Hands-on session: Python

Research Data Visualisation Workshop

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Elementary Perceptual Tasks [a]

[a] Cleveland & McGill (1984) *J. Am. Stat. Ass.*

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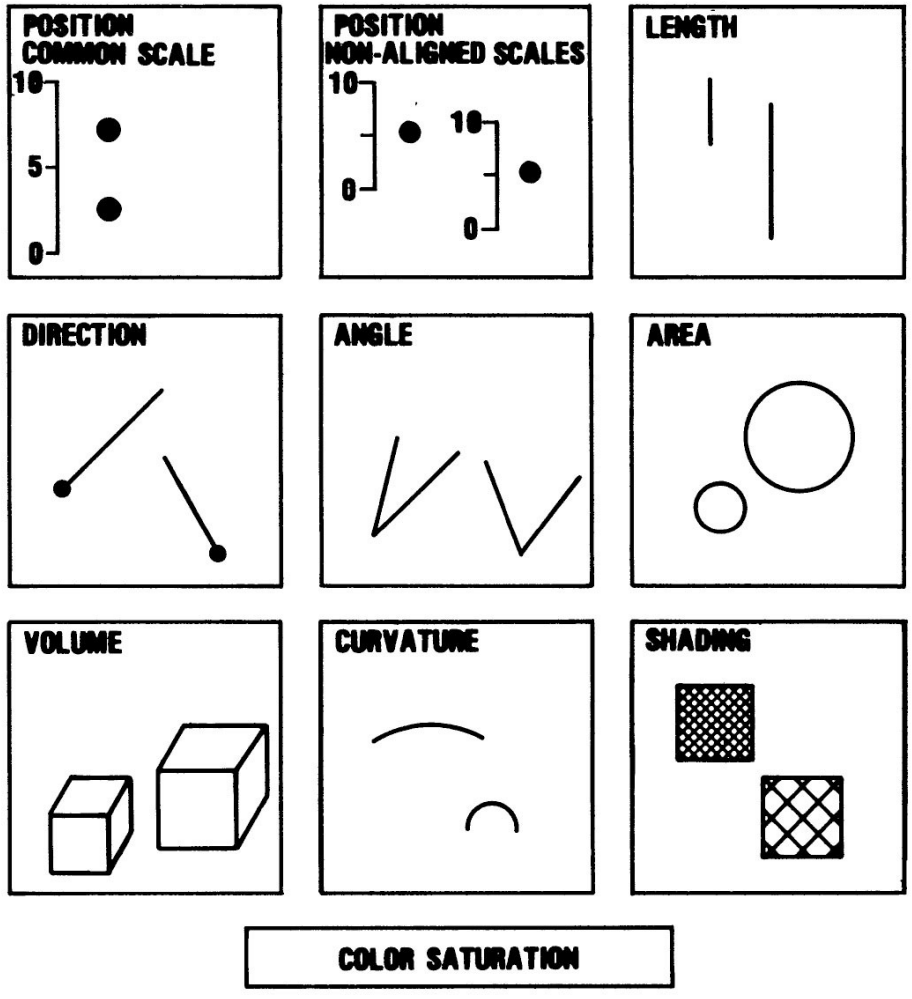
The most basic visual tasks:

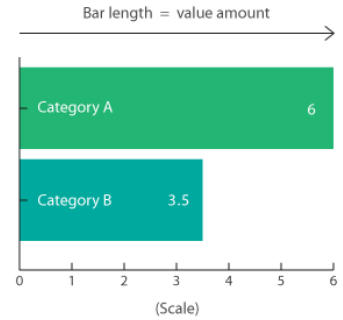


Implementations [a]

[a] http://www.datavizcatalogue.com/

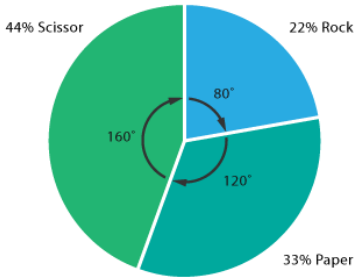
Position: common scale

- Scatterplot
- Bar Chart



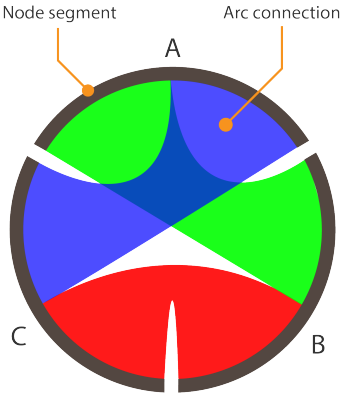
Angle

- Pie Chart
- Do(ugh)nut Chart



Curvature

- Arc Diagram
- Chord Diagram



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What works best? Experiment [a] [b]

[a] Cleveland & McGill (1984) *J. Am. Stat. Ass.*
[b] Heer & Bostock (2010) *CHI 2010*

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Empirical measurements of interpretation

- Subjects shown graphs representing same data
- ($\log_2$) Error in subjects' accuracy compared by graph type

Judgement types

- 1-3: Position on a common scale (bar chart, stacked bar chart)
- 4-5: Length encoding (stacked bar chart)
- 6: Angle (pie chart)
- 7-9: Area (bubble chart, aligned rectangles, treemap)

What works best? Result [a] [b]

[a] Cleveland & McGill (1984) *J. Am. Stat. Ass.*
[b] Heer & Bostock (2010) *CHI 2010*

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- We have inherent biases that can distort information recovered
- Position > Angle ≈ Length > Area
- Accuracy plateaus as charts increase in size
- Gridlines improve accuracy
- Aspect ratios affect area judgements (squares worst)

