A GIRL GEEK'S GUIDE TO NEW RESEARCH ON INTERACTIVE DATA VISUALIZATION FOR STATISTICS WITH LOTS OF DATA

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OUTLINE

- Break-throughs by women in graphics research
- Graphics research: formal protocol for testing merit of new methods, interactive graphics
- Hurdles, funding, promotions, journal and R package numbers
- Support today (R-Ladies, forwards, pyladies, WISDS), skills

FEMALE PIONEERS

Kruskal

1962

1970 **FIRST INSTANCE OF ROTATING DATA IN HIGH-D SPACE**
Jih-Jie Chang, Real-time Rotation,
http://stat-graphics.org/movies/rotation.html

Tukey, PRIM-9

1973

S

1976 http://blog.revolutionanalytics.com/2016/07/rick-becker-s-talk.html

1978 **FIRST EXAMPLE OF BRUSHING A PLOT**

Carol Newton, Graphics: From Alpha to Omega in Data Analysis

Becker & McGill Brushing a Scatterplot Matrix

1985

1988 Catherine Hurley, with Buja, Stuetzle, McDonald

1989 Marilyn Becker, Linda Clark with Pregibon; Tree tools

1991 Penny Rheingans with Young; Psychometrics

1991 Deborah F. Swayne XGobi

There have always been women involved in graphics research

SKILLS REQUIRED

- Curiosity, persistence
- Foundations of statistical theory and methods
- Computing languages, R, and a lower level or some classical training
- Experience working with data, e.g. JSM Data Expo's, InfoVis challenges, kaggle
- Interactive data visualisation methodology
- Payoff is huge - researchers in this area are in high demand in highly paid interdisciplinary academic research positions, and especially in industry

STATE OF THE ART

- R fabulous static plots, and
  - close integration with models and
  - statistical thinking and
  - inference
- Interactive graphics: 10 steps back from software in the 90s
  - Programmmability
  - Tight links with modelling
  - Portability
  - Speed and data size
  - Different kinds of linking, brushes
  - Conceptual frameworks

Messy data

```
head(messy_data)
```

```
## # A tibble: 6 × 22
##    iso2  year  m_04 m_514 m_014 m_1524 m_2534 m_3544 m_4554 m_5564  m_65
##   <chr> <int> <int> <int> <int>  <int>  <int>  <int>  <int>  <int> <int>
## 1    AD  1989    NA    NA    NA     NA     NA     NA     NA     NA    NA
## 2    AD  1990    NA    NA    NA     NA     NA     NA     NA     NA    NA
## 3    AD  1991    NA    NA    NA     NA     NA     NA     NA     NA    NA
## 4    AD  1992    NA    NA    NA     NA     NA     NA     NA     NA    NA
## 5    AD  1993    NA    NA    NA     NA     NA     NA     NA     NA    NA
## 6    AD  1994    NA    NA    NA     NA     NA     NA     NA     NA    NA
## # ... with 11 more variables: m_u <int>, f_04 <int>, f_514 <int>,
## #   f_014 <int>, f_1524 <int>, f_2534 <int>, f_3544 <int>, f_4554 <int>,
## #   f_5564 <int>, f_65 <int>, f_u <int>
```

random variables

X_1 X_2 X_3 X_4 X_5

Tidy data

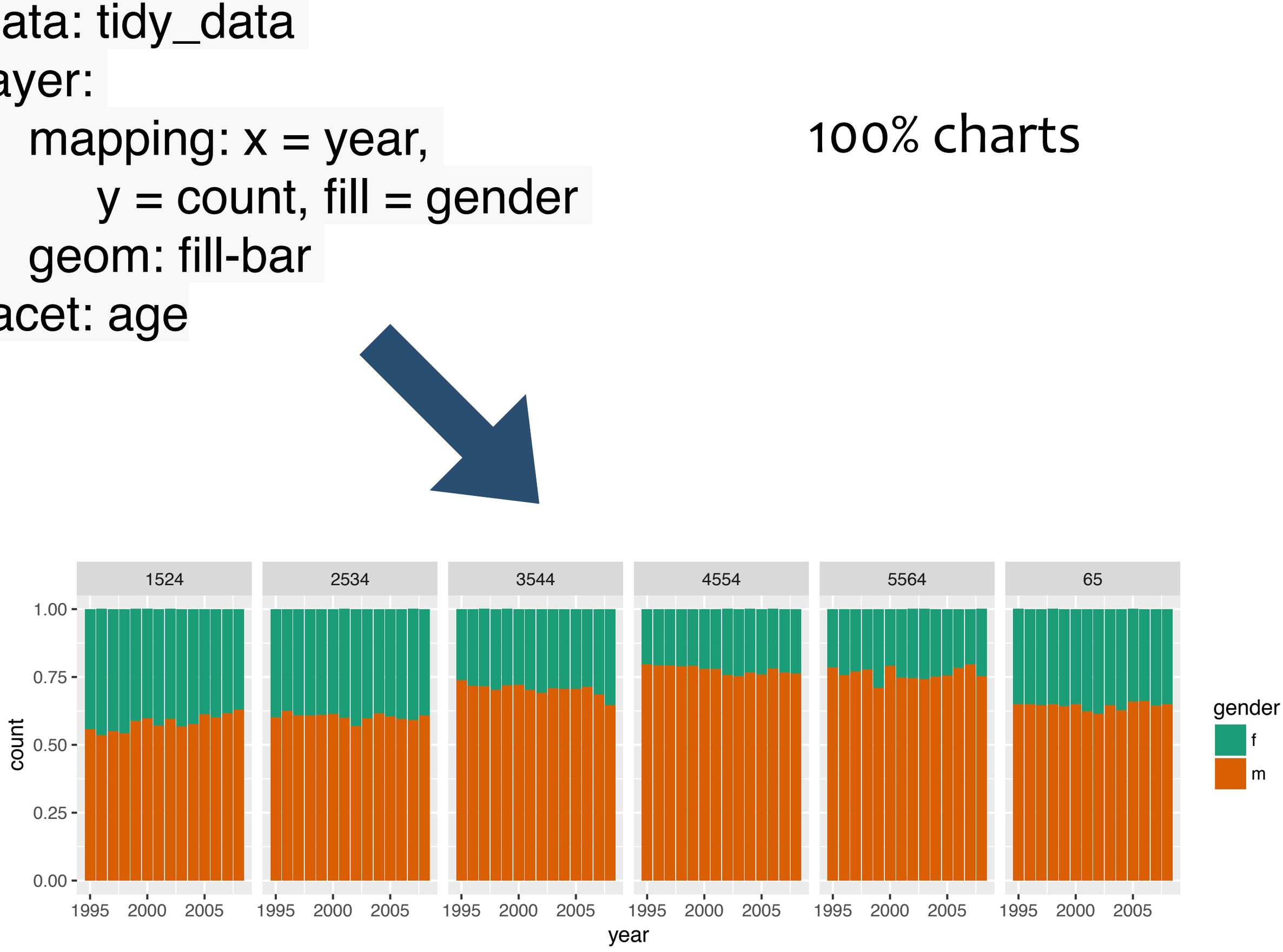
```
## # A tibble: 6 × 5
##    iso2  year gender   age count
##   <chr> <int>  <chr> <chr> <int>
## 1    AD  1996      m  1524     0
## 2    AD  1997      m  1524     0
## 3    AD  1998      m  1524     0
## 4    AD  1999      m  1524     0
## 5    AD  2000      m  1524     0
## 6    AD  2002      m  1524     0
```

```
## # A tibble: 6 × 5
##    iso2  year gender   age count
##   <chr> <int>  <chr> <chr> <int>
## 1    AD  1996      m  1524     0
## 2    AD  1997      m  1524     0
## 3    AD  1998      m  1524     0
## 4    AD  1999      m  1524     0
## 5    AD  2000      m  1524     0
## 6    AD  2002      m  1524     0
```

```
data: tidy_data
layer:
    mapping: x = year,
          y = count, fill = gender
    geom: fill-bar
facet: age
```

