Accounting Approach to Climate Change Statistics and Indicators

Data Visualization [Good] Practices

[- Why Visualizing Data? -]

How many "3" in that sequence?

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4592907805977209877597265566511004983664527107462144654207079014738109743897010971439070973492668478587158190486309018890742574707235474566614201877407284987531066

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45929078059772098775972655665110049836645
27107462144654207079014738109743897010971
43907097349266847858715819048630901889074
25747072354745666142018774072849875310665

45929078059772098775972655665110049836645
27107462144654207079014738109743897010971
43907097349266847858715819048630901889074
25747072354745666142018774072849875310665

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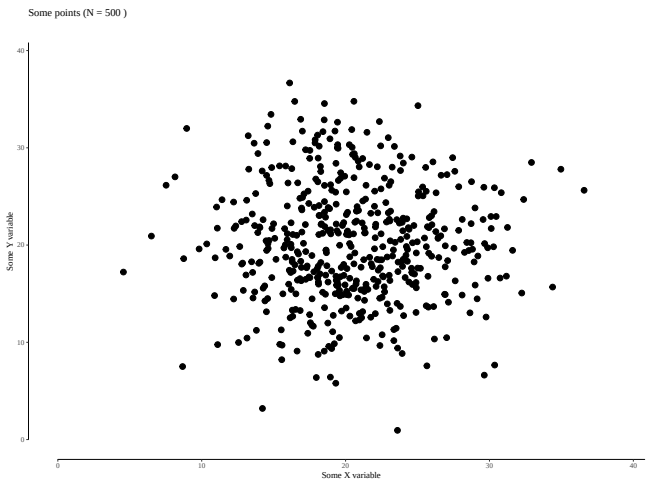
4592907805977209877597265566511004983664 5
2710746214465420707901473810974389701097 1
4390709734926684785871581904863090188907 4
2574707235474566614201877407284987531066 5

4592907805977209877597265566511004983664 5
2710746214465420707901473810974389701097 1
4390709734926684785871581904863090188907 4
2574707235474566614201877407284987531066 5

from Ware (2012)

[- Why Visualizing Data? -]

What can you say from this graphic?



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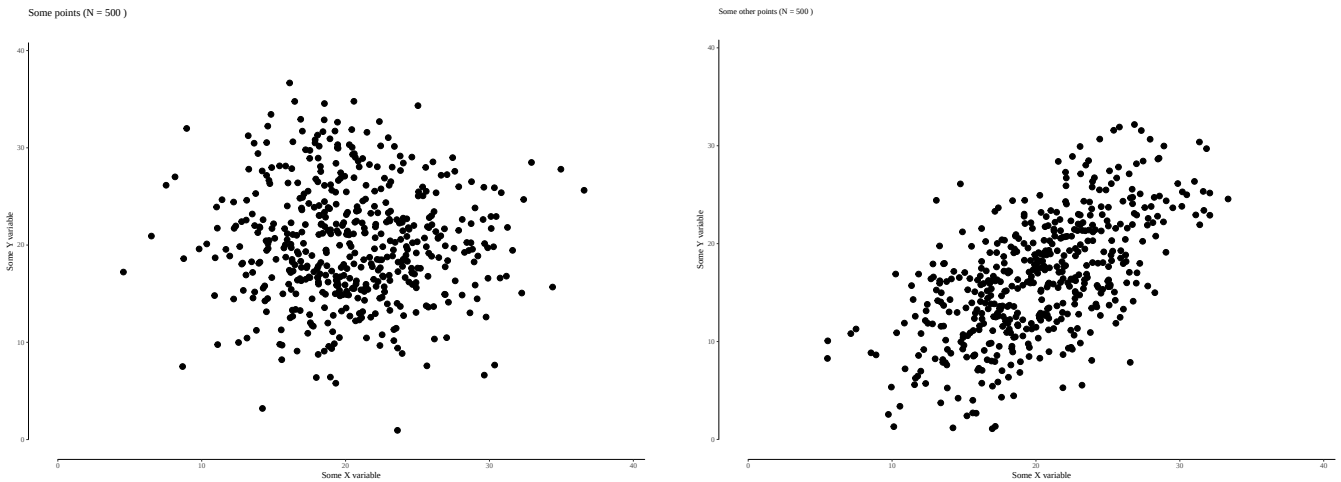

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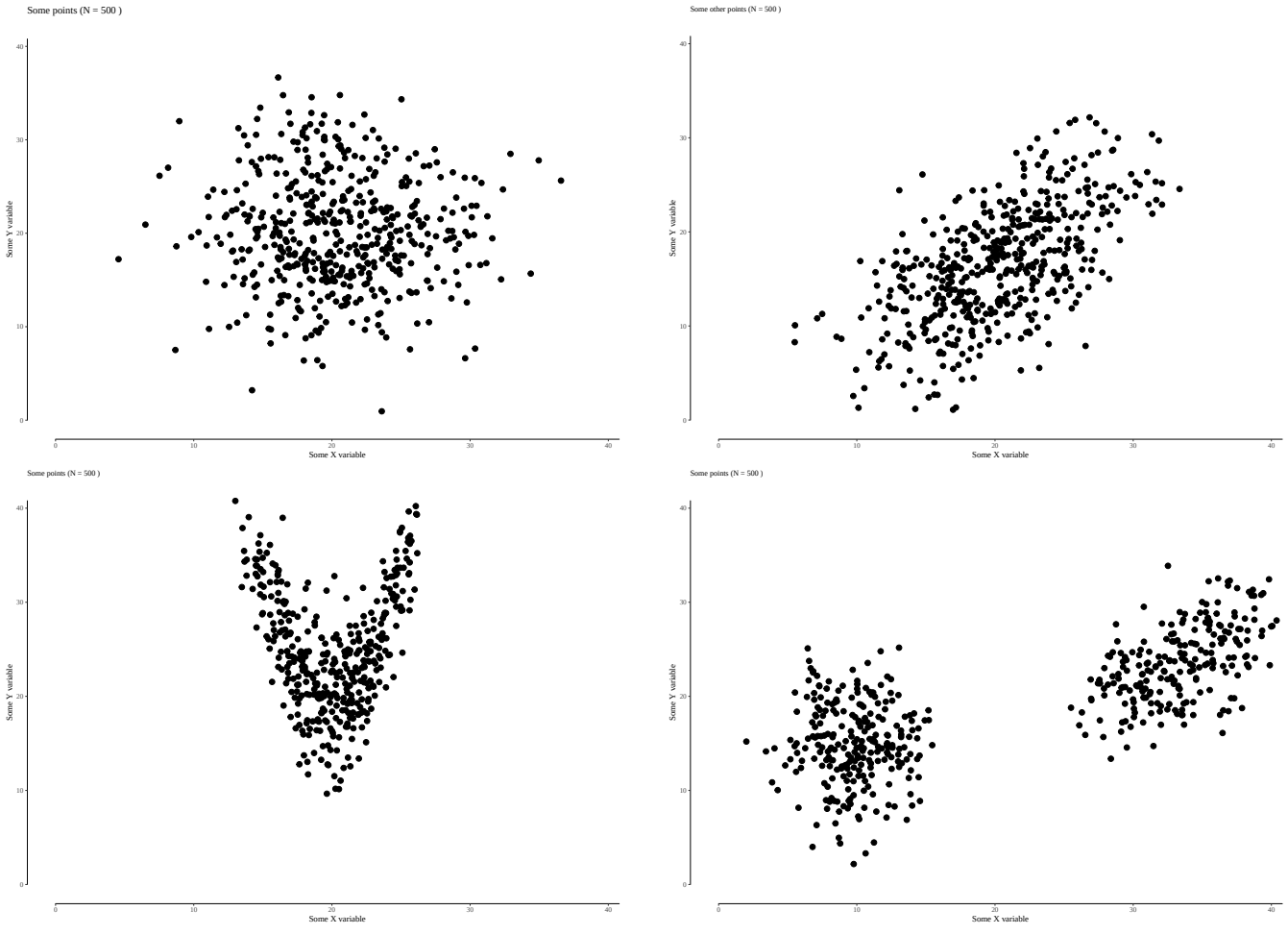
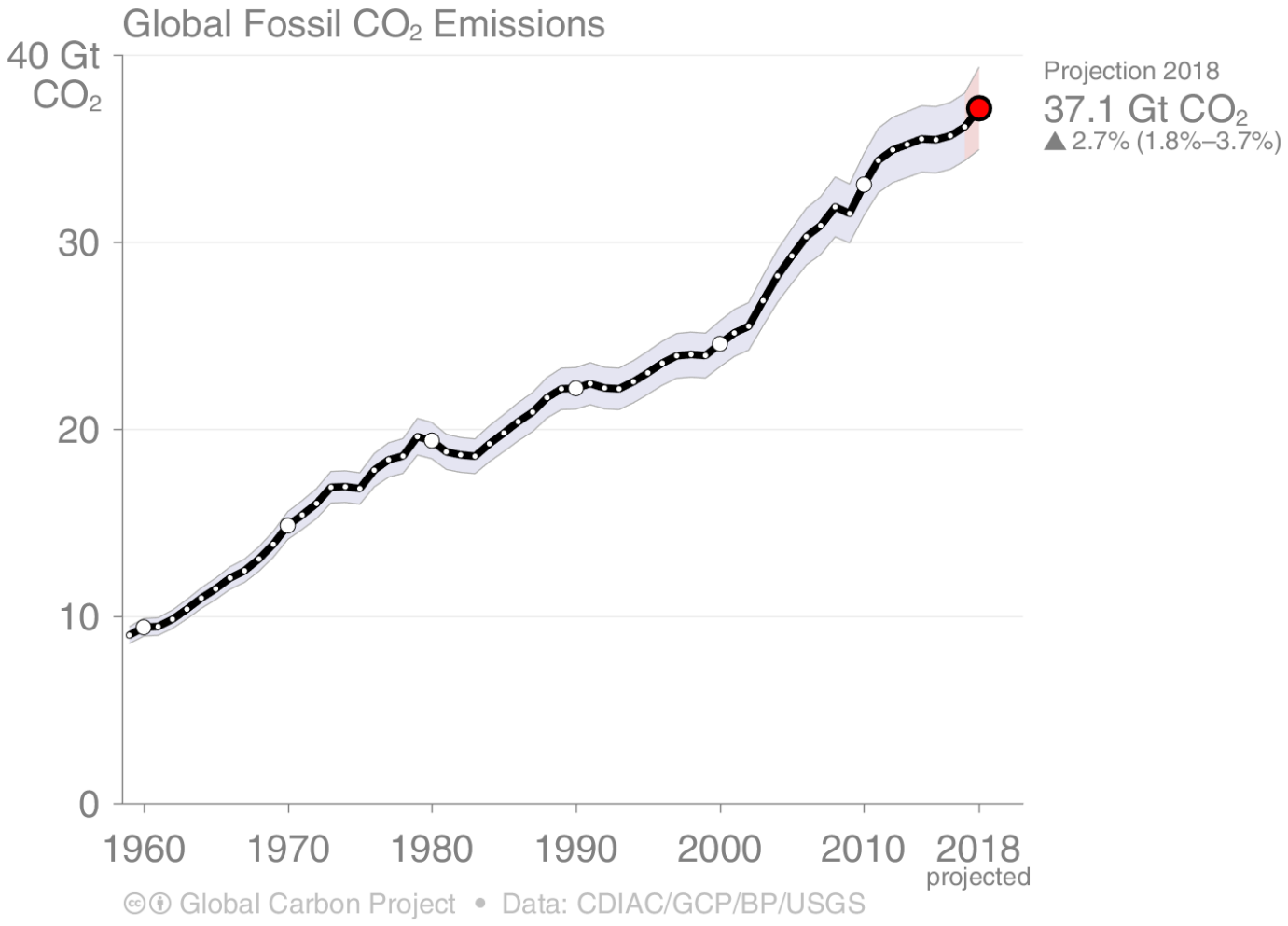


[- What we do: -]: Implicit comparisons

What does this curve tells you ?

