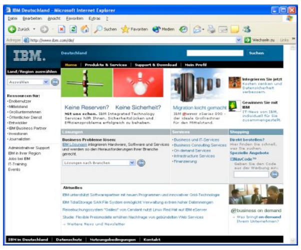
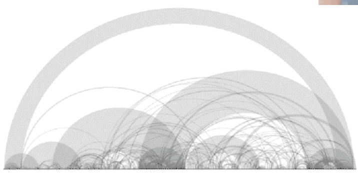
Structure

- Chapter 1:
  HCI and the WWW



- Chapter 2:
  Mobile and Ubiquitous User Interfaces

- Chapter 3:
  Information Visualization



3 Information Visualization

3.1 Motivation and Examples

3.2 Basics of Human Perception

3.3 Principles and Terminology

3.4 Standard Techniques for Visualization

Literature:

- Marti Hearst
  - http://bailando.sims.berkeley.edu/infovis.html
  - http://bailando.sims.berkeley.edu/talks/chi03-tutorial.ppt
- Margret-Anne Storey
  - http://www.csr.uvic.ca/~mstorey/
  - http://www.cs.uvic.ca/~mstorey/teaching/infovis/course_notes/introduction.pdf
- Ben Shneiderman
  - http://www.cs.ubc.ca/~tmm/courses/cpsc533c-03-spr/readings/shneiderman96eyes.pdf

"Graphical excellence is that which gives to the viewer the greatest number of ideas in the shortest time with the least ink in the smallest space."

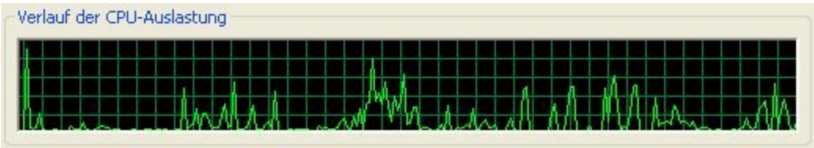
-- Edward R. Tufte
(1942–)

Representation

- What is a good visual Representation?
  - Capture and present the essential
  - Deliberately hide irrelevant parts
  - Appropriate for the recipient and his/her abilities
  - Understandable and interpretable by the recipient
  - Appropriate for the task
- "Solving a problem simply means representing it so as to make the solution transparent" (Simon, 1981)
- Allow people to look at the presentation and draw the "right" conclusions!

Representations

- Figures / numbers
- Numbers in bar graph
- Plot with history



How to Read Representations

- Read the plain facts
- Compare representations (visual calculations)
- Identify patterns
- Make interpretations

- Can be enhanced by active diagrams
  – Allow interactive manipulation

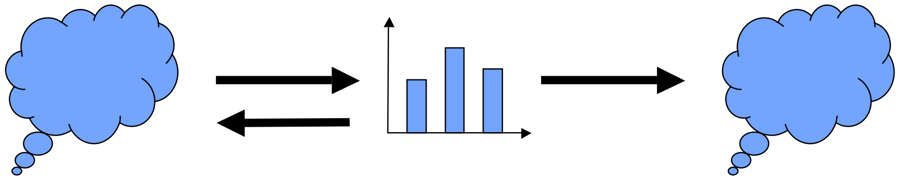
External Aids for Thinking

The power of the unaided mind is highly overrated. Without external aids, memory, thought, and reasoning are all constrained. But human intelligence is highly flexible and adaptive, superb at inventing procedures and objects that overcome its own limits. The real powers come from devising external aids that enhance cognitive abilities. How have we increased memory, thought, and reasoning? By the inventions of external aids: It is things that make us smart. (Norman, 1993)

- External cognition
  - Internal and external representation and processing weave together in thought
- External cognitive aids can enhance cognition
- An important class of external cognitive aids that make us smart are graphical inventions
  - Charts for navigation
  - Diagrams

Use of Visual Representations

- Pictures and diagrams are used to communicate existing ideas and thoughts
- Graphical representations can help in developing and formulating ideas and thoughts
- Using visual representations "to think"



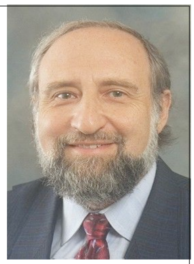
Information – to Visualize

- What is "Information"?
  - Entities, concepts, things, items that may not have a direct physical correspondence
  - Information is often abstract
- Large sets of data and information
  - Great amount of data
  - Information is generated in many processes
- To visualize: to form a mental image or vision of …
- To visualize: to imagine or remember as if actually seeing.
  (American Heritage dictionary, Concise Oxford dictionary)

What is Information Visualization?

- The use of computer-supported, interactive visual representations of data to amplify cognition.
  (Card, Mackinlay, Shneiderman '98)
- "Transformation of the symbolic into the geometric'"
  (McCormick et al., 1987)
- "... augmenting … natural intelligence in the best possible way, ... finding the artificial memory that best supports our natural means of perception."
  (Bertin, 1983)
- "The depiction of information using spatial or graphical representations, to facilitate comparison, pattern recognition, change detection, and other cognitive skills that make use of the visual system."
  (Hearst, 2003, CHI-Tutorial)
- "The purpose of visualization is insight, not pictures"
  (Hearst)

Definition by Shneiderman



- Compact graphical presentation and
  - user interface for
  - manipulating large numbers of items (10^2 - 10^6),
  - possibly extracted from far larger datasets.
- Enables users to make
  - discoveries,
  - decisions, or
  - explanations
- about
  - patterns (trend, cluster, gap, outlier...),
  - groups of items, or
  - individual items.

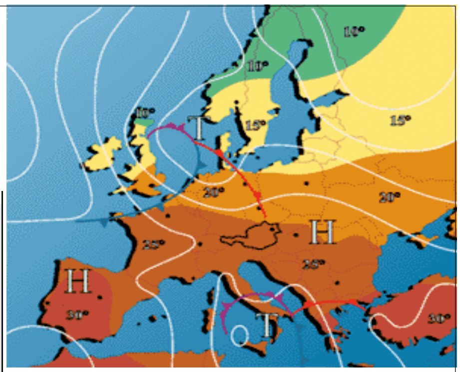
Tasks Supported by Information Visualization

- Search
  - Finding a specific information in a data set
- Browse
  - survey, inspect, look for interesting information
- Analysis
  - Comparison-Difference, find outliers and extremes, spot patterns

- Many more…
  - Categorize, Associate
  - Locate, Rank
  - Identify, Reveal
  - Monitor, Maintain awareness

Examples ...