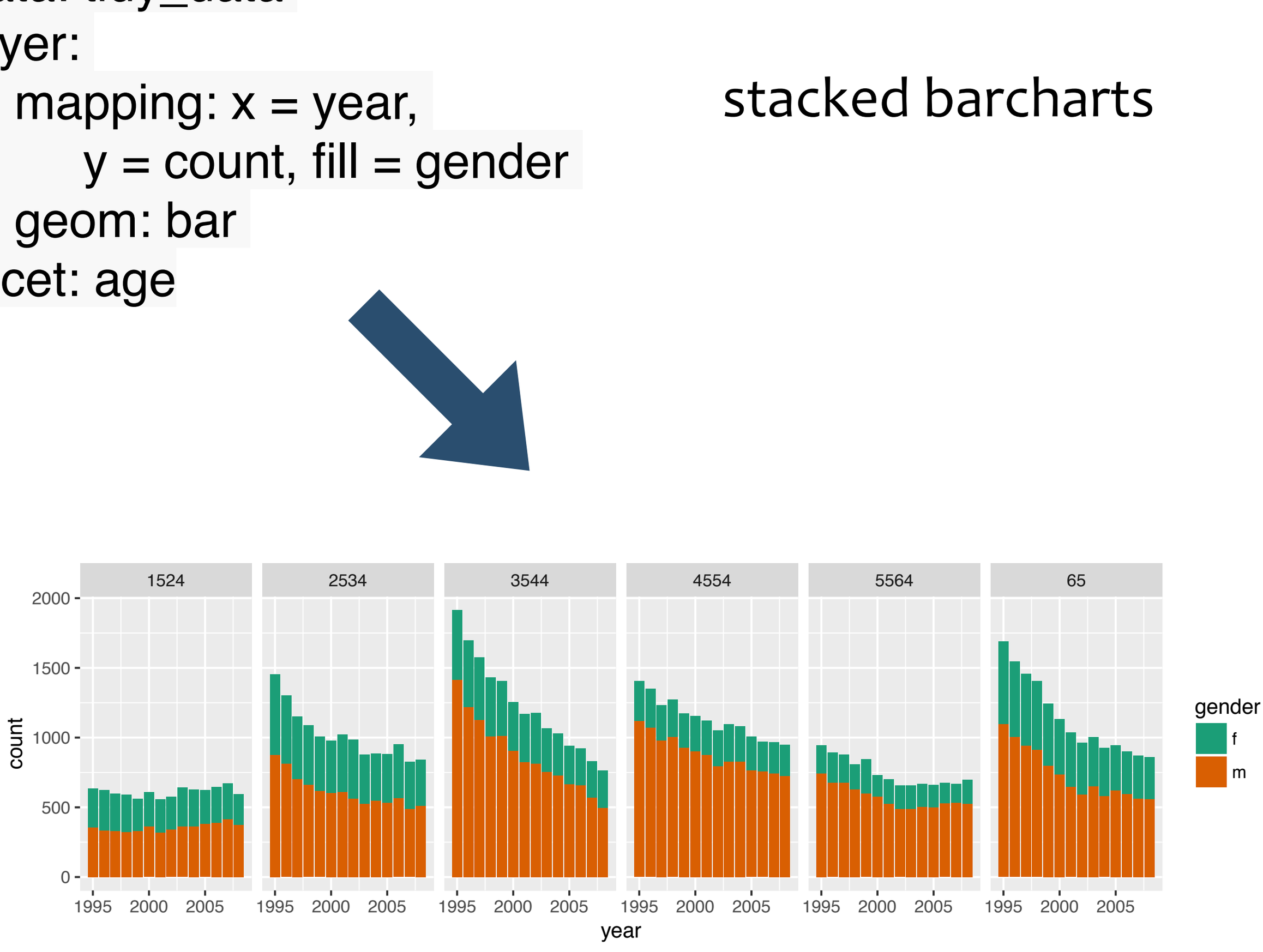
```
data: tidy_data
layer:
    mapping: x = year,
         y = count, fill = gender
    geom: fill-bar
facet: age
```

100% charts



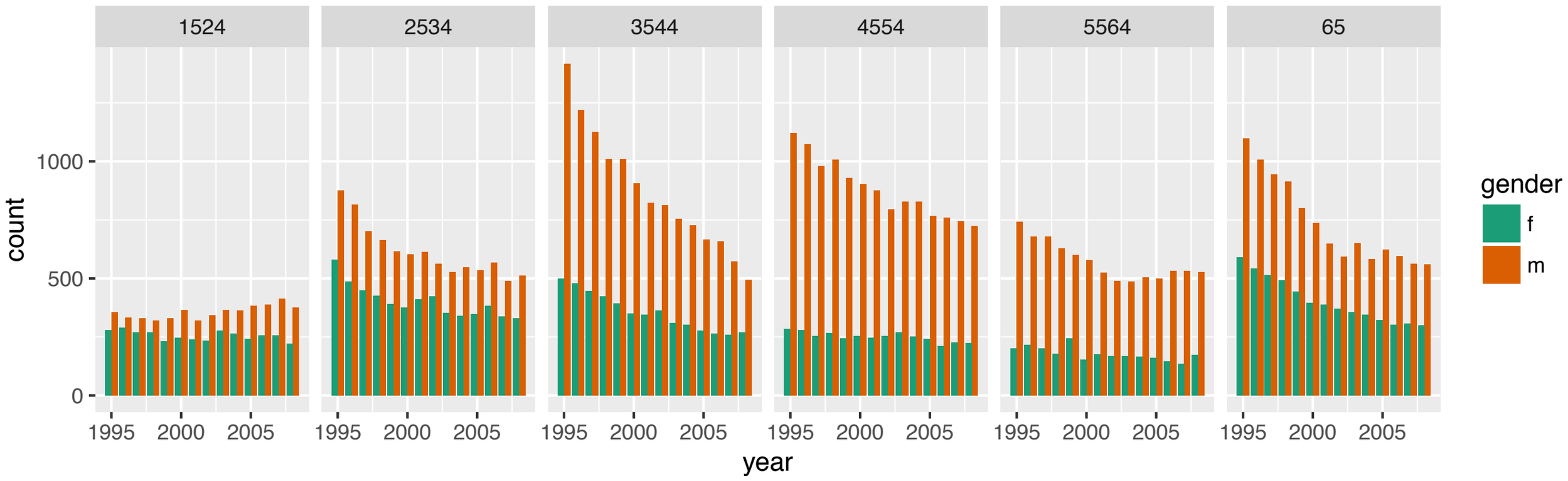
```
data: tidy_data
layer:
    mapping: x = year,
        y = count, fill = gender
    geom: bar
facet: age
```

stacked barcharts



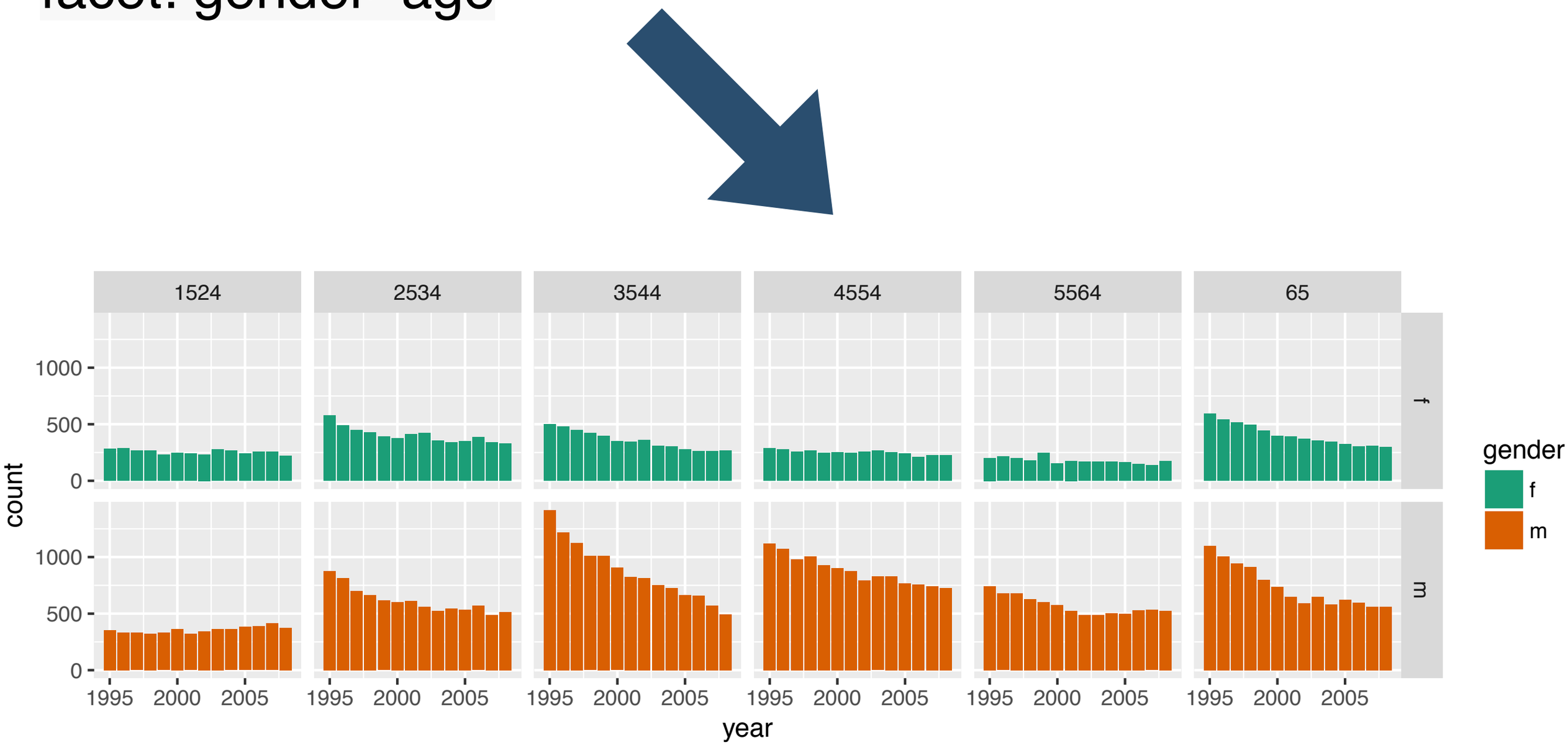
```
data: tidy_data
layer:
    mapping: x = year,
        y = count, fill = gender
    geom: dodge-bar
facet: age
```

