Principles Of Information Visualization

What is information visualization

Tufte's guidelines

Visual variables for representing information

The principle of small multiples for displaying information

How metaphors can be used and misused

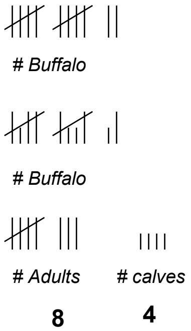
Direct manipulation and direct engagement

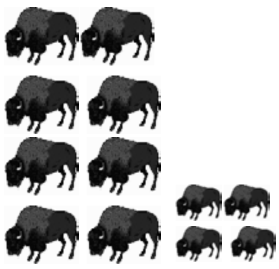
Representations

Good representations

- Captures essential elements of the event / world
- Deliberately leaves out / mutes the irrelevant
- Appropriate for the person and their interpretation
- Appropriate for the task, enhancing judgment ability

How many buffalo?





Representation

A representation is

- **A formal system or mapping by which the information can be specified** (D. Marr)
- **A sign system in that it stands for something other than its self** (unknown source)
- **A method of encoding information** (my description)

For example: the number thirty-four *or* the buffalo example

Decimal:	34,	(the most familiar number base)
Binary:	100010,	(most closely parallels machine architecture)
Roman:	XXXIV	(counting)

Presentation

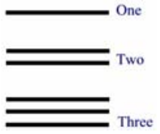
Not the same as representation!

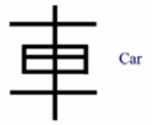
The presentation of information deals with how the representation is placed or organized on the screen

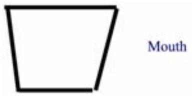
5, **5,**

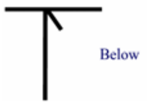
IV, ***IV***

Chinese…Sort Of









This method of representation makes it easier to remember the symbols

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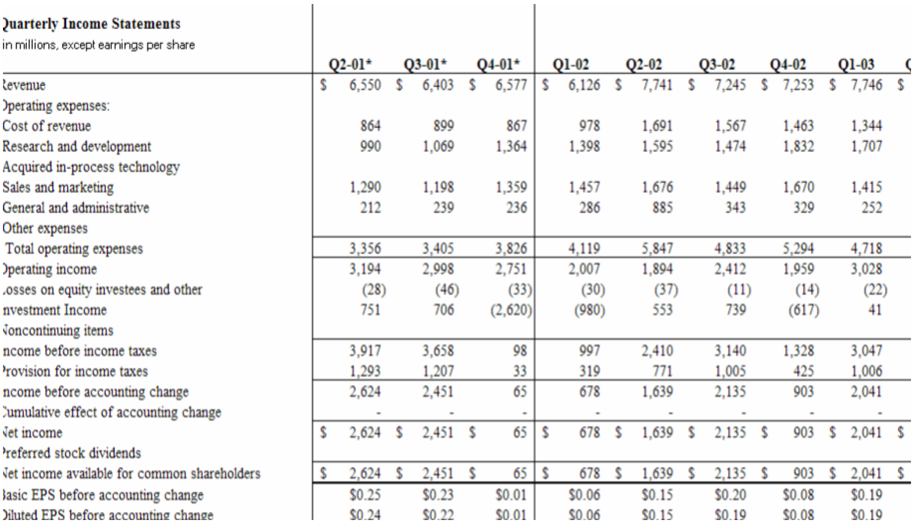
Characteristics Of Good Representations

1. **The representation makes it easier to find the relevant information.**
   - Solving a problem simply means representing it so as to make the solution transparent … ***(Simon, 1981)***
2. **(Once the information has been found) good representations makes it easier to make use of the information.**
   - Allow people to *compute* desired conclusions
   - Trying to make use of the information may be a difficult process or “for free” depending on the representation chosen

Representations: The Information Is Present But Hard To Find

Representations: The Information Is Present But Making Sense Of It Requires Much Effort



Quarterly Income Statements
in millions, except earnings per share

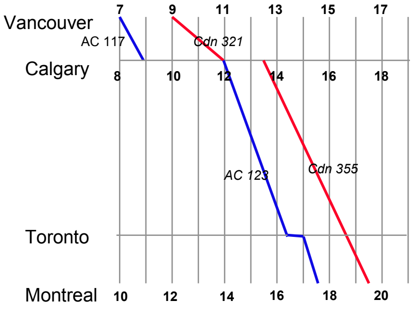
	Q2-01*	Q3-01*	Q4-01*	Q1-02	Q2-02	Q3-02	Q4-02	Q1-03	
Revenue	$ 6,550	$ 6,403	$ 6,577	$ 6,126	$ 7,741	$ 7,245	$ 7,253	$ 7,746	$
Operating expenses:									
Cost of revenue	864	899	867	978	1,691	1,567	1,463	1,344	
Research and development	990	1,069	1,364	1,398	1,595	1,474	1,832	1,707	
Acquired in-process technology									
Sales and marketing	1,290	1,198	1,359	1,457	1,676	1,449	1,670	1,415	
General and administrative	212	239	236	286	885	343	329	252	
Other expenses									
Total operating expenses	3,356	3,405	3,826	4,119	5,847	4,833	5,294	4,718	
Operating income	3,194	2,998	2,751	2,007	1,894	2,412	1,959	3,028	
Losses on equity investees and other	(28)	(46)	(33)	(30)	(37)	(11)	(14)	(22)	
nvestment Income	751	706	(2,620)	(980)	553	739	(617)	41	
Noncontinuing items									
ncome before income taxes	3,917	3,658	98	997	2,410	3,140	1,328	3,047	
Provision for income taxes	1,293	1,207	33	319	771	1,005	425	1,006	
ncome before accounting change	2,624	2,451	65	678	1,639	2,135	903	2,041	
Cumulative effect of accounting change	-	-	-	-	-	-	-	-	
Net income	$ 2,624	$ 2,451	$ 65	$ 678	$ 1,639	$ 2,135	$ 903	$ 2,041	$
Preferred stock dividends									
Net income available for common shareholders	$ 2,624	$ 2,451	$ 65	$ 678	$ 1,639	$ 2,135	$ 903	$ 2,041	$
Basic EPS before accounting change	$0.25	$0.23	$0.01	$0.06	$0.15	$0.20	$0.08	$0.19	
Diluted EPS before accounting change	$0.24	$0.22	$0.01	$0.06	$0.15	$0.19	$0.08	$0.19	

Example One: Which Is The Best Flight?

Length, stop-overs, switches...

		Depart	*Arrive*
AC 117	Vancouver - Calgary	7:00	9:00
Cdn 321	Vancouver - Calgary	9:00	12:00
Cdn 355	Calgary - Montreal	13:30	19:30
AC 123	Calgary - Toronto	12:30	16:30
AC 123	Toronto - Montreal	16:45	17:30

`*time zone: +1 van-cal, +2 cal-tor, mtl`



Example Two: When Do I Take My Drugs? (From "Things That Make Us Smart" By Don Norman

Note: 10 - 30% error rate in taking pills, same for pillbox organizers

Inderal - 1 tablet 3 times a day
Lanoxin -1 tablet every a.m.
Carafate - 1 tablet before meals and at bedtime
Zantac - 1 tablet every 12 hours (twice a day)
Quinag - 1 tablet 4 times a day
Couma - 1 tablet a day

	Breakfast	Lunch	Dinner	Bedtime
Lanoxin	O			
Inderal	O	O	O	
Quinag	O	O	O	O
Carafate	O	O	O	O
Zantac		O		O
Couma				O

Breakfast	Lunch	Dinner	Bedtime
Lanoxin			
Inderal	Inderal	Inderal	
Quinag	Quinag	Quinag	Quinag
Carafate	Carafate	Carafate	Carafate
	Zantac		Zantac
			Couma

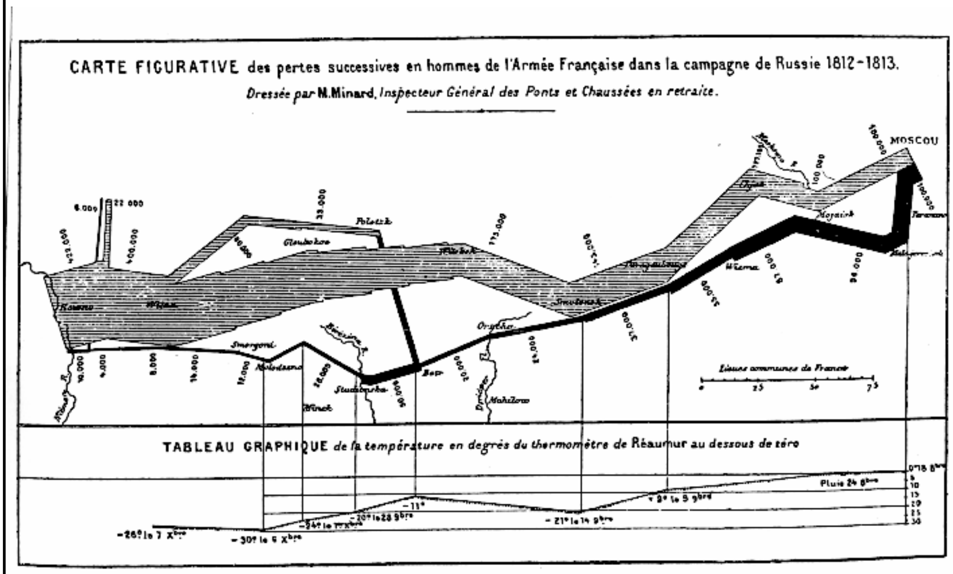
Organized by both time of day and by drug

Example Three: Napoleon's March To Moscow

by Charles Minard

Example Three: Napoleon's March To Moscow

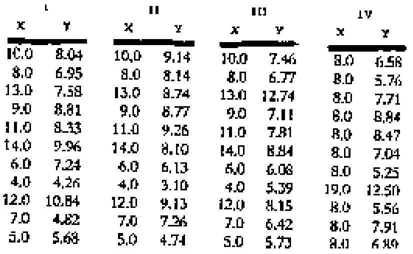
by Charles Minard



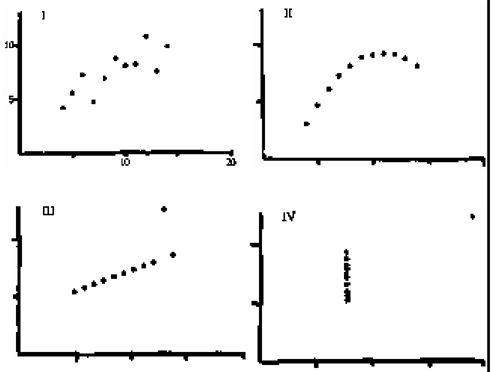
9bre = November

8bre = October

Example Four: Anscombe's Quartet

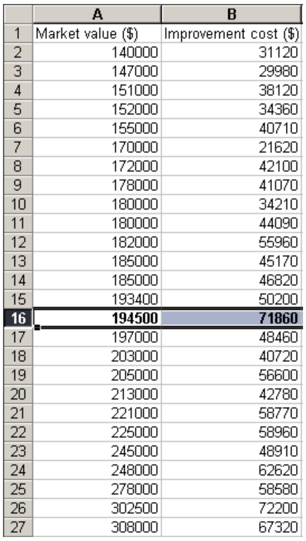


I x	I y	II x	II y	III x	III y	IV x	IV y
10.0	8.04	10.0	9.14	10.0	7.46	8.0	6.58
8.0	6.95	8.0	8.14	8.0	6.77	8.0	5.76
13.0	7.58	13.0	8.74	13.0	12.74	8.0	7.71
9.0	8.81	9.0	8.77	9.0	7.11	8.0	8.84
11.0	8.33	11.0	9.26	11.0	7.81	8.0	8.47
14.0	9.96	14.0	8.10	14.0	8.84	8.0	7.04
6.0	7.24	6.0	6.13	6.0	6.08	8.0	5.25
4.0	4.26	4.0	3.10	4.0	5.39	19.0	12.50
12.0	10.84	12.0	9.13	12.0	8.15	8.0	5.56
7.0	4.82	7.0	7.26	7.0	6.42	8.0	7.91
5.0	5.68	5.0	4.74	5.0	5.73	8.0	6.89

