Visualizing Effect Sizes Across the Full Distribution

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Background

- Effect sizes generally defined by standardized mean differences
  - Cohen's *d*
  - Hedges' *g*
- Particularly in non-experimental settings, interest may lie at other locations of the scale
  - Achievement gaps at proficiency cut scores on statewide tests
- Depending on the shape of each distribution, magnitude of group differences may depend upon scale location

Cohen's *d* & Hedges' *g*

$$d = \frac{\bar{X}_{foc} - \bar{X}_{ref}}{\sqrt{\frac{(n_{foc}-1)Var_{foc}+(n_{ref}-1)Var_{ref}}{n_{foc}+n_{ref}-2}}}$$

$$g = d\left(1 - \frac{3}{4(n_{foc} + n_{ref}) - 9}\right)$$

Percentage above the cut effect sizes

Percentage Above the Cut

$$d^{pac} = PAC_{ref} - PAC_{foc}$$

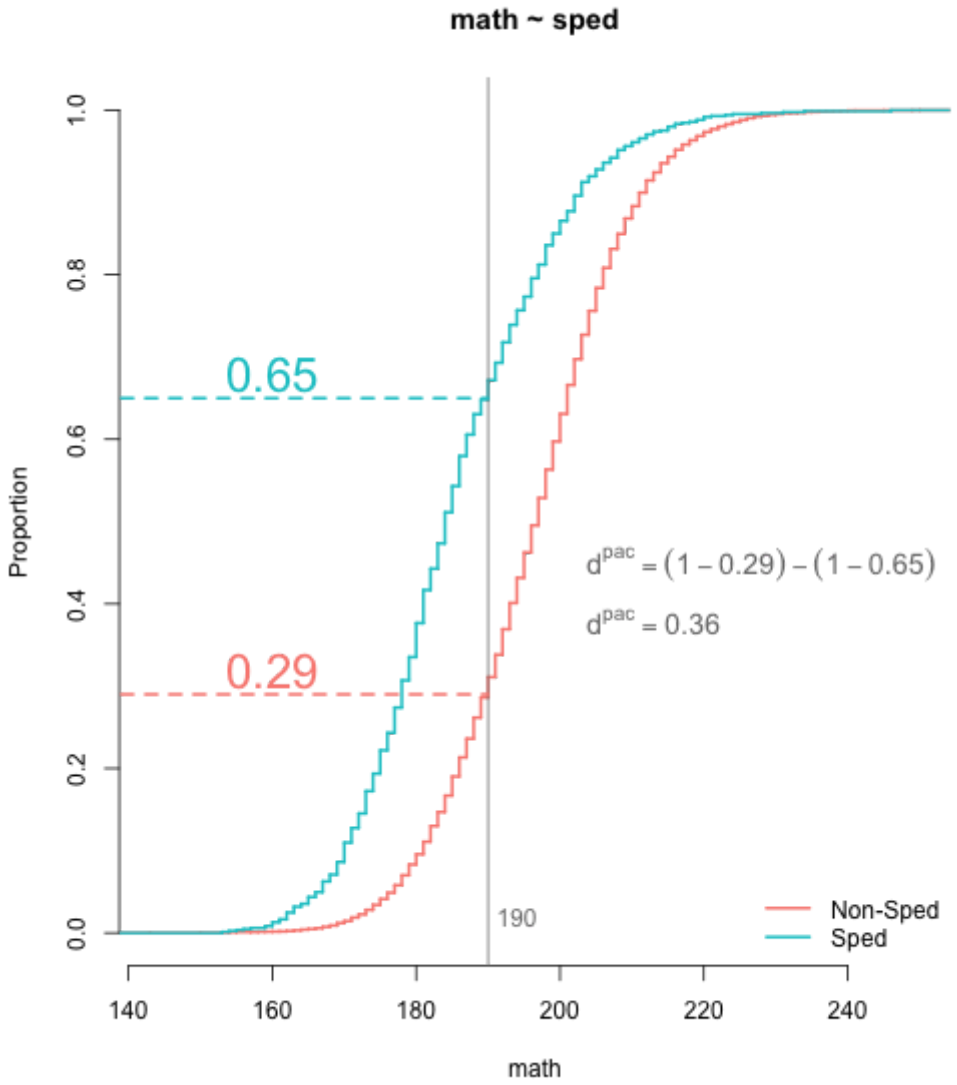
- Highly dependent on scale location

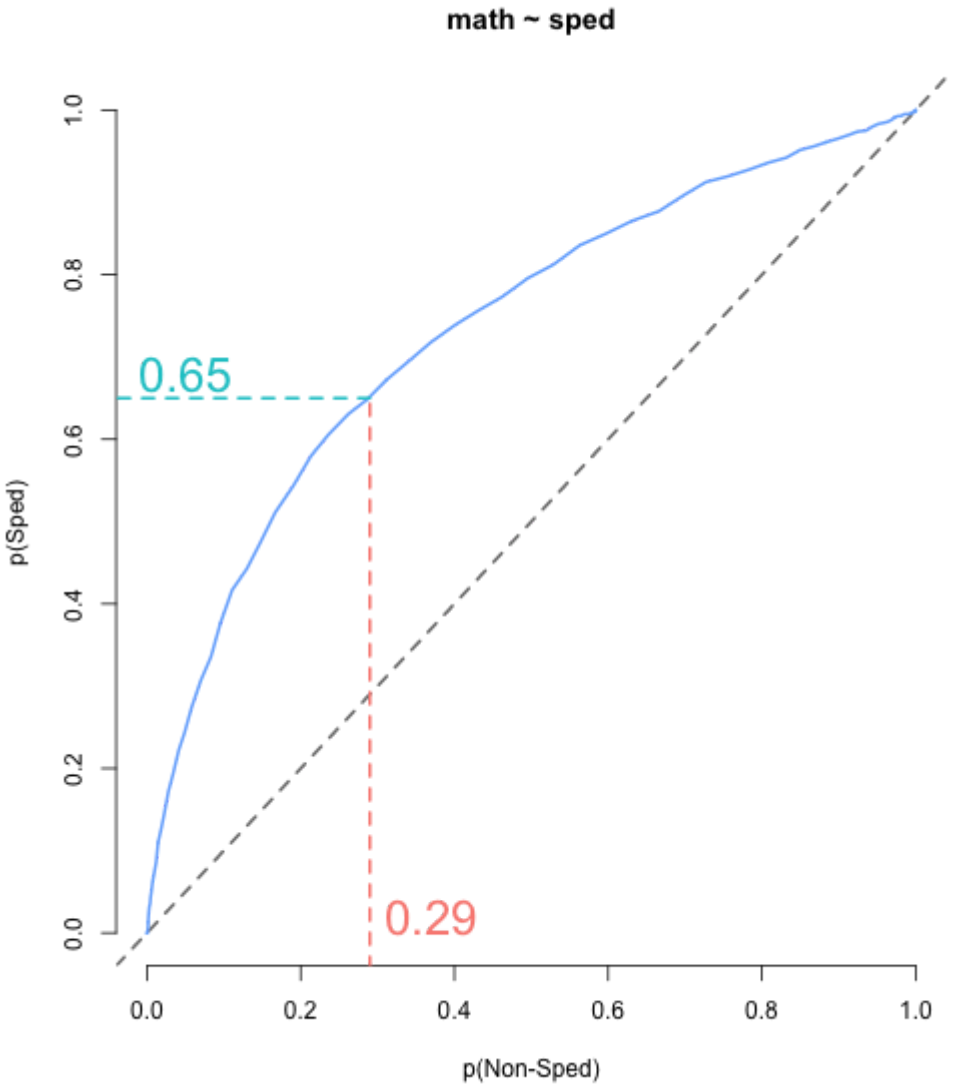
