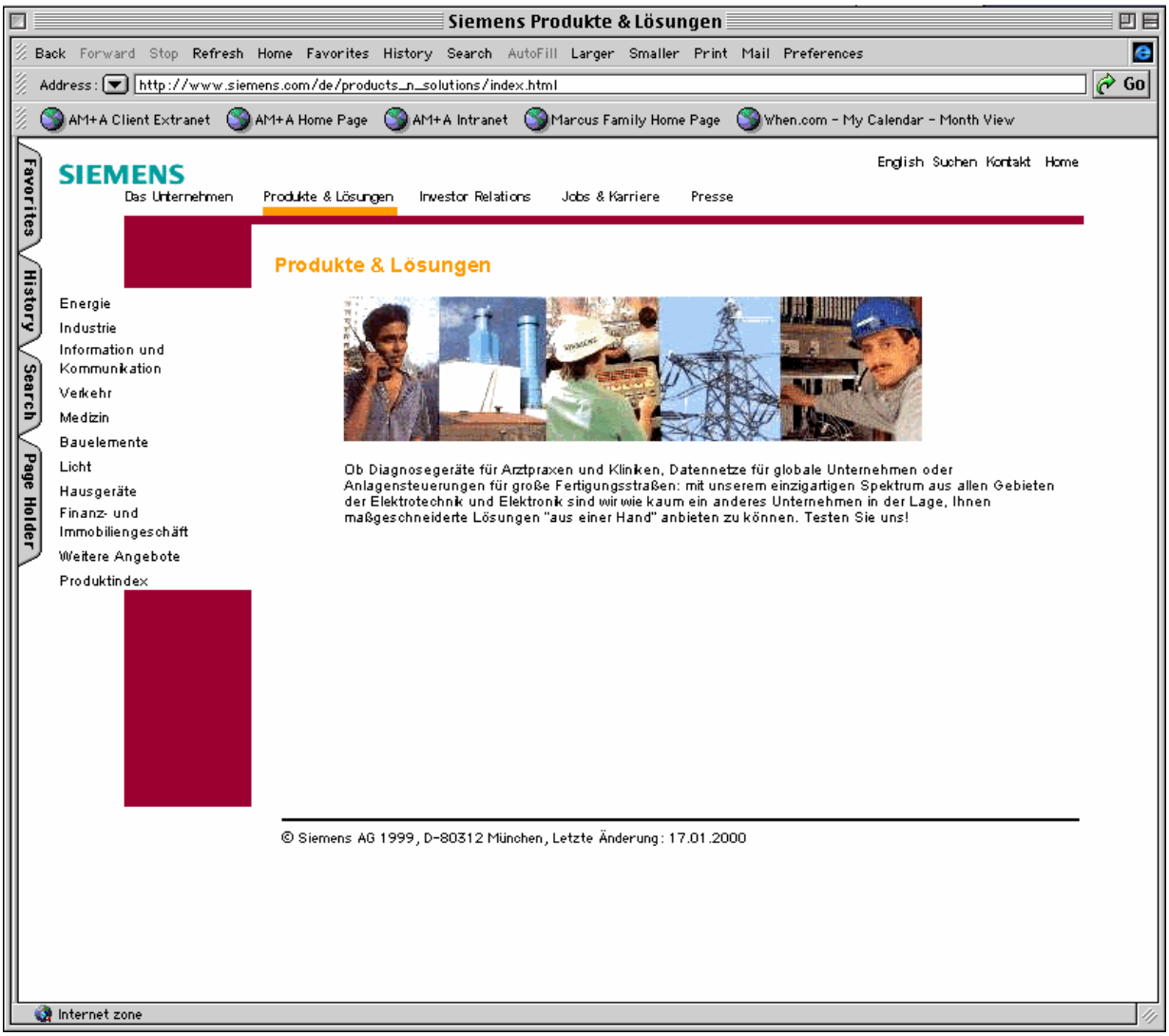
Western countries, by contrast, were more likely to promote equalrelationships, emphasize individualism, focus on treating others as youwould like to be treated, and find fulfillment through creativity andself-actualization. When Hofstede and Bond developed a survey specificallyfor Asia and reevaluated earlier data, they found that long-term orientationcancelled out some of the effects of Masculinity/Femininity and UncertaintyAvoidance. They concluded that Asian countries are oriented to practiceand the search for virtuous behavior while Western countries are orientedto belief and the search for truth. Of the 23 countries compared, the following showed the most extreme values:

118 China (ranked 1)
80 Japan (4)
29 USA (17)
0 Pakistan (23)

Based on this definition, high LT countries wouldemphasize the followingaspects of user-interface design:
•Content focused on practice andpractical value
•Relationships as a source of informationand credibility
•Patience in achieving results and goals
Low LT countries would emphasize the contrary
•Content focused on truth and certaintyof beliefs
•Rules as a source of information andcredibility
•Desire for immediate results andachievement of goals

Examples of LTO differences on the Web can be illustrated by examiningversions of the same company's Website from two countries with differentLT values (Figures 12 and 13). The Siemens Website (www.siemens.co.de) from Germany (LT=31) shows a typical Western corporate layout that emphasizes crisp, clean functionaldesign aimed at achieving goals quickly.

Figure 12 Low Long-termorientation: Website formSiemens Germany.



The Chinese version from Beijingrequires more patience to achieve navigational and functional goals.

Figure 13: High Long-TermOrientation. WebsitefromSiemens in China.

Conclusions

Hofstede notes that some cultural relativism is necessary: it is difficultto establish absolute criteria for what is noble and what is disgusting.There is no escaping bias; all people develop cultural values based ontheir environment and early training as children. Not everyone in a societyfits the cultural pattern precisely, but there is enough statistical regularityto identify trends and tendencies. These trends and tendencies shouldnot be treated as defective or used to create negative stereotypes butrecognized as different patterns of values and thought. In a multi-culturalworld, it is necessary to cooperate to achieve practical goals without requiring everyone to think, act, and believe identically.

This review of cultural dimensions raises many issues about UIdesign, especially for the Web. We have explored a number of design differencesthrough sample Websites but other, more strategic questions remain. Incrafting Websites and Web applications, the questions can be narrow orbroad:
•How formal or rewarding should interaction be?
•What will motivate different groups of people? Money? Fame?Honor? Achievement?
•How much conflict can people tolerate in content or styleof argumentation?
•Should sincerity, harmony, or honesty be used to make appeals?
•What role exists for personal opinion vs. group opinion?
•How well are ambiguity and uncertainty avoidance received?
•Will shame or guilt constrain negative behavior?
•What role should community values play in individualist vscollectivist cultures?

Other questions might relate to specific types of Websites:
•Does the objective of distance learning change what can belearned in individualist vs. collectivist cultures? Should these sites focus on tradition? Skills? Expertise? Earning power?
•How should online teachers or trainers act – as friendsor gurus?
•Would job sites differ for individualist vs. collectivistcultures?
•Should there be different sites for men and women in differentcultures?
•Would personal Webcams be OK or Not OK?
•How much advertising hyperbole could be tolerated in a collectiveculture focused on modesty?
•Would an emphasis on truth as opposed to practice and virtuerequire different types of procedural Websites for Western or Asian audiences?

Finally, if crosscultural theory becomes an accepted element ofuser-interface design, then we need to change our current practices anddevelop new tools. We need to make it feasible to develop multiple versionsof Websites in a cost-effective manner, perhaps through templates or throughspecific versioning tools. As the Web continues to develop globally, answeringthese questions, and exploring, then exploiting, these dimensions of culture,will become a necessity and not an option for successful theory and practice.

Acknowledgements

The author acknowledges the work of Geert Hofstede

Bibliography

DelGaldo Elise, and Nielsen, Jakob, ed., *International UserInterfaces*, John Wiley & Sons, 1996, ISBN: 0471149659.

Elashmawi, Farid, and Philip R. Harris, *Multicultural Management2000: Essential Cultural Insights for Global BusinessSuccess*, GulfPublishing, Houston, 1998.

Fernandes, Tony, *Global Interface Design*: *A Guide toDesigning International User Interfaces*, AP Professional, Boston,1995, ISBN: 0-12-253790-4 (paperback), 0-12-253791-2 (CD-ROM).

Hall, Edward, *The Hidden Dimension*, Doubleday & Company,Incorporated, 1969, ISBN: 0385084765.

Harel, Dan, and Girish Prabhu, "Global User Experience (GLUE), Designfor Cultural Diversity: Japan, China, and India," *Designing for GlobalMarkets*, Proceedings of First International Workshop on Internationalizationof Products and Systems (IWIPS-99), 20-22 May 1999, Rochester, NY, ISBN0-9656691, Backhouse Press, Rochester, NY, pp. 205-216.

Harris, Philip R., and Robert T. Moran, *Managing Cultural Differences*,Gulf Publishing, Houston, 1991.

Hofstede, Geert, *Cultures and Organizations:Software of the Mind*,McGraw-Hill, New York, 1997.

Honold, Pia, "Learning How to Use a CellularPhone: ComparisonBetween German and Chinese Users," *Jour* Soc. Tech. Comm., Vol. 46, No. 2, May 1999, pp. 196-205.

Lewis, Richard, *When Cultures Collide*,Nicholas Brealey, London,1991.

Marcus, Aaron, "International and InterculturalUser-Interface Design,"in Stephanidis, Constantine, ed., *User Interfacesfor All*, LawrenceErlbaum, New York, 2000.

Nielsen, Jakob, ed., *Designing User Interfaces for InternationalUse (Advances in Human Factors/Ergonomics, 13)*, Elsevier Science Ltd.,New York, 1990, ISBN: 0444884289.

Trompenaars, Fons, and Charles Hampden Turner, *Riding the Wavesof Culture*, McGraw-Hill, NY, 1998.

URLs and Other Resources

Selected URLs from the list at http://www.AmandA.com.

ACM/SIGCHI Intercultural listserve: chi-intercultural@acm.org. Moderator:Donald Day, d.day@acm.org.

African-American Websites: bet.com, netnoir.com,blackfamilies.com

Color: colortool.com

Cultural comparisons: culturebank.com

Digital divide: digitaldivide.gov,digitaldivide.org, digitaldividenetwork.org/

Indian culture: indiagov.org/culture/overview.htm

Internationalization resources:world-ready.com/r_intl.htm,world-ready.com/biblio.htm

Internet statistics by language:euromktg.com/globstats/index.html,world-ready.com/biblio.htm

Localization: http://www.lisa.org/home_sigs.html

Native-American-oriented Website:hanksville.org/NAresources/

Simplified English: userlab.com/SE.html

Women: wow.com, oxygen.com, chickclick.com

www.HCIBib.org//SIGCHI/Intercultural

Figures

Figures appear above in the article near the text citations.

Appendix 1: Indexes from: Hofstede, Geert, *Cultures and Organizations:Software of the Mind: Intercultural Cooperation andits Importance forSurvival,* McGraw Hill, New York, 1991, ISBN:0-07-029307-4.

PDI:Power distance index

IDV:Individualism index

MAS:Masculinity index

UAI:Uncertainty avoidance index

LTO:Long-term orientation index

	PDI		IDV		MAS		UAI		LTO	
	rank	score	rank	score	rank	score	rank	score	rank	score
Arab Countries	7	80	26/27	38	23	53	27	68		
Argentina	35/36	49	22/23	46	20/21	56	10/15	86		
Australia	41	36	2	90	16	61	37	51	15	31
Austria	53	11	18	55	2	79	24/25	70		
Bangladesh									11	40
Belgium	20	65	8	75	22	54	5/6	94		
Brazil	14	69	26/27	38	27	49	21/22	76	6	65
Canada	39	39	4/5	80	24	52	41/42	48	20	23

Chile	24/25	63	38	23	46	28	10/15	86		
China									1	118
Columbia	17	67	49	13	11/12	64	20	80		
Costa Rica	42/44	35	46	15	48/49	21	10/15	86		
Denmark	51	18	9	74	50	16	51	23		
East Africa	21/23	64	33/35	27	39	41	36	52		
Equador	8/9	78	52	8	13/14	63	28	67		
Finland	46	33	17	63	47	26	31/32	59		
France	15/16	68	10/11	71	35/36	43	10/15	86		
Germany FR	42/44	35	15	67	9/10	66	29	65	14	31
Great Britain	42/44	35	3	89	9/10	66	47/48	35	18	25
Greece	27/28	60	30	35	18/19	57	1	112		
Guatemala	2/3	95	53	6	43	37	3	101		
Hong Kong	15/16	68	37	25	18/19	57	49/50	29	2	96
India	10/11	77	21	48	20/21	56	45	40	7	61
Indonesia	8/9	78	47/48	14	30/31	46	41/42	48		
Iran	29/30	58	24	41	35/36	43	31/32	59		
Ireland (Rep of)	49	28	12	70	7/8	68	47/48	35		
Israel	52	13	19	54	29	47	19	81		
Italy	34	50	7	76	4/5	70	23	75		
Jamaica	37	45	25	39	7/8	68	52	13		
Japan	33	54	22/23	46	1	95	7	92	4	80
Malaysia	1	104	36	26	25/26	50	46	36		
Mexico	5/6	81	32	30	6	69	18	82		
Netherlands	40	38	4/5	80	51	14	35	53	10	44
New Zealand	50	22	6	79	17	58	39/40	49	16	30
Nigeria									22	16
Norway	47/48	31	13	69	52	8	38	50		
Pakistan	32	55	47/48	14	25/26	50	24/25	70	23	0
Panama	2/3	95	51	11	34	44	10/15	86		
Peru	21/23	64	45	16	37/38	42	9	87		
Philippines	4	94	31	32	11/12	64	44	44	21	19
Poland									13	32
Portugal	24/25	63	33/35	27	45	31	2	104		
Salvador	18/19	66	42	19	40	40	5/6	94		
Singapore	13	74	39/41	20	28	48	53	8	9	48
South Africa	35/36	49	16	65	13/14	63	39/40	49		
South Korea	27/28	60	43	18	41	39	16/17	85	5	75
Spain	31	57	20	51	37/38	42	10/15	86		
Sweden	47/48	31	10/11	71	53	5	49/50	29	12	33
Switzerland	45	34	14	68	4/5	70	33	58		
Taiwan	29/30	58	44	17	32/33	45	26	69	3	87
Thailand	21/23	64	39/41	20	44	34	30	64	8	56
Turkey	18/19	66	28	37	32/3	45	16/17	85		
Uruguay	26	61	29	36	42	38	4	100		
USA	38	40	1	91	15	62	43	46	17	29
Venezuela	5/6	81	50	12	3	73	21/22	76		
West Africa	10/11	77	39/41	20	30/31	46	34	54		
Yugoslavia	12	76	33/35	27	48/49	21	8	88		
Zimbabwe									19	25

AM+A

Aaron Marcus and Associates, Inc.
California and New York

California

1144 65th Street, Suite F
Emeryville, CA 94608-1053 USA

Tel: 510-601-0994
Fax: 510-547-6125
E-mail: Mail@AMandA.com
Web: www.AMandA.com

HCI-2000
Principles of Effective Visual Communication for Graphical User Interface Design

Date and Status	1994, Reprint
Client	Morgan Kaufman Publishers
Publication	HCI-2000 Edited by Ronald Baecker, Bill Buxton, et al
Client Contact	Morgan Kaufman Publishers Palo Alto, CA
Author	Aaron Marcus, President Aaron Marcus and Associates, Inc.
Copyright Notice	Text and Figures © Copyright 1994 by Aaron Marcus and Associates, Inc.
Summary	This article reviews essential principles of information-oriented graphic design useful for achieving effective communication in user interfaces and in multimedia presentations and documents

Abstract

Researchers and developers should develop a high-quality, integrated approach to the graphical presentation of all elements of human-computer (user) interface (HCI) design. Principles from information-oriented, systematic design can assist in providing guidance for simple, clear, consistent solutions to the design of menus, windows, icons, dialogue boxes, and control panels that are not explicitly specified by current graphical user interface (GUI) paradigms.

Introduction

Some researchers and developers think their user interface design problems are solved because industry conventions for window managers have emerged. However, programmers have discovered that graphical user interface (GUI) paradigms such as Microsoft Windows™, Motif™, Apple Macintosh™, or NextStep™ do not solve the essential task of visually communicating a product's data and functions.

In this tutorial article, you will learn how information-oriented, systematic graphic design can benefit graphical user interface design in conveying information about data and functions. Some basic principles of visual communication can go a long way towards achieving better graphical user interface design.

In the article, I introduce the terminology of visible language and discuss how to achieve effective visual communication in graphical user interfaces, electronic publishing, and presentations. I emphasized three basic principles: organize, economize, and communicate. I show how to apply those principles to the essential elements of typography, symbolism, and layout inherent in all menus, control panels, icons, and dialogue boxes whose visual attributes are not sufficiently specified by current GUI. In the concluding part of my tutorial, I cover the subject of color. This complex and interesting topic requires some detailed examination.

GUIs and Graphic Design

A GUI design must account for the following:

- A comprehensible mental image (metaphor)
- Appropriate organization of data, functions, tasks, and roles (cognitive model)
- Efficient navigation schema among these data and functions, tasks, and roles
- Quality appearance characteristics (the look)
- Effective interaction sequencing (the feel)

Graphic design can help GUIs achieve their potential to communicate. Information-oriented, systematic graphic design is the use of typography, symbols, color, and other static and dynamic graphics to convey facts, concepts, and emotions. Graphic design is found in almost every facet of life, from the design of books, films, magazines, and videos, to the design of exhibits, highway signage, and maps.

Information-oriented, systematic graphic design helps people understand complex information. So, why shouldn't graphic design help users find *their* way through data and functions, and make the trip more pleasant as well?

Information-oriented, systematic graphic design can help in almost every phase of product development providing effective communication for every kind of user, application, platform, and GUI

How is this possible? Because successful visual communication through information-oriented, systematic graphic design relies on some fundamental graphic design principles. Once you are aware of these principles, you will be able to appreciate why some displays are better than others, and, after a little practice, you'll find your own decision making and accomplishments are improving. You can apply these principles to the design of all typical GUI components: screens, windows, menus, dialogue boxes, control panels, icons, and pointers/cursors.

Design Considerations for Successful GUIs

When designing successful GUIs, development, usability, and acceptance factors are of critical importance.

© Copyright 1994 by **AM+A** Aaron Marcus and Associates, Inc. All Rights Reserved.

Development factors include the following: platform constraints, tool kits and component libraries, support for rapid prototyping, and customizability. In all of these areas, graphic design can help by improving visual communication.

Usability factors typically include the following: human abilities, product identity, clear conceptual model, and multiple representations. Again, graphic design principles can assist by taking into account human factors and expressing a strong visual identity.

Finally, acceptance factors include these: installed base, corporate politics, international markets, and documentation and training.

All of these factors benefit from improved visual communication in the user interface. A conceptually distinct organization, a visually consistent presentation, and an effective use of visible language contribute to improved visual communication.

Visible Language

The term “visible language” may not be familiar to you. The concept of visible language refers to all the graphical techniques used to communicate the message or content. The term includes the following:

- Layout: formats, proportions, and grids; two-dimensional and three-dimensional organization.
- Typography: selection of typefaces and typesetting, including variable-width sans-serif and serif fonts as well as fixed-width fonts found on most computer displays.
- Color and texture: color, texture and light that convey complex information and pictoral reality.
- Imagery: signs, icons, and symbols, from the photographically real to the abstract.
- Animation: a dynamic or kinetic display that is especially important for video-related imagery.
- Sequencing: the overall approach to visual storytelling.
- Sound: abstract, vocal, concrete, or musical cues. These have been called “earcons”, a pun on icons.
- Visual identity: the additional, unique rules that lend overall consistency to a user interface.

All information-oriented, systematic graphic design relies on these visual signs to convey meaning to a viewer. Notice that two strange items appear in the list. Obviously, sound is not visual, but acoustic cues increasingly will be part of the repertoire of the information designer of GUIs. The last item, visual identity, refers to overall decisions about how the corporation or the product line expresses itself in visible language.

The basic technique in achieving effective visual communication involves establishing explicit rules, specifications, and guidelines for visible language that affect the user interface.

Principles of User Interface Design

The manipulation of visible language is a basic task of user interface design. This set of principles can be a useful guide to professional practice, research, and development.

- **Organize:** Provide the user with a clear and consistent conceptual structure.
- **Economize:** Maximize the effectiveness of a minimal set of cues.
- **Communicate:** Match the presentation to the capabilities of the user.

Let’s look at each of these principles in detail.

Principle 1: Organize

The first principle is to get organized (see Figure 1). The Bauhaus artist and designer Josef Albers (*Despite Straight Lines*, Yale University Press) expressed it this way:

To design is to plan and organize,
to order, to relate, and to control.

In short, it embraces all means
opposing disorder and accident.

Therefore, it signifies a human
need and qualifies man’s thinking
and doing.