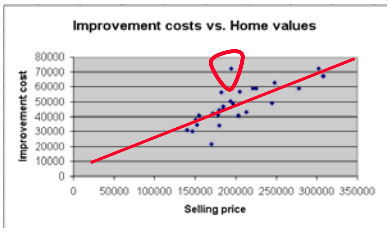


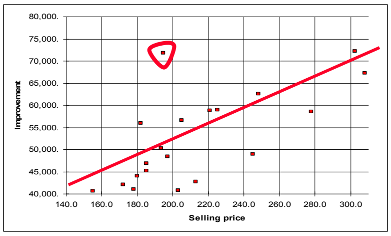
N:	11.0
mean X's :	9.0
mean Y's :	7.5
standard error of slope estimate:	0.1
sum of squares:	110.0
regression sum of squares:	27.5
residual sum of squares of Y:	13.8
correlation coefficient:	0.8
r squared:	0.7
regression line:	Y=3+0.5X

Example Five: Do I Deserve A Tax Break

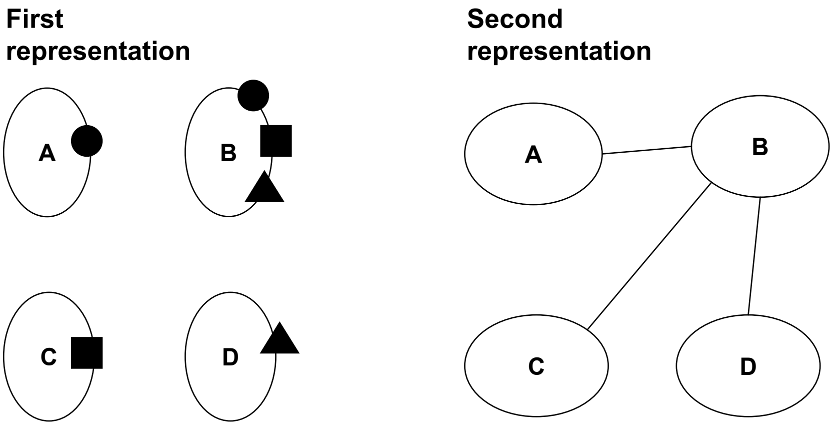


	A	B
1	Market value ($)	Improvement cost ($)
2	140000	31120
3	147000	29980
4	151000	38120
5	152000	34360
6	155000	40710
7	170000	21620
8	172000	42100
9	178000	41070
10	180000	34210
11	180000	44090
12	182000	55960
13	185000	45170
14	185000	46820
15	193400	50200
16	194500	71860
17	197000	48460
18	203000	40720
19	205000	56600
20	213000	42780
21	221000	58770
22	225000	58960
23	245000	48910
24	248000	62620
25	278000	58580
26	302500	72200
27	308000	67320





Not All Diagrammatic Representations Are Equally Effective



From Information Visualization: Perception for Design by Colin Ware.

Tufte's Principles Of Information Visualization[1]

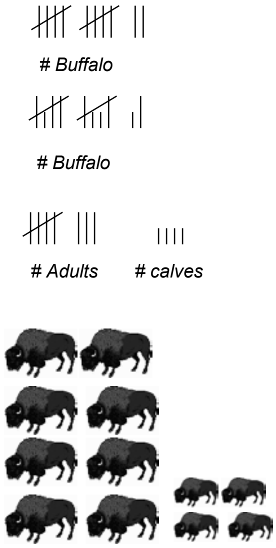
Graphics should reveal the data

- Show the data
- Not get in the way of the message
- Avoid distortion
- Present many numbers in a small space
- Make large data sets coherent
- Encourage comparison between data
- Supply both a broad overview and fine detail
- Serve a clear purpose

[1] *"Visual Display of Quantitative Information" by E. Tufte*

Note: Some of the visual examples on the following slides are taken from Tufte's books

Show The Data


# Buffalo
# Buffalo
# Adults
# calves

Not Get In The Way Of The Message

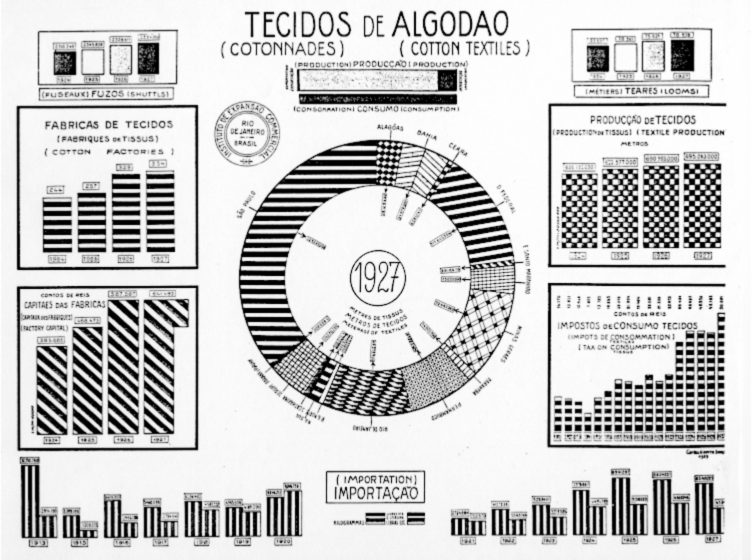
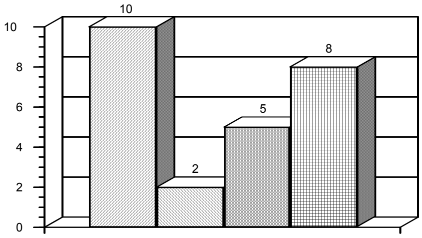
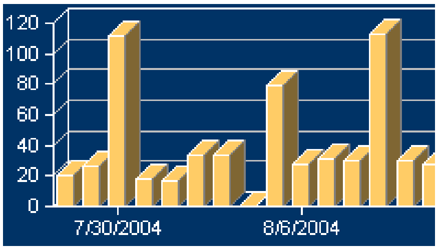


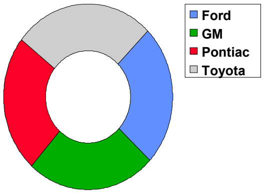
Chart Junk: A Common Error (The Representation Getting In The Way Of The Message)

Information display is not just pretty graphics

- Graphical re-design by amateurs on computers gives us
  - Overly complicated or even deceptive representations



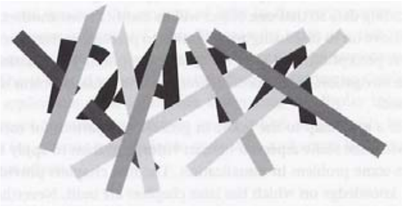




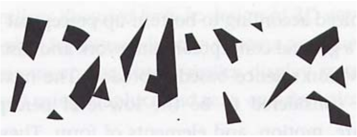
The Representation Should Not Get In The Way Of The Message

But it's not just as simple as removing "irrelevant" information.

Extra clutter?

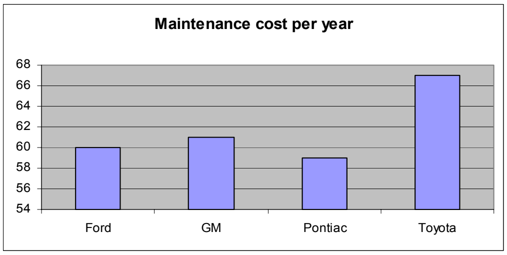


Is the message clearer?

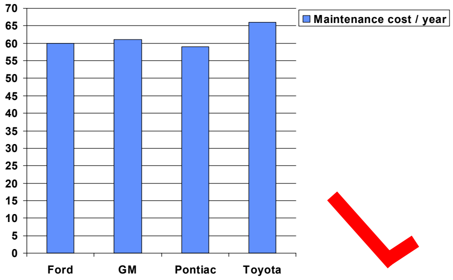


From "Information Visualization: Perception for Design" by Colin Ware

Avoid Distortion: The Representation Alters The Message



✗

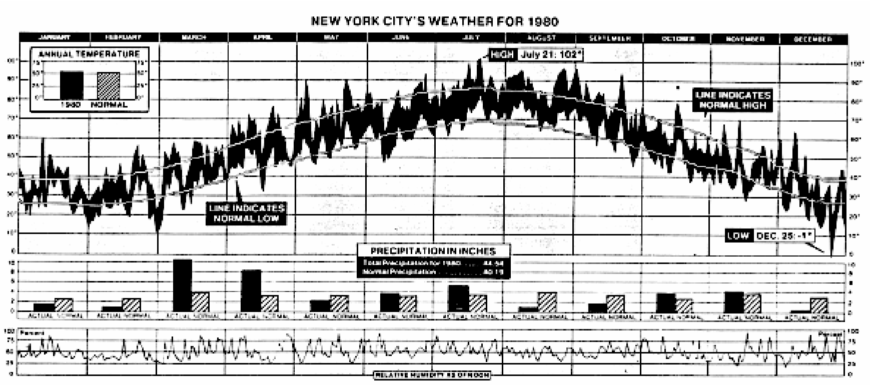


✓

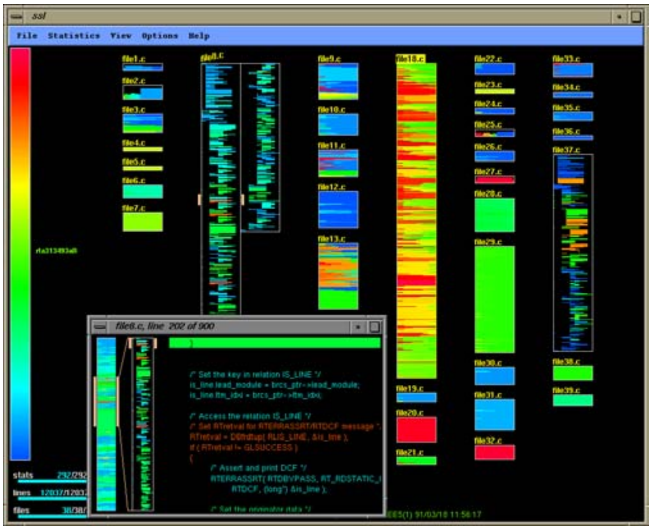
Present Many Numbers In A Small Space, Make Large Data Sets Coherent

