

Creating effective figures and tables

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@kwbroman

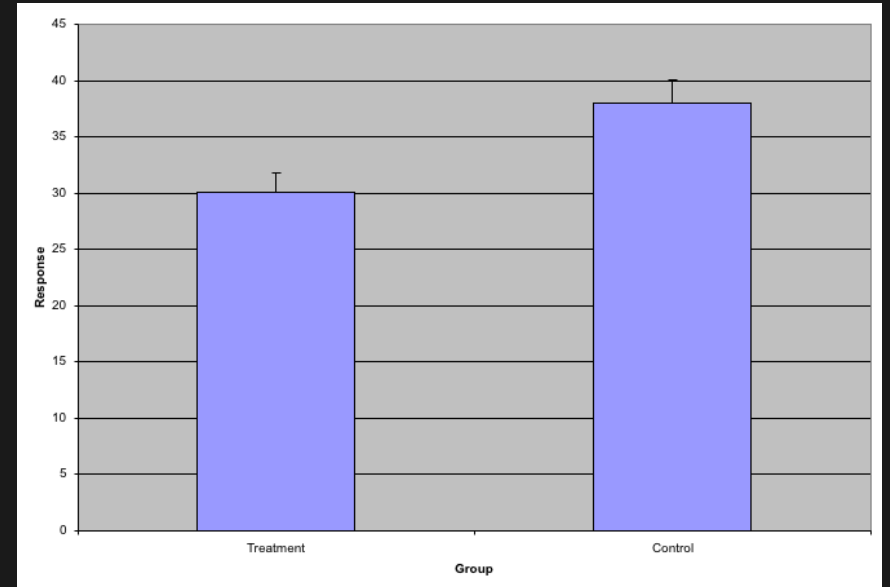
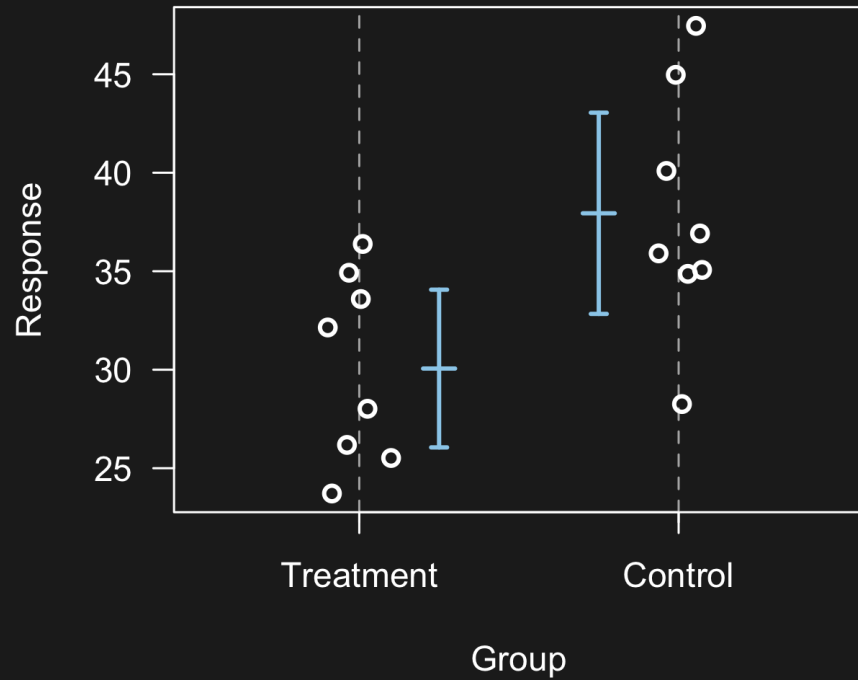
Slides: tinyurl.com/graphs2017



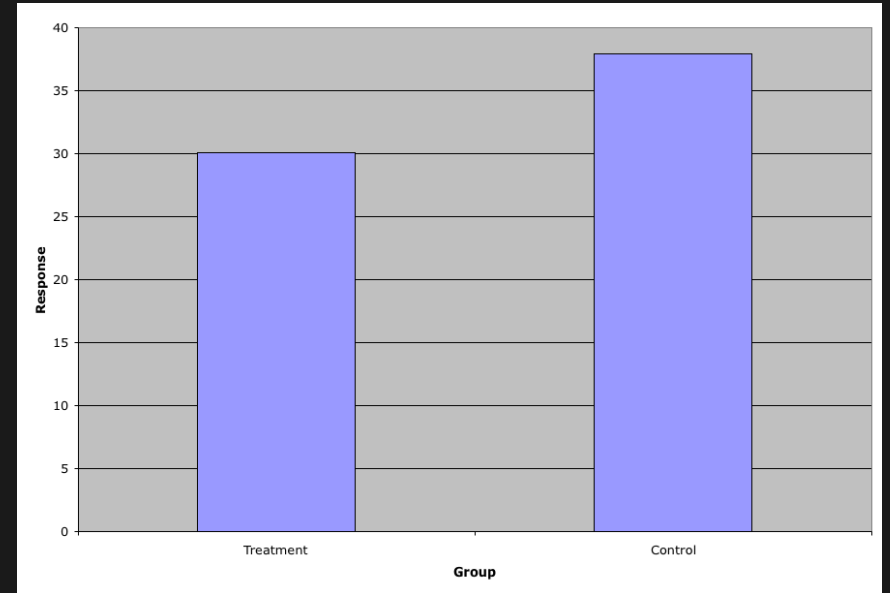
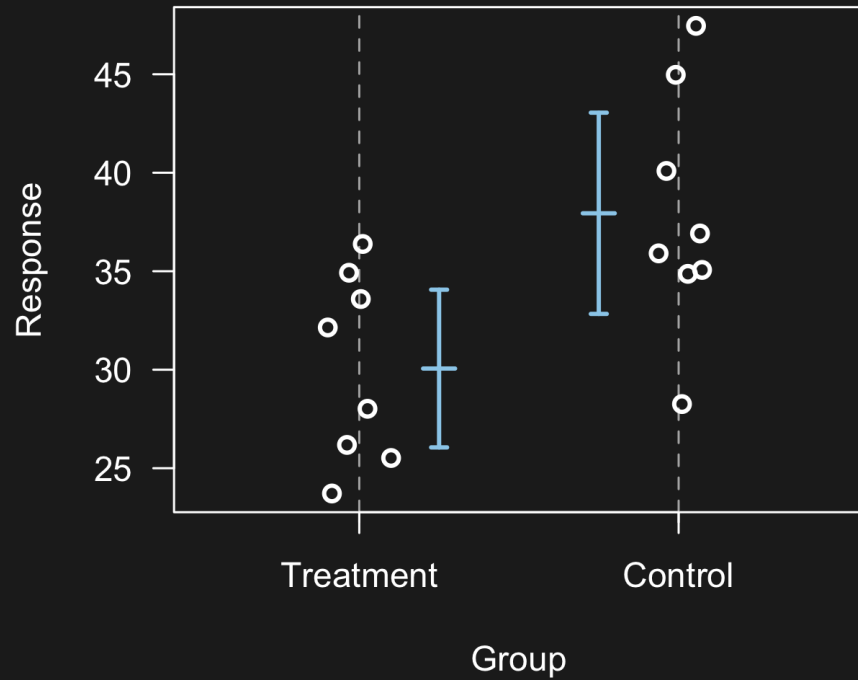
Displaying data well

- Be accurate and clear.
- Let the data speak.
 - Show as much information as possible, taking care not to obscure the message.
- Science not sales.
 - Avoid unnecessary frills (esp. gratuitous 3d).
- In tables, every digit should be meaningful. Don't drop ending 0's.

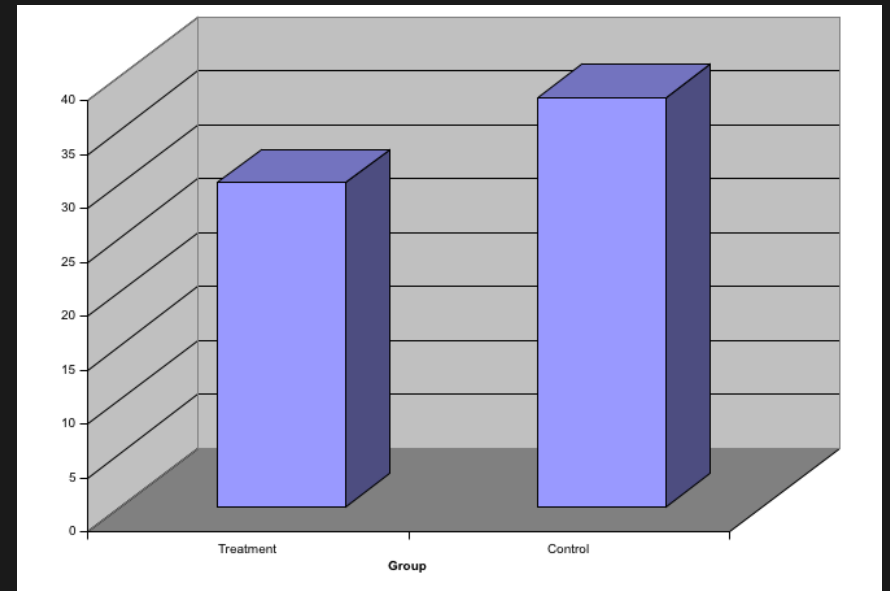
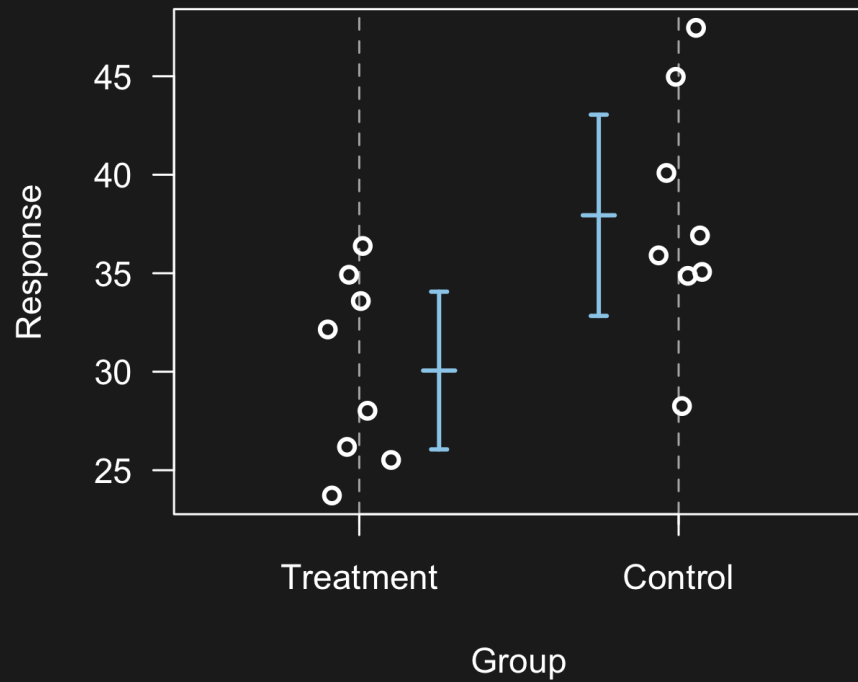
Show the data



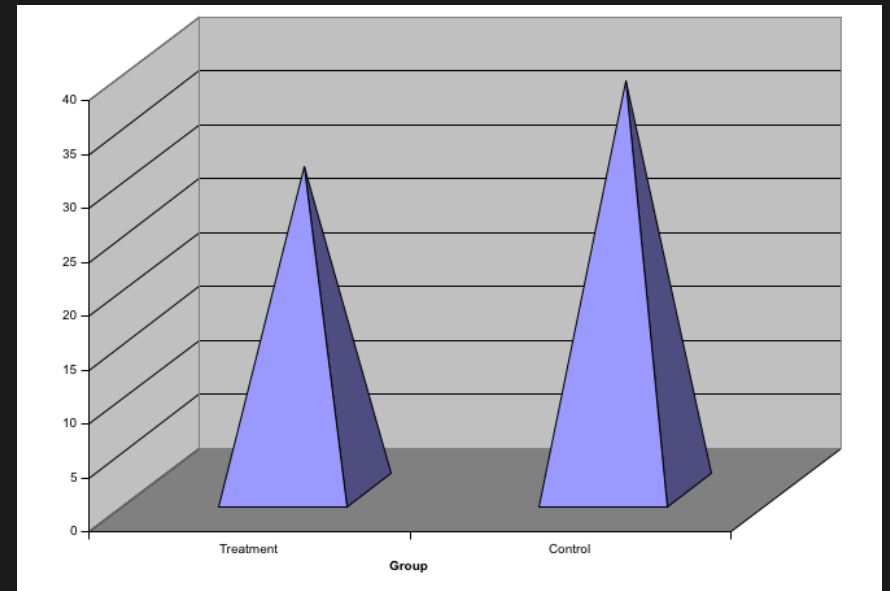
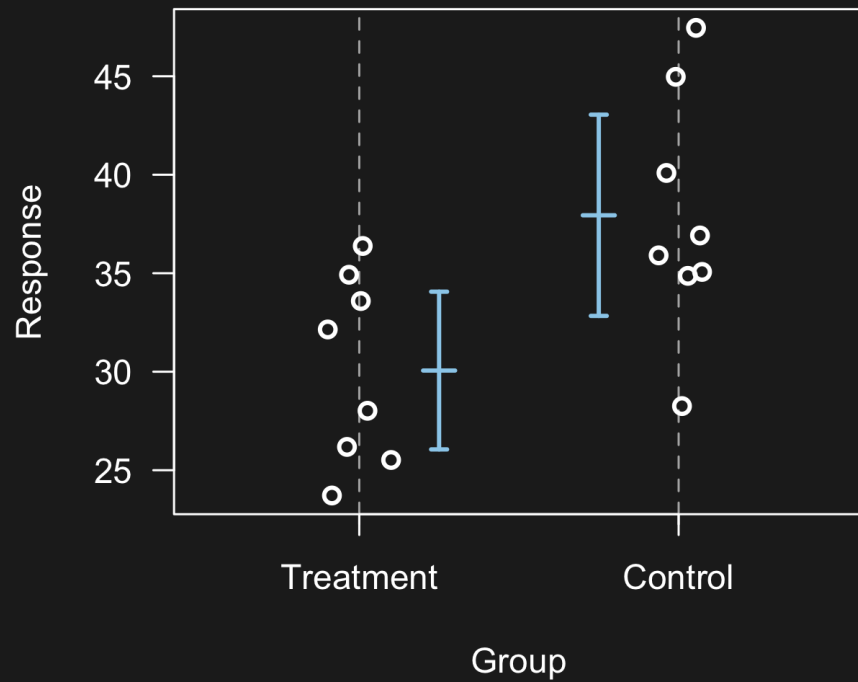
Show the data



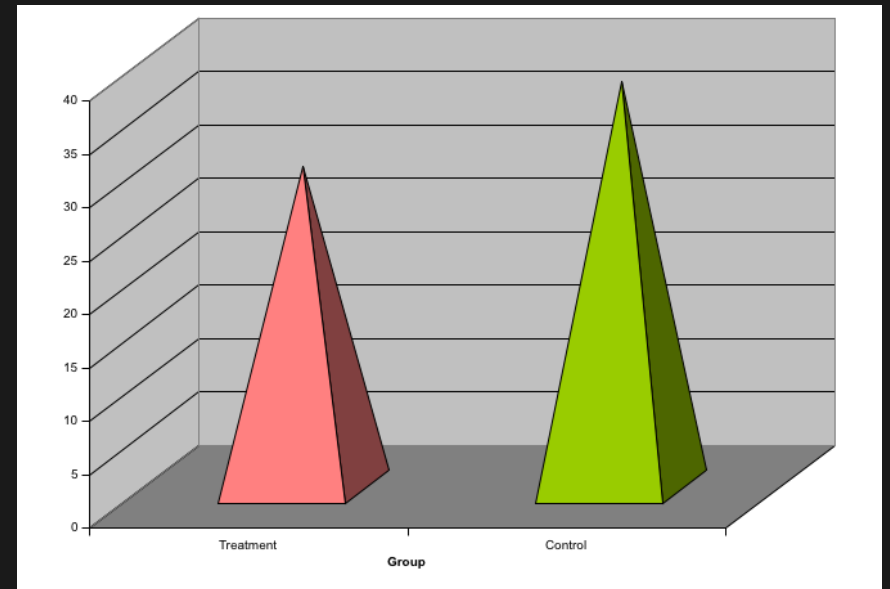
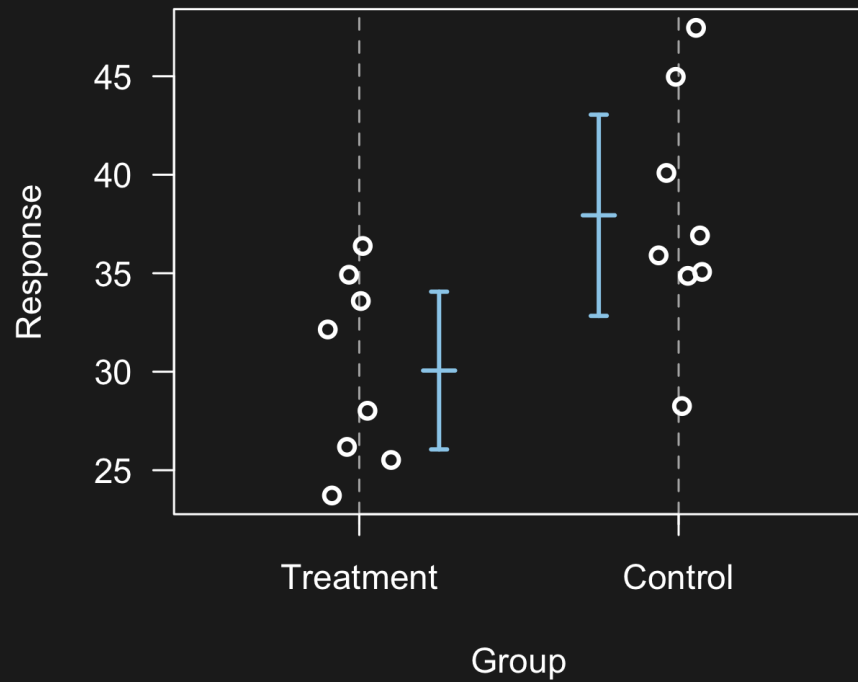
Show the data