side-by-side bar charts



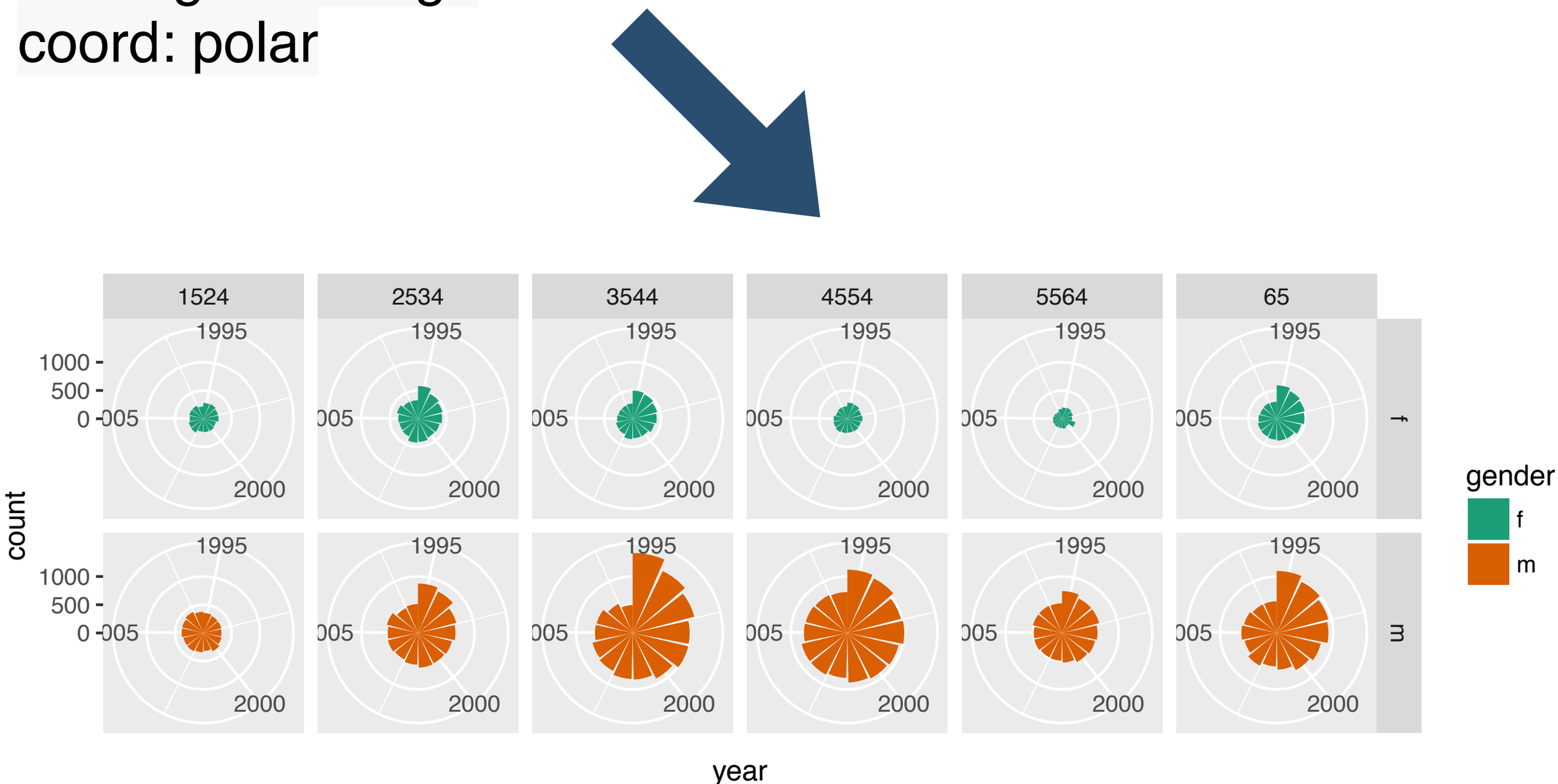
```
data: tidy_data
layer:
    mapping: x = year,
         y = count, fill = gender
    geom: bar
facet: gender~age
```

bar charts



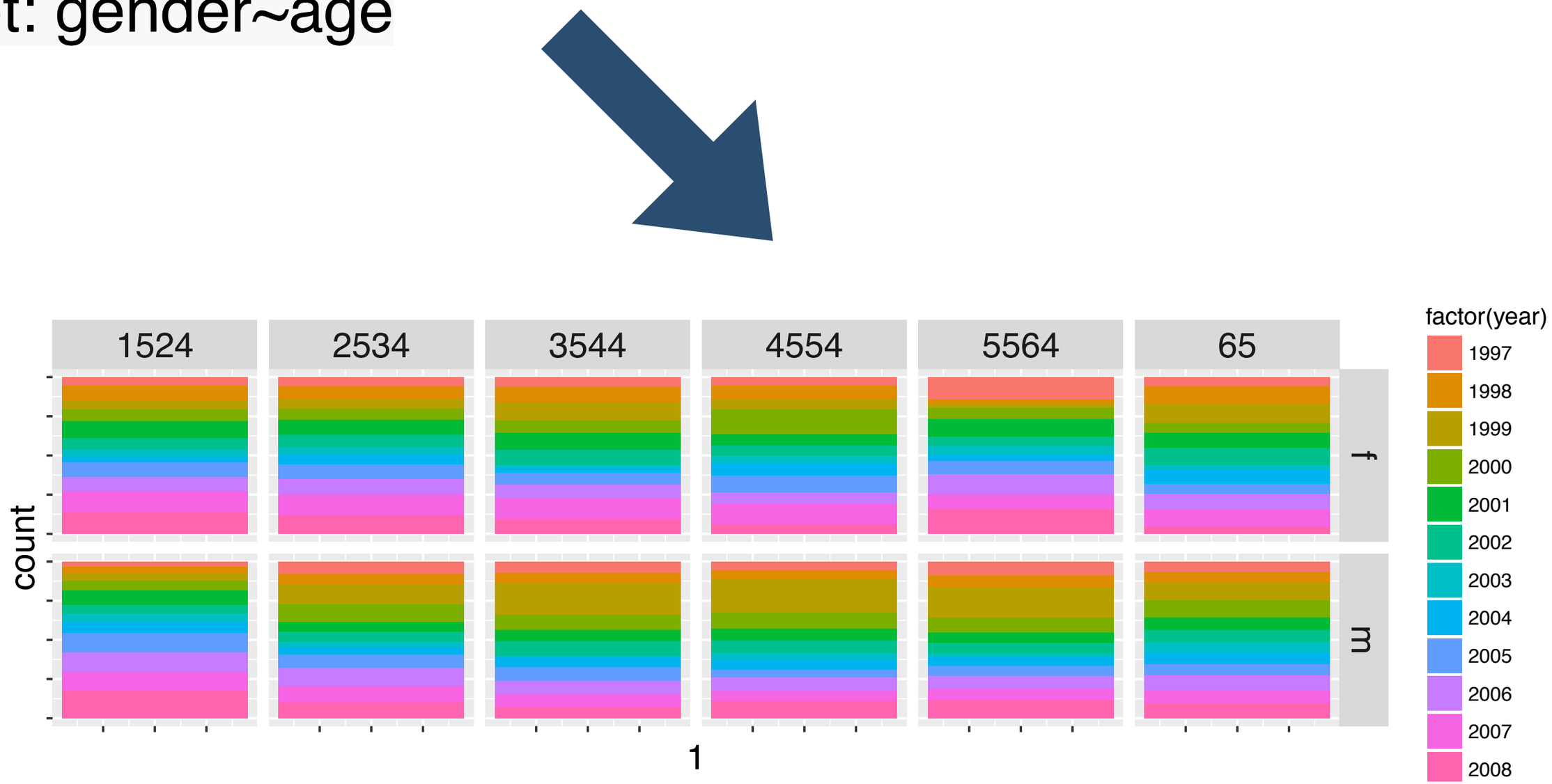
```
data: tidy_data
layer:
    mapping: x = year,
         y = count, fill = gender
    geom: bar
facet: gender~age
coord: polar
```

rose plots



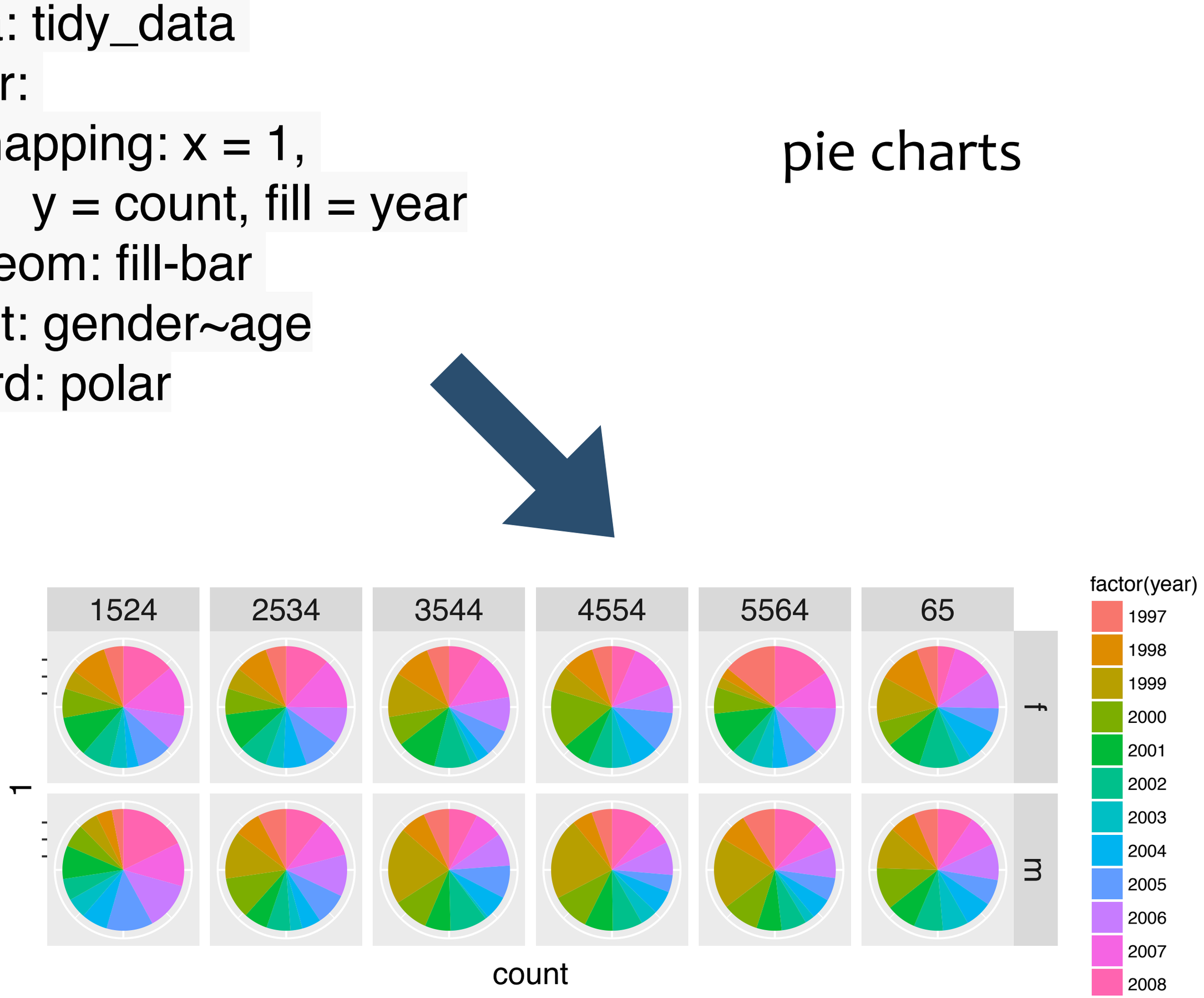
```
data: tidy_data
layer:
    mapping: x = 1,
        y = count, fill = year
    geom: fill-bar
facet: gender~age
```

