Three common mistakes in statistics and how to avoid them

Elizabeth Pankratz

Department of Psychology
The University of Edinburgh

Something you won't be able to unsee

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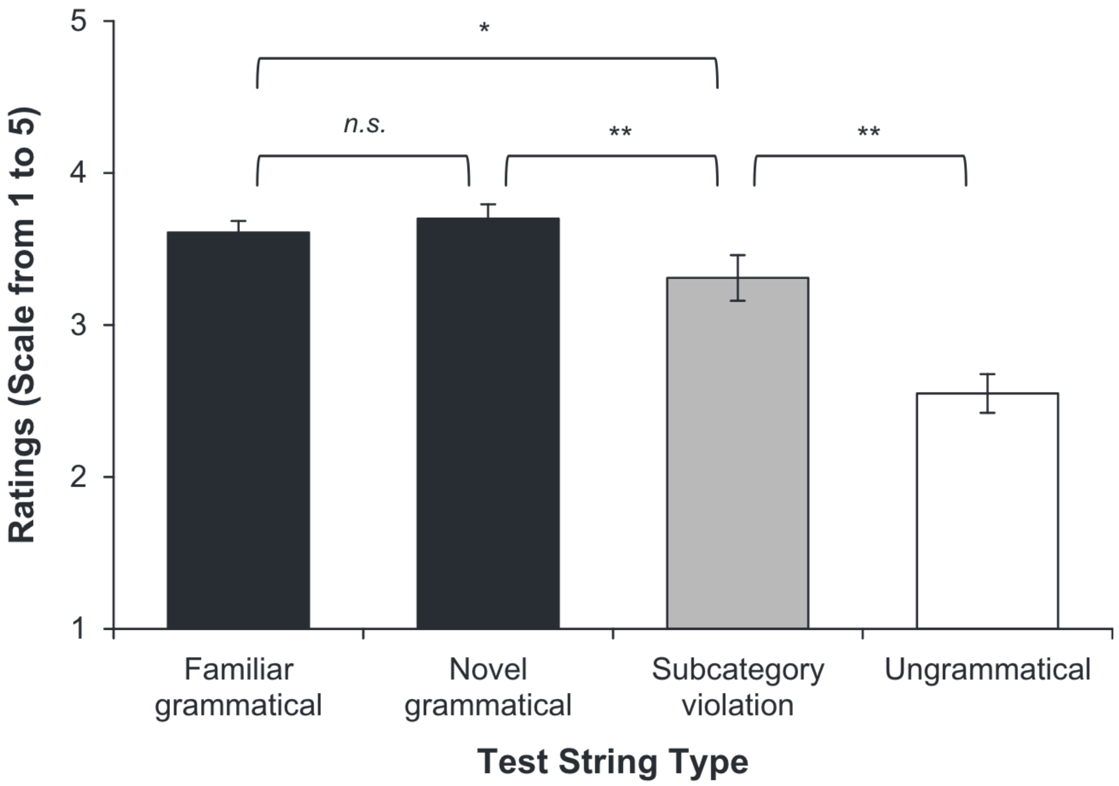

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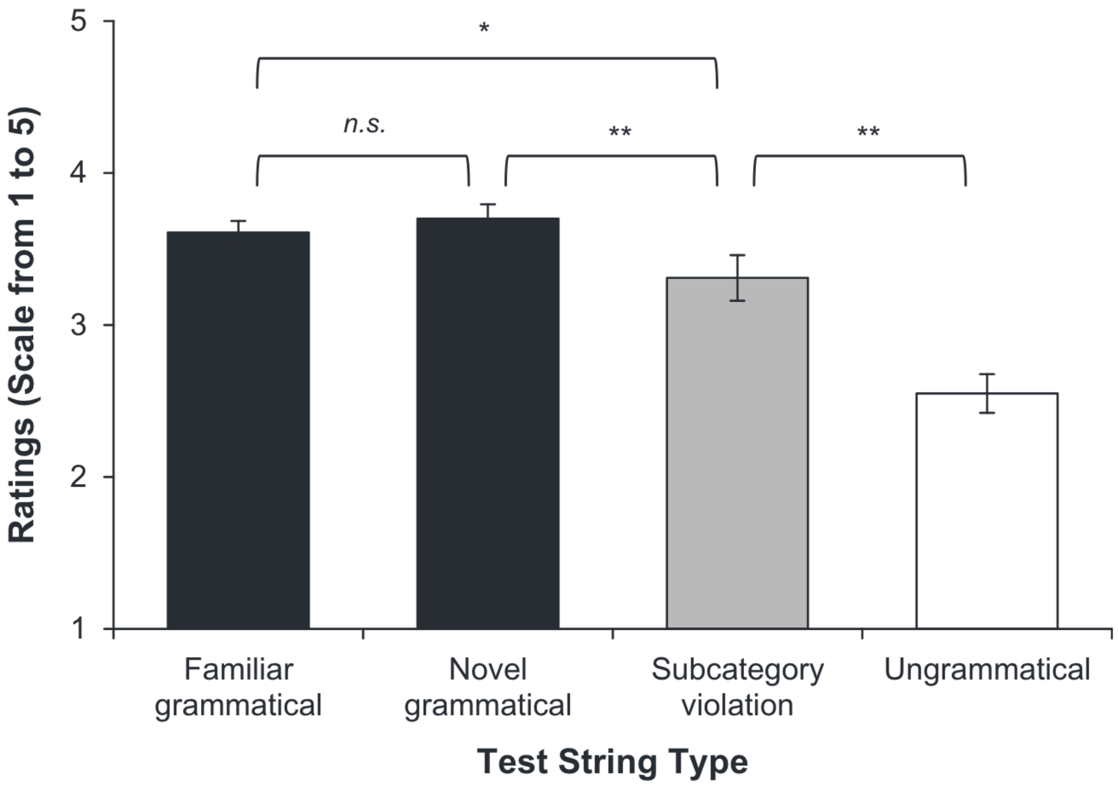

Taking the means of discrete ratings is very common—but a little strange!

Why Likert scale ratings aren't continuous numeric

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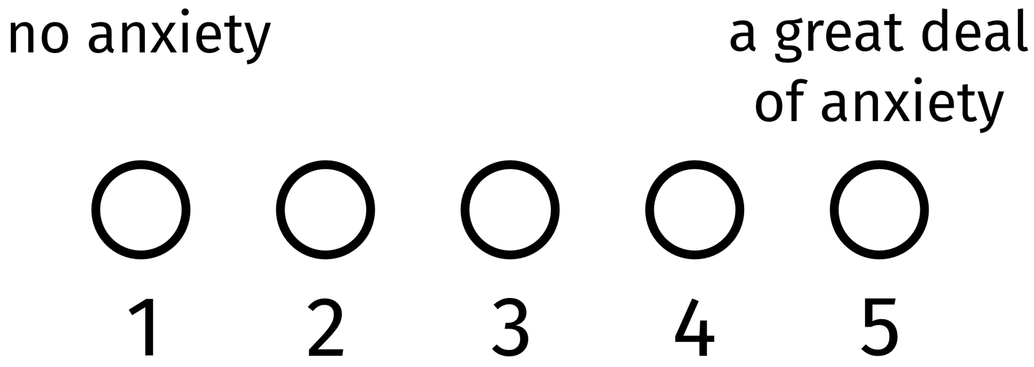

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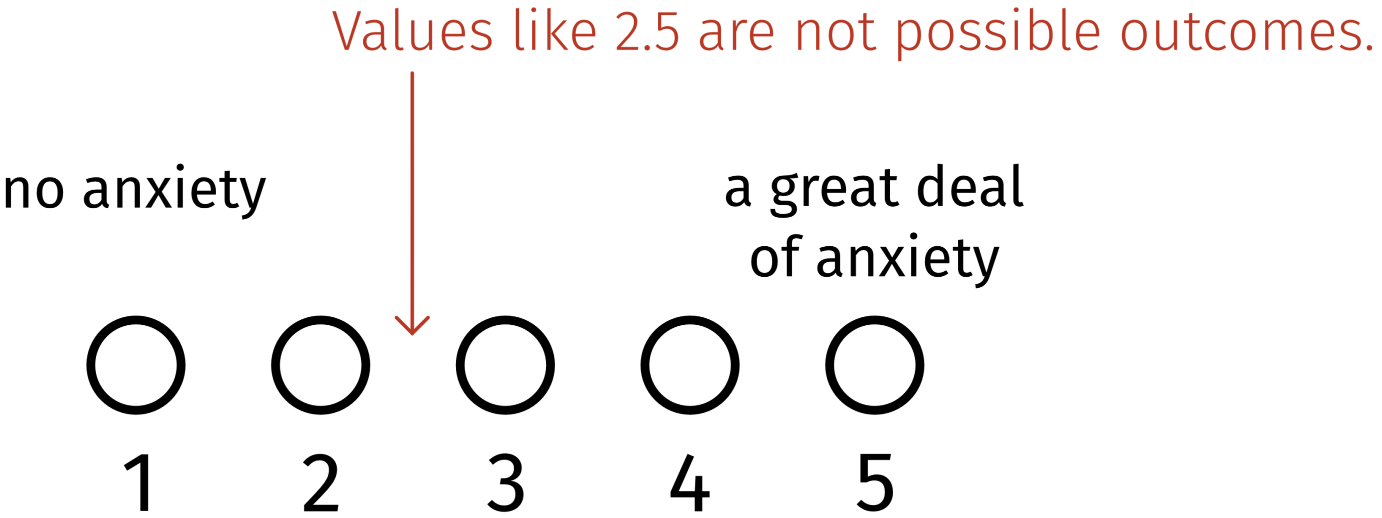

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