There are several important concepts within the major principle of organization: consistency, screen layout, relationships, and navigability

© Copyright 1994 by **AM+A** Aaron Marcus and Associates, Inc. All Rights Reserved.

Consistency

There are four important aspects of consistency: internal consistency, external consistency, real world consistency, and when *not* to be consistent, i.e., when to deviate from the norm.

The principle of internal consistency says: observe the *same* conventions and rules for *all* elements of the GUI. Figure 2 provides an example.
Casual differences should be avoided. Without a strong motivating reason, these casual differences cause the viewer to work harder to understand the essential message of the display.

The second point is external consistency: follow existing platform and cultural conventions across user interfaces. Figure 3 provides an example.

The lack of external consistency can cause confusion for users moving across applications. Imagine the chaos on the interstate highway network if the Stop sign changed visually from state to state! What we need for GUIs is the same kind of consistency for *conceptual* landscapes. Remember: designing a GUI is like designing a city full of exciting and useful people, places, and activities.

The third point is real world consistency: make the conventions consistent with real world experience. Figure 4 provides an example.

The fourth and last point is innovation: deviate from existing conventions only when doing so provides a clear benefit to the user. In other words, have a good reason for being inconsistent! In an article on the topic of consistency, Jonathan Grudin, a GUI researcher (see Bibliography), showed that sometimes it is impossible to avoid some kinds of inconsistency, and that inconsistency even can be beneficial. However, as a general rule, strive for consistency, without being slavish about it.

Screen Layout

The second major way to organize visual displays is to design their spatial layout or composition. There are three primary ways of achieving organization of screen layout: use a grid structure, standardize the screen layout, and group related elements.

Grids of horizontal and vertical lines can help locate items in menus, major window components, and other two-dimensional compositions such as dialogue boxes or control panels. The exact measurements must be worked out very carefully to take into account the content to be displayed, spaces between text groups, the screen resolution, and the viewing conditions. Generally, the maximum number of major divisions in the horizontal or vertical direction follows what human factors specialists call Miller's magic number, namely, 7 ± 2. This recommendation derives from the maximum number of coding items we can easily remember in short-term memory.

The same idea can be applied to a control panel, menu, dialogue box, or even the small area of icons, in which case a small grid helps to locate individual pieces of these pictograms and ideograms. Figure 5 shows some examples.

Relationships

Another technique helpful in achieving visual organization is to establish clear relationships by linking related elements and disassociating unrelated elements. This simple precept may be complex to carry out in practice. Figure 6 presents an example.

Navigability

The final means of organizing visual elements is navigability. Important techniques include these: provide an initial focus for the viewer's attention, direct attention to important, secondary, or peripheral items, and assist in navigation throughout the material. Figure 7 provides an example.

Principle 2: Economize! (or Make Do with What You Have)

In this first part of the tutorial we have introduced the subject of information-oriented, systematic graphic design for GUIs and the idea of visual language. We have looked at one important principal for achieving effective visual communication: organization. In this next section, we shall investigate how to use the best techniques to reach the user with the message of functions or data that the user interface must communicate.

The second major principle is to economize (doing the most with the least). Don Norman, a cognitive scientist, comments on economy, in his book *The Psychology of Everyday Things* (Basic Books, New York, 1969). Here are some excerpts:

- *How many controls does a device need?*

© Copyright 1994 by **AM+A** Aaron Marcus and Associates, Inc. All Rights Reserved.

- *The fewer the controls, the easier it looks to use and the easier it is to find the relevant controls...*

- *To make something look easy, minimize the number of controls.*

The concept of economy can be broken down into four major subtopics: simplicity, clarity, distinctiveness, and emphasis.

Simplicity suggests that we include only those elements that are essential for communication. In addition, we should be as unobtrusive as possible.

As they say in the business world, use the KISS method: Keep it *Supremely Simple*. Do *not* assume that your audience is stupid; we all have natural limits to the rate at which we can take in informational-rich content. If you exceed natural limits, you will induce indifference, boredom, or anxiety.

No matter to whom you're communicating, simplicity is a virtue, unless your objective is to confuse, entertain, or beautify, in which cases, overindulgence *may* be justified. In general, the GUI components should be modest and *not* overly attract the viewer's attention. Users should be almost unconscious of the GUI working to convey meaning. Figure 8 provides an example.

Keep It Crystal Clear

The second technique for being economical is clarity: design all components so that their meaning is not ambiguous. Figure 9 provides an example.

The third technique for achieving economy is distinctiveness: distinguish important properties of essential elements. Figure 10 illustrates this technique.

The final technique of economizing is emphasis. In general, make the most important elements *salient*, i.e., easily perceived. De-emphasize non-critical elements and minimize clutter so that critical information is not hidden. Figure 11 makes this point.

Principle 3: Communicate!

The previous comments explored the principles of organization and economy. The third main principle is, communicate! The visual communication researcher Sol Worth puts it this way in his book, *Studying Visual Communication* (University of Pennsylvania Press, Philadelphia)

Communication...is...a social process, within a specified context, in which signs are produced and transmitted, perceived, and treated as messages from which meaning can be inferred.

To communicate successfully, a GUI must keep in balance these factors: legibility, readability, typography, symbolism, multiple views, and color/texture.

The first factor is legibility: design individual characters, symbols, and graphic elements to be easily noticeable and distinguishable. Figure 12 shows some examples.

Typefonts, desktop icons, control panel symbols, etc. all need to be designed so that their parts show up well. You must select visualization techniques that are appropriate to the output display technology (*e.g.*, the spatial resolution, color, and animation characteristics). Keep in mind that many viewers over 40 years of age often need help with glasses or contact lenses just to see the screen well.

Another factor to remember is that dark screen backgrounds in brightly lighted rooms may cause distracting reflections that can diminish screen legibility. In contrast, brightly lighted screens in dark rooms may be too glaring and hard to see.

Closely related to legibility is readability. The term readability means that the display is comprehensible, i.e., easy to identify and interpret, as well as inviting and attractive. Figure 13 presents an example.

One of the key contributors to legibility and readability is the use of typography in the user interface. We still rely on text, tables, lists, and annotation, even if we are showing charts, diagrams, or other graphical displays. Typography includes the characteristics of individual elements (typefaces and typestyles) and their groupings (typesetting techniques).

Use a small number of typefaces of suitable legibility, clarity, and distinctiveness to distinguish between different classes of information. Within each typeface, select a set of enhanced letterforms, punctuation marks, and symbols. Figure 14 provides some examples. Usually, one to three typefaces are sufficient for most situations, even the very complex code displays that Ron Baecker and I recommend for code visualization in our book *Human Factors and Typography For More Readable Programs*

© Copyright 1994 by **AM+A** Aaron Marcus and Associates, Inc. All Rights Reserved.

(see Bibliography).

The third and final typographic recommendation concerns typesetting: Within menus, dialogue boxes, control panels, forms, and other window components, adjust the point size, word spacing, paragraph indentation, and line spacing to enhance the readability and to emphasize critical information.

The following are some basic recommendations:

- Generally, you should use a maximum of three typefaces in a maximum of three sizes, no matter what the application.

- Lines of text should have from 40 to 60 characters maximum, and words should be spaced correctly, usually the width of a lower case “r” or “i” for a variable-width text.

- Text should be set in appropriate formats, that is, set text flush left, set numbers flush right, avoid centered text in lists, and avoid short justified lines of text.

- For fixed-width fonts, justified lines of text can slow reading speed by 12 percent.

Use upper and lower case characters whenever possible, i.e., avoid all capital lines of text, which can also slow reading speed by 12 percent.

Of course, one can always find exceptions to these guidelines, but the basic recommendations should serve for most typographic settings.

Making Sense of Symbolism

Typographic characters are not the only visible language elements that must be designed so that they communicate their content efficiently. Icons, symbols, charts, maps, diagrams, and photographic imagery used in the displays also must be carefully selected and refined to communicate the desired contents.

The specific principles for designing charts, maps, diagrams, pictograms and ideograms are more numerous than space permits at this time. The Bibliography provides references to some outstanding sources of guidelines and case studies, such as the work of Tufte, Bertin, and Ota.

Multiple Views

One important technique for improving communication in the user interface is to provide multiple perspectives on the display of complex structures and processes. An important principle of good design, then, is making use of these multiple views:

- Multiple forms of representation
- Multiple levels of abstraction
- Simultaneous alternative views
- Links and cross references
- Metadata, metatext, metagraphics

Figure 15 shows two examples.

Color/Texture

Our final topic, color, is a very complex subject and will be treated specially to conclude this tutorial. Color can be a powerful tool for communication if used correctly. The basic recommendation is this: use appropriate highlighting and deemphasis techniques to convey meaningful semantic distinctions.

A human factors researcher, Dr. Gerald Murch, comments on color in his paper “The Effective Use of Color in Visual Displays: Text and Graphics Applications” this way: “Color can be a powerful tool to improve the usefulness of an information display in a wide variety of areas if color is used properly. Conversely, the inappropriate use of color can seriously reduce the functionality of a display system.”

Color Terms and Concepts

Color discussions can be confusing because scientists, artists, designers, programmers, and marketing professionals describe color phenomena in different ways. Let’s first discuss the color terms using one useful set of dimensions: hue, value, and chroma. These color terms are derived from the Munsell system of color used by artists, designers, and manufacturers. The dimensions differ from the red, green, and blue basis of the “RGB” color system familiar to users of CRT display devices. The approach also differs from another color system, the International Commission on Illumination (CIE), which uses specific spectral measurements to unambiguously specify color.

Hue is the spectral wavelength composition of a color that produces perceptions of being blue, orange, green, etc. Value is the relative amount of lightness or darkness of the color in a range of black to white (also called intensity).

Chroma is the purity of the color in a scale from gray to

© Copyright 1994 by **AM+A** Aaron Marcus and Associates, Inc. All Rights Reserved.

the most vivid variant of the perceived color (also called saturation). Figure 16 shows the interrelations of all of these dimensions. Brightness, a fourth key term, refers to the amount of light energy creating the color. Different amounts levels of brightness affect the shape and size of the hue-value-lightness solid.

The circle of hues, the vertical range of values, and the range of chromas going out from the central vertical axis provide a basic specification of the color. Note that one further dimension, brightness, is required, which refers to the amount of energy in the light. In effect, there is a color solid for each brightness level, and the detailed, shape of the color solid change somewhat, based on the human eye's performance characteristics.

One important point to bear in mind is that color combinations can take place in different media in several ways. Figure 17 shows three typical means of combining color. At the left, primary colors of illuminated light like red, blue, and green, additively combine in pairs to produce magenta, cyan, and yellow, and together produce white light.

In the center, primary colors of pigment like red, blue, and yellow subtractively combine to produce a dark brown-black. CRT screens typically combine light additively, while most hardcopy color is obtained through subtractive mixtures of pigments, dyes, or tints.

At the right is an example of optical mixture in which small lines blend into a single color. Typical four-color process printing of images on paper uses closely spaced small dots of cyan, yellow, and magenta, plus black (the graphic arts industry's CYMK specification of color) to achieve an optical mixing of colors due to the eye's inability to resolve the individual color elements in "full-color" graphic arts printing.

A typical need for screen design is to combine colors so they make visual sense. Artists and designers have proposed several basic approaches to harmonious combinations, which are illustrated in Figure 18.

Beyond the basic technology of color for screen display, it is important to understand how color can help communication. Here are some basic advantages:

- Emphasize important information
- identify subsystems or structures
- Portray natural objects realistically
- Portray time and progress
- Reduce errors of interpretation
- Add coding dimensions
- Increase comprehensibility
- Increase believability and appeal

With respect to learning and comprehension, color is superior to black-and-white in terms of the viewer's processing time and emotional reactions, and there is a difference in a viewer's ability to interpret information. People often can learn more from a color display if color is used correctly. Another crucial factor is that color is more enjoyable. With respect to memory performance, memory for color information appears to be superior to black-and-white.

These benefits indicate that color can work for you in communicating facts, concepts, and emotions; but color is definitely a complex tool. At the same time, color has these potential drawbacks:

- Color requires more expensive and complicated display equipment.

- Color displays may not accommodate color deficient vision, which occurs in about 8 percent of Caucasian males.

- Some colors may cause visual discomfort and afterimages.

- Color may contribute to visual confusion or may catalyze negative associations through cross-disciplinary and cross-cultural connotations.

Because color can be misused easily, there is a clear need for guidelines. Establishing complete rules or specifications for color use is difficult. The International Standards Organization (ISO) has begun by publishing draft standards for some aspects of basic color legibility. Their report and some general guidelines on color are referred to in the Bibliography.

Color Design Principles

To keep recommendations simple, we can refer to the original three basic principles, but this time apply them to color. We'll examine selected guidelines under each principle: color organization, color economy, and color communication.

Color Organization

The first set of recommendations about color concerns consistency of organization. Use color to group related items, and use a consistent color code for screen

© Copyright 1994 by **AM+A** Aaron Marcus and Associates, Inc. All Rights Reserved.

displays, documentation, and training materials. Figure 19 presents an example.

In general, similar colors should imply a relation among objects. A viewer can sense the relatedness by color over space and over time in sequences of images. Be complete and consistent in your color groupings. For example, command and control colors in menus should be avoided for information coding within a work area, unless a specific connection is intended. Another recommendation is to use similar background colors for related areas. This color coding can subtly orient the viewer to the conceptual link among these areas.

Once color coding is established, the same colors should be used throughout the GUI and all related publications. This color continuity may require designing colors to appear in different media. Remember: CRT screens use additive color mixtures, while most hardcopy devices use subtractive color mixtures. The color gamuts (that is, available color ranges) of these two media usually are not identical.

Color Economy

The next recommendations concern economical use of color:

The principle of color simplicity suggests using a maximum of 5±2 colors where the meaning must be remembered. Note that this maximum is even less than the so called Miller's magic number from human factors, 7±2. If appropriate, use redundant coding based on shape as well as color.

The basic idea is to use color to enhance black-and-white information, that is, design the display to work well first in black-and-white.
For documentation tasks, for example, using color to portray an object, the maximum number of colors needed is dependent on the application. For aesthetic purposes such as design style, emotional expression, or realism, many more colors may be required. Figure 20 shows some examples of using minimal color.

In figure 20 at the left, 5±2 colors may use a set of a few grays and some strongly different hues, or the set may use only different values for a given hue.

In the center, the rainbow is a reminder to use spectral order in color coding. To code a large set of colors, use the spectral sequence: red, orange, yellow, green, blue, and violet. Francine Frome, a human factors researcher (see Bibliography), has shown that viewers see a spectral order as a natural one and would select red, green, and blue as intuitive choices for the front, middle, and back layers, respectively, when viewing a multi-layer display.

Note, however, that brightness can change a viewer's perception of depth. If the colors are balanced, then red seems to come forward.

At the right, the images are a reminder to use redundant coding of shape as well as color, which aids those with color deficient vision and makes the display more resilient to color distortions caused by ambient light changes or by medium-to-medium conversion. Ambient light can cause changes in perceived hue, value, and chroma. Conversion from one medium to another can cause unforeseen and sometimes uncontrollable changes. Remember that among Caucasian viewers, 8% of males have some form of color-deficient viewing.

Color Emphasis

Among the remaining principles, color emphasis suggests using strong contrast in value and chroma to focus the user's attention on critical information.

The use of bright colors for danger signals, attention getters, reminders, and cursors is entirely appropriate. High chroma red-alerts seem to aid faster response than yellow or yellow-orange if brightness is equal, but of course this also depends upon the background colors. When too many figures or background fields compete for the viewer's attention, confusion arises, as can happen in the Las Vegas approach to color design. The hierarchy of highlighted, neutral, and lowlighted states for all areas of the visual display must be carefully designed to maximize simplicity and clarity. Here again we find the basic maxim: simplicity, clarity, and consistency are especially important for color design.
Use saturated or high-chroma colors for older viewers, or for those who have viewed displays for very long periods of time. Bear in mind that frequent, but short term viewing can benefit from low-chroma displays, and that very bright displays of letters, symbols or lines tend to bloom, that is, the light spreads out against the background.

Color Communication

In color communication, recommendations for legibility include the following: use colors appropriately for the central and peripheral areas of the visual field. Use color combinations whose discriminability is influenced least by the relative area of each color. Do not use

© Copyright 1994 by **AM+A** Aaron Marcus and Associates, Inc. All Rights Reserved.

colors that are simultaneously high in chroma and spectrally extreme. Figure 21 presents some examples.

The outer edges of the retina are not particularly sensitive to colors in general. Thus, red or green should be used in the center of the visual field, not in the periphery, as in the example at the left. If they are used at the periphery, some signal to the viewer must be given to capture attention, e.g., size change or blinking. Use blue, black, white, and yellow near the periphery of the visual field. The retina remains sensitive to these colors near the periphery.

Color Interactions

The interaction of color is a very complex subject that cannot be presented in this limited space. The basic text on the subject is Albers' book, *The Interaction of Color* (see Bibliography). Designers of user interfaces need to become familiar with there phenomena, which students of art and design often study. Figure 22 shows two examples of color interaction phenomena.

Color Symbolism

Finally, we recall the importance of symbolism in communication: use color codes that respect existing cultural and professional usage. Figure 23 shows typical examples.

Use color connotations with great care. Connotations vary strongly among different kinds of viewers, especially from different cultures. The correct use of color requires careful analysis of the experience and expectations of the viewers.

For example, mailboxes are blue in the USA, bright red in England, and bright yellow in Greece. If color is used in an electronic mail icon on the screen, this suggests that color sets might be changed for different countries to allow for differences in international markets.

Conclusion

The many recommendations of this tutorial are based on three basic principles: organize! economize! and communicate! These principles may not solve all of the precise GUI design challenges that researchers, developers, and other professionals face when using available GUI paradigms, but these principles can point you in the right direction and get you started.

The next task is to incorporate these principles into your own individual design efforts so that your GUI prototypes and products are better because they communicate their message more effectively. A next stage is to incorporate the principles into your own styleguides, templates, and clip-art so that others may adapt and apply these principles of effective communication.

Developing better visual communication in GUIs will make it possible for everyone to benefit from the capability of high performance computer graphics systems to communicate more efficiently and effectively through high performance graphic design.

Acknowledgments

This article is a slightly edited version of three articles that appeared in *UnixWorld*, 1990, cited in the Bibliography and are reprinted with the permission of *UnixWorld* and McGraw-Hill. The article is based on principles identified in Baecker and Marcus, *Human Factors and Typography for More Readable Programs* (see Bibliography). The current formulation was developed for *MacWeek*'s first national user's conference on user interface design for the Macintosh, MacWeek ID 89, October 1989, and are presented in a videotape available from Aaron Marcus and Associates, Inc. The author would like to thank the following past and current members of his staff for their assistance in preparing this article in its original form: David Collier, N. Gregory Galle, Grant Letz, Sherry Markwart, Adam Miramon, Kevin Mullet, and Sandra Ragan.

Bibliography

Albers, Josef, *Interaction of Color*, Yale University Press, New Haven, 1975.

Baecker, Ronald, and Marcus, Aaron, *Human Factors and Typography for More Readable Programs*, Addison-Wesley, Reading, Mass., 1990.

Bertin, Jacques, *Semiology of Graphics,* University of Wisconsin Press, 1083.

Durrett, H. John, ed., *Color and the Computer*, Academic Press,Orlando, Florida, 1987.

Durrett, John and Judi Trezona, "How to Use Color Displays Effectively," *Byte,* Vol. 7, No. 4, April 1982, pp. 50-53.

© Copyright 1994 by **AM+A** Aaron Marcus and Associates, Inc. All Rights Reserved.

Frome, Francine, “Incorporating the Human Factor in Color CAD Systems,” *IEEE Proceedings of the 20th Design Automation Conference,* 1983, pp. 189-195.

Grudin, Jonathan, “The Case Against User Interface Consistency,” *Communications of the ACM,* Vol. 32, No. 10, October 1989, pp. 1164-1173.

International Standards Organization (ISO) “Computer Display Color,” Draft Standard, Doc. 9241-8, ISO, Zurich, 1989.

Jones, Gerald E., “Color Use, Abuse in Presentations,” *Computer Graphics World*, Vol. 9, No. 5, May 1986, pp. 119-120ff.

Marcus, Aaron, “Color: A Tool for Computer Graphics Communication,” in Greenberg, Donald, *et al*., *The Computer Image*, Addison-Wesley, Reading, 1982, pp. 76-90.

Marcus, Aaron, “Users Must Establish Own Rules for Color, “ *Computer Graphics Today*, Vol. 2, No. 9, September 1985, pp. 7ff.

Marcus, Aaron, “The Ten Commandments of Color,” *Computer Graphics Today,* official publication of the National Computer Graphics Association, Media Horizons, Inc., New York, November 1986, pp. 7ff, reprinted in part in *Color News*, Vol. 2, No. 2, Pantone Color Institute Newsletter, Pantone, Inc.,1987.