100% charts



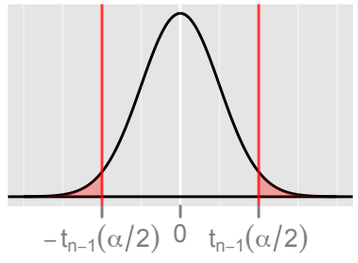
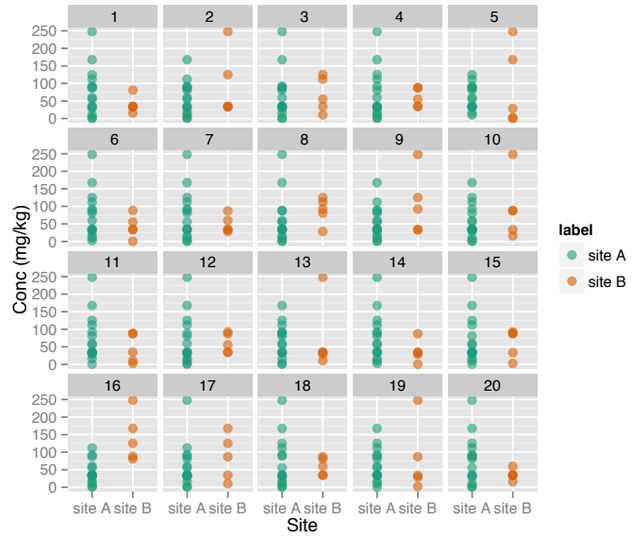
```
data: tidy_data
layer:
    mapping: x = 1,
         y = count, fill = year
    geom: fill-bar
facet: gender~age
coord: polar
```

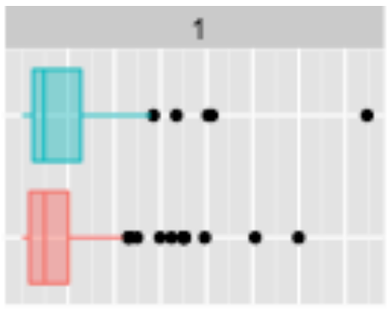
pie charts



http://knowyourmeme.com/memes/morphing/photos/sort/favorites

VISUAL INFERENCE

	Mathematical Inference	Visual Inference
Hypothesis	$H_o : \mu_1 = \mu_2$ vs $H_a : \mu_1 \neq \mu_2$	$H_o : \mu_1 = \mu_2$ vs $H_a : \mu_1 \neq \mu_2$
Test Statistic	$T(y) = \frac{\overline{y}_1 - \overline{y}_2}{s\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$	$V(y) =$ 
Sampling Distribution	$f_{T(y)}(t);$ 	$f_{V(y)}(t);$ 
Reject H_o if	observed T is extreme	observed data plot is identifiable



What is the question?

Is there a difference between the two groups

Ho: no difference, H_1: difference

What is the data?

Two variables: V1, V2; V1 is categorical

What is the mapping?

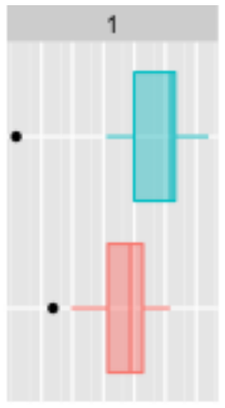
x=V2, y=V1, colour=V1
geom=boxplot

What is a null generating mechanism?

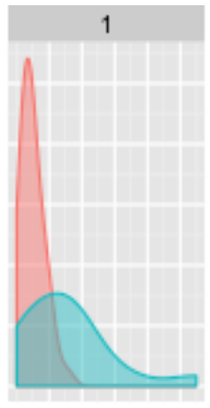
permute the values of V1, relative to V2

boxplot_3_135_135_12_13

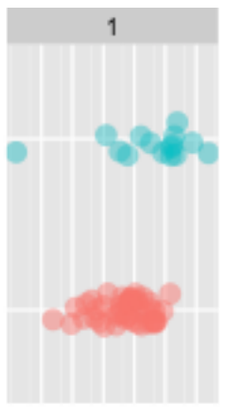
Which is the Best design?



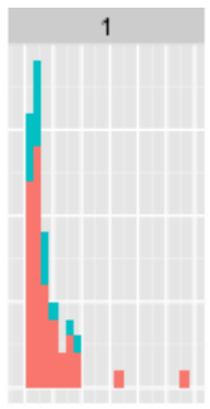
mapping:
x = V_2
y = V_1
geom: boxplot



mapping:
x = V_1
color = V_2
geom: density



mapping:
x = V_2
y = V_1
geom: dotplot

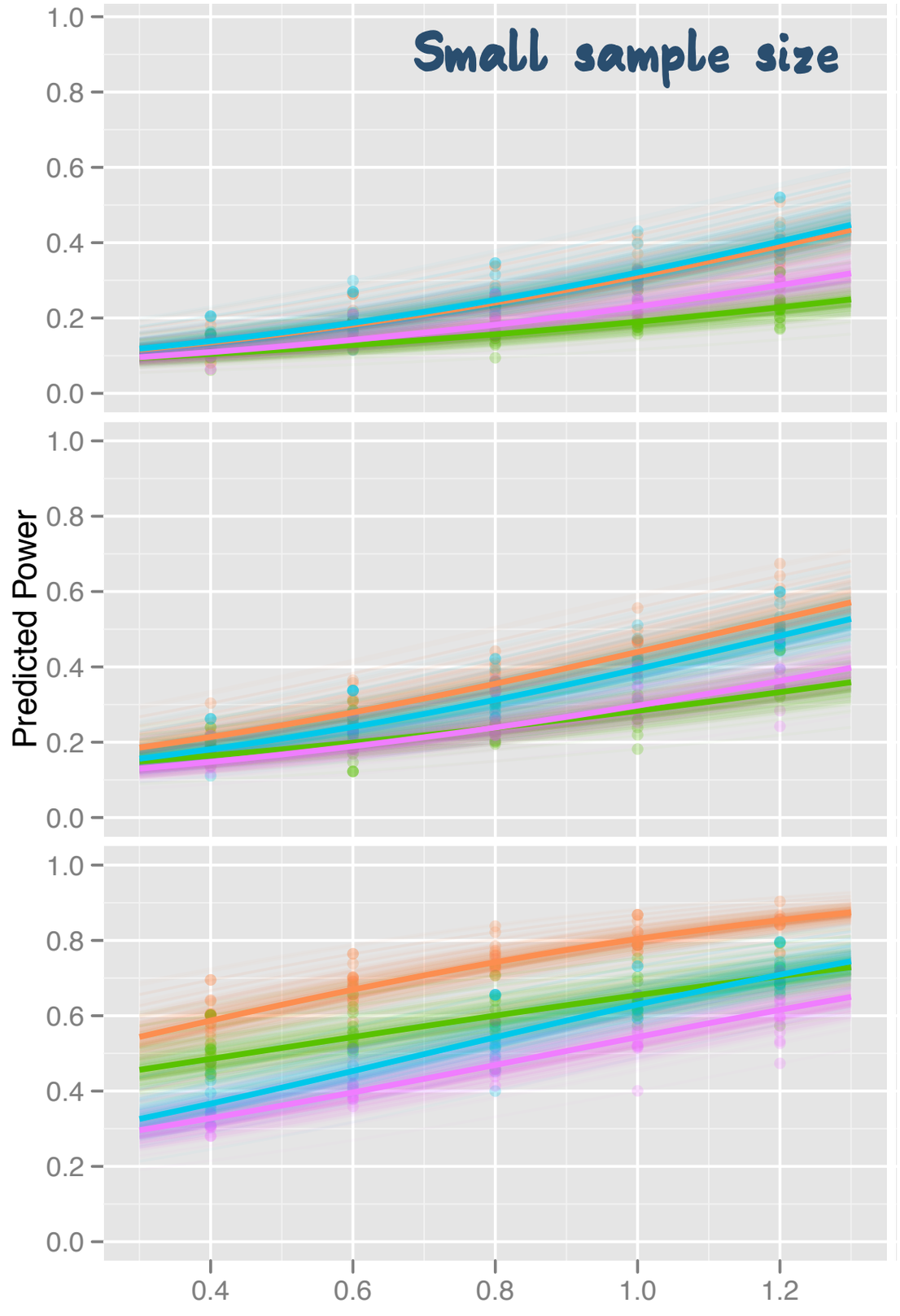


mapping:
x = V_1
color = V_2
geom: histogram

Compute power for each design.
The design which allows reader to detect the difference more frequently is the most powerful statistic.

