Cognitive Load and Visual Design

MIS561 Data Visualization
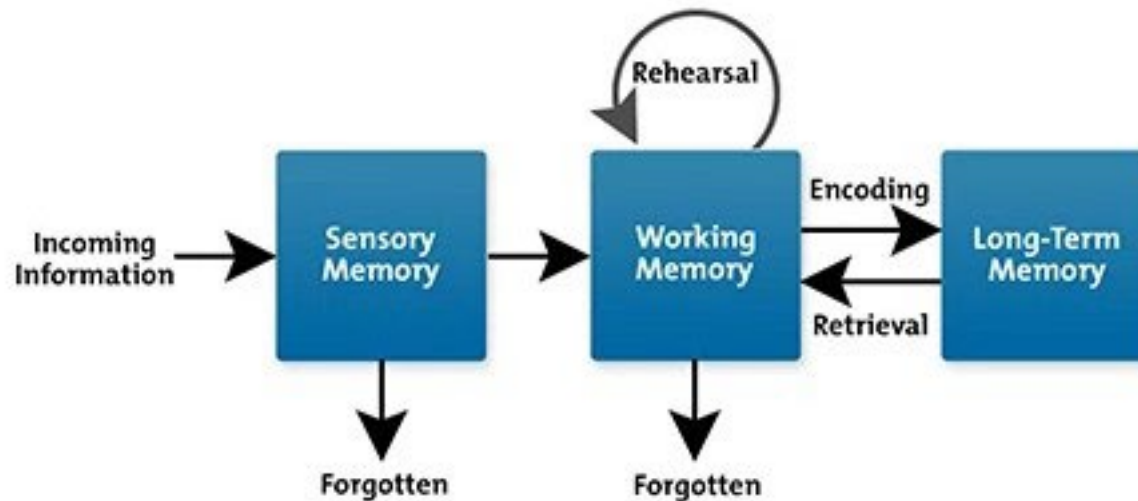Original Author: Lusi Yang

Outline

- **Cognitive load**
- **Clutter**
- **Gestalt principles of visual perception**
- **Practice: decluttering**

How do we process information?

Adapted from Atkinson, R.C. and Shiffrin, R.M. (1968). 'Human memory: A Proposed System and its Control Processes'. In Spence, K.W. and Spence, J.T. *The psychology of learning and motivation*, (Volume 2). New York: Academic Press. pp. 89–195.

Cognitive load theory

Cognitive load

- The amount of information that working memory can hold at one time.
- Cognitive Load Theory was developed by John Sweller (1988).

Processing that takes up mental resources but doesn't help the audience understand the information. This is something we want to avoid.

The data-ink or signal-to-noise ratio

A number of concepts have been introduced over time in an effort to explain and help provide guidance for reducing the cognitive load we push to our audience through our visual communications. In his book *The Visual Display of Quantitative Information*, Edward Tufte refers to maximizing the data-ink ratio, saying "the larger the share of a graphic's ink devoted to data, the better (other relevant matters being equal)." This can also be referred to as maximizing the signal-to-noise ratio (see Nancy Duarte's book *Resonate*), where the signal is the information we want to communicate, and the noise are those elements that either don't add to, or in some cases detract from, the message we are trying to impart to our audience.

Clutter is the enemy!

Clutter

- Visual elements that take up space but don't increase understanding

- Why we should aim to reduce clutter?
  - It make our visuals appears more complicated than necessary

Gestalt principles of visual perception

Gestalt Principles

- The Gestalt School of Psychology set out in the early 1900s to understand how individuals perceive order in the world around them.

- What they came away with are the principles of visual perception still accepted today that define how people interact with and create order out of visual stimuli.