1997
1998
1999
2000
2001
2002
381,75
400,00
350,00
300,00
250,00
200,00
150,00
100,00
50,00
53,60
VOD.ISE
612 %HIGH-LOW
Splits
BPC
Volumen(rot-grün)
Steigende Kurse
Fallende Kurse
875M
555M
235M
(c) 2002 Innovative Software
Intervall: 1 Tag
24.05.02 14:43



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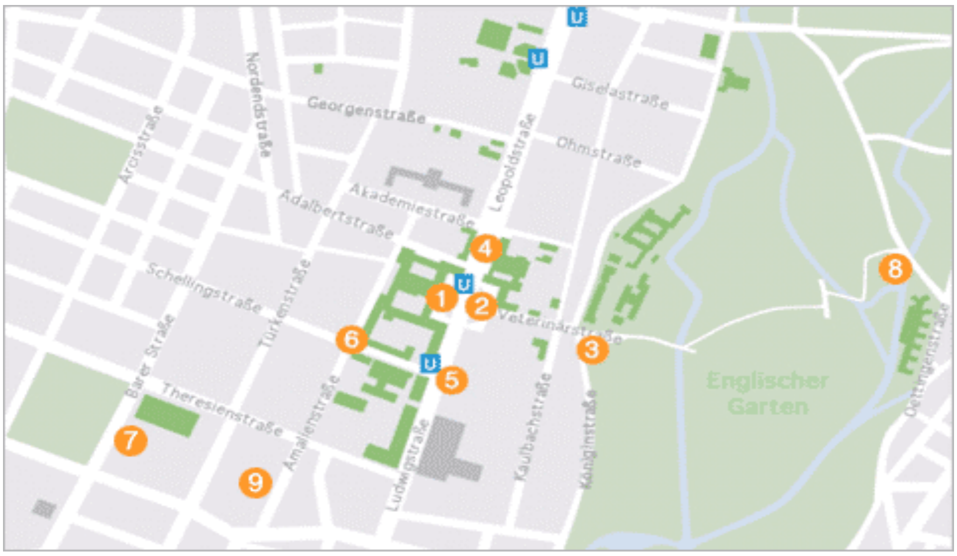

Nordendstraße
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Giselastraße
Ohmstraße
Arcisstraße
Akademiestraße
Adalbertstraße
Leopoldstraße
Schellingstraße
Türkenstraße
Veterinärstraße
Barer Straße
Theresienstraße
Amalienstraße
Ludwigstraße
Kaulbachstraße
Königinstraße
Englischer Garten
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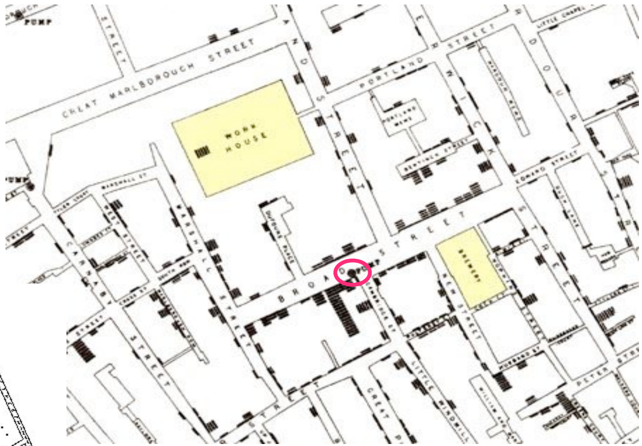
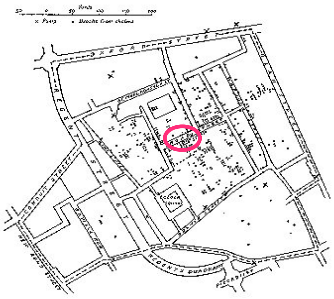
Visualization Success Story

Illustration of John Snow's
deduction that a cholera epidemic
was caused by a bad water pump, circa 1854.

Horizontal lines indicate location of deaths.



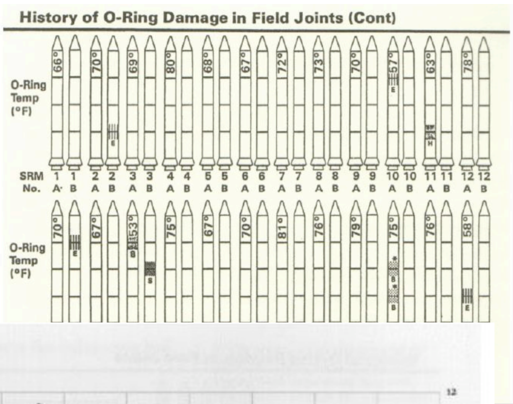


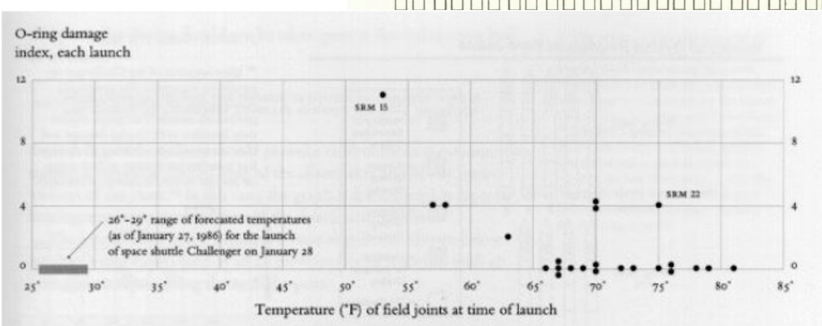
From Visual Explanations by Edward Tufte, Graphics Press, 1997