People detect the data plot significantly more often when side-by-side boxplots are used, except when the sample size is small, and then side-by-side dotplots win

Hofmann et al "Comparing Designs" InfoVis 2012



INTERACTIVE GRAPHICS

Show some video, particularly of Deb
What can be done today, tourr packa
What are the weak points
https://github.com/dicook/useR.201

- There have been a lot of advances in interactive graphics in the last couple of years, e.g. plotly (Sievert), ggvis (Wickham), htmlwidgets (RStudio), rbokeh (Hafen), crosstalk (Cheng), rCharts (Vaidyanathan), ...
- BUT we are still decades behind the state-of-the-art of the 90s
- The gold standards were XLispStat, DataDesk, XGobi/GGobi

http://stat-graphics.org/movies/xgobi.html

0:56 / 11:58

PLOTLY

- Takes a ggplot2 object and converts to javascript
- Mouse over labels are easy
- Brushing of groups of points possible, bit harder
- Linking between plots possible, a little trickier
- Tours, rotation in high-d, possible via animation, not live projection computation

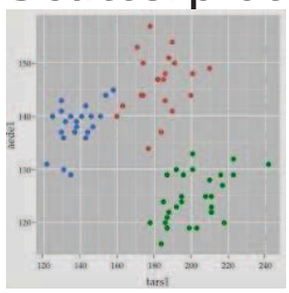
See Australian election app https://vimeo.com/167367369

CRANVAS

- qt widget set - speed, but trouble with portability
- R wrappers to qt functionality
- Fixed set of plot types, but new could be programmed directly in R
- Have to program plots from first principles
- Brushes and linking defined
- Linking by mutable objects (plumbr), and reference classes (ObjectSignals)

Xie, Cheng, Hofmann, Cook, Schloerke, Vendettuoli, built on foundation by Lawrence, Wickham

Scatterplot



Meta -- scatterplot

qscatter()

Mutaframe

DATA

Features: e.g. brushed color, size

listener

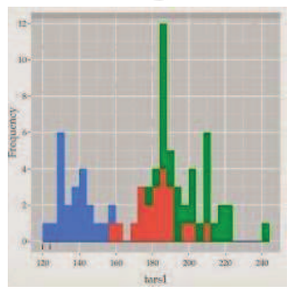
listener

listener

listener

qhist()

Histogram

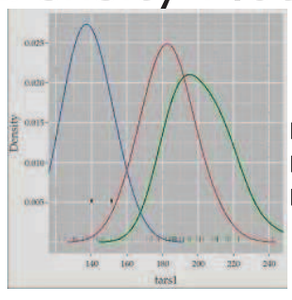


Meta -- histogram

qparallel()

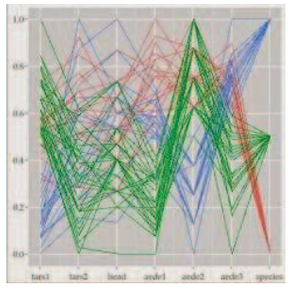
qdensity()

Density Plot



Meta -- density plot

Parallel Coordinates Plot



Meta -- para coord plot

```
library(cranvas)
data(nrcstat)
nrcstat$Inst.Prg <- paste(nrcstat$Institution, nrcstat$ProgramName)
nrcdist <- dist(scale(nrcstat[,c(20,21,26,30,32,33,34,36,41,43,46)]))
nrc.hc <- hclust(nrcdist, method="ward")
plot(nrc.hc)
nrc.clust <- data.frame(nrc, cl2=cutr
                        cl3=cutree(n
                        cl4=cutree(n
                        cl5=cutree(n
                        cl6=cutree(n
                        cl7=cutree(n
                        cl8=cutree(n
qnrc.clust <- qdata(nrc.clust)
qparallel(c(20,21,26,30,32,33,34,36,41,43,46), data=qnrc.clust,
          center = median, horizontal=T, glyph = "tick")
qparallel(80:74, data=qnrc.clust, horizontal=T,
          jitter=c("cl2","cl3","cl4","cl5","cl6","cl7","cl8"))
qscatter(RRankings5th, SRankings5th, data=qnrc.clust)
record_selector(Inst.Prg, qnrc.clust)
```

Load library, data, add better id variable

Use Euclidean distance

Open a pcp on ranking criteria, pcp for dendrogram, scatterplot, and label browser

Set up data for cranvas

iShowU-Capture71.mov

Parallel coordinate plot of ranking criteria

Dendrogram displaying results from 2-8 clusters

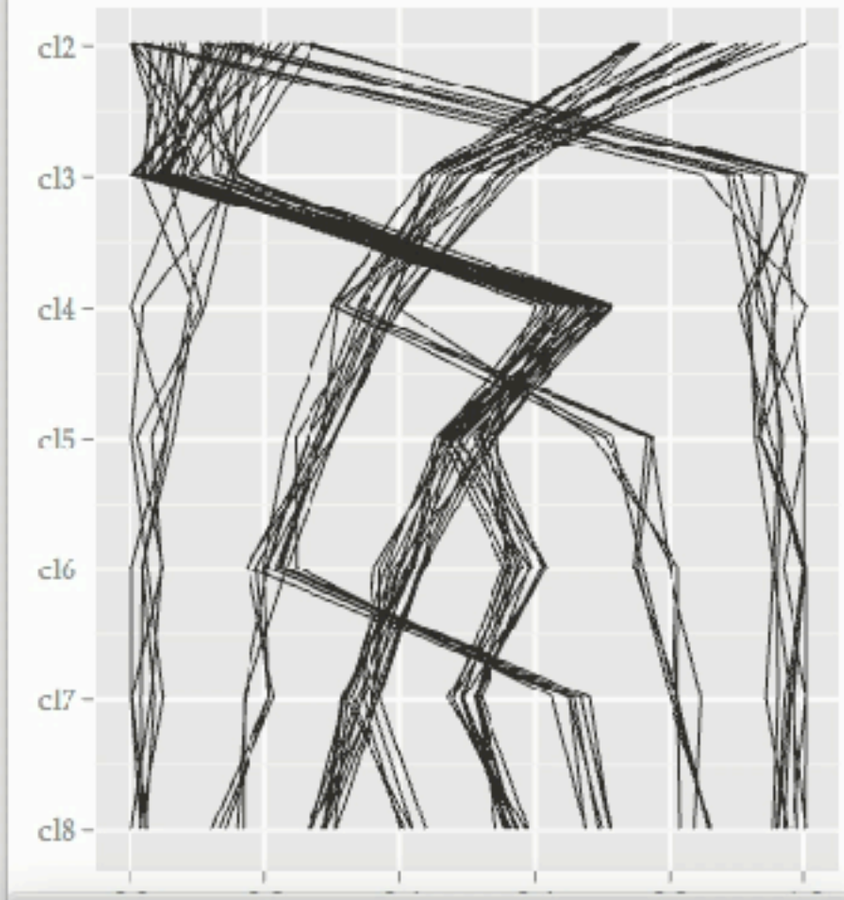
List of programs

Scatterplot of ranks by two different schemes

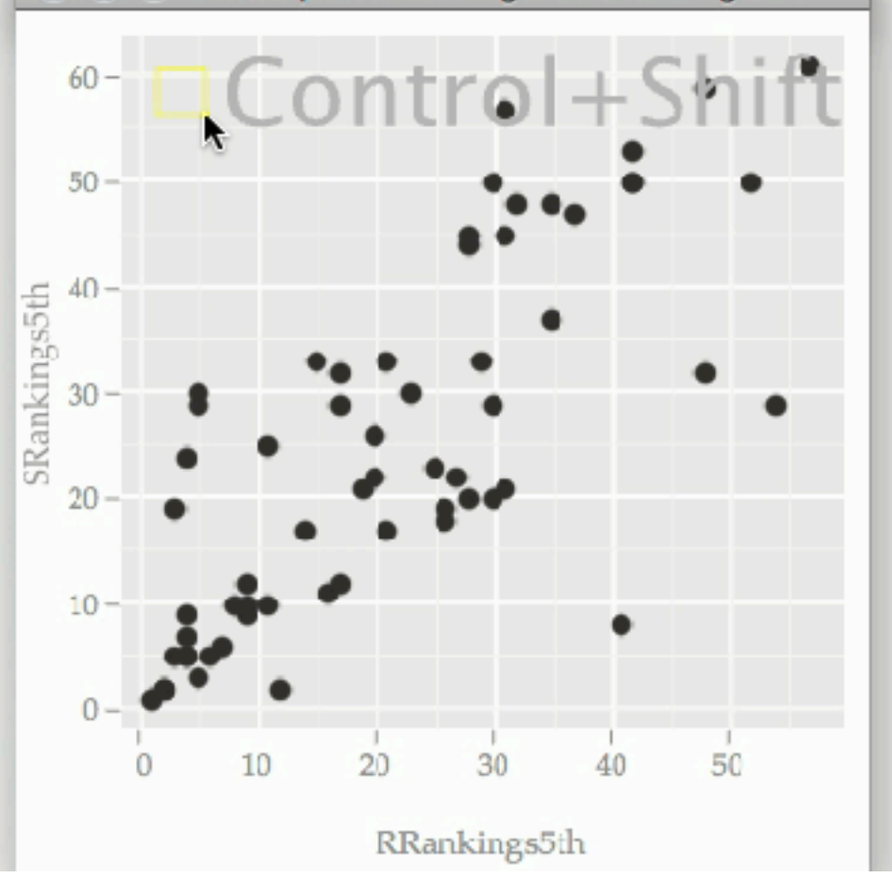
00:00:00 -00:01:27

Par-coords plot: AvNumPubs, AvCitations, MedianTimetoDegr...

Par-coords plot: cl8, cl7, cl6, cl5, cl4, cl...