Marcus, Aaron, “The User Interface Standards Manual: A Tool for Effective Management,” *Proceedings*, National Computer Graphics Association National Conference, Philadelphia, 22-26 March 1987, Vol. 3, Technical Sessions, pp. 461-470.

Marcus Aaron, “Computer Iconographics: Readings on Signs,” *Computer Graphics Today*, official publication of the National Computer Graphics Association, Media Horizons, Inc., New York, Vol. 4, No. 7, July 1987, pp. 19-20.

Marcus, Aaron, “Design Tips for Winning Forms,” *Computer Graphics Today*, Vol. 5, No. 11, November 1988, pp. 27ff., and in excerpted form in Marcus, Aaron, “Design Tips for Developing Good Form,” *Publish!*, Vol. 3, No. 6, PCW Communications, San Francisco, June 1988, p. 68.

Marcus, Aaron, “Visual Arts: Tips for Icon Design,” *Computer Graphics Today,* official publication of the National Computer Graphics Association, Media Horizons, Inc., New York, Vol. 6, No. 1, January 1989, pp. 24.

Marcus, Aaron, “Designing Graphical User Interfaces,” three-part article, *UnixWorld*, Vol. 7, No. 8, August 1990, pp. 107-116; No. 9, September 1990, pp. 121-127; No. 10, October 1990, pp. 135-138.

Murch, Gerald M., “Effective Use of Color: Cognitive Principles,”*Tekniques*,
Vol. 8, No. 2, Summer 1984, pp. 25-31.

Murch, Gerald M., “Physiological Principles for the Effective Use of Color,” *IEEE Computer Graphics and Applications*, Vol. 4, No. 11, November 1984, pp. 49-54.

Ota, Yuko, *Pictogram Design*, Kawashi Shobo Publishers, Tokyo, Japan, 1987

Rehe, Rolf F.,*Typography: How to Make it Legible,* Design Research International, Carmel, Indiana, 1974.

Taylor, Joann M. and Gerald M. Murch, “The Effective Use of Color in Visual Displays: Text and Graphics Applications,” *Color Research and Application,* Vol. 11, Supplement 1986, pp. S3-S10.

Thorrell, L. G. and W. J. Smith, *Using Computer Color Effectively: An Illustrated Reference*, Prentice Hall, Englewood Cliffs, NJ. 1990.

Tufte, Edward R., *The Visual Display of Quantative Information Maters,* Graphics Press, Chelshive, Connecticuit, 1983.

Author’s Biography

Aaron Marcus received a BA in physics from Princeton University (1965) and a BFA and MFA in graphic design from Yale University Art School (1968). He is an internationally recognized authority on the design of human-computer interfaces and electronic publishing documents, including chart, form, document, icon, and screen design. He has given tutorials at SIGGRAPH, NCGA, and SIGCHI conferences in addition to seminars at businesses and academic institutions in the USA, Canada, Australia, Israel, Finland, Singapore, and Japan.

© Copyright 1994 by **AM+A** Aaron Marcus and Associates, Inc. All Rights Reserved.

As president of Aaron Marcus and Associates, Inc., he and his staff design user interfaces, electronic publishing documents, multimedia, and information displays, such as the visualization of complex structures and processes, executive presentations, and libraries of clip art and templates for computer graphic systems for such clients as Apple, Canon Information Systems, Digital Equipment, Dupont, Eastman Kodak, Hewlett-Packard, IBM, MCC, McDonnell-Douglas, Motorola, NCR, Prime-Computervision, Reuters, Ricoh, and 3M, among others.

Figures

Figure 1: Chaotic Screen, Ordered Screen. This figure summarizes the ideas of being consistent, using an organized screen layout, making relationships clear, and assisting the user's navigation. This example is *not* intended to imply that tiled screen layouts are always the *correct* solution.
Figure 2: Internal Consistency: Dialogue Boxes. In general, you should maximize the similarity of the major components of a user interface, i.e., maximize the regularity of the location and appearance of all items. In the two examples of dialogue boxes, notice that the same kinds of elements are shown in the same place, and those with different kinds of behavior each have their own special appearance.

Figure 3: External Consistency for Text Tool Icons. These text tool icons come from different applications but generally have the same meaning in desktop publishing. The obvious lack of consistency has a negative impact on users using new or similar products.

Figure 4: Real World Consistency: Highway Signage for Screen Display Icons. It is possible to take advantage of objects, processes, or events that are already familiar to the user and build upon this knowledge. This principle is the basis of the success of the desktop metaphor.

Figure 5: Screen, Control Panel and Icon Grids. Screen, control panel and icon grids show how a set of horizontal and vertical lines control size, location, and extent of visual elements.

Figure 6: Relationships. In the example at the left, shape, location, and color can all create strong visual relationships that may be completely inappropriate. Ask yourself if all the bold items are related. Probably not. In the improved example on the right, the relationships are clear, consistent, appropriate, and strong. These monochrome examples are not intended to suggest that monochrome displays are superior, only that the out-of control visual relationships in the example at the left have been brought into greater control.

Figure 7: Navigation. In this example of poor design and improved design, notice how very simple techniques of spatial layout and color (in this case gray values) can help focus the viewer's attention to the most important titlebar areas of the display. Then, the bulleted items guide the viewer through the secondary contents.

Figure 8: Complicated and Simpler Designs. In the example on the left, the design is overdone, with useless differentiation. At the right, the presentation is simpler, with fewer extraneous changes of direction, typefaces, and capitalization. Once you have reduced the display to its utmost simplicity, you can *then* begin to add more as soon as you can justify the additions.

Figure 9: Ambiguous and Clear Icons. In these examples of icons, notice how the ones on the left can be confusing, while the ones on the right are more understandable. Note that the same symbol appears in two situations.

Figure 10: Too Little and Too Much Distinctiveness. The first example shows a typical screen design in which everything is too bland, too much the same. The second example shows a typical Las Vegas approach in which *every* component is trying to be too distinctive. A happy medium is the correct solution.

Figure 11: Too Much and Improved Emphasis. The busy figure that you have seen before emphasizes too many things at once, making a clutter. The second example establishes a clear hierarchy. Remember that this approach can be used in achromatic (black, gray, white) as well as polychrome displays.

Figure 12: Illegible and Legible Texts. The top left example is a classic case of an illegible font. The example below it shows differences in size that are too minimal.

© Copyright 1994 by **AM+A** Aaron Marcus and Associates, Inc. All Rights Reserved.

Figure 13: Unreadable and Readable Texts. The top example shows a more unreadable text in which it is difficult to detect the presence of a subtitle. The second example shows a more readable arrangement of the same contents.

Figure 14: Typefaces and Typestyles. Small caps, and special characters that are routinely available for CRT display, as for laser printers, and other hard copy devices.

Figure 15: Verbal and Visual Multiple Views. With multiple views, you can provide the user with the ability to view simultaneously a major "focus" plus additional information on a single screen. You can also provide links and cross references among these views to facilitate navigation through the contents.

Figure 16: Color Dimensions. The image presents color interrelationships in a simplification of a hue, value, and chroma space based on the TekHVC color model. Detailed descriptions of this color space and others appear in the Appendix on color specification systems.

Figure 17: Color Mixtures Showing Additive, Subtractive, and Optical Mixtures. Typical display media use different means of achieving color mixtures. CRT displays use additive mixtures while hardcopy devices use subtractive. Both can use optical mixtures.

Figure 18: Color Harmonies. The approaches show (beginning at the top left) adjacent hues, varying values of a single hue, varying chromas of a single hue, opposing hues (complementary hues), nearly opposing hues (split complements), and equidistant hues (triads).

Figure 19: Color Consistency. On the left, multiple elements unrelatead but with similar colors, can cause confusion about which elements should be understood as a group. On the right, color is used together with location to reinforce grouping. Keep in mind that different values of the same color or different shapes of the same hue can be used to group related elements.

Figure 20: Color Simplicity. Limiting the number of colors, in color codes using a spectral order, and/or using redundant coding of shape increase the simplicity of a color display.

Figure 21: Color Legibility. Correct use of colors that account for the retina’s physiological characteristics can improve the legibility of color displays.

Figure 22: Color Interactions. Color interactions with the background color fields can create illusions like that shown in the first example: one color appears like two and two different colors appear like one. This illusion often occurs in area maps or complex diagrams. Colors must be chosen to avoid these illusions. The second example shows Mach banding, in which flat areas of color give a fluted effect, like the sides of a column.

Figure 23: Color Symbolism. Commonly used codes are the traffic light at the left (often used in executive displays for exception reporting); the colors of writing: (black on white with red highlighting, used in financial accounting) and the typical colors of water, earth, and vegetation used in maps.

© Copyright 1994 by **AM+A** Aaron Marcus and Associates, Inc. All Rights Reserved.

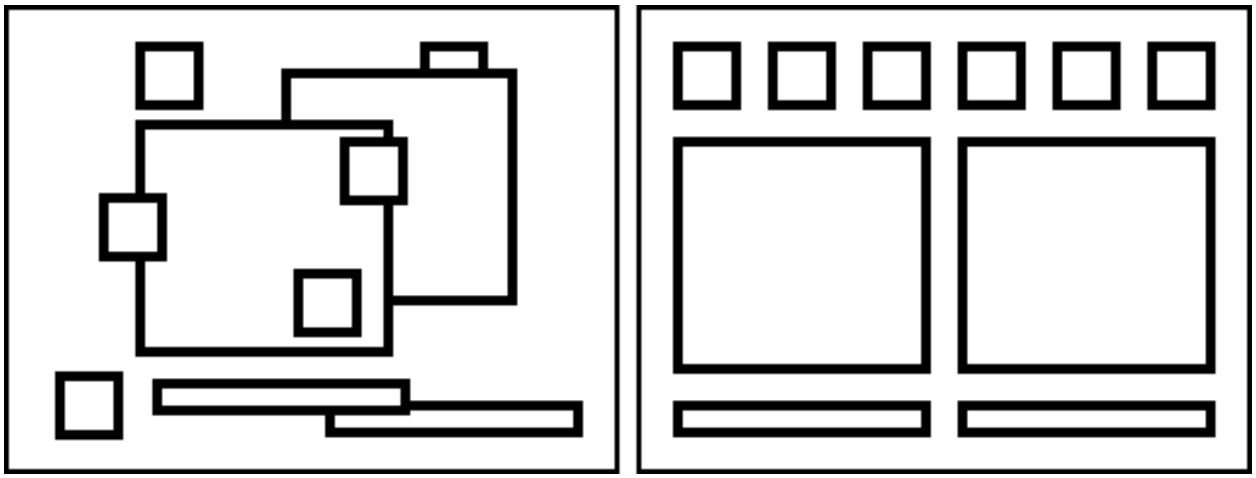


Figure 1: Chaotic Screen, Ordered Screen

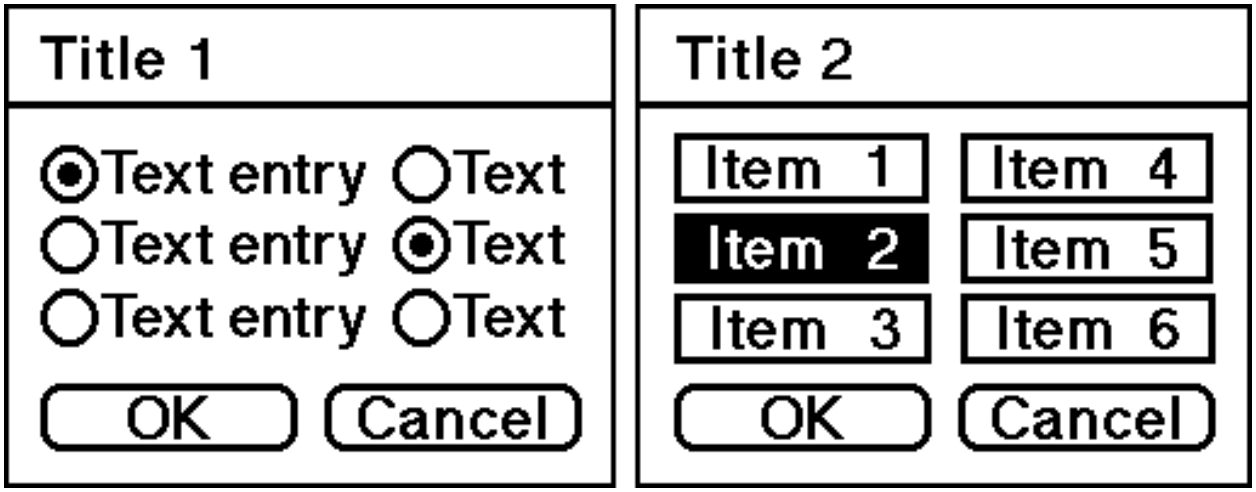


Figure 2: Internal Consistency: Dialogue Boxes

Figure 3: External Consistency for Text Tool Icons

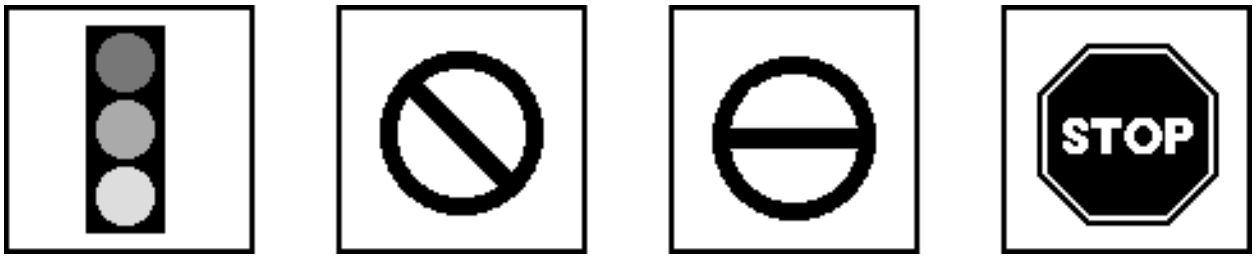


Figure 4: Real World Consistency: Highway Signage for Screen Display Icons

© Copyright 1994 by **AM+A** Aaron Marcus and Associates, Inc. All Rights Reserved.

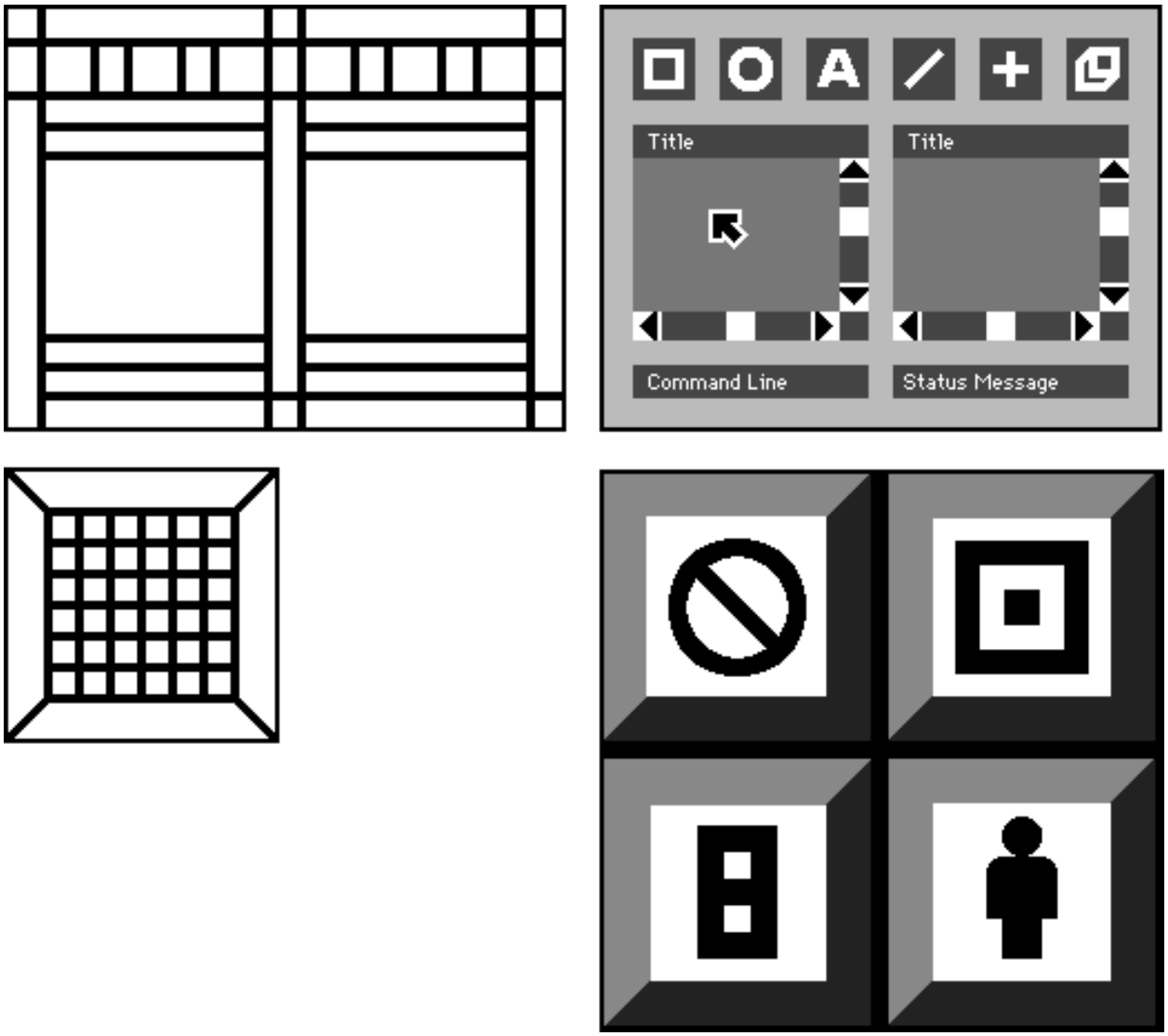


Figure 5: Screen, Control Panel and Icon Grids

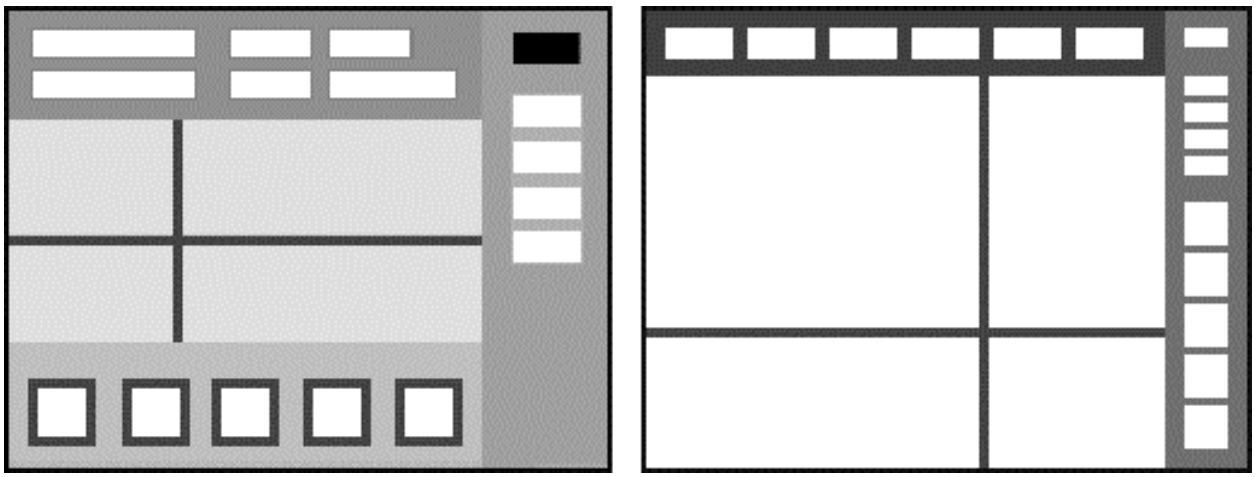


Figure 6: Relationships

© Copyright 1994 by **AM+A** Aaron Marcus and Associates, Inc. All Rights Reserved.