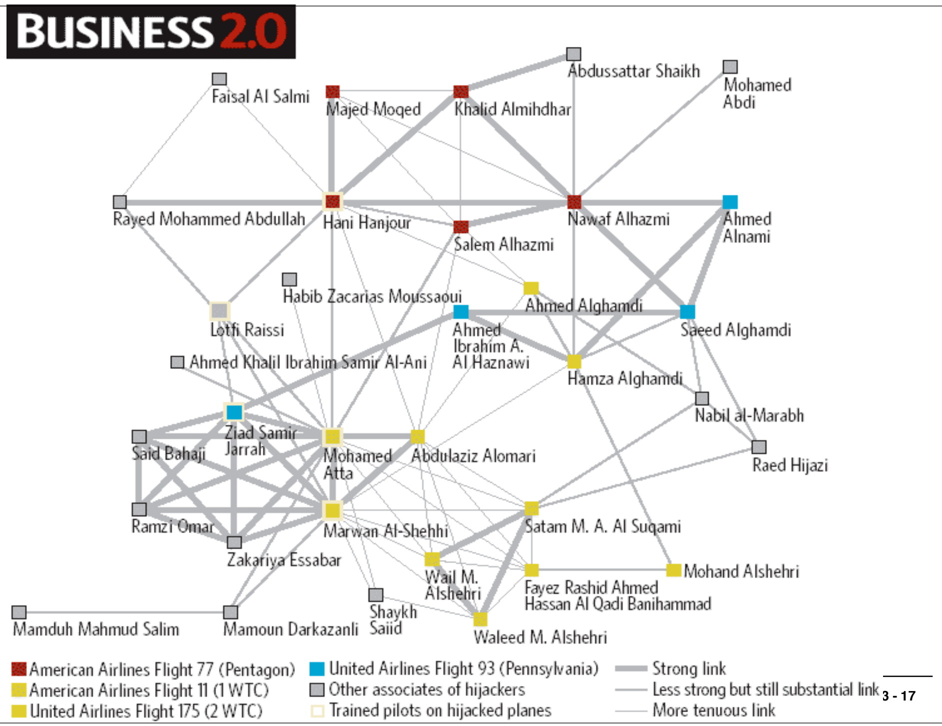
Source: Hearst

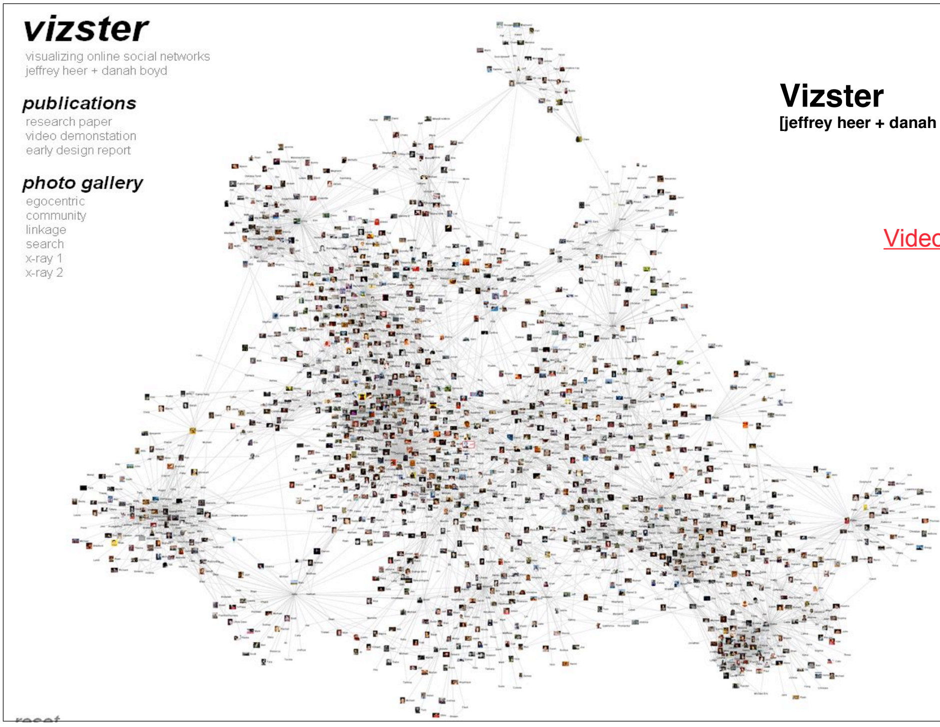
Challenger Example

(Source: Storey)



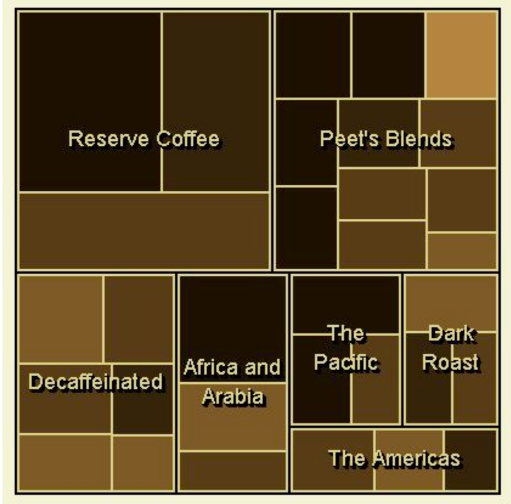


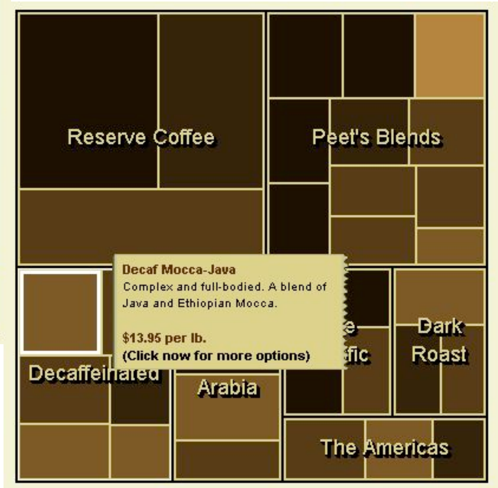




Vizster
[jeffrey heer + danah boyd]