New York Weather History

- 181 numbers/sq inch



Encourage Comparison Between The Data

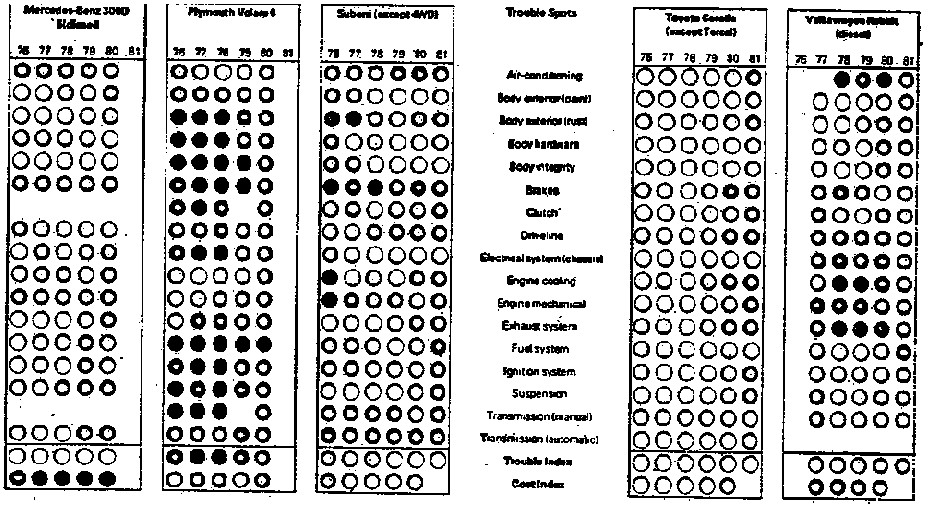

ssl
File Statistics View Options Help
file1.c
file2.c
file3.c
file4.c
file5.c
file6.c
file7.c
file8.c
file9.c
file10.c
file11.c
file12.c
file13.c
file18.c
file19.c
file20.c
file21.c
file22.c
file23.c
file24.c
file25.c
file26.c
file27.c
file28.c
file29.c
file30.c
file31.c
file32.c
file33.c
file34.c
file35.c
file36.c
file37.c
file38.c
file39.c
stats 292/292
lines 12037/1203
files 38/38
file8.c, line 202 of 900

```
/* Set the key in relation IS_LINE */
is_line.lead_module = brcs_ptr->lead_module;
is_line.ftn_idx = brcs_ptr->ftn_idx;

/* Access the relation IS_LINE */
/* Set RTretval for RTERRASSRT/RTDCF message */
RTretval = DBfindtup( RLIS_LINE, &is_line );
if ( RTretval != GLSUCCESS )
{
        /* Assert and print DCF */
        RTERRASSRT( RTDBYPASS, RT_RDSTATIC_
                RTDCF, (long*) &is_line );
```

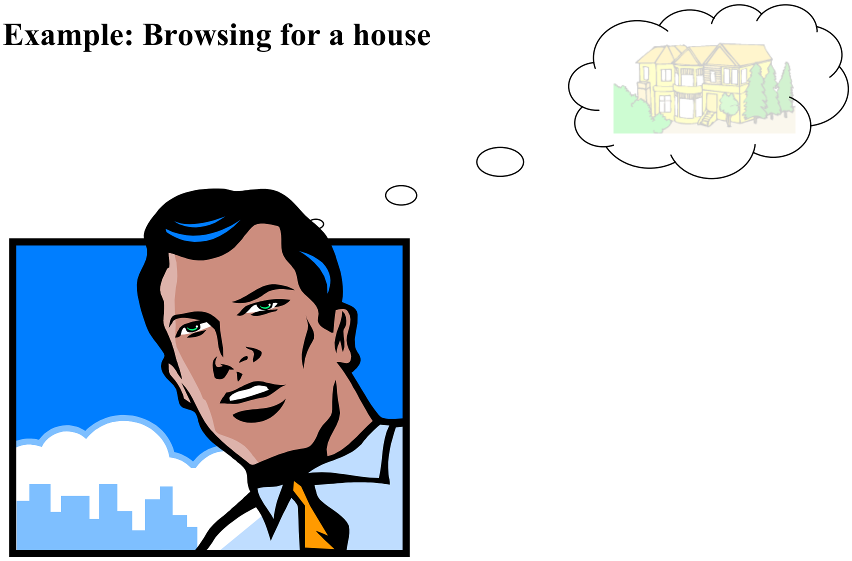
1) *"Seesoft—A Tool for Visualizing Line Oriented Software Statistics",* Eick S.G., Steffen J.L. and Sumner E.E

Broad Overview And Fine Detail



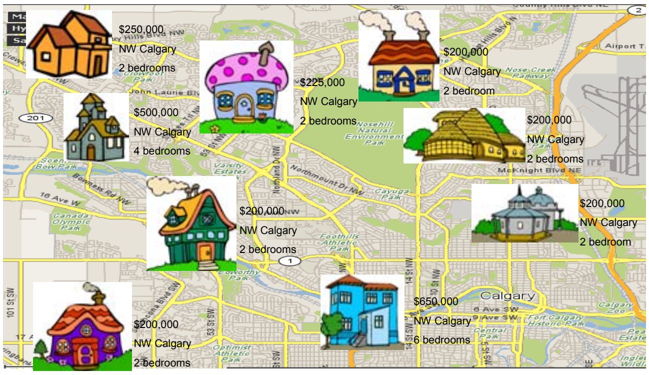
Applying Visual Representations To A Common Task: Browsing A Large Dataset

Example: Browsing for a house



A Model Of Perceptual Processing[1]

- The set of information is large to show all at once.
- Example search results:



$250,000
NW Calgary
2 bedrooms
$225,000
NW Calgary
2 bedrooms
$200,000
NW Calgary
2 bedroom
$500,000
NW Calgary
4 bedrooms
$200,000
NW Calgary
2 bedrooms
$200,000
NW Calgary
2 bedrooms
$200,000
NW Calgary
2 bedroom
$650,000
NW Calgary
6 bedrooms
$200,000
NW Calgary
2 bedrooms
Calgary

- To help assist the person in this type of situation, take advantage of how people process visual information.

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[1] From "Information Visualization: Perception for Design" by Colin Ware

Stage 1: Parallel Processing To Extract Low Level Properties Of The Visual Scene

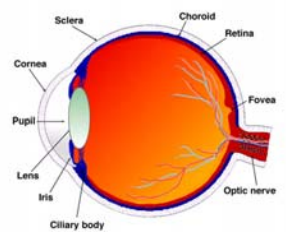
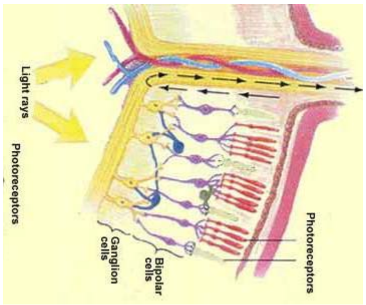
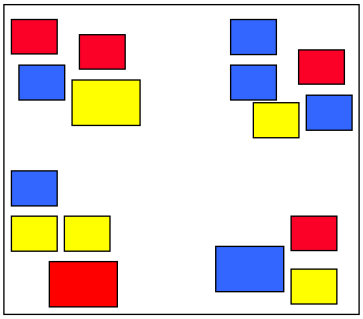

Sclera
Choroid
Retina
Cornea
Fovea
Pupil
Lens
Iris
Optic nerve
Ciliary body

Diagram of the human eye from The John Moran Eye Center


Light rays
Photoreceptors
Ganglion cells
Bipolar cells
Photoreceptors

The Brain from top to bottom

Stage 1: Parallel Processing To Extract Low Level Properties Of The Visual Scene (2)



A Diagram

- Different properties of diagram are processed by the neurons in the retinal.
- This processing automatically occurs.
- The processing is done in parallel

Color

Size

Position

Stage 1: Parallel Processing To Extract Low Level Properties Of The Visual Scene (3)

Characteristics of visual information that can be automatically processed:

1. Processing cannot be inhibited
2. Information is rapidly processed
3. Information can be processed in parallel
4. Can be understood without training

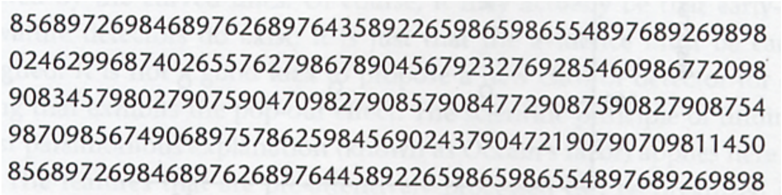
Communicate information by relying on perceptual powers of the brain without learning.

Examples:

- Color 🟦 🟥
- Size ▪ ■
- Many more to come...

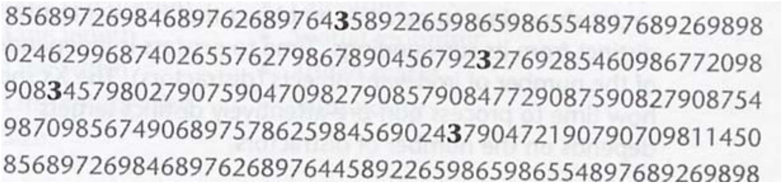
Applying Stage 1 Processing To The Problem Of Browsing A Large Dataset

Representing information in a manner that can be automatically processed can help the person browse a large data set.



85689726984689762689764358922659865986554897689269898
02462996874026557627986789045679232769285460986772098
90834579802790759047098279085790847729087590827908754
98709856749068975786259845690243790472190790709811450
85689726984689762689764458922659865986554897689269898

Vs.



85689726984689762689764**3**58922659865986554897689269898
024629968740265576279867890456792**3**2769285460986772098
908**3**4579802790759047098279085790847729087590827908754
9870985674906897578625984569024**3**790472190790709811450
85689726984689762689764458922659865986554897689269898

Stage 2: Sequential Goal-Directed Processing

The focus now shifts from gathering perceptual information about large quantities of information to getting details about a single object.

At this stage information can be represented in a fashion that requires controlled processing (not automatic).

Characteristics of representations that require controlled processing:

1. Requires conscious effort
2. Slow serial processing
3. Hard to learn
4. Easy to forget
5. Formally powerful

Example of a representation that require controlled processing:

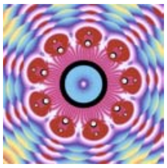
- Written language

Automatic Vs. Controlled Processing Of Information

Controlled

Automatic

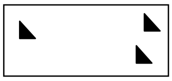
For this question you are to write a function that will take as input a string and return an integer value that is the length of the string. The end of the string will always...



Visual Variables

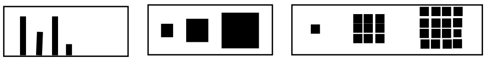
Position

- Changes in the x, y, z location



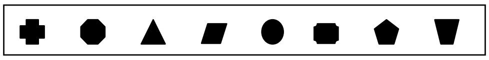
Size

- Changes in length, area or repetition



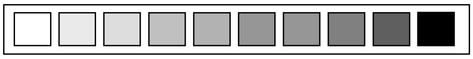
Shape

- Changes in form



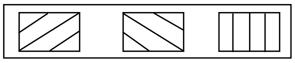
Value

- Changes in brightness



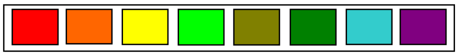
Orientation

- Changes in alignment



Colour

- Changes in hue



Visual Variables (2)

Texture

- Variations in pattern

Motion

www.st-duffer.com

Visual Variables (3)

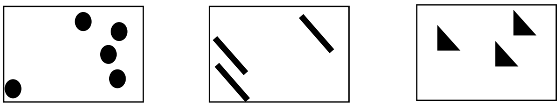
Characteristics of visual variables

- **Selective**
  Is a change in this variable enough to allow us to select it *from a group*?
- **Associative**
  Is a change in this variable enough to allow us to perceive them *as a group*?
- **Quantitative**
  Is there a numerical reading obtainable from changes in this variable?
- **Order**
  Do changes in the visual variable indicate some sort of ranking?
- **Length**[1]
  Across how many changes in this variable are distinctly perceptible?