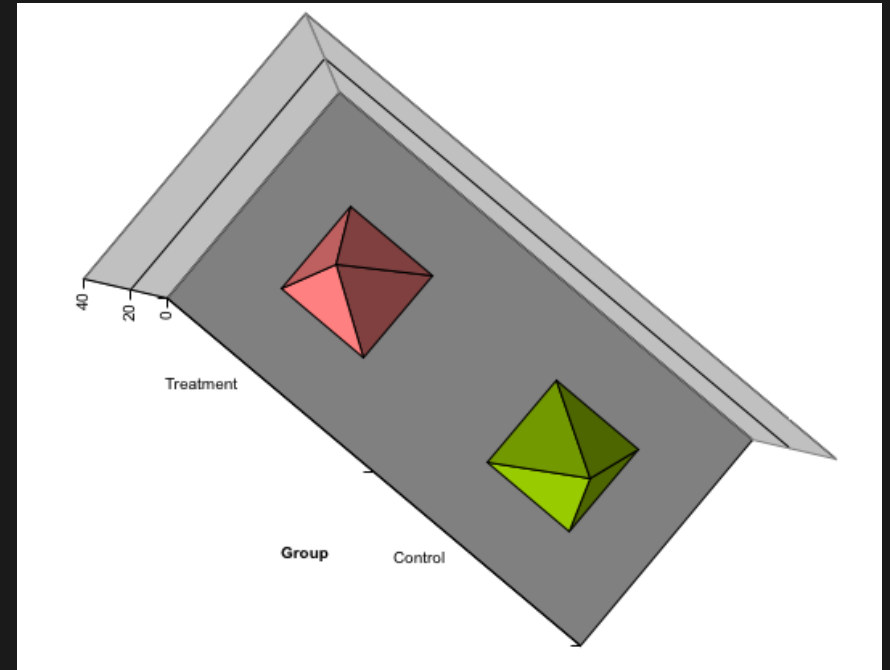
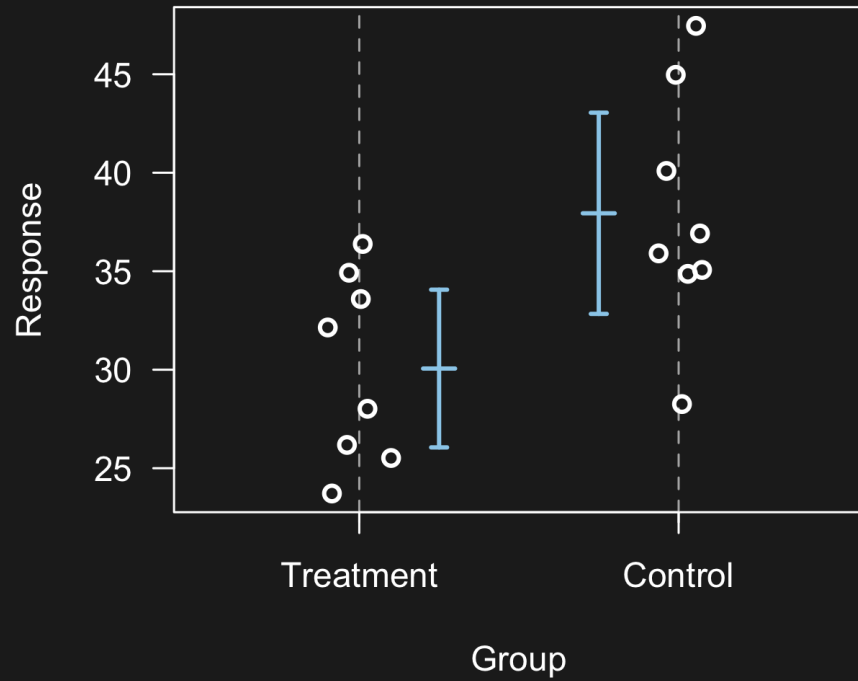
Show the data



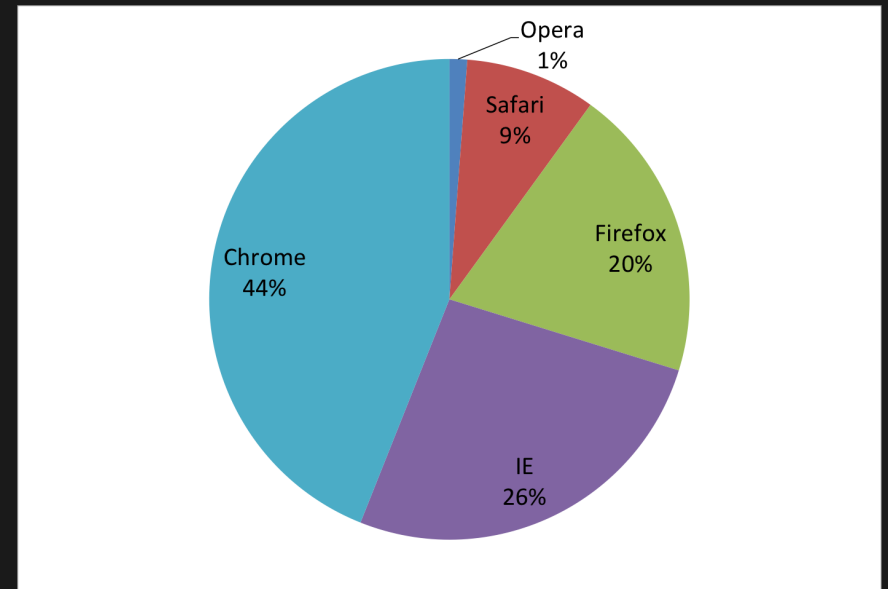
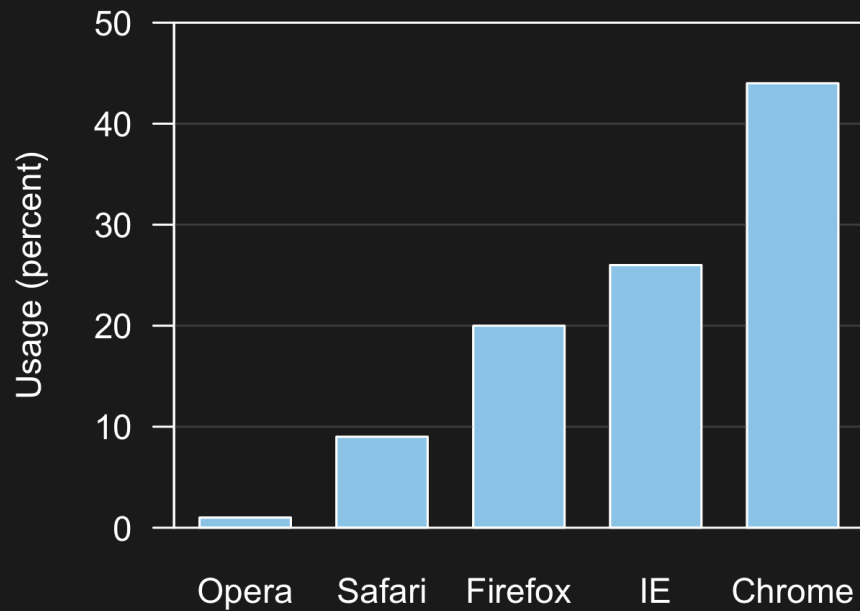
Show the data



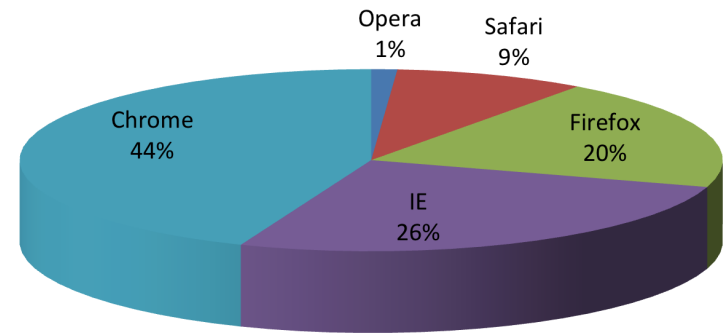
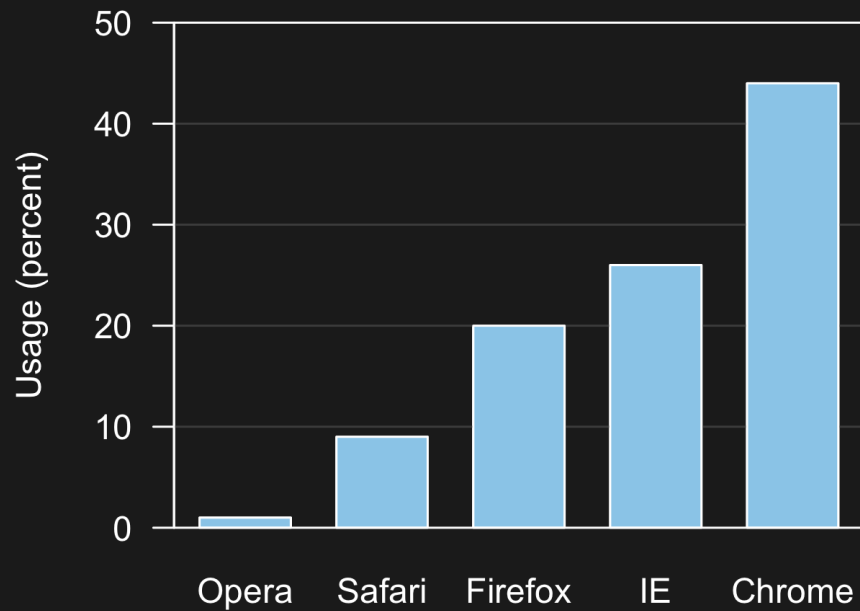
Show the data



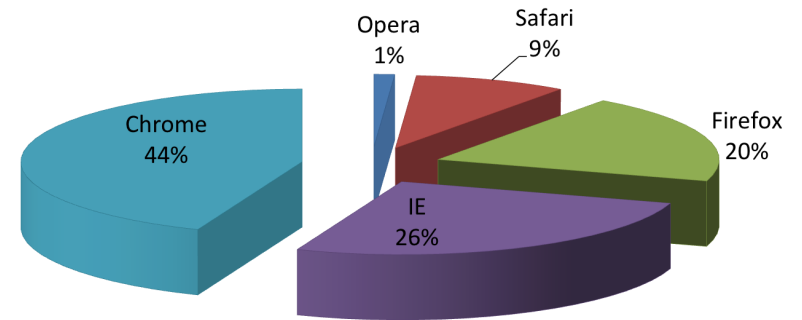
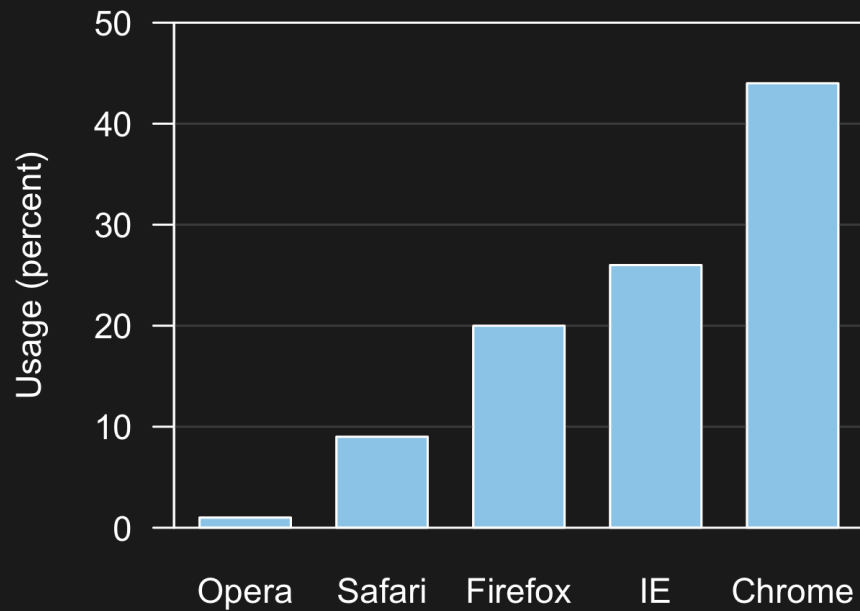
Avoid pie charts



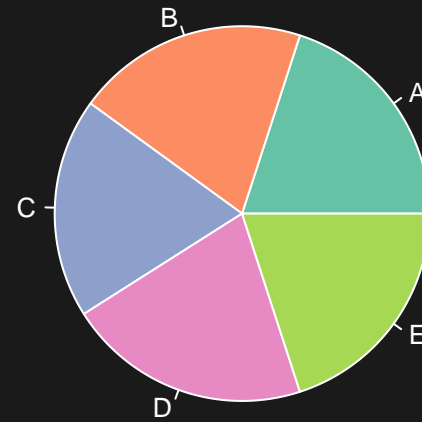
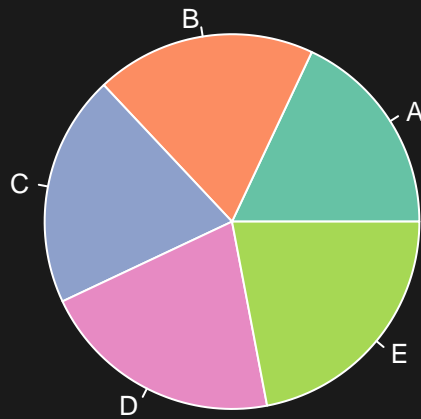
Avoid pie charts



Avoid pie charts

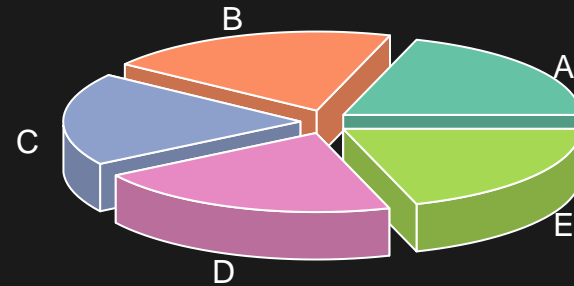
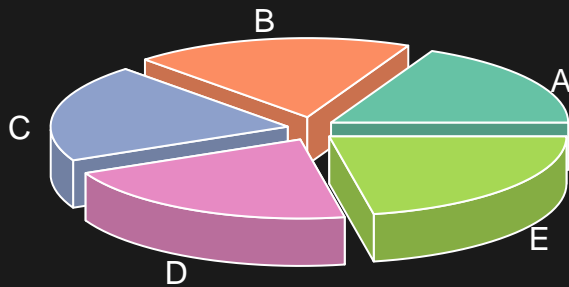


Avoid pie charts



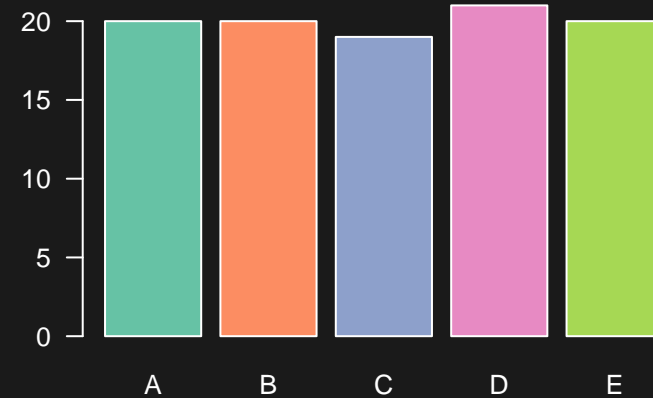
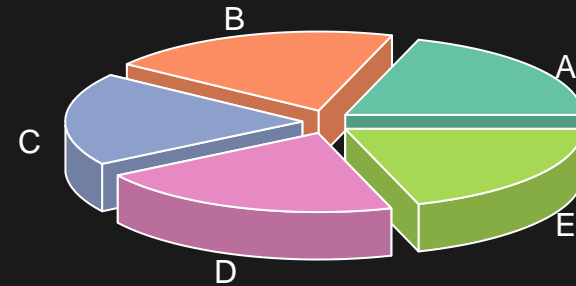
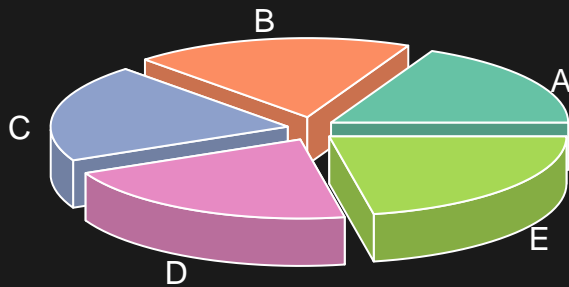
via @MonaChalabi (bit.ly/pie_vs_barchart)

Avoid pie charts



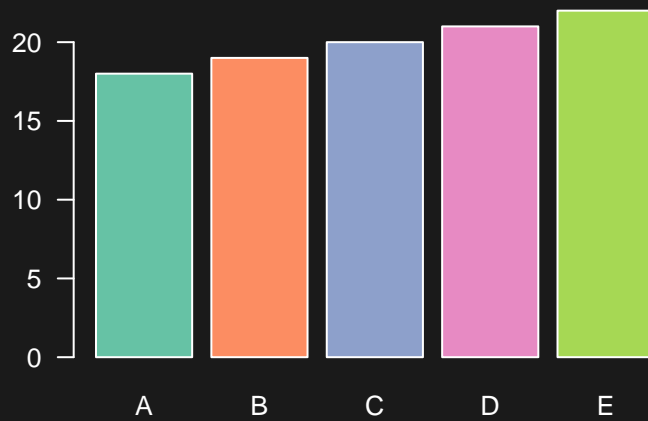
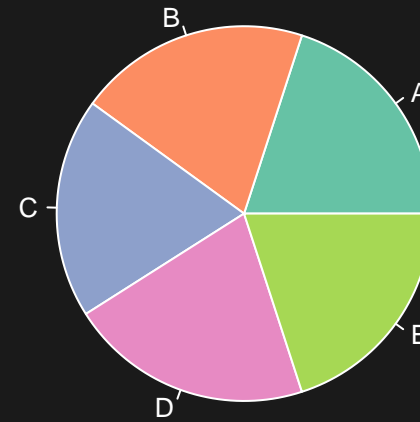
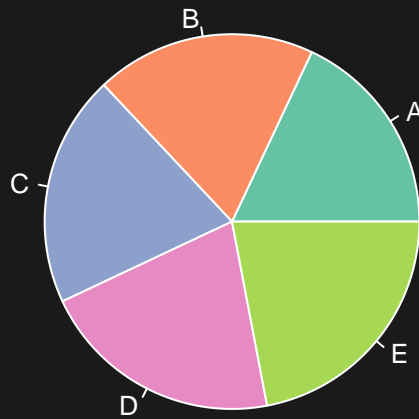
via @MonaChalabi (bit.ly/pie_vs_barchart)