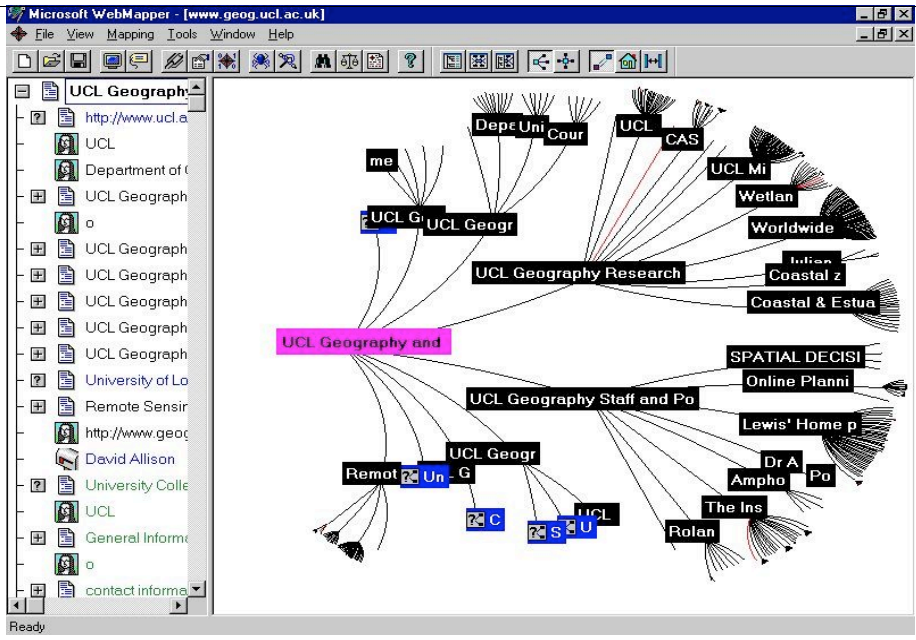
Video





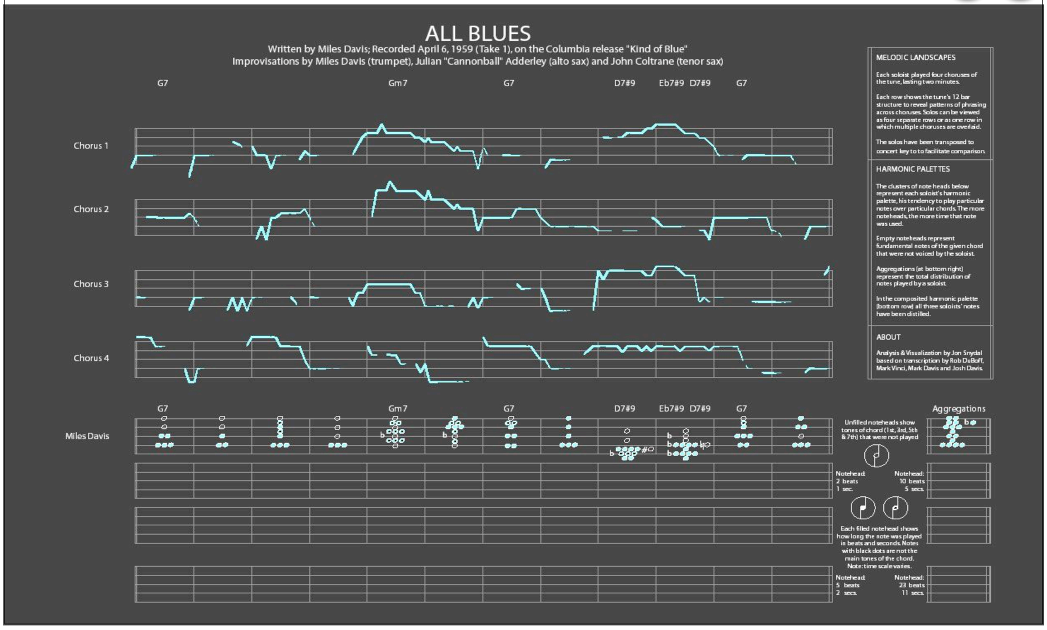
http://www.peets.com/selector_coffee/coffee_selector.asp

See also: www.smartmoney.com

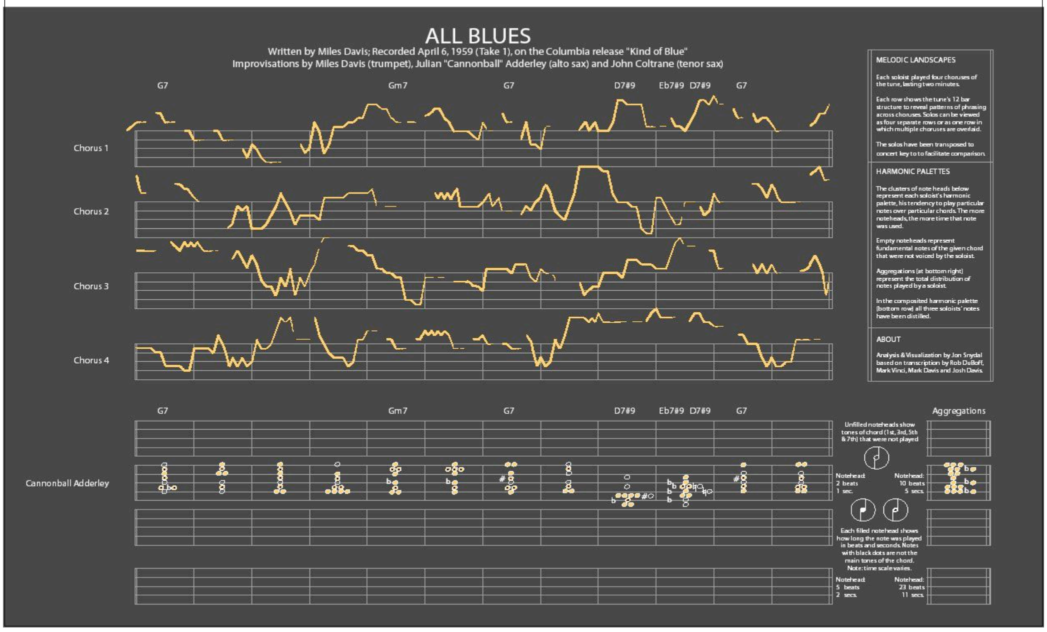


http://www.cybergeography.org/atlas/siteanalyst.jpg

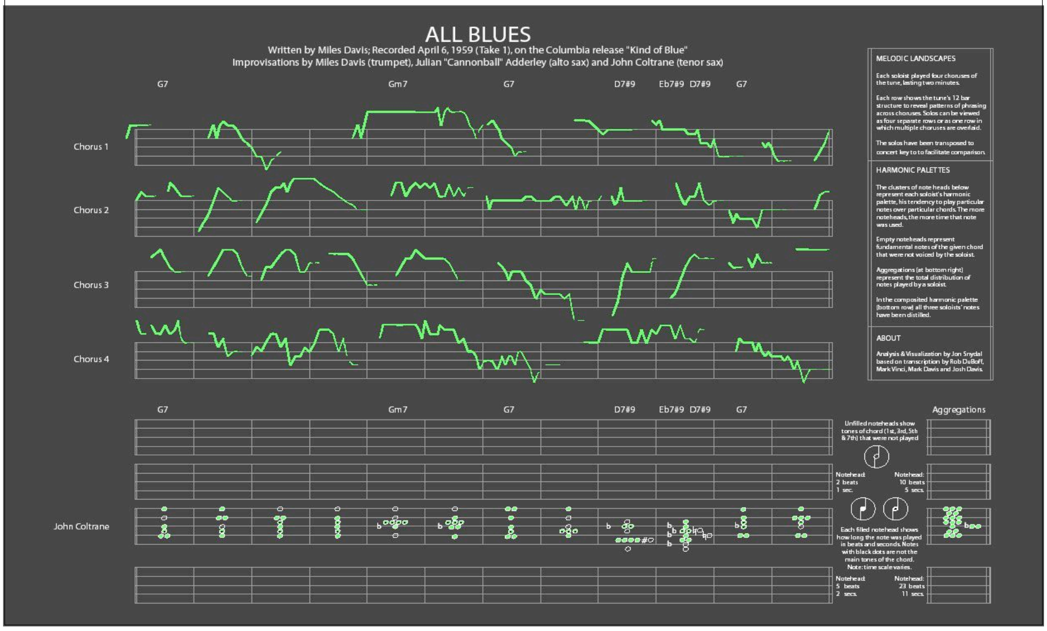
ImproViz [Snydal & Hearst, CHI 2005]