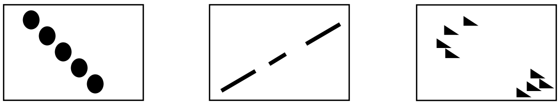
[1] Think of it as variation

Visual Variable: Position

✓ **Selective**



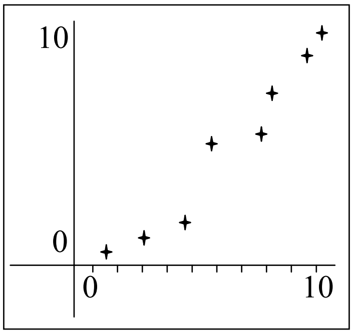
✓ **Associative**



✓ **Quantitative**

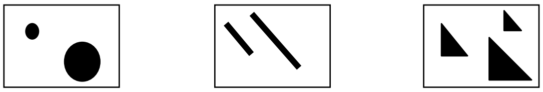
✓ **Order**

✓ **Length**

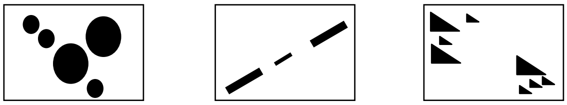


Visual Variable: Size

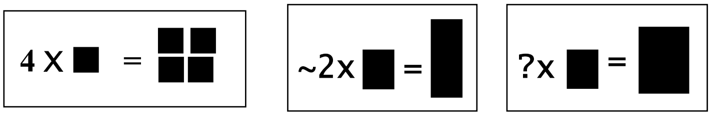
✓ **Selective**



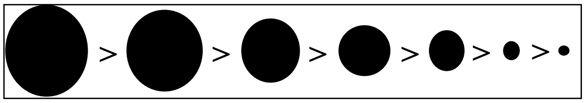
✓ **Associative**



≃ **Quantitative**



✓ **Order**

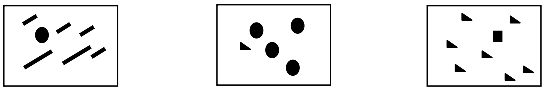


✓ **Length**

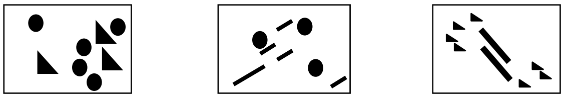
Theoretically infinite but practically limited

Visual Variable: Shape

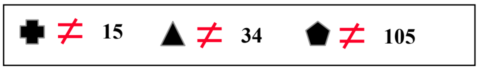
≃ **Selective**



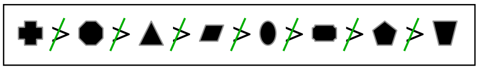
≃ **Associative**



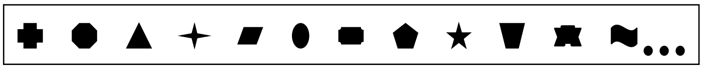
≠ **Quantitative**



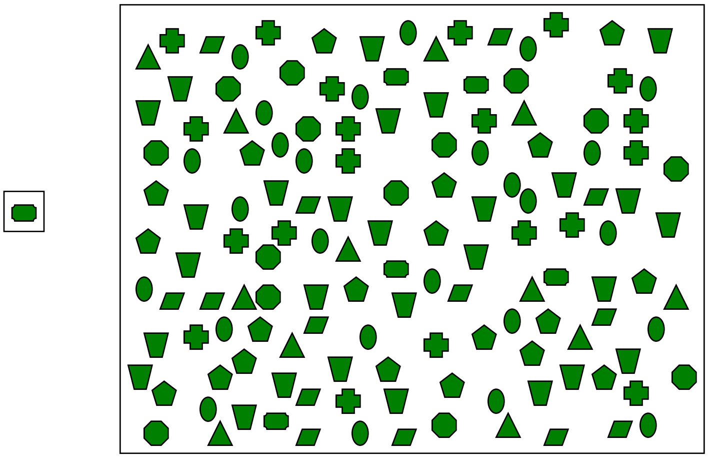
≠ **Order**



✓ **Length**

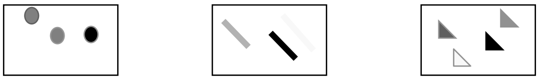


Shape

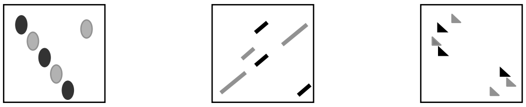


Visual Variable: Value

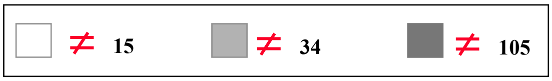
✓**Selective**



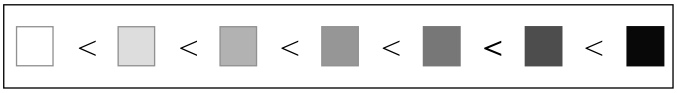
✓**Associative**



≠**Quantitative**



✓**Order**

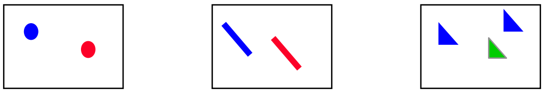


✓**Length**

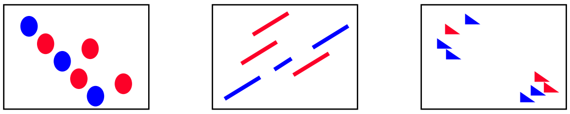
- Theoretically infinite but practically limited
- Association ~ < 7 and selection ~ 10

Visual Variable: Color

✓**Selective**



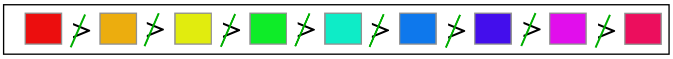
✓**Associative**



≠**Quantitative**

🟥 ≠ 15 🟨 ≠ 13 🟩 ≠ 34 🟦 ≠ 67

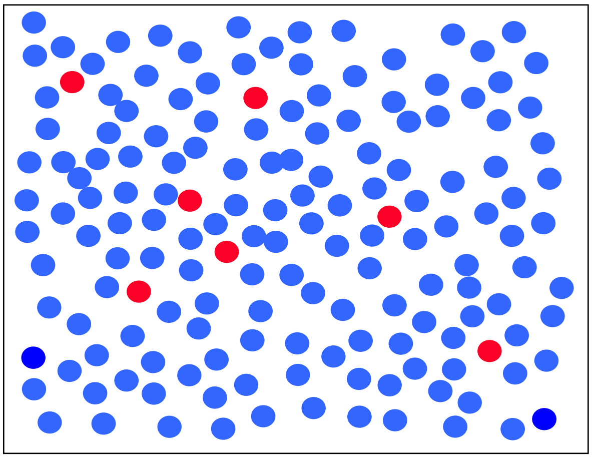
≠**Order**



✓**Length**

- Theoretically infinite but practically limited
- Association ~ < 7 and selection ~ 20

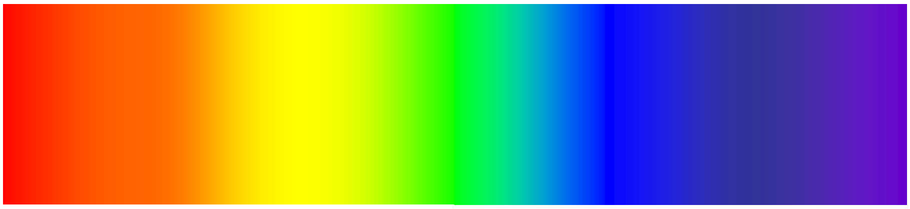
Color



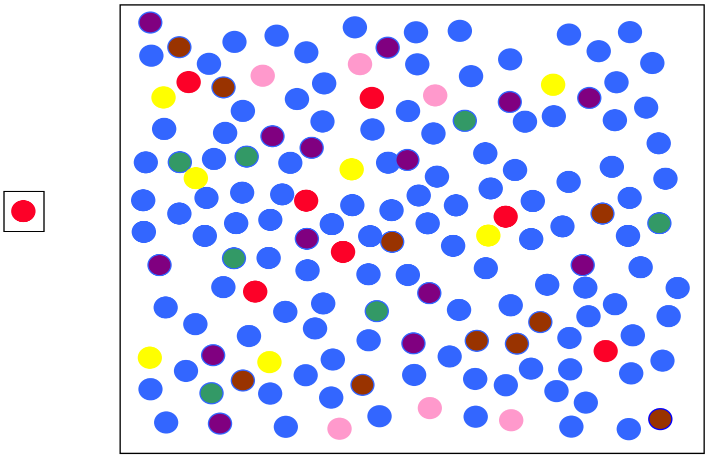
Color Encoding

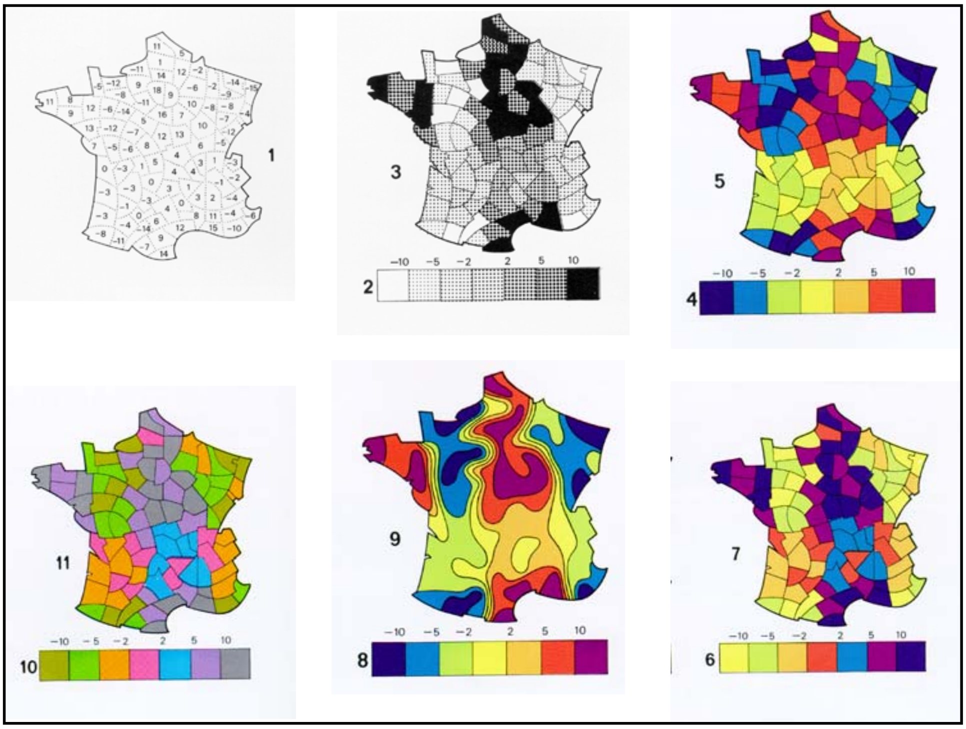
Common advice says use a rainbow scale

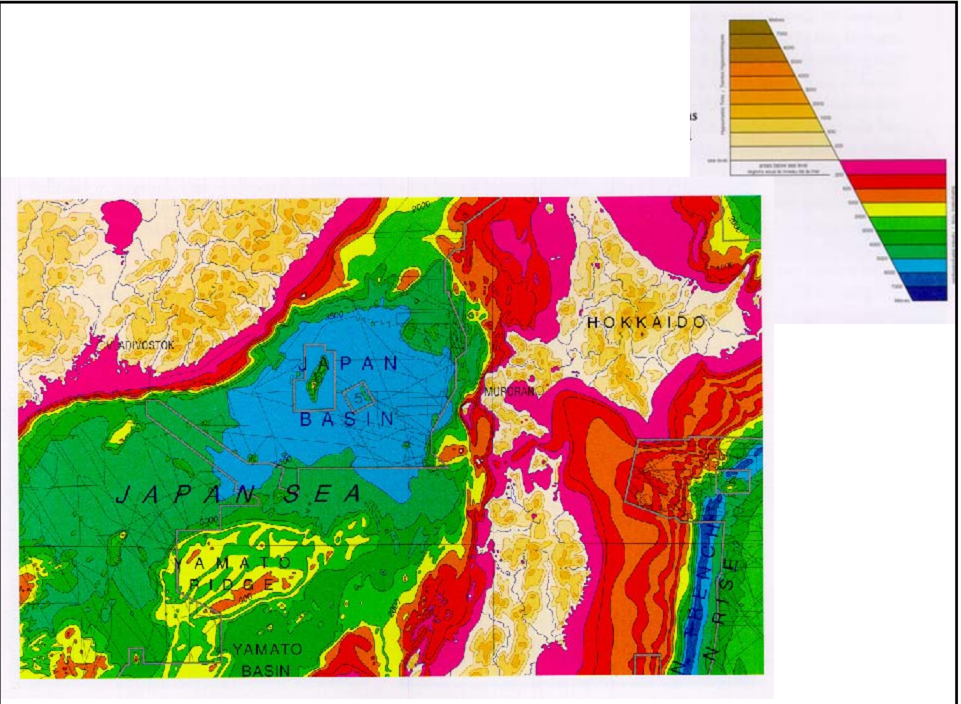
- Marcus, Murch, Healey
- There are problems with rainbows