- Identifying which elements in our visuals are signal and which might be noise

- Six principles
    - proximity, similarity, enclosure, closure, continuity, and connection

Proximity

Three distinct groups   Columns and rows, simply due to dot spacing

Similarity

We naturally associate the blue circles together on the left or the grey squares together on the right.
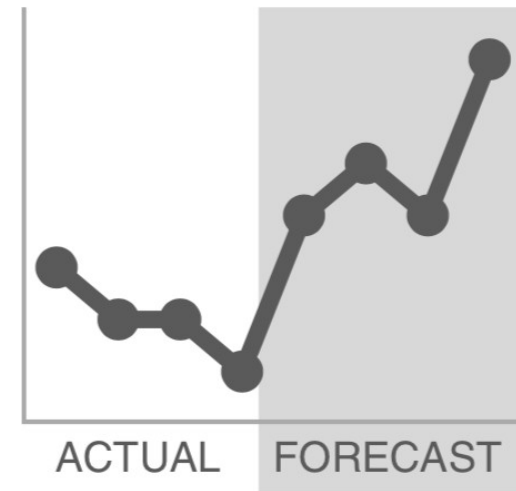
Rows due to similarity of color

Enclosure

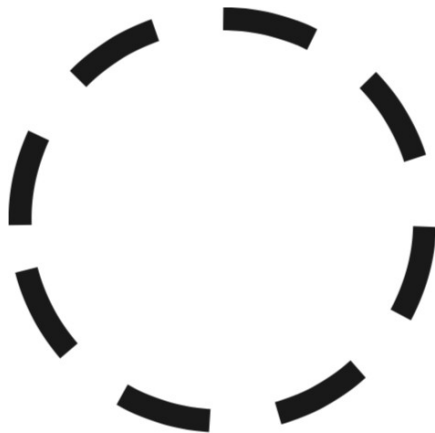objects that are physically enclosed together belonging to part of a group
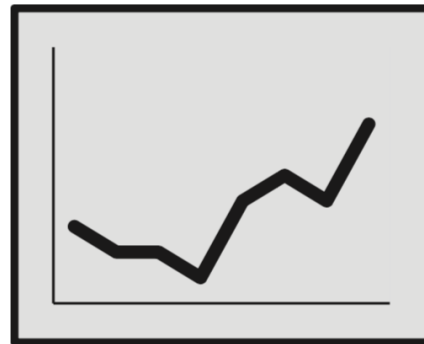
separate the forecast from actual data

ACTUAL   FORECAST

Closure

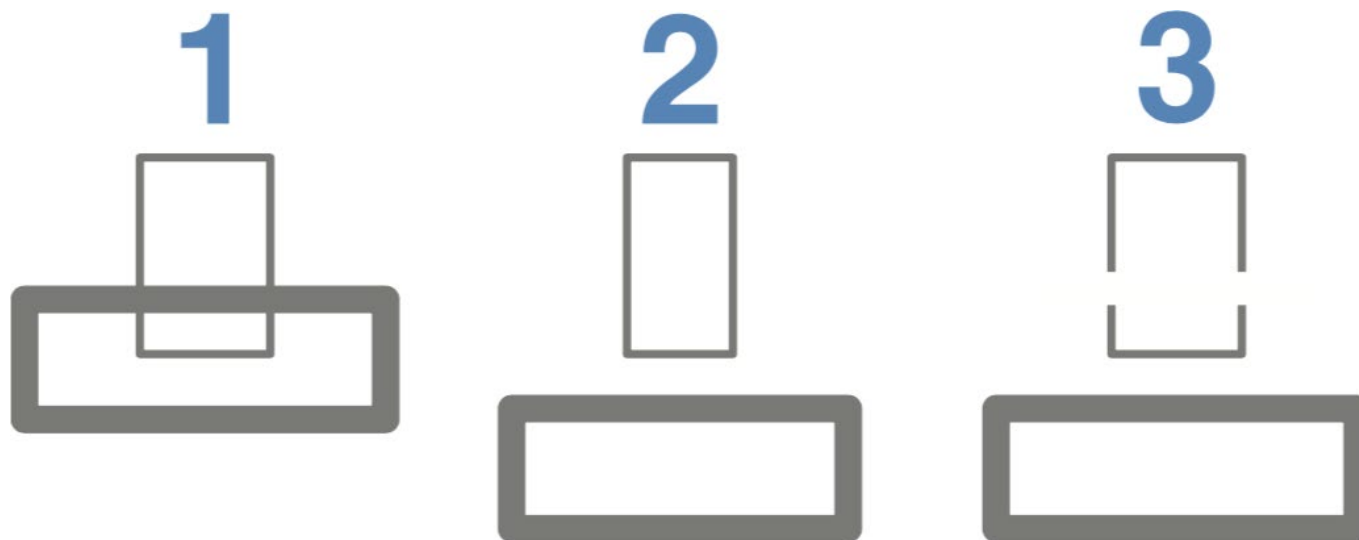elements will tend to be perceived as a circle first