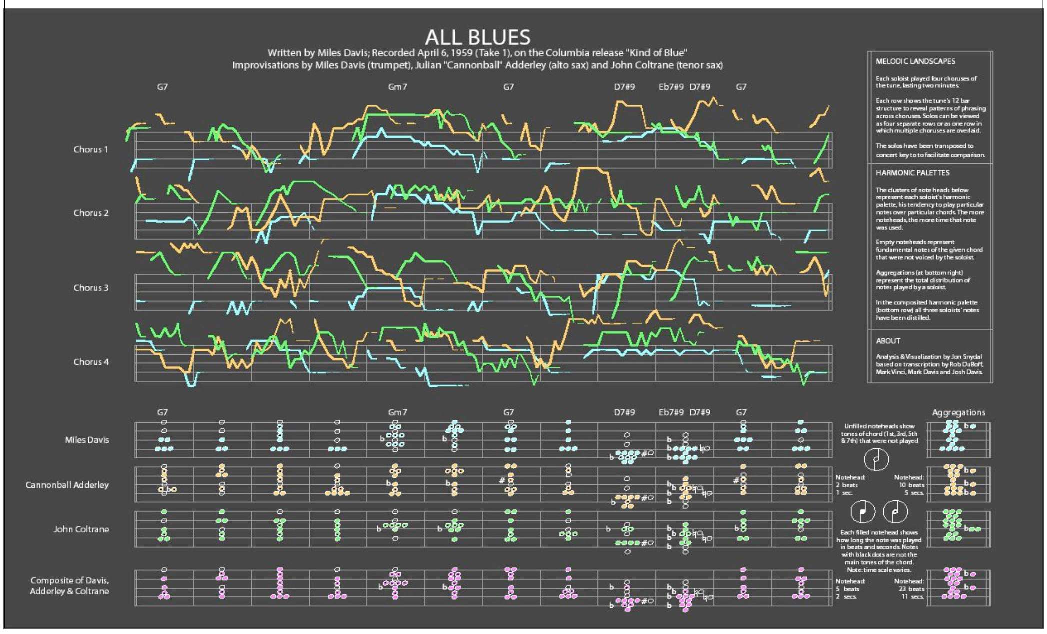
ImproViz [Snydal & Hearst, CHI 2005]



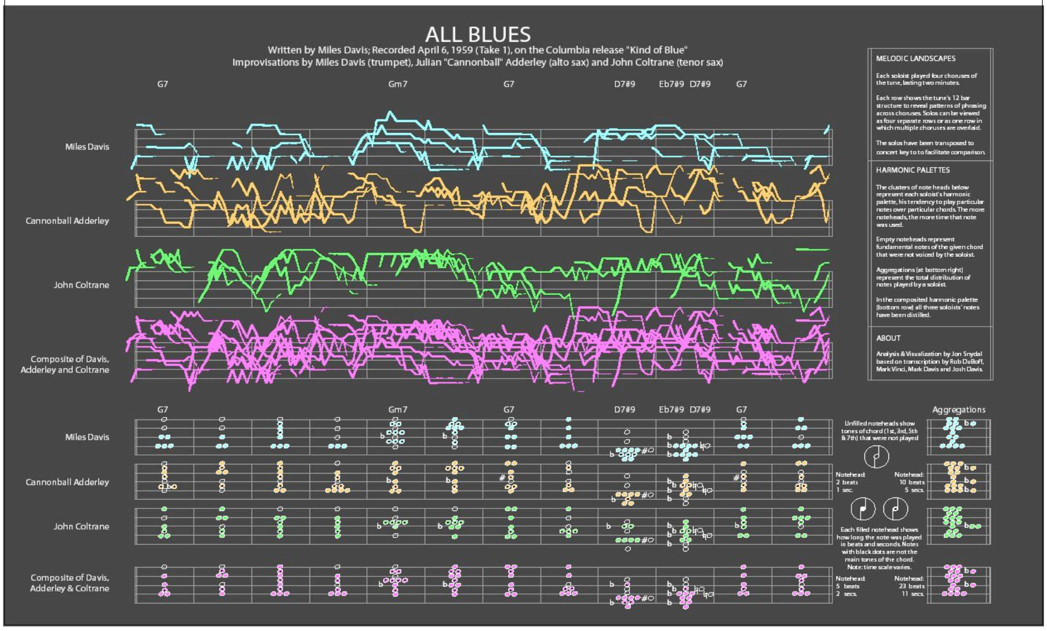
ImproViz [Snydal & Hearst, CHI 2005]



ImproViz [Snydal & Hearst, CHI 2005]



ImproViz [Snydal & Hearst, CHI 2005]

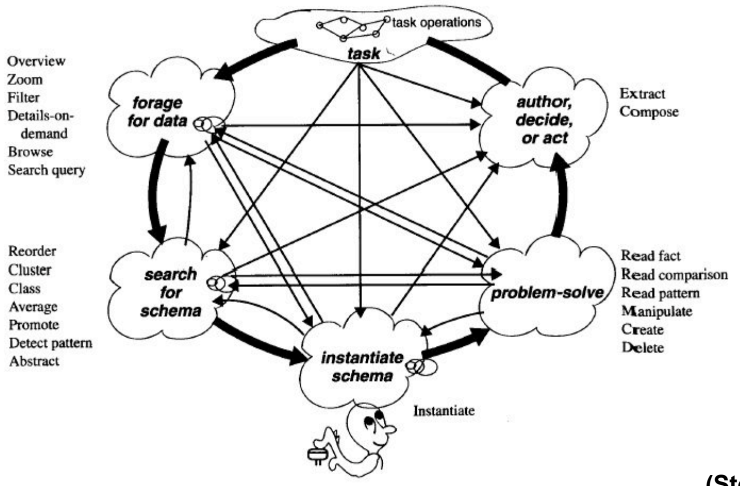


Knowledge Crystallization

(Storey, 2004)

- Knowledge crystallization involves getting insight about data relative to some task
- Steps required in a Knowledge Crystallization task:
  - Information foraging/browsing (from repositories, people…)
  - Search for/build a schema (representation) –need to know what to include/omit
  - Instantiate schema with data
  - Problem solve to trade-off features
  - May have to search for a new schema..
  - Package the patterns found in some output product (i.e. a concise briefing of results)
- A visualization tool has to support or automate some of these steps, it is a cognitive aid during our process of schematization
- So we need data, a task and a schema