Avoid pie charts



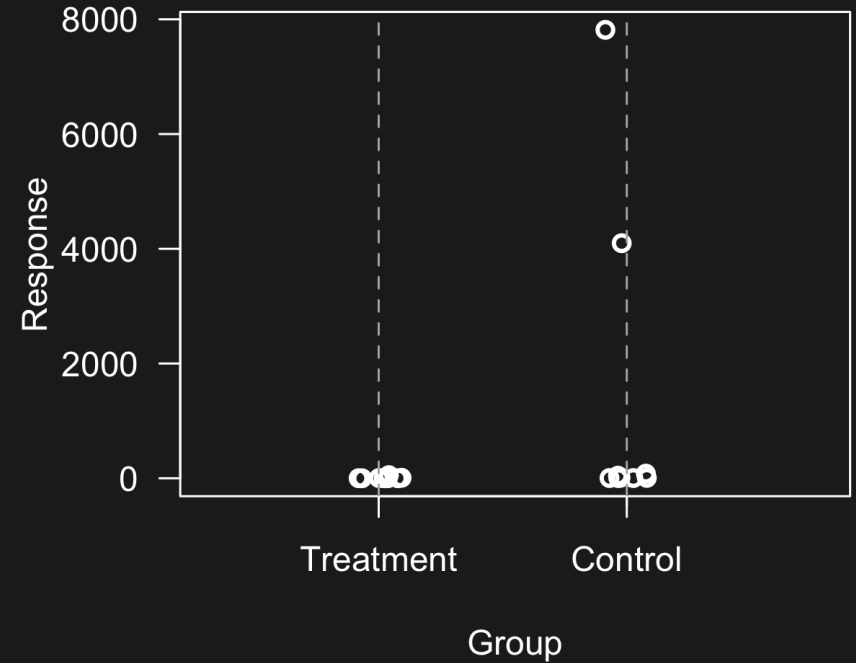
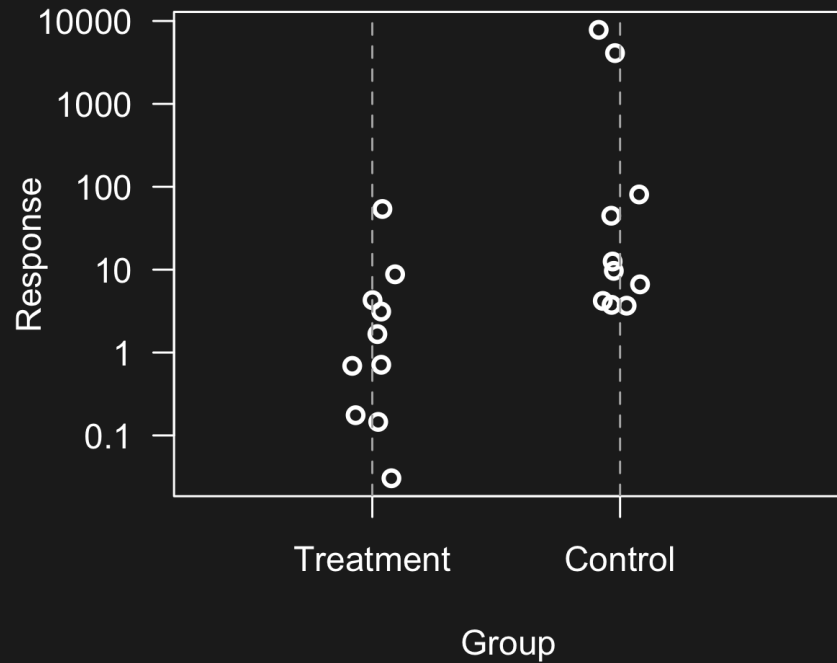
via @MonaChalabi (bit.ly/pie_vs_barchart)

Avoid pie charts

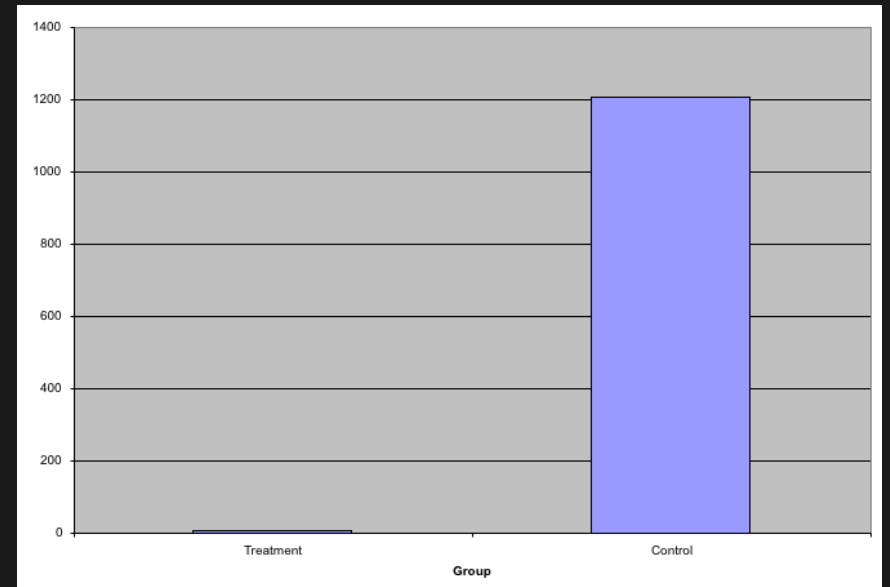
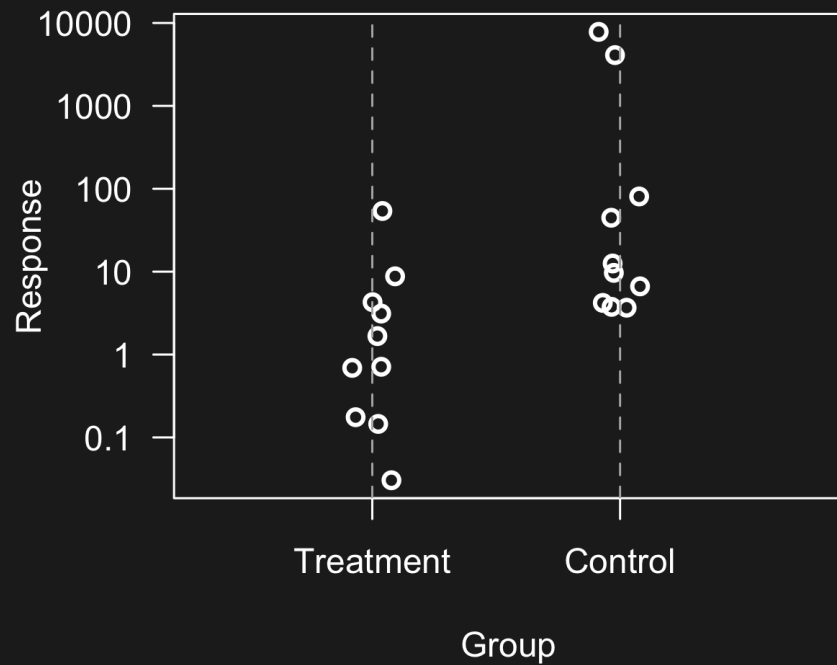


via @MonaChalabi (bit.ly/pie_vs_barchart)

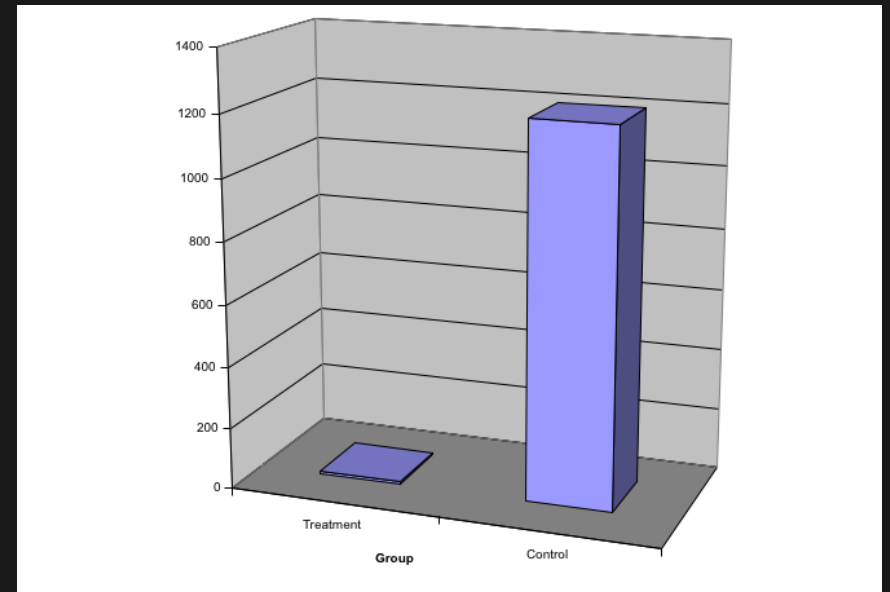
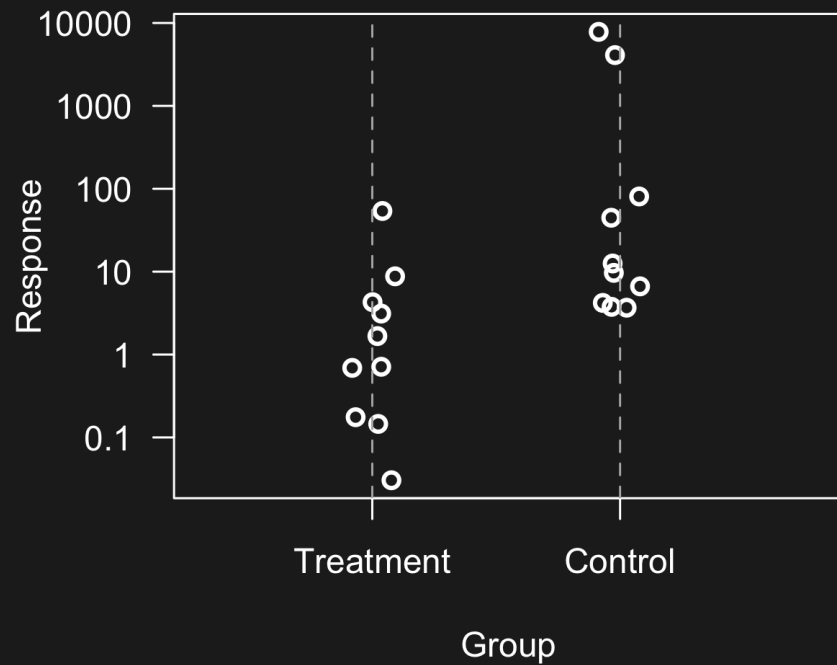
Consider logs