[- What we do: -]: Implicit comparisons



Source: Global Carbon Budget 2018

[- What we do: -]: Explicit comparisons

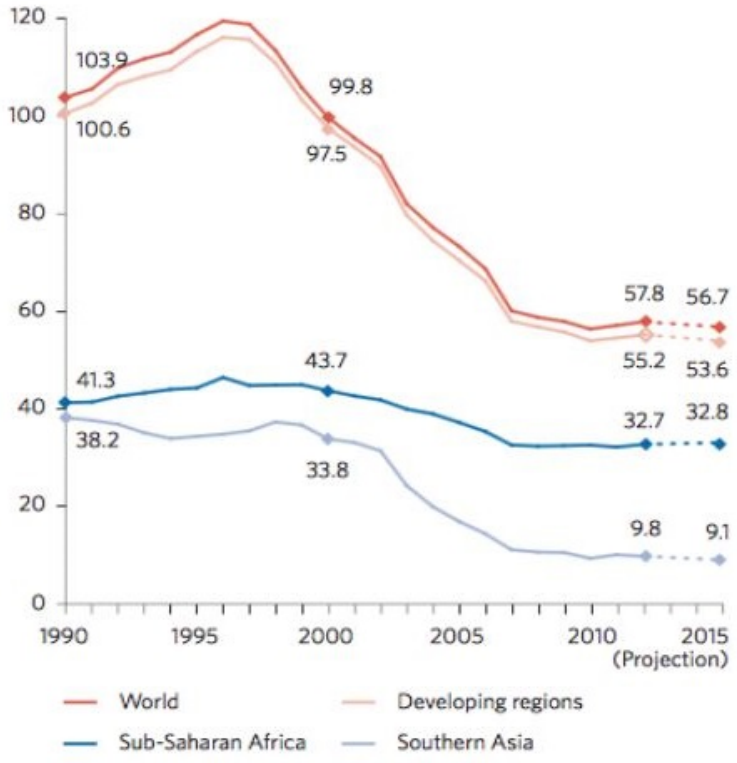
We compare: **Surfaces**...

Source: Nowethic

[- WHAT WE DO: -]: EXPLICIT COMPARISONS

Lines...

Number of out-of-school children of primary school age, selected regions, 1990-2015 (million)



Source: UNDP

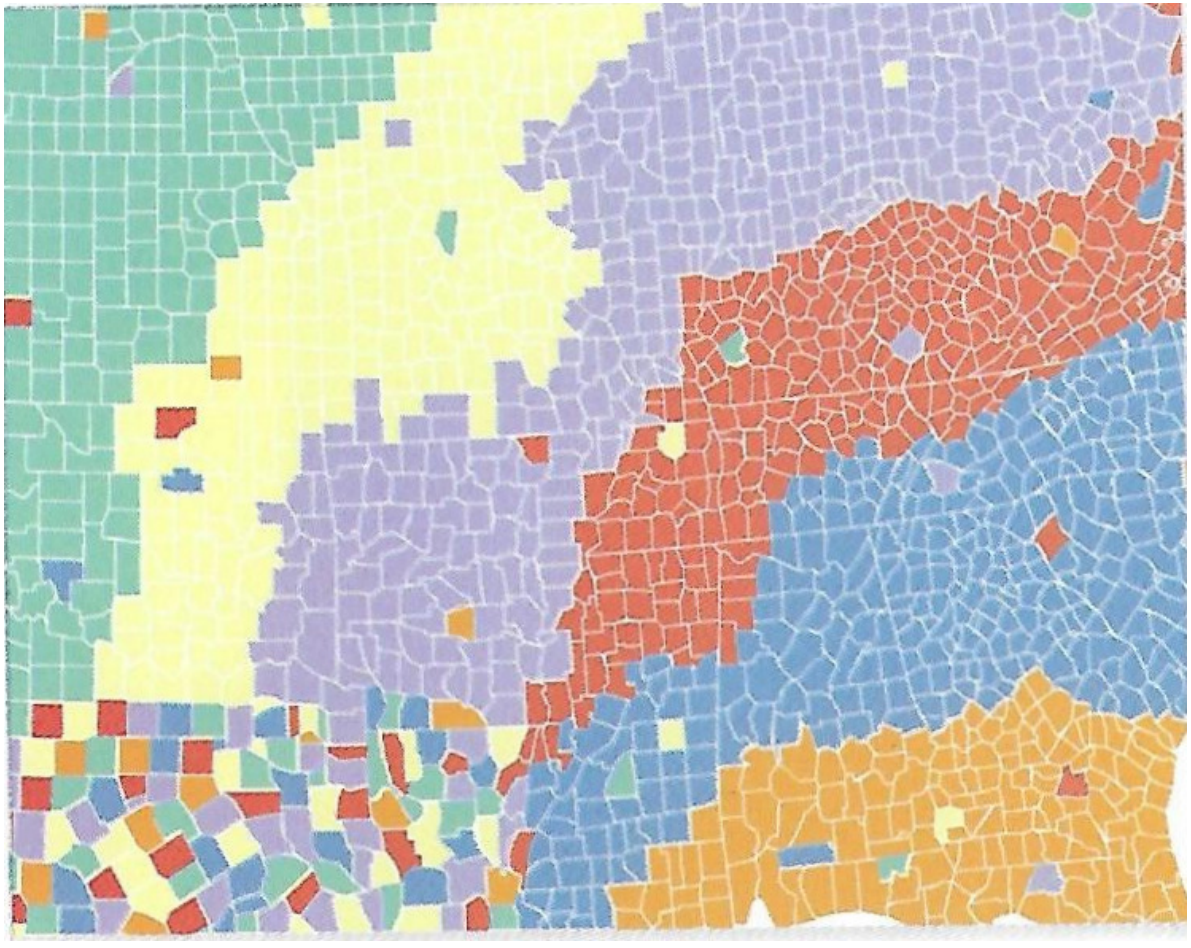
[- What we do: -]: Explicit comparisons

Bars...

Source: Meera Umasankar

[- What we do: -]: Explicit comparisons

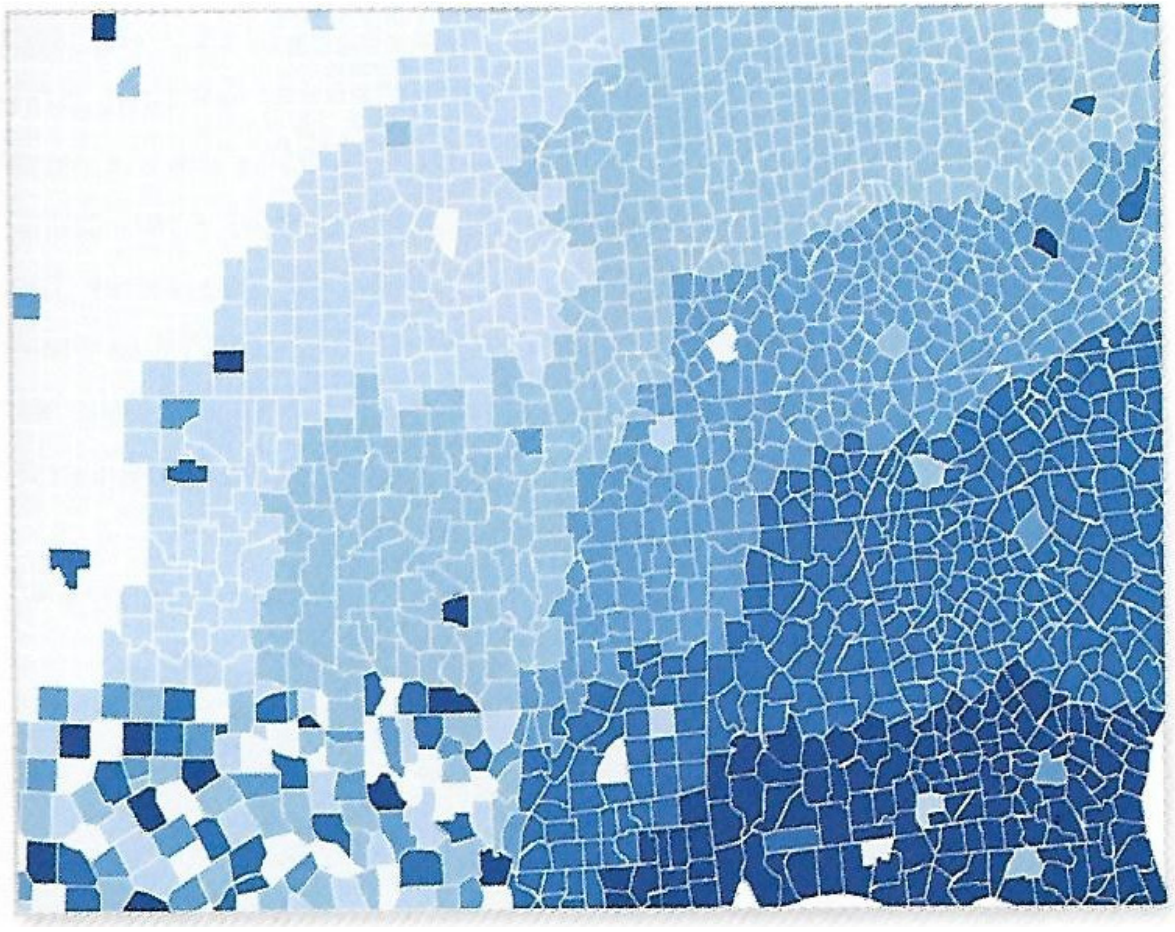
Colors?



source: Datawrapper

[- What we do: -]: Explicit comparisons

Color **intensity!**



source: Datawrapper

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Ecosystem Accounts

[- National River Ecosystem Accounts -]

What can you say from this table?