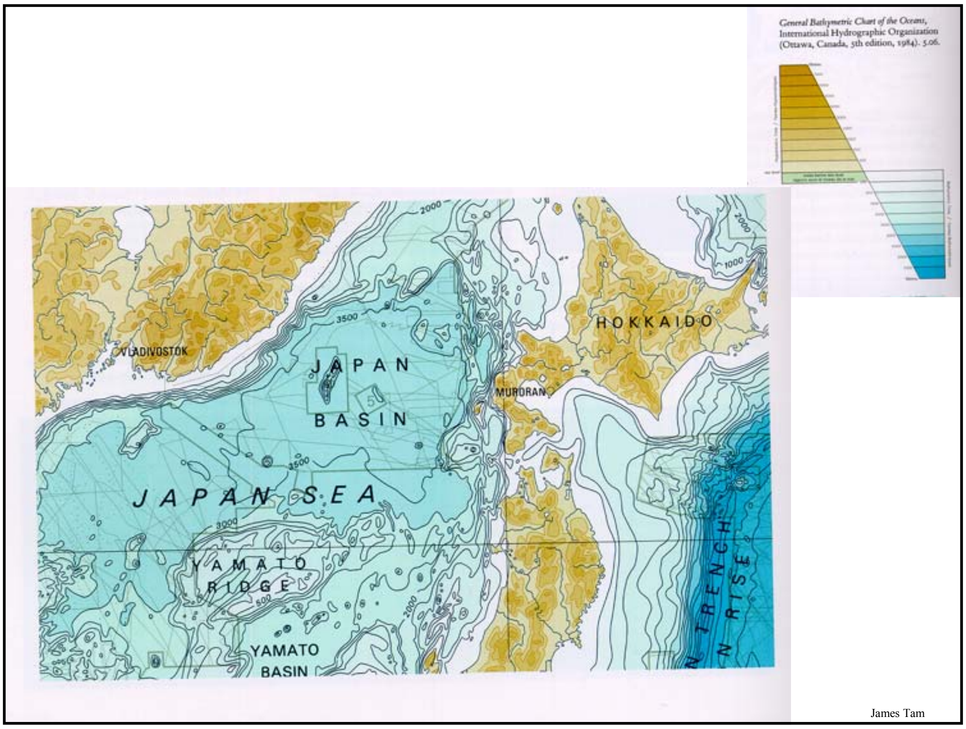


Color




1
3
2
−10 −5 −2 2 5 10
5
4
−10 −5 −2 2 5 10
11
10
−10 −5 −2 2 5 10
9
8
−10 −5 −2 2 5 10
7
6
−10 −5 −2 2 5 10


HOKKAIDO
ADIVOSTOK
JAPAN BASIN
MURORAN
JAPAN SEA
YAMATO RIDGE
YAMATO BASIN
TRENCH
RISE



2000
2000
1000
3500
VLADIVOSTOK
JAPAN
BASIN
HOKKAIDO
MURORAN
3500
JAPAN SEA
3000
YAMATO
RIDGE
500
YAMATO
BASIN
TRENCH
N RISE

General Bathymetric Chart of the Oceans, International Hydrographic Organization (Ottawa, Canada, 5th edition, 1984). 5.06.

Additional Issues Associated With Color

Color blindness:

- The majority of people who are color blind are red-green color blind so these colors should be avoided when communicating information.

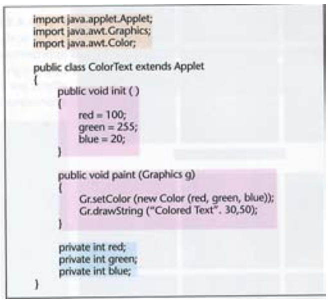
Field size

- The larger the area to be color coded, the more easily that colors can be distinguished.
- When objects are small and color is used to distinguish the colors use highly saturated colors.

Additional Issues Associated With Color (2)

Field Size (continued)

- When large color coded regions are used (e.g., maps) use colors with low saturation (reduces interference with detailed information e.g., text)



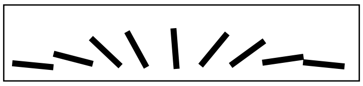
```
import java.applet.Applet;
import java.awt.Graphics;
import java.awt.Color;

public class ColorText extends Applet
{
        public void init ( )
        {
                red = 100;
                green = 255;
                blue = 20;
        }

        public void paint (Graphics g)
        {
                Gr.setColor (new Color (red, green, blue));
                Gr.drawString ("Colored Text". 30,50);
        }

        private int red;
        private int green;
        private int blue;
}
```

Conventions

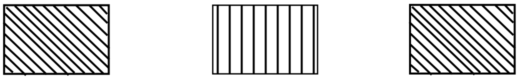
- "Commonly accepted" conventions can vary widely by culture and their use should be carefully considered e.g., white is associated with purity in some Western cultures and death with some Eastern cultures.

Visual Variable: Orientation

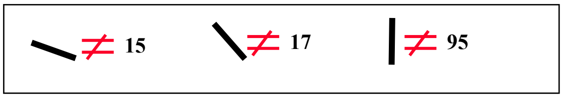
✓ **Selective**



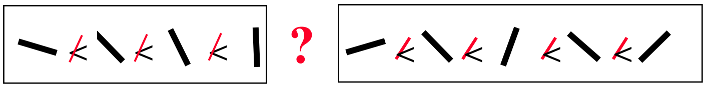
✓ **Associative**



≠ **Quantitative**



≠ **Order**



✓ **Length**

~5 in 2D

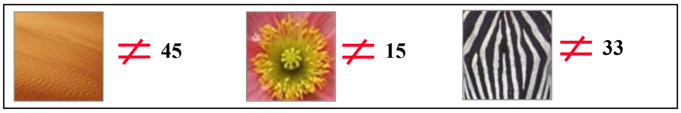
? in 3D

Visual Variable: Texture

✓**Selective**

✓**Associative**

≠**Quantitative**



≠**Order**

✓**Length**

- Theoretically infinite

Visual Variable: Motion

✓**Selective -** motion is one of our most powerful attention grabbers

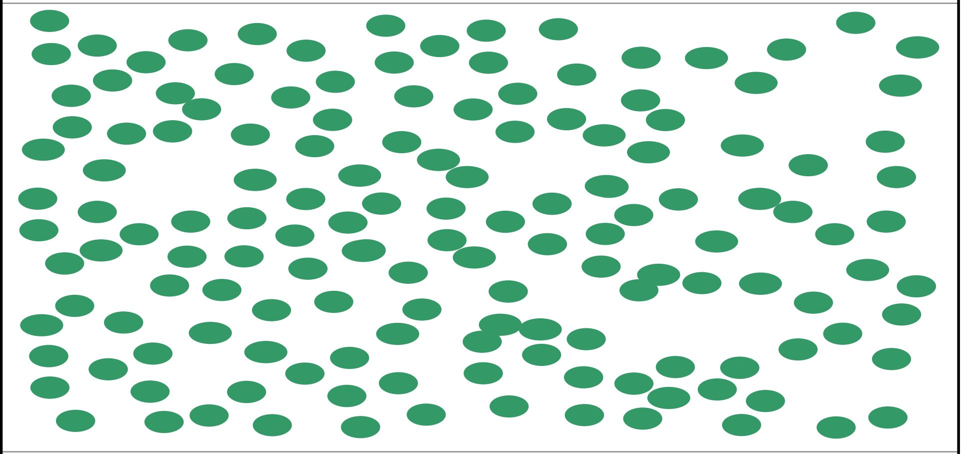
✓**Associative** – objects moving in unison groups them effectively

≠**Quantitative -** subjective perception

≠**Order**

? **Length - distinguishable types of motion?**

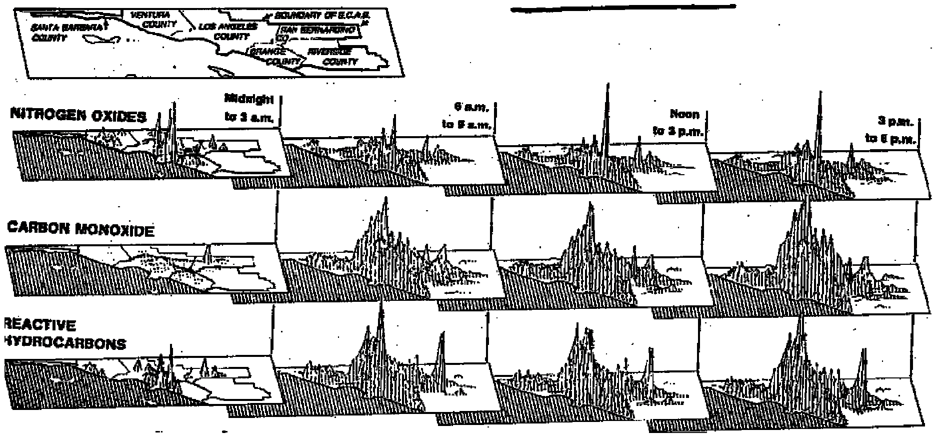
Motion



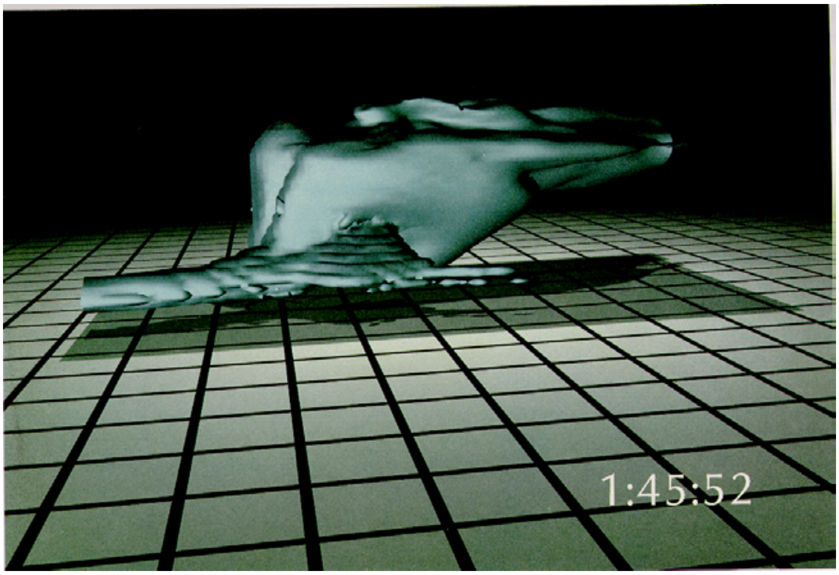
Small Multiples: General Principles

Learn once

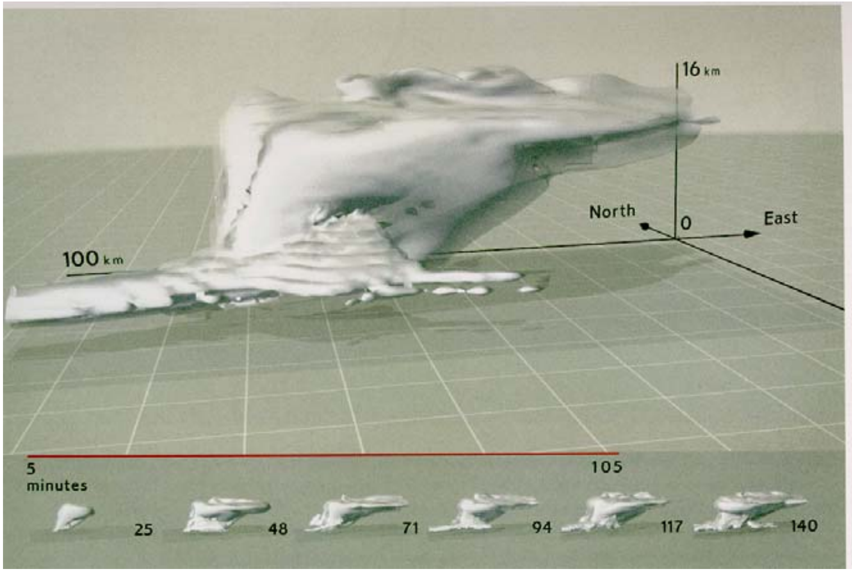
Invite comparisons



Small Multiples: Showing Time And Change



Small Multiples: Showing Time And Change


16 km
North
0
East
100 km
5
minutes
105
25
48
71
94
117
140

Metaphors

Definition of a Metaphor

- One kind of object or idea is used in place of another to suggest a likeness or analogy between them
- Application of name or descriptive term to an object to which it is not literally applicable

