Interaction

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CS 448B: Visualization
Fall 2017
Last Time: Perception

Just noticeable difference

JND (Weber’s Law)

\[ \Delta S = k \frac{\Delta I}{I} \]

- Ratios more important than magnitude
- Most continuous variations in stimuli are perceived in discrete steps
Steven’s power law

\[ S = I^p \]

- \( p < 1 \): underestimate
- \( p > 1 \): overestimate

The law predicts bias: the deviation of population-averaged estimates from the true values.

It doesn’t necessarily predict error! What if length averages to the true value but most estimates exhibit high deviation?

[graph from Wilkinson 99, based on Stevens 61]
Figure 3. Graphs from position–angle experiment.

[Cleveland and McGill 84]
Relative magnitude estimation

Most accurate
- Position (common) scale
- Position (non-aligned) scale
- Length
- Slope
- Angle
- Area
- Volume

Least accurate
- Color hue-saturation-density

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/MC10220/visper06.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 traceline becomes caught up in a thick grid. Below, the screened-down grid stays behind traces from each of 12 monitoring leads.^[4]

Electrocardiogram tracelines [from Tufte 90]
Layering: Gridlines

Stravinsky score [from Tufte 90]

Setting Gridline Contrast

How light can gridlines be and remain visible?
How dark can gridlines be and not distract?

Safe setting: 20% Alpha
[Stone & Bartram 2009]
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://www.csc.ncsu.edu/faculty/healey/PP/index.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
Announcements

Assignment 2: Exploratory Data Analysis

Use Tableau to formulate & answer questions

First steps
- Step 1: Pick a domain
- Step 2: Pose questions
- Step 3: Find data
- Iterate

Create visualizations
- Interact with data
- Question will evolve
- Tableau

Make notebook
- Keep record of all steps you took to answer the questions

Due before class on Oct 16, 2017
Interaction

Gulfs of execution & evaluation

Gulfs

Evaluation

Conceptual model

Real world

Execution

[Norman 1986]
Gulf of Execution
The difference between the user’s intentions and the allowable actions.

Gulf of Evaluation
The amount of effort that the person must exert to interpret the state of the system and to determine how well the expectations and intentions have been met.

[Norman 1986]
Gulf of evaluation

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

Evaluation

Gulf

Real world:
$ho = -.29$
Gulf of execution

Conceptual model: Draw a scatterplot

Real world

Move 90 30
Rotate 35
Pen down
...

Execution
<table>
<thead>
<tr>
<th>Topics</th>
</tr>
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<tbody>
<tr>
<td>Early interactive systems</td>
</tr>
<tr>
<td>Brushing and linking</td>
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<tr>
<td>Dynamic queries</td>
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<tr>
<td>Generalized selections</td>
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</table>
### Bertin Matrices

**Research question**

- Encode table cells visually
- Group similar rows and columns to reveal patterns

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<td>55</td>
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</tbody>
</table>

| 20  |

1.Encode table cells visually
2.Group similar rows and columns to reveal patterns

[Graphics and Graphic Information Processing, Bertin 81]
Group similar rows and columns

Choose a row with a particular visual aspect. Move to extremity of matrix.

Move similar rows close, opposite rows to bottom. (Creates two opposing groups and a middle group)

Repeat for columns

Iterate
<table>
<thead>
<tr>
<th>Active and Slow Periods</th>
<th>Discovery Factors</th>
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</thead>
<tbody>
<tr>
<td>18% Occupancy</td>
<td></td>
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<tr>
<td>18 Length of Stay</td>
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<tr>
<td>20 Conventions</td>
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<tr>
<td>18 Businessmen</td>
<td></td>
</tr>
<tr>
<td>17 Agency Reservations</td>
<td></td>
</tr>
<tr>
<td>11 South America</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Recovery Factors</th>
<th>Winter</th>
<th>Winter-Summer</th>
<th>Summer</th>
</tr>
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<tbody>
<tr>
<td>18 Air Crews</td>
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<tr>
<td>18 Clients Under 20 Years</td>
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<tr>
<td>17 Clients More Than 55 Years</td>
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<td>16 Clients From 20-35 Years</td>
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<td>14 Female Cliente</td>
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<td>12 Local Clientele</td>
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<td>7 Asia</td>
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<td>6 Tourists</td>
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<td>5 Direct Reservation</td>
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<td>4 Middle East, Africa</td>
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<td>3 U.S.A</td>
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<td>2 Europe</td>
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<tr>
<td>15 Clients From 35-55 Years</td>
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</tbody>
</table>

(Graphics and Graphic Information Processing, Bertin 81)
<table>
<thead>
<tr>
<th>Household income</th>
<th>Belgium</th>
<th>Denmark</th>
<th>Finland</th>
<th>France</th>
<th>Germany</th>
<th>Greece</th>
<th>Italy</th>
<th>Portugal</th>
<th>Russia</th>
<th>United Kingdom</th>
<th>Spain</th>
<th>Sweden</th>
<th>Switzerland</th>
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<tbody>
<tr>
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<td>Against cohabitation without marriage</td>
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<td>Belief in God</td>
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<td>Confidence in government</td>
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<td>Confidence in the armed forces</td>
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<td>Confidence in the church</td>
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<td>Confidence in the health care system</td>
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<td>Confidence in the justice system</td>
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<td>Important in a job: good pay</td>
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<td>Against abortion</td>
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<td>Not as a neighbour: homosexuals</td>
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<td>Attend church at least once a week</td>
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Bertifier [Perin 2014]
Visual encodings

Quantity of ink is proportional to the normalized data value
Reordering methods

Manual

Automatic

PRIM-9, Tukey, Fisherkeller, Friedman 1972
Pointing

Basic Pointing Methods

- Point Selection
- Mouse Hover / Click
- Touch / Tap
- Select Nearby Element (e.g., Bubble Cursor)
Basic Pointing Methods

Point Selection
Mouse Hover / Click
Touch / Tap
Select Nearby Element (e.g., Bubble Cursor)

Region Selection
Rubber-band or Lasso
Area Cursors (“Brushes”)
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

Brushing Scatterplots, Becker & Cleveland 1982
Baseball statistics [from Wills 95]

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

Linking assists to positions
GGobi: Brushing

http://www.ggobi.org/