Knowledge Crystallization (2)

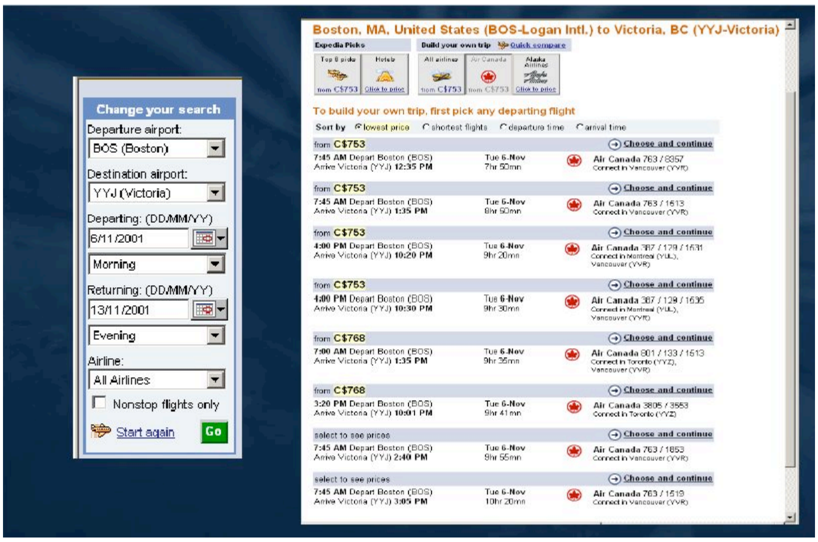


(Storey, 2004)

FIGURE 1.15

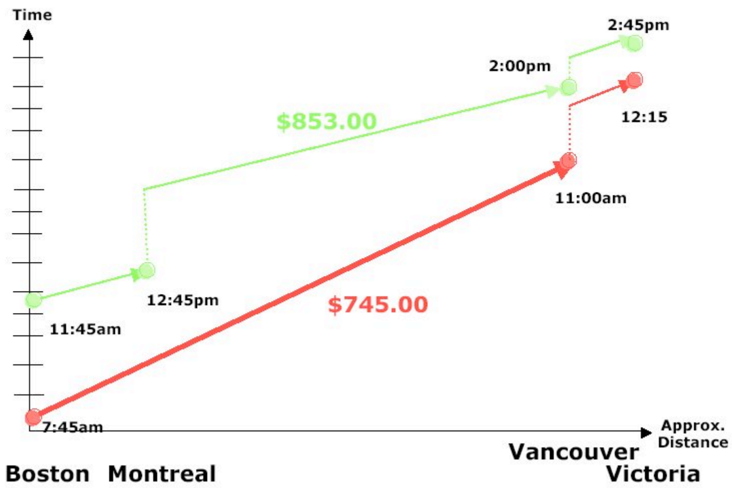
Knowledge crystallization.

Example – Air Fare (1)



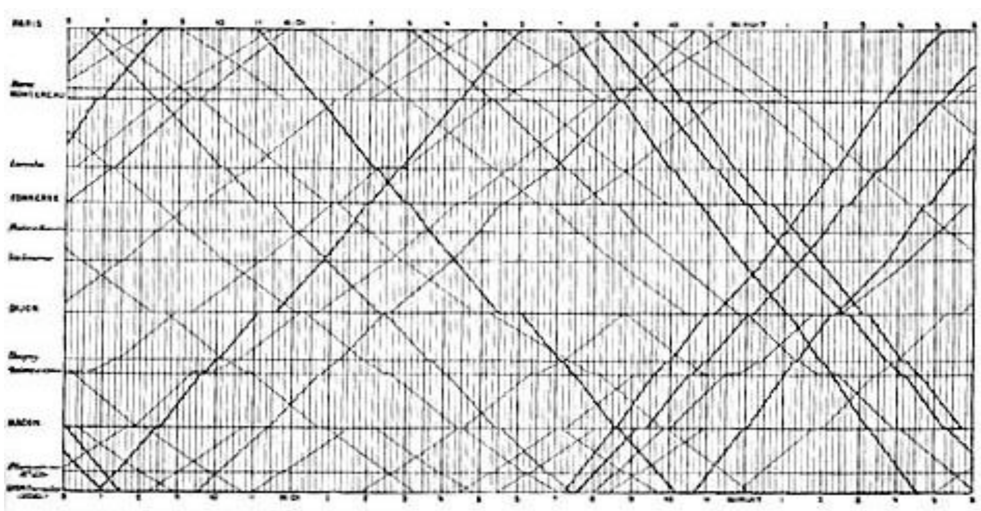
(Storey, 2004)

Example – Air Fare (2)



(Storey, 2004)

1885 French Train Schedule by E.J. Marey



Mapping Problem

- A lot of information does not imply any obvious spatial mapping!
- Basic Question:
  How to map non-spatial abstractions into effective visual representation?
- Approach:
  Use interactive techniques and visual representations to augment or amplify the user's cognition

Information Visualization To Amplify Cognition

Different ways in which visualizations *could* help amplify cognition:

- By increasing memory and processing resources available
  - Parallel perceptual processing
  - Offload work from cognitive to perceptual system
- By reducing the amount of time to search
  - High data density
  - Greater access speed
- Enhancing the detections of patterns and enabling perceptual inference operations
  - Abstraction and Aggregation
- Aid perceptual monitoring
  - Color or motion coding to create pop out effect
- By encoding information in an Interactive Medium

3 Information Visualization

Literature:

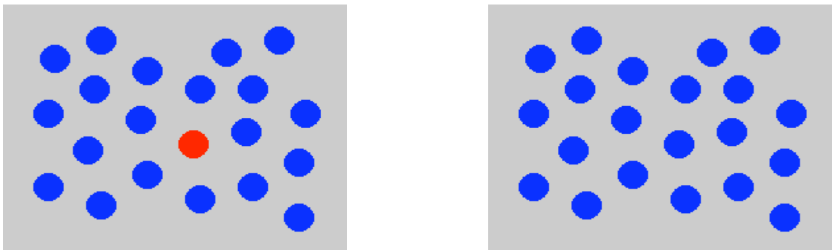
- Preattentive Processing
  http://www4.ncsu.edu/~healey/PP/

Preattentive Processing

- A limited set of visual properties are processed preattentively
  - (without need for focusing attention).
- This is important for design of visualizations
  - what can be perceived immediately
  - what properties are good discriminators
  - what can mislead viewers

Hearst, 2003

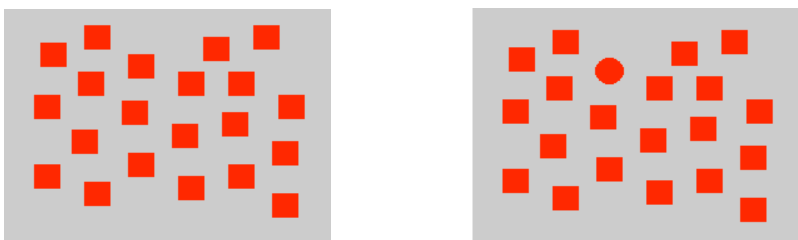
Example: Color Selection



Viewer can rapidly and accurately determine whether the target (red circle) is present or absent. Difference detected in color.