Figure 7: Navigation

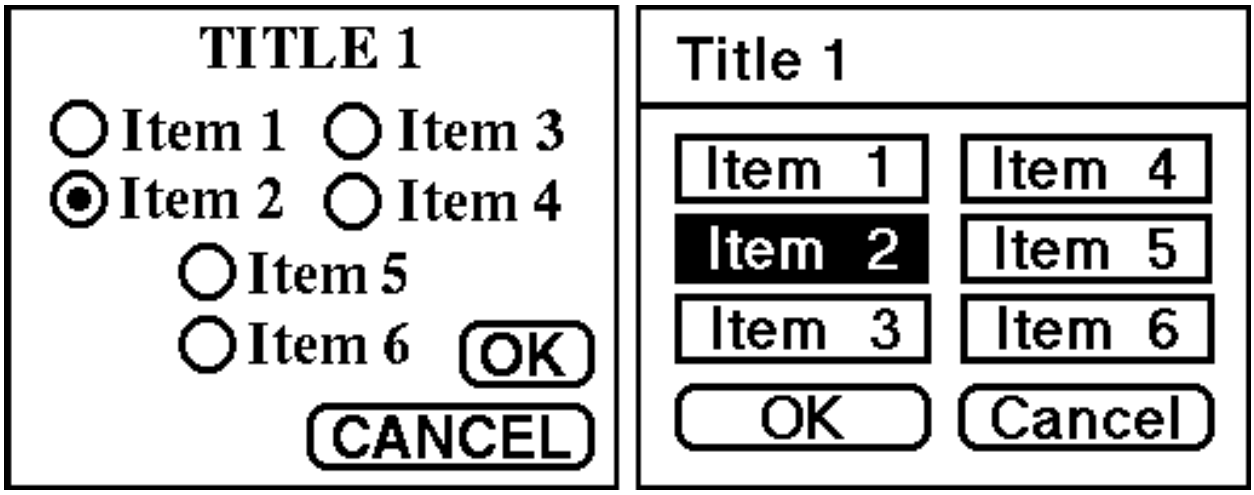


Figure 8: Complicated and Simpler Designs

© Copyright 1994 by **AM+A** Aaron Marcus and Associates, Inc. All Rights Reserved.

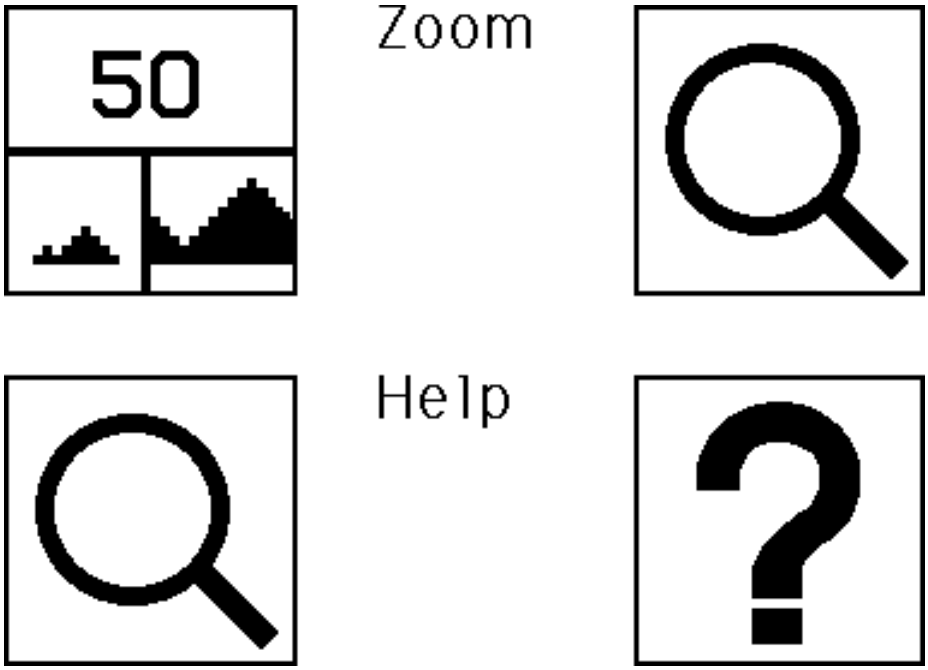


Figure 9: Ambiguous and Clear Icons

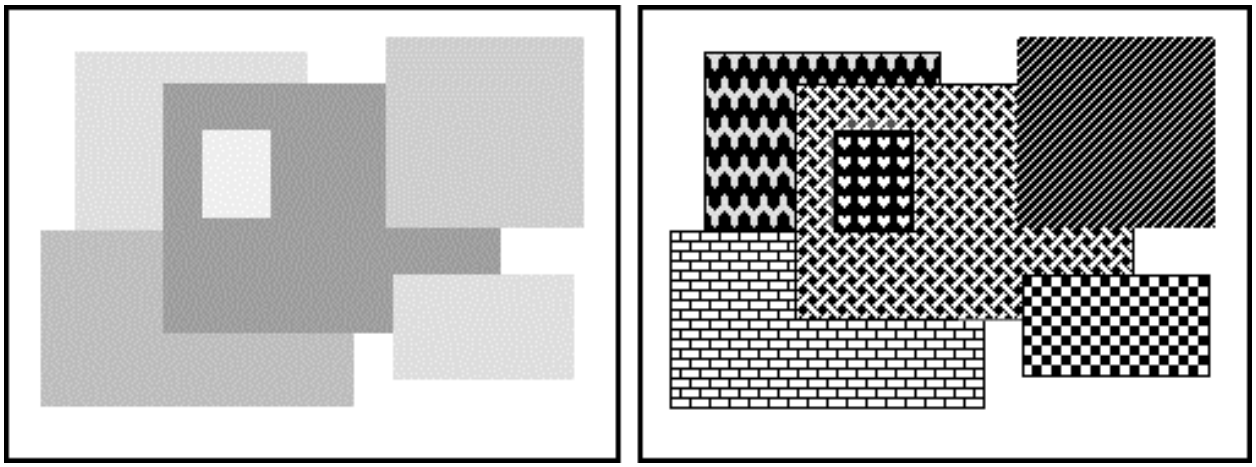


Figure 10: Too Much and Too Little Distinctiveness

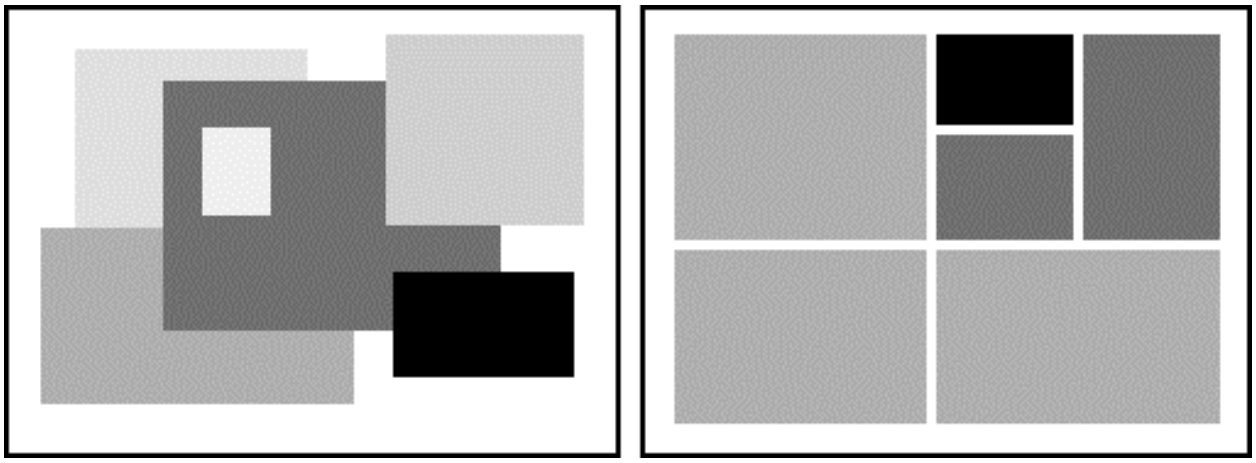


Figure 11: Too Much and Improved Emphasis

© Copyright 1994 by **AM+A** Aaron Marcus and Associates, Inc. All Rights Reserved.

Illegible	Legible	Illegible	Legible
Text Set in Old English	Text Set in Universe	Large Medium Small	Large Medium Small

Figure 12: Illegible and Legible Texts Based on Fonts and Relative Sizes

Unreadable: Design components to be easy to interpret and understand. Design components to be inviting and attractive

Readable

Design components to be easy to interpret and understand

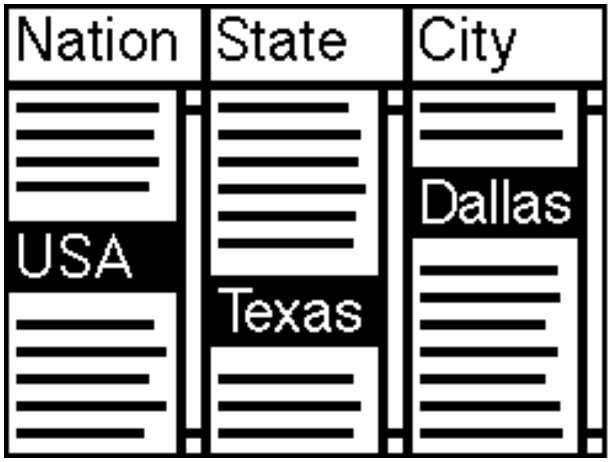
Design components to be inviting and attractive

Figure 13: Unreadable and Readable Texts

Univers
Helvetica
Times Roman
Palatino
Courier

ABCDEfghijkl
ABCDEfghijkl
ABCDEfghijkl

Figure 14: Typefaces and Typestyles



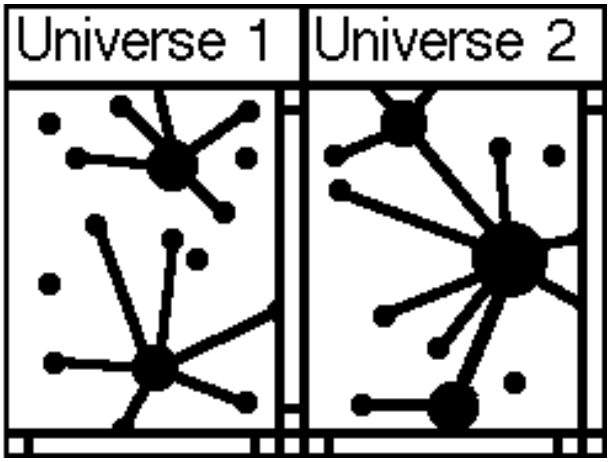


Figure 15: Verbal and Visual Multiple Views

© Copyright 1994 by **AM+A** Aaron Marcus and Associates, Inc. All Rights Reserved.

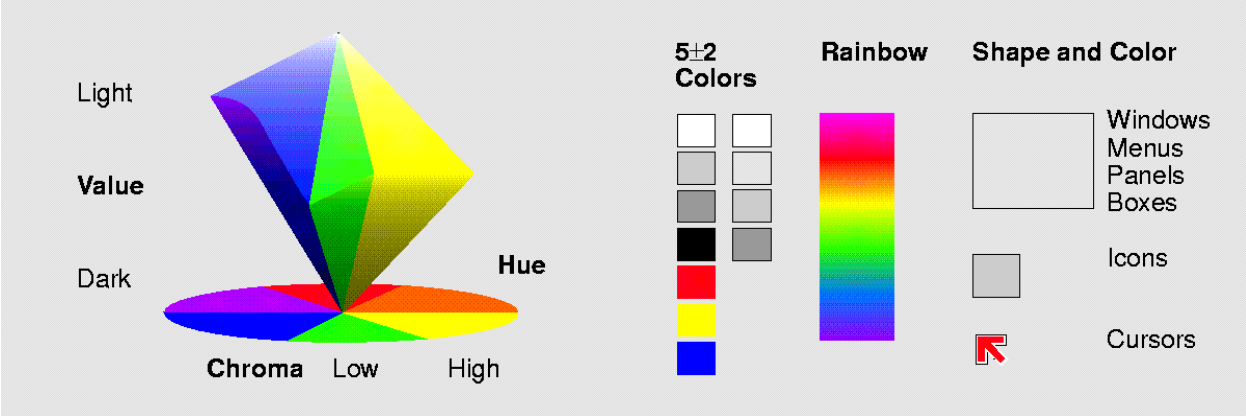


Figure 16: Color Dimensions

Figure 17: Color Simplicity

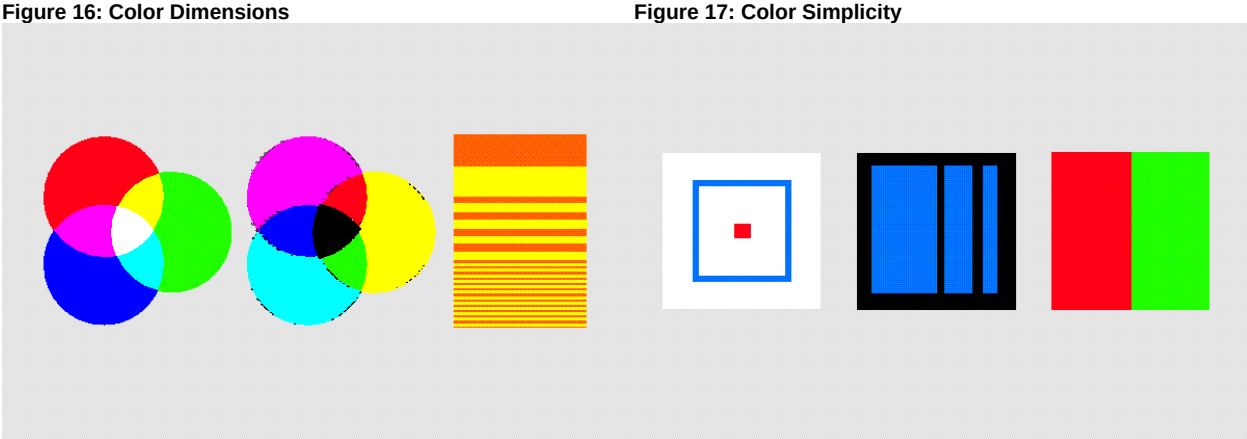


Figure 18: Color Mixtures

Figure 19: Color Legibility

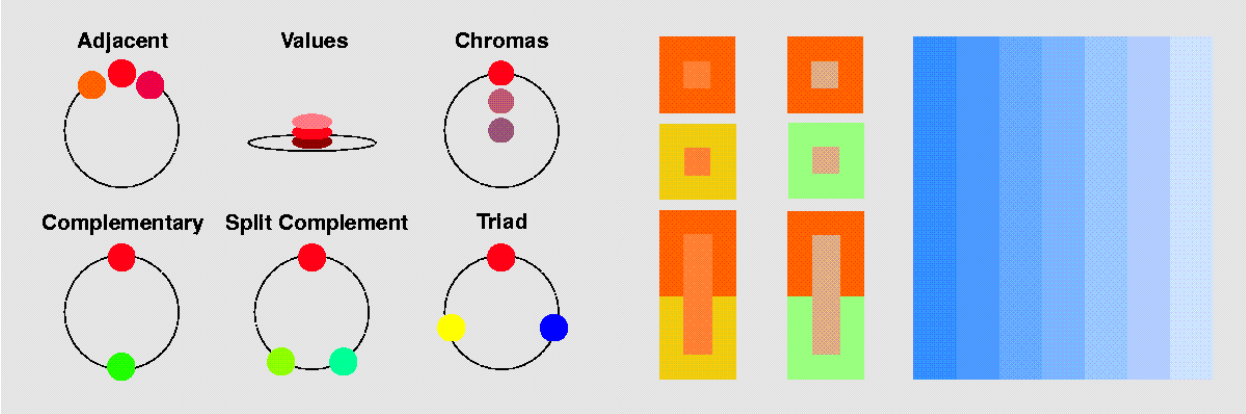


Figure 20: Color Harmony

Figure 21: Color Interactions

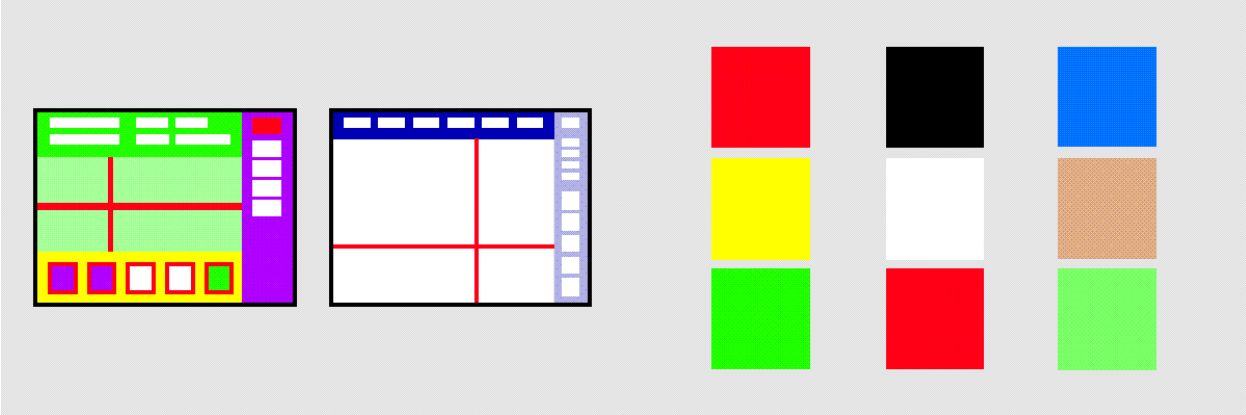


Figure 22: Color Consistency

Figure 23: Color Symbolism

© Copyright 1994 by **AM+A** Aaron Marcus and Associates, Inc. All Rights Reserved.

AM+A

California

Aaron Marcus and Associates, Inc.
California and New York

1144 65th Street, Suite F
Emeryville, CA 94608-1053 USA

Tel: 510-601-0994
Fax: 510-547-6125
E-mail: Mail@AMandA.com
Web: www.AMandA.com

Mastering Web Design
User Interface Issues In Web Design

Date May 1996, reprint

Client SYBEX, Inc.

Publication Mastering Web site Publishing (ISBN 0-7821-1911-5)
Sybex Computer Books
Sybex, Inc.

Client Contact John McCoy, Senior Editor
SYBEX, Inc.
1151 Marina Village Parkway
Alameda, CA 94501

Author Mr. Aaron Marcus, President
Aaron Marcus and Associates, Inc. (AM+A)

Copyright Notice © Copyright 1996 by Aaron Marcus and Associates, Inc.

Abstract Web site development has focused in the recent past on technical issues and how to improve the appeal of Web sites through the addition of functional components (interactivity, chatrooms, bulletin boards, etc.) Many Web sites suffer from insufficient attention to user interface design issues whose focus is on usability and productivity through user-centered, task-oriented design. Successful Web site design consists of both general and unique solutions to the design of metaphors, mental models, navigation, appearance, and interaction characteristics. Designs can be evaluated according to professionally established criteria in the user interface design community.

User Interface Issues in Web Design

Since the early 1980s, hypertext and hypermedia systems began to flourish. In the last few years, the spectacular growth of Internet use—in particular, the World-Wide Web—has focused attention on the possibilities and challenges of good communication in Web sites. During that same period beginning in the 1980s, graphical user interface (GUI) designers have been sensitized to an increasingly complex set of design issues that promote utility, appeal, and productivity—in short, “user friendliness.”

Because of the perceived need for Web sites and the availability of some tools, even if some are still in a rudimentary stage of development, many neophytes have suddenly found themselves assigned the task of building a Web site and have begun to call themselves Web site designers. In addition, many professionals from related fields such as illustration, technical editing, computer science, and graphic design, to name a few, have jumped into this new area of computer-based visual communication. The situation is similar to the early days of desktop publishing.

Too often, analyses of Web sites have focused on technical issues of setting up and maintaining systems. Articles in industry publications often focus on the extent of information content and links, the functional capabilities of the sites (whether they have chat rooms, bulletin boards, interactive forms, transaction capability, etc.) or appeal (whether their imagery grabs viewers to a site or page). Beyond these considerations lie the user interface design of the Web site—the sum total of its controls and displays, which affect the appeal to user, but which also affect the user’s ease of learning, ease of use, and productivity.

User interface research and development have given considerable attention to user interfaces for business productivity tools, training environments, and consumer products, on both applications and interactive documents or hypermedia search/retrieval environments. There are many valuable lessons for both neophytes and professionals to be learned by applying some of the insights gained in the user interface design community to Web site design. The legacy and ongoing research undertaken in the user interface design community is extensive and easily available. Resources for information, user interface-oriented design organizations, and new technology sites on the Web plus a bibliography on the subject appear at the close of this article. This article introduces some key issues and provides examples of what can make the user interface design of a Web site more successful.

© 1996 Aaron Marcus and Associates, Inc., AM+A.. All Rights Reserved.

What are User Interfaces?

User interfaces are a mixture of functional and formal content. One definition of user interfaces is the physical display of informational, aesthetic, and persuasive content affording the means for interacting with that content. For the purposes of specific users and their tasks, user interfaces provide metaphors, mental models, navigation, appearance (including sound, for example), and interaction. These components may be defined in this way [Marcus, 1995]:

- *Metaphors: the essential terms, images, and concepts*
- *Mental Model: the organization of data, functions, tasks, roles, and people*
- *Navigation: the movement through the mental model afforded by menus, dialogue boxes, control panels, etc.*
- *Appearance: the verbal, visual, and acoustic characteristics of the displays*
- *Interaction: the means by which users input changes to the system and the feedback supplied by the system*

Note that an application, its data, the graphical user interface (GUI), the hardware platform, the network, the input and output display devices, all contribute to the user interface.