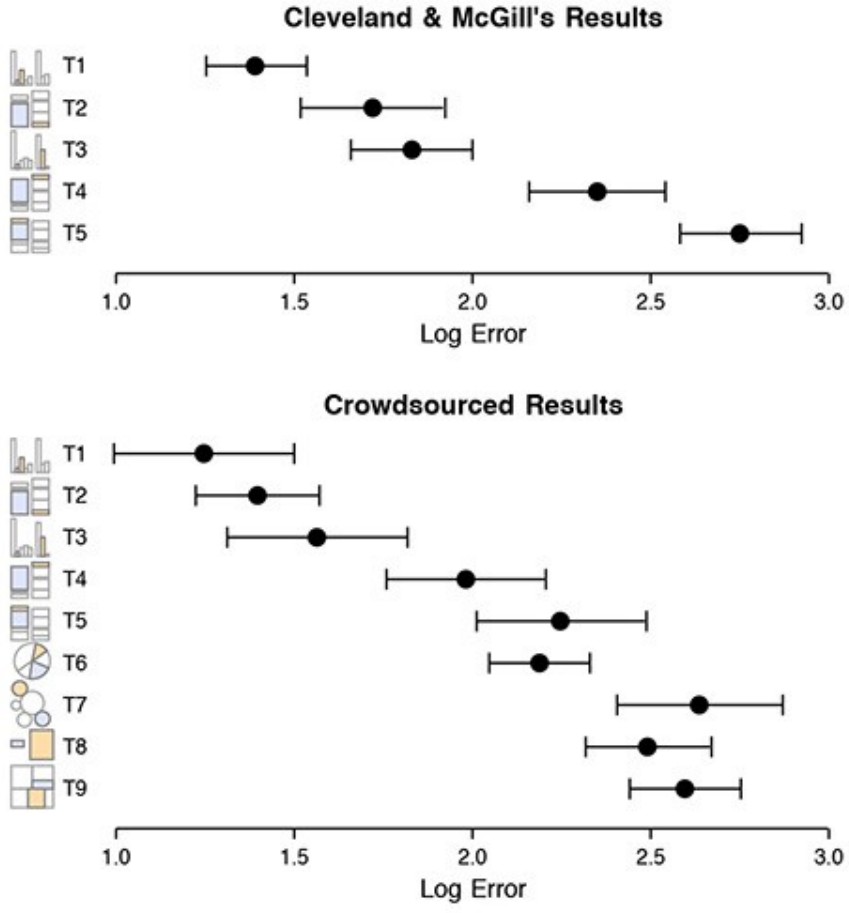

Figure 4: Proportional judgment results (Exp. 1A & B). Top: Cleveland & McGill's [7] lab study. Bottom: MTurk studies. Error bars indicate 95% confidence intervals.

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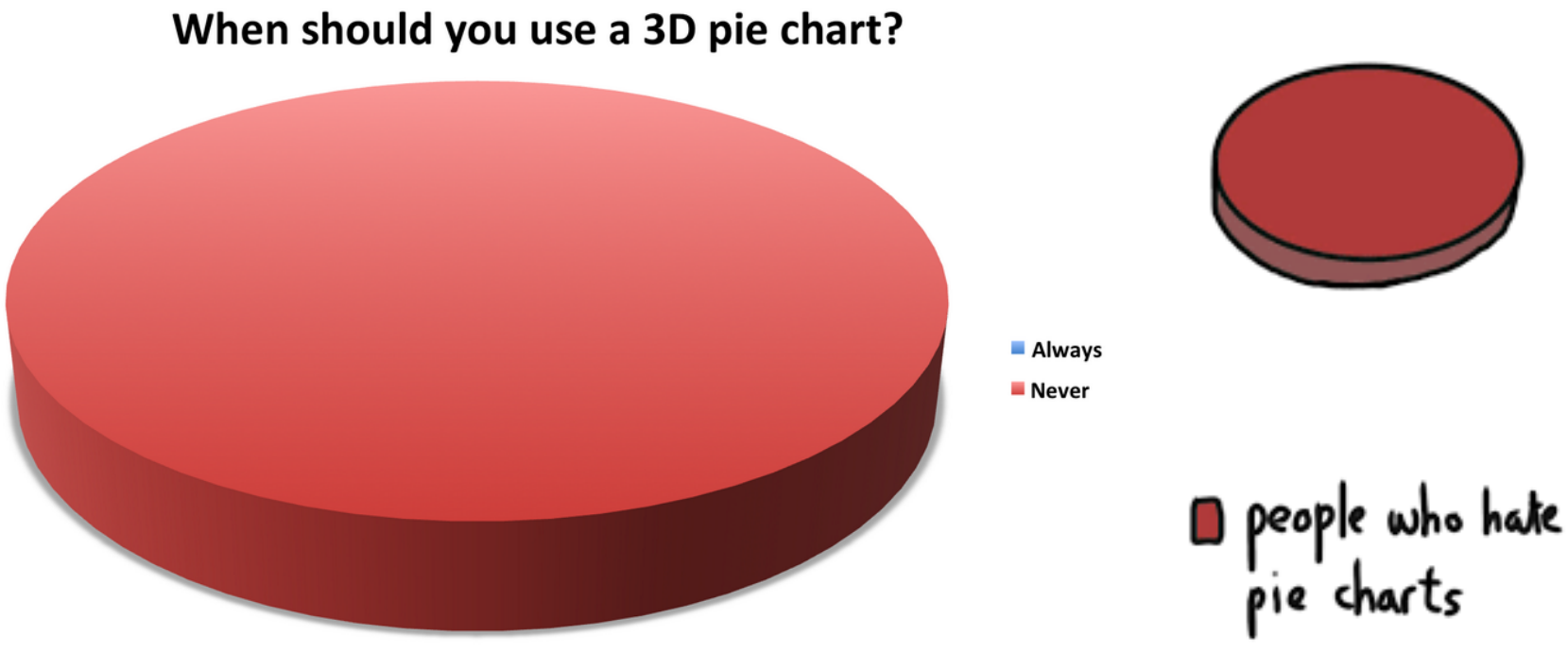
People hate pie charts

http://www.storytellingwithdata.com/blog/2011/07/death-to-pie-charts

especially Edward Tufte

A table is nearly always better than a dumb pie chart; the only worse design than a pie chart is several of them[...] pie charts should never be used. - *"The Visual Display of Quantitative Information"*



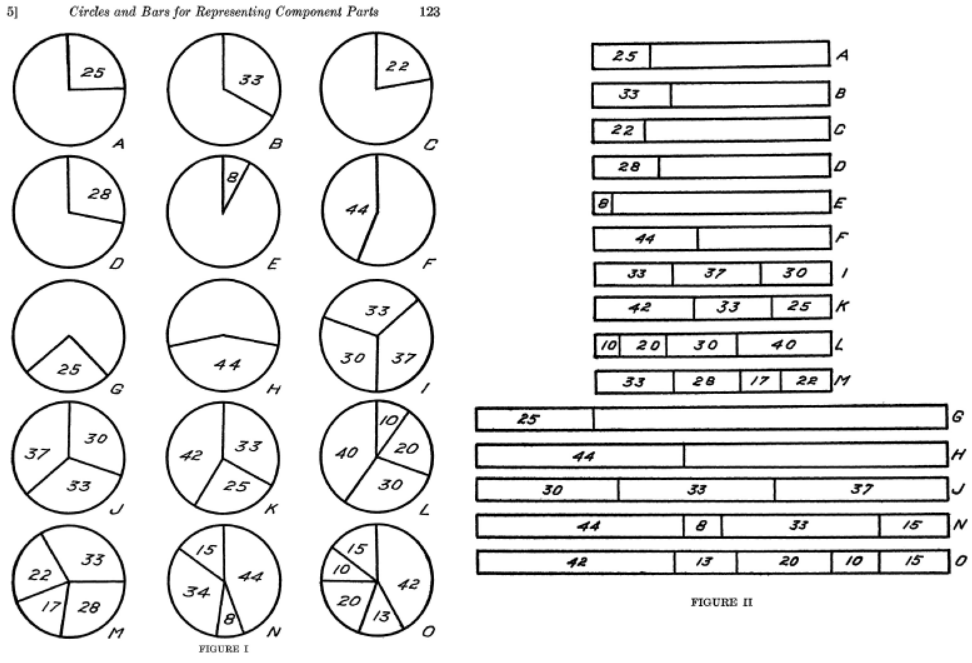
"E pur si muove..." [a] [b]

