Guidelines for effective data visualisation

Direction Access to and Reuse of Public Information

Unit EU Open Data and CORDIS

Sector EU Open Data
This training course is organized in the scope of OP project within the ISA2 programme

ISA2 supports the development of digital solutions enabling public administrations, businesses and citizens in Europe to benefit from interoperable cross-border and cross-sector public services.

How OP is involved in ISA2?

OP is aiming at developing open data related activities in the areas of:

- Data visualisation
- Linked open data
- Persistent identification
# Upcoming training & workshop sessions

<table>
<thead>
<tr>
<th>Topic</th>
<th>Type of session</th>
<th>Lux + webex</th>
<th>Bxl</th>
</tr>
</thead>
<tbody>
<tr>
<td>Garbage in, garbage out: how to assure data quality for visualisation</td>
<td>Training</td>
<td>30/04</td>
<td>13/05</td>
</tr>
<tr>
<td>Exploratory data analysis through data visualisation (R-ggplot)</td>
<td>Training</td>
<td>24/05</td>
<td>04/06</td>
</tr>
<tr>
<td>Telling your story through data visualisation</td>
<td>Training</td>
<td>25/06</td>
<td>28/06</td>
</tr>
<tr>
<td>Making great online data visualisations without coding</td>
<td>workshop</td>
<td>26/06</td>
<td>-</td>
</tr>
<tr>
<td>Going beyond bars and lines: practising non-standard data visualisation</td>
<td>Training</td>
<td>24/09</td>
<td>Sep-Oct</td>
</tr>
<tr>
<td>Making data visualisations like a pro: D3.js</td>
<td>Workshop</td>
<td>25/09</td>
<td>-</td>
</tr>
<tr>
<td>Applying data visualisation best practices in real use cases</td>
<td>workshop</td>
<td>24/10</td>
<td>-</td>
</tr>
</tbody>
</table>

and **webinars (topic like for the trainings)** ... stay tuned!

Visualisation catalogue

The catalogue is a collection of visualisation tools, trainings and re-usable visualisations for all levels of data visualisation expertise, from beginner to expert.

Total number of entries: 102

Tools

**Leaflet.js**
Open-source JavaScript library for mobile-friendly interactive maps.

**Input Formats:** GeoJSON

**GeoJSON Editor (GEOD)**
The GeoJSON Editor (GEOD) is a map editor allowing you to draw shapes (lines, polygons) and create markers on a map, in a multilingual way. Features can be exported an...

**Input Formats:** GeoJSON, CSV, ZIP

**Basic Map (BMAP)**
Basic map (BMAP) is a "light" version of the Commission Map service. It allows configuring a simple, static map without the need to define business

Browse tools by visualisation type

- Bars
- Dots / bubbles
- Grids
- Infographics
- Lines
- Maps
- Relations/
- Shapes/
- Other
Data visualization events in 2019

EU Datathon 2019

- Date: 13 June 2019
- Venue: Residence Palace - Brussels
- Website: https://publications.europa.eu/eudatathon
- e-mail: op-datathon@publications.europa.eu

EU DataViz 2019 - Data Visualisation for the Public Sector

- Date: 12 November 2019
- Venue: European Convention Center - Luxembourg
- Website: https://publications.europa.eu/eudataviz
- e-mail: op-eu-dataviz@publications.europa.eu
Agenda

09:00  Introduction
       Fundamentals and concepts of design

10:30  Coffee break

11:00  Fundamentals of data visualisation

12:00 - 13:00  Lunch
       Choosing a chart type
       Text-chart integration

14:30  Coffee break

       Pitfalls to avoid
       The Data Visualisation Checklist

16:30  Q&A
1. INTRODUCTION
Participants

Institution/DG and role?
What data do you work with?
Experience in data visualisation?
Expectations for today?
2. FUNDAMENTALS
Fundamentals

Gestalt

The whole is something else than the sum of its parts
Gestalt
Similarity
Gestalt
Proximity
Gestalt
Enclosure
Gestalt
Figure-ground
3.
CONCEPTS OF DESIGN
"Graphic designers create and combine symbols, images and text to form visual representations of ideas and messages. They use typography, visual arts and page layout techniques to create visual compositions."

- Wikipedia

"Perfection is achieved, not when there is nothing more to add, but when there is nothing more to take away."