Table E: Ecosystem condition account for rivers based on the aggregated ecological condition category, for main rivers, tributaries and all rivers

Kilometres	Degree of modification from natural					Total
	Natural	Moderately modified	Heavily modified	Unaccept-ably modified	No Data	
MAIN RIVERS						
Opening stock 1999	**46 541**	**22 315**	**2 791**	**1 026**	**3 637**	**76 310**
Opening stock as a % total river length	61	29	4	1	5	100
Increase/decreases	-24 100	9 467	13 168	1 465		
Increases/decreases as % opening stock	-52	42	472	143		
Opening stock 2011	**22 441**	**31 782**	**15 960**	**2 492**	**3 637**	**76 310**
Opening stock as a % total river length	29	42	21	3	5	100
TRIBUTARIES						
Opening stock 1999	**40 294**	**7 470**	**2 084**	**328**	**37 047**	**87 223**
Opening stock as a % total river length	46	9	2		42	100
Increase/decreases	-17 062	11 339	4 766	957		
Increases/decreases as % opening stock	-42	152	229	292		
Opening stock 2011	**23 232**	**18 809**	**6 850**	**1 285**	**37 047**	**87 223**
Opening stock as a % total river length	27	22	8	1	42	100
ALL RIVERS						
Opening stock 1999	**86 835**	**29 784**	**4 875**	**1 354**	**40 684**	**163 533**
Opening stock as a % total river length	53	18	3	1	25	100
Increase/decreases	-41 163	20 806	17 935	2 422		
Increases/decreases as % opening stock	-47	70	368	179		
Opening stock 2011	**45 673**	**50 591**	**22 810**	**3 776**	**40 684**	**163 533**
Opening stock as a % total river length	28	31	14	2	25	100

[- National River Ecosystem Accounts -]

What can you say from this graphic?

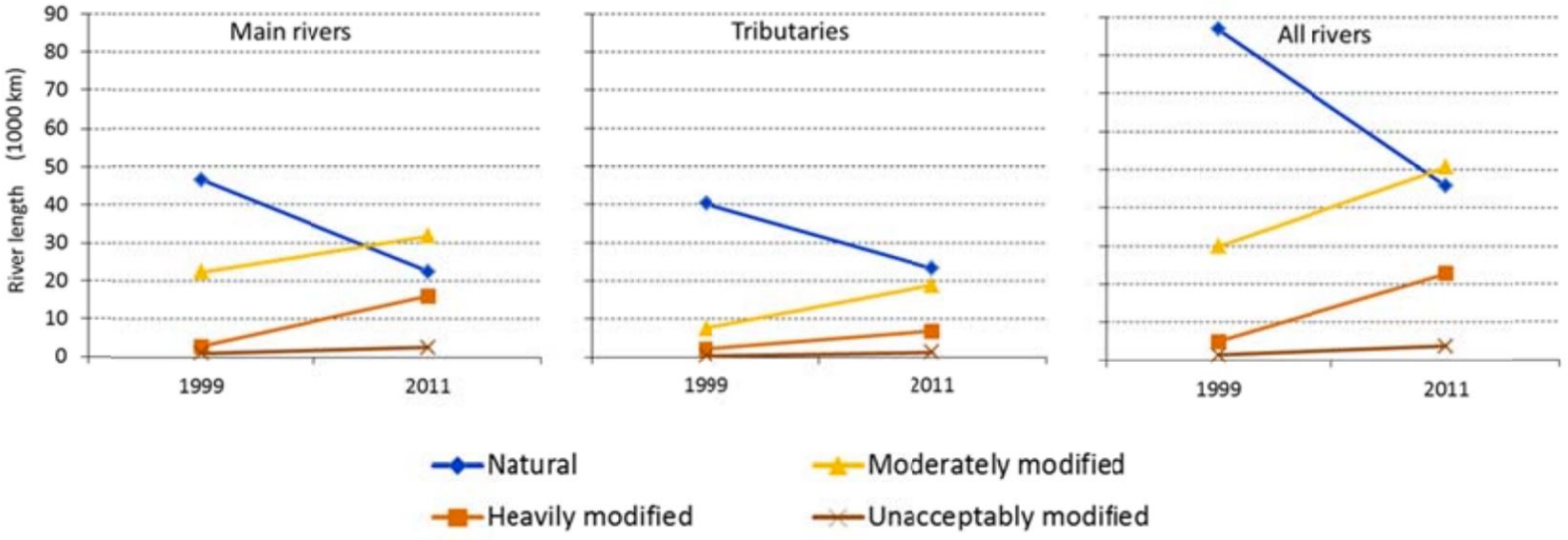
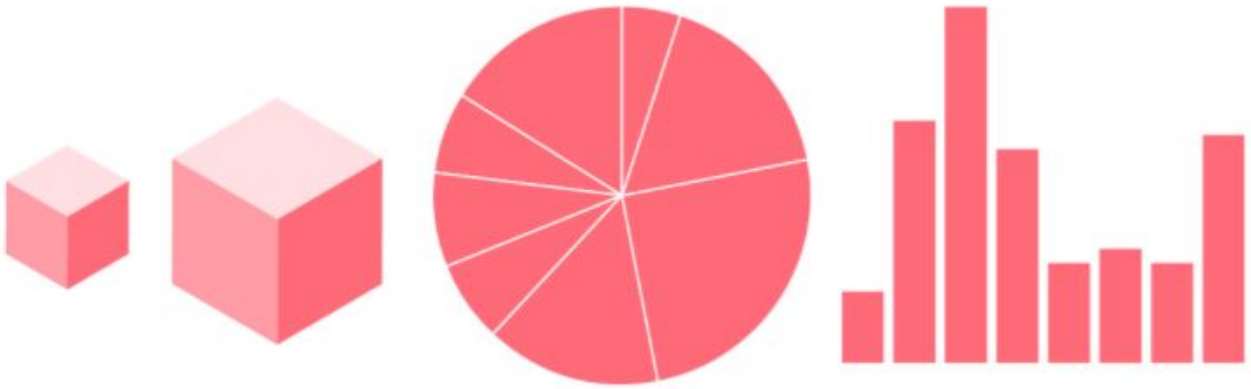


Figure C: Change in the extent of river length in each aggregated ecological condition category, for main rivers, tributaries and all rivers, 1999 – 2011

Source: National River Ecosystem Accounts for South Africa (2015

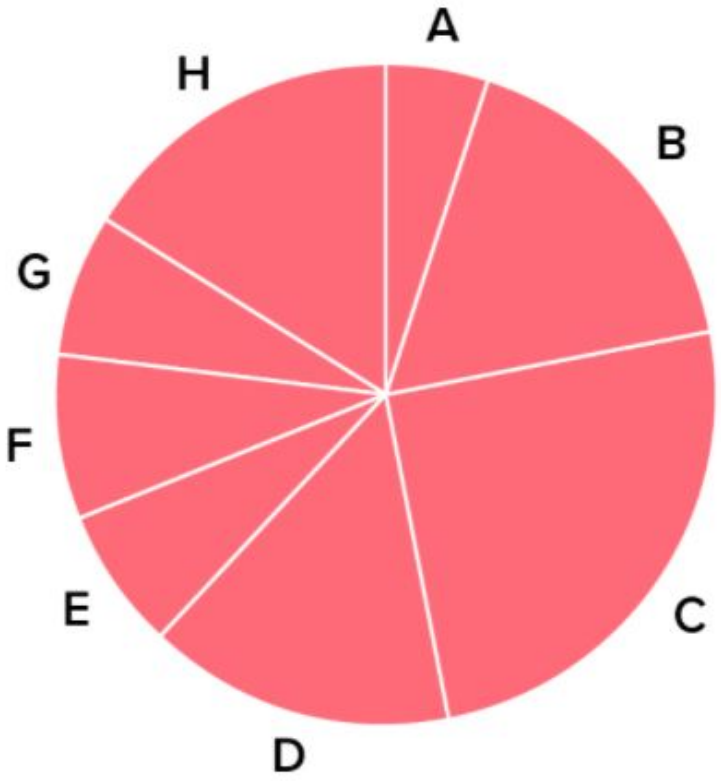
Decoding visual Information

Quiz: Decode classics



Source: Knowable magazine

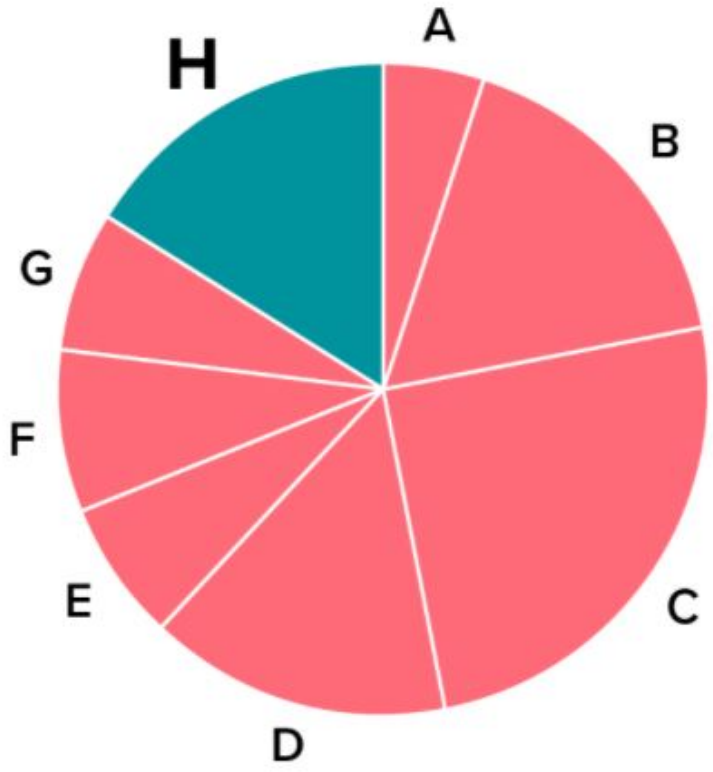
Quiz: Decode classics



Which is the third largest segment in the pie chart?