Scatterplot: RRankings5th SRankings5th



Record Selector: Inst.Prg

BOSTON UNIVERSITY Biostatistics
CARNEGIE MELLON UNIVERSITY Statistics
CASE WESTERN RESERVE UNIVERSITY Stat
COLORADO STATE UNIVERSITY Statistics
COLUMBIA UNIVERSITY IN THE CITY OF N
CORNELL UNIVERSITY Biometry
CORNELL UNIVERSITY Statistics
DUKE UNIVERSITY Statistics and Decision
FLORIDA STATE UNIVERSITY Statistics
GEORGE WASHINGTON UNIVERSITY Statis
HARVARD UNIVERSITY Statistics
IOWA STATE UNIVERSITY Statistics
JOHNS HOPKINS UNIVERSITY Applied Mat
KANSAS STATE UNIVERSITY Statistics
MICHIGAN STATE UNIVERSITY Statistics
NORTH CAROLINA STATE UNIVERSITY Sta
NORTH DAKOTA STATE UNIVERSITY MAI
NORTHWESTERN UNIVERSITY Statistics
OHIO STATE UNIVERSITY MAIN CAMPUS E
OHIO STATE UNIVERSITY MAIN CAMPUS S
OKLAHOMA STATE UNIVERSITY MAIN CA
OREGON STATE UNIVERSITY Statistics
PENN STATE UNIVERSITY Statistics
PURDUE UNIVERSITY MAIN CAMPUS Statis
RICE UNIVERSITY Statistics
RUTGERS THE STATE UNIVERSITY OF NEW
SOUTHERN METHODIST UNIVERSITY Stati
STANFORD UNIVERSITY Statistics
TEMPLE UNIVERSITY Statistics
TEXAS A & M UNIVERSITY Statistics
UNIVERSITY OF CALIFORNIA-BERKELEY St
UNIVERSITY OF CALIFORNIA-DAVIS Statis
UNIVERSITY OF CALIFORNIA-LOS ANGELE
UNIVERSITY OF CALIFORNIA-RIVERSIDE A
UNIVERSITY OF CALIFORNIA-SANTA BARE
UNIVERSITY OF CHICAGO Statistics
UNIVERSITY OF CONNECTICUT Statistics
UNIVERSITY OF FLORIDA Statistics
UNIVERSITY OF GEORGIA Statistics

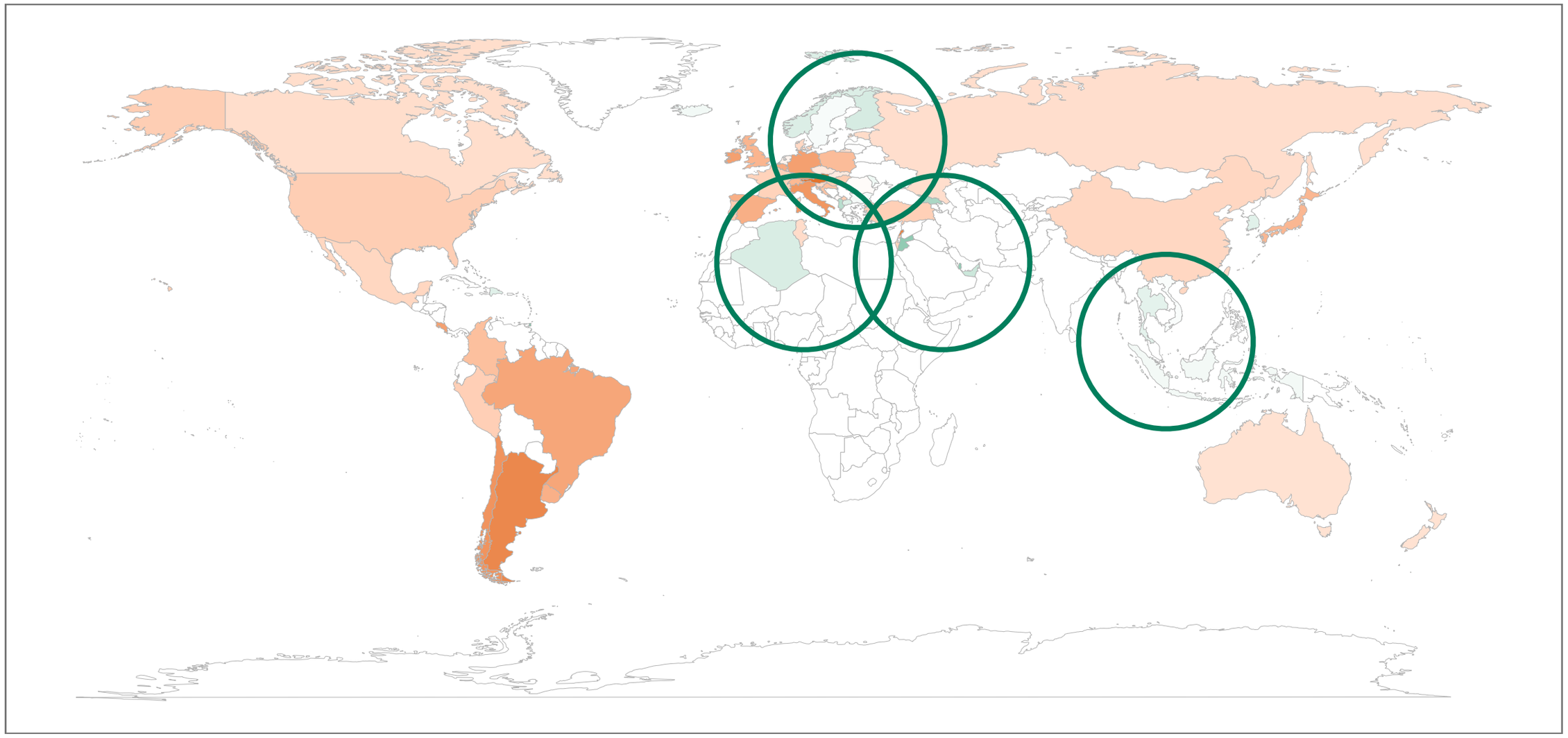
INTERACTIVE GRAPHICS

- cranvas not portable!
- More detailed wish list for research activity are at **https://github.com/dicook/useR.2015** (Keynote talk at useR! 2015 Denmark)
- Group started discussing more complete, portable system options at **https://github.com/ropenscilabs/rivis** - keen to get people involved, open discussion, no real leader, but support for anyone interested in the area.

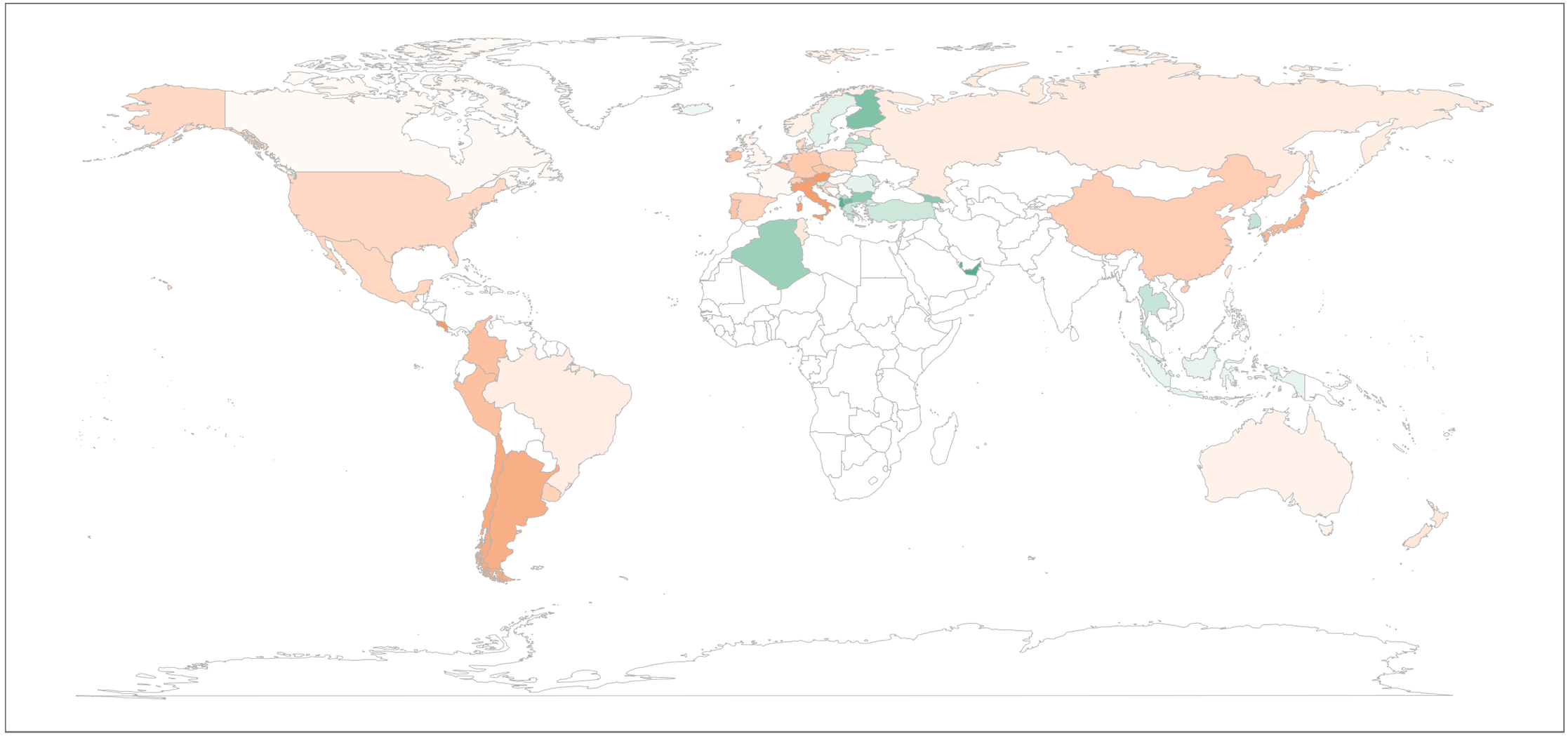
Why get involved?