The Beginning and the End of the Design Process

User interface design is a process that begins with getting to know the target user community. The user interface design community has placed increasing importance on knowing as much about the user as possible: cognitive habits, educational and cultural background, perceived needs and desires, and the nature of jobs, roles, and tasks within an organization of work or play. Focus groups and usability tests have become valuable sources of information to determine the task specifications or requirement documents that help to generate a user interface design solution.

In many Web design situations, insufficient attention is given to determining precisely who is going to access the information, what their goals might be, and what responses should be provided for special needs. This situation has occurred with many corporate sites that began to build Web sites primarily as “trophies” or because of some sense of urgency to make a corporate presence known on the Web and to provide corporate documents, with little or no consideration of what might be useful to novice or expert “cybernauts.” One example is a paper company that provided details of corporate financial documents but did not provide sufficient information about paper stocks, their prices, and

© 1996 Aaron Marcus and Associates, Inc., AM+A.. All Rights Reserved.

recommended uses that would aid graphic designers in making good selections. This situation is similar to the early years of multimedia when some publishers merely poured books into CD-ROMs with little or no consideration for the user interface of interactive access to content.

Once a Web site design is determined, the design rules should be captured in documents that describe and explain the essential elements. Too often, designs are retained only in the heads of a few key people who have set up a Web site. Even if specifications are prepared, they may not provide sufficient information on user interface design components. Some user interface design specification documents for Web sites have begun to appear. One exemplary Web-oriented resource is the Yale University Web site (**http://info.med.yale.edu/claim/C_HOME.HTML).** *In Graphic Design for Electronic Documents and User Interfaces* [Marcus, 1992], a chapter devoted to user interface design specification documents helps to introduce the topic. Let us now turn to the essential components themselves.

Metaphors

Metaphors concern the essential themes, concepts, imagery and terms of the Web site, especially the top-level labels and images provided to users, by which they are expected to understand the fundamental organization and purpose of the site. Because the entire world of Web sites is so new and growing so fast, conventions are not particularly stable. For example, is a Web site a “bulletin board,” a “treasury,” an “archive,” a “tool,” a “store,” and “adventure,” or a “meeting place”? Each approach might lead to very different imagery themes and terminology.

The essential categories of content and functions beyond those provided by established browsers vary widely, making it difficult to know where to go for certain needs, especially for a novice user. A “What’s Cool” button in one site may be labeled “What’s Hot” in another. The example in Figure 1, a home page for a Nynex Yellow Pages site (**http://www.niyp.com**), shows a “More Stuff” button whose semantics are somewhat vague: is it more content, more functions, both? Note, also, that the page states a “Business Name Search” button as well as a “Business Type Search.” When pressed, each of these leads to essentially similar functions and content, suggesting that a “Search” button alone might have been more useful and would have simplified the construction of these essential choices.

In designing good metaphors, designers should seek well-established terms and images if they want users to immediately recognize and use buttons and labels quickly. Novel, unique terms and images should be checked carefully with representatives of the user community to determine whether the elements are undesirably obscure, annoying, or even offensive.

© 1996 Aaron Marcus and Associates, Inc., AM+A.. All Rights Reserved.

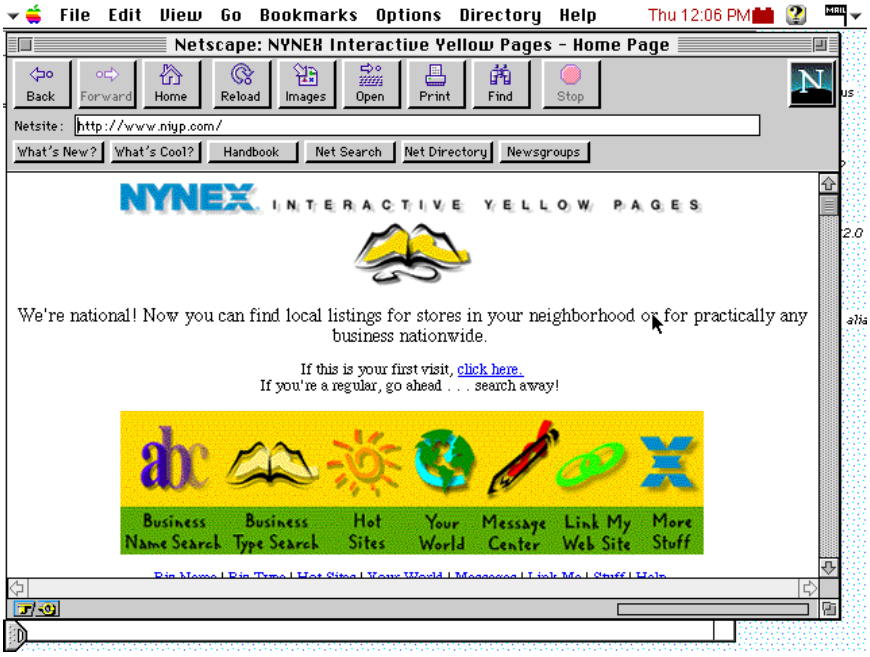


Figure 1: *The home page screen from the Nynex Yellow Pages site, showing main choices*

Mental Models and Navigation

The mental model is the organization of functions and data within the site, especially that among the layers below the first home page. Navigation concerns the means by which the user can move within and among layers to reveal new content: buttons, lists, tables, etc.

One of the primary challenges of Web site design is to organize the content in useful ways so that users can intuitively understand the site and can find easily what they seek. Designers should allocate a significant amount of time designing alternative approaches to organization and navigation, then evaluating with typical users what seem to be simple, clear, approaches. Often many surprises will result: what the designer thought was “obvious” may be obscure to the user. One typical trade-off is simplicity of higher levels vs. the consequent complexity of lower levels for a given system of content. Generally, novice users (e.g., consumers) prefer simpler organization, while experts (e.g., professionals familiar with the content subject matter) prefer getting more immediate access to a larger number of functions and data groups.

The navigation controls (also called *widgets)* for Web user interfaces often do not follow standards of classical graphical user interfaces (e.g., Windows, Macintosh, and Motif) or multimedia collections of content (e.g., games and titles on CD-ROMs). For example, the way buttons are drawn, the location of button within an area for dialogue, the user of underlined text as buttons, or the absence of default next-action symbols

© 1996 Aaron Marcus and Associates, Inc., AM+A.. All Rights Reserved.

are all differences between the Web user interface and other interactive environments. In the future, Web user interfaces will be have more variety of widgets, raising many of the design issues that other kinds of user interfaces currently face. For those interested in considering the widgets of classical GUIs and pondering how Web sites might provide them, *The Cross-GUI Handbook for Multiplatform User Interface Design* [Marcus, et al, 1995] provides a fairly complete taxonomy of all the widgets of all classical GUIs.

Consider Figure 2, which shows one portion of Xerox Corporation's Web site (**http://www.xerox.com**). A visitor to the Web site soon encounters a fairly long list of items that might be of interest. These entries are broken into a few groups, but no group titles appear. In addition, the organizing principle of the lists may not be readily apparent, and no information about the timeliness or size of the possible next link is provided. In other words, many cues that would assist a user in deciding where to go next are missing.

In general, areas of a page or form should be clearly and consistently labeled so that novice, and even intermediate or occasional users will not have a problem understanding what kind of functions or content is being displayed. Lists, and especially tables, should have simple, clear, and consistent column labels. Long heterogeneous lists should be broken up into smaller groups wherever possible, Long homogeneous lists should be clearly organized by time, space, alphabetical sequence, ordinal number, or some other simple means. Ideally, lists (and tables) ought to be sortable by different means, e.g., to see the topics in the Xerox list organized by several categories including the time-stamping of the addition of the entry to the list. In this way, users can have some flexibility in their strategies for searching and evaluating content, then taking action.

© 1996 Aaron Marcus and Associates, Inc., AM+A.. All Rights Reserved.

Figure 2: *The home page screen from the Xerox Corporation's Web site, showing a list of subordinate links of possible interest to users*

Appearance and Interaction

Appearance covers all aspects of the “look” of the user interface: typography, symbolism, color, layout, and animation, but also verbal appearance, that is, the language choice (English, Spanish, etc.) and the terminology choice (informal, technical, etc.). Interaction concerns all of the “feel,” the input and feedback techniques, including mouse vs. keyboard input, any future drag-and-drop functionality, highlighting for location or selection, etc.

Each of these attributes is itself a complex set of design choices and trade-offs. Many Web sites routinely ignore traditional human factors and ergonomics concerns about appearance and interaction. For example, in Figure 3, the CNN Web site’s home page (**http://www.cnn.com**) presents major news topics in condensed all capital letters, a choice that guarantees decreased legibility. Words set in all capital letters do not have distinguishing descenders and ascenders, and in this case, several words are approximately the same length. These rectangular blocks of symbols must be read in detail, rather than by word shape, as is typically done. (In the Nynex example in Figure 1, note that the cursive black letters on medium green buttons are not a particularly legible typeface and color choice; they are made even less legible on a color that reduces the contrast between text and background.)

© 1996 Aaron Marcus and Associates, Inc., AM+A.. All Rights Reserved.

Figure 3: *The top of the CNN home page, showing major categories of news*

Lower down in the CNN page, as shown in Figure 4, text and photographs are presented in several layouts that compete for attention in the viewer's mind. Notice that no standard layout grid seems to govern these areas. Similar contents ought to be presented in similar layouts, unless there is a compelling reason to be inconsistent. In this example, even two two-column areas at the top and bottom of the screen have varying choices of column widths. Within these set-off areas, the illustrations sometimes appear at the far right or, in this example, at the far left and also centered, again an inconsistency that can distract the viewer. Notice, also, that text appears for the most part flush-left, ragged right (generally useful for pieces of non-continuos text), but one text block at the upper right is centered. Inconsistencies like these cause the viewer to be uncertain about visual cues and to waste effort in trying to understand the significance of what may well be differences of appearance with little or no significance.

© 1996 Aaron Marcus and Associates, Inc., AM+A.. All Rights Reserved.

Figure 4: *The bottom of the CNN home page, showing subordinate groupings of content*

In general, designers should choose a limited number of legible typefaces, type sizes, locations, symbols, illustration styles, and layouts with which to present all content. *Graphic Design for Electronic Documents* [Marcus, 1992] and "Metaphor Mayhem: Mismanaging Expectation and Surprise" [Marcus, 1994] provide some essential principles for effective use of information-oriented graphic design in making some of these design decisions.

Bear in mind, also , that designers must establish clear paradigms for providing feedback to the user that items are selectable, have been located by the pointer, are being selected, and have already been selected. The conventions for establishing these interaction states also vary widely in the world of Web sites.

Even the original color sets proposed by Netscape for available and already-viewed links contains a non-ergonomic color choice: blue has become a convention signifying available selection, while red means already selected. From a communication design perspective, hot red on a white background seems a more suitable, legible color for links that must be highlighted, noticed, selected, and reviewed, while the “cool” color blue seems more appropriate for already-selected links, just the opposite of the current industry convention that has already influenced many Web site designers.

Another challenge to designers is continuity of the use of mouse and keyboard. Currently, many Web sites make extensive use of scrolling to get to additional downloaded content and buttons. The Web designer

© 1996 Aaron Marcus and Associates, Inc., AM+A.. All Rights Reserved.

must examine carefully whether all of the manipulation of screen contents is a satisfactory alternative to waiting for a hyperlink to connect. Web site designers will be challenged to re-invent many of the widgets that traditional GUI designers have spent a decade or more perfecting. Often, relatively little time and money is available to redesign or reinvent these widgets. Consequently, designers must analyze in a practical manner the appearance and interaction schemes, then evaluate them with users to determine optimum choices.

An example: Planet SABRE™

Each of the components described above requires significant time to perfect for any user interface to online services. In many cases, too little time is provided by the project developers. One example in which significant time was provided is the Planet SABRE™ project, a new design of the user interface for American Airlines' SABRE Travel Information Network (STIN), one of the largest private online information and transaction systems. Figure 5 shows a scene from the opening or home screen. The author's firm, in conjunction with the staff of STIN, is developing a new user interface specifically oriented to travel agents. ([Steyer-Coyne, 1996]). In the limited space available, this article will consider just one aspect, metaphor design.

Figure 5: An opening screen for Planet SABRE, a new means of presenting the functions and data of the American Airlines SABRE travel Information Network for travel agents

The developers considered for some time how better to represent the core functions of a complex database system for reservations to travel

© 1996 Aaron Marcus and Associates, Inc., AM+A.. All Rights Reserved.

agents. In think-tank sessions, several different metaphorical scenes emerged (e.g., depicting all the primary functions as an airport environment or a cityscape). One approach seemed promising as both novel yet intuitive: the functional modules depicted as three-dimensional objects on the surface of a planet viewed from outer space. Once this Planet SABRE metaphor was determined, the design team tried many styles of depiction (e.g., pictographic, cartoon-like, and representational) for the modules—application suites for reserving flights, car, and hotels— eventually deciding on representational, intuitive icons.

The large land mass or planet metaphor is useful for depicting elements of an operating system or a suite of applications. In a sense, this image is a very large extension of the concept of the desktop, which is in a room, in a building, in a city, in a country, on a continent, on a world.

Notice that some of the items are culturally biased. For example, the mailbox representing an electronic mail application makes sense for a user in the United States, but a British user would expect to see a red, columnar British postbox. The Planet SABRE design standards actually provide for a variety of icons to be available to represent better items that differ among countries and cultures. In this manner, the user interface design is attempting to make differences not only of language, but of symbolism and illustration suitable for a truly world-wide user group. This diversity in user interface design will eventually need to be considered for most Web sites as they become visited by more varied and international groups of users.

Conclusions

With each passing day, more Web sites, more sophisticated browsers, and more elaborate Web authoring and designing tools emerge. As with previous developments in technology, these advances do not guarantee good user interface design. There are many opportunities for creative invention of metaphors, mental models, navigation, appearance, and interaction; there are also many opportunities to thwart clear and effective communication. As object-oriented construction of these user interfaces becomes more widespread, designers may be able to develop user interfaces more efficiently and effectively, but the underlying challenge to communicate effectively remains.

Designers must not only give extensive energy to the design of appealing illustrations and opening scenes of Web sites, they must grapple with the extensive verbal naming and conceptual organization issues as well, then go on to determine the appropriate similarities and differences of layout, color, lines, textures, illustrations, sounds, and music in user interfaces. Because Web sites demand so much effort to build and maintain, the ability of designers to develop a systematic set of user interface elements means that items can be re-used or managed in effective ways without damaging the freshness of Web sites and that

© 1996 Aaron Marcus and Associates, Inc., AM+A.. All Rights Reserved.

changes in fundamental design characteristics can be implemented more efficiently because of the systematic nature and inheritance of change that occurs in a large system of signs.

Designers will contribute significantly to the invention of new forms of communication, especially to the means of formulating queries and to displaying results visually. These efforts should be acknowledged, valued, and protected. One way to encourage better design is to take the time to evaluate Web sites and to “prove” in some quantitative manner some significant benefit to implementations. Web site design has much to contribute that is new and fresh; on the other hand, Web site designers can benefit greatly by learning about lessons from the recent history of the user interface design community.

Web Resources

If you're looking for more information, the Web itself is probably your best source for general Web knowledge, Web design organizations, and advanced Web technology.

Information Resources on the Web

The following Web sites provide information of general interest and use to Web site designers. The Web site’s URL appears in parentheses.

AM+A (http://www.AMandA.com) Aaron Marcus and Associates, Inc., maintains a Web site that provides links of interest to Web designers focusing on user interface design and information visualization.

C|net Online (http://www.cnet.com) A well-organized site, covering new WWW and multimedia technologies and products.

DesignOnline (http://www.dol.com/Root/welcome/welcome.html): An information and conversation hub for designers.

HCI Index: Links to Newsgroups (http://is.twi.tudelft.nl/hci/communication.html) A thorough set of links to Human-Computer Interaction and related newsgroups from a large archive of user interface design resources.

MIT Media Lab (http://www.1010.org) Innovative research and technology. Designers should look into Design Interactions Paradigms Home Page, **(http://design-paradigms.www.media.mit.edu/projects/design-paradigms/)**, a product of MIT's Visible Language Workshop.

The Yale Center for Advanced Instructional Media: WWW Style Manual (http://info.med.yale.edu/caim/C_HOME.HTML) A well-organized and thorough guide to WWW design.

© 1996 Aaron Marcus and Associates, Inc., AM+A.. All Rights Reserved.

UI-Design Web (http://duto02.tudelft.nl/uidesign) An excellent site, formerly known as UIWORLD, containing over 175 valuable resources for multimedia and interaction design professionals, e.g., tools, books, editorials, events, studios, jobs, and Net sites.

Design Organizations on the Web

The following sites provide information about user interface design and related topics, together with information about tutorials, publications, and events.

ACD (http://www.design.chi.il.us/ac4d/) The American Center for Design, a national design organization that emphasizes technologies, systems, and information. Links to conferences, membership information, and areas of interest.

ACM-SIGCHI (http://www.acm.org/sigchi/) The Association for Computing Machinery's Special Interest Group on Computer-Human Interaction. Links to local SIGs, annual conference, and user interface design resources on the WWW.

ACM-SIGGRAPH (http://www.siggraph.org) The Association for Computing Machinery's Special Interest Group on Computer Graphics. Links to design resources, publications (including SIGCHI videos), and local SIGs, and annual conference. AM+A has presented keynote lectures and tutorials at SIGGRAPH annual conferences since 1980.

AIGA (http://www.dol.com/AIGA/) The American Institute of Graphic Arts, a national organization promoting excellence in graphic design. Links to membership information, events, publications, and local chapters.

HFES (http://www.hfes.vt.edu/HFES/) Human Factors and Ergonomics Society, an international organization with many specialized SIGs and an annual conference. See also Human Factors Perspectives on Human-Computer Interaction **(http://www.cis.ohio-state.edu/~perlman/hfeshci/contents.html),** selected proceedings from HFES Annual Meetings 1983-1994.

IICS (http://www.dnai.com/~sfiics/) The San Francisco Bay Area Chapter of the International Interactive Communications Society, an organization that promotes, informs and represents multimedia professionals. Links to an online gallery, calendar, publications, and other local-chapter home pages.

MDG (http://www.mdg.org/) Multimedia Development Group, an international trade association that promotes growth within the industry by linking developers, producers, and tech firms. Links to monthly calendar and an MDG bulletin.

© 1996 Aaron Marcus and Associates, Inc., AM+A.. All Rights Reserved.

Advanced Technology on the Web

To keep up with some of the latest technology, consider the following sites providing information or demonstrations.

Java (http://www.sun.com) Sun's new approach, with its own programming language, to support communicating small applications or applets on the Internet presents a major alternative to the way information is stored and distributed.

Shockwave (http://www.macromedia.com) This software adds Macromedia Director's functionality to the Web.

VRML (http://www.virtus.com) A viewer for virtual reality displays on the Web is available for the Macintosh platform.

Caveats and Acknowledgments

Because Web sites are in constant flux, comments made about a particular site's design may no longer be valid. The reader should bear this in mind upon examining any Web sites referenced. The text above attempts to clarify the design issue without reference to the current status of the site.

In preparing this article, the author would like to acknowledge the assistance of the staff and associates of Aaron Marcus and Associates, Inc., particularly Mr. Anthony Sokolowski, and Mr. Hank Duderstadt, and to acknowledge AM+A's client, American Airlines SABRE Travel Information Network, for permission to reprint an image from an ongoing project.

Bibliography

The following references, some of which are cited above, are useful resources for further investigation of the issues addressed in the essay.

Albertson, Rick, Jeffrey Fine, Mike Zender, et al*, Designer's Guide to the Internet*. Hayden Books: Indianapolis, 1995, ISBN: 1-56830-229-0.

Marcus, Aaron, "Principles of Effective Visual Communication for Graphical User Interface Design," *Readings in Human-Computer Interaction*, Second Edition, Ed. Baecker, Grudin, Buxton, and Greenberg. Morgan Kaufman: Palo Alto, 1995, pp. 425-441. ISBN: 1-55860-246-1.

Marcus, Aaron, "Metaphor Mayhem: Mismanaging Expectation and Surprise," *Interactions*, Vol. 1, No. 1, January 1994 pp. 41-43.

© 1996 Aaron Marcus and Associates, Inc., AM+A.. All Rights Reserved.

Marcus, Aaron, *Graphic Design for Electronic Documents and User Interfaces*. Addison-Wesley: Reading, MA, 1992.

Marcus, Aaron, Nick Smilonich, and Lynne Thompson, *The Cross-GUI Handbook for Multiplatform User Interface Design*. Addison-Wesley Publishing Company, Menlo Park, CA, 1995.