[a] Eells (1926) *J Am. Stat. Ass.*

[b] Simkin & Hastie (1987) *J Am. Stat. Ass.*

For proportions of a whole:

- Pie charts read as accurately as bar charts
- As number of components in the chart increases, bars are less efficient than pie charts



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Bar charts are bad...mmmkay?

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There is an ongoing backlash against bar charts

(and I'm not picking on Nick, he just tweets a lot...)

But are they really that bad?

Interpretation of bars and lines [a]

[a] Zacks & Tversky (1999) *Mem. Cognit.*

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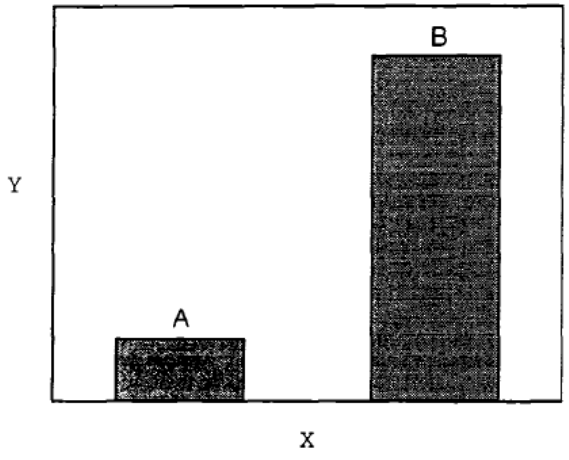
People interpret bars and lines differently

Experiment 1: In absence of context (arbitrary X, Y)

- **bars**: discrete comparison (24:0)
- **lines**: trend assessment (0:35)



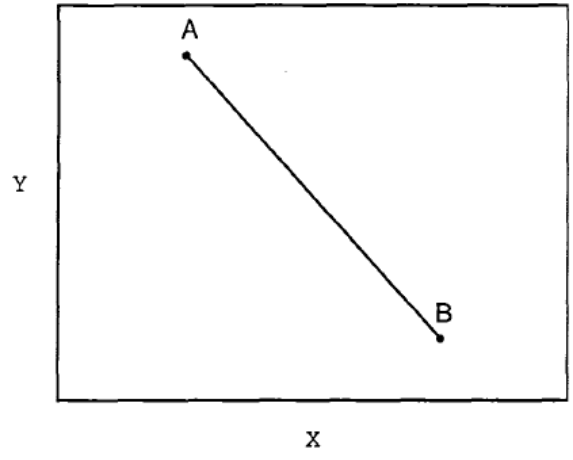


Figure 1: Examples of the bar and line graph stimuli used in Experiment 1.

Interpretation of bars and lines [a]

[a] Zacks & Tversky (1999) *Mem. Cognit.*

People interpret bars and lines differently

Experiment 2: With context (discrete or continuous data)

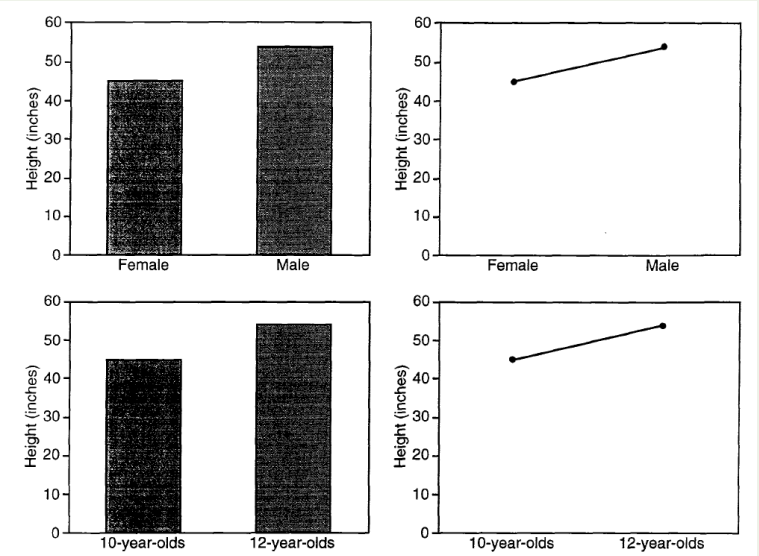


Figure 2: Examples of the bar and line graph stimuli, and the continuous and discrete conceptual domains used in Experiment 2.

	Gender (discrete domain)		Age (continuous domain)	
	Bar graph	Line graph	Bar graph	Line graph
Discrete comparison	28	22	28	9
Trend assessment	0	3	2	14

Table 2: Frequency of data characterization responses as a function of graph type (bar graph or line graph) and conceptual domain (gender or age).

Bars vs. lines

- People naturally interpret bar charts as categorical data
- People naturally interpret line graphs as trends
- Using bars for trend data or lines for categorical data can mislead the reader

Bar charts can mislead [a]