graph still appears complete without the border and background shading
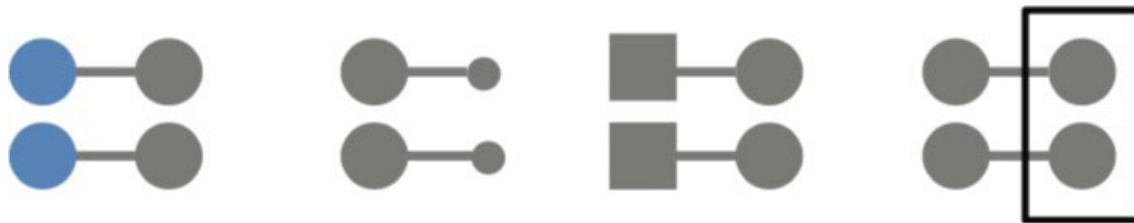
Continuity

We take the objects (1) and pull them apart, most people will expect to see what is shown next (2), whereas it could as easily be what is shown after that (3).
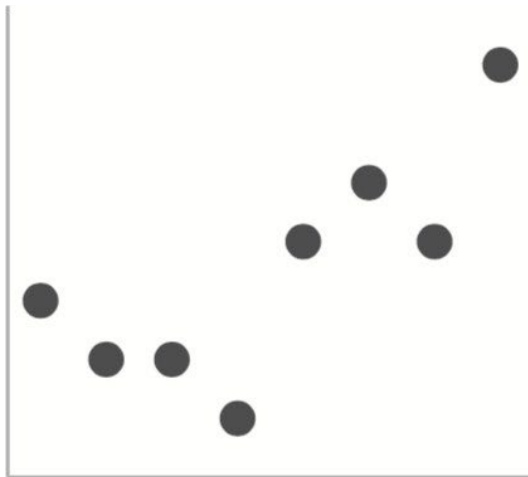
Connection

Our eyes pair the shapes connected by lines (rather than similar color, size, or shape).

- connection > similarity (color, size, shape)
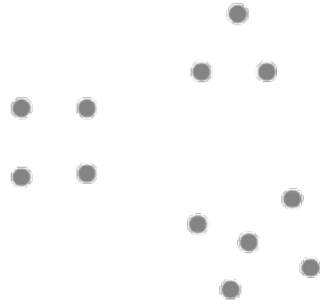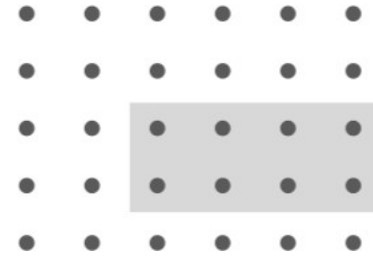- connection < enclosure

Connection

lines connect the dots

Gestalt principles of visual perception

proximity

similarity

enclosure

closure

continuity

connection

Demonstrating effectiveness is most important consideration when selecting a provider

In general, what attributes are the most important to you in selecting a service provider?
(Choose up to 3)

Survey shows that demonstration of results is the single most important dimension when choosing a service provider.