Hearst, 2003

Example: Shape Selection



Viewer can rapidly and accurately determine whether the target (red circle) is present or absent. Difference detected in form (curvature)

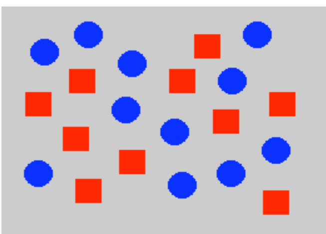
Hearst, 2003

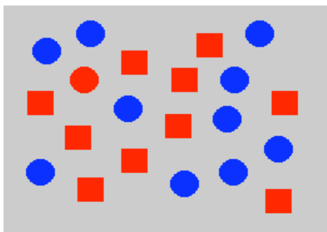
Pre-attentive Processing

- < 200 - 250ms qualifies as pre-attentive
  - eye movements take at least 200ms
  - yet certain processing can be done very quickly, implying low-level processing in parallel
- If a decision takes a fixed amount of time regardless of the number of distractors, it is considered to be preattentive.

Hearst, 2003

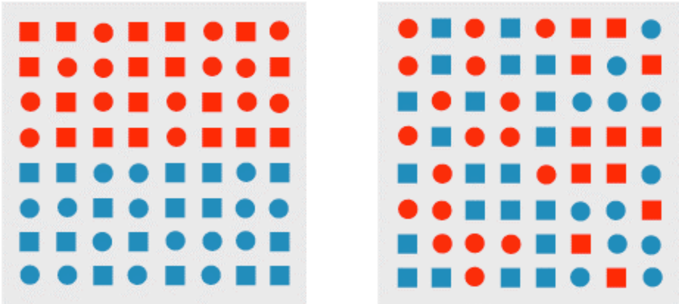
Example: Conjunction of Features (1)





Viewer *cannot* rapidly and accurately determine whether the target (red circle) is present or absent when target has two or more features, each of which are present in the distractors. Viewer must search sequentially.

Example: Conjunction of Features (2)



Boundary detection (Treisman)

Preattentive Visual Properties

(Healey 97)

length	Triesman & Gormican [1988]
width	Julesz [1985]
size	Triesman & Gelade [1980]
curvature	Triesman & Gormican [1988]
number	Julesz [1985]; Trick & Pylyshyn [1994]
terminators	Julesz & Bergen [1983]
intersection	Julesz & Bergen [1983]
closure	Enns [1986]; Triesman & Souther [1985]
colour (hue)	Nagy & Sanchez [1990, 1992]; D'Zmura [1991] Kawai et al. [1995]; Bauer et al. [1996]
intensity	Beck et al. [1983]; Triesman & Gormican [1988]
flicker	Julesz [1971]
direction of motion	Nakayama & Silverman [1986]; Driver & McLeod [1992]
binocular lustre	Wolfe & Franzel [1988]
stereoscopic depth	Nakayama & Silverman [1986]
3-D depth cues	Enns [1990]
lighting direction	Enns [1990]

Hearst, 2003

Text NOT Preattentive

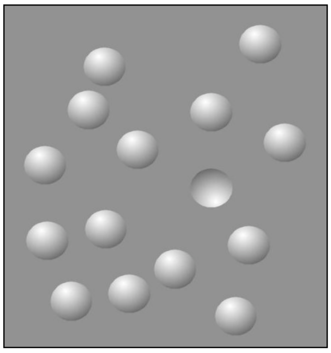
SUBJECT PUNCHED QUICKLY OXIDIZED TCEJBUS DEHCNUP YLKCIUQ DEZIDIXO
CERTAIN QUICKLY PUNCHED METHODS NIATREC YLKCIUQ DEHCNUP SDOHTEM
SCIENCE ENGLISH RECORDS COLUMNS ECNEICS HSILGNE SDROCER SNMULOC
GOVERNS PRECISE EXAMPLE MERCURY SNREVOG ESICERP ELPMAXE YRUCREM
CERTAIN QUICKLY PUNCHED METHODS NIATREC YLKCIUQ DEHCNUP SDOHTEM
GOVERNS PRECISE EXAMPLE MERCURY SNREVOG ESICERP ELPMAXE YRUCREM
SCIENCE ENGLISH RECORDS COLUMNS ECNEICS HSILGNE SDROCER SNMULOC
SUBJECT PUNCHED QUICKLY OXIDIZED TCEJBUS DEHCNUP YLKCIUQ DEZIDIXO
CERTAIN QUICKLY PUNCHED METHODS NIATREC YLKCIUQ DEHCNUP SDOHTEM
SCIENCE ENGLISH RECORDS COLUMNS ECNEICS HSILGNE SDROCER SNMULOC

Pop-Out Effect by Preattentive Processing

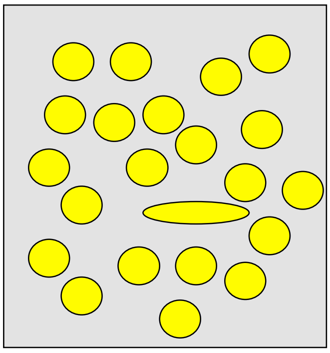
- Pop-Out =
  Time required to find target
  independent of overall number

- Form:
  - line orientation, length, width
  - spatial orientation, added marks, numerosity (4)
- Colour:
  - hue, intensity
- Motion:
  - flicker, direction of motion
- Spatial Position:
  - stereoscopic depth, convex/concave shape, shadows

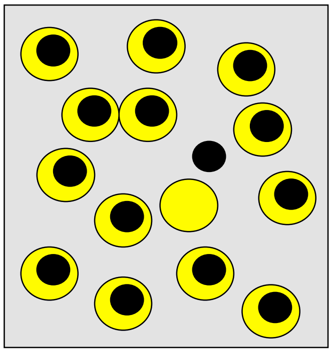
Examples for Pop-Out (1)