Steyer-Coyne, Stephanie, “The ACD Conference: Design for the Internet, *Communication Arts*, Vol. 37, No. 8, January/February 1996, pp. 137-142.

© 1996 Aaron Marcus and Associates, Inc., AM+A.. All Rights Reserved.

AM+A

California

Aaron Marcus and Associates, Inc.
California and New York

1144 65th Street, Suite F
Emeryville, CA 94608-1053 USA

Tel: 510-601-0994
Fax: 510-547-6125
E-mail: Mail@AMandA.com
Web: www.AMandA.com

Metaphor Design in User Interfaces

Author Aaron Marcus

Author Contact Data
Mr. Aaron Marcus, President
Aaron Marcus and Associates, Inc. (AM+A)
1144 65th Street, Suite F
Emeryville, California 94608-1053 USA
Tel: 510-601-0994, Ext 19, Fax: 510-547-6125
E-mail: Aaron@AMandA.com
Web: http://www.AMandA.com

Publication ACM SIGDOC, the Journal of Computer Documentation, pre-print

Publisher Contact Data
Mr. T. R. Girill, Ph.D., Editor-in-Chief
ACM *SIGDOC* Journal of Computer Documentation
Lawrence Livermore National Laboratory
Livermore, CA
Tel: 510-XXX-XXXX, Fax: 510-423-8963
Email: “T. R. Girill” <trg@llnl.gov>
Web: http://www.acm.org/sigdoc/journal.html

Copyright © Copyright 1997 by Aaron Marcus and Associates, Inc.

Abstract
Successful user interfaces consist of partially general and partially unique solutions to the design of metaphors, the fundamental concepts communicated through words and images, as well as through sound and interaction. By controlling the user’s expectation of familiar structures and processes and surprise at novel approaches, the user-interface designer can achieve compelling forms that enable the user to be more productive.

Introduction

In 1997, The US Justice Department asked a Federal judge to fine Microsoft Corporation $1 million per day relating to the inclusion of Microsoft's Internet browser with the Windows 95 operating system. A contemporary article in the *New York Times* [Johnson, 1997] commenting on the fracas described this landmark antitrust case in cyberspace as essentially a fight about the power of metaphors. The author compared the situation to a company controlling almost all office desk manufacturing that added a free built-in phone to the desk and declared that the concept of the desk now includes the concept of the phone, and by the way, all other phone manufacturers, which charged for phones, might be out of business. Metaphors, it seems, have become big business.

What exactly are metaphors, and why are they so important? Metaphors figure prominently in user interfaces. User interfaces, a mixture of function and form, are the physical display of informational, aesthetic, and persuasive content affording the means for interacting with that content. For specific users (defined by their demographics, experience, education, and roles in organizations of work or play) and their tasks, user interfaces provide metaphors, mental models, navigation, appearance (including sound, for example), and interaction. These components may be defined in this way [Marcus, 1995; Marcus, 1997]:

Metaphors: essential conveyed visually through words and images, or through acoustic or tactile means
Mental Models: organization of data, functions, tasks, roles, and people in groups at work or play
Navigation: movement through mental models afforded by windows, menus, dialogue areas, control panels, etc.
Appearance: verbal, visual, and acoustic and tactile perceptual characteristics of the displays
Interaction: the means by which users input changes to the system and the feedback supplied by the system.

Note that an application, its data, the graphical user interface (GUI) environment, and the hardware all contribute to the functional and formal attributes of the user interface, in particular to its metaphors. An advanced text editor working within the Microsoft Windows 95™ GUI environment on a mouse- and keyboard-driven Intel Pentium™ processor-based PC presents one set of metaphors. The LCD displays and buttons on the front panel of a paper copier or the colorful displays and fighter-pilot-like joysticks for a children's video game on a Sega game machine present alternative metaphors.

© Copyright 1997 by **AM+A** Aaron Marcus and Associates, Inc. All Rights Reserved.

This article will introduce fundamental distinctions of metaphors, review their history in computer systems, and demonstrate why they are so vital to the success of computer-based communication products.

Types of Metaphors

Centuries ago, almost all university students learned how to use metaphors in effective communication as they studied rhetoric, which comprises over 1000 rhetorical techniques [Lanham, 1961]. Rhetoric, in turn, is a component of semantics, one of three dimensions of semiotics, the science of signs [Eco, 1976]. The semiotic dimensions are these:

Lexical: how we produce signs, e.g., how to make lines on a CRT

Syntactic: how signs are arranged in time and space, e.g., bigger or bluer

Semantic: to what signs refer, e.g., denoting structures or processes

Pragmatics: how we consume signs, e.g., their legibility and readability.

The term *metaphor*, derived from the Greek words for “carrying across,” is specifically the technique of substituting one sign for another in order to make communication more effective. To describe the incoming fog as “creeping silently into the bay,” is to describe its movement as though it were a cat, thereby clarifying and intensifying the listener’s experience. We use metaphors in our daily speech, e.g., when we say “do you get the picture” to mean “do you understand what I am saying?” Linguists have analyzed and categorized how we use metaphors in daily speech [Lakoff and Johnson, 1980] and find metaphors often to be fundamentally spatial. For example, we say “why are you looking so down,” “things are looking up,” “ that idea is too far out for me,” and “I’m getting into organic foods.” In general, metaphors help in these ways:

- Represent (denote) people, objects, structures, and processes, e.g., in a GUI, dropping a file in a desktop trash can is equivalent to deleting the file.

- Describe a structure or process: e.g., in a GUI, an outline file/folder list refers to a hierarchical structure.

© Copyright 1997 by **AM+A** Aaron Marcus and Associates, Inc. All Rights Reserved.

- Explain causes and effects of a structure or process, e.g., in a GUI, a progress bar “explains” the delay in downloading a file.

- Express (imply or connote) concepts or values, e.g., in a GUI, a recycling arrow instead of a trash can suggests re-use or ecology.

There are standard kinds of metaphors:

- Structural: These substitute parts of one system for another, e.g., in UIs, an outline structure for nested folder/file structure

- Operational: These substitute behavior of one system for another, e.g., in GUIs, dragging-and-dropping a file to the trash can for deleting the file

- Pragmatic: These enable a user to absorb or understand more , e.g., in GUIs, concrete desktop objects and processes represent more abstract components of operating systems such as DOS and UNIX.

In considering metaphors, it is important to make some further distinctions.

- *Metaphors* are limited in the scope of the substitutions; they are not complete exchanges. For example, one might use a limited number of military terms in business discussions. If someone got carried away and took the metaphor too far, listeners would think they were being too literal, or obsessive.

- *Models* are detailed representation of structures or processes either smaller in scale or more abstract, in which the substitution is more complete. For example, one would praise a model airplane that included a complete engine in miniature.

- *Analogies* are point-by-point similar in function with a different structure or source. For example, in linguistics, one can find analogous terms such as these: energy, energize; apology, apologize.

- *Similes* are directly stated comparisons in which the listener or viewer is aware of the comparison, e.g., “Marriage is like a job; you have to work at it.” Metaphors, on the other hand, are often more subtle, unconscious, or “invisible.” Metaphors help people think and, in some ways, may constrain what they can think about, much like language in general.

© Copyright 1997 by **AM+A** Aaron Marcus and Associates, Inc. All Rights Reserved.

Two other rhetorical techniques of substitution related to metaphor are more specific:

- *Metonomy* is substitution of an associated sign. For example, when reporters say, “The White House announced a new executive decree” they mean the President of the United States, but they use the building to refer to the person who works in it.

- *Synecdoche* is substitution of a part for a whole, or vice-versa. For example, when a farm-owner describes a worker as a really good “hand,” a part of the worker stands for the whole person.

The verbal communication techniques that have served written literature well for thousands of years have also served visual communication. Now that computers are such intense multimedia experiences, employing icons, pictures, video, and sound, designing effective metaphors is essential to the success of innovation in computer technology.

The History of Metaphors in Computing

Computer research, development, marketing, and sales personnel, as well as the general public, have employed many picturesque terms to refer to computers. In fact, the term “computer” originally referred to a human being, a person who calculates or computes. The word came to be applied to a machine, and the concept transformed itself from a mechanical calculating “engine” to an electronic “brain.” As input devices and output displays became more sophisticated, further metaphors developed to enable people to learn, use, remember, and enjoy computers more quickly and completely. The user interface emerged as a collection of metaphorical references embodying the controls and data displays by which the user interacts with the central processing unit and the stored programs, i.e., with both the hardware and the software. Over a half-century of development, these metaphors changed dramatically:

- Character-based user interfaces used references to teletypewriters, clerical files, and word-processing.

- Graphical user interfaces (GUIs) used the concept of the desktop to organize representations of peripheral equipment as icons, the contents of files inside windows, and the trashcan for deleting files.

© Copyright 1997 by **AM+A** Aaron Marcus and Associates, Inc. All Rights Reserved.

- Pen-based user interfaces introduced written character gestures and marks, such as circling an item to delete it.

- Virtual reality-based user interfaces introduced marks and gestures associated with flying (such as yaw, pitch, and roll) and new techniques of object selection and manipulation, such as pinching and 3D-twisting.

- Web-based browser user interfaces introduced new or transformed concepts such as browsing, chatting, and linking.

Metaphors in user interfaces can be classified in many ways. Hutchins [1989], as cited in Neale and Carroll [1997, p. 444] provides a comprehensive, general classification of metaphors:

- "*Activity metaphors* are determined by the users' highest level goals. For example, is the user controlling a process, communicating, or playing a game?

- *Mode of interaction metaphors* organize the fundamental nature in which the user thinks about interacting with the computer. These metaphors are task independent and determine how the user views what the computer is.

- *Task domain metaphors* provide an understanding for how tasks are structured."

Another way to classify user interface metaphors is by level. Generally, two levels of metaphors contribute to the complete set used in a user interface: systemic, or over-arching, metaphors and individual metaphors. Over-arching metaphors provide a complete basis for understanding a system; individual metaphors provide references for specific controls or data displays.

An example of over-arching metaphor is the desktop metaphor popularized originally by Apple Computer in its Macintosh products. An example of a specific control metaphorical reference is the "radio button" that represents exclusive selection of functions and/or data attributes. In any user interface, many specific terms used in conjunction with the application domain, together with its functions and data, provide additional metaphorical references. For example, an architectural program might include a "punch list" to refer to unresolved issues of a building's form or function.

© Copyright 1997 by **AM+A** Aaron Marcus and Associates, Inc. All Rights Reserved.

Developers have employed many different metaphorical substitutions in the past half-century. Examples of overarching metaphors include the following:

Physical places: rooms, buildings, cities, landscapes, planets

Specific places: libraries, storehouses, banks, malls, chatrooms

Activities: travel, fly, browse, search

Objects: desktops, books, Rolodexes™, television sets

For objects and actions, the user interface must determine specific ways to depict essential nouns and verbs. For each kind of noun, specific secondary objects become relevant: e.g., a book might have a bookmark, a desk might have a drawer or a wastebasket nearby. Noun metaphors of collection and some associated objects include the following.

Desk: folders, documents, drawers, papers

Books, newspapers: Pages, sections, bookmarks, indexes

Photographs: albums, photos

Television: programs, channels, remote control devices

Slides, phonograph record: Tracks, sorting devices

Cards, boxes: Shelves, containers

Photography: rolls, trays, reels

Trees: branches, leaves

Theater: programs, actors, scripts

Verb metaphors of action (some of which were first discussed in [Foley and Wallace, 1974]) and their visualizations in GUIs include the following:

Locate: move pointer to an object

Select: single or double-click on a located object

Add: select object from a repertoire and drag-and-drop it into a place

© Copyright 1997 by **AM+A** Aaron Marcus and Associates, Inc. All Rights Reserved.

Delete: drag-and-drop object in trash can or wastebasket

Save: drag-and-drop object into a place

Quit: select button or switch

Cancel: make “X” or circular movement with pointer

Acknowledge: make “check-off” movement with pointer

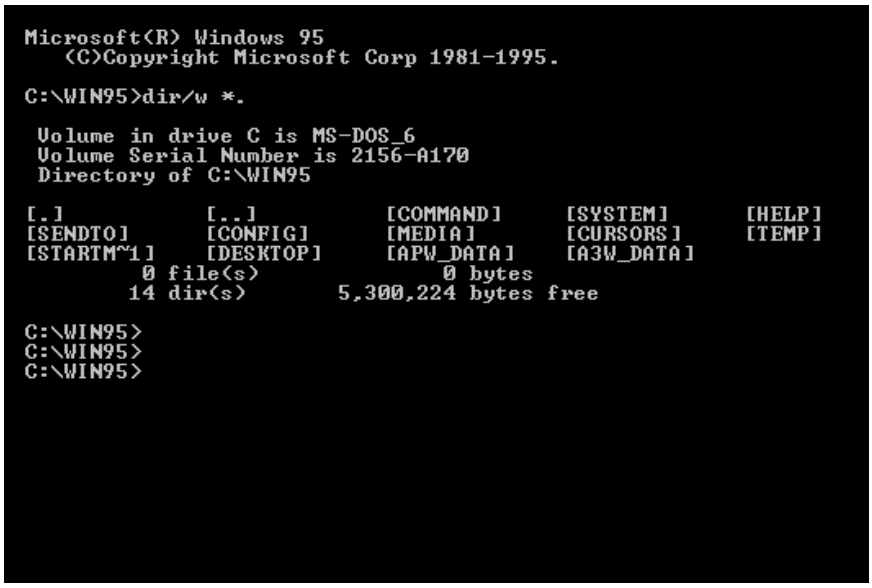
Valuate: slide/ rotate control along metric of values

Move left/right, forward/backward, up/down, in/out, to/from: drag control

Stop: select button or switch

Examples of some of the basic kinds of user interfaces and their metaphors appear in the accompanying Figures 1-6.

Figure 1: *A text-based user interface uses metaphorical references to typewriter-like controls.*



© Copyright 1997 by **AM+A** Aaron Marcus and Associates, Inc. All Rights Reserved.

Figure 2: *A graphical user interface (GUI) uses metaphorical references such as folders, windows, and the trash can.*

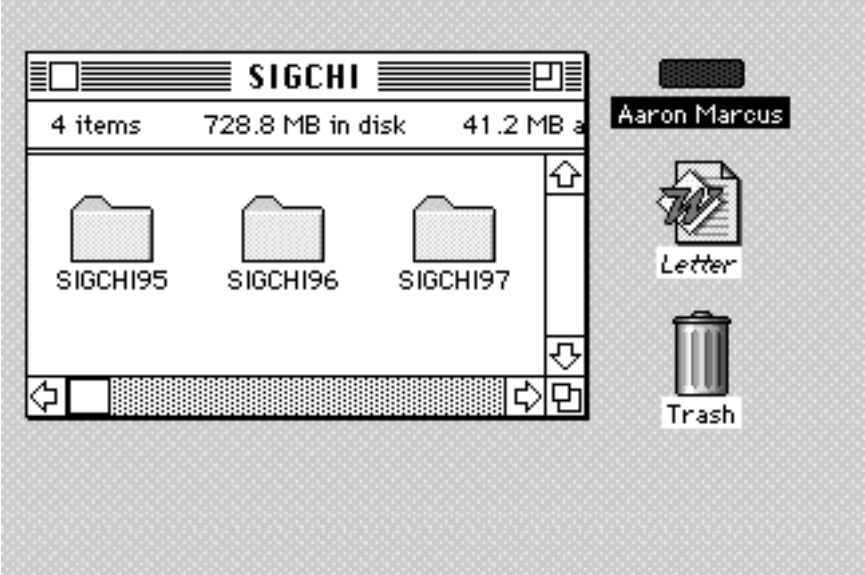
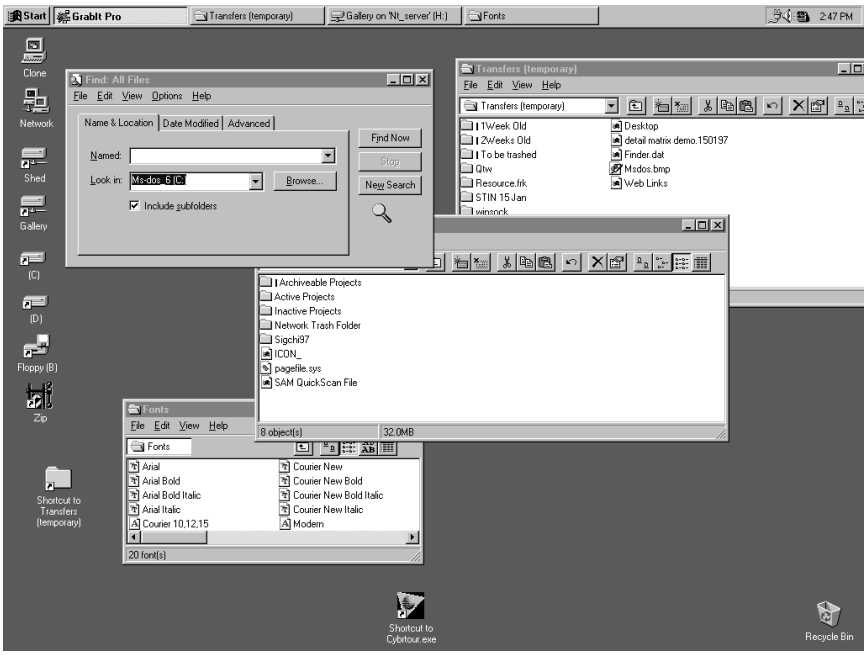


Figure 3: *Multi-window user interfaces add additional complexity but generally employ metaphors similar to the basic GUI metaphors.*



© Copyright 1997 by **AM+A** Aaron Marcus and Associates, Inc. All Rights Reserved.

Figure 4: *Virtual Reality user interfaces use three-dimensional movement metaphors and three-dimensional objects metaphors.*

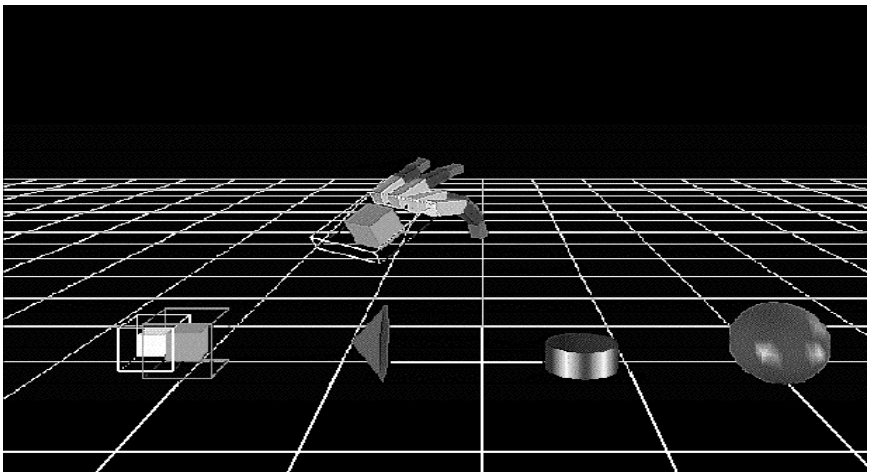
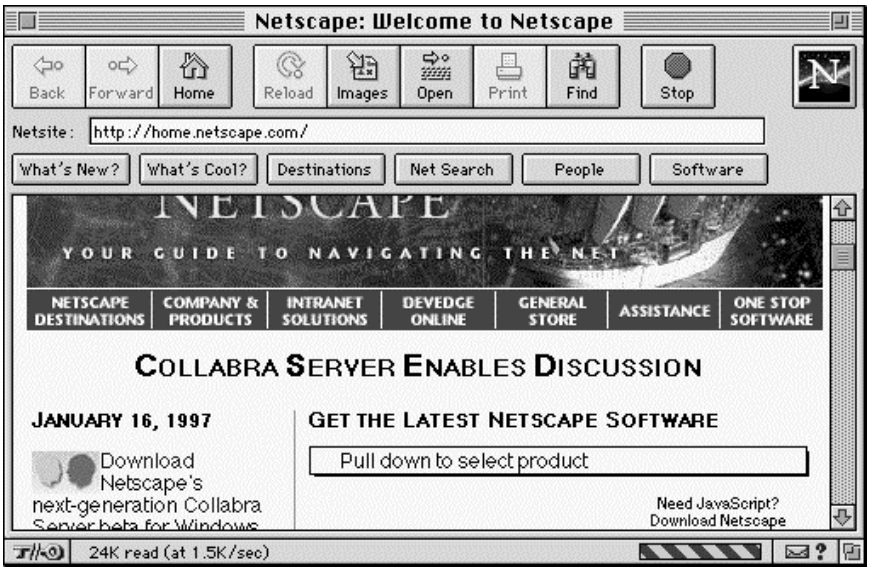
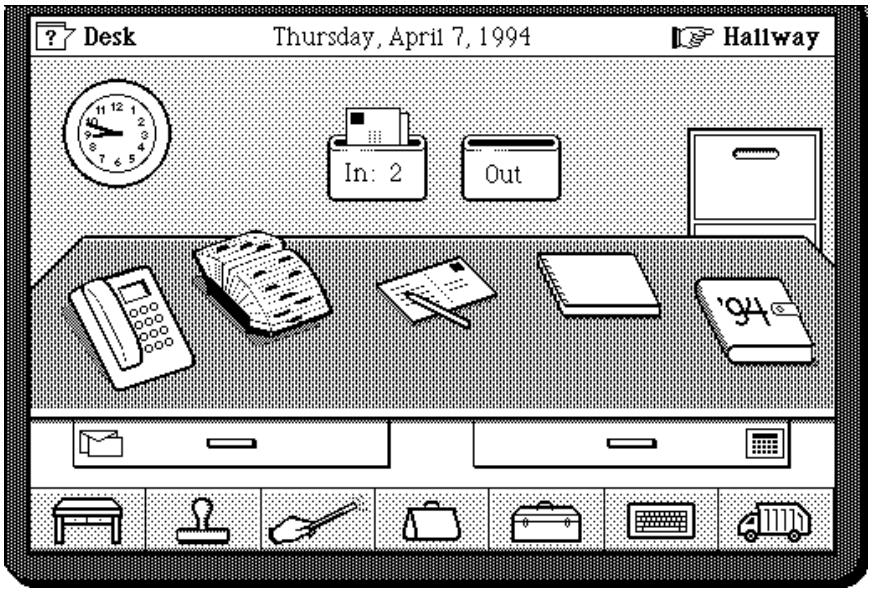


Figure 5: *Web-based user interfaces introduce metaphors associated with connectivity and browsing.*



© Copyright 1997 by **AM+A** Aaron Marcus and Associates, Inc. All Rights Reserved.