- Demonstration of results
- Content expertise
- Local knowledge
- National reputation
- Affordability of services
- Previous work together
- Colleague recommendation

0% 20% 40% 60% 80%

% selecting given attribute

Affordability and experience working together previously, which were hypothesized to be very important in the decision making process, were both cited less frequently as important attributes.

Data source: xyz; includes N number of survey respondents. Note that respondents were able to choose up to 3 options.
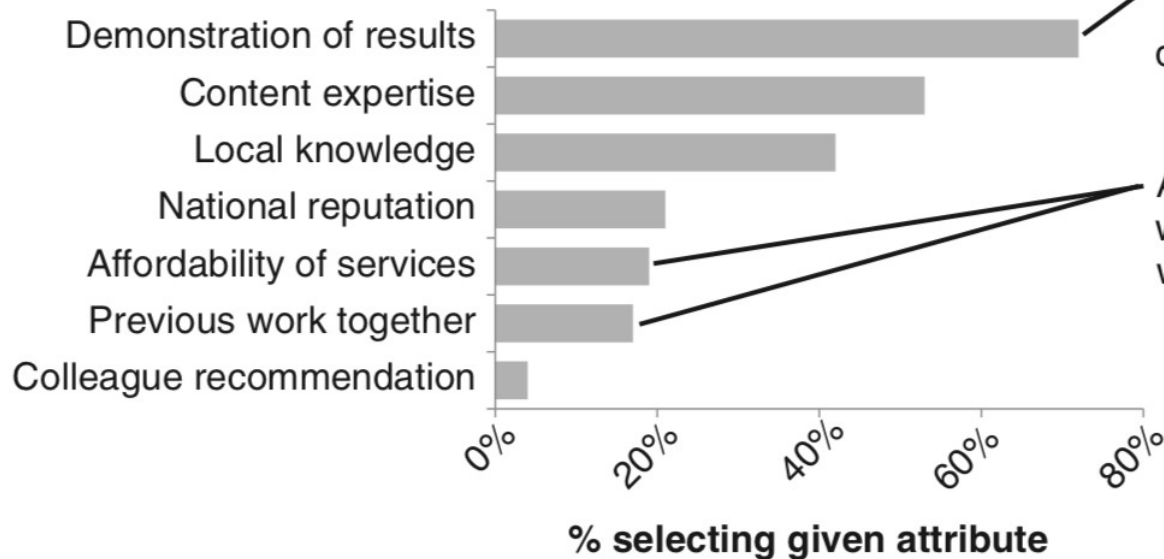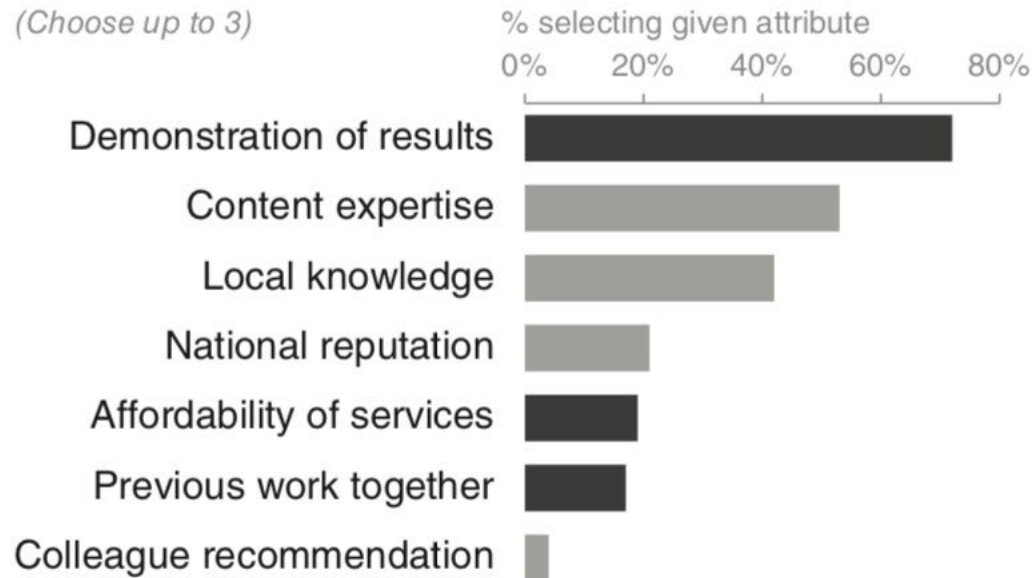
Lack of visual order