Transformed Percentage Above the Cut

$$d^{tpac} = \Phi^{-1}(PAC_{ref}) - \Phi^{-1}(PAC_{foc})$$

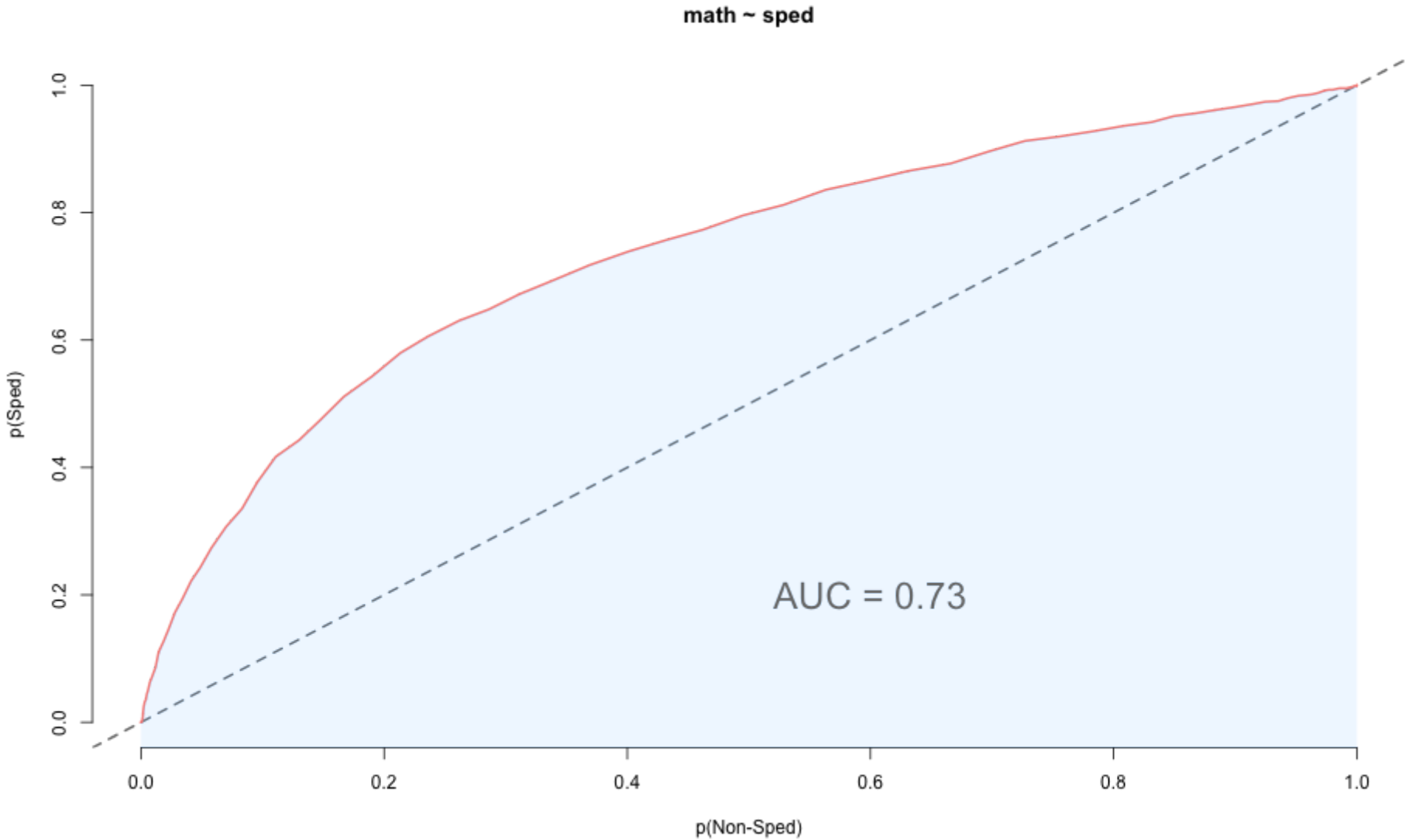
- Assumes both distributions are normally distributed with equal variance

Probability-Probability Plots





Area Under the PP Curve



Putting AUC in SD units

Ho and colleagues

$$V = \sqrt{2}\Phi^{-1}(AUC)$$

- Scale invariant
- Assumes respective normality
    - Normal with respect to each other under a shared transformation

- *AUC* and *V* make fewer assumptions about the data, but are nonetheless summary measures.
- May miss nuances in the data that can be picked up by visualizations - particularly if the magnitude of the effect depends on scale location.

Implementation in `esvis`

R package actively in development

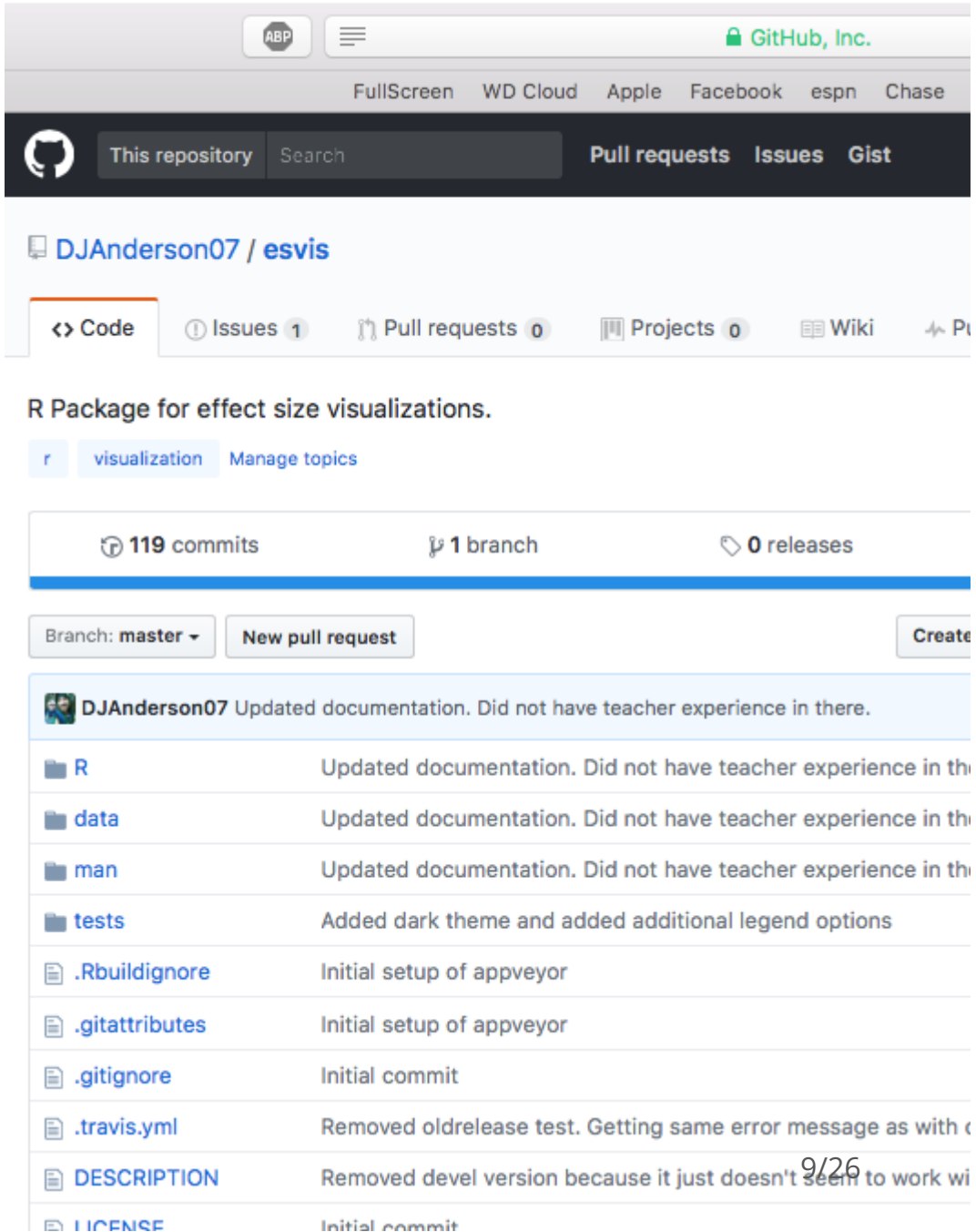
- Install using the *devtools* package

```
install.packages("devtools")
library(devtools)
install_github("DJAnderson07/esvis")
```

- Release to CRAN planned for summer
- Has many useful features currently

See current development at

https://github.com/DJAnderson07/esvis



Example data

I have stored a dataset in an object called `d`. Below are the first six rows of these data.

```
##         sid cohort     sped  ethnicity frl     ell season reading math
## 2873 332347      1 Non-Sped   Hispanic FRL  Active Spring     167  192
## 162  400047      1 Non-Sped Native Am. FRL Non-ELL Spring     191  191
## 355  400047      1 Non-Sped Native Am. FRL Non-ELL   Fall     183  182
## 387  400047      1 Non-Sped Native Am. FRL Non-ELL Winter     178  179
## 230  400277      1 Non-Sped Native Am. FRL Non-ELL Winter     199  197
## 648  400277      1 Non-Sped Native Am. FRL Non-ELL   Fall     203  196
```

Standard argument structure

- All functions in *esvis* take a common argument structure, as follows

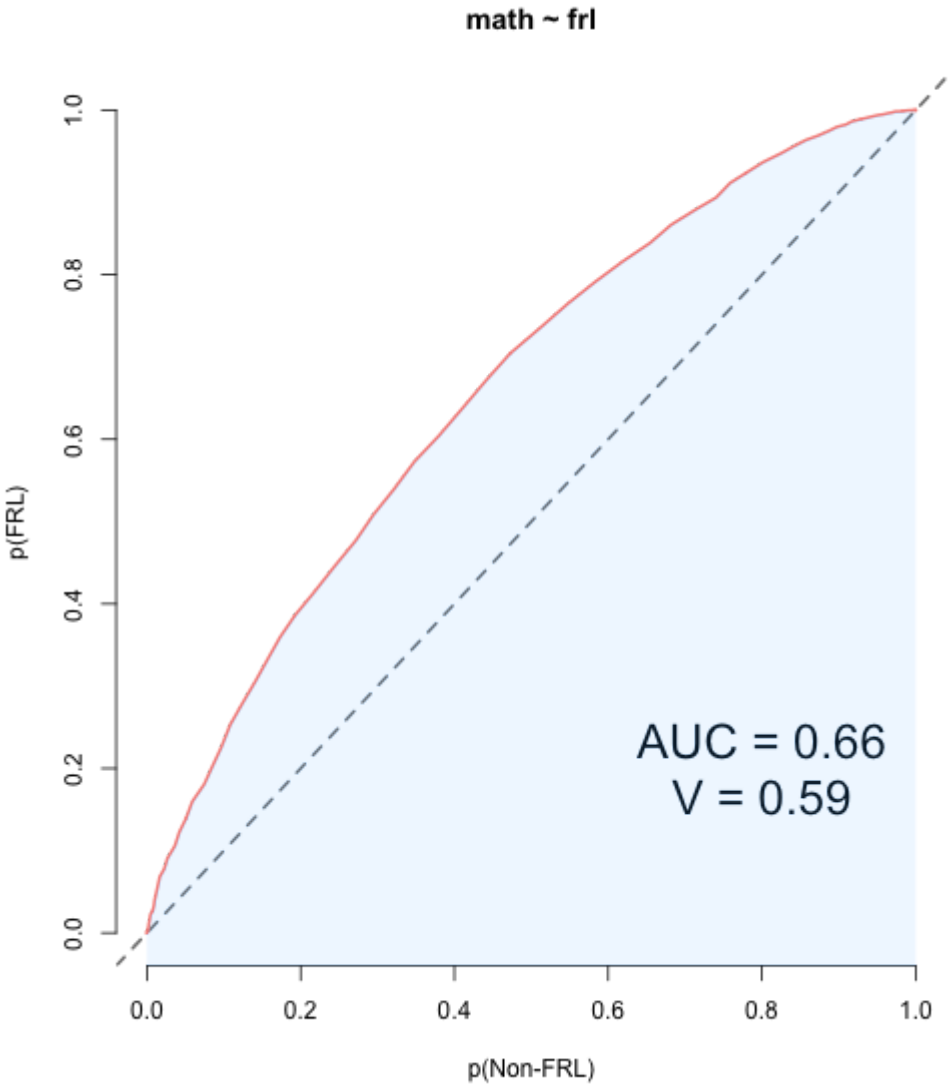
```
fun_name(outcome ~ group, data, additional_optional_args)
```

PP Plots

- Examine math differences by free or reduced lunch status

```
pp_plot(math ~ frl, d)
```

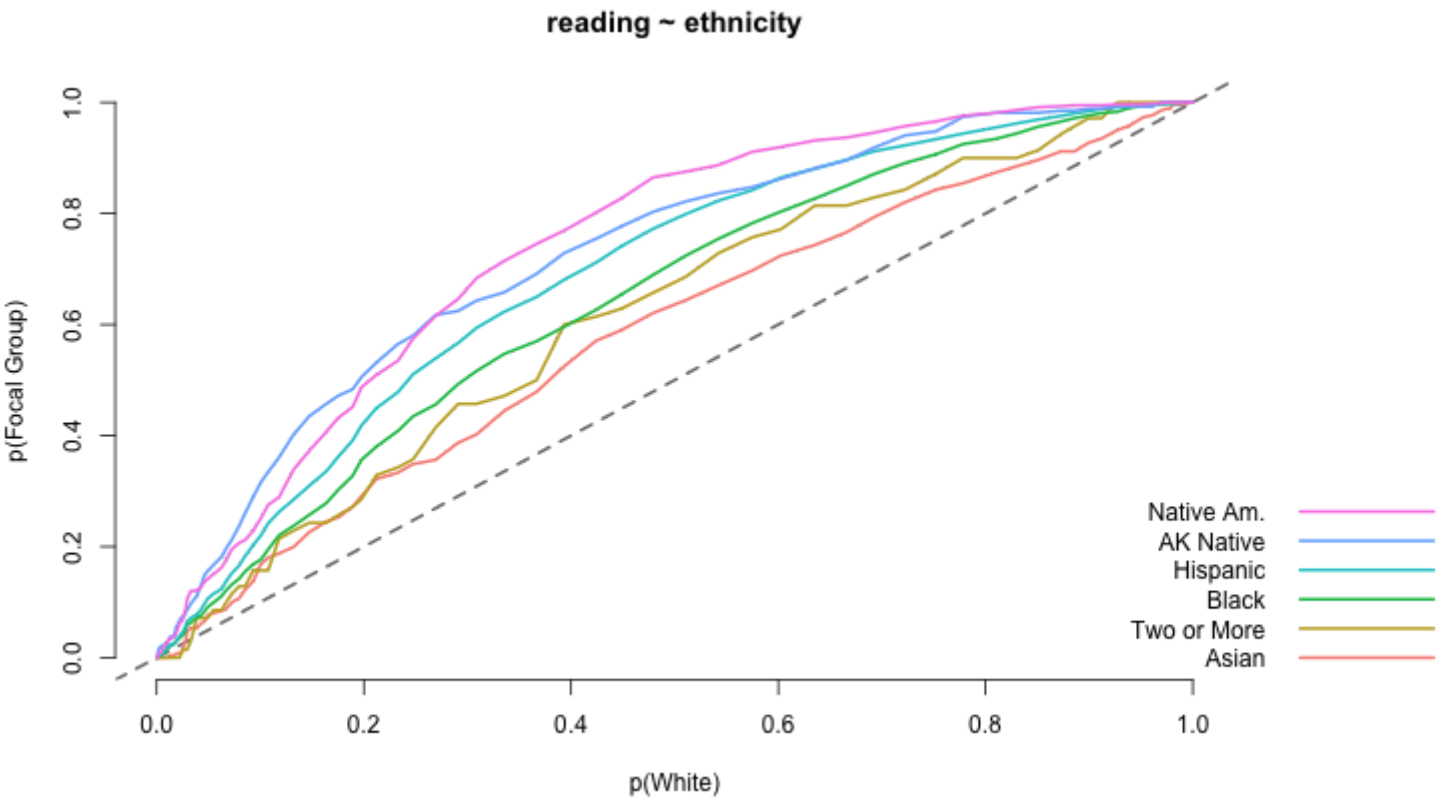
- Notice shading by default when only two groups are compared.
- *AUC* and *V* annotated to the plot, by default
- Plot is fully customizable with calls to base plotting functions (e.g., `main`, `col`, etc.)



More than one group?

- Highest performing group selected by default

```
pp_plot(reading ~ ethnicity, d)
```



Investigating ELL differences

- Three groups: Non, Active, Monitor
- Same syntax for estimates

Default output

```
coh_d(reading ~ ell, d)
```

```
##   ref_group foc_group    estimate
## 1   Monitor   Non-ELL  0.05421767
## 2   Monitor    Active  0.70109139
## 3   Non-ELL    Active  0.95679846
## 4    Active   Non-ELL -0.95679846
## 5    Active   Monitor -0.70109139
## 6   Non-ELL   Monitor -0.05421767
```

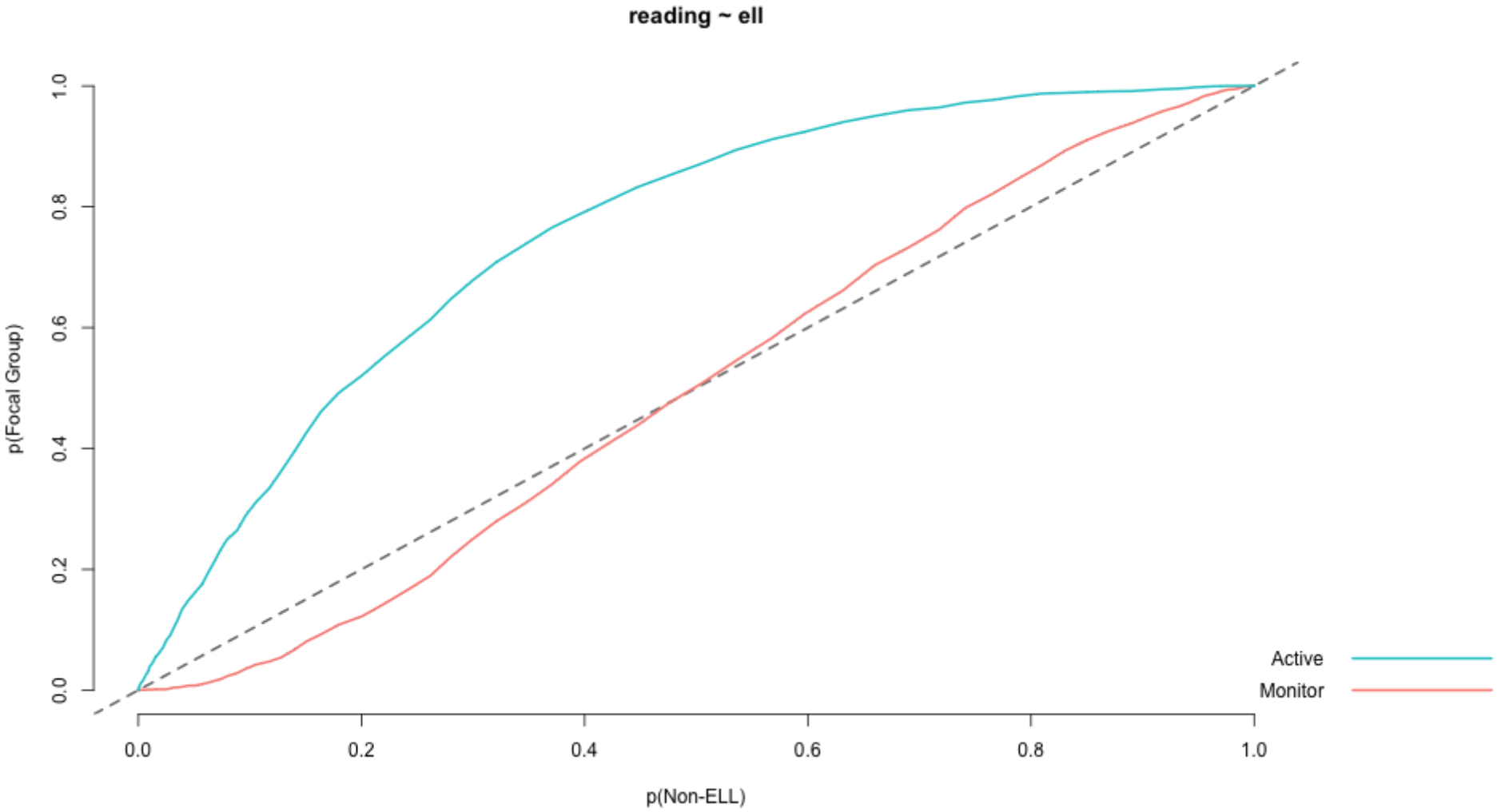
Or choose a reference group

```
auc(reading ~ ell, d,
        ref_group = "Non-ELL")
```

```
##   ref_group foc_group  estimate
## 3   Non-ELL    Active 0.7552992
## 6   Non-ELL   Monitor 0.4965789
```

Visualization provides more nuance

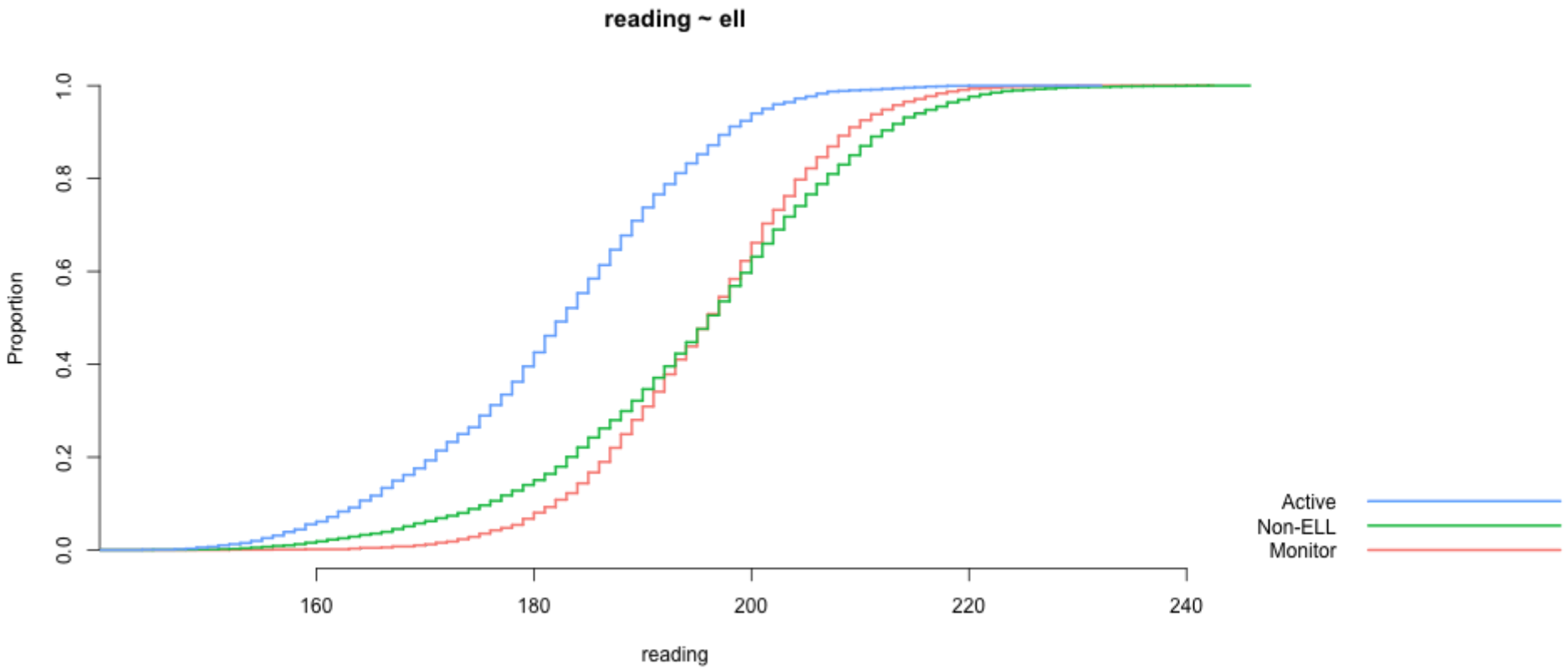
```
pp_plot(reading ~ ell, d, ref_group = "Non-ELL")
```



ECDFs

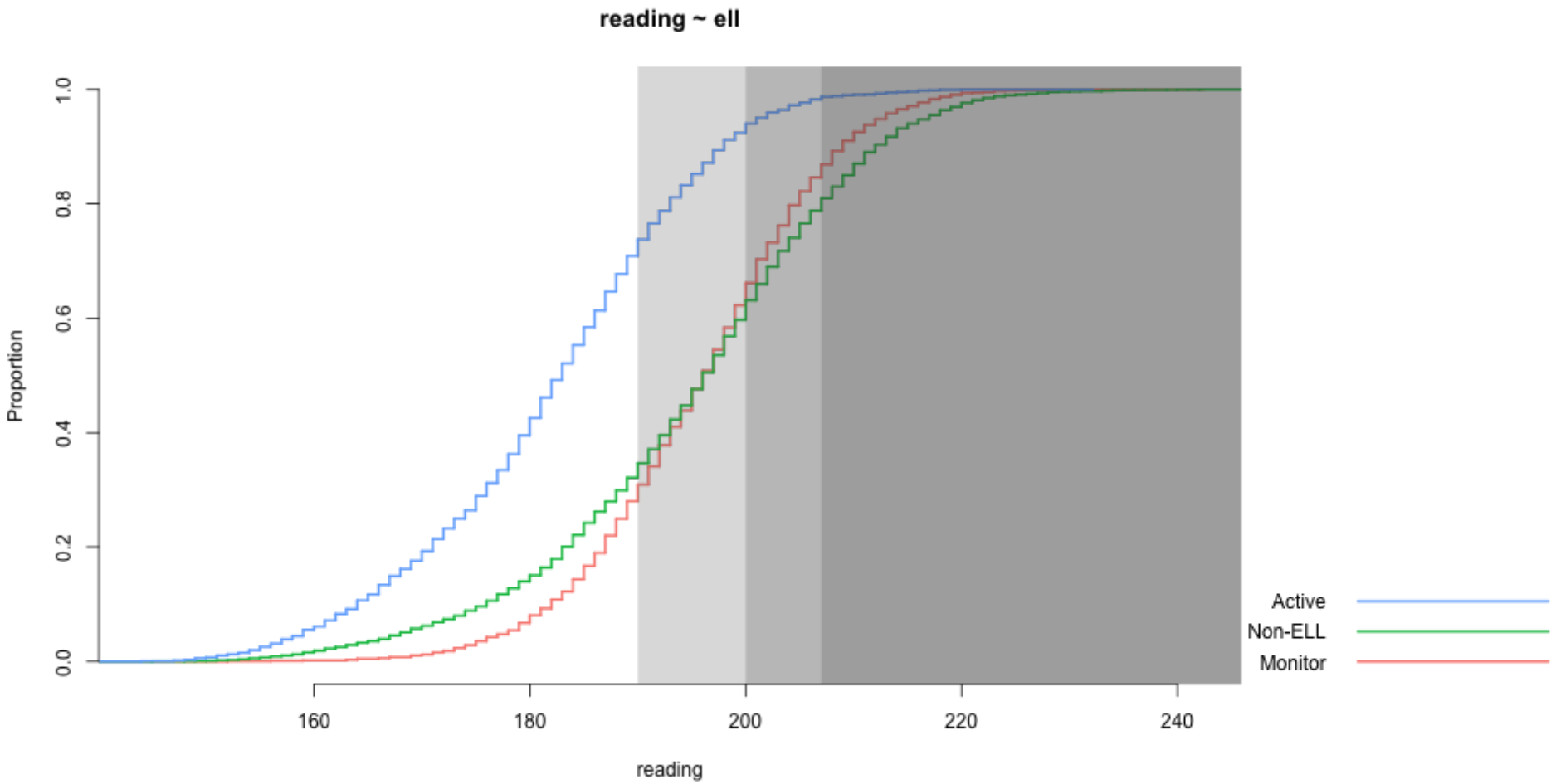
- Produced equivalently

```
ecdf_plot(reading ~ ell, d)
```



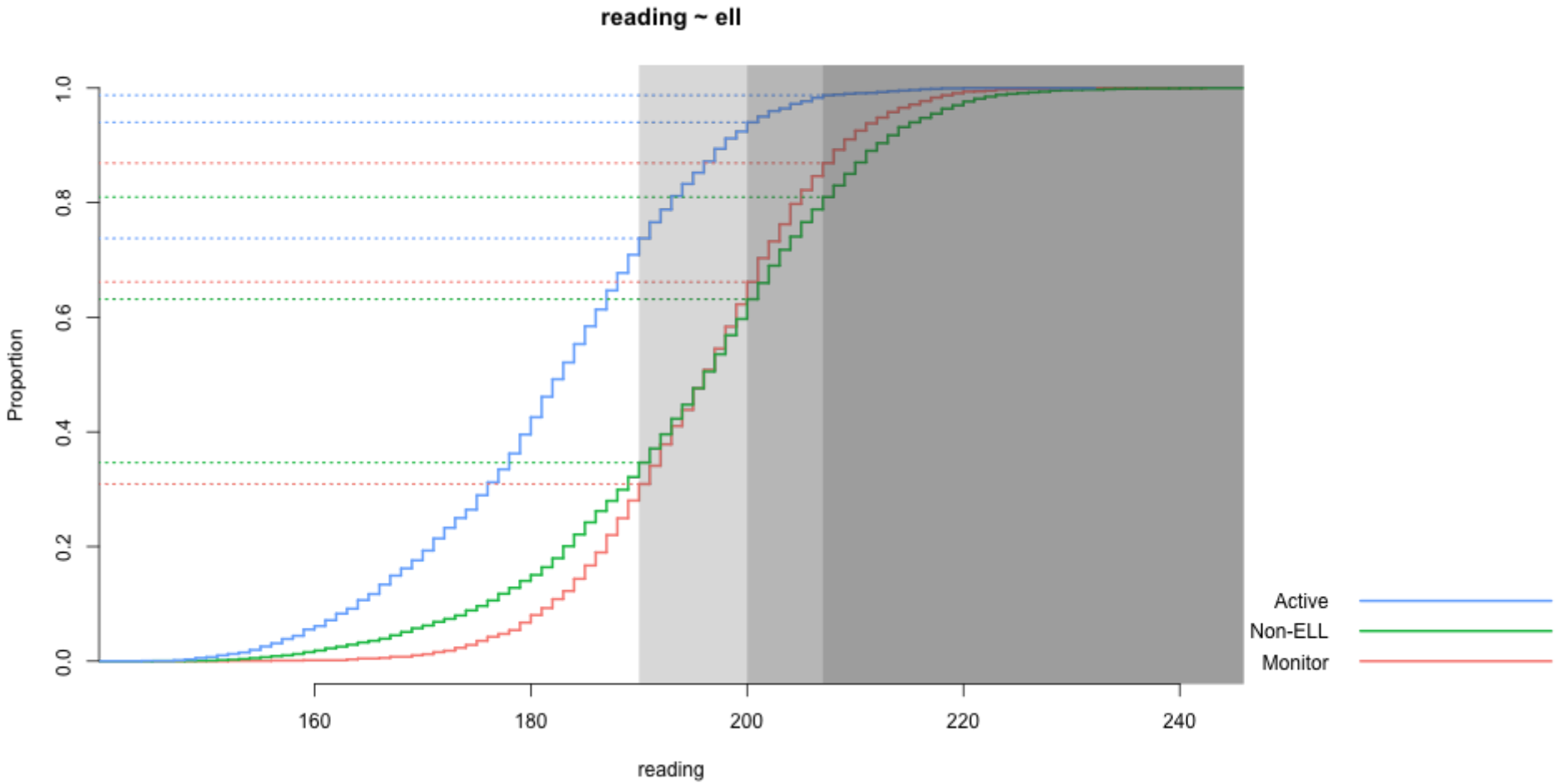
Cut-point?

```
ecdf_plot(reading ~ ell, d, ref_cut = c(190, 200, 207))
```



Add horizontal reference lines

```
ecdf_plot(reading ~ ell, d, ref_cut = c(190, 200, 207), hor_ref = TRUE)
```



Binned ES Plot

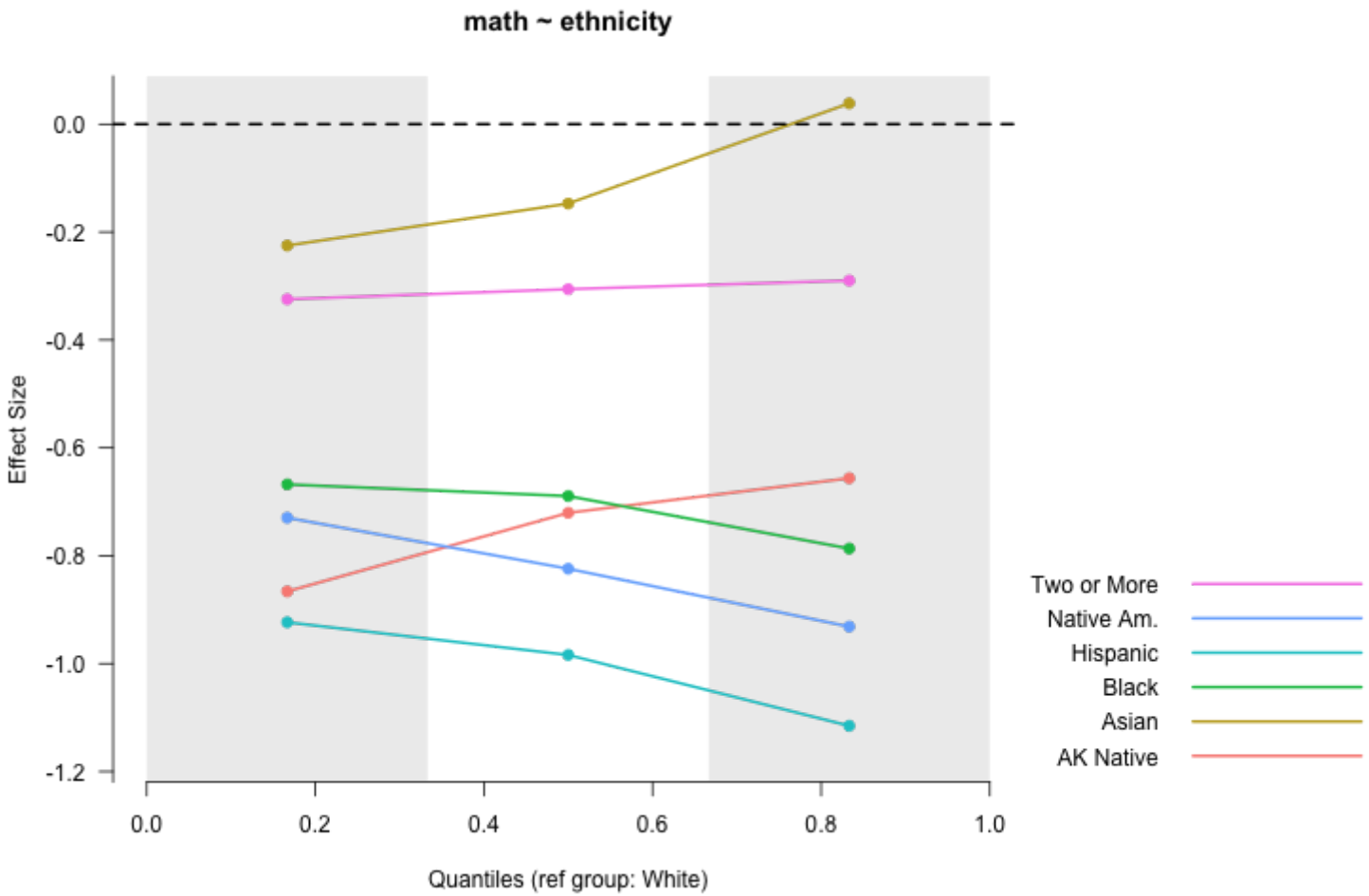
- Split each distribution into arbitrary (even) quantile bins
- Calculate mean difference within each bin
- Divide by overall pooled standard deviation

$$d_{[i]} = \frac{\bar{X}_{foc_{[i]}} - \bar{X}_{ref_{[i]}}}{\sqrt{\frac{(n_{foc}-1)Var_{foc}+(n_{ref}-1)Var_{ref}}{n_{foc}+n_{ref}-2}}}$$

- In this case, essentially equivalent to Cohen's *d*, except that there are multiple mean differences (one for each bin)

Ethnicity differences

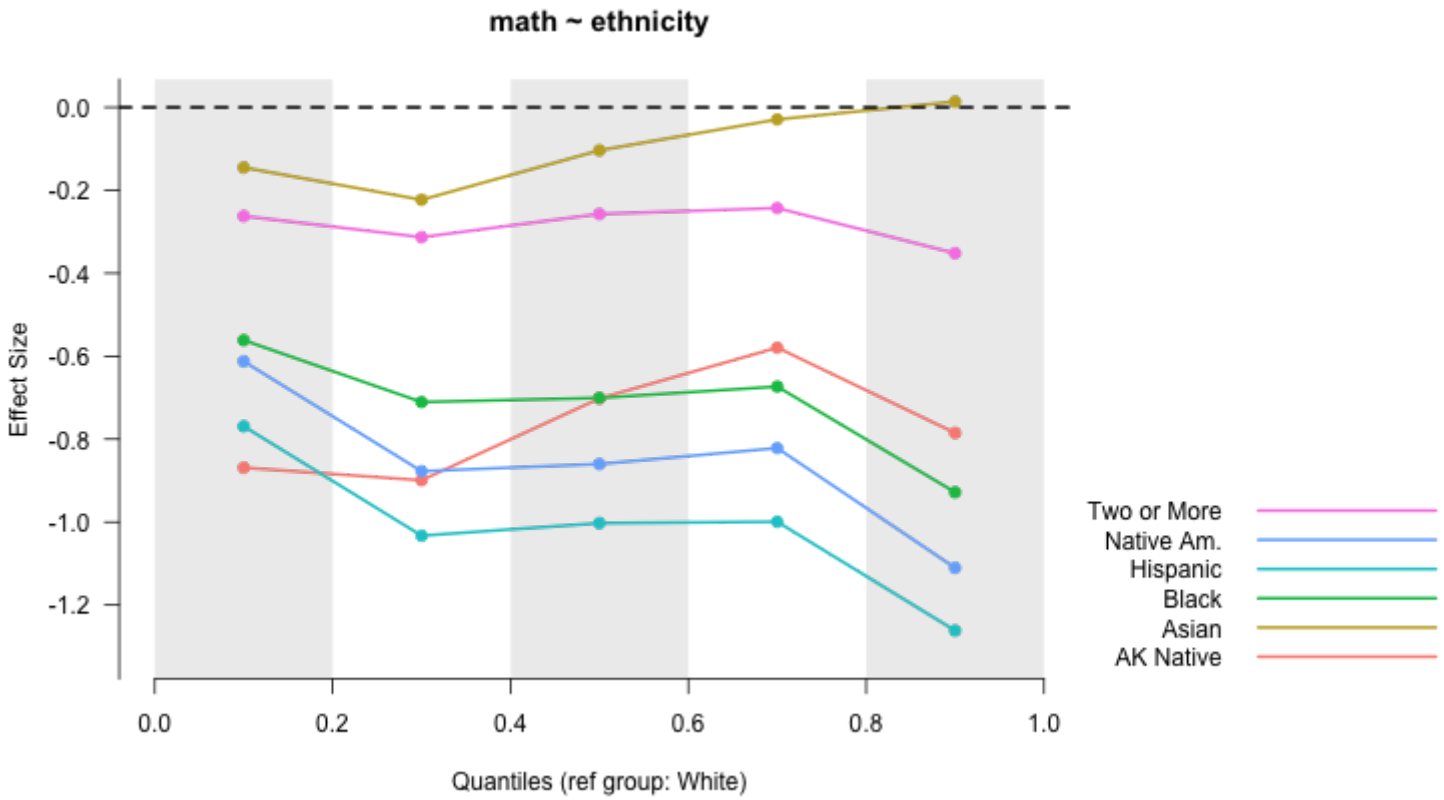
```
binned_plot(math ~ ethnicity, d)
```



Change binning

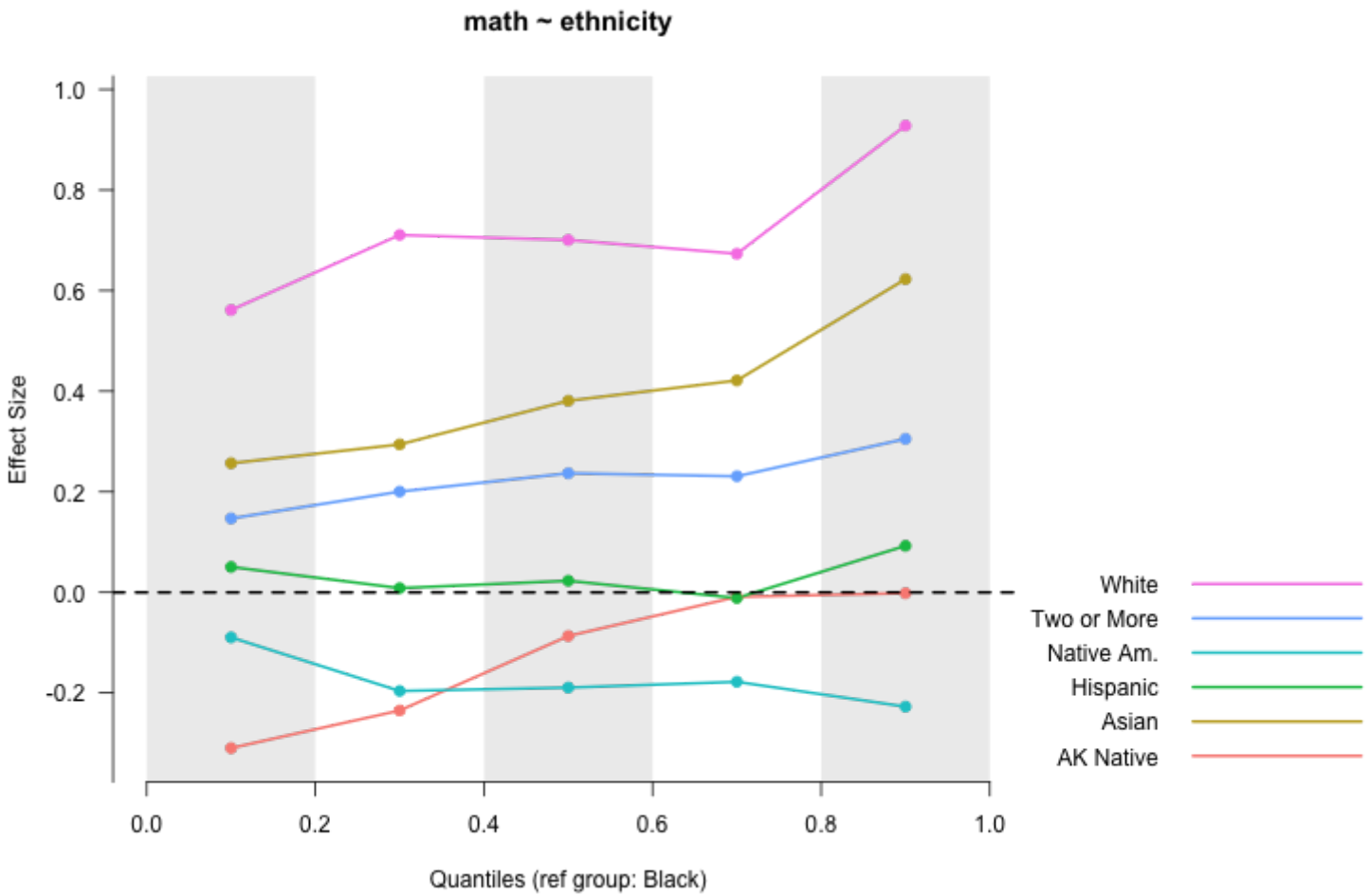
Quintile binning

```
binned_plot(math ~ ethnicity, d, qtiles = seq(0, 1, .2))
```



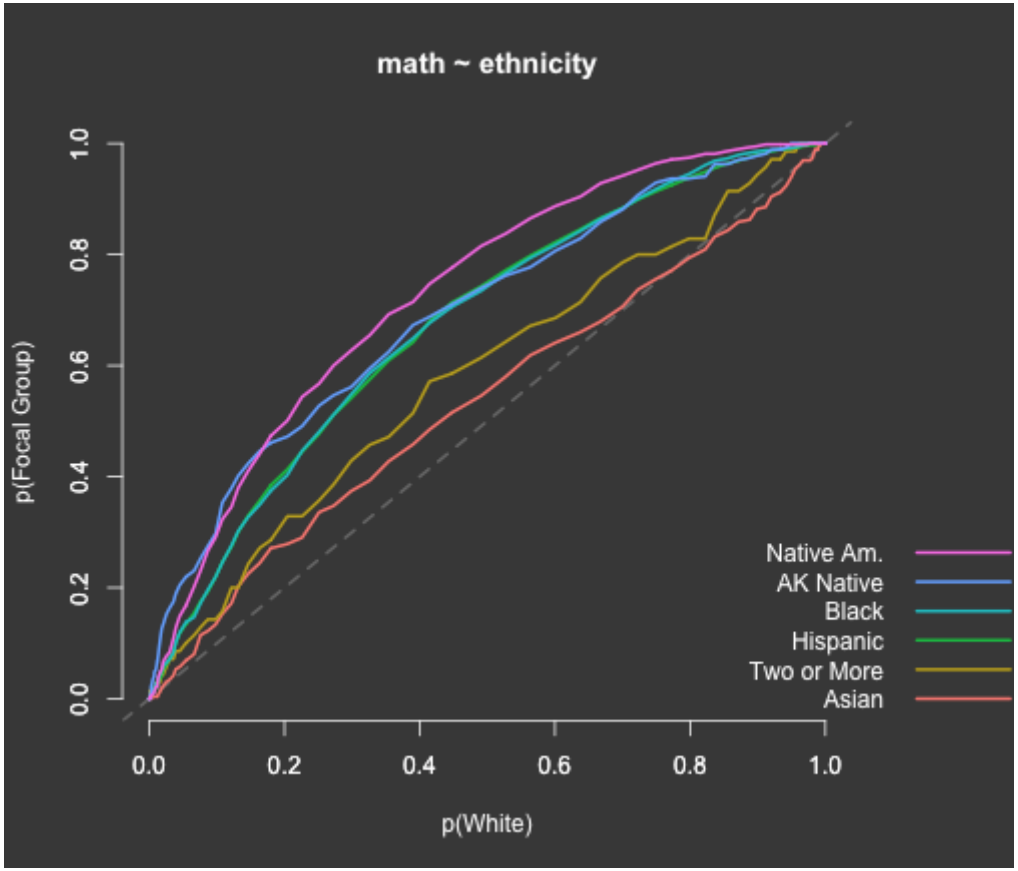
Change reference group

```
binned_plot(math ~ ethnicity, d, ref_group = "Black", qtiles = seq(0, 1, .2))
```

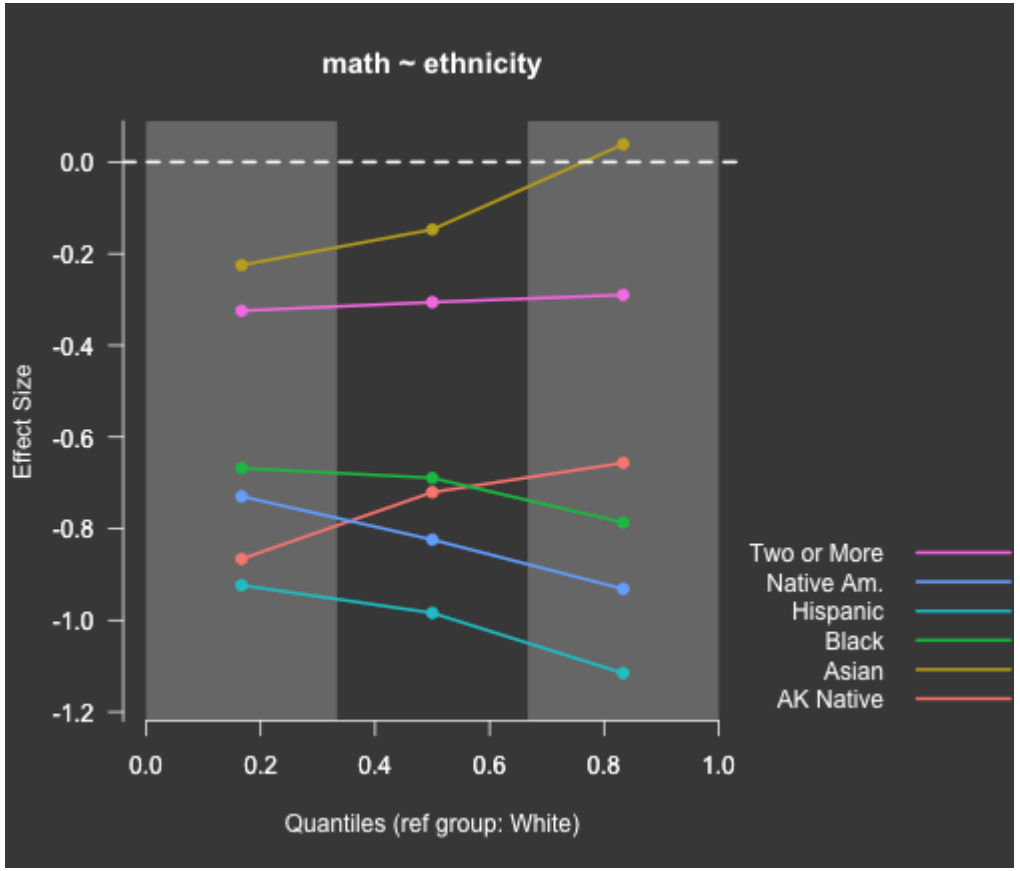


Theme dark

```
pp_plot(math ~ ethnicity, d,
    theme = "dark")
```




```
binned_plot(math ~ ethnicity, d,
    theme = "dark")
```



Estimation

`esvis` will also calculate a number of effect sizes using the same argument structure, including:

- Cohen's *d*
- Hedges' *g*
- *AUC*
- *V*
- *PAC* with **any set** of cut scores
- *TPAC* with **one** cut score (currently)

By default, effect sizes are produced for all possible pairwise comparisons, but reference groups can be selected as well.

Summary and future developments

- Visualizing group differences across the full scale, or at particular points of the scale, is important for interpretation and communication.
- `esvis` provides a simple interface to produce powerful visualizations

Future development

- Interactions with `:`
- Interactions via panel plotting
- Others?

Slides available at: https://djanderson07.github.io/ncme_2017/

Thanks!