Shading

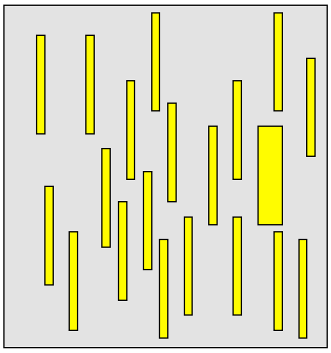


Shape

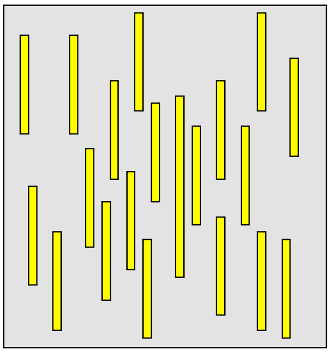


Enclosure

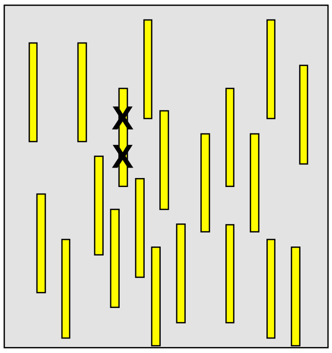
Examples for Pop-Out (2)



width



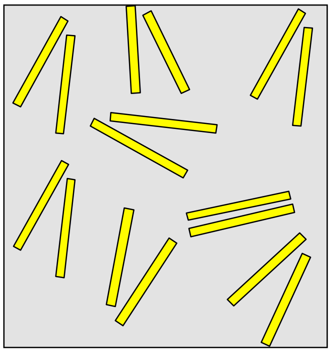
length

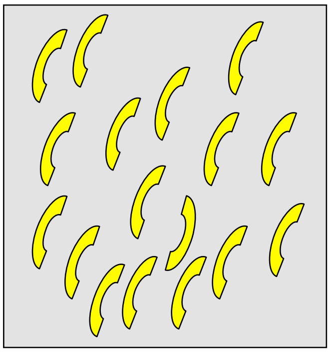


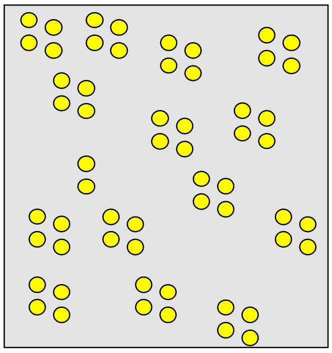
marked

Hiding features
due to placement

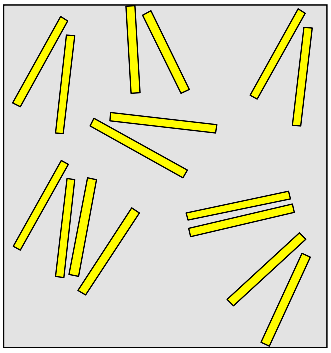
Examples for Pop-Out (3)

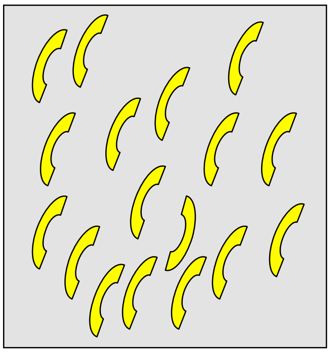

angle

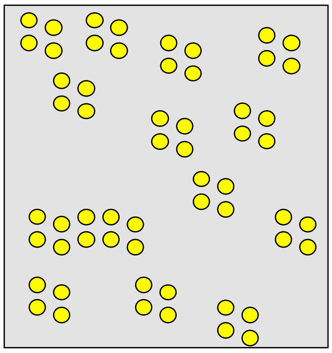

curve


Clusters/count

Examples for Pop-Out (3)


angle


curve


Clusters/count

Hiding features
due to placement

Hiding features
due to placement

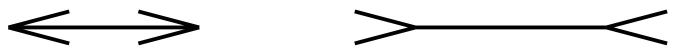
Visual Illusions

- People don’t perceive length, area, angle, brightness they way they “should”.
- Some illusions have been reclassified as systematic perceptual errors
  - e.g., brightness contrasts (grey square on white background vs. on black background)
  - partly due to increase in our understanding of the relevant parts of the visual system
- Nevertheless, the visual system does some really unexpected things.

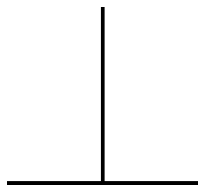
Hearst, 2003

Illusions of Linear Extent

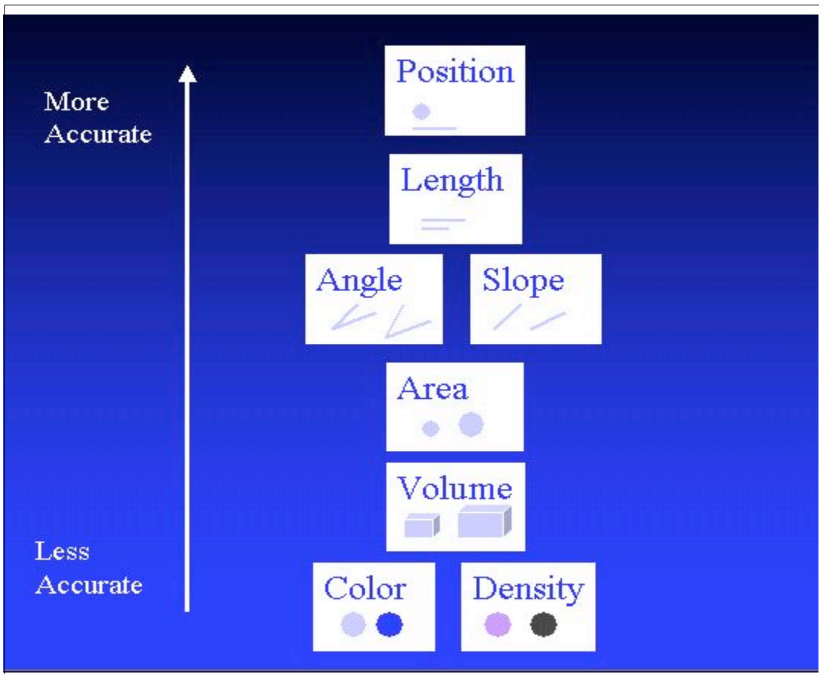
- Mueller-Lyon (off by 25-30%)



- Horizontal-Vertical



Hearst, 2003



Accuracy Ranking of Quantitative Perceptual Tasks
Estimated; only pairwise comparisons have been validated
(Mackinlay 88 from Cleveland & McGill)

Hearst, 2003