- other types of visual clutter

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Alignment

- other types of visual clutter

Presentation software tips for aligning elements

To help ensure that your elements line up when you are placing them on a page within your presentation software, turn on the rulers or gridlines that are built into most programs. This will allow you to precisely align your elements to create a cleaner look and feel. The table functionality built into most presentation applications can also be used as a makeshift brute-force method: create a table to give yourself guidelines for the placement of discrete elements. When you have everything lined up exactly like you want it, remove the table or make the table's borders invisible so that all that is left is your perfectly arranged page.
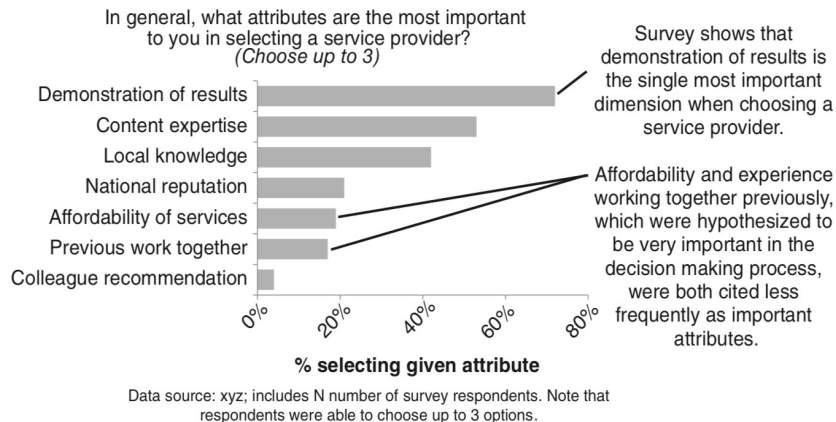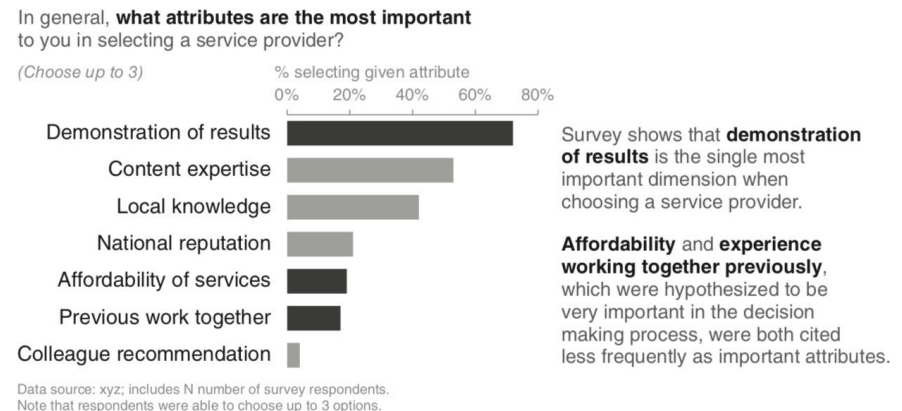
Alignment
- other types of visual clutter

before

after

Generally, diagonal elements such as lines and text should be avoided. They look messy and, in the case of text, are harder to read than their horizontal counterparts.

White space
- other types of visual clutter

- Never add data for the sake of adding data – only add data with a thoughtful and specific purpose in mind!