[a] Weissgerber *et al.* (2015) *PLoS Biol.* doi:10.1371/journal.pbio.1002128

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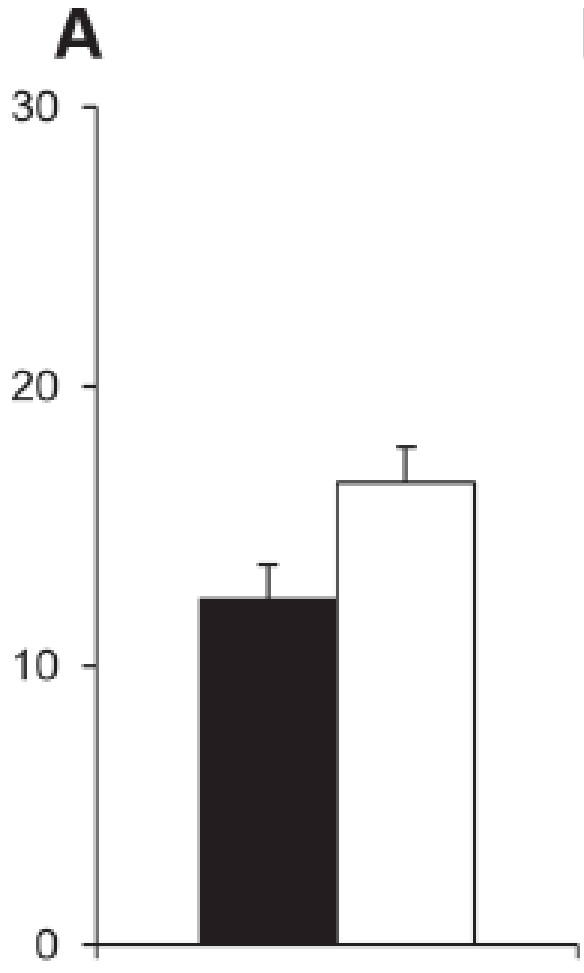
- Do these bars differ in value?



Bar charts can mislead [a]

[a] Weissgerber *et al.* (2015) *PLoS Biol.* doi:10.1371/journal.pbio.1002128

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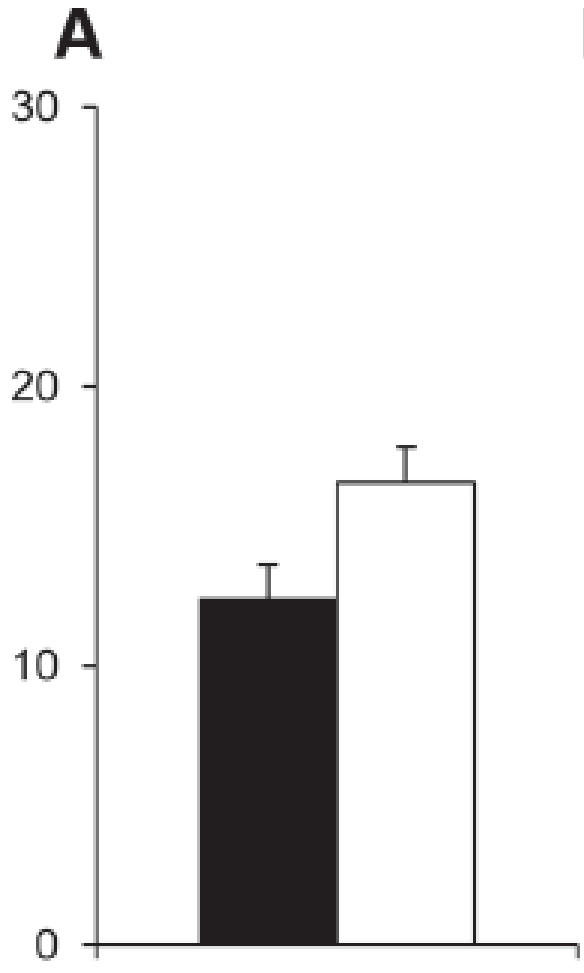
- Do these bars differ in value?
- Bar charts represent data as a single point: lossy compression.
- Could different datasets give the same bar chart?



Bars are lossy compression [a]

[a] Weissgerber *et al.* (2015) *PLoS Biol.* doi:10.1371/journal.pbio.1002128

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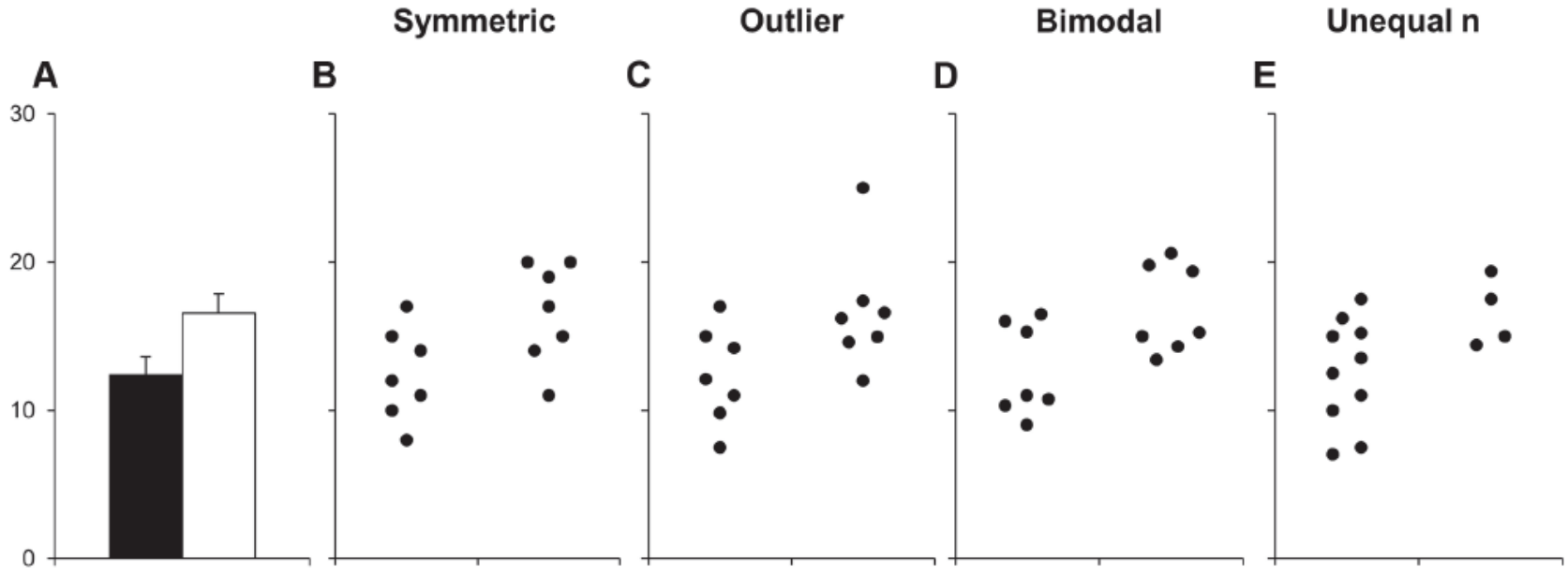
Bars hide detail:

- Number of data points
- Variance of data points
- Distribution of data points (outliers, etc.)