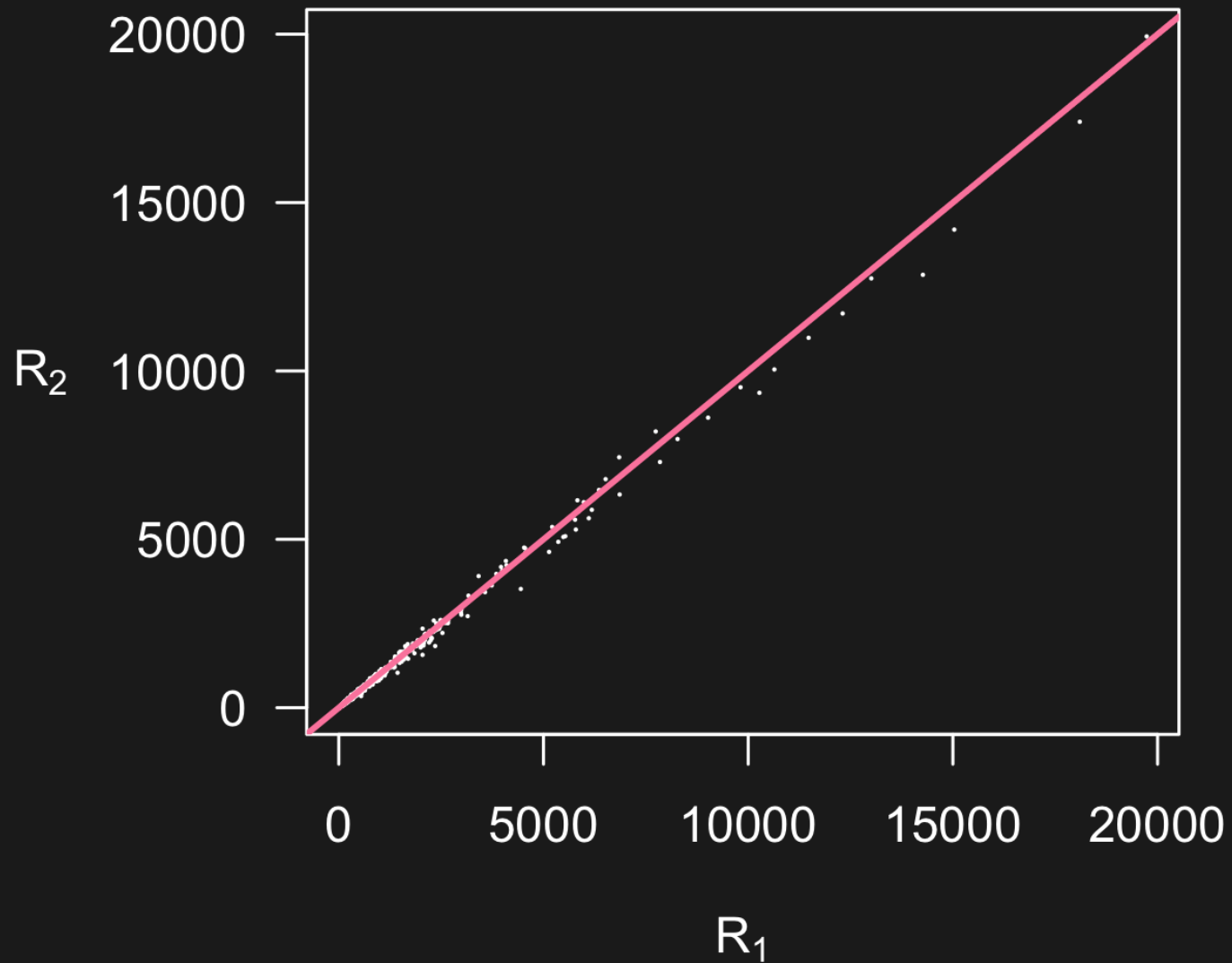
Consider logs



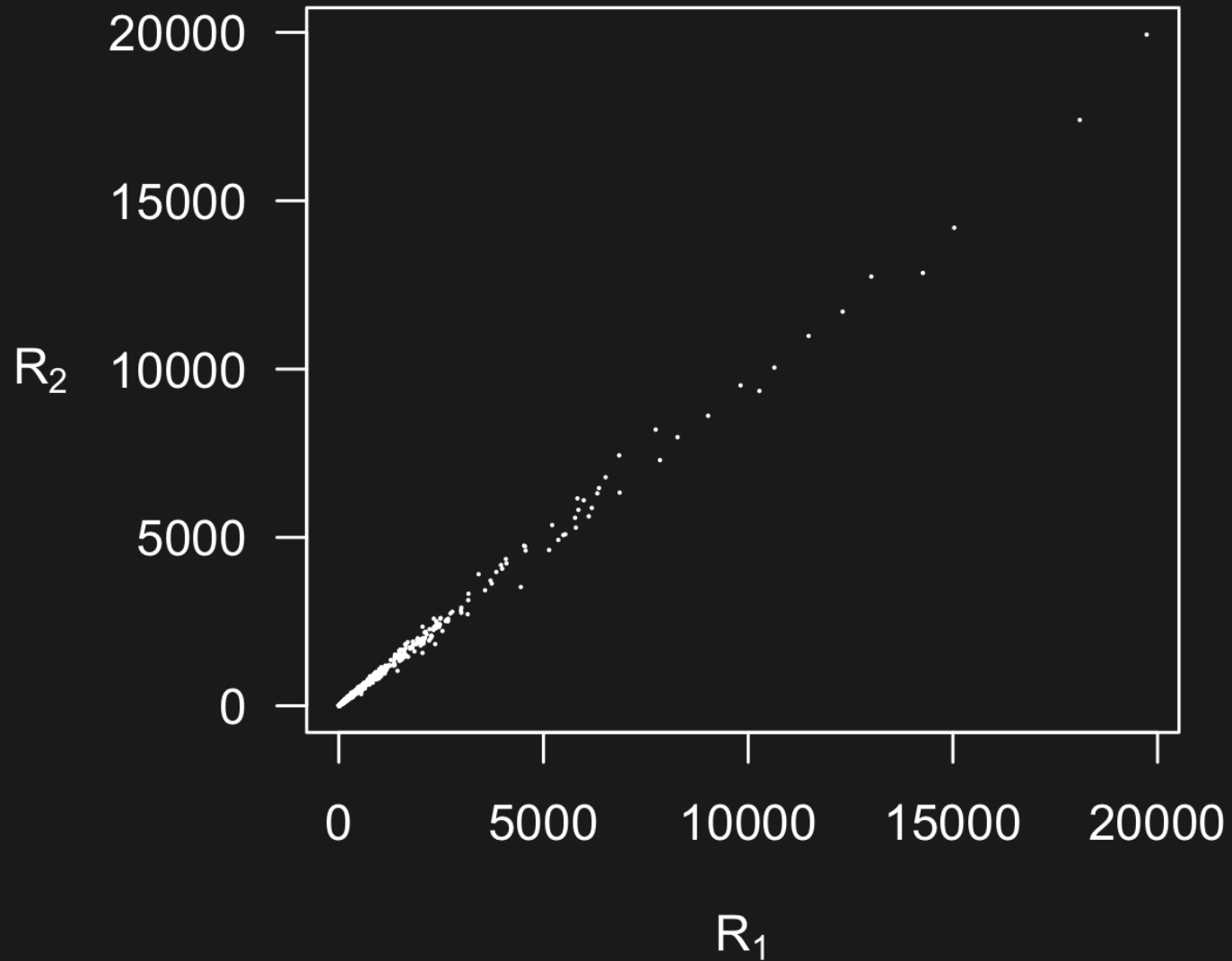
Consider logs



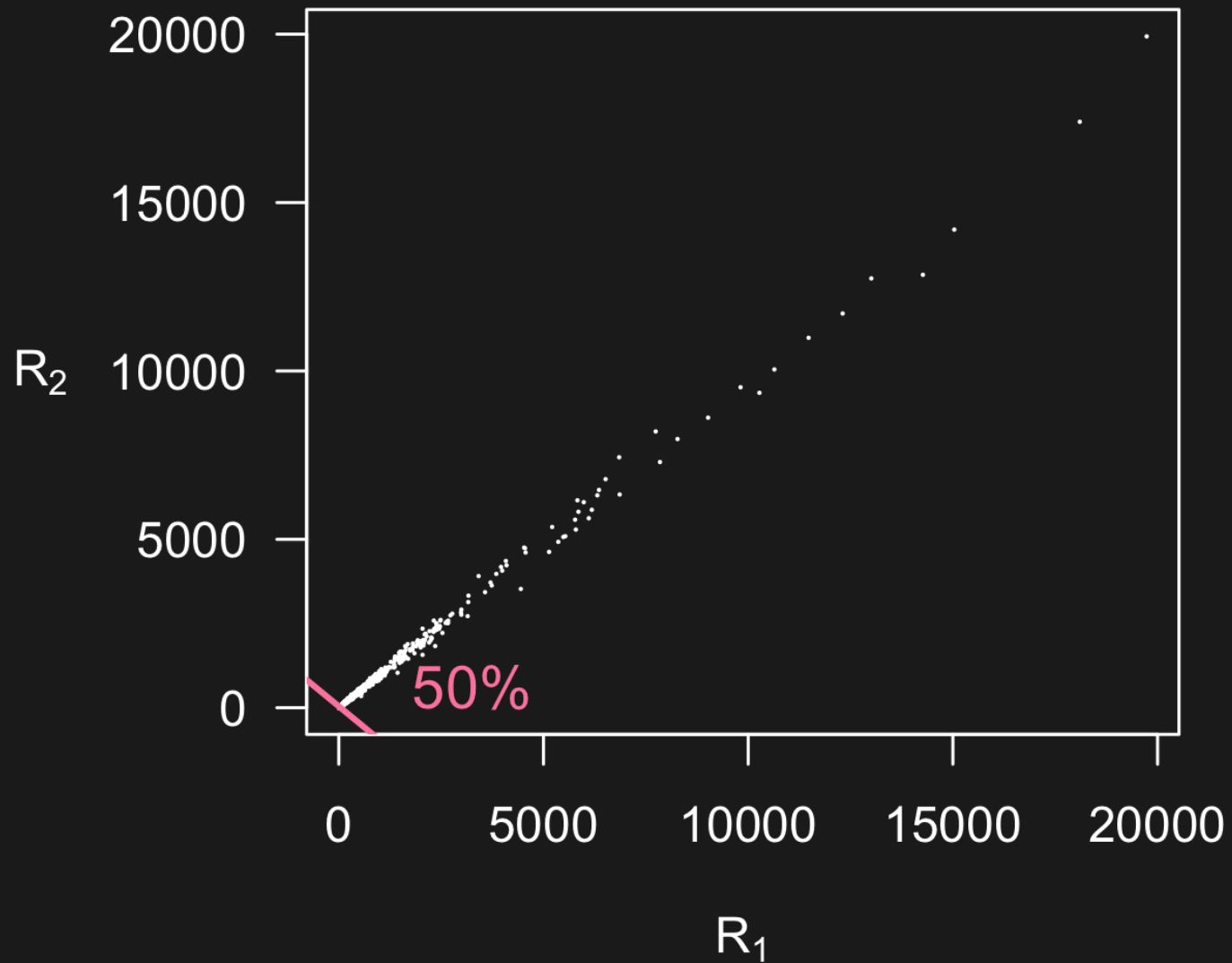
Consider logs



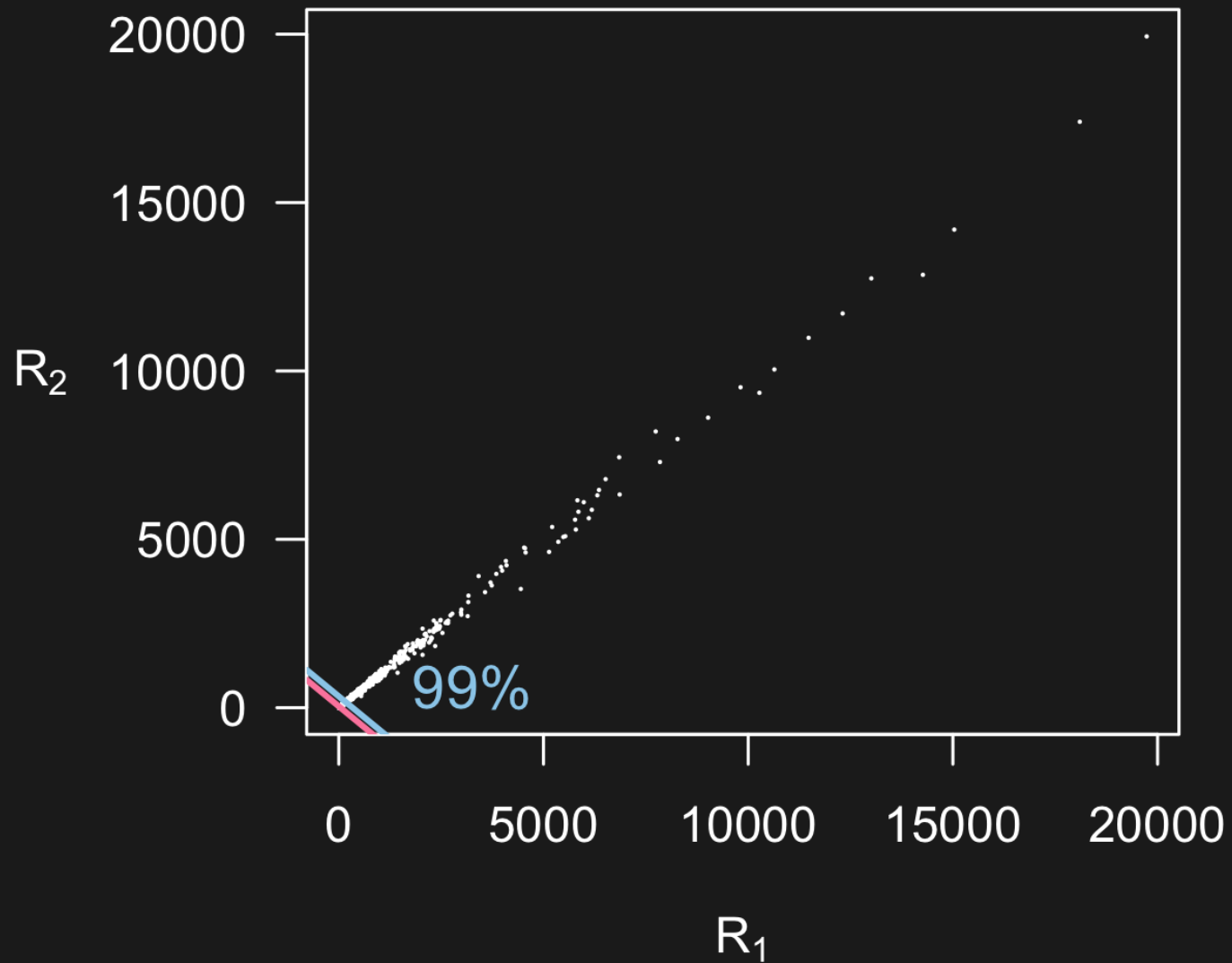
Consider logs



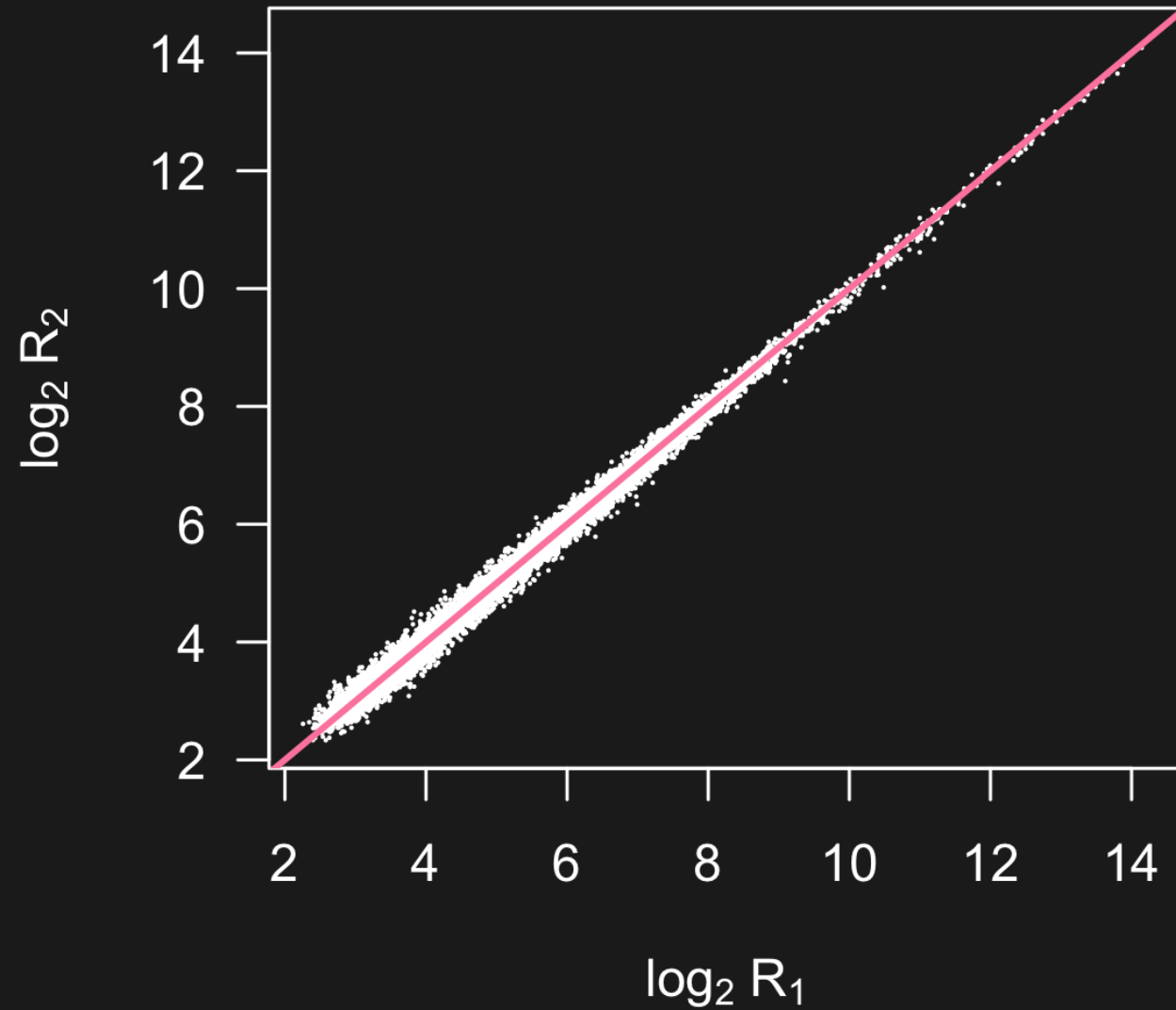
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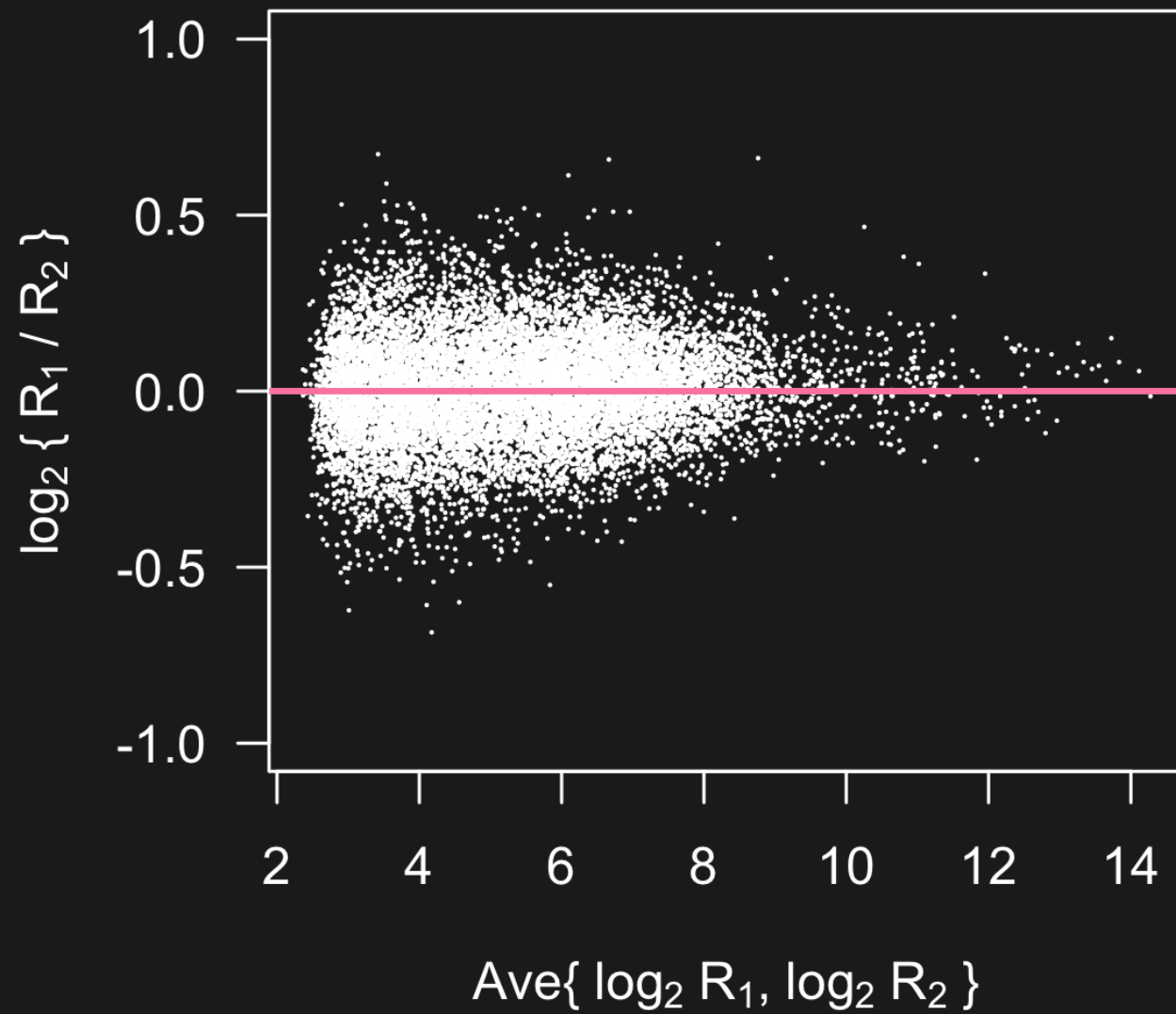
Consider logs