- A
- H
- B
- D

Quiz: Decode classics



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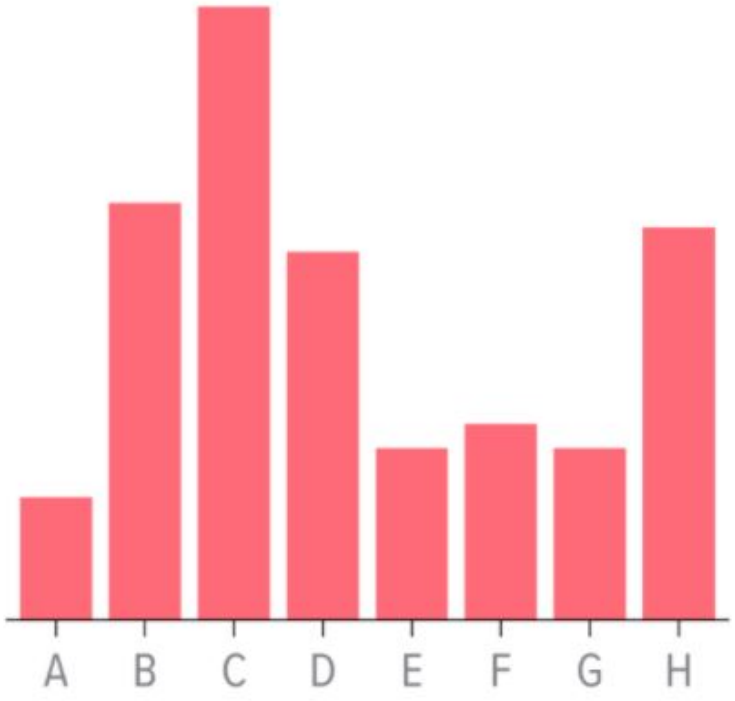
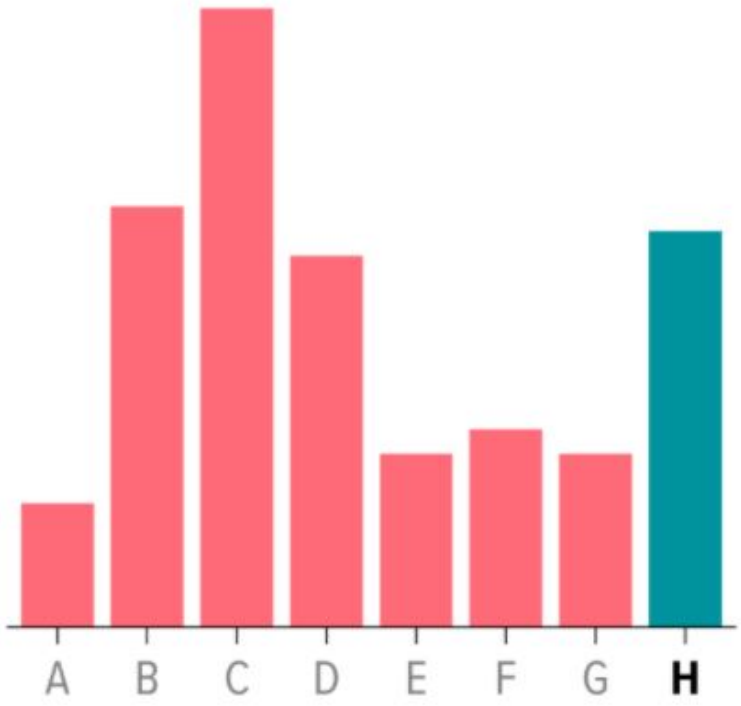


Which is the third tallest bar?

- H
- B
- D
- F

Quiz: Decode classics



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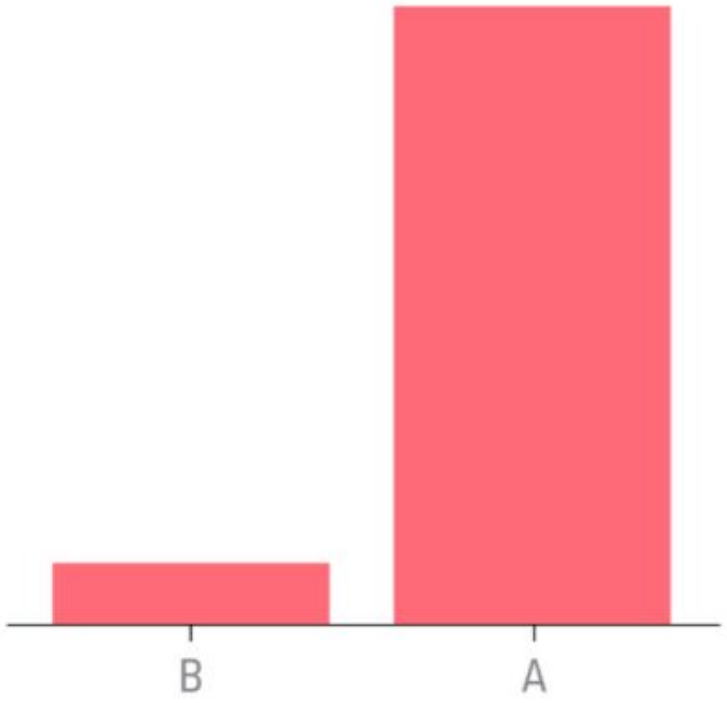
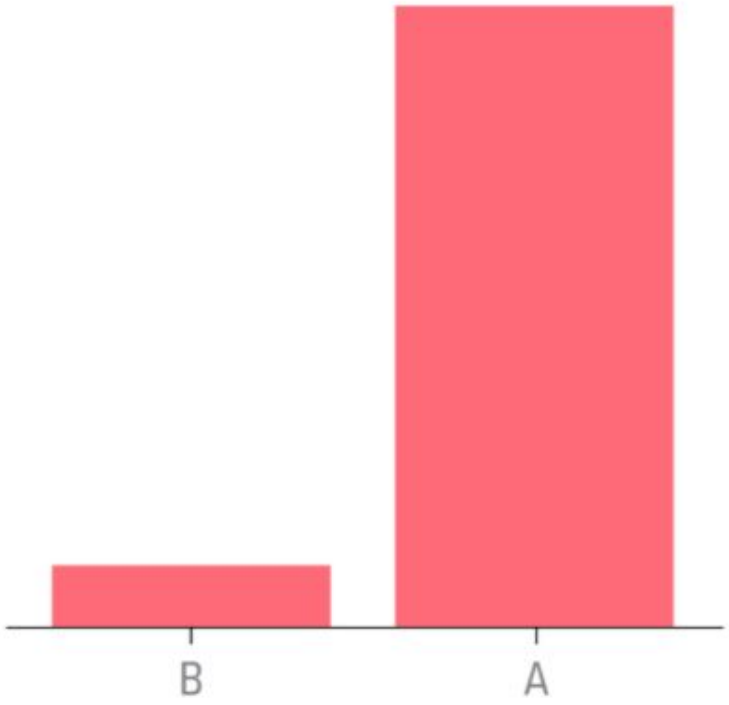


The value of A is how many times as large as the value of B?

- 9
- 8
- 10
- 5

Quiz: Decode classics



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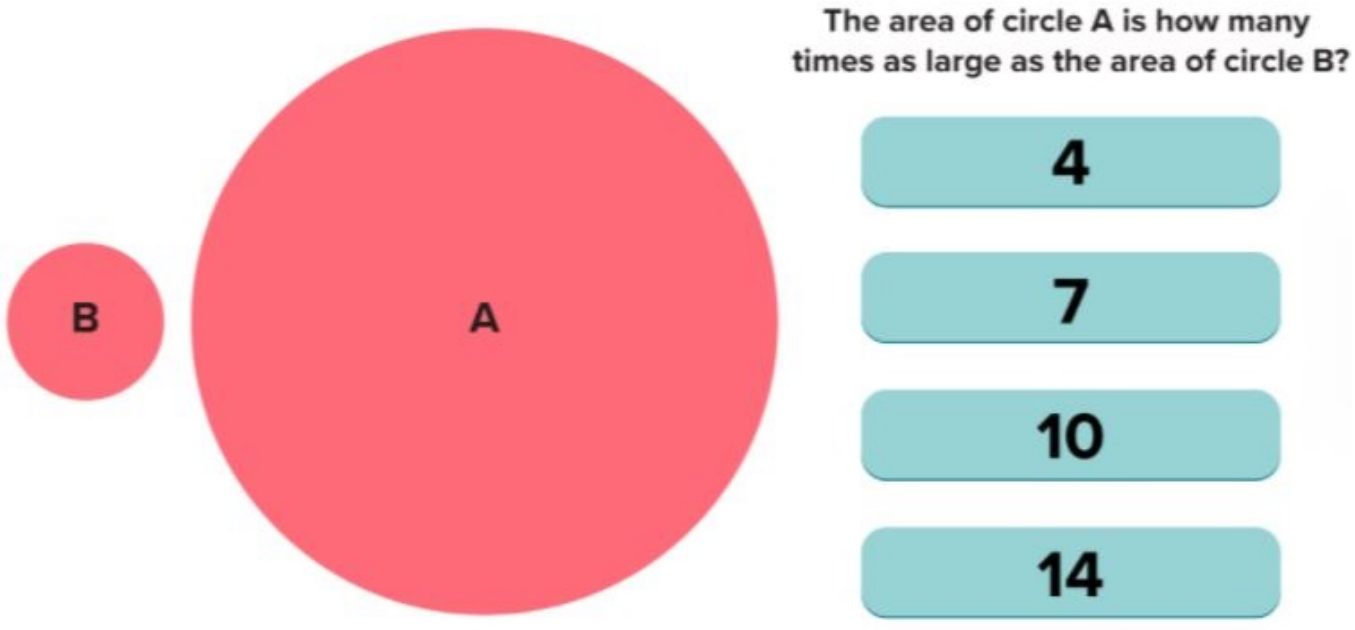