- Antoine de Saint Exupéry

"Content precedes design. Design in the absence of content isn't design, it's decoration"

- Jeffrey Zeldman
### Concepts of design

#### The grid

Framework to structure content

Columns, rows and gutters

Widely used

Both in print and in web design

<table>
<thead>
<tr>
<th>Vermont Symphony Orchestra</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Winter 2007 Season</strong></td>
</tr>
<tr>
<td><strong>Aaron Copland</strong></td>
</tr>
<tr>
<td><strong>The Tender Land</strong></td>
</tr>
<tr>
<td><strong>January 2007</strong></td>
</tr>
<tr>
<td><strong>Eric Satie</strong></td>
</tr>
<tr>
<td><strong>Gymnopedie 1, 2</strong></td>
</tr>
<tr>
<td><strong>February 2007</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Date</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>01/12/07</td>
<td>Middlebury College Center for the Arts 8:00 pm</td>
</tr>
<tr>
<td>02/03/07</td>
<td>Johnson State College Dibden Center for the Arts 8:00 pm</td>
</tr>
<tr>
<td>01/19/07</td>
<td>Johnson State College Dibden Center for the Arts 8:00 pm</td>
</tr>
<tr>
<td>02/10/07</td>
<td>Castleton State College Fine Arts Center 8:00 pm</td>
</tr>
<tr>
<td>01/26/07</td>
<td>Lyndon State College Alexander Twilight Theater 8:00 pm</td>
</tr>
<tr>
<td>02/17/07</td>
<td>Middlebury College Center for the Arts 8:00 pm</td>
</tr>
</tbody>
</table>
Almost all publication software has some kind of grid settings.

12 is a popular number of columns in grids. What do you think is the reason for that?
Concepts of design
The grid

Why use the grid?

Grids align
Grids organize
Grids are flexible
Grids make readable

Broken grids are dynamic
Broken grids draw attention
Can be applied everywhere
Let you use the rule of thirds
Concepts of design

The grid

Guidelines

Align visualisations to the grid of the publication

Align elements of a chart
Hierarchy — it’s a big word, but an easy-to-implement (albeit important) concept when it comes to typography. And this guide will show you how to use it to improve your design projects. Even if you’re not familiar with the term, you’ve likely run into typographic hierarchy many times. Just picture in a newspaper, with a headline, subheadline, and body copy. This is a classic example of three levels of typographic hierarchy, an approach that’s still used today, both in print and online. Newspapers from the early- to mid-20th century offer especially exaggerated examples, like this one. These days, our headlines or titles don’t have to be six inches tall to catch readers’ attention, but the image above provides a dramatic reminder of just what typographic hierarchy is all about — organizing and formatting your type choices in such a way that readers or users can clearly see what’s most important, which enables them to easily navigate the layout at a glance and quickly scan to find the information they’re looking for.
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Does this text invite you to read it?

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Make it scannable

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Concepts of design
Hierarchy

HEADLINE
(Level One)

SUBHEADS
(Level Two)

TEXT
(Level Three)
Concepts of design
Hierarchy

How is the visual hierarchy built up here?

Map Layout

CUBA Maritime Zones and Limits

Cuban Sovereign Areas

Limits

- Maritime boundary
- 200 nautical miles limit
- Contiguous zone
- Territorial sea
- Straight baseline
Concepts of design

Hierarchy

Font size is the one of the strongest signals in the visual hierarchy

It goes without saying that font size matters

The biggest letters get the most attention
Concepts of design

Hierarchy

Font weight

Weight

Weight

Weight
Concepts of design
Hierarchy

Letter spacing

Spacing
Spacing
Spacing
Concepts of design

Hierarchy

Visual hierarchy in data visualisation
Visual hierarchy in data visualisation

The data is the most important element: it should be high in the visual hierarchy

Supportive elements, like axes and axes labels, should retreat to the background

Font sizes of text elements should reflect the hierarchy
Concepts of design

Typography

Sans serif:
- Simplicity
- Modern
- Minimal
- Screens

Serif:
- Traditional
- Ease of reading
- Body text
Stop
Concepts of design
Typography

Avoid playful and "dated" fonts
A sans-serif title
Vestibulum vel velit ut augue euismodeleifend sit amet ut orci. Maecenas varius dictum metus, quis varius duiiaculis id.

A serif title
Vestibulum vel velit ut augue euismodeleifend sit amet ut orci. Maecenas varius dictum metus, quis varius duiiaculis id.
Fruit production

- Pineapples: 6000
- Melons: 5120
- Oranges: 5000
- Apples: 4320
- Pears: 3250
You can mix serif and sans-serif fonts, for example for the chart title versus data labels.