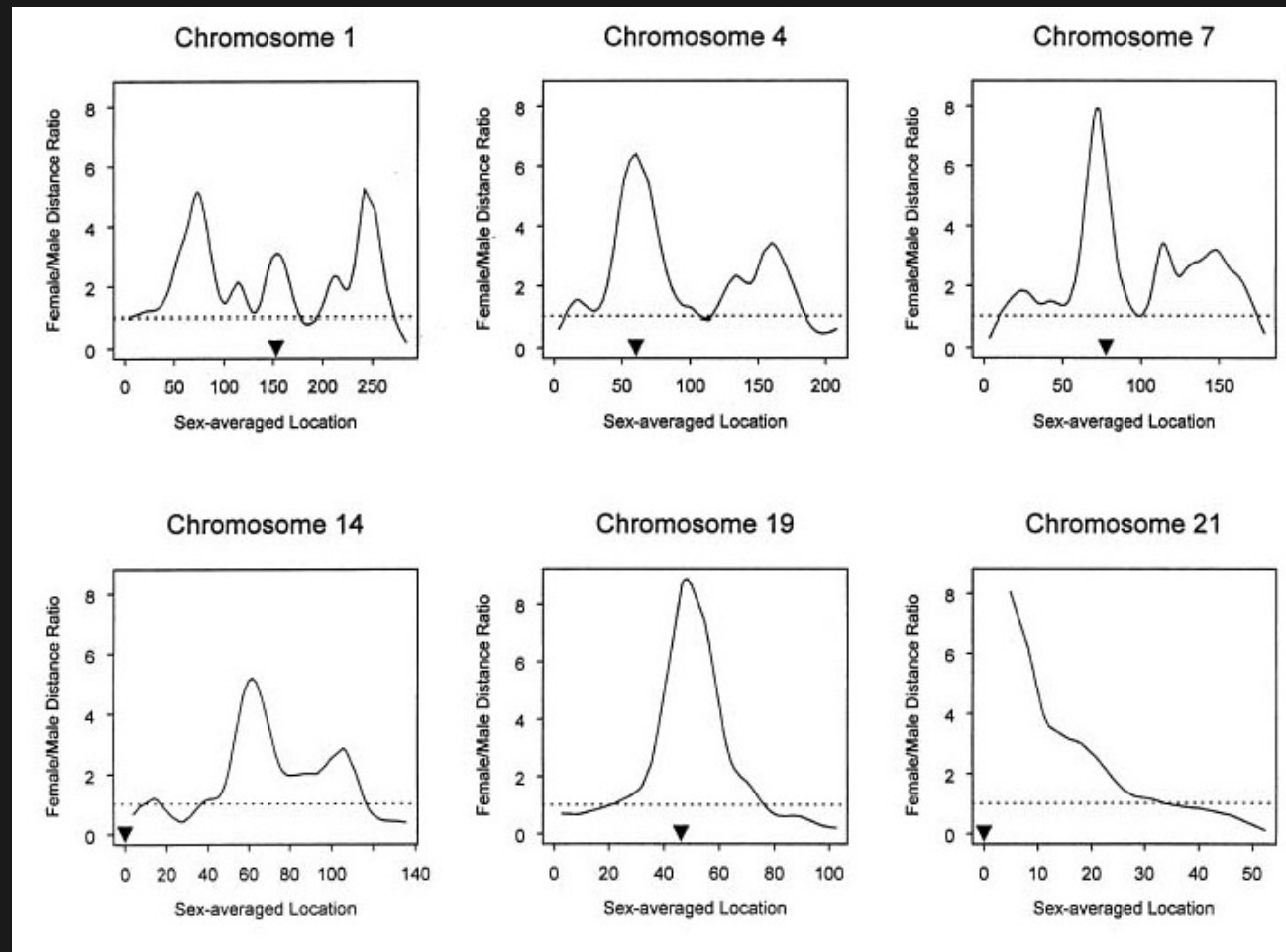
Consider logs



Take differences

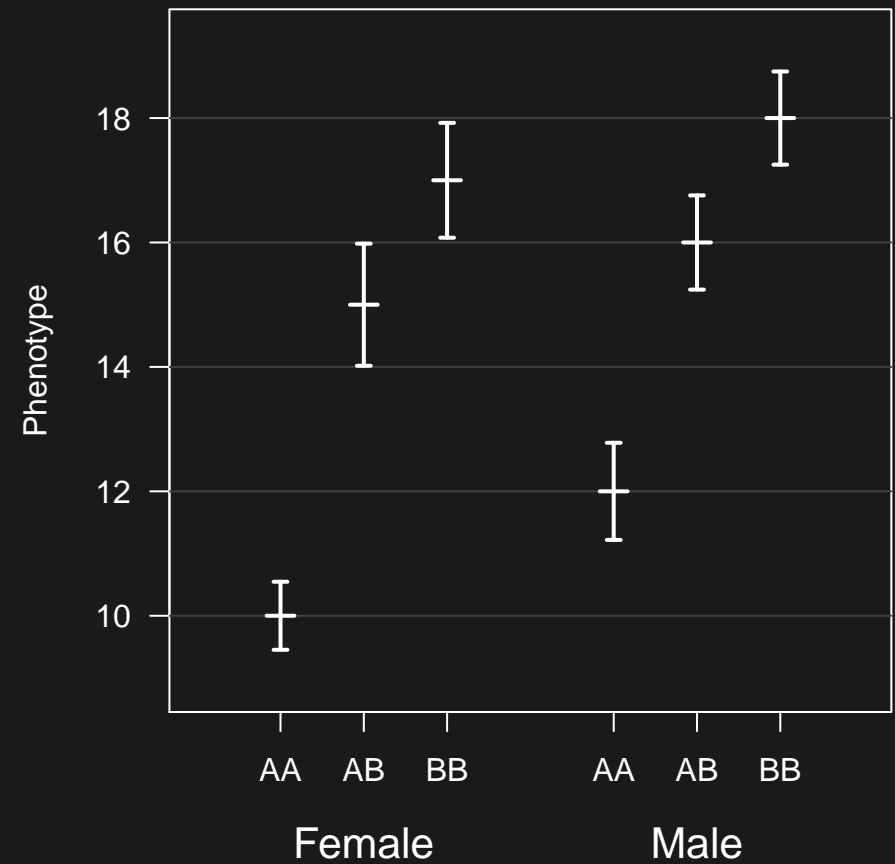
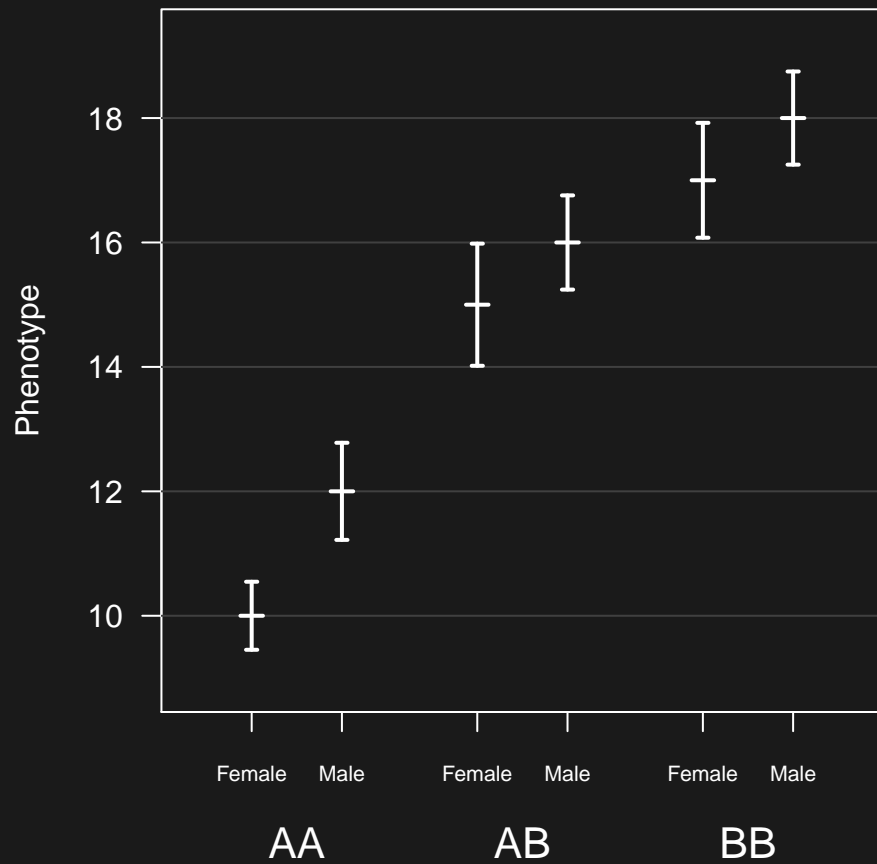


Another “take logs” example



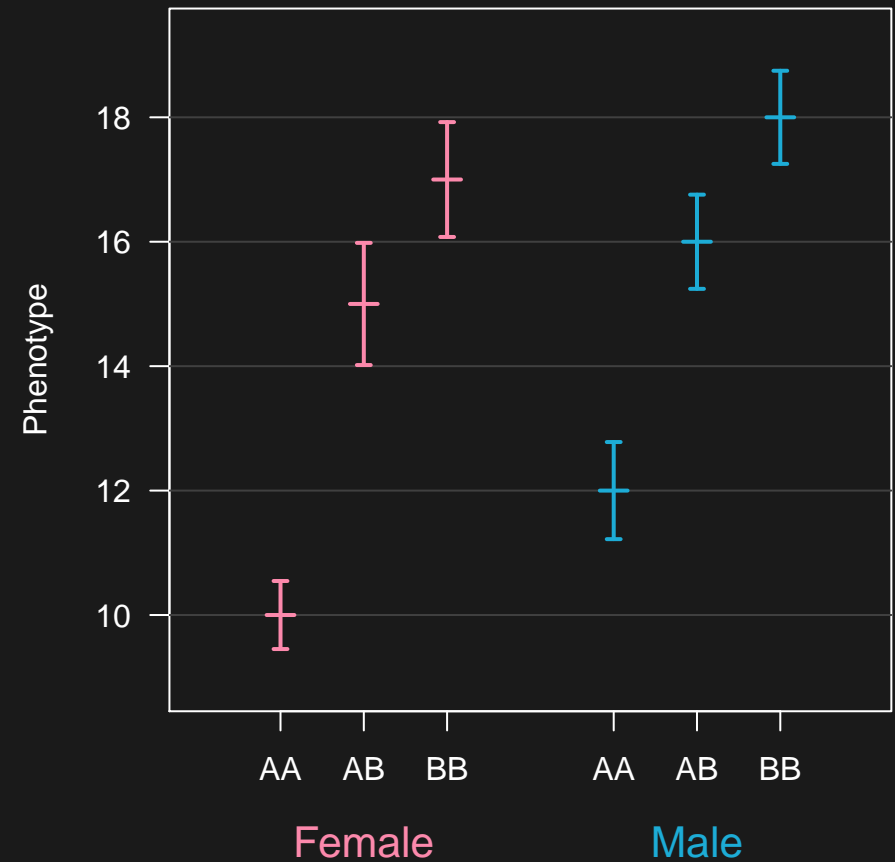
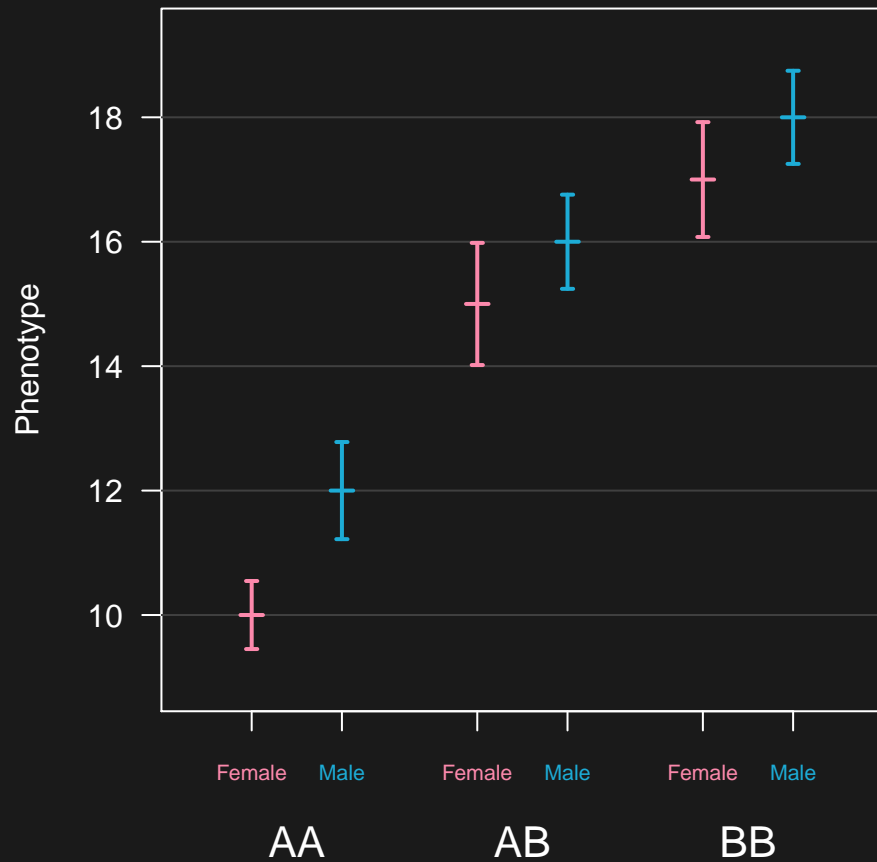
Ease comparisons

(things to be compared should be adjacent)

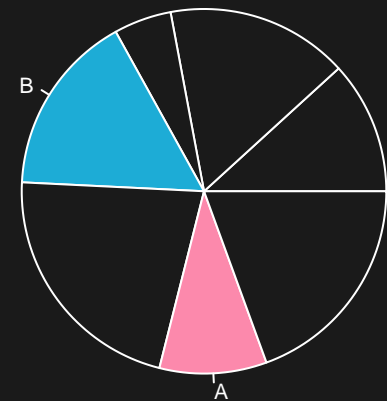
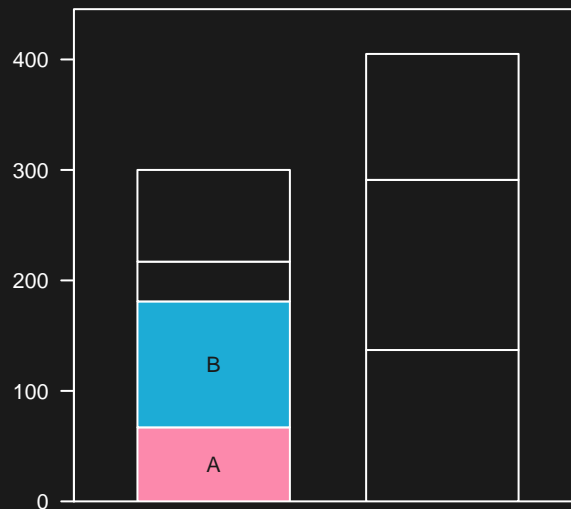
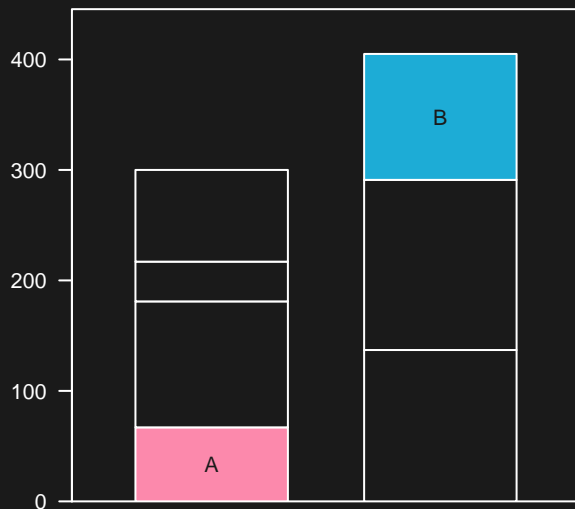
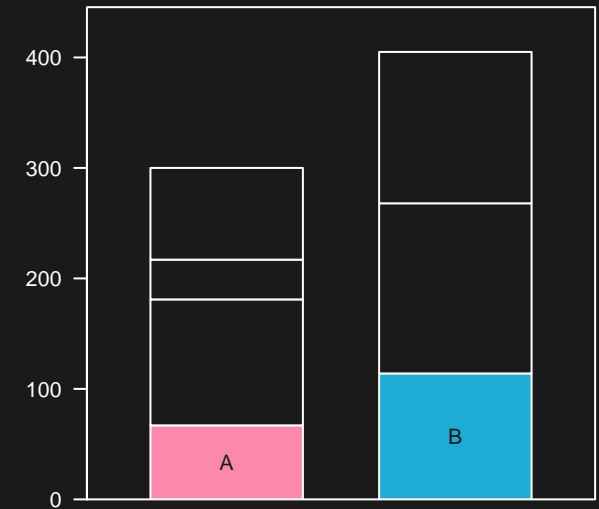
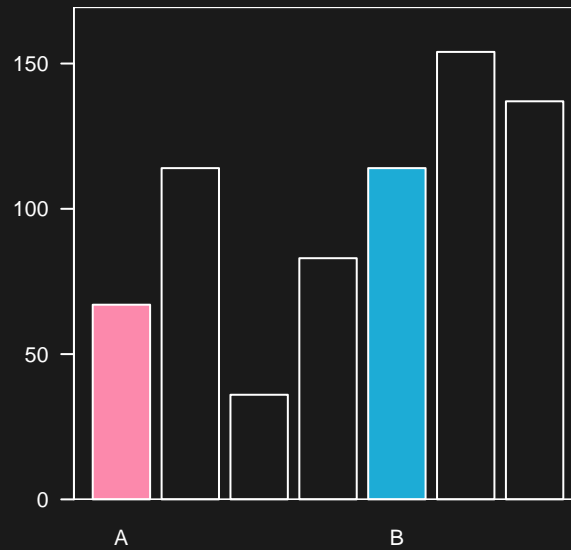
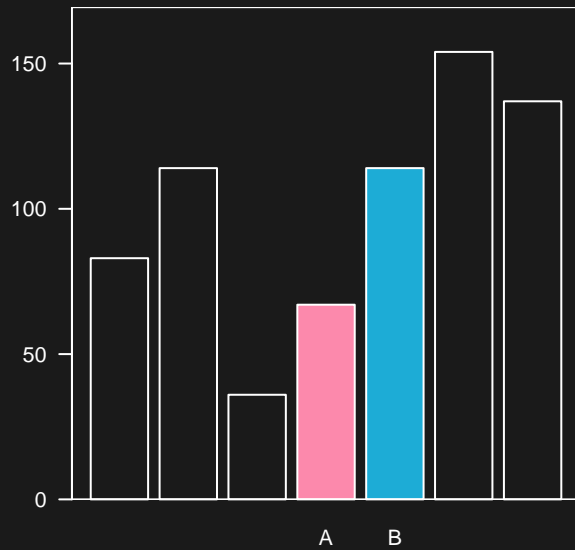


Ease comparisons

(add a bit of color)

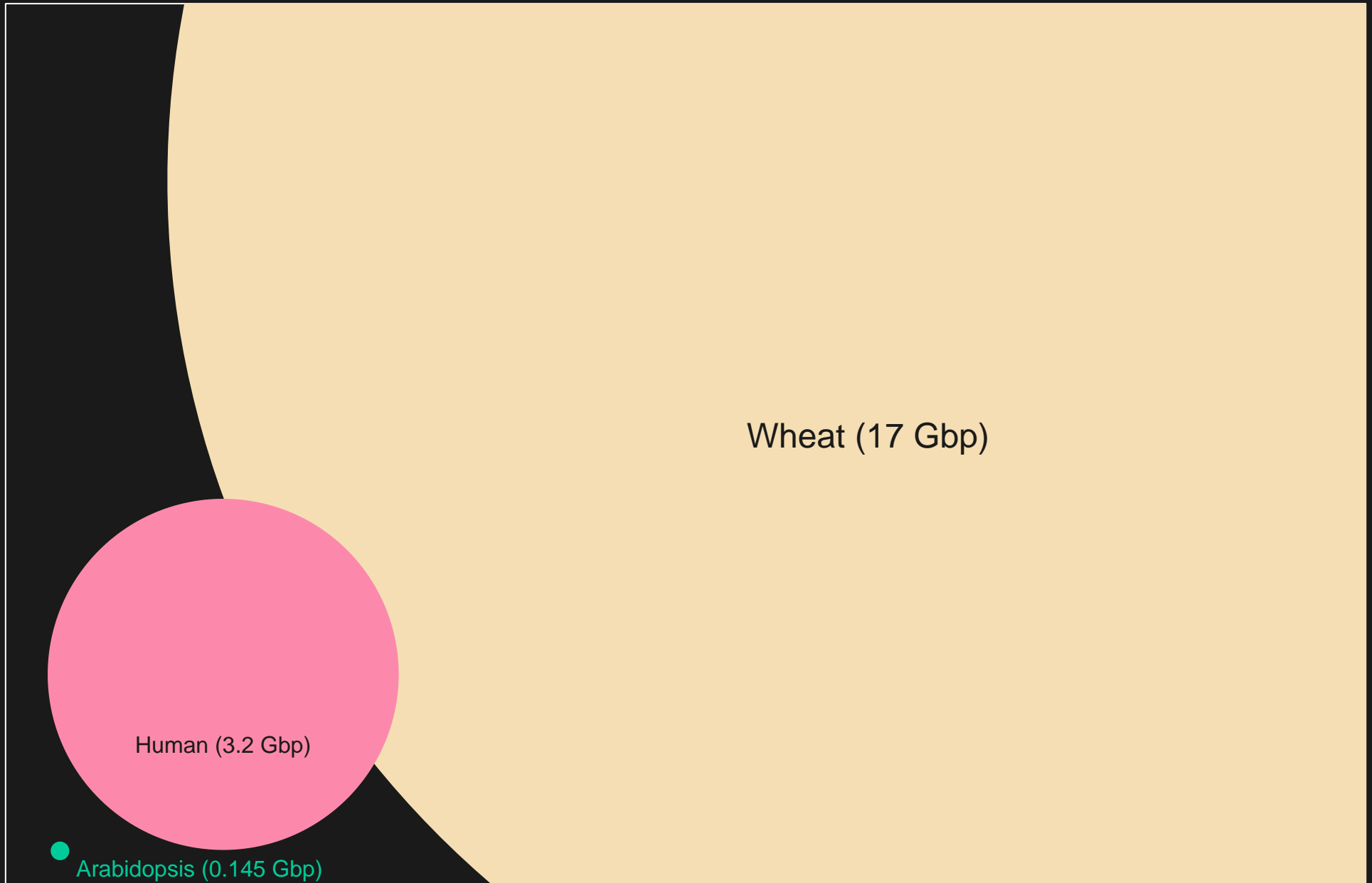


Which comparison is easiest?