Bars may mislead on statistics [a]

[a] Weissgerber *et al.* (2015) *PLoS Biol.* doi:10.1371/journal.pbio.1002128

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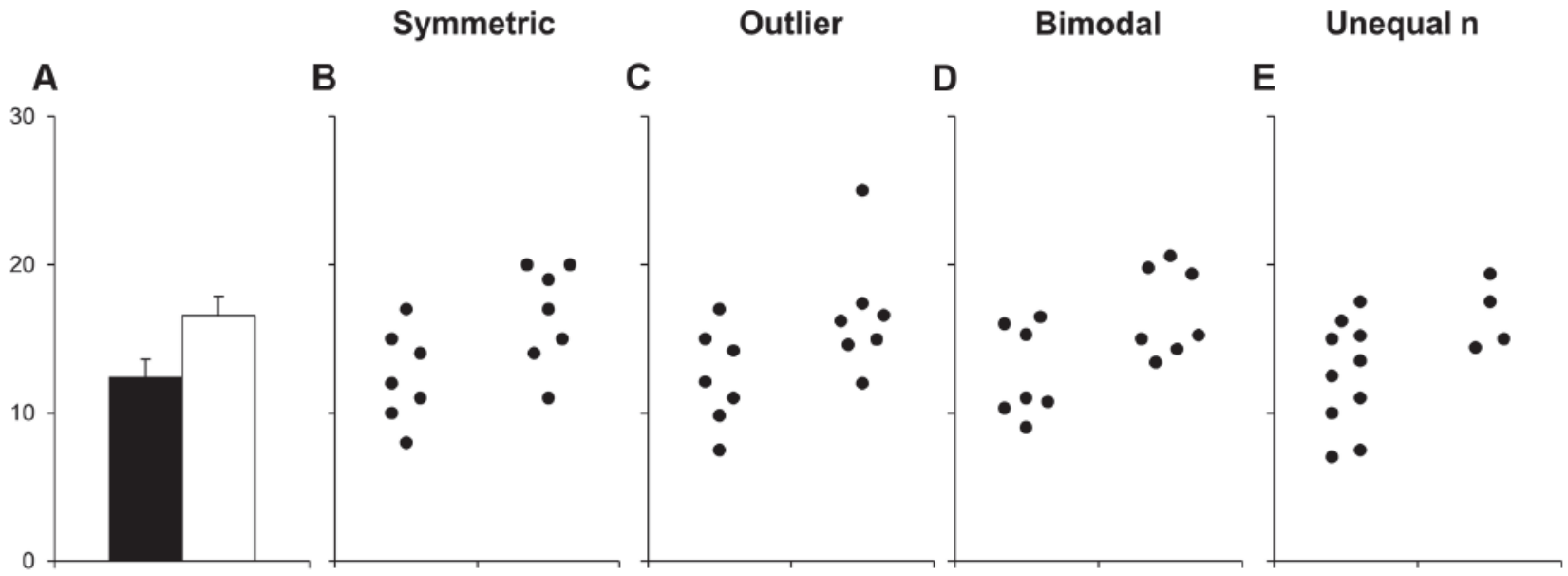
Bars may imply incorrect test statistics:

Overlaps, outliers, covariates, sample sizes masked



Test				
	p value			
T-test: Equal var.	0.035	0.050	0.026	0.063
T-test: Unequal var.	0.035	0.050	0.026	0.035
Wilcoxon	0.054	0.073	0.128	0.103

Bars for paired data [a]

[a] Weissgerber *et al.* (2015) *PLoS Biol.* doi:10.1371/journal.pbio.1002128

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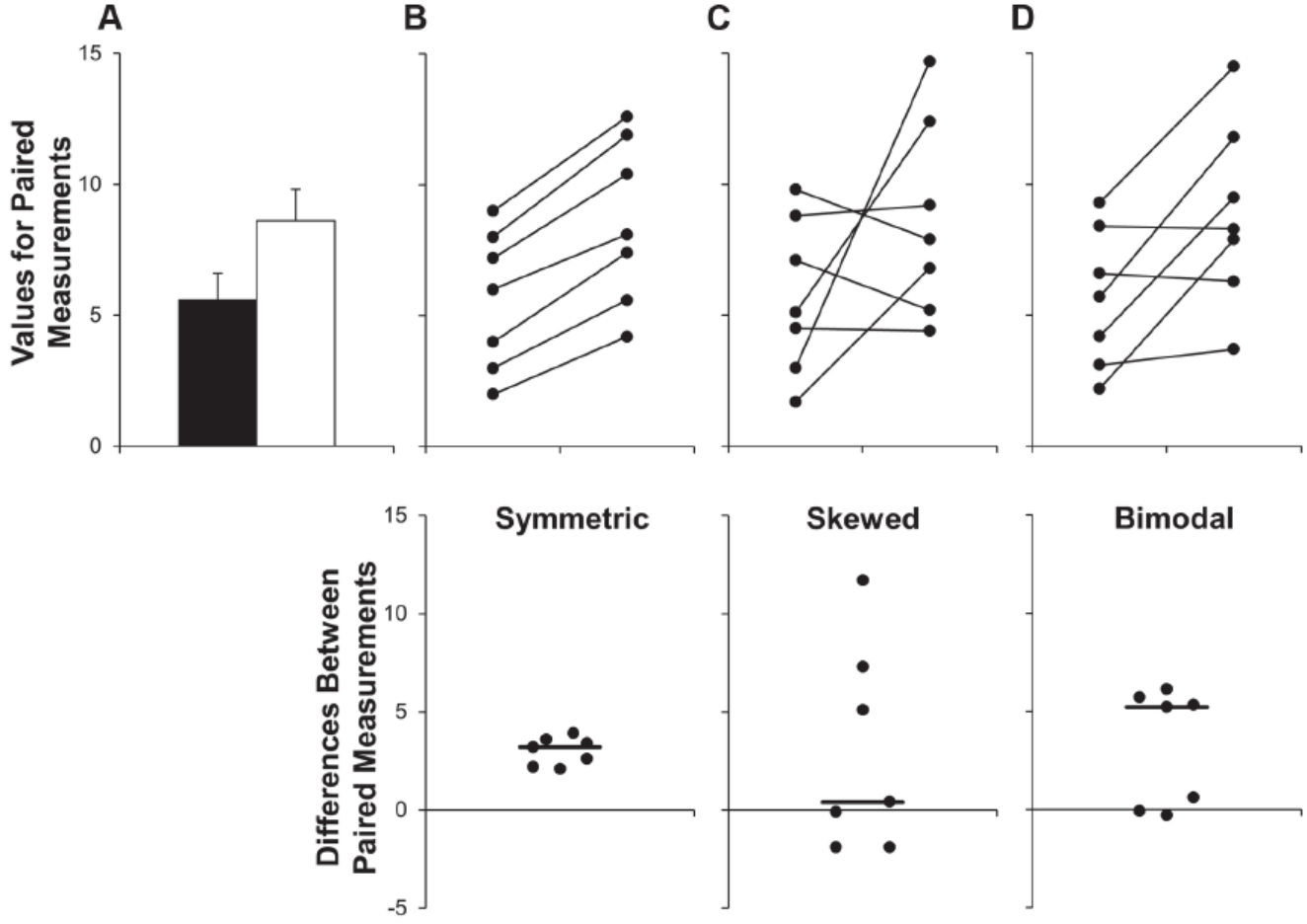
Bars imply independence of data:



Better than bar charts?