- myth busting
- gender/diversity (im)balance

PISA - MATH



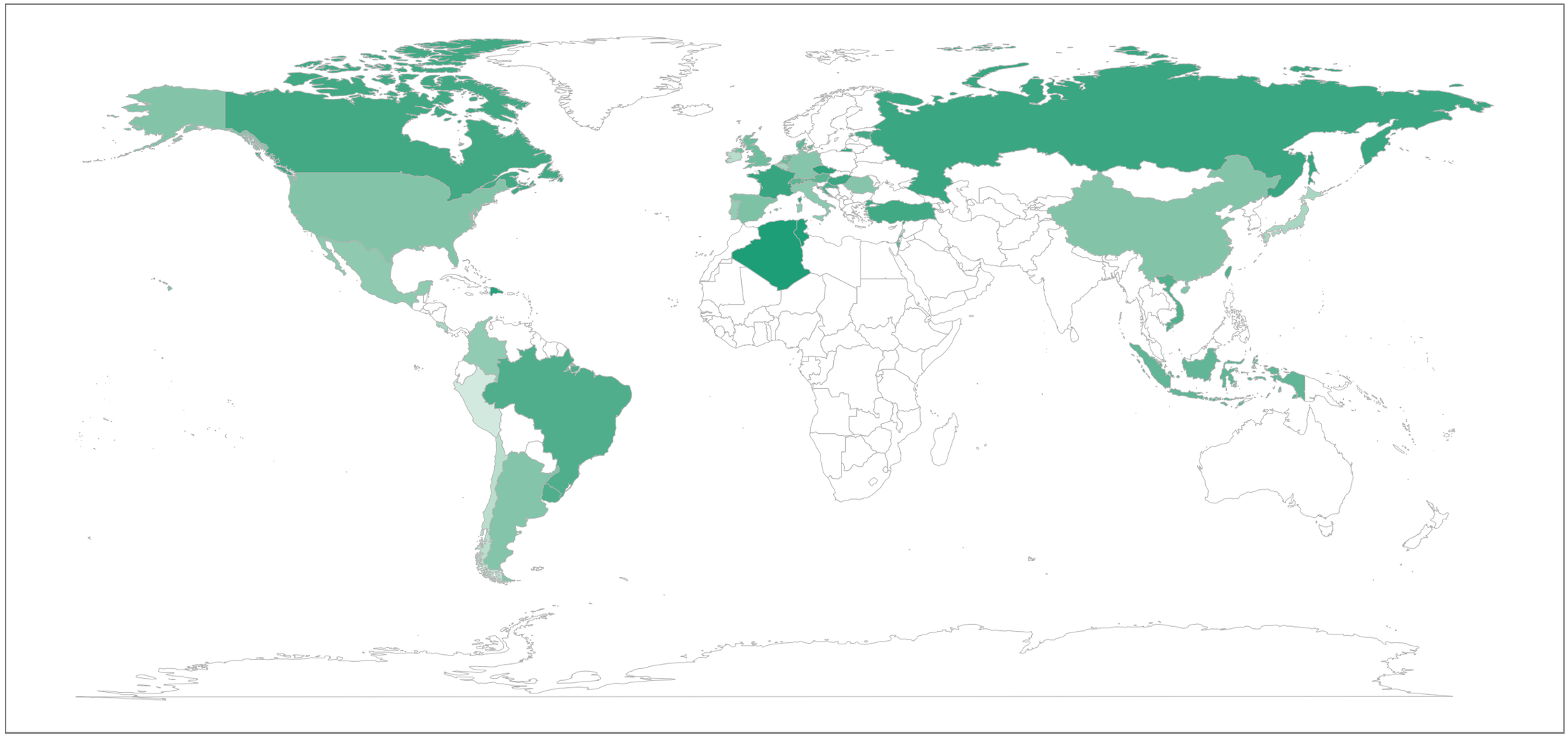
PISA - SCIENCE



Science gap

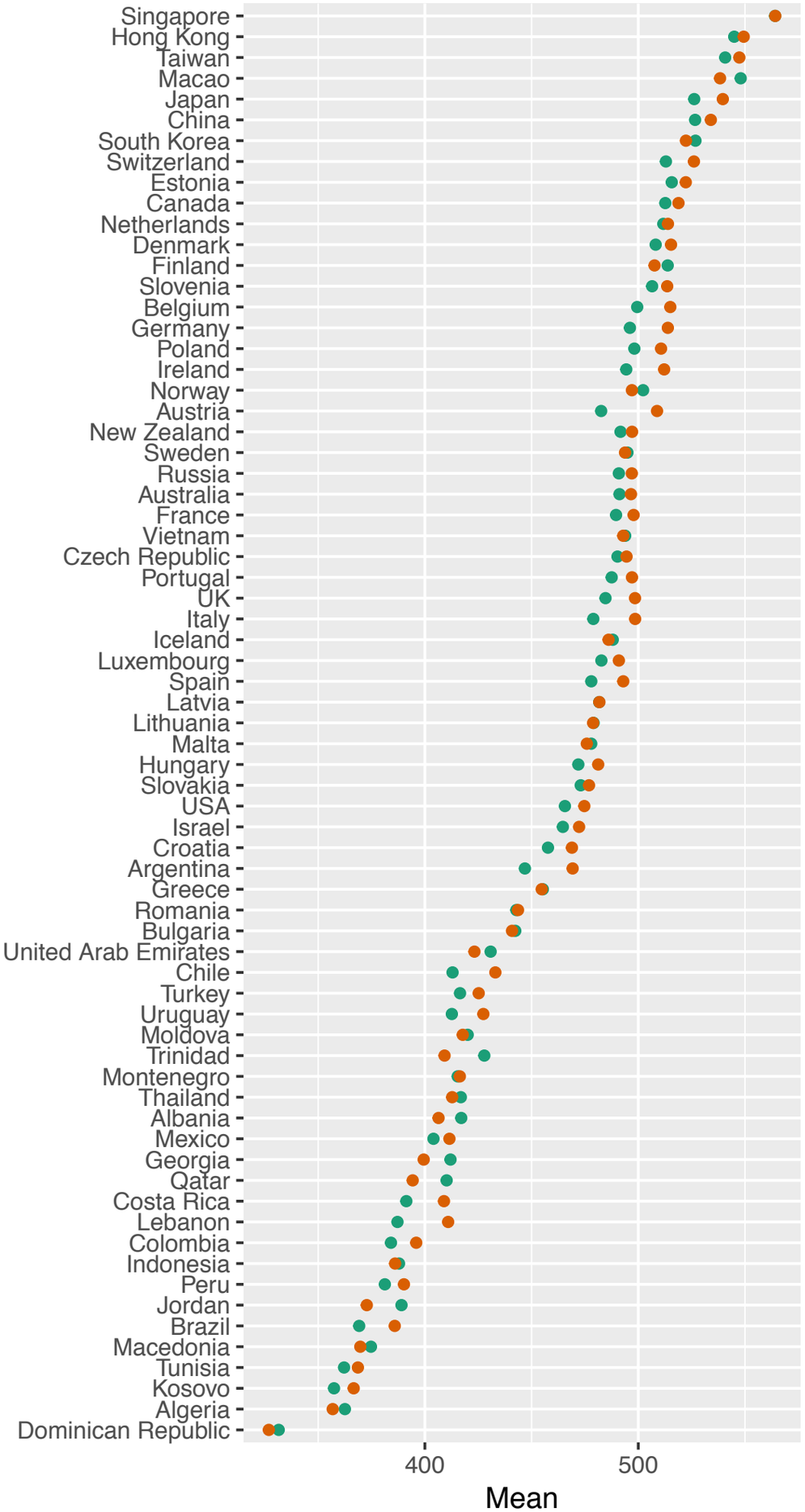
−30 −20 −10 0 10 20 30

PISA - READING

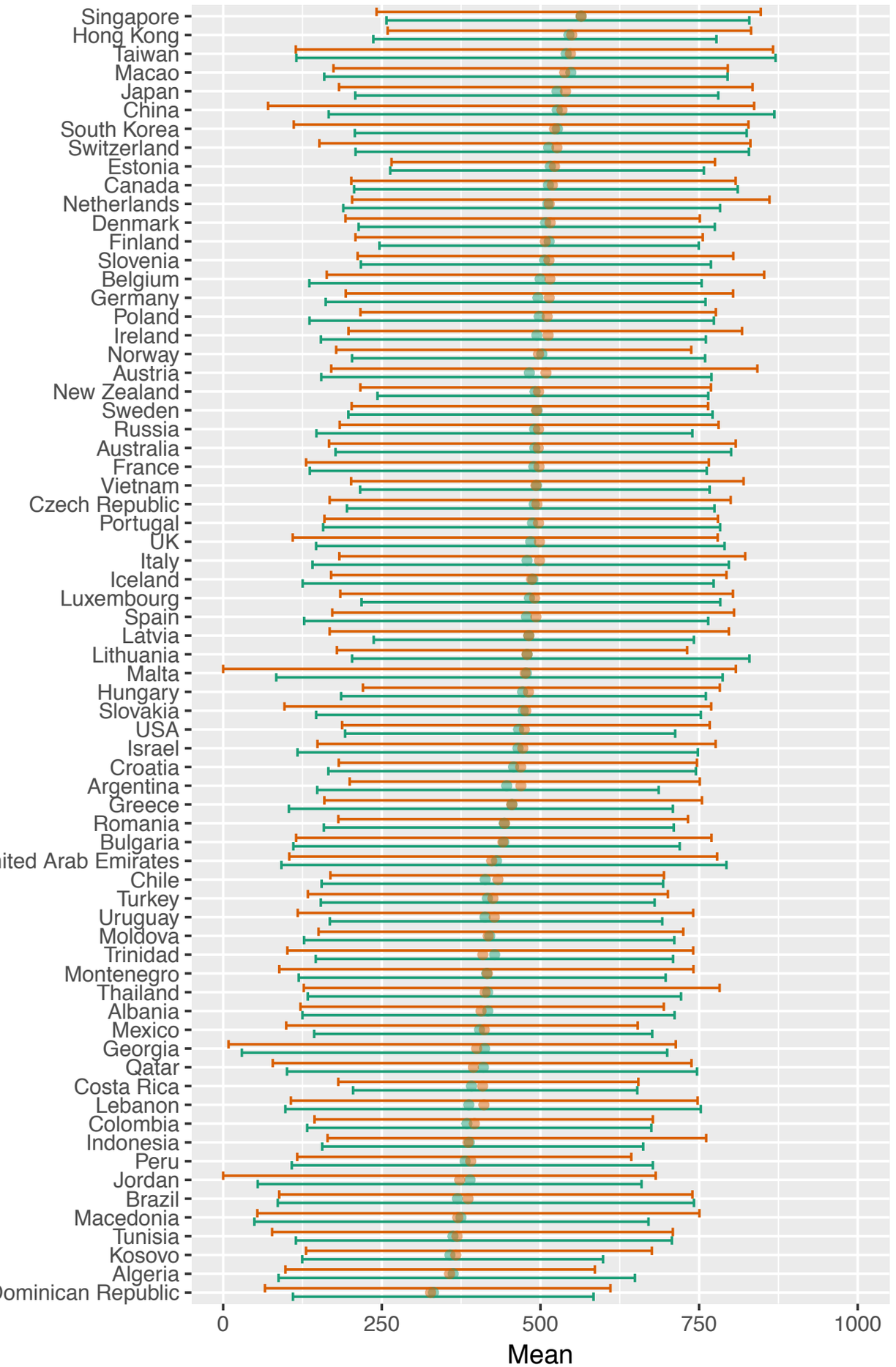


Reading gap

–30 –20 –10 0 10 20 30


Singapore
Hong Kong
Taiwan
Macao
Japan
China
South Korea
Switzerland
Estonia
Canada
Netherlands
Denmark
Finland
Slovenia
Belgium
Germany
Poland
Ireland
Norway
Austria
New Zealand
Sweden
Russia
Australia
France
Vietnam
Czech Republic
Portugal
UK
Italy
Iceland
Luxembourg
Spain
Latvia
Lithuania
Malta
Hungary
Slovakia
USA
Israel
Croatia
Argentina
Greece
Romania
Bulgaria
United Arab Emirates
Chile
Turkey
Uruguay
Moldova
Trinidad
Montenegro
Thailand
Albania
Mexico
Georgia
Qatar
Costa Rica
Lebanon
Colombia
Indonesia
Peru
Jordan
Brazil
Macedonia
Tunisia
Kosovo
Algeria
Dominican Republic
400
500
Mean


ST004I
fem
mal


Singapore
Hong Kong
Taiwan
Macao
Japan
China
South Korea
Switzerland
Estonia
Canada
Netherlands
Denmark
Finland
Slovenia
Belgium
Germany
Poland
Ireland
Norway
Austria
New Zealand
Sweden
Russia
Australia
France
Vietnam
Czech Republic
Portugal
UK
Italy
Iceland
Luxembourg
Spain
Latvia
Lithuania
Malta
Hungary
Slovakia
USA
Israel
Croatia
Argentina
Greece
Romania
Bulgaria
United Arab Emirates
Chile
Turkey
Uruguay
Moldova
Trinidad
Montenegro
Thailand
Albania
Mexico
Georgia
Qatar
Costa Rica
Lebanon
Colombia
Indonesia
Peru
Jordan
Brazil
Macedonia
Tunisia
Kosovo