Space for text is usually limited on charts, so you could consider a condensed font or reduce the letter spacing.

Choose a font that fits your publication and the topic.

For numbers, use a monospaced font with lining.
Concepts of design

Color

Colors have feelings

Is red good or bad?

What is happier: yellow or grey?

Do you want your banker to wear a blue or an orange suit?

Is it fresh or fresh?
Concepts of design
Color
Let colors make sense

Banana
Tomato
Orange
Grass
Concepts of design

Color

Color harmonies:
- Analogous
- Monochromatic
- Complementary
- Triad

Get inspired by art you love

Adobe color wheel
Concepts of design

Color

Contrast is the difference in the color and brightness between an object and its surroundings.

Contrast determines legibility of text.
Contrast determines legibility, not only for text but also for visual elements in your visualization.

Optimised color palettes: ColorBrewer
Concepts of design

Color

Guidelines

Avoid colors and color schemes with strong connotations or cliche color schemes

Let colors make sense

Use color consistently

Use tools to pick harmonious color palettes

Assure enough contrast

Think about color blindness
Concepts of design
Negative space
Can you see it?
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Concepts of design

The grid
Hierarchy
Fonts
Color
Negative space
4. FUNDAMENTALS OF DATA VISUALISATION
Preattentive features

Color
Preattentive features
Size
Preattentive features

Position
Preattentive features

Rotation
Pre-attentive features

Shape
Data visualisation is mapping data to color, size, position, rotation, shape so we can go from interpreting numbers to spotting patterns immediately.
Gestalt Similarity
Gestalt
Proximity
Gestalt Enclosure
Gestalt: Figure-ground
Gestalt:
Figure-ground
Gestalt:
Figure-ground
Exercise
Data encodings

Exercise:
How can you represent 2 numbers?
Fundamentals of data visualisation

Encodings

Some encodings are more efficiently decoded by the reader
5. CHART CHOOSERS
Chart choosers
Visual Vocabulary
By the Financial Times
Chart choosers
Dataviz Project
By Ferdio
Exercise
Choosing a chart type

Dataset:
• yearly gdp/capita, 2008-2017
• By EU country

In what different ways could you visualise this data?

For what kind of story or message would you choose one over the other?

<table>
<thead>
<tr>
<th>Country</th>
<th>Year</th>
<th>GDP/capita</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgium</td>
<td>2008</td>
<td>30100</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>2008</td>
<td>11100</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>Sweden</td>
<td>2017</td>
<td>36300</td>
</tr>
<tr>
<td>UK</td>
<td>2017</td>
<td>31600</td>
</tr>
</tbody>
</table>
Chart choosers
Chartmaker
Directory

By Andy Kirk and the visualisation community
6. TEXT AND VISUALISATION INTEGRATION
Text - visualisation integration

Text on charts

Titles (or at least units) are needed to interpret a visualisation.

Datalabels provide hierarchy: not all data points are equally important.
Text - visualisation integration

Text on charts

A descriptive title tells the story

Optional subtitle can give details and metadata

Source and credits make the chart self-contained

Almost 6 million Brits signed up to stop Brexit

Petition to Revoke Article 50 and remain in the EU - Sign Up Count

Based on Ben Howard • Source: petition.parliament.uk • Get the data • Created with Datawrapper
Text - visualisation integration

Text on charts

Annotations make the reader focus and tell the story even more

Almost 6 million Brits signed up to stop Brexit

Petition to Revoke Article 50 and remain in the EU - Sign Up Count

Based on Ben Howard • Source: petition.parliament.uk • Get the data • Created with Datawrapper
Tell the message of the chart in the title

Optional subtitle

Always specify the units of the data

Use data labels to indicate hierarchy

Use annotations to tell the story

Make your visualisation self contained: data source, author/graphic source
Keep charts on the same page as their reference in the text

Don’t repeat the message

Don’t contradict the message

Reinforce: explain in the text, show with a visualisation
Text - visualisation integration

The medium

Online

Make sure scaled text is legible on all screens

Maximum size for big screens

Use a resolution that is high enough, also for HD screens

Keep fluid integration in mind: chart can be to the side of the reference, but also above or below

Consider flipping the chart orientation on small screens
The outgoing Italian parliament