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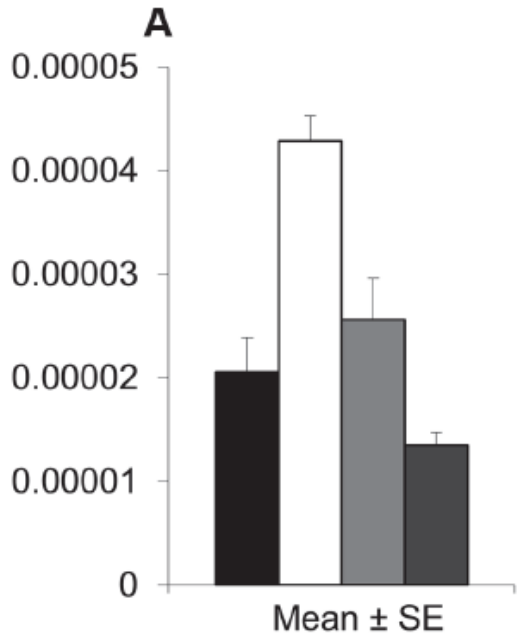
Bar chart with SE bars suggests group 2 is highest



Better than bar charts?

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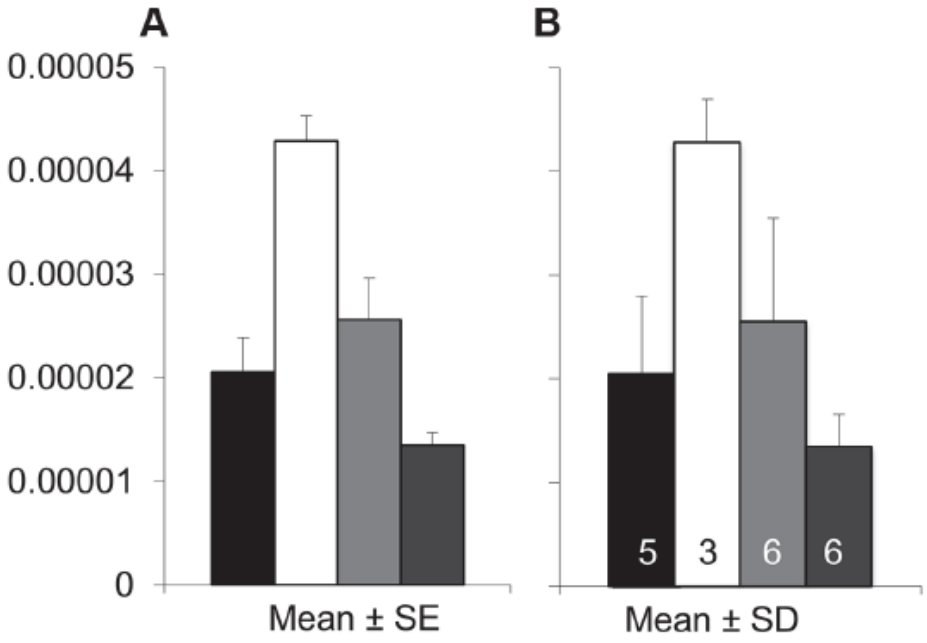
Bar chart with SD bars suggests there is overlap



Better than bar charts?

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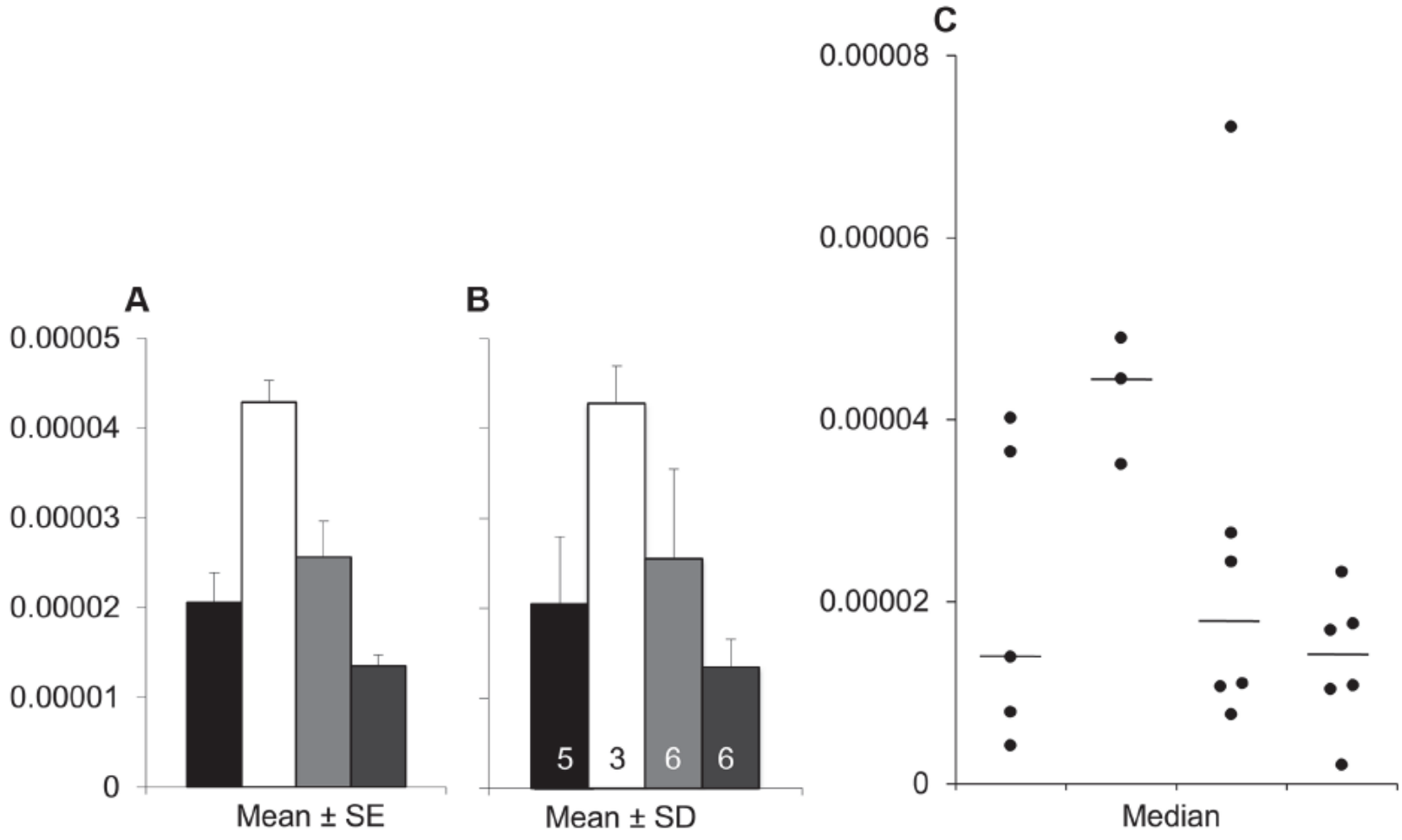
Univariate scatterplots show sample sizes, outliers, variance