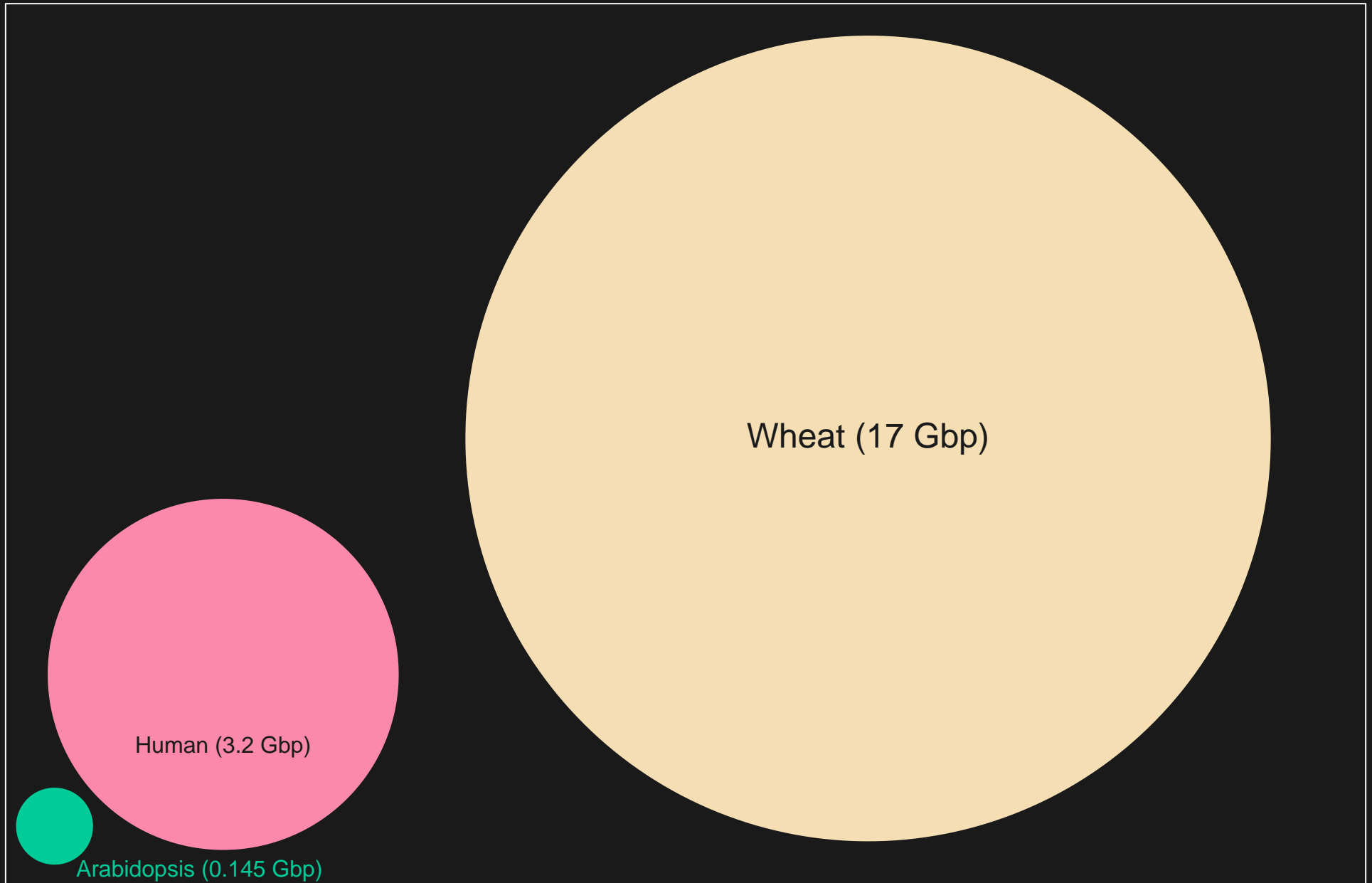
Don't distort the quantities

(value \propto radius)

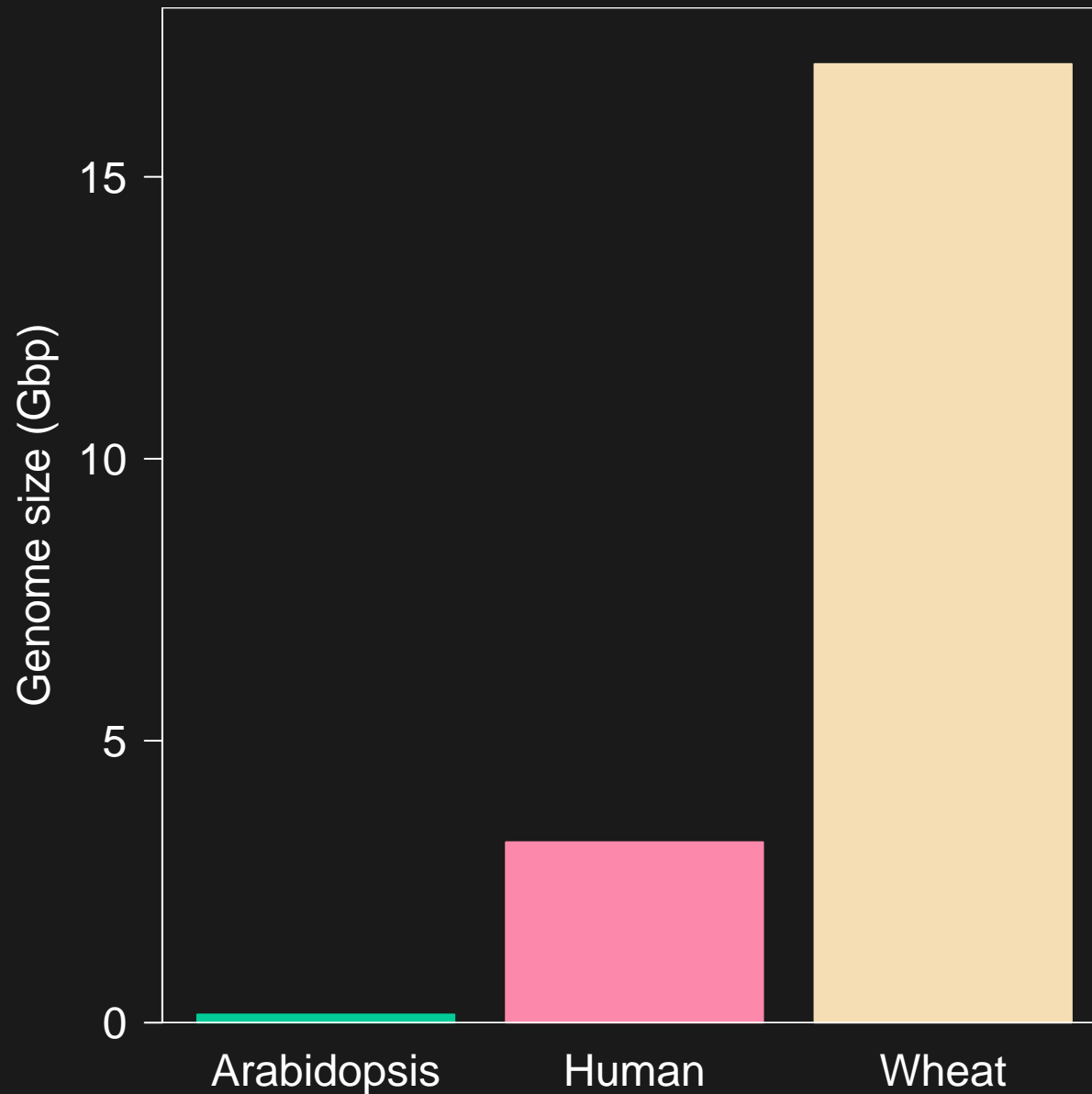


Don't distort the quantities

(value \propto area)



Don't use areas at all
(value \propto length)



Encoding data

Quantities

- Position
- Length
- Angle
- Area
- Luminance (light/dark)
- Chroma (amount of color)

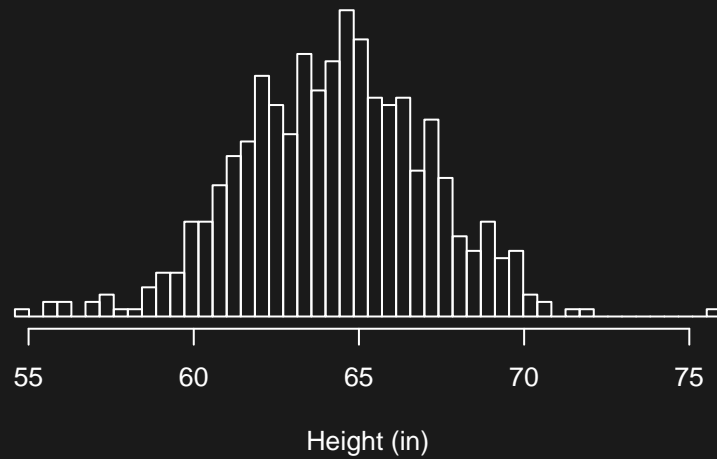
Categories

- Shape
- Hue (which color)
- Texture
- Width

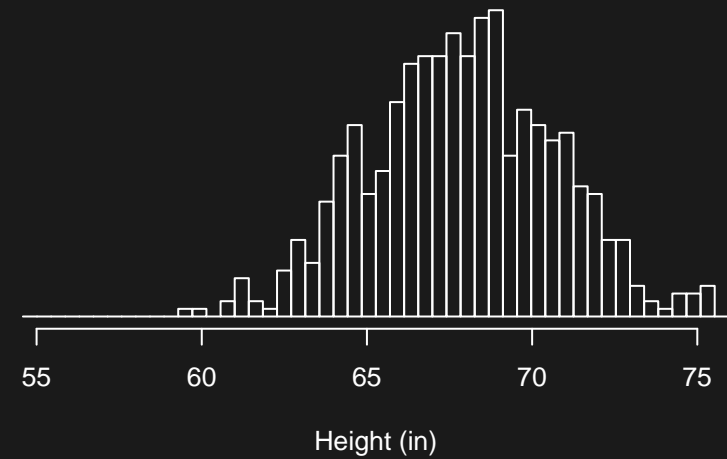
Ease comparisons

(align things vertically)

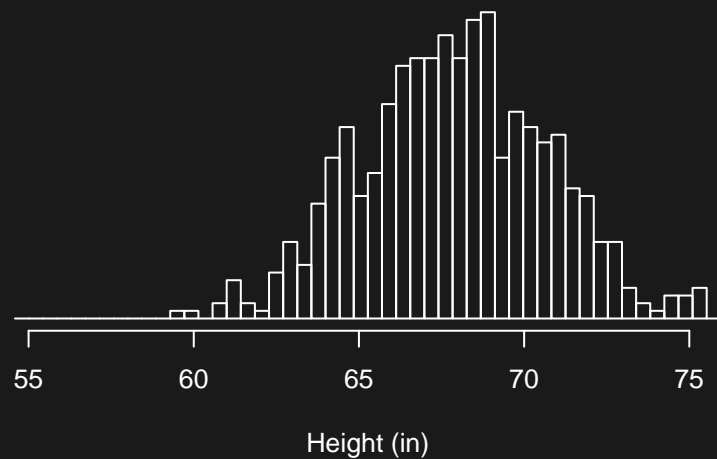
Women



Men



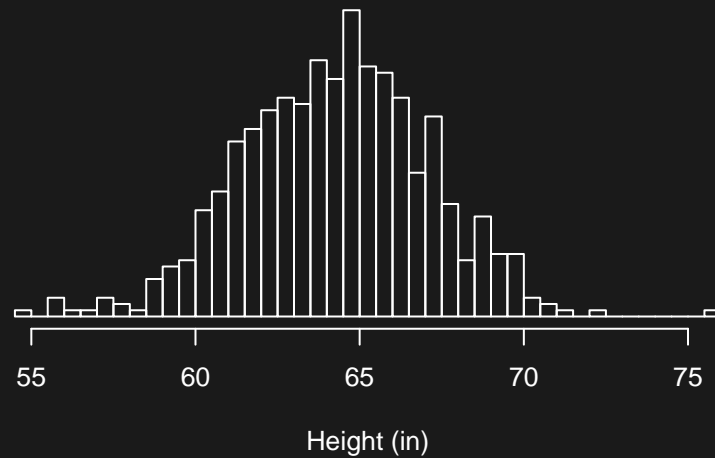
Men



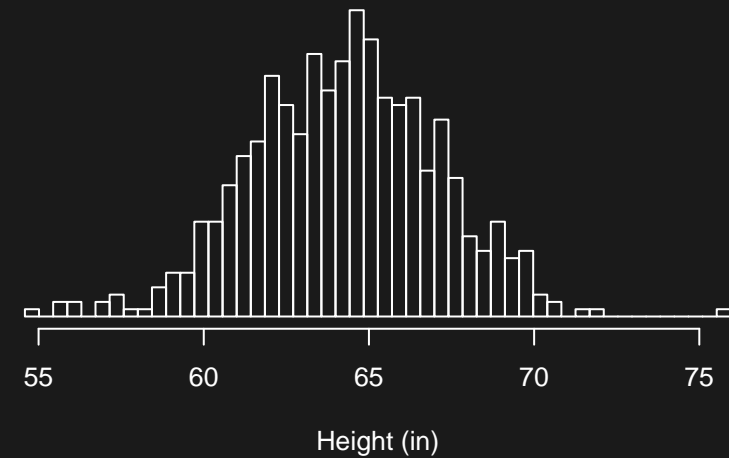
Ease comparisons

(use common axes)

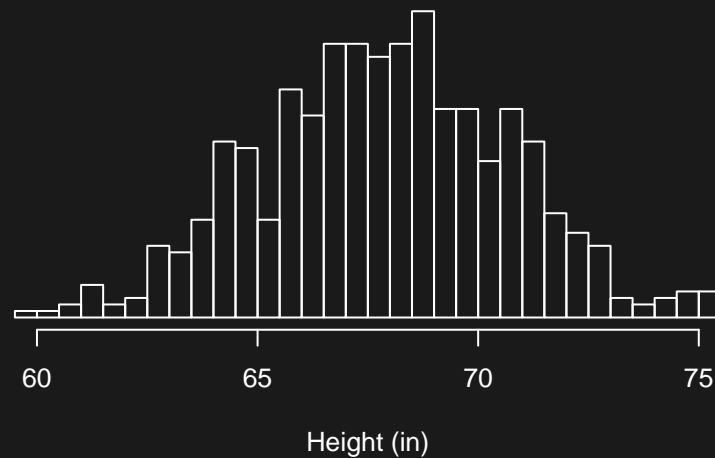
Women



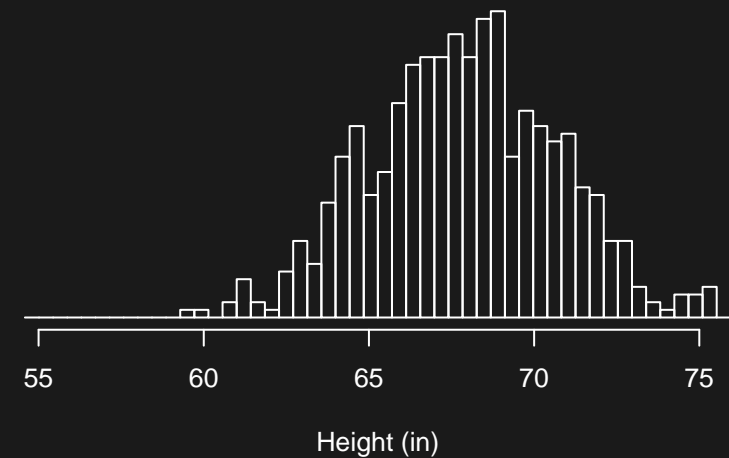
Women



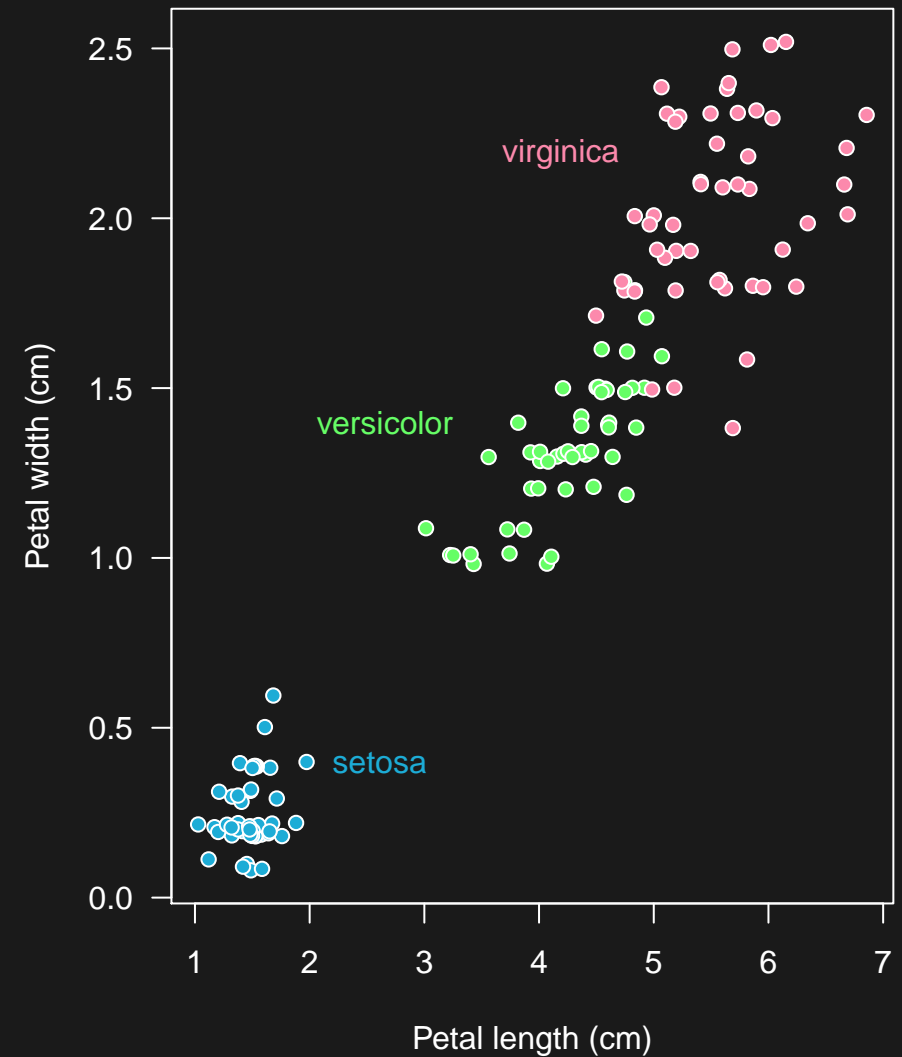
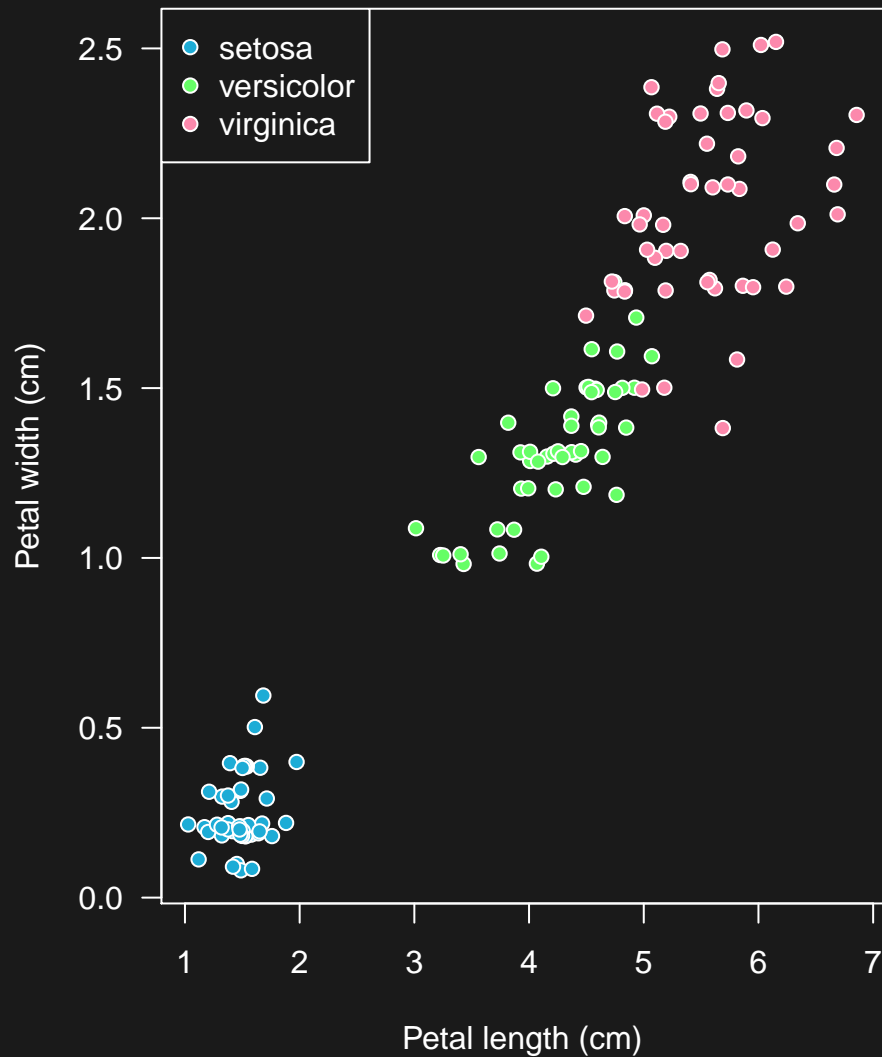
Men