- We need to get more comfortable with white space.

- The lack of white space in a visual—like the lack of pauses in a spoken presentation—is simply uncomfortable for our audience.
  - o Margins should be free of text and visuals
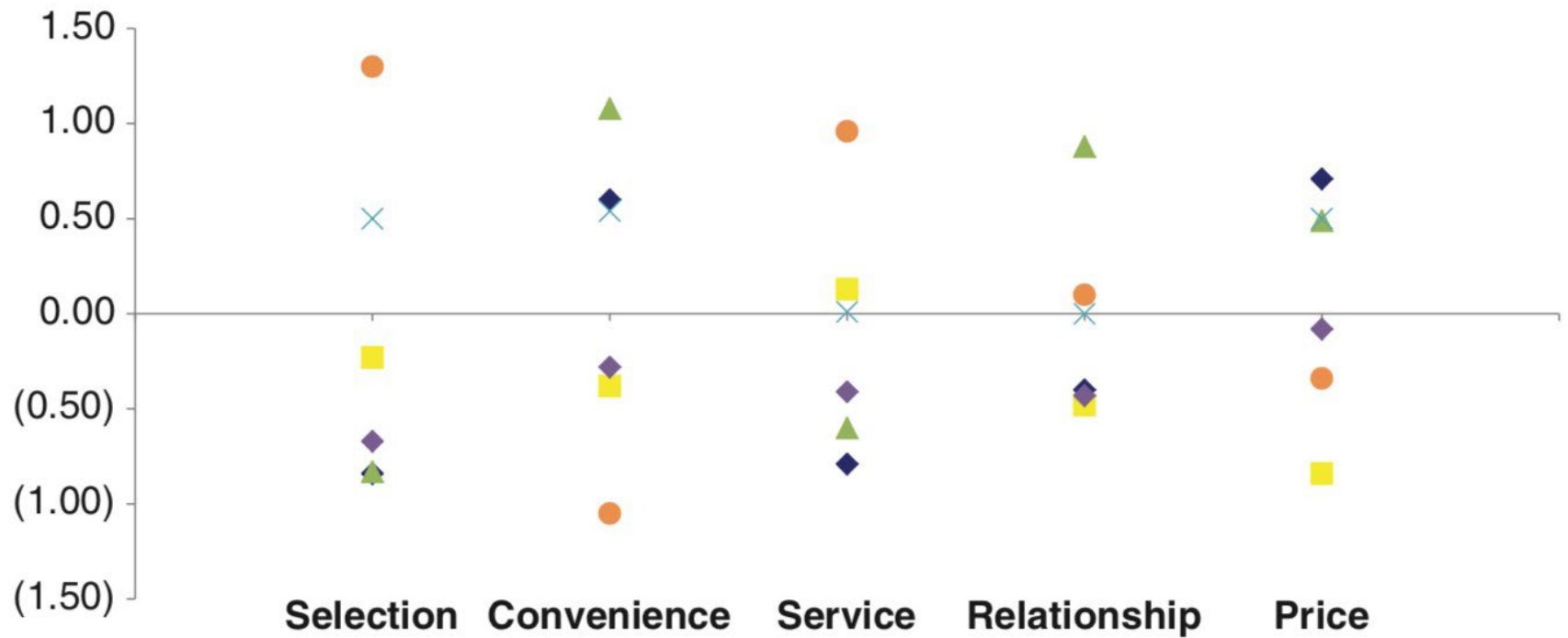 - o Use white space strategically for emphasis

Non-strategic use of contrast
- other types of visual clutter

Weighted Performance Index

Non-strategic use of contrast

- other types of visual clutter

Revamped graph, using contrast strategically

Summary

What we have learnt today?

- **Information processing**

- **Cognitive load theory**

    limited capabilities in the working memory

- **Clutter**

    why clutter is bad?

    types of clutter

- **Gestalt principles of visual perception**

    proximity, similarity, enclosure

    closure, continuity, connection