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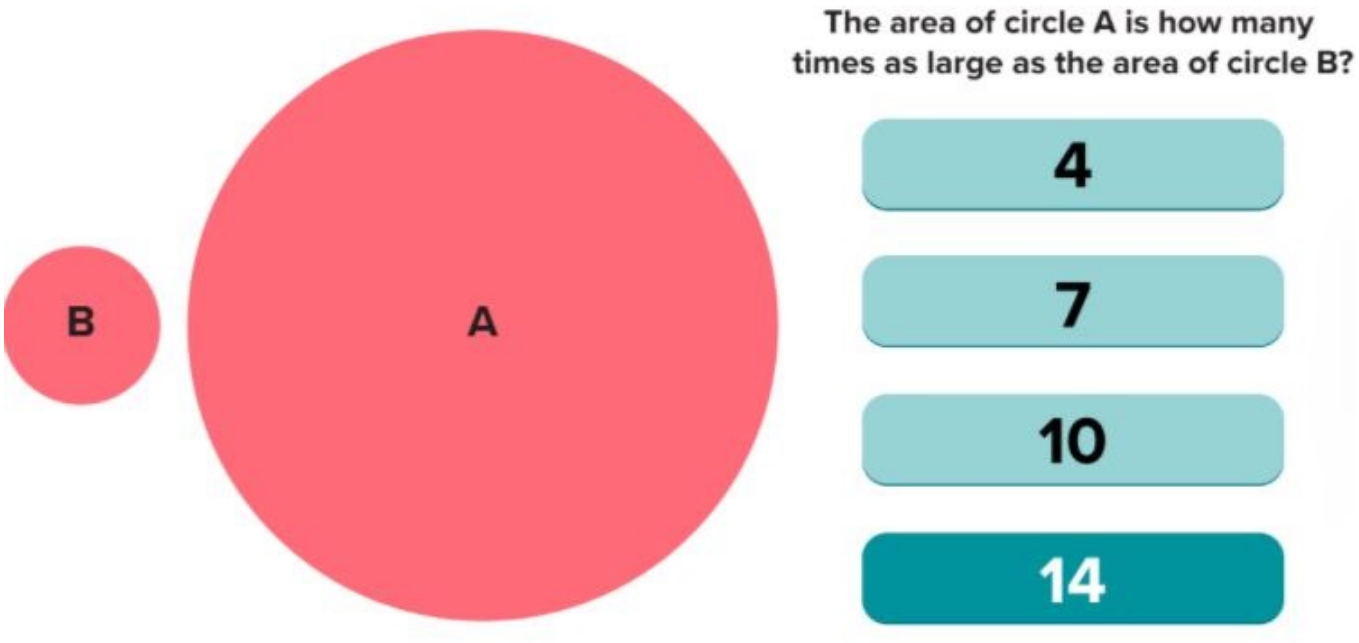

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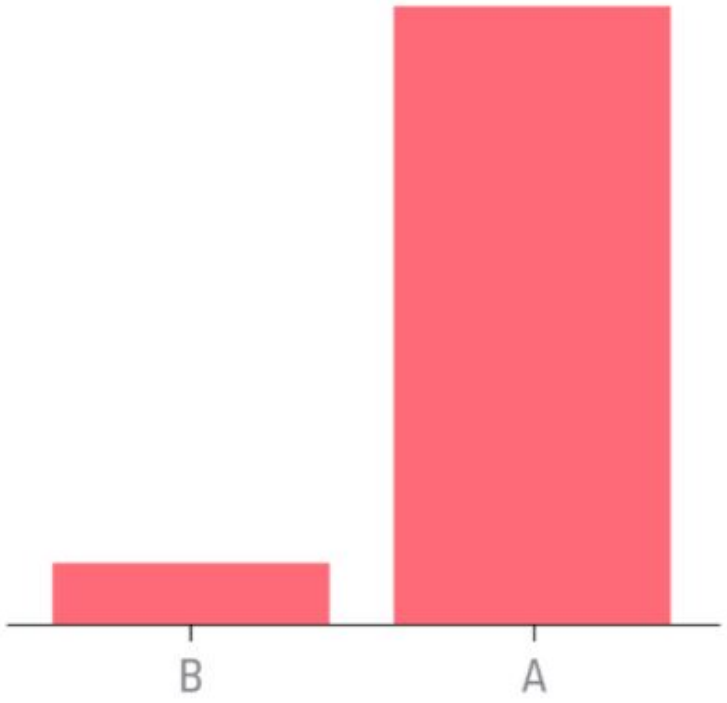

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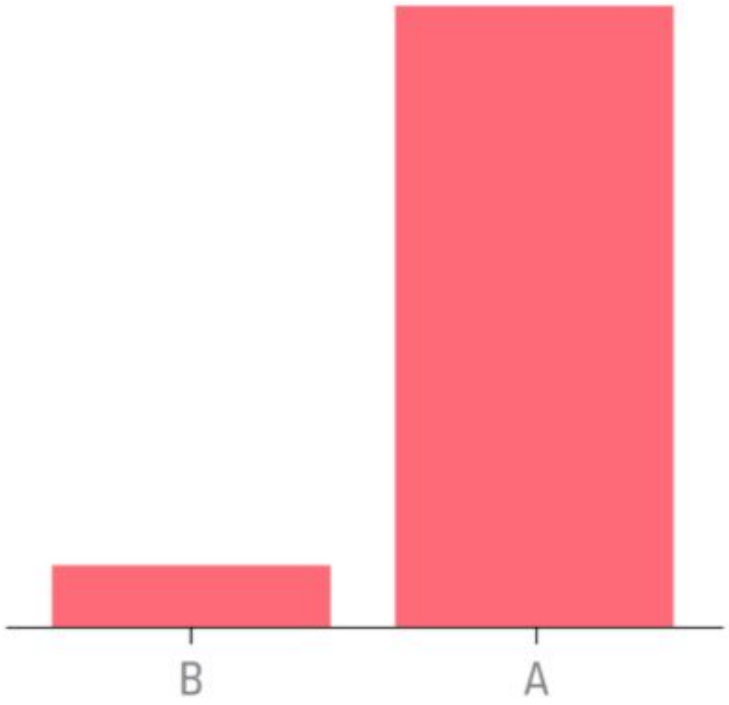

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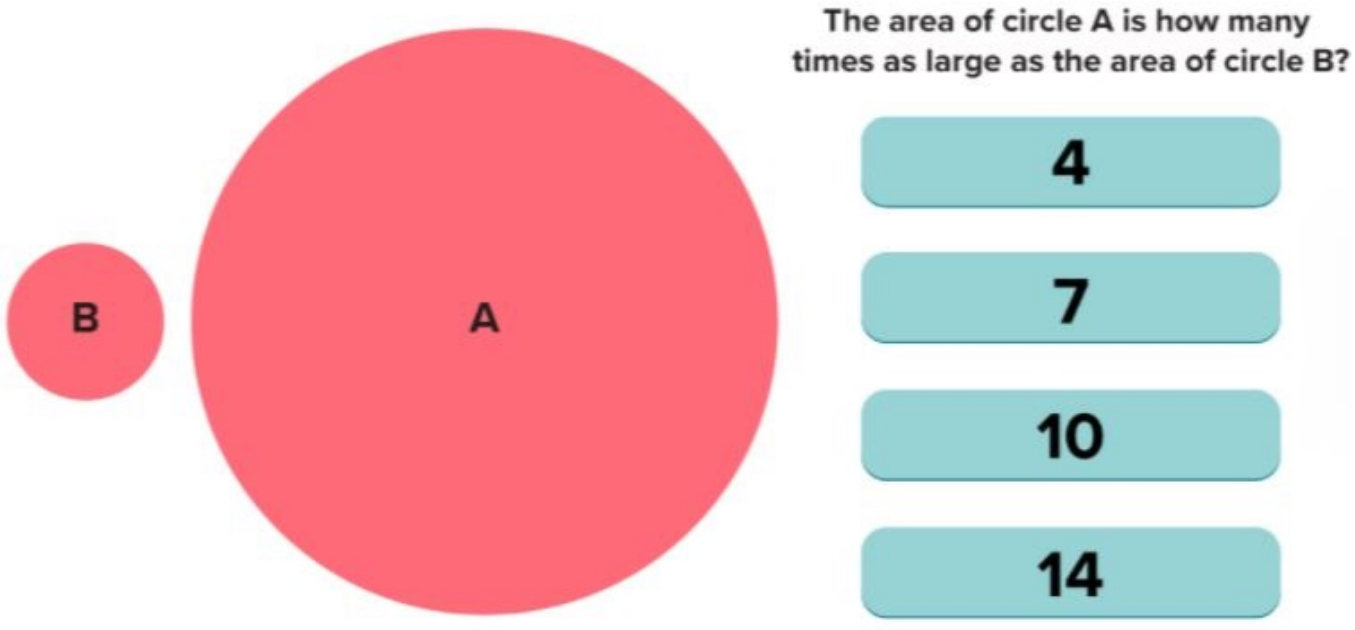