Algeria
Dominican Republic
0
250
500
750
1000
Mean

You as an individual matter more than your demographic!

The perception of ACTUAL gender difference is magnified way out of all proportion, EXCEPT FOR READING!

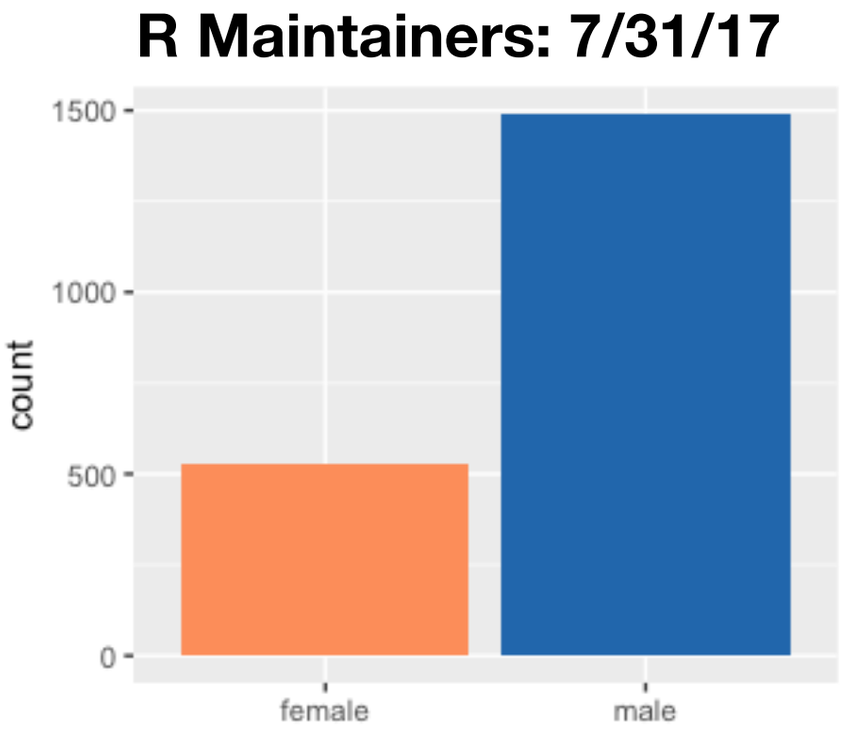
PUBLISHING

Proportion of papers with at least one female author in JCGS (our flagship journal) is low

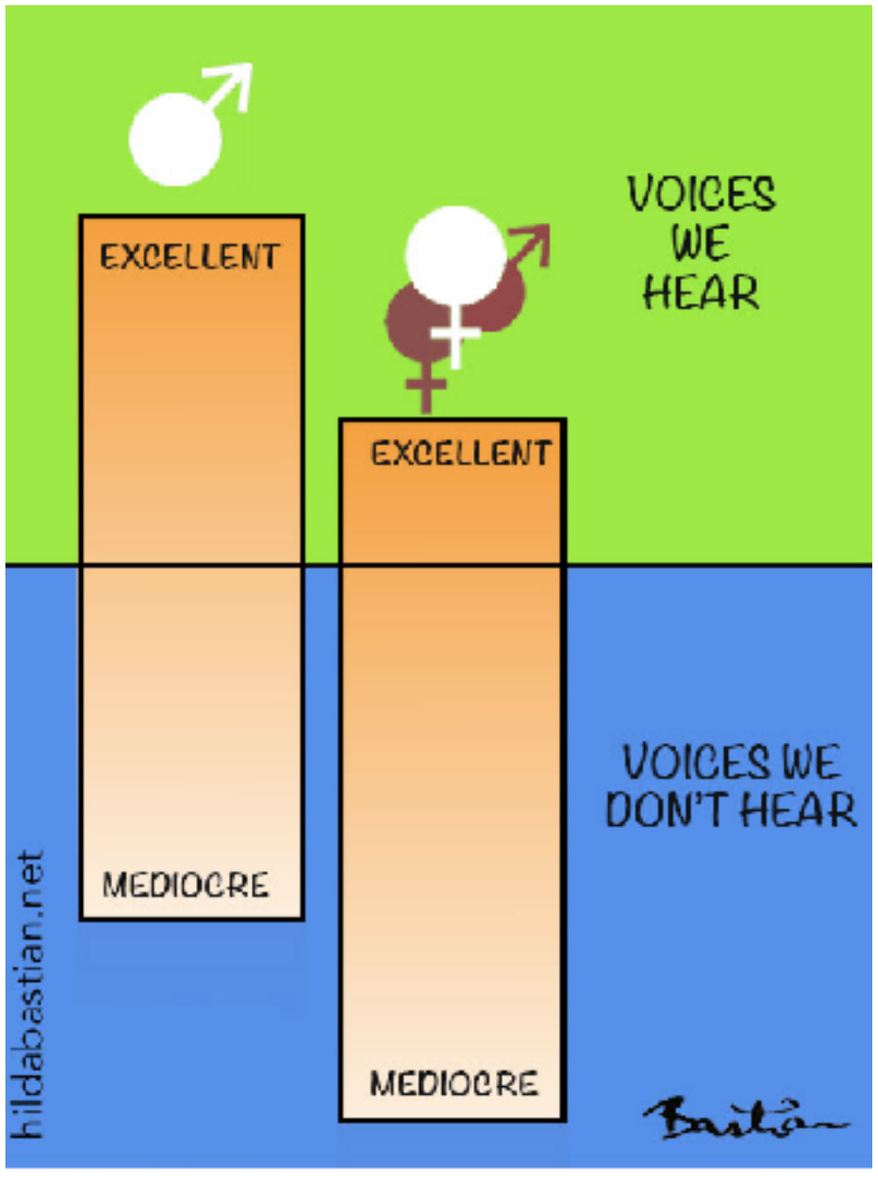
Year	Prop female
2015-2016	0.25
2016-2017	0.33

SOFTWARE

- Proportion of female R package authors and maintainers is low
- 2010 survey of 1087 maintainers of packages on CRAN/ Bioconductor, 9% of package authors were women
- Mar 2016 genderizer analysis of R package maintainers, 11% women
- Jul 31 2017 genderizer analysis of R package maintainers, 26% women!!!!!



ABSOLUTELY MAYBE



LACK OF DIVERSITY CAN BE A GREAT WAY TO OVER-SAMPLE FOR MEDIOCRITY!

Hilda Bastian's blog

This cartoon comes from Jul 22 post "Why Pockets and Waves of De-Feminization in Science's Past Matter Now"

- Get published
- Get research funds
- Get promoted
- You are not alone

SUMMARY

- Data visualisation is a hot topic
- Lots of open problems in interactive graphics, and in thinking of plots at another type of statistic in order to do inference
- Great opportunities to make big contributions in data science
- Lots of room to improve gender imbalance in academic research, and in producing computer softwre

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THANKS FOR COMING!