Interaction

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CS 294-10: Visualization
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Assignment 2: Visualization Design

Perception

Steven’s power law

$S = I^p$

p < 1: underestimate
p > 1: overestimate

(graph from Wilkinson 99, based on Stevens 61)
Relative magnitude estimation

<table>
<thead>
<tr>
<th>Most accurate</th>
<th>Least accurate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Position (common) scale</td>
<td>Color hue-saturation-density</td>
</tr>
<tr>
<td>Position (non-aligned) scale</td>
<td></td>
</tr>
<tr>
<td>Length</td>
<td></td>
</tr>
<tr>
<td>Slope</td>
<td></td>
</tr>
<tr>
<td>Angle</td>
<td></td>
</tr>
<tr>
<td>Area</td>
<td></td>
</tr>
<tr>
<td>Volume</td>
<td></td>
</tr>
</tbody>
</table>
One-dimensional: Lightness

- White
- Black
- White
- Black
- White
- Black

One-dimensional: Shape

- Circle
- Square
- Circle
- Square
- Circle
- Square

Correlated dims: Shape or lightness

- Circle
- Square
- Circle
- Square
- Circle
- Square

Orthogonal dims: Shape & lightness

- Circle
- Square
- Circle
- Square
- Circle
- Square
**Speeded classification**

Redundancy gain  
Facilitation in reading one dimension when the other provides redundant information

Filtering interference  
Difficulty in ignoring one dimension while attending to the other

**Types of dimensions**

Integral  
Filtering interference and redundancy gain

Separable  
No interference or gain

Configural  
Only interference, but no redundancy gain

Asymmetrical  
One dimension separable from other, not vice versa

Stroop effect – Color naming influenced by word identity, but word naming not influenced by color

**Summary of Integral-Separaible**

(Figure 5.25, Color Plate 10, Ware 00)
Set

Each card has 4 features:
- Color
- Symbol
- Number
- Shading/Texture

A set consists of 3 cards in which each feature is the SAME or DIFFERENT on each card.

Adrien Treuille's applet
http://www.cs.washington.edu/homes/treuille/resc/set

Gestalt

Principles

- figure/ground
- proximity
- similarity
- symmetry
- connectedness
- continuity
- closure
- common fate
- transparency

Figure/Ground

Ambiguous

Principle of surroundedness

Principle of relative size

http://www.aber.ac.uk/media/Modules/MC1022/figureground.html
Figure/Ground

Ambiguous

Unambiguous

http://www.aber.ac.uk/media/Modules/MC10220/visper06.html

Proximity

[Ware 00]

Similarity

Rows dominate due to similarity [from Ware 04]

Symmetry

Bilateral symmetry gives strong sense of figure [from Ware 04]
**Connectedness**

Connectedness overrules proximity, size, color shape [from Ware 04]

**Continuity**

We prefer smooth not abrupt changes [from Ware 04]

Connections are clearer with smooth contours [from Ware 04]

**Continuity: Vector fields**

Prefer field that shows smooth continuous contours [from Ware 04]

**Closure**

We see a circle behind a rectangle, not a broken circle [from Ware 04]

Illusory contours [from Durand 02]
Common fate

Dots moving together are grouped

http://coe.sdsu.edu/eet/articles/visualperc1/start.htm

Transparency

Requires continuity and proper color correspondence (from Ware 04)

Layering and Small Multiples

Layering: Gridlines

Signal and background compete above, as an electrocardiogram trace-line becomes caught up in a thick grid. Below, the screened-down grid stays behind traces from each of 12 monitoring leads.*

Electrocardiogram tracelines (from Tufte 90)
Layering: Gridlines

Stravinsky score [from Tufte 90]

Layering: Color and line width

IBM Series III Copier [from Tufte 90]

Small multiples

[Figure 2.11, p. 38, MacEachren 95]

Small multiples

Operating trains. Redrawn by Tufte to emphasize colored lights. [from Tufte 90]
Change blindness

[Example from Palmer 99, originally due to Rock]

Change detection

Rensink’s demonstration

http://people.usd.edu/~schieber/coglab/ChangeBlindness.html
Summary

Choosing effective visual encodings requires knowledge of visual perception

Visual features/attributes
- Individual attributes often preattentive
- Multiple attributes may be separable, often integral

Gestalt principles provide higher level design guidelines

We don’t always see everything that is there

Interaction

Gulfs of execution & evaluation

<table>
<thead>
<tr>
<th>Conceptual model</th>
<th>Real world</th>
<th>Execution</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Evaluation</td>
</tr>
</tbody>
</table>

Gulf of evaluation

Real world: x,y correlated?

<table>
<thead>
<tr>
<th>x</th>
<th>y</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>0.2</td>
</tr>
<tr>
<td>0.7</td>
<td>0.1</td>
</tr>
<tr>
<td>0.6</td>
<td>0.5</td>
</tr>
<tr>
<td>0.4</td>
<td>0.3</td>
</tr>
<tr>
<td>0.8</td>
<td>0.4</td>
</tr>
</tbody>
</table>

[Norman 1986]
Gulf of evaluation

Real world:
Conceptual model: $x, y$ correlated?

Evaluation

Gulf of execution

Real world:
Conceptual model: Draw a scatterplot

Execution

Gulf of evaluation

Real world:
Conceptual model: $x, y$ correlated?

Evaluation

Gulf of execution

Real world:
Conceptual model: Draw a scatterplot

Execution

$\rho = -0.29$
Topics
Brushing and linking
Dynamic queries
Rearrangements

Brushing and Linking

Highlighting

Focus user attention on a subset of the data within one graph [from Wills 95]

Brushing
- Interactively select subset of data
- See selected data in other views
- Two things (normally views) must be linked to allow for brushing
Baseball statistics [from Wills 95]

- select high salaries
- avg career HRs vs avg career hits (hitting ability)
- avg assists vs avg putouts (fielding ability)
- how long in majors
- distribution of positions played

Linking assists to positions

GGobi: Brushing

http://www.ggobi.org/

Dynamic Queries
Query and results

```
SELECT house
FROM east bay
WHERE price < 1,000,000 AND bedrooms > 2
ORDER BY price
```

<table>
<thead>
<tr>
<th>Issues</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. For programmers</td>
</tr>
<tr>
<td>2. Rigid syntax</td>
</tr>
<tr>
<td>3. Only shows exact matches</td>
</tr>
<tr>
<td>4. Too few or too many hits</td>
</tr>
<tr>
<td>5. No hint on how to reformulate the query</td>
</tr>
<tr>
<td>6. Slow question-answer loop</td>
</tr>
<tr>
<td>7. Results returned as table</td>
</tr>
</tbody>
</table>

HomeFinder

1. Visual representation of objects and actions
2. Rapid, incremental and reversible actions
3. Selection by pointing (not typing)
4. Immediate and continuous display of results
Alphaslider

Title: Moonstruck

FilmFinder

[Ahlberg and Schneiderman 94]

FilmFinder

[Ahlberg and Schneiderman 93]

FilmFinder

[Ahlberg and Schneiderman 93]

FilmFinder

[Ahlberg and Schneiderman 93]
Cellphones

http://www.myrateplan.com/cellphones/