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Scatterplots [a]

[a] http://www.datavizcatalogue.com/

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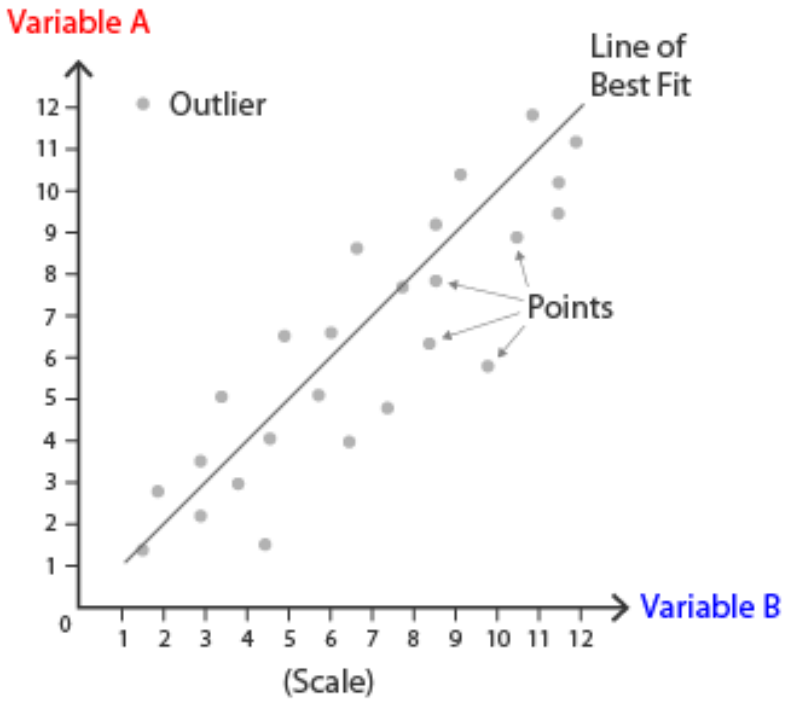
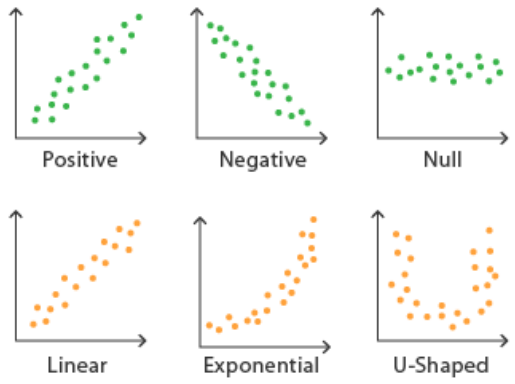
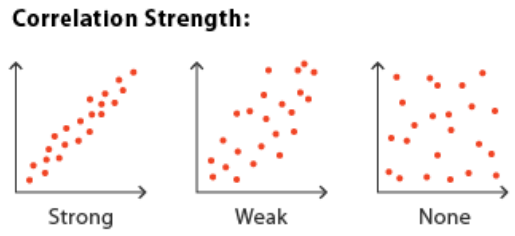
Scatterplots should be awesome:

- Positions on common scale (lowest error representation)
- Show all data: outliers, sample sizes, trends, etc.







Framing affects interpretation [a]

[a] Cleveland *et al.* (1982) *Science* doi:10.1126/science.216.4550.1138

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Point cloud size affects interpretation of correlation (more diffuse interpreted as lower correlation coefficient)