---

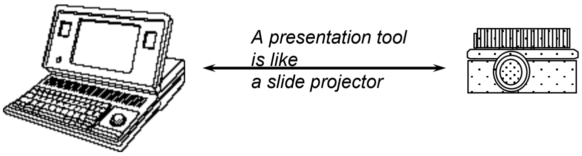
Interface Metaphors

Purpose

- Function as natural models
- Leverages our knowledge of familiar, concrete objects/experiences to understand abstract computer and task concepts

Problem

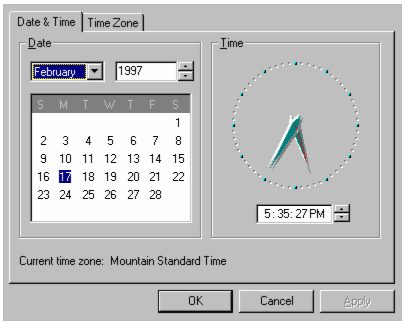
- Metaphor may portray inaccurate or naive conceptual model of the system



A presentation tool
is like
a slide projector

Interface Metaphors

Pervade excellent interfaces


Date & Time
Time Zone
Date
Time
S M T W T F S
OK
Cancel
Apply

February 1997

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	

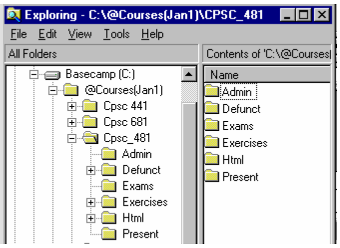
5:35:27 PM

Current time zone: Mountain Standard Time

Control Panels with familiar controls

Name:_______________
Address:_______________
City:_______________
Province:_______________
Postal Code:_______________

Forms

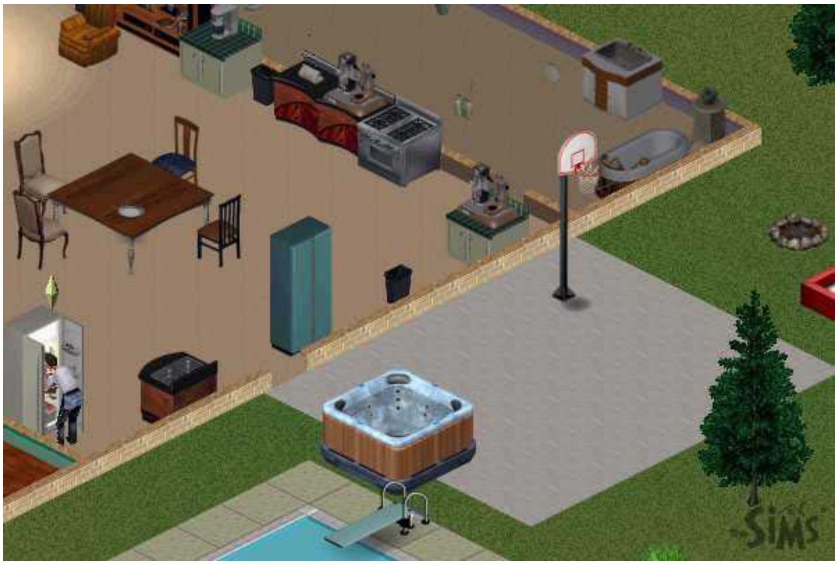

Exploring - C:\@Courses(Jan1)\CPSC_481
File Edit View Tools Help
All Folders
Contents of 'C:\@Courses
Name

- Basecamp (C:)
  - @Courses(Jan1)
    - Cpsc 441
    - Cpsc 681
    - Cpsc_481
      - Admin
      - Defunct
      - Exams
      - Exercises
      - Html
      - Present

Admin
Defunct
Exams
Exercises
Html
Present

Hierarchical Folders

A Real Life Metaphor: Life!



The Sims House Party © Maxis

Creating Interface Metaphors

Generating metaphors

- Use metaphors that matches user's conceptual task
  - —Desktop metaphor for office workers
  - —Paintbrush metaphor for artists...
- Given a choice, choose the metaphor close to the way the system works
- Ensure emotional tone is appropriate to users
  - e.g., file deletion metaphors
    - Trashcan
    - Black hole
    - Paper shredder
    - Pit bull terrier
    - Nuclear disposal unit...

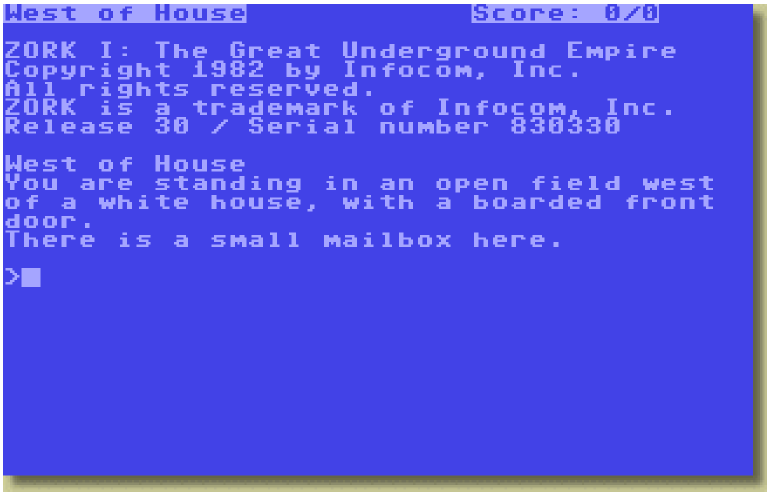
Evaluating Metaphors

Potential problems:

- The metaphor has attributes that the system does not have.
- The system has attributes that are not suggested by the metaphor.
- An attribute exists both in the metaphor and in the system but works differently in each.

The Metaphor Is More Powerful Than The System

Will the metaphor make people believe that the system can do more than it currently can?



```
West of House                       Score: 0/0

ZORK I: The Great Underground Empire
Copyright 1982 by Infocom, Inc.
All rights reserved.
ZORK is a trademark of Infocom, Inc.
Release 30 / Serial number 830330

West of House
You are standing in an open field west
of a white house, with a boarded front
door.
There is a small mailbox here.

>
```

Zork © Infocom

The System Is More Powerful Than The Metaphor Implies

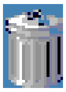
Will the metaphor restrict how people will try to use the system?

- e.g., file folders

An Attribute Differs Between The Metaphor And The System

e.g., The trash can

Real trashcan

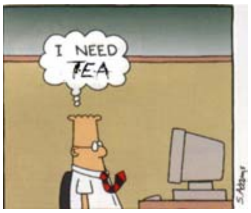


Desk top trashcan

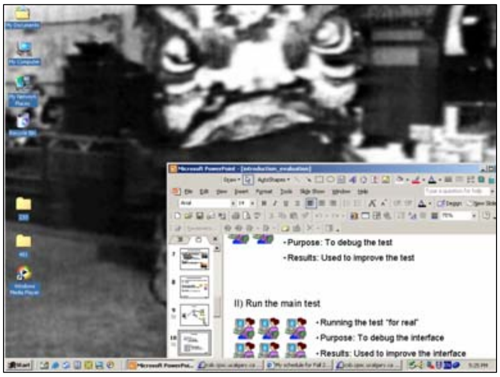
Metaphors Should Not Be Static

Evolve metaphors

- Is metaphor extensible to new features?
- When is the metaphor no longer useful?



Dilbert © United Features Syndicate



- Purpose: To debug the test
- Results: Used to improve the test

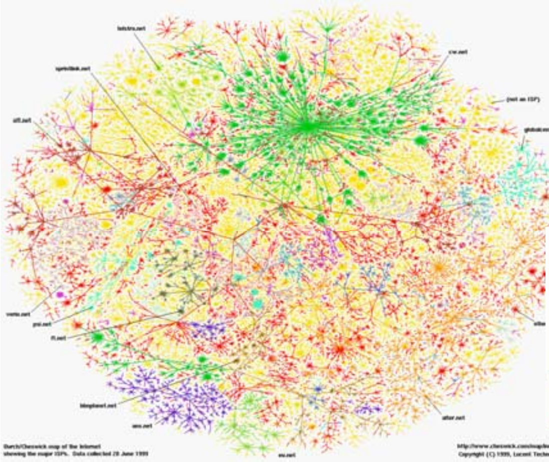
II) Run the main test

- Running the test "for real"
- Purpose: To debug the interface
- Results: Used to improve the interface

Metaphors Should Not Be Static (2)

Evolve metaphors

- Is metaphor extensible to new features?
- When is the metaphor no longer useful?



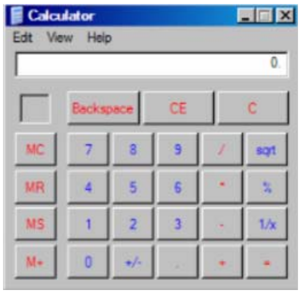
Misuse Of Metaphors

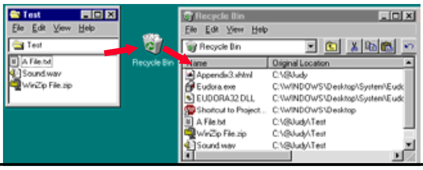
Caveat

- Metaphors can be overdone!