Figure 6: *General Magic's Magic Cap User Interface [Gibbs, 1994; Hill, 1995] places a desk in a room. The room is along a hallway, in a building, on a street, in a user-interface metaphor with an urban scale. Note that the garbage can has become a garbage truck in keeping with the urban reference.*



Advantages and Disadvantages of Metaphors

Used correctly, well-designed metaphors in user interfaces offer numerous advantages for successful, effective communication:

- Using concepts familiar to users may require less training time, because users can intuit primary attributes of structure or processing. Domain knowledge of one area may be transferable to another. In addition, the metaphors prepare the user for transferring the content domain model or role-task model into the user's mental model. For example, most office workers, knowing the hierarchy of files and folders stored in file cabinets, find the desktop metaphor's representation of these entities intuitively clear.

- Familiar concepts in an unfamiliar environment can add appeal. When users are new to a topic or application domain, seeing familiar references can reduce tension, stress, boredom, confusion, anxiety, and alienation, while increasing their self-assurance, calm, interest, engagement, and dependence upon the user interface.

© Copyright 1997 by **AM+A** Aaron Marcus and Associates, Inc. All Rights Reserved.

- Because the metaphor's representation may not be complete (as noted earlier, it is not a model), the very incompleteness may invite "filling" in of details from the user's experience, providing there is a basic sufficiency of familiarity. McLuhan [1964] called this an attribute of "cool" media.

- Metaphors can increase ease of learning, memorization, and use. Simple, clear, and consistent conceptual "monuments" in a cognitive landscape enable users to focus on and retain a limited number of primary attributes of a complex system [Carroll and Mack, 1985; Laurel, 1993; Anderson, 1983]. By reducing operational complexity, users may be able to achieve greater initial productivity.

- Metaphors selected for particular user communities can assist in making communication more direct and effective. For example, in US consumer products, terms and images oriented to particular target markets such as children, seniors, Hispanic/Latino, Asian, African-American, or other groups are routinely used to facilitate communication.

- Besides making communication more effective, metaphors are also used to appeal to the aesthetic taste, self-image, or cultural associations of user communities. Examples include the "hip," "cool," or "hot" terms and images of Wired.com's Website, the graphic-design-oriented treatment of contents in magazines such as *Wired* or *ID*, an industrial/graphic design publication, or the treatment of contents in television or magazines for electronic products.

Designing metaphors is a powerful technique of communication. Used well, metaphors can stimulate users' interest in products, facilitate understanding of complex content, and promote a positive attitude toward products and their use. Designed inappropriately, however, metaphors can promote misunderstanding and alienation on the part of users and impede their performance:

- One source of confusion among users as well as is the distinction between metaphors and mental models. Metaphors are simple, limited relationships, either at a global or local scale. Models, on the other hand, are intended to have thorough, systematic similarities to the original, in other words to be a "miniature." Note that the upper layers of mental models may contain many primary words, icons, or images that represent fundamental metaphorical concepts of the user interface.

© Copyright 1997 by **AM+A** Aaron Marcus and Associates, Inc. All Rights Reserved.

- Other “costs” of designing metaphors are these: While diverse markets may benefit from diverse metaphors targeted for their communities, the cost of developing these variations may be considerable, requiring study of particular cultures or communities and their terminology. Maintaining metaphors also has a cost: Metaphorical references vary over time, especially with changes in technology or cultural/aesthetic shifts, and users eventually may not understand or appreciate the references.

For example, the telephone concept and image has changed markedly in the last century. The speaking tube of early telephones has disappeared, and the circular dial of the telephone has evolved into push-buttons. Consequently these earlier images, in general, have been phased out as icon/symbol references. The blended functionality of the typical desktop phone, fax, pager, cellular phone, Internet-PC phone, and other devices make the reference to “telephone” somewhat fuzzy as a concept. The telephone handset has survived in many pictographic icon/symbol references, however, the availability of telephones as accessories pinned to clothing, tucked into pockets, hanging from cords around the neck, or attached to the wrist like a wristwatch, signal the gradual disappearance and eventual un-readability of the traditional telephone metaphorical references.

- Note that new metaphorical items may themselves become a metaphorical basis for further technology developments. For example, the interactive spreadsheet on the personal computer is quite different from the previous historical, static object, the ledger page. The interactive spreadsheet, in turn, becomes a tool to use in other contexts, turning the spreadsheet display and functionality into a basis for understanding programming languages or database queries.

Given the significant costs and benefits of metaphors, the design process should be considered carefully when planning user interface development.

Metaphor Design Process

The user-interface development process may be summarized as follows:

- Plan: Define the problems or opportunities; establish objectives and tactics; determine budget, schedule, tasks, and development-team and other resources

© Copyright 1997 by **AM+A** Aaron Marcus and Associates, Inc. All Rights Reserved.

- Research: Investigate dimensions and techniques for all subsequent steps, e.g., techniques for analysis, criteria for evaluation, media for documentation, etc.

- Analyze: Examine results of research, e.g., problem or opportunity (conduct market research), refine criteria for success in solving problem or exploiting opportunity (write marketing or technical requirements), determine key usability criteria; and define the design brief, or primary statement of the design's goals

- Design: Visualize alternative ways to satisfy criteria using alternative prototypes; based on prior or current evaluations, select the design that best satisfies criteria; prepare documents that enable consistent, efficient, precise, accurate implementation.

- Implement: Build or carry out the design to complete the final product, e.g., write code using appropriate tools.

- Evaluate: Test results at any stage in the marketplace against defined criteria for success, e.g., conduct focus groups, test usability on specific functions, gather sales and user feedback.

- Document: Record development history, issues, and decisions in specifications, guidelines, and recommendation documents.

- *Note:* User-interface development is cyclical and partially or completely repetitive. For example, evaluation may be carried out prior to, during, or after the design step.

Within the overall user-interface development process, the metaphor design process may be defined in this way:

- Identify items among data and functions that should be targets

- Identify sources of metaphorical reference

- Generate many possible metaphors

- Identify and evaluate matches and mismatches

- Revise metaphors to strengthen effective matches and reduce harmful mismatches

© Copyright 1997 by **AM+A** Aaron Marcus and Associates, Inc. All Rights Reserved.

Metaphors are mappings from one domain to another. The designer first must identify targets, i.e., those objects, structures, or processes, that seem confusing, unrelated, or inappropriate.

For example, a set of functions in an application may seem likely to be useful together. How might they be thought of or perceived as an integrated group? The designer must then identify possible sources, or metaphorical references, which enable the user to understand or perceive this grouping in a “natural” and forceful manner. Or, as another example, a particular collection of data seems likely to benefit from a memorable name that is associated with some aspects of the function that acts upon the data. What terms or images might enhance the clarity and memorability of this relationship between functions and data?

The sources may arise form the user’s context, i.e., from daily use of existing tools and documents and subject matter in a typical work or play environment. They also may arise from other relevant subject-matter domains or work/play contexts, or they may arise from ordinary everyday experience.

By making matches, and attempting to optimize them, the designer can also observe the mismatches: terms that seem too inappropriate, overly forced, inappropriately comical, or dysfunctional. By evaluating them among designers, clients, and users, then revising them, just as for all other components of user interfaces, the disruptive mismatches will lessen, and a well designed management of the user’s expectation and surprise will emerge.

Mismatches in metaphors may occur for several reasons. One is that the target domain cannot provide a match for a primary attribute in the source domain, especially if the source is real-world objects, structures, or processes. Consider the confusion that has arisen among novice users of text-editing software who use a *typewriting* metaphor to understand their activities. Users may become confused by the change of visual representation of the real-world object (e.g., there is no moving carriage or type-element) or the difference of operations (e.g., operations required to delete a mis-typed character). In such cases, the users’ confusion may lead to performance degradation or errors.

Because metaphors inevitably are limited, designers may need to add unique functions to the context of a given metaphor that go beyond it or real-world experience. Smith [1987] has referred to this kind of mismatch as a tension between *literalism* and *magic*. For

© Copyright 1997 by **AM+A** Aaron Marcus and Associates, Inc. All Rights Reserved.

example, with a space metaphor for a hypertext document, there may be links that jump to other spaces quite unlike anything in everyday real-world experience. Another example is in the *pile* metaphor, a representation of a stack of documents on the screen that, among other things, can be re-organized automatically at the selection of an appropriate command, quite unlike piles of documents in the real world.

The result is often, especially in rich, multimedia applications, that metaphorical references sometimes are quite inconsistent as a group. These contradictions may not necessarily be harmful. As Neale and Carroll point out [1997], “mismatches raise new questions that require examining existing assumptions about the source domain based on the metaphor. When these questions are answered, dissimilarities result in further development of the user’s [understanding].”

The primary success criteria for metaphors is the extent to which they can facilitate understanding, diminish misinterpretation, and promote positive, desired associations with the product, its use, or the self-image of the user. In theory, these characteristics can be evaluated comparatively in focus groups or tested among users. Managing expectation and surprise through the selection of appropriate metaphors remains a complex discipline, mixing art, science, and professional experience. In a word, it is a *design* activity.

A Case Study of Metaphor Design

To illustrate metaphor design practice in user interfaces, consider Figure 7-16, which illustrate the design of the opening, or launch, screen of Planet SABRE™, a new design for the SABRE Travel Information Network (STIN). The metaphor was developed by the author’s firm in conjunction with the staff of STIN during 1994-1996. SABRE is one of the world’s largest private on-line networks serving approximately one-third of all travel agents worldwide to enable bookings of flights, rental cars, and hotels. The existing Legacy mainframe database query-and-retrieval system with a textual user interface offers users hundreds of arcane alphanumeric commands to access fixed frames of alphanumeric data. The new system offers a Microsoft-Windows graphical user interface for a client-server network. This new technology offered an opportunity to change radically how users understood the SABRE software.

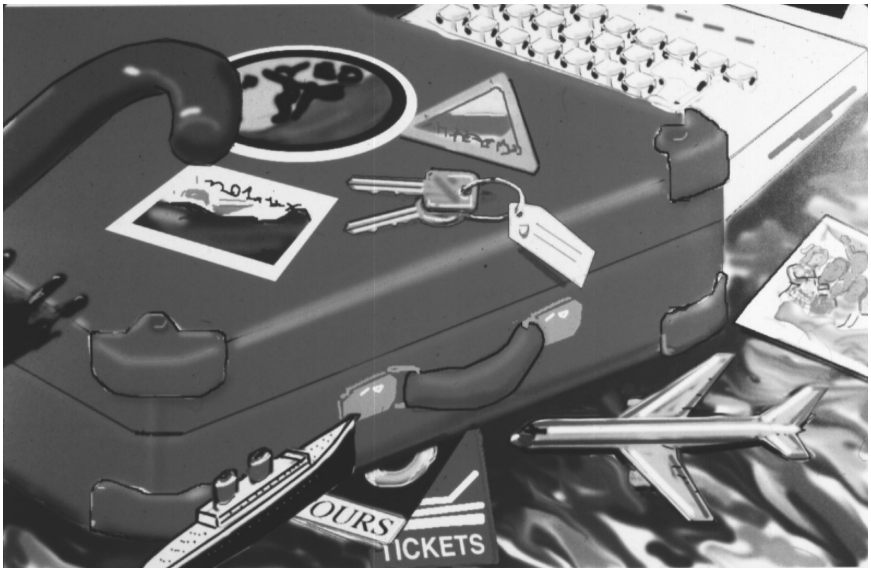
The development team considered for some time how better to represent the core applications and associated data. During a

© Copyright 1997 by **AM+A** Aaron Marcus and Associates, Inc. All Rights Reserved.

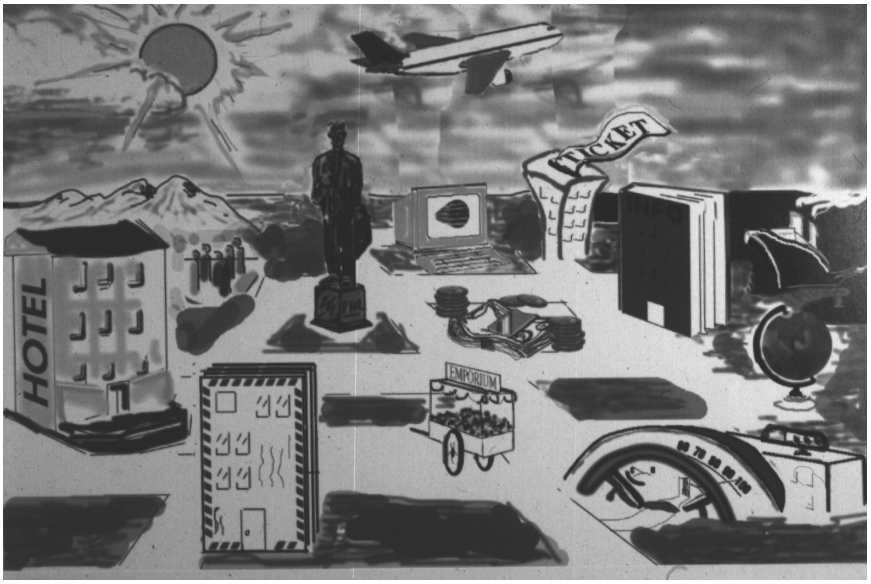
three-day think-tank series of discussions, they explored both abstract and pictorial approaches to visualizing the upper levels of the mental model and communicating the novel qualities of the new graphical approach to formulating queries and retrieving information. In addition to abstract representations of the system, several different physical scenes emerged that seemed more likely to be memorable and appealing to the user group (see Figures 7-10). Each of the scenes showed physical, spatial metaphors: an airport terminal, a view of a traveler's suitcase with travel gear, an urban scene, etc. One approach in particular seemed promising, as judged by initial interviews with a limited number of travel agents: the functional modules depicted as three-dimensional objects on the surface of a planet viewed from outer space.

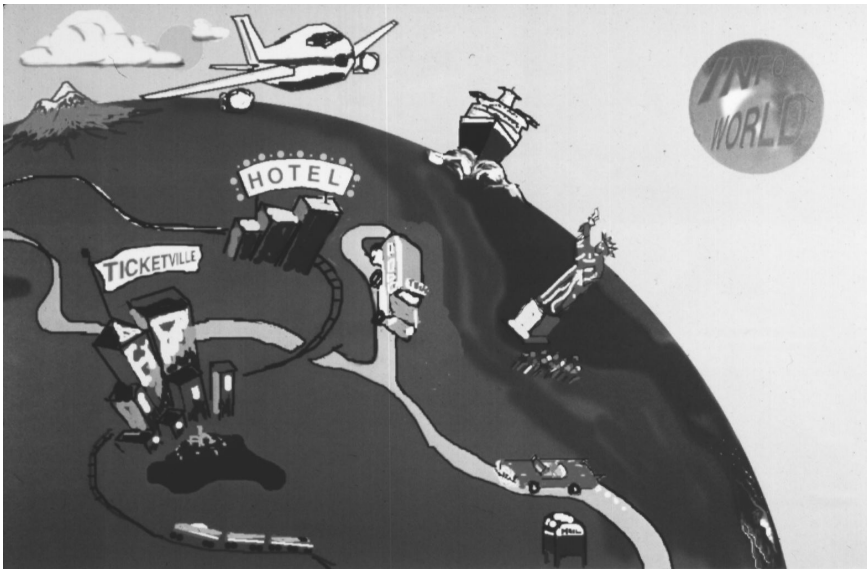
© Copyright 1997 by **AM+A** Aaron Marcus and Associates, Inc. All Rights Reserved.

Figures 7-10: *Initial sketches of four alternative metaphorical scenes for the Planet SABRE user interface.*



© Copyright 1997 by **AM+A** Aaron Marcus and Associates, Inc. All Rights Reserved.





Note that the airplane representing air reservation booking is flying in outer space, a patently impossible situation. This is typical of metaphors, as noted by Black [1979]: "...such 'absurdity' and 'falsity' are of the essence: in their absence, we should have no metaphor but merely a literal utterance."

The large land-mass or planet metaphor has been used in other products and is one of several spatial or *geographic* metaphors typically useful for depicting elements of an operating system or a suite of applications. In a sense, this image is a very large extension of the concept of the desktop, which is in a room, in a

© Copyright 1997 by **AM+A** Aaron Marcus and Associates, Inc. All Rights Reserved.

building, in a city, in a country, on a continent, on a world, somewhat like a larger-scaled version of General Magic's Magic Cap user interface (see Figure 6).

Once any metaphor is determined, the context of the metaphor may influence strongly certain appearance and interaction issues such as spatial organization, size, image style, means of highlighting, etc. The designer's task is not finished merely with metaphor selection: the metaphors must be detailed correctly to be successful.

In spatial metaphors, especially at the scale of urban form, Lynch [1960] has identified organizing attributes of paths, edges, landmarks, nodes, and districts. On Planet SABRE, these elements presented themselves in the image at a global scale. The user-interface development team tried many variations of locating the elements of the display: both application modules, such as those for booking air, car, and hotel reservations, as well as ornamental characteristics of the planet, such as its land masses and seas. They also tried many variations of images depicting these application modules, such as using a building, a vehicle, or a landscape object for a particular application. The planet was meant to connote generic land masses and not to denote specific countries.

The team also considered the size of the icons representing applications. To keep the spatial perspective consistent, the icons needed to change size depending on how far away they were in the scene. Using the implications of the metaphor, the team decided to make the representation of the four most important applications central in the scene and closer to the viewer, therefore larger: passenger data, air bookings, car bookings, and hotel bookings. Other items were supplementary and therefore placed in a more distant, peripheral, and smaller position.

Considering spatial orientation, the icons would have to appear upside down if they appeared south of the equator of the planet to be consistent with the metaphorical image. This orientation of objects, for example, a tour bus with passengers, appeared strange, even absurd, and was abandoned. Therefore, the view had to emphasize a "front" half of a northern hemisphere in order to show objects in familiar, recognizable positions.

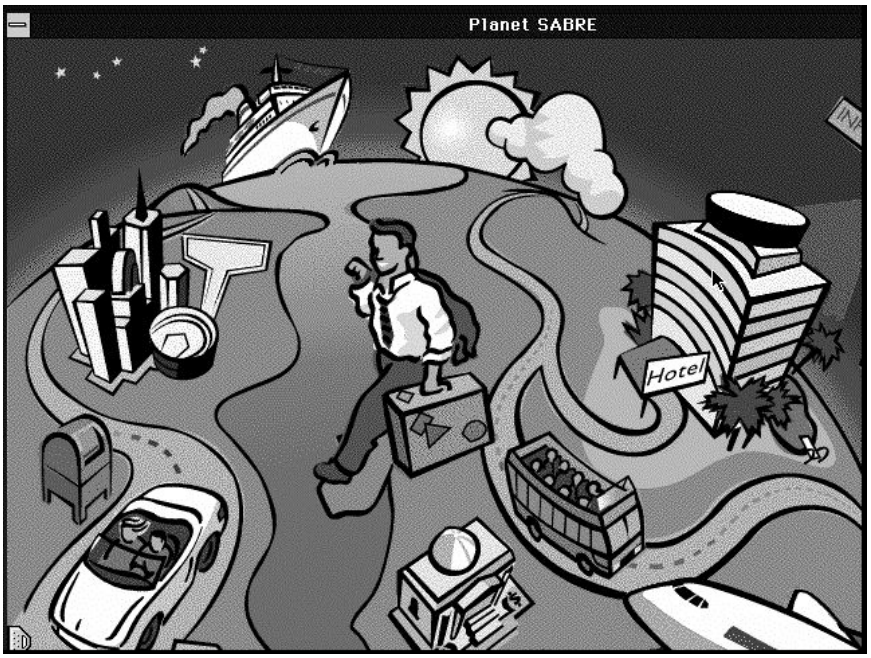
Metaphorical images can appear in many styles or treatments. For example, furniture appearing in a room metaphor will inevitably convey a certain epoch and aesthetic approach. Microsoft's Bob, a

© Copyright 1997 by **AM+A** Aaron Marcus and Associates, Inc. All Rights Reserved.