Seats in the Chamber of Deputies

- Democratic Party: 281 seats
- Centre right: 23 seats
- Other centre: 28 seats
- Mixed Group: 61 seats
- Five Star Movement: 88 seats
- Forza Italia (Berlusconi): 56 seats
- Northern League: 22 seats
- Brothers of Italy: 12 seats

*Free and Equal (and allies): 59 seats
The outgoing Italian parliament

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- Northern League: 22 seats
- Brothers of Italy: 12 seats
- Free and Equal (and allies)*: 59 seats

*Includes Articolo 1 - Movimento Democratico e Progressista, Sinistra Italiana - Sinistra Ecologia Libertà - Possibile

Source: Open Parlamento
© FT
Boil the message down (space is limited)

Fixed integration: you can be creative
Xi Jinping réaffirme le rôle central du Parti communiste

Quarante ans après l'ouverture de la Chine

Comment le pays a opéré sa mue

Le ralentissement de la croissance place Pékin face à des choix délicats

Interview avec Jean-François di Meglio, président du centre de recherche Asia Centre

« Aucun dirigeant chinois n'a opéré la même conversion que Gorbachev »

Les chiffres clés

34,000 Mille millions

266 %

En pourcentage du PIB des Chinois
Text - visualisation integration
The medium

Slides

Use big font sizes
Use horizontal chart orientation
7. PITFALLS IN DATA VISUALISATION
Pitfalls in data visualisation

What is going wrong here?

Don’t cut barts

Make text run horizontal
Pitfalls in data visualisation

What is going wrong here?

Don’t cut time axes
Pitfalls in data visualisation

What can go wrong here?

Label directly

What Happened To Women In Computer Science?

% Of Women Majors, By Field
Pitfalls in data visualisation
Pitfalls in data visualisation

Use colors deliberately

Use colors hierarchically (make grey your best friend)
Pitfalls in data visualisation

Is this a good chart?

Be careful with "chart junk"
Calories per 100g for different foods

- French Fries: 600 calories
- Potato Chips: 500 calories
- Bacon: 700 calories
- Pizza: 300 calories
- Chili Dog: 200 calories
Remove to improve (the data-ink ratio)
Remove to improve the pie chart edition
Pitfalls in data visualisation

Width-to-height ratio

Axes that encode data should have enough space to show the data

- Total consumption of chemicals (hazardous and non-hazardous)
- Hazardous to health
- Hazardous to the environment
Pitfalls in data visualisation

What is wrong here?
Pitfalls in data visualisation

Scale circles by area, not radius
Pitfalls in data visualisation

What’s going on here?

**US spending on science, space, and technology correlates with Suicides by hanging, strangulation and suffocation**
Pitfalls in data visualisation

What’s going on here?

**Number of people who drowned by falling into a pool correlates with Films Nicolas Cage appeared in**

- **Swimming pool drownings**: 80, 100, 120, 140
- **Nicolas Cage**: 0, 2, 4, 6 films


[tylervigen.com]
Pitfalls in data visualisation

What's going on here?

Don't double the axis
Pitfalls in data visualisation

What’s going on here?

Be careful with scatterplots, correlation is not causation

---

$r = 0.791$

$P < 0.0001$
Pitfalls in data visualisation

What’s going on here?