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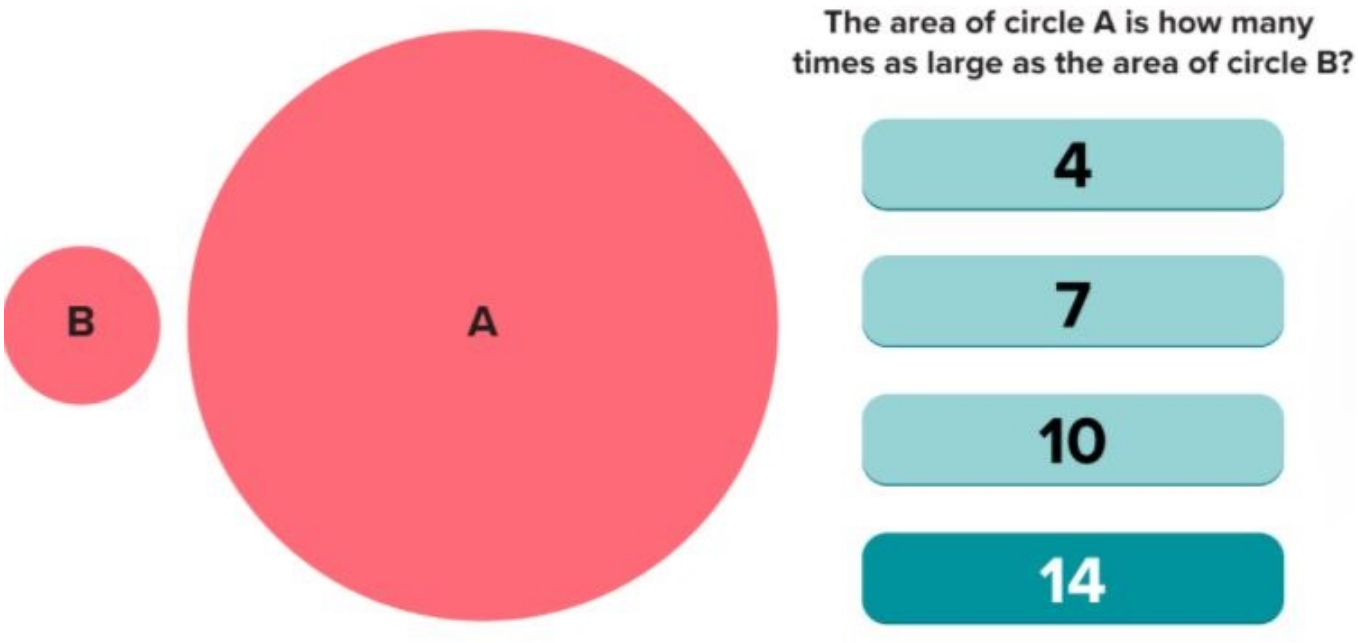
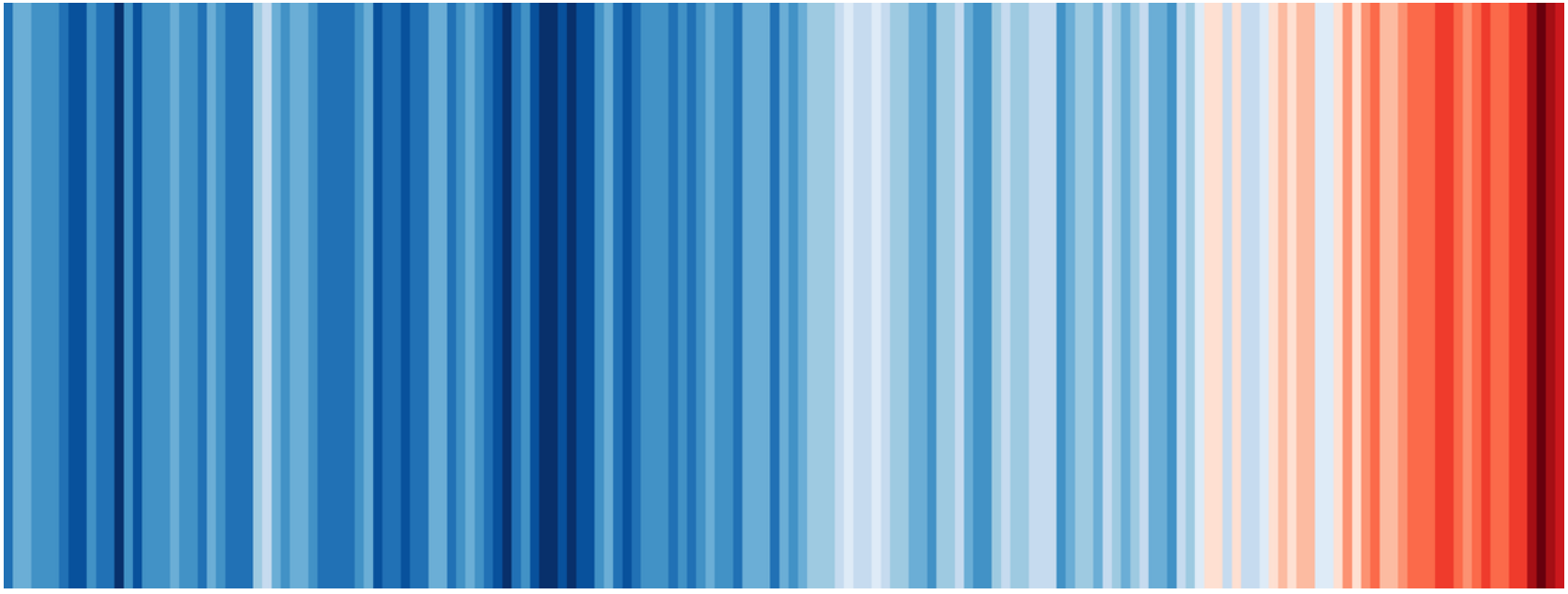


[Good?] Practices & Takeaways

[- TAKEAWAYS -]

- KISS: **K**eep **I**t **S**imple **S**tupid!

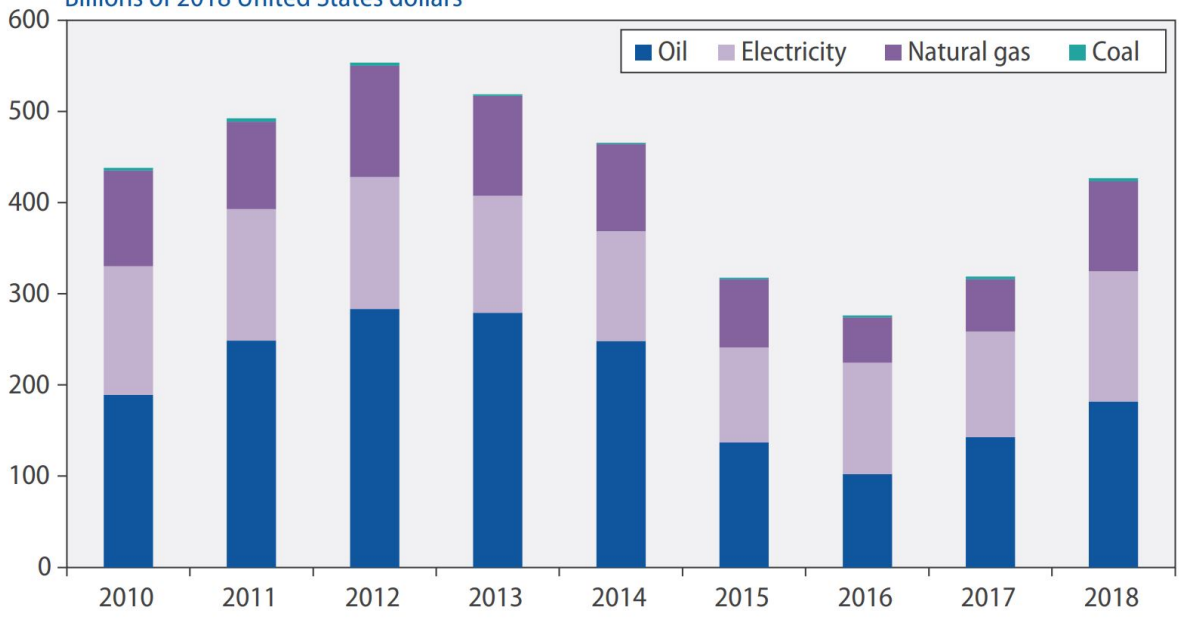


Ed Hawkins

[- TAKEAWAYS -]

- Facilitate comparisons

Figure II.9
Global subsidies for fossil-fuel consumption

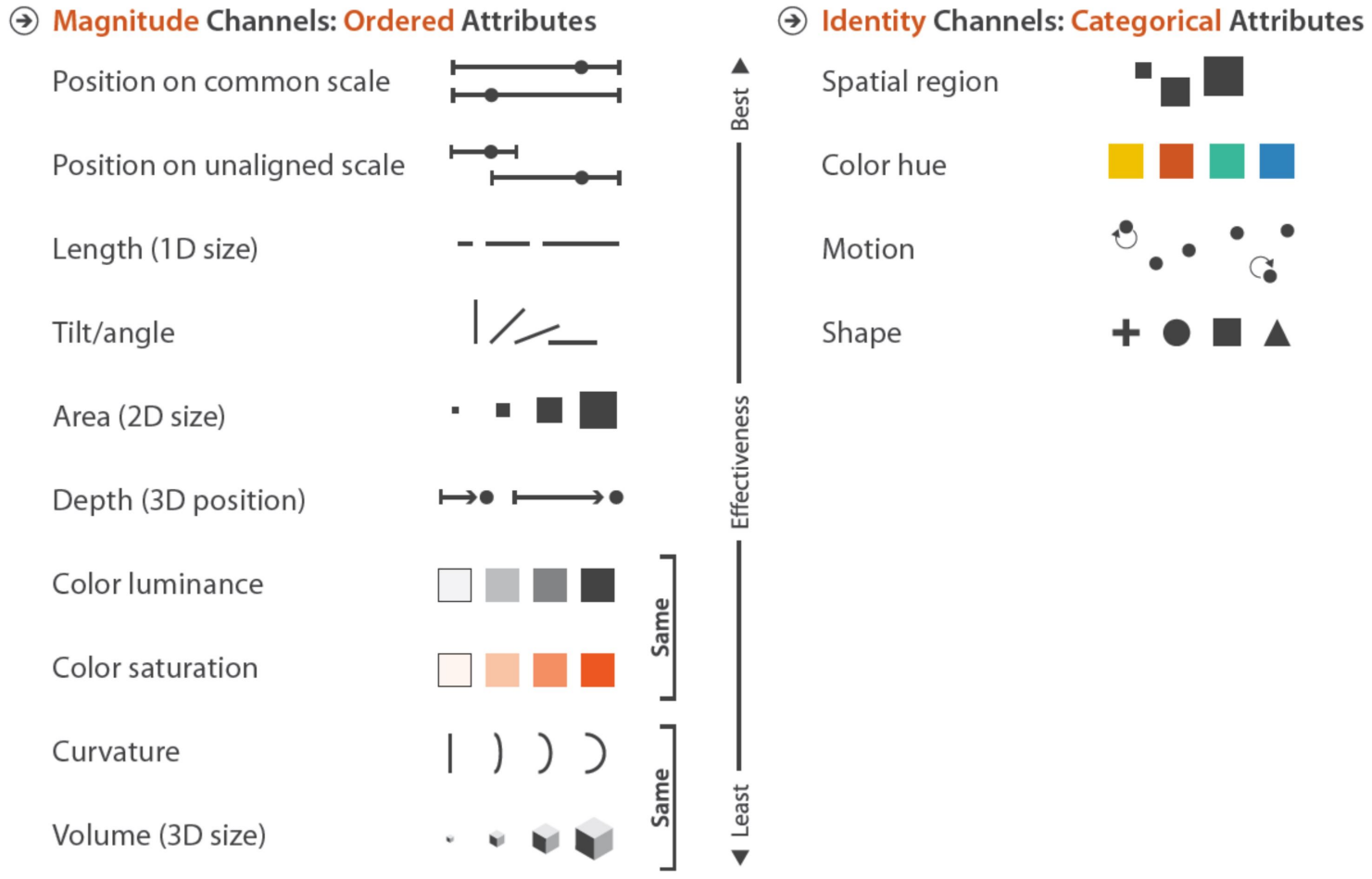


Source: UN DESA, based on data from the IEA fossil fuel subsidies database.

↪ Can you see the evolution of electricity?