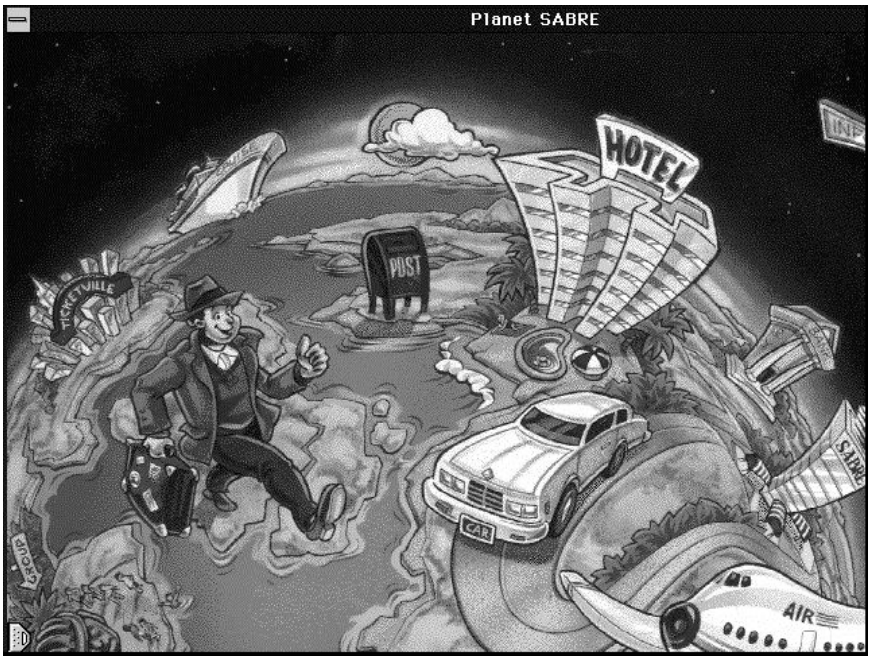
set of basic applications for first-time computer users, showed what might have been intended as a cartoon-like caricature of the den or library of Bill Gates, Microsoft's President. Although short-lived, the product was reported by a Microsoft user-interface design staff member to be popular with housewives in the Mid-West, who presumably found its style comfortable and unthreatening. An appropriate style needs to be determined for the user community.

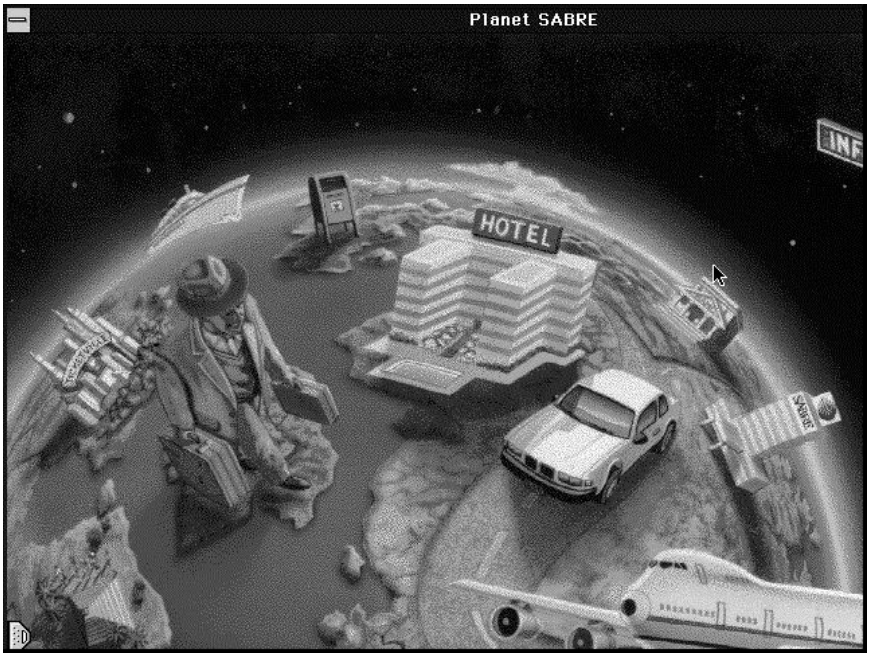
The Planet SABRE development team designed three different styles of presentation: pictographic, cartoon, and realistic (see Figures 11-13). Representative travel agents stated that the cartoon style was undesirable because it seemed to diminish the seriousness of users' tasks and roles. This reaction demonstrated the importance of the user interface, and specifically metaphors, as a "mirror" depicting the user's self-image, not only a "window" looking into a world of content operated upon by special tools. Discussions among users and the client's product development managers eventually led to the realistic view as most appropriate.

Figures 11-13*: Examples of pictographic, cartoon, and realistic alternative versions of the Planet SABRE planet-metaphor image****.***



© Copyright 1997 by **AM+A** Aaron Marcus and Associates, Inc. All Rights Reserved.



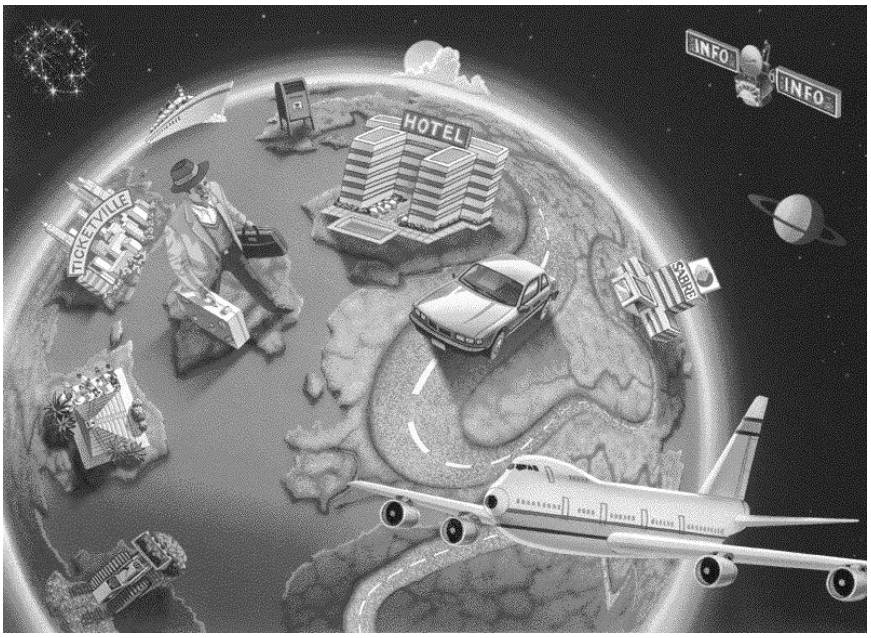


This final scene went through many refinements as the total image was “debugged” as a metaphor, including revisions of color and shape to make the scene and icons appear brighter and “happier” **(**see Figure 14**)**, of icon image selection to account for different representations of objects, e.g., mail boxes, in different countries

© Copyright 1997 by **AM+A** Aaron Marcus and Associates, Inc. All Rights Reserved.

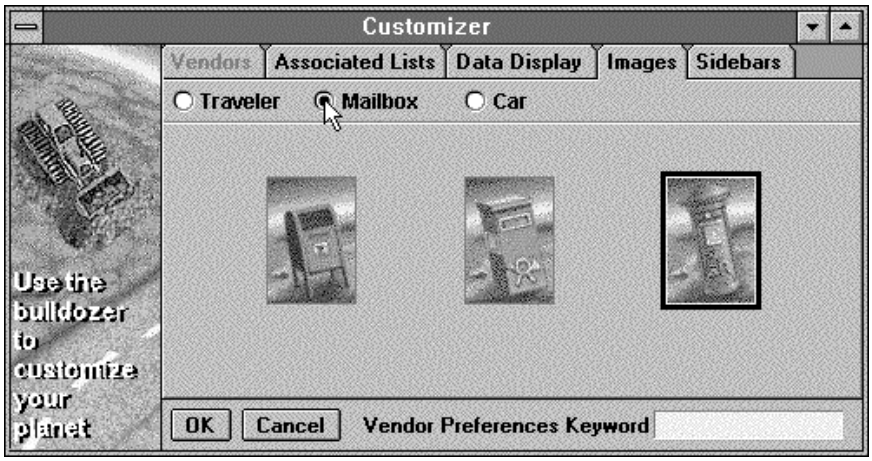
(see Figure 15), and of icon positioning to accommodate necessary sizes and shapes.

Figure 14*: The near-final version of the Planet SABRE launch screen featured a "happier" representation of the traveler/customer and brighter, "happier" colors in the vegetation of the planet.*



© Copyright 1997 by **AM+A** Aaron Marcus and Associates, Inc. All Rights Reserved.

Figure 15: *A dialogue box enables users to change the image of a mailbox on the planet to represent better the object as known for a particular country or region.*

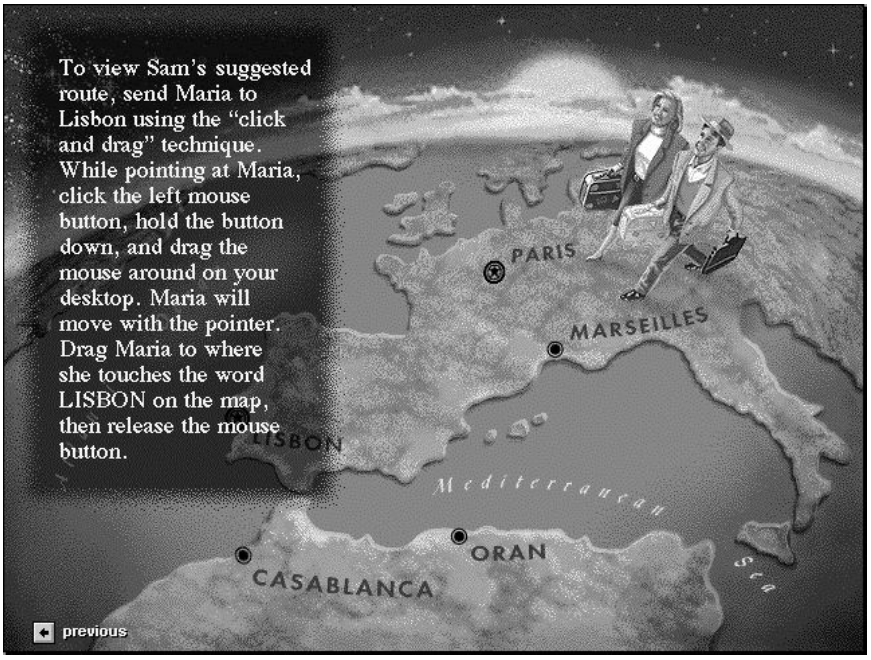


Note that the metaphor in this product development had primary importance for marketing and training, not performance by experts. The launch-screen metaphor was a significant marketing tool for the product. A marketing objective was to demonstrate dramatically to long-time users that a revolutionary change in the product was coming in the near future and to win purchasers' approval for and commitment to the new version. The Planet SABRE image was both surprising and potentially threatening to new users, but also exciting, and, once users' emotions calmed down, reassuring, and friendly.

The planet metaphor was also helpful in initial training and introductory use of the product to communicate the re-organized mental model of the system (see Figure 16). Once novice users were familiar with the product and understood the organization of applications, most of them would spend most of their time in specific primary applications such as air travel booking and not return to the initial launch screen, because the primary functions were available as a tool bar.

© Copyright 1997 by **AM+A** Aaron Marcus and Associates, Inc. All Rights Reserved.

Figure 16: *A scene from a training game used to introduce the metaphors and controls of Microsoft Windows as well as those of Planet SABRE.*



Conclusions

Metaphors have been and will continue to be a significant component of user-interface designs, at all levels of the mental model and its navigation, as well as intimately connected to the detailed appearance of and users' interaction with controls and status displays.

As products continue to increase the number and kinds of functions and to increase the amount and kinds of data available through computer-based communication media, the challenge of enabling more people and more kinds of people to use this content and these tools effectively will increasingly depend upon metaphorical embodiment of complexity. In addition, it is likely that metaphorical references will change more rapidly, requiring frequent updating of users' assumptions.

Future analysis of metaphors may address the following issues:

- How might metaphors be designed for different kinds of intelligence? Gardner has identified the following kinds of intelligence [Gardner, 1985]. They suggest users might have varying dimensions of conceptual competence with regard to using metaphors:

© Copyright 1997 by **AM+A** Aaron Marcus and Associates, Inc. All Rights Reserved.

  - Verbal/image comprehension
  - Word/image fluency
  - Numerical/graphical fluency
  - Spatial visualization
  - Associative memory
  - Perceptual speed
  - Reasoning
  - Image

- How might metaphors be designed for different cultures that differ by such dimensions as age, gender, national or regional group, or profession? The author has posed this as a question before to the user-interface analysis/design community previously [Marcus, 1993]. The topic is discussed broadly in [DelGaldo and Nielsen,1996].

The taxonomic analyses of metaphors for user interfaces, the theoretical basis for metaphor selection, the criteria for metaphor evaluation, and the design method are still emerging in the user-interface design discipline. Nevertheless, designers should be aware of the scope of the activity, know sources of insight, and incorporate professional techniques in their development process in order to improve the value and success of their products.

Acknowledgments

The author thanks his staff at Aaron Marcus and Associates, Inc., and their client, SABRE Travel Information Network, in particular, Mr. Michael Sites, Planet SABRE product development director, for their assistance in preparing this text. The author also acknowledges an article by Neale and Carroll [1997], which has provided a basis for many points raised in this text.

Figures

The figure throughout the text depict an opening screen for Planet SABRE, a new means of presenting to travel agents the functions and data of the American Airlines SABRE Travel Information Network by means of PCs running Microsoft Windows 3.1 and eventually Microsoft Windows 95.

© Copyright 1997 by **AM+A** Aaron Marcus and Associates, Inc. All Rights Reserved.

Bibliography

The following references, some of which are cited in the article, are useful resources for further investigation of the issues addressed above.

Anderson, J. R., *The Architecture of Cognition*, Harvard University Press, Cambridge, MA, 1983.

Black, Max, "More about Metaphor," in Ortony, Andrew, Ed., *Metaphor and Thought*, Second Edition, Cambridge University Press, New York, NY, 1993, 678pp., ISBN: 0-521-40561-0, pp. 21.

Caroll, J. M., and Mack, R. L., "Metaphor, Computing Systems, and Active Learning," *International Journal of Man-Machine Studies*, 22:1, 1985, pp. 39-57.

Carroll, John M., Mack, R.L., and Kellogg, Wendy A., "Interface Metaphors and User Interface Design," in M. Helander, ed*., Handbook of Human-Computer Interaction*, Elsevier Science Publishers, North-Holland, The Hague, Netherlands, 1988, pp. 67-85.

DelGaldo, Elisa, and Jakob Nielsen, ed., *International User Interfaces*, Wiley, New York, 1996.

Eco, Umberto, *A Theory of Semiotics*, Indiana University Press, Bloomington, 1976. ISBN 0-253-35955-4.

Foley, James D. and Victor L. Wallace, "The Art of Natural Graphic Man-Machine Conversation," *Proceedings of the IEEE,* Vol. 62, No. 4, 1974, pp. 462-470.

Gardner, Howard*, Frames of Mind, The Theory of Multiple Intelligences*, Basic Books, 1985.

Gibbs, W. Wayt, "Heads in the Cloud," *Scientific American*, Vol. 273, No. 2, February 1994, pp. 112-123.

Hill, G. Christian, and Jim Carlton, Getting Personal, *The Wall Street Journal*, 11 February 1995, p. R6.

Hutchins, E., "Metaphors for Interface Design," in Taylor, M. M., F. Neel, and D.G. Bouwhuis, Eds, *The Structure of Multimodal Dialogue*, Elsevier Science Publishers, Amsterdam, 1989, pp. 11-28.

© Copyright 1997 by **AM+A** Aaron Marcus and Associates, Inc. All Rights Reserved.

Iwayama, M., Tokunaga, T. and Tanaka, H., “A Method of Calculating the Measure of Salience in Understanding Metaphors, “ *Proceedings*, AAAI-90, 1990, pp. 298-303.

Johnson, Steven, “Metaphor Monopoly,” *New York Times*, 23 October 1997, p. A-21.

Lakoff, George, and Johnson, Mark, *Metaphors We Live By*, The University of Chicago Press, Chicago, 1980.

Lanham, Richard A., *A Handlist of Rhetorical Terms,* Second Edition, University of California Press, Berkeley, 1991, ISBN 0-520-07668-0, p. 205.

Laurel, Brenda, *Computers as Theater*, Addison-Wesley, Reading MA, 1993.

Lynch, Kevin, *The Image of the City*, MIT Press, Cambridge, 1960, 194 pp., ISBN 0-262-62001-4.

Marcus, Aaron, *Graphic Design for Electronic Documents and User Interfaces*, Addison-Wesley, Reading, 1992.

Marcus, Aaron, “Human Communication Issues in Advanced UIs,” *Communications of the ACM*, Vol. 36, No. 4. April 1993, pp. 101-109.

Marcus, Aaron, “Principles of Effective Visual Communication for Graphical User Interface Design,” *Readings in Human-Computer Interaction*, 2nd Edition, Ed. Baecker, Grudin, Buxton, and Greenberg, Morgan Kaufman, Palo Alto, 1995, pp. 425-441. ISBN: 1-55860-246-1.

McLuhan, Marshall, *Understanding Media: The Extensions of Man*, McGraw-Hill, New York, 1964, 359 pp., LC: 64-16296.

Neale, Dennis C. and John M. Carroll, “The Role of Metaphors in User Interface Design,” in Helander, M., Landauer, T.K., and Prabhu, P., Eds*., Handbook of Human-Computer Interaction*, Second, revised edition, Elsevier Science, B.V., The Hague, Netherlands, 1997, pp. 441-462.

Norman, Donald A., “Some Observations on Mental Models,” in D. Gentner and A. L. Stevens, ed., *Mental Models*, Erlbaum, Hilldale, NJ, 1983, pp. 7-14.

© Copyright 1997 by **AM+A** Aaron Marcus and Associates, Inc. All Rights Reserved.

Ortony, Andrew, Ed., *Metaphor and Thought*, Second Edition, Cambridge University Press, New York, NY, 1993, 678pp., ISBN: 0-521-40561-0.

Smith, R. B., "Experiences with the Alternate Reality Kit: An example of the Tension between Literalism and Magic," *Proceedings*, ACM CHI-87 Conference on Human Factors in Computing Systems, Association for Computing Machinery, New York,1987, pp. 61-67.

Väänänen, Kaisa, *Metaphor-Based User Interfaces for Information Authoring, Visualization and Navigation in Multimedia Environments*, Verlag Shaker, Aachen, Germany,1995, ISBN 3-8265-0751-7, 271 pages.

Author Biography

Aaron Marcus received a BA in physics from Princeton University (1965) and a BFA and MFA in graphic design from Yale University Art School (1968). He is an internationally recognized authority on the design of user interfaces, interactive multimedia, and printing/publishing documents. He co-authored *Human Factors and Typography for More Readable Programs* (1990) and *The Cross-GUI Handbook for Multiplatform User Interface Design* (1994), and he authored *Graphic Design for Electronic Documents and User Interfaces* (1992), all published by Addison-Wesley. Mr. Marcus was the world's first professional graphic designer to be involved full-time in computer graphics (1967), the first graphic designer to program a desktop publishing system (for the AT&T Picturephone (1969-71), the first graphic designer to design virtual realities (1971-73), the first graphic designer to establish an independent computer-based graphic design firm, Aaron Marcus and Associates (AM+A), to design user interfaces, electronic documents, and multimedia (1982), and the only graphic designer to receive the National Computer Graphics Association (USA) Industry Achievement Award for his contributions to computer graphics (1992). AM+A has completed projects for major companies in the USA, Europe, Israel, and Japan. In 1995, AM+A was cited as one of the Top 100 Multimedia firms by *Multimedia Producer*.

© Copyright 1997 by **AM+A** Aaron Marcus and Associates, Inc. All Rights Reserved.