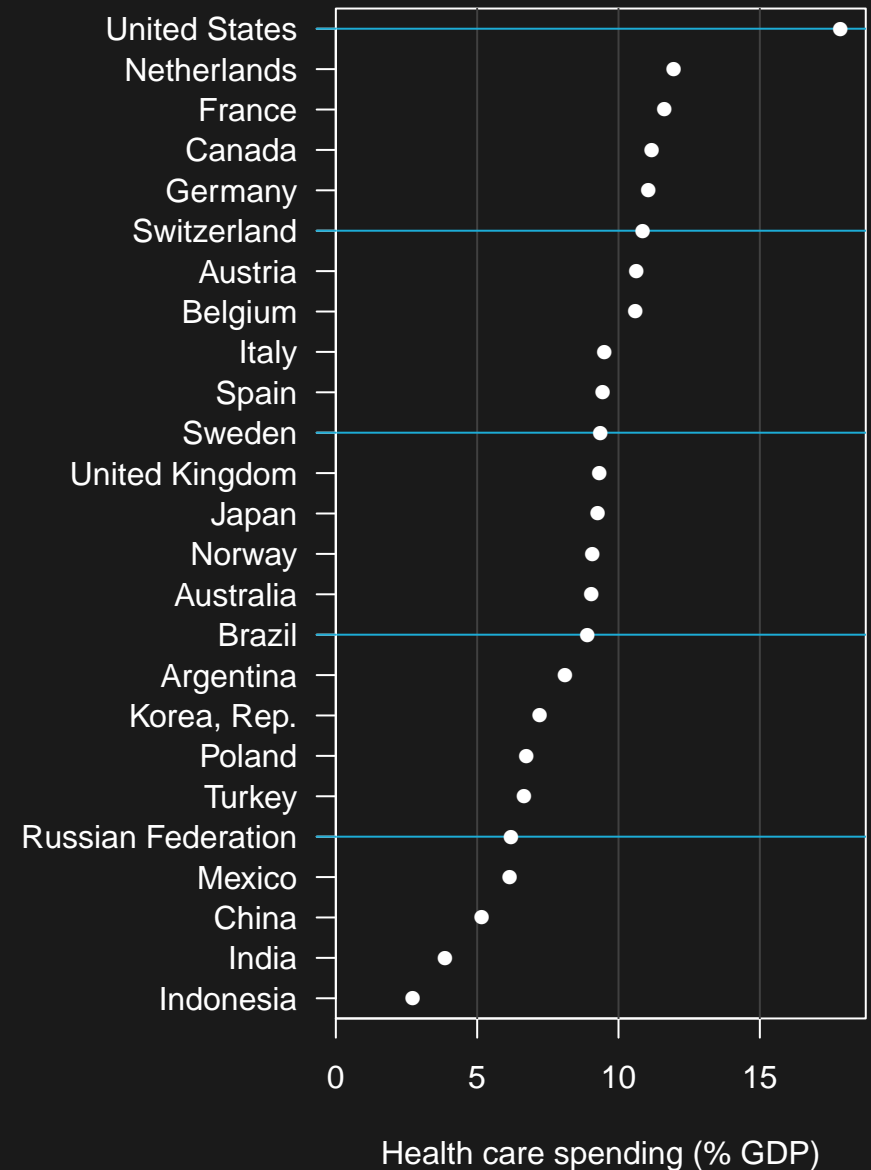
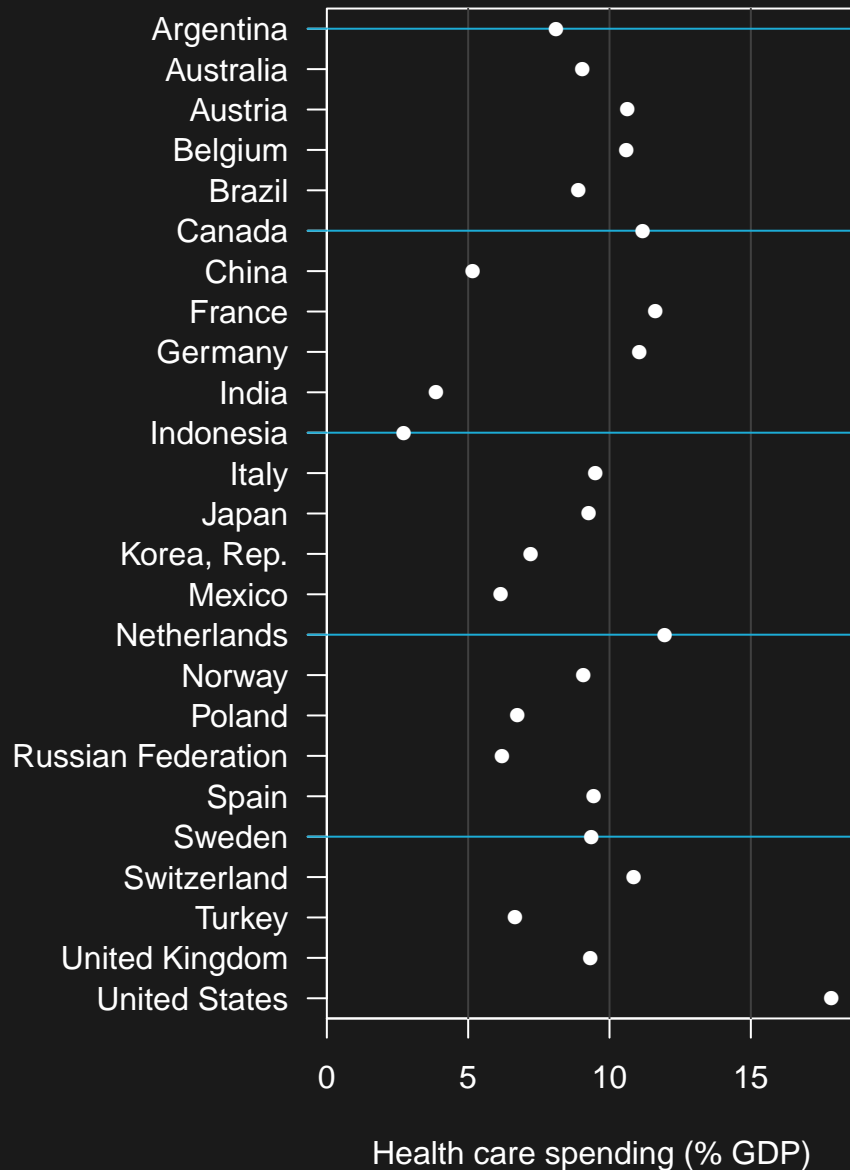
Men



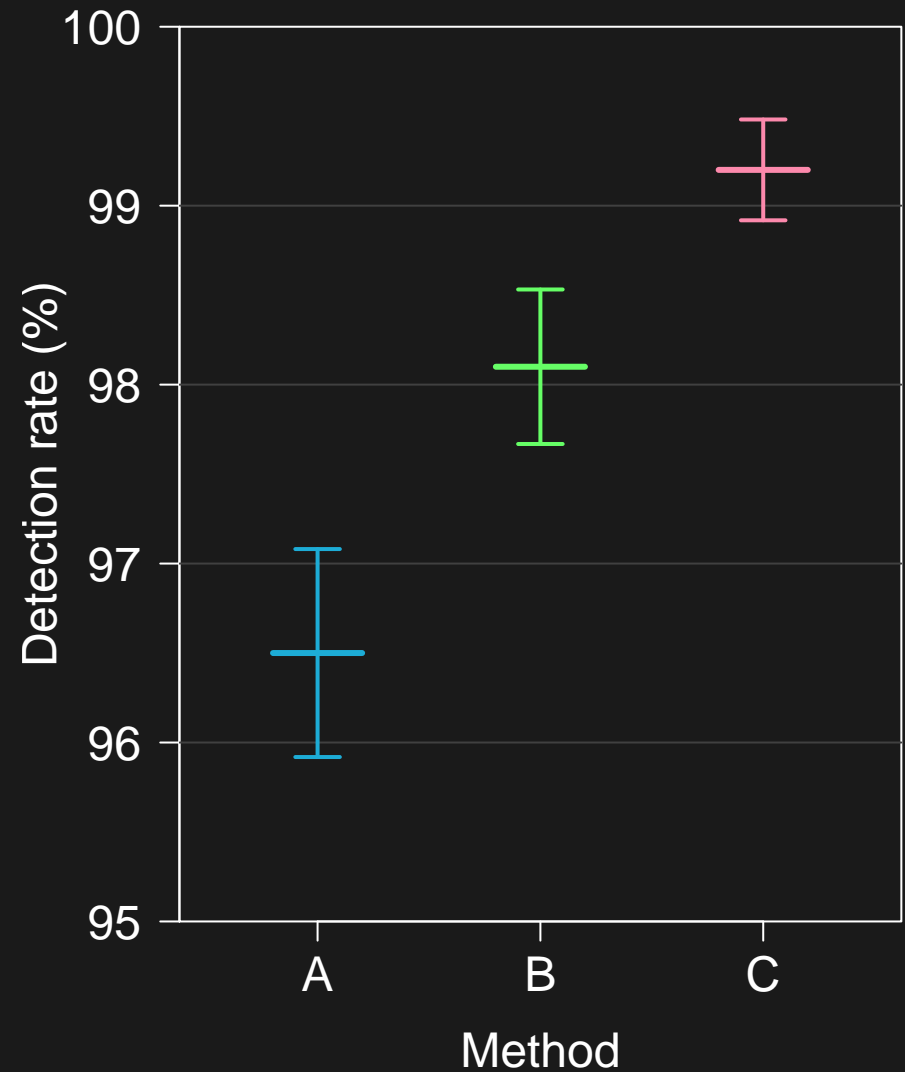
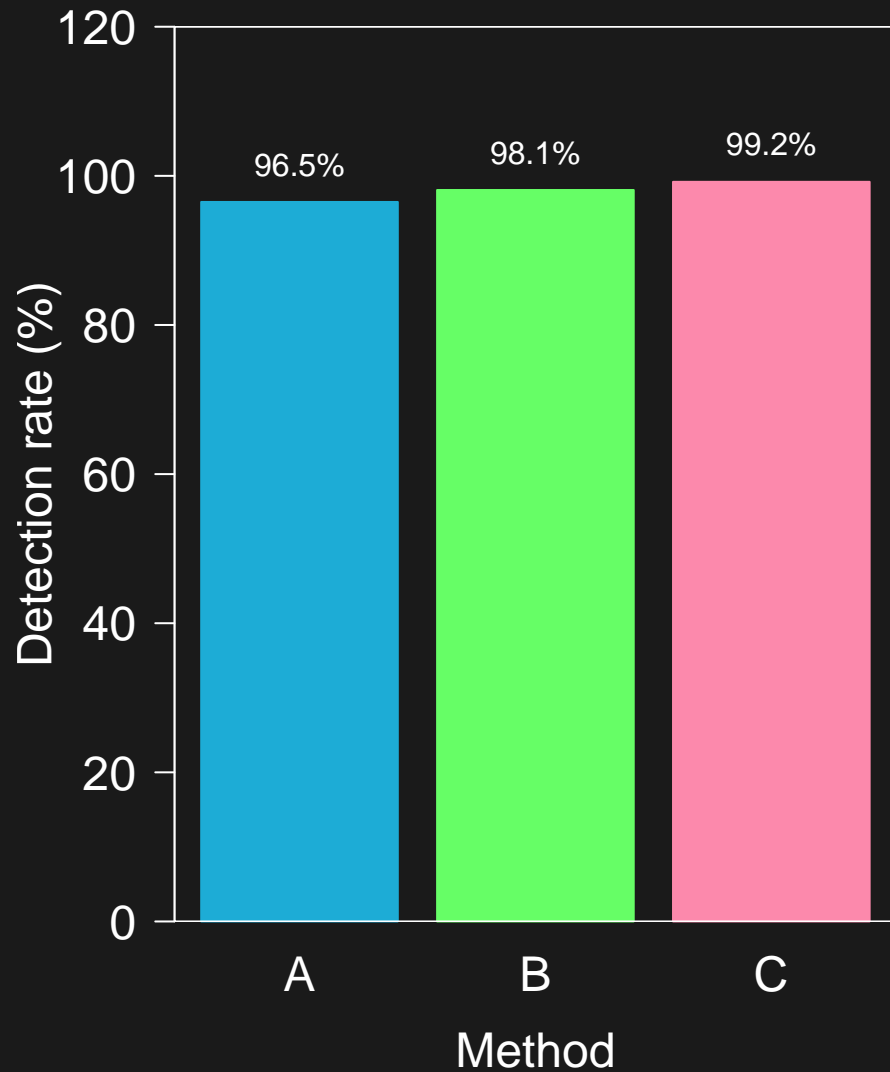
Use labels not legends



Don't sort alphabetically



Must you include 0?



A bad table

N	$b/c = 10.0$		$b/c = 10.0$		$b/c = 100.0$	
	r^*	G	r^*	G	r^*	G
3	2	0.2	2	2.225	2	22.47499
4	2	0.26333	2	2.88833	2	29.13832
5	2	0.32333	3	3.54167	3	35.79166
6	3	0.38267	3	4.23767	3	42.78764
7	3	0.446	3	4.901	3	49.45097
8	3	0.50743	4	5.5765	4	56.33005
9	3	0.56743	4	6.26025	4	63.20129
10	4	0.62948	4	6.92358	4	69.86462

Fewer digits

N	$b/c = 10.0$		$b/c = 10.0$		$b/c = 100.0$	
	r^*	G	r^*	G	r^*	G
3	2	0.20	2	2.2	2	22
4	2	0.26	2	2.9	2	29
5	2	0.32	3	3.5	3	36
6	3	0.38	3	4.2	3	43
7	3	0.45	3	4.9	3	49
8	3	0.51	4	5.6	4	56
9	3	0.57	4	6.3	4	63
10	4	0.63	4	6.9	4	70

Yuck!

	1990		2005		2010		p value
	n	Rate (95% CI)	n	Rate (95% CI)	n	Rate (95% CI)	
(Continued from previous page)							
Globally							
<75 years							
Incidence	6 353 868	159.22 (145.32–174.98)	9 288 048	167.45 (150.96–187.11)	10 469 624	168.75 (152.43–187.09)	0.208
Prevalence	13 234 062	324.26 (288.74–374.96)	20 187 246	358.58 (317.58–412.79)	23 052 804	366.93 (328.04–420.66)	0.086
MIR	..	0.359 (0.318–0.409)	..	0.293 (0.249–0.332)	..	0.254 (0.212–0.287)	<0.001
DALYs lost	63 991 864	1543.96 (1452.03–1728.25)	74 855 520	1326.17 (1172.08–1388.74)	73 293 552	1163.448 (1011.43–1232.19)	<0.001
Mortality	2 301 435	57.38 (54.12–64.27)	2 734 251	49.16 (43.60–51.55)	2 668 499	42.89 (37.65–45.81)	<0.001
≥75 years							
Incidence	3 725 067	3173.50 (2932.14–3422.23)	5 446 077	3082.97 (2819.52–3372.55)	6 424 911	3113.00 (2850.95–3403.57)	0.361
Prevalence	4 681 276	3974.37 (3609.66–4441.23)	8 308 337	4700.18 (4239.37–5256.84)	9 972 153	4835.38 (4382.63–5433.92)	0.005
MIR	..	0.634 (0.575–0.709)	..	0.543 (0.476–0.607)	..	0.500 (0.439–0.560)	<0.001
DALYs	22 018 520	18665.35 (17 464.55–20 408.51)	27 096 178	15 300.36 (13 987.78–16 317.62)	28 938 754	14 053.63 (12 761.98–15 088.12)	<0.001
Mortality	2 359 013	2033.21 (1888.78–2233.65)	2 950 719	1678.65 (1528.60–1807.22)	3 205 682	1545.29 (1412.76–1685.12)	<0.001
All ages							
Incidence	10 078 935	250.55 (229.70–273.25)	14 734 124	255.79 (232.10–283.88)	16 894 536	257.96 (234.40–284.11)	0.335
Prevalence	17 915 338	434.86 (389.45–496.84)	28 495 582	490.13 (436.60–557.52)	33 024 958	502.32 (451.26–572.18)	0.047
MIR	..	0.461 (0.415–0.518)	..	0.386 (0.336–0.432)	..	0.348 (0.299–0.390)	<0.001
DALYs lost	86 010 384	2062.74 (1949.53–2280.29)	101 951 696	1749.59 (1568.67–1830.82)	102 232 304	1554.02 (1373.94–1642.26)	<0.001
Mortality	4 660 449	117.25 (111.51–129.68)	5 684 970	98.53 (89.02–103.86)	5 874 182	88.41 (79.84–94.41)	<0.001

*p value for the difference in age-adjusted rates between 1990 and 2010 only.