[- Takeaways -]

- Not all graphics are born equal



Source: Munzner (2014)

[- TAKEAWAYS -]

- Tables can be graphics

Goal	Target	Indicator	esCode	SeriesDescription
3	3.1	3.1.1	_STA_MI	Maternal mortality ratio

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Algeria	161	155	148	145	134	127	108.6	119	117	117	115	116	116	105.8	114	114	113	112
Angola	827	766	690	628	574	519	473	239.2	395	359	326	300	281	269	258	251	146.3	241
Antigua and Barbuda	71.95	72	43	71.5	70.5	69.95	72.95	74	75	72.5	72	43	72	71.5	71	71.5	43	71
Argentina	82.55	82.7	81.95	81.85	80.05	79.05	78.2	77.7	73.9	76.95	73	72.55	72.6	70.5	70.8	70.3	69.2	66.45
Armenia	69.9	70.2	68.9	68.6	67.75	66.4	67.85	65.95	67.95	66	65.75	65	65	63	63.5	28	62.9	26
Australia	53.15	52.65	52.65	52.65	52.15	52.2	52.15	52.1	52.05	52.05	52.05	52.55	52.6	52.65	52.85	52.85	51.5	51.35
Bahamas	87	76	88.5	89	88	77	88.5	88	88	78	88.5	88.5	78	88	88.45	86	85.5	70
Bahrain	62.35	58.25	61.3	59.4	59.35	58.25	60.75	56.7	57.75	59.2	58.65	57.3	58.9	58.4	57.4	57.45	57.35	56.95
Barbados	74	48	73.5	72.5	71.5	71	70.5	70	69.5	38	36	67.5	66.45	65.3	65.4	65	64.55	27
Belarus	60.95	59.45	58.95	57.45	56.45	55.5	54.45	53.45	52.95	52.95	52.45	52.4	52	51.4	51.4	3	3	2
Belize	89	88	82	80	75	70	80.4	75.85	76.95	75.25	74	74.1	50	71.1	46	66	67.9	65
Botswana	180.25	181.5	187.25	187.05	180.65	166.5	160.15	151.8	150.7	144.25	139.05	137.9	134.9	131.95	129.75	127.85	125.35	121.9
Brazil	83.8	83.15	83.75	84.2	84.8	84.8	84.5	84.8	84.4	83.95	81.95	80	79.5	80.05	80.55	81.05	80.55	79.55
Brunei Darussalam	63.6	63.85	64.2	64.7	64.7	64.3	63.8	63.45	63.35	63.4	63.9	63.8	64.4	63.85	64.45	65	65.5	65.4
Bulgaria	59.4	58.45	58.1	57.6	57.7	57.2	56.7	56.3	56.3	55.8	55.75	12	11	54.85	55.35	54.9	10	10
Burkina Faso	516	501	486	254.4	454	437	237.75	410	401	393	225.45	377	369	362	353	211.4	331	320

[- Takeaways -]

- Tables can be graphics

Goal	Target	Indicator	esCode	SeriesDescription
3	3.1	3.1.1	_STA_MI	Maternal mortality ratio

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
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Angola	827	766	690	628	574	519	473	239.2	395	359	326	300	281	269	258	251	146.3	241
Antigua and Barbuda	71.95	72	43	71.5	70.5	69.95	72.95	74	75	72.5	72	43	72	71.5	71	71.5	43	71
Argentina	82.55	82.7	81.95	81.85	80.05	79.05	78.2	77.7	73.9	76.95	73	72.55	72.6	70.5	70.8	70.3	69.2	66.45
Armenia	69.9	70.2	68.9	68.6	67.75	66.4	67.85	65.95	67.95	66	65.75	65	65	63	63.5	28	62.9	26
Australia	53.15	52.65	52.65	52.65	52.15	52.2	52.15	52.1	52.05	52.05	52.05	52.55	52.6	52.65	52.85	52.85	51.5	51.35
Bahamas	87	76	88.5	89	88	77	88.5	88	88	78	88.5	88.5	78	88	88.45	86	85.5	70
Bahrain	62.35	58.25	61.3	59.4	59.35	58.25	60.75	56.7	57.75	59.2	58.65	57.3	58.9	58.4	57.4	57.45	57.35	56.95
Barbados	74	48	73.5	72.5	71.5	71	70.5	70	69.5	38	36	67.5	66.45	65.3	65.4	65	64.55	27
Belarus	60.95	59.45	58.95	57.45	56.45	55.5	54.45	53.45	52.95	52.95	52.45	52.4	52	51.4	51.4	3	3	2
Belize	89	88	82	80	75	70	80.4	75.85	76.95	75.25	74	74.1	50	71.1	46	66	67.9	65
Botswana	180.25	181.5	187.25	187.05	180.65	166.5	160.15	151.8	150.7	144.25	139.05	137.9	134.9	131.95	129.75	127.85	125.35	121.9
Brazil	83.8	83.15	83.75	84.2	84.8	84.8	84.5	84.8	84.4	83.95	81.95	80	79.5	80.05	80.55	81.05	80.55	79.55
Brunei Darussalam	63.6	63.85	64.2	64.7	64.7	64.3	63.8	63.45	63.35	63.4	63.9	63.8	64.4	63.85	64.45	65	65.5	65.4
Bulgaria	59.4	58.45	58.1	57.6	57.7	57.2	56.7	56.3	56.3	55.8	55.75	12	11	54.85	55.35	54.9	10	10
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Angola	827	766	690	628	574	519	473	239.2	395	359	326	300	281	269	258	251	146.3	241
Antigua and Barbuda	71.95	72	43	71.5	70.5	69.95	72.95	74	75	72.5	72	43	72	71.5	71	71.5	43	71
Argentina	82.55	82.7	81.95	81.85	80.05	79.05	78.2	77.7	73.9	76.95	73	72.55	72.6	70.5	70.8	70.3	69.2	66.45
Armenia	69.9	70.2	68.9	68.6	67.75	66.4	67.85	65.95	67.95	66	65.75	65	65	63	63.5	28	62.9	26
Australia	53.15	52.65	52.65	52.65	52.15	52.2	52.15	52.1	52.05	52.05	52.05	52.55	52.6	52.65	52.85	52.85	51.5	51.35
Bahamas	87	76	88.5	89	88	77	88.5	88	88	78	88.5	88.5	78	88	88.45	86	85.5	70
Bahrain	62.35	58.25	61.3	59.4	59.35	58.25	60.75	56.7	57.75	59.2	58.65	57.3	58.9	58.4	57.4	57.45	57.35	56.95
Barbados	74	48	73.5	72.5	71.5	71	70.5	70	69.5	38	36	67.5	66.45	65.3	65.4	65	64.55	27
Belarus	60.95	59.45	58.95	57.45	56.45	55.5	54.45	53.45	52.95	52.95	52.45	52.4	52	51.4	51.4	3	3	2
Belize	89	88	82	80	75	70	80.4	75.85	76.95	75.25	74	74.1	50	71.1	46	66	67.9	65
Botswana	180.25	181.5	187.25	187.05	180.65	166.5	160.15	151.8	150.7	144.25	139.05	137.9	134.9	131.95	129.75	127.85	125.35	121.9
Brazil	83.8	83.15	83.75	84.2	84.8	84.8	84.5	84.8	84.4	83.95	81.95	80	79.5	80.05	80.55	81.05	80.55	79.55
Brunei Darussalam	63.6	63.85	64.2	64.7	64.7	64.3	63.8	63.45	63.35	63.4	63.9	63.8	64.4	63.85	64.45	65	65.5	65.4
Bulgaria	59.4	58.45	58.1	57.6	57.7	57.2	56.7	56.3	56.3	55.8	55.75	12	11	54.85	55.35	54.9	10	10
Burkina Faso	516	501	486	254.4	454	437	237.75	410	401	393	225.45	377	369	362	353	211.4	331	320
Burundi	517.6	956	925	890	844	422.9	785	756	733	698	362.65	635	608	591	576	568	558	316.55

[- Takeaways -]

- Tables can be graphics

Goal	Target	Indicator	esCode	SeriesDescription
3	3.1	3.1.1	_STA_MI	Maternal mortality ratio

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Algeria	161	155	148	145	134	127	108.6	119	117	117	115	116	116	105.8	114	114	113	112
Angola	827	766	690	628	574	519	473	239.2	395	359	326	300	281	269	258	251	146.3	241
Antigua and Barbuda	71.95	72	43	71.5	70.5	69.95	72.95	74	75	72.5	72	43	72	71.5	71	71.5	43	71
Argentina	82.55	82.7	81.95	81.85	80.05	79.05	78.2	77.7	73.9	76.95	73	72.55	72.6	70.5	70.8	70.3	69.2	66.45
Armenia	69.9	70.2	68.9	68.6	67.75	66.4	67.85	65.95	67.95	66	65.75	65	65	63	63.5	28	62.9	26
Australia	53.15	52.65	52.65	52.65	52.15	52.2	52.15	52.1	52.05	52.05	52.05	52.55	52.6	52.65	52.85	52.85	51.5	51.35
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Belarus	60.95	59.45	58.95	57.45	56.45	55.5	54.45	53.45	52.95	52.95	52.45	52.4	52	51.4	51.4	3	3	2
Belize	89	88	82	80	75	70	80.4	75.85	76.95	75.25	74	74.1	50	71.1	46	66	67.9	65
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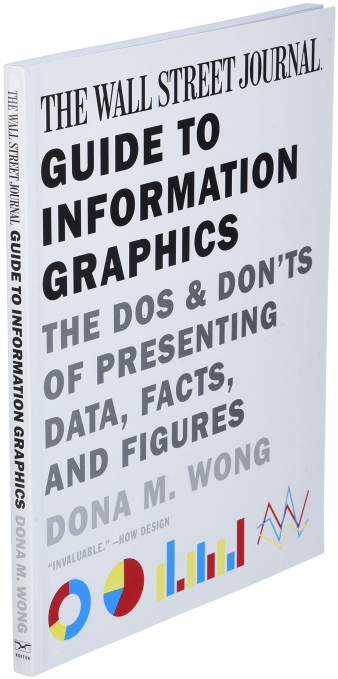
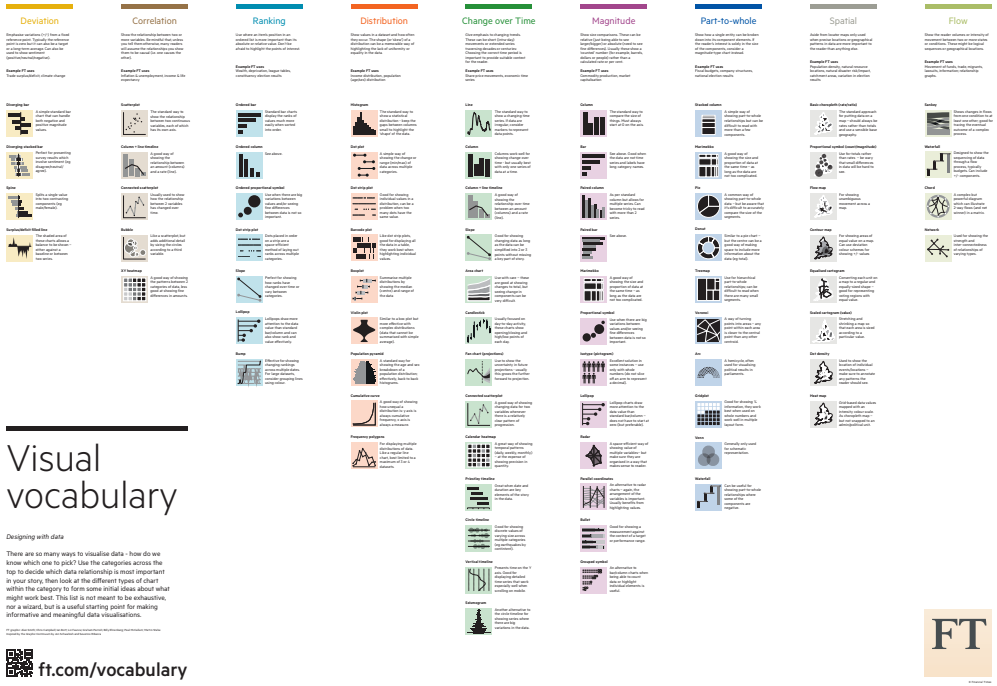
Burundi	517.6	956	925	890	844	422.9	785	756	733	698	362.65	635	608	591	576	568	558	316.55