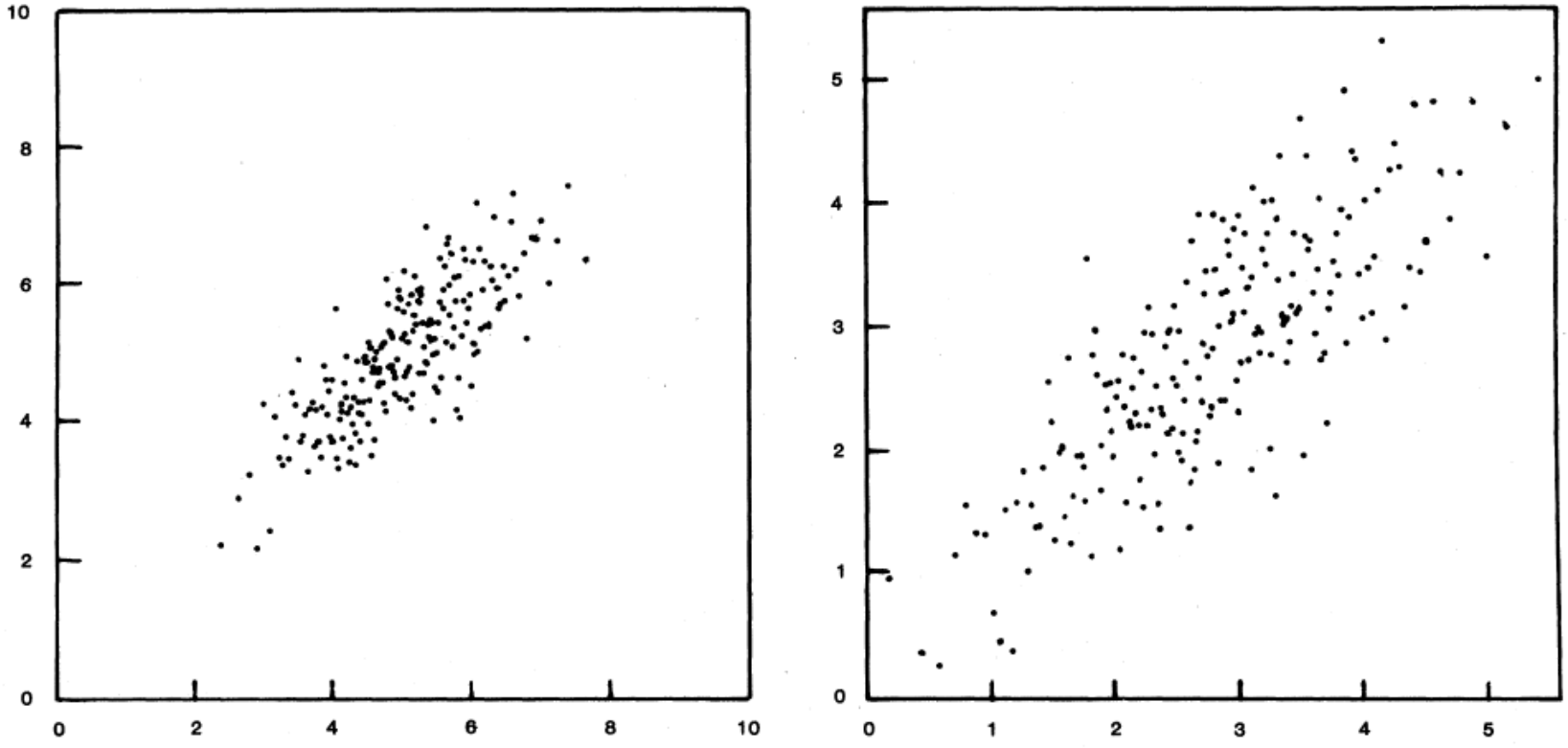

Fig. 1. Reductions of two scatterplots used in the three types of experiments. The left panel is point-cloud size 2 and the right panel is point-cloud size 4. In both panels $w(r) = .4$ and $r = .8$.

Interpreting correlation is difficult [a]

[a] Fisher *et al.* (2014) *PeerJ* doi:10.7717/peerj.589

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People don't judge significance well

- 47.4% of significant relationships correctly classified
- 74.6% of non-significant relationships correctly classified

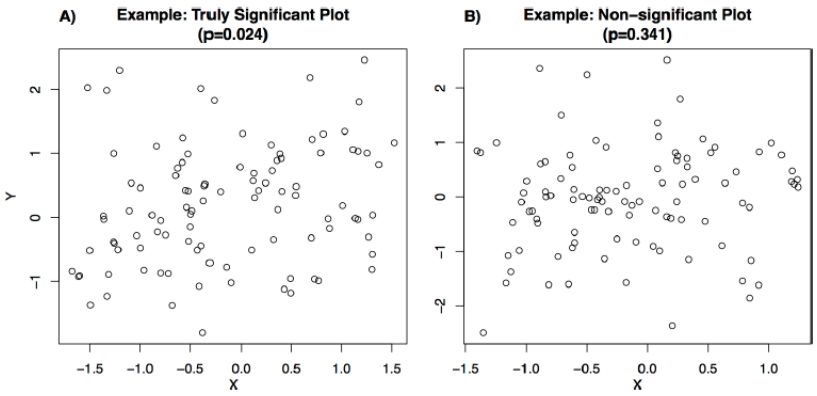
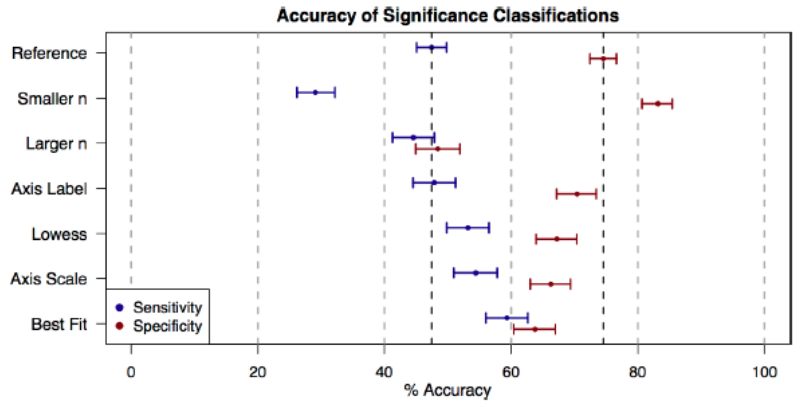


Figure 1 Examples of plots shown to users.



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Latency affects usage

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Increasing latency to 0.5s:

- decreases user activity
- decreases dataset coverage
- reduces rate of hypothesis generation
- changes data exploration strategy
- reduces future interaction with other graphics

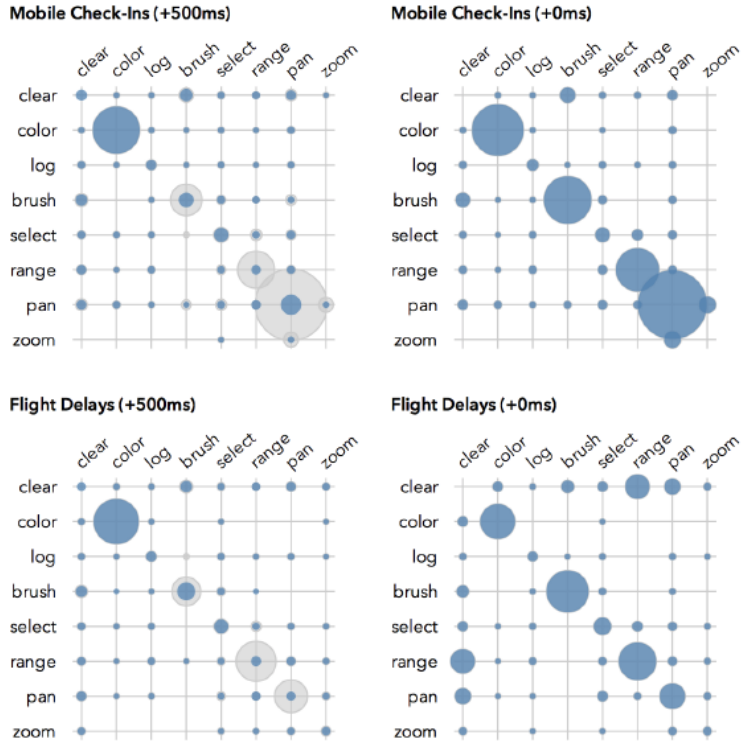

Fig. 4. Transitions between application events by analysis scenario and latency condition. Circular area represents the number of transitions between pairs of event types. Gray circles represent transitions between triggered events; blue circles between processed events. Rows represent source nodes and columns represent target nodes.

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