Table 1: Age-adjusted annual incidence and mortality rates (per 100 000 person-years), disability-adjusted life-years (DALYs) lost, prevalence (per 100 000 people), and mortality-to-incidence ratio (MIR) by age groups in high-income and low-income and middle-income countries, and globally in 1990, 2005, and 2010

Yuck!

	1990	
	n	Rate (95% CI)
(Continued from previous page)		
Globally		
<75 years		
Incidence	6 353 868	159.22 (145.32–174.98)
Prevalence	13 234 062	324.26 (288.74–374.96)
MIR	..	0.359 (0.318–0.409)
DALYs lost	63 991 864	1543.96 (1452.03–1728.25)
Mortality	2 301 435	57.38 (54.12–64.27)

Feigen et al., Lancet 383:245-255, 2014, Table 1

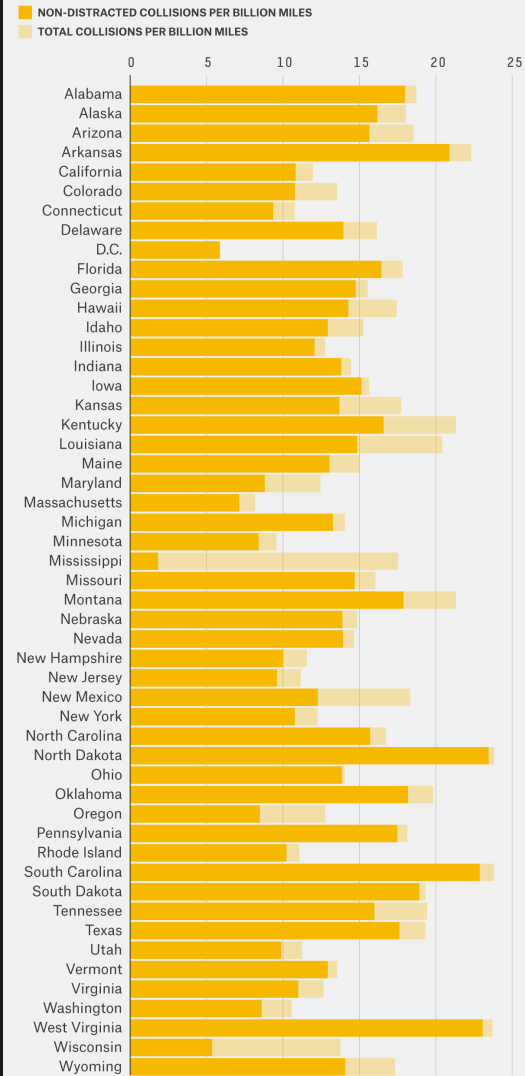
What was wrong with that?

- *Way* too many digits.
- Numbers aren't aligned.
- Numbers to be compared aren't anywhere near each other.
- The interesting comparisons are horizontal rather than vertical.
- It would be much better as a multi-panel figure.

One last example

Drivers Involved In Fatal Collisions Who Were Not Distracted

As a share of the number of fatal collisions per billion miles, 2012

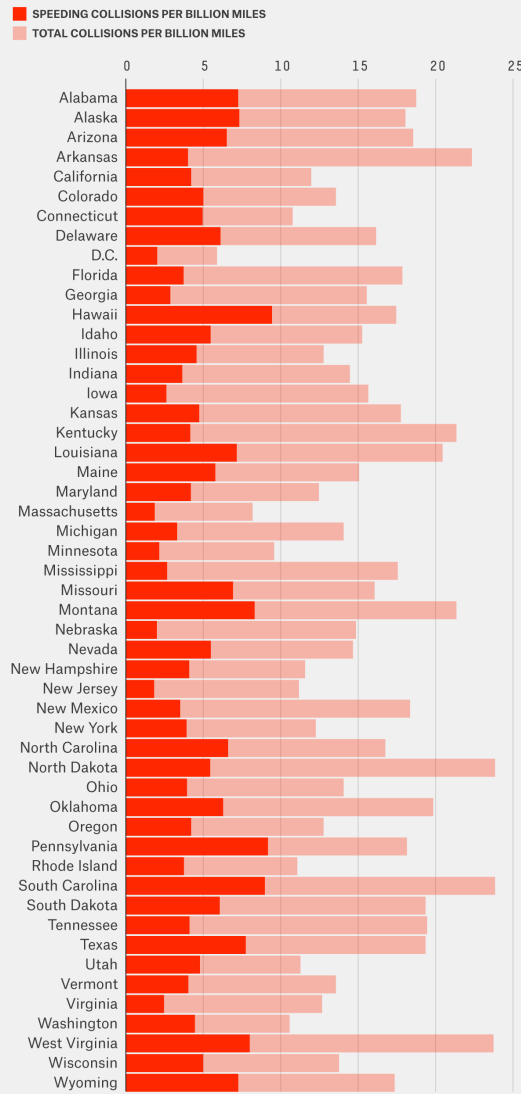


FIVETHIRTYEIGHT

SOURCE: NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION

Drivers Involved In Fatal Collisions While Speeding

As a share of the number of fatal collisions per billion miles, 2009

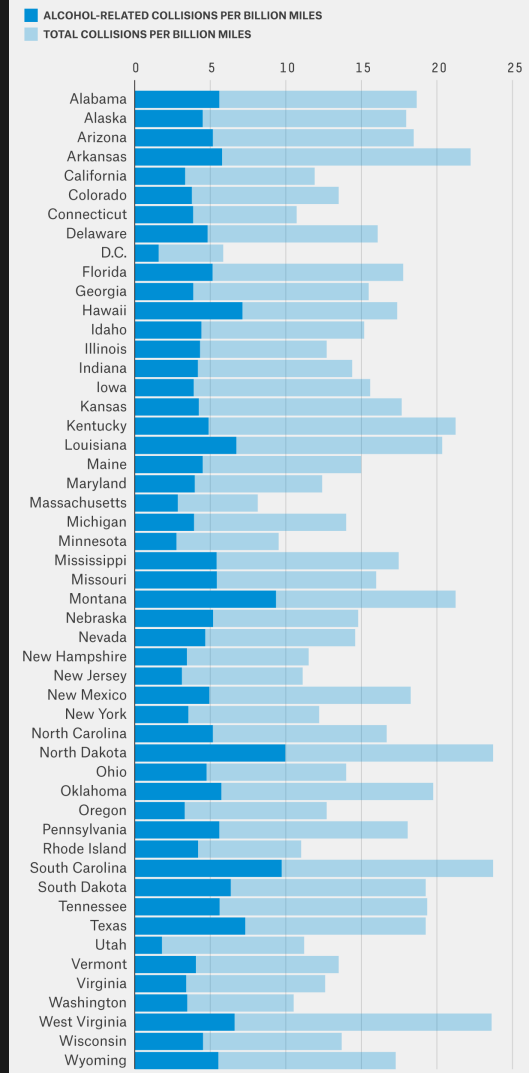


FIVETHIRTYEIGHT

SOURCE: NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION

Drivers Involved In Fatal Collisions While Alcohol-Impaired

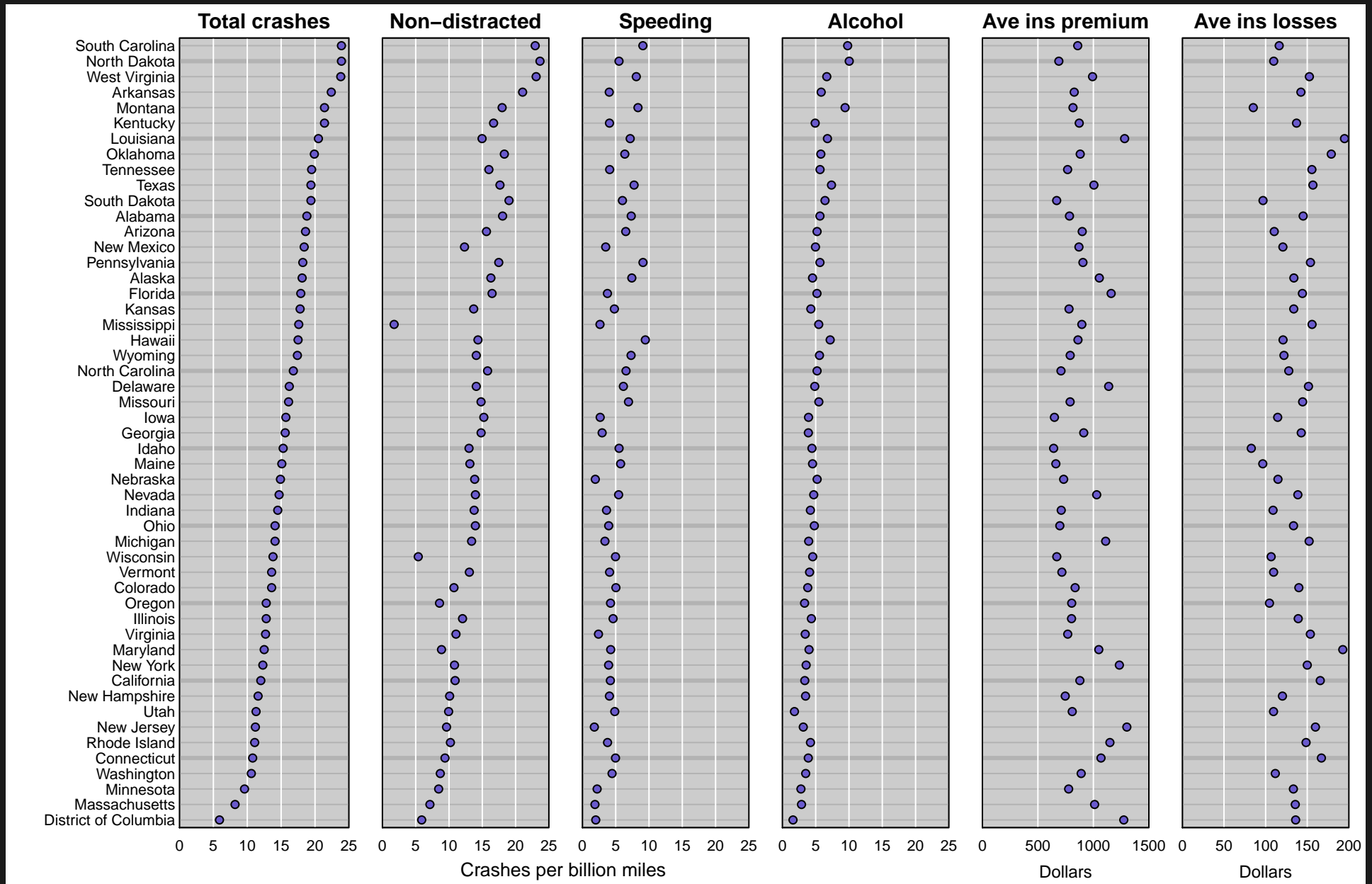
As a share of the number of fatal collisions per billion miles, 2012



FIVETHIRTYEIGHT

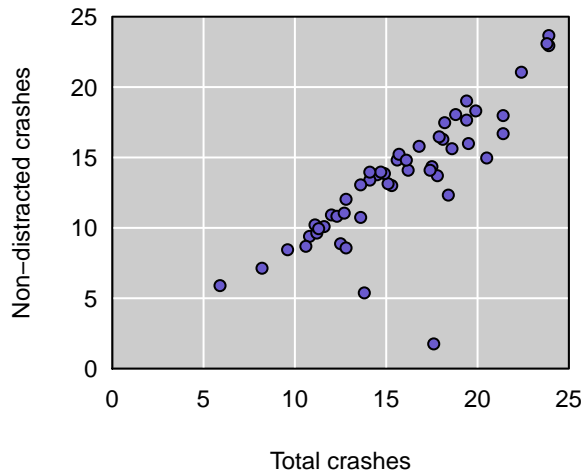
SOURCE: NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION

An alternative

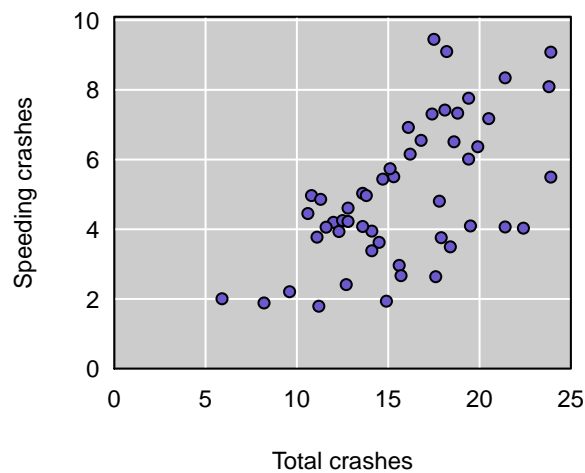


Scatterplots

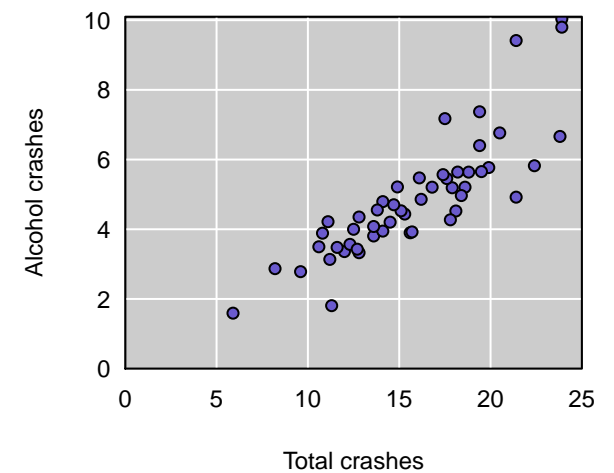
Non-distracted



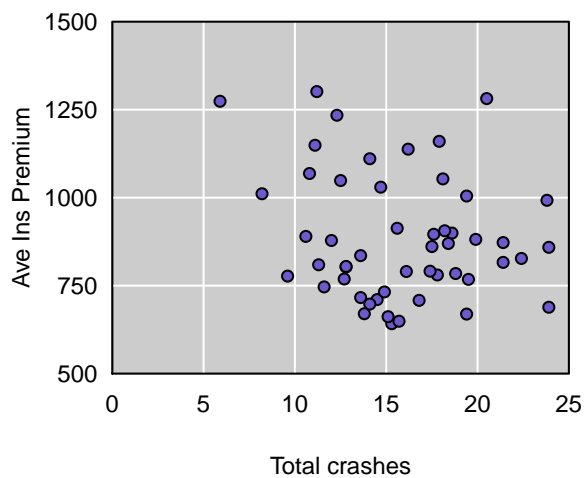
Speeding



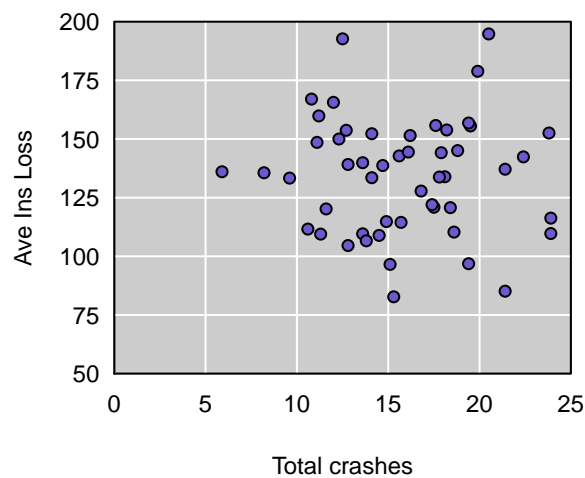
Alcohol



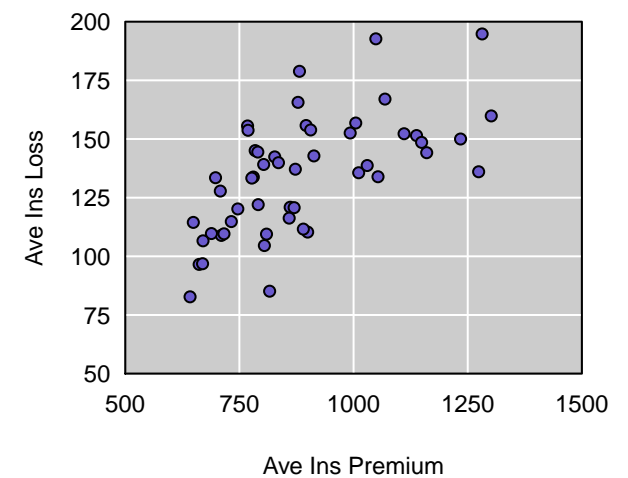
Ave Ins Premium



Ave Ins Loss



Premium vs Loss



Summary I

- Show the data
- Avoid chart junk
- Consider taking logs and/or differences
- Put the things to be compared next to each other
- Use color to set things apart, but consider color blind folks
- Use position rather than angle or area to represent quantities

Summary II

- Align things vertically to ease comparisons
- Use common axis limits to ease comparisons
- Use labels rather than legends
- Sort on meaningful variables (not alphabetically)
- Must 0 be included in the axis limits?
- Use scatterplots to explore relationships

Inspirations

- Hadley Wickham (slides at <http://courses.had.co.nz>)
- Naomi Robbins (*Creating more effective graphs*)
- Howard Wainer
- Andrew Gelman
- Dan Carr
- Edward Tufte

Further reading

- ER Tufte (1983) The visual display of quantitative information. Graphics Press.
- ER Tufte (1990) Envisioning information. Graphics Press.
- ER Tufte (1997) Visual explanations. Graphics Press.
- A Gelman, C Pasarica, R Dodhia (2002) Let's practice what we preach: Turning tables into graphs. The American Statistician 56:121-130
- NB Robbins (2004) Creating more effective graphs. Wiley
- Nature Methods columns: <http://bang.clearscience.info/?p=546>
- These slides: tinyurl.com/graphs2017