Don’t do 3D
### Pitfalls in data visualisation

Sort on the data

#### Obesity rate by country

**In percent, 2014**

<table>
<thead>
<tr>
<th>Country</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgium</td>
<td>13.7</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>14.4</td>
</tr>
<tr>
<td>Czechia</td>
<td>18.7</td>
</tr>
<tr>
<td>Denmark</td>
<td>14.4</td>
</tr>
<tr>
<td>Germany</td>
<td>16.4</td>
</tr>
<tr>
<td>Estonia</td>
<td>19.7</td>
</tr>
<tr>
<td>Ireland</td>
<td>18.2</td>
</tr>
<tr>
<td>Greece</td>
<td>16.9</td>
</tr>
<tr>
<td>Spain</td>
<td>16.2</td>
</tr>
<tr>
<td>France</td>
<td>14.7</td>
</tr>
<tr>
<td>Croatia</td>
<td>18</td>
</tr>
<tr>
<td>Italy</td>
<td>10.5</td>
</tr>
<tr>
<td>Cyprus</td>
<td>13.9</td>
</tr>
<tr>
<td>Latvia</td>
<td>13.9</td>
</tr>
<tr>
<td>Lithuania</td>
<td>16.6</td>
</tr>
<tr>
<td>Luxembourg</td>
<td>15.1</td>
</tr>
<tr>
<td>Hungary</td>
<td>20.6</td>
</tr>
<tr>
<td>Malta</td>
<td>25.2</td>
</tr>
<tr>
<td>Netherlands</td>
<td>12.9</td>
</tr>
<tr>
<td>Austria</td>
<td>14.3</td>
</tr>
<tr>
<td>Poland</td>
<td>16.7</td>
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<tr>
<td>Portugal</td>
<td>16.1</td>
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<tr>
<td>Romania</td>
<td>9.1</td>
</tr>
<tr>
<td>Slovenia</td>
<td>18.6</td>
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<tr>
<td>Slovakia</td>
<td>15.9</td>
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<td>Finland</td>
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<tr>
<td>France</td>
<td>14.7</td>
</tr>
<tr>
<td>Denmark</td>
<td>14.4</td>
</tr>
<tr>
<td>Bulgaria</td>
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</tr>
<tr>
<td>Austria</td>
<td>14.3</td>
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<tr>
<td>Cyprus</td>
<td>13.9</td>
</tr>
<tr>
<td>Belgium</td>
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<td>Sweden</td>
<td>13.4</td>
</tr>
<tr>
<td>Netherlands</td>
<td>12.9</td>
</tr>
<tr>
<td>Norway</td>
<td>12.6</td>
</tr>
<tr>
<td>Italy</td>
<td>10.5</td>
</tr>
<tr>
<td>Romania</td>
<td>9.1</td>
</tr>
</tbody>
</table>
Pitfalls in data visualisation

Countries by gdp
Ireland, Netherlands and Austria are the richest EU countries

Pitfalls in data visualisation

Tell the story
Pitfalls in data visualisation

Do you think this a good chart?
Pitfalls in data visualisation

One message, one chart

“I’ll pause for a moment so you can let this information sink in.”
After Great Recession, debt increased substantially in most G-7 economies

Total gross debt as a share of GDP in the Group of Seven nations

Note: Gross debt represents total liabilities of all levels and units of government — national, state/provincial and local — less liabilities held by other levels or units of government, unless otherwise noted by source.

Source: The International Monetary Fund, World Economic Outlook, accessed Sept 7, 2017.

PEW RESEARCH CENTER
Pitfalls in data visualisation

Ozone concentrations in the northern hemisphere: a clear front between the yellow and the green areas?
Pitfalls in data visualisation

Sometimes the patterns are in the color scale, not in the data

Use perceptually uniform color scales for encoding numbers with color
Pitfalls in data visualisation

More arguments against rainbow color scales
Pitfalls in data visualisation

More arguments against rainbow color scales
Pitfalls in data visualisation

More arguments against rainbow color scales
Pitfalls in data visualisation

More arguments against rainbow color scales
Pitfalls in data visualisation

More arguments against rainbow color scales

#Endrainbow
Pitfalls in data visualisation
Pitfalls in data visualisation

Scale numbers on the map
Pitfalls in data visualisation

What’s wrong here?

All maps lie, especially Mercator world maps
8.

THE DATAVIZ CHECKLIST
The Dataviz Checklist

Evaluate a chart, based on 25 guidelines

datavizchecklist.stephanieevergreen.com

For effective communication of data with visualisations
Evaluate your work or others work and learn the guidelines
Q&A
Resources

Gestalt
interaction-design.org/literature/article/the-law-of-similarity-gestalt-principles-1
daydreamingnumbers.com/concepts/gestalt-laws-data-visualization
medium.com/@Elijah_Meeks/gestalt-principles-for-data-visualization-59f18f20bd40

Grid
15 reasons Why a Grid Based Design Will Improve Your Designs
Visual hierarchy
gistbok.ucgis.org/bok-topics/visual-hierarchy-and-layout

Typography for numbers
invisionapp.com/inside-design/best-free-fonts-for-numbers/

Preattentive Attributes
daydreamingnumbers.com/blog/preattentive-attributes-example/

Pitfalls in visualisation
data-to-viz.com/caveats.html

Tools
Color wheel
Visual Vocabulary
Dataviz Project
Chartmaker Directory
Viz Palette

Blogs
Datawrapper Weekly Chart
Financial Times Chart Doctor (paywall)

Books
The Functional Art (Alberto Cairo)
Effective Data Visualization (Stephanie Green)
Data Points (Nathan Yau)