[- Takeaways -]

- Good practices & Guidance





Wong (2013) & Financial Times Visual Vocabulary

[- TAKEAWAYS -]

- Be careful of "*visual Lies*"

How [Not] To Lie with Graphics
A practitioner guide

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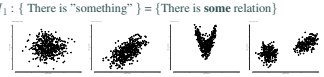
Data visualization is one of the key elements to inform a wide range of statistics consumers, from medias to politicians and obviously, the general public. In this field of communication, NSOs who are in competition with other public and private communication channels, must differentiate themselves by the quality, accuracy and efficiency of the information they release, in particular though statistically-based graphics and graphical interfaces. But as for any statistics, data visualization should be designed to help the understanding of complex phenomena and facilitate fair comparisons. They must act as visual statistical tests and reveal unambiguous patterns and data-based "truths". This paper propose to highlighting commonly encountered "visual lies" - defined as situations where what is represented or perceived is not what is not present in the data set - that can alter the perception of the underlying statistical values. Our approach is based on 10 rules that can be used to drastically change the understanding of the information represented from any given data set. We preach here counterexamples to reveal the best practices, in an attempt to highlight the difficulties of designing trustworthy data visualizations.

Data visualization as visual test

Following the work of Buja et al. (2009), we consider data visualization as a visual statistical test aimed at detecting structural information in a given data set. More precisely, the null hypothesis tested by looking ant a graphic is:

H_0 : {There is "nothing" } = {**No** relation}
vs
H_1 : { There is "something" } = {There is **some** relation}



Visual detection of patterns and groups (no rejection, rejection, rejection, rejection)

When the data visualization is well designed to unambiguously reveal the intrinsic properties of the data, this visual test would help the practitioner to choose a specific hypothesis and statistical test.
Bad graphic design may bias the visual test!

1 Rule #1: Modify Axes

One of the most common problem is the truncation of the vertical axe in bar charts, inducing an exaggerating effect.

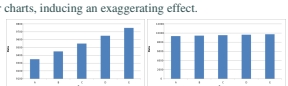


Figure 1: Truncation exaggerating effect (left), small absolute variation(right)

Interestingly Correll et al. (2019) experimentally showed that this exaggerating effect is also found in line charts (Figure 1b). This poses the question of when it is appropriate to start line chart at the origin, in particular when the origin is out of the range of the data set (ex: Earth temperature in Fahrenheit).

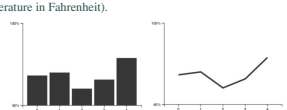


Figure 1b: Truncation serves to exaggerate effect sizes in both line and bar charts.

Rule #2: Modify the Framing Design

Framing a graphic in a wide or tall format can also affect the perception of a phenomena, typically for time series.

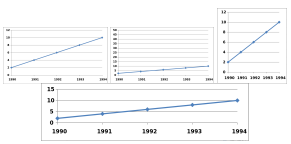


Figure 2: The perception of a time series increases is affected by the framing

But the framing, and space left around data points can subtly affect our perception of correlation Cleveland et al. (1982).

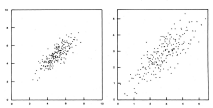


Figure 2b: The correlation between Xs and Ys is the same in the two data sets.

Rule #3: Use Double Axes

Plotting two times series with different units on two axis (left and right) is a tempting practice that results in a spurious visual correlation. This has been well illustrated in Muth (2018) (see also Vigen (2015)).

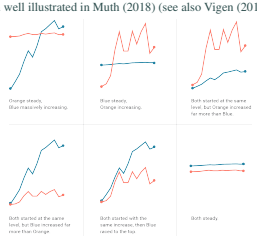


Figure 3: Playing with left and right axes (source: Muth (2018))

Rule #4: Select Your Scope

Cherry-picking the data through an (in)appropriate choice of the range in any time series, is alsovery misleading. This is particularly true for time serie and scatter plots but can also change the representation of maps when only a part of the world is selected as illustrated in Bahoken and Lambert (2020).

Figure 4: A growing exchange rate (left) "picked" within a declining period (right)

Rule #5: Use Several Pie Charts

Pie charts are among the most popular and most used graphics although they are not suited for fair comparisons (Cleveland and McGill (1984))

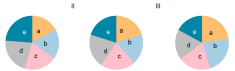


Figure 5: Comparing pie charts can be a difficult visual test and should be avoided

Rule #6: Use Areas

Our perception of areas is very bad but area-based comparisons still flourishing in publication, in particular in statistical maps where buble maps are one of the most popular encoding (see rule #10)

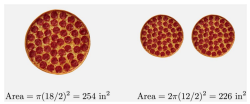


Figure 6: A simple exercise show that people think 2 pizzas are bigger than one

Rule #7: Use unaligned bars

Stacked bars are a good example of unaligned visual variables that are difficult to compare. In the example below, it is difficult to test whether the red category is steadily increasing or not.

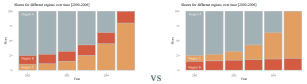


Figure 7: In simple situations, ordering the categories may solve the problem

Rule #8: Cross The Lines

This is probably the most challenging as plotting several crossing lines is likely to produce a graphic where not clear pattern emerges as illustrated by Schwabish (2014) Alternative design using small multiples graphics, where only one line is highlighted while others are greyed for global reference, helps displaying clear information.

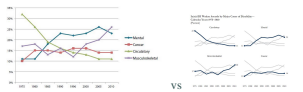


Figure 8: In simple situations, ordering the categories may solve the problem

Rule #9: Use Radar Plots

Comparing individuals in many dimension is challenging, even when the sample in small. Using a data set of 4 individuals Bontemps (2017) illustrated that the area representing the overall performance is highly dependant of the ordering of the axes. This undesirable feature is a major undocumented drawback of radar plots.

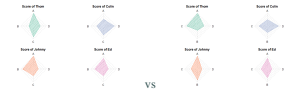


Figure 9: The order of the axes changes the areas representing global performance

Rule #10: Use Maps

Maps are probably the most complex graphical objects and are prone to many issues as documented by Monmonier (2018) and others. Statistical maps use all the visual encoding described here, and thus concentrate all the problems hindering fair visual tests.

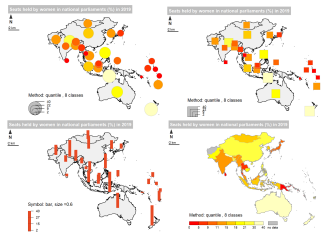


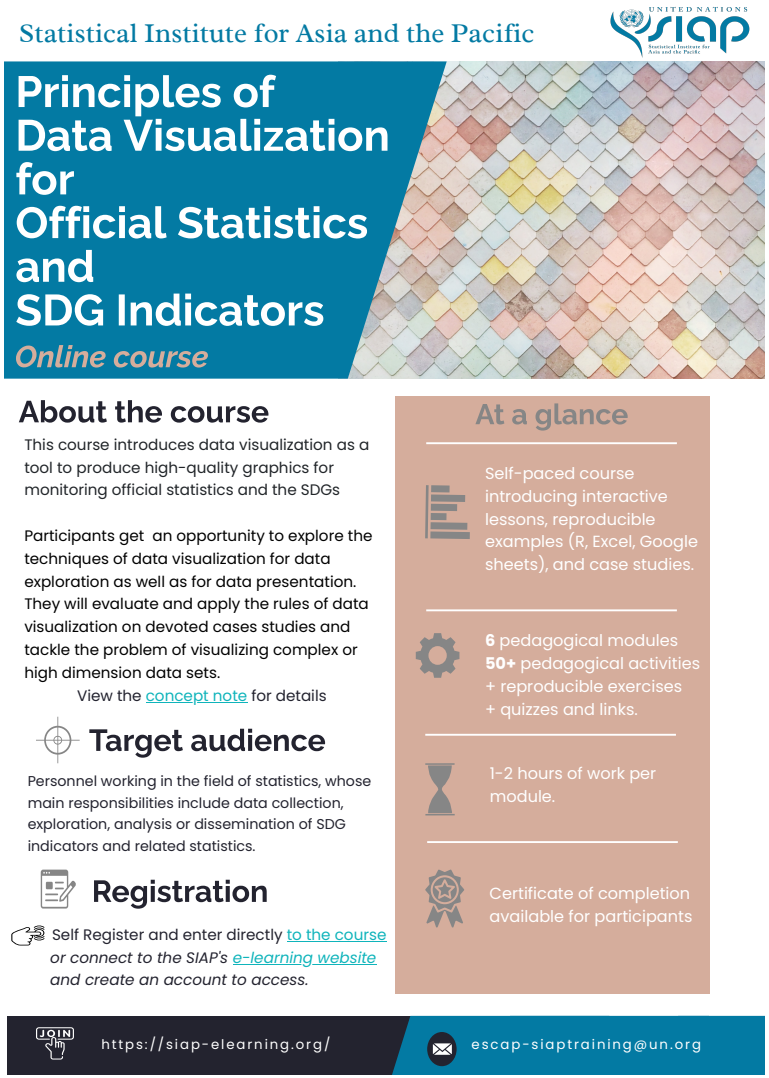
Figure 10: 4 ways of representing statistical information on a map, and many issues!

Conclusion

Since the publication of Bertin (1977), a lot has been learned on the design of statistical information and on the use of data visualization as a visual language, with a clear semiology. Many publications have highlighted good practices for quite a long time (see the "old" Brinton (1914)), but despite this abundant literature, very few articles have illustrated the dangers of easy-to-produce and popular graphics. We should not let these useful visual tests be biased by software default settings, misconceived designs or uninformed statisticians.

[- TAKEAWAYS -]

- Train with SIAP!



Self-Paced course SIAP e-learning platform

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