Common pitfalls

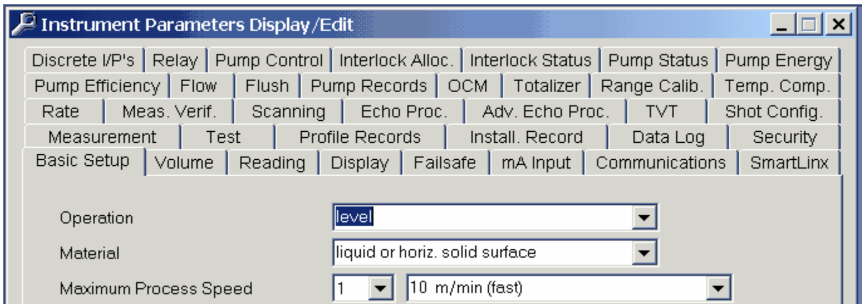
- Overly literal
  - Unnecessary fidelity
  - Excessive interactions
- Overly cute
  - Novelty quickly wears off
- Overly restrictive
  - Capabilities suggested by the metaphor don’t match the actual capabilities
- Mismatched
  - Does not match user’s task and/or thinking


Calculator
Edit View Help
0
Backspace CE C
MC 7 8 9 / sqrt
MR 4 5 6 * %
MS 1 2 3 - 1/x
M+ 0 +/- . + =


Test
File Edit View Help
Test
A File.txt
Sound.wav
WinZip File.zip
Recycle Bin
Recycle Bin
File Edit View Help
Recycle Bin

Name	Original Location
Appendix3.shtml	C:\@Judy
Eudora.exe	C:\WINDOWS\Desktop\System\Eudc
EUDORA32.DLL	C:\WINDOWS\Desktop\System\Eudc
Shortcut to Project...	C:\WINDOWS\Desktop
A File.txt	C:\@Judy\Test
WinZip File.zip	C:\@Judy\Test
Sound.wav	C:\@Judy\Test

Misuse Of Metaphors (2)


Instrument Parameters Display/Edit
Discrete I/P's
Relay
Pump Control
Interlock Alloc.
Interlock Status
Pump Status
Pump Energy
Pump Efficiency
Flow
Flush
Pump Records
OCM
Totalizer
Range Calib.
Temp. Comp.
Rate
Meas. Verif.
Scanning
Echo Proc.
Adv. Echo Proc.
TVT
Shot Config.
Measurement
Test
Profile Records
Install. Record
Data Log
Security
Basic Setup
Volume
Reading
Display
Failsafe
mA Input
Communications
SmartLinx

Operation: level

Material: liquid or horiz. solid surface

Maximum Process Speed: 1 | 10 m/min (fast)

Milltronics' *Dolphin Plus* a configuration package for industrial level and flow sensors

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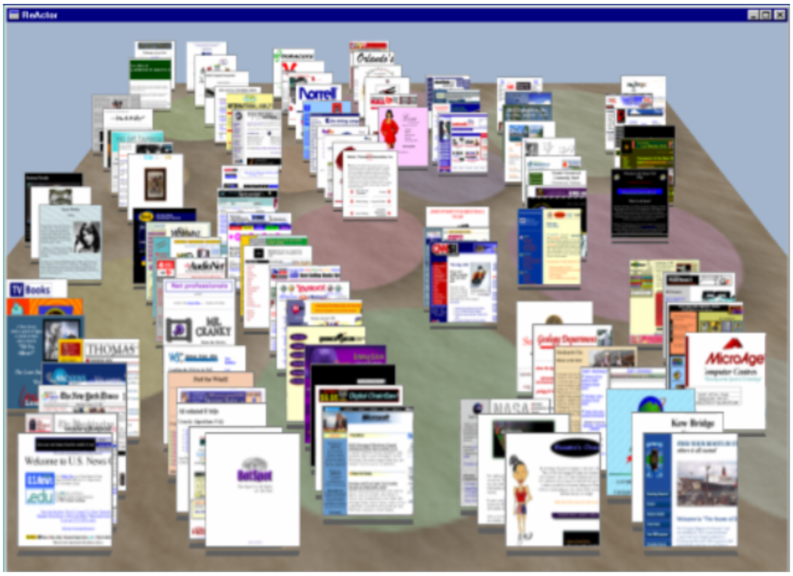
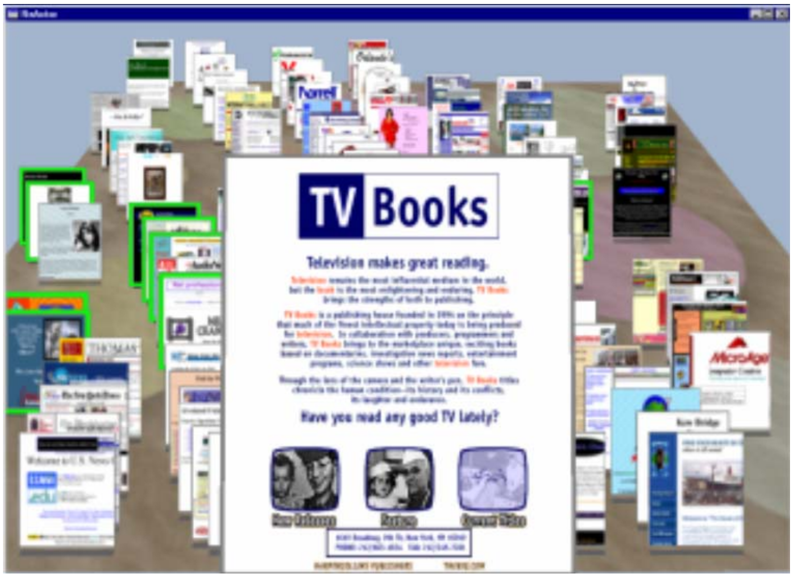
A Example System That Applies A Metaphor: The Data Mountain



Robertson / Czerwinski / Larson / Robbins / Thiel / van Dantzich
Data Mountain: Using Spatial Memory for Document Management Proc ACM UIST'98

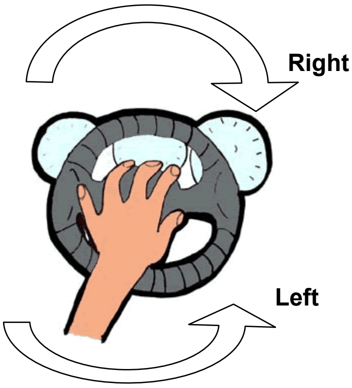
A Example System That Applies A Metaphor: The Data Mountain


TV Books
Television makes great reading.
Have you read any good TV lately?
MicroAge

Robertson / Czerwinski / Larson / Robbins / Thiel / van Dantzich
Data Mountain: Using Spatial Memory for Document Management Proc ACM UIST'98

Manipulating Real World Objects

Example steering a car:

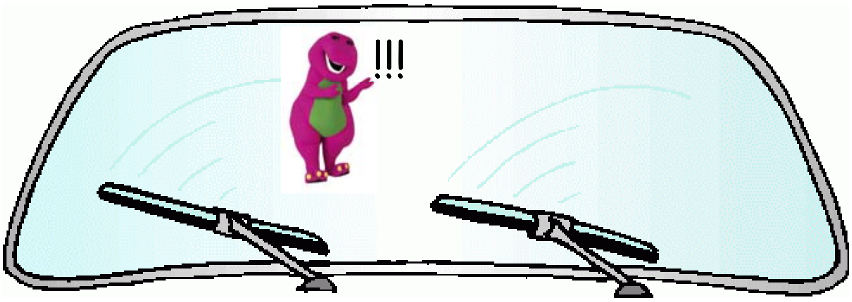


Direct mapping between the driver's actions and how the car reacts.

Objects of interest are visible

- Steering wheel
- The world outside of the car

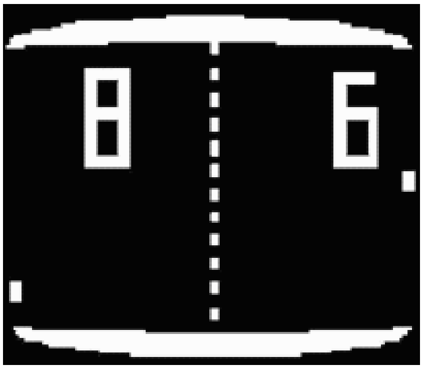
Imagine: Operating A Car In A Indirect Fashion



> Select: steering wheel, rotate left -30d

Direct Manipulation

- An interface that behaves as though the interaction was with a real-world object rather than with an abstract system
- Almost always based on a metaphor
  - Mapped onto some facet of the real world task semantics

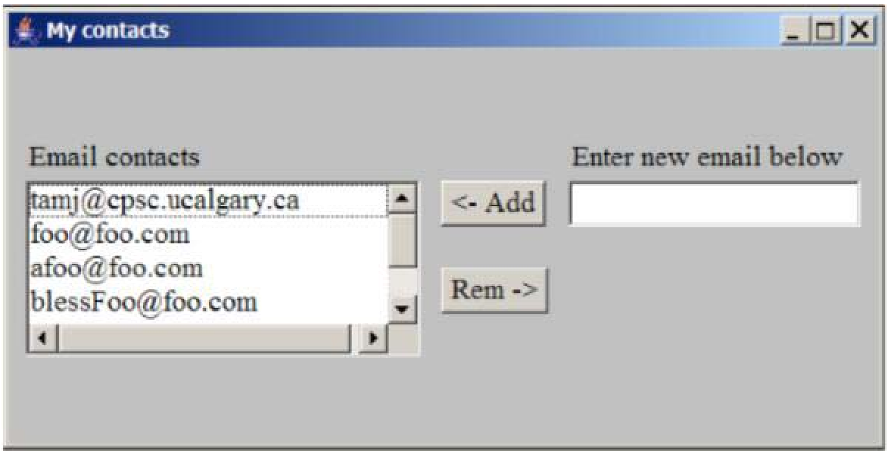


Ping was created by Nolan Bushnell

Characteristics Of Direct Manipulation

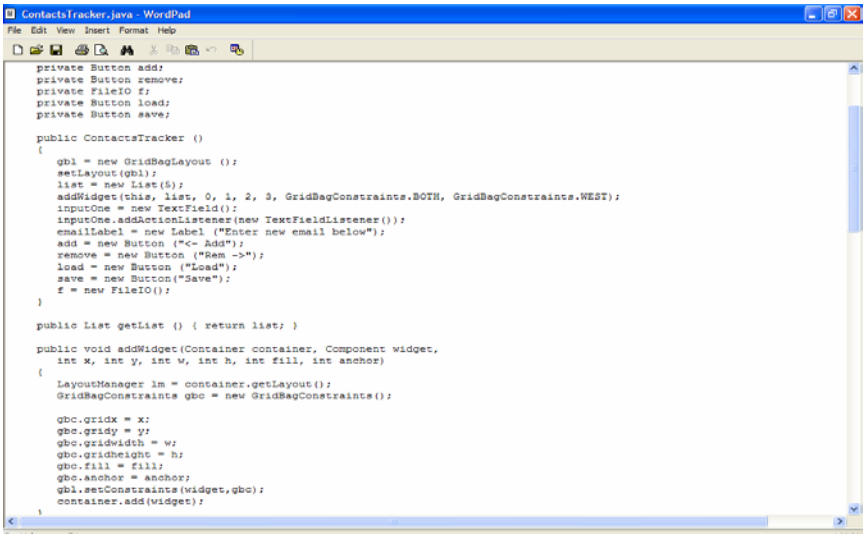
- Objects of interest are visible
- When it is logical: visible objects can be manipulated
- Manipulation occurs by pointing and moving

Indirect Interaction: Traditional Approach To Writing Java GUI's


My contacts
Email contacts
<- Add
Rem ->
Enter new email below

tamj@cpsc.ucalgary.ca
foo@foo.com
afoo@foo.com
blessFoo@foo.com

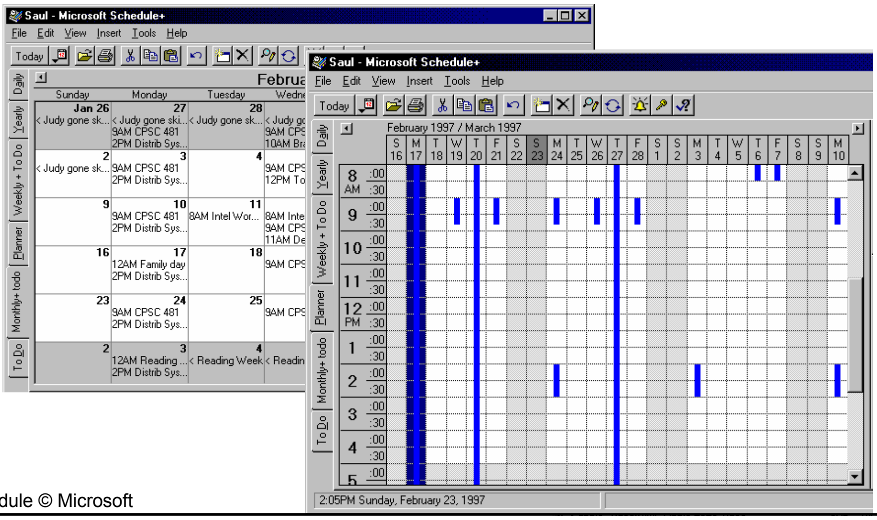
Indirect Interaction: Changing The Java Code


ContactsTracker.java - WordPad
File Edit View Insert Format Help

```
    private Button add;
    private Button remove;
    private FileIO f;
    private Button load;
    private Button save;

    public ContactsTracker ()
    {
       gbl = new GridBagLayout ();
       setLayout(gbl);
       list = new List(5);
       addWidget(this, list, 0, 1, 2, 3, GridBagConstraints.BOTH, GridBagConstraints.WEST);
       inputOne = new TextField();
       inputOne.addActionListener(new TextFieldListener());
       emailLabel = new Label ("Enter new email below");
       add = new Button ("<- Add");
       remove = new Button ("Rem ->");
       load = new Button ("Load");
       save = new Button("Save");
       f = new FileIO();
    }

    public List getList () { return list; }

    public void addWidget(Container container, Component widget,
       int x, int y, int w, int h, int fill, int anchor)
    {
       LayoutManager lm = container.getLayout();
       GridBagConstraints gbc = new GridBagConstraints();

       gbc.gridx = x;
       gbc.gridy = y;
       gbc.gridwidth = w;
       gbc.gridheight = h;
       gbc.fill = fill;
       gbc.anchor = anchor;
       gbl.setConstraints(widget,gbc);
       container.add(widget);
    }
```

Direct Manipulation

The representation directly affects what can be directly manipulated


Saul - Microsoft Schedule+
File Edit View Insert Tools Help
Today
Daily
Yearly
Weekly + To Do
Planner
Monthly+ todo
To Do
Februa

Sunday	Monday	Tuesday	Wedne
Jan 26 < Judy gone sk...	27 < Judy gone ski... 9AM CPSC 481 2PM Distrib Sys...	28 < Judy gone sk...	< Judy gc 9AM CPS 10AM Bra
2 < Judy gone sk...	3 9AM CPSC 481 2PM Distrib Sys...	4	9AM CPS 12PM To
9	10 9AM CPSC 481 2PM Distrib Sys...	11 8AM Intel Wor...	8AM Inte 9AM CPS 11AM De
16	17 12AM Family day 2PM Distrib Sys...	18	9AM CPS
23	24 9AM CPSC 481 2PM Distrib Sys...	25	9AM CPS
2	3 12AM Reading ... 2PM Distrib Sys...	4 < Reading Week	< Readin

Saul - Microsoft Schedule+
File Edit View Insert Tools Help
Today
Daily
Yearly
Weekly + To Do
Planner
Monthly+ todo
To Do
February 1997 / March 1997
S 16 M 17 T 18 W 19 T 20 F 21 S 22 S 23 M 24 T 25 W 26 T 27 F 28 S 1 S 2 M 3 T 4 W 5 T 6 F 7 S 8 S 9 M 10
8 AM :00 :30
9 :00 :30
10 :00 :30
11 :00 :30
12 PM :00 :30
1 :00 :30
2 :00 :30
3 :00 :30
4 :00 :30
5 :00

2:05PM Sunday, February 23, 1997

Schedule © Microsoft

Is Direct Manipulation The Way To Go?

Some Disadvantages

- Ill-suited for abstract operations or for vision impaired users
  - Spell-checker?
- Tedium
  - Manually search large database vs. query
- Metaphor may be misleading:
  - Overly restrictive may limit usage or overly powerful may imply functions that aren't available
- Direct manipulation systems require more screen space

Solution

- Most systems combine direct manipulation and abstractions
  - Word processor:
    WYSIWYG document (direct manipulation)
    buttons, menus, dialog boxes (abstractions, but direct manipulation "in the small")

Conventional Applications: A Mix

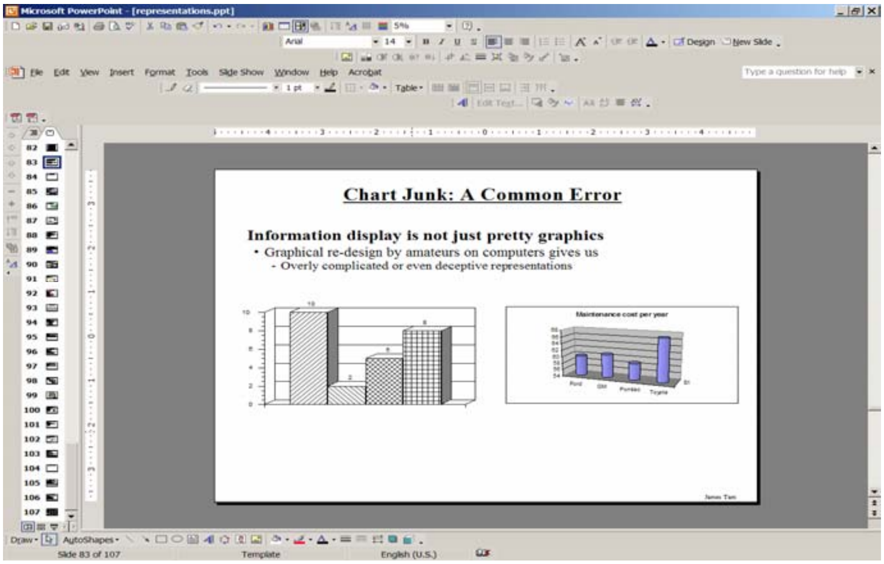

Microsoft PowerPoint - [representations.ppt]
File Edit View Insert Format Tools Slide Show Window Help Acrobat
Arial
14
Design
New Slide
Type a question for help
Table
Draw
AutoShapes
Slide 83 of 107
Template
English (U.S.)
Maintenance cost per year

Chart Junk: A Common Error

Information display is not just pretty graphics
- Graphical re-design by amateurs on computers gives us
  - Overly complicated or even deceptive representations

PowerPoint © Microsoft

Direct Engagement

- **The feeling of working directly on the task (as opposed to using a particular tool).**
- **To employ it, you need to consider the user of the system and the tasks that he or she engages in.**
- **Often direct manipulation is an important requirement for direct engagement.**
  - e.g., A drawing program provides tools that are familiar to artists (brushes, palettes etc.)

Direct Engagement: A Telephone Database

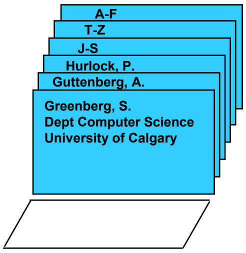
Find "Green"
>S. Greenberg
>Dept Computer Science
>University of Calgary

Command system
no direct manipulation

Search for: **Green**

Result: **S. Greenberg**
Dept Computer Science
University of Calgary

Form metaphor:
syntactic direct manipulation


A-F
T-Z
J-S
Hurlock, P.
Guttenberg, A.
Greenberg, S.
Dept Computer Science
University of Calgary

Rolodex metaphor:
full direct manipulation

Action-Object

The traditional approach for writing software.

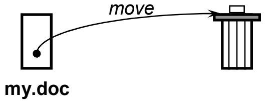
Focus on verbs, actions or functions that the software is capable of.

Often requires learning a complex and arbitrary syntax that varies greatly from system to system and platform to platform:

- e.g., Deleting text: <Ctrl>-<h>, <ctrl-g>, <ctrl-d>, <delete>, <backspace> etc.

Object-Action

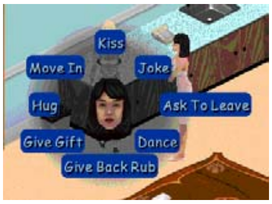
- **Focus on nouns, objects which already have meaning in the task domain of the user.**
- **Select an object which then has a set of allowable actions.**



- **Because the user is already familiar with these objects, previous knowledge can help leverage when learning the new systems:**
  - e.g., Trash cans for deletion, folders for storing information, inbox for reading new messages, outbox for sending messages
- **It requires that the objects of interest have a visual representation (compatible with Direct Manipulation)**

Advantages Of The Object-Action Approach

- The syntax is already familiar so the time spent learning the capabilities of the system is reduced.
- The new syntax that the user is required to learn is fairly limited e.g., there are only so many ways that a button can be used.
- Error messages are rarely needed. Actions that are inappropriate, given the current state of system, can be excluded:



The Sims House Party © Maxis

What You Now Know

Good Representations

- Captures essential elements of the event / world
- Deliberately leaves out / mutes the irrelevant
- Appropriate for the person, their task, and their interpretation

Information Visualization

- Tufte's principles
- Exploits our knowledge of visual variables
- Many techniques now available (illustrated with research and commercial systems)

What You Now Know (2)

Metaphors

- Uses our knowledge of the familiar and concrete to represent abstract concepts
- Need not be literal
- Has limitations that must be understood

Direct manipulation

- Visibility of the objects of interest
- Manipulation by pointing and moving

These four components are the foundation of a true Visual Interface

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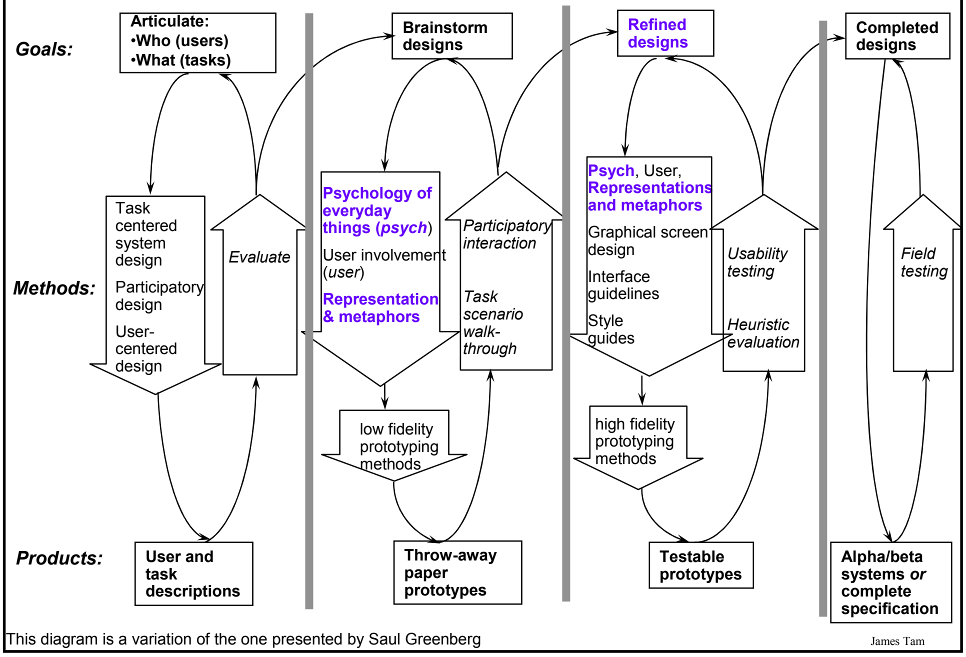
Interface Design And Usability Engineering



Goals:

Articulate:
•Who (users)
•What (tasks)

Brainstorm designs

Refined designs

Completed designs

Methods:

Task centered system design

Participatory design

User-centered design

Evaluate

Psychology of everyday things (*psych*)

User involvement (*user*)

Representation & metaphors

Participatory interaction

Task scenario walk-through

low fidelity prototyping methods

Psych, User, **Representations and metaphors**

Graphical screen design

Interface guidelines

Style guides

Usability testing

Heuristic evaluation

high fidelity prototyping methods

Field testing

Products:

User and task descriptions

Throw-away paper prototypes

Testable prototypes

Alpha/beta systems *or* complete specification

This diagram is a variation of the one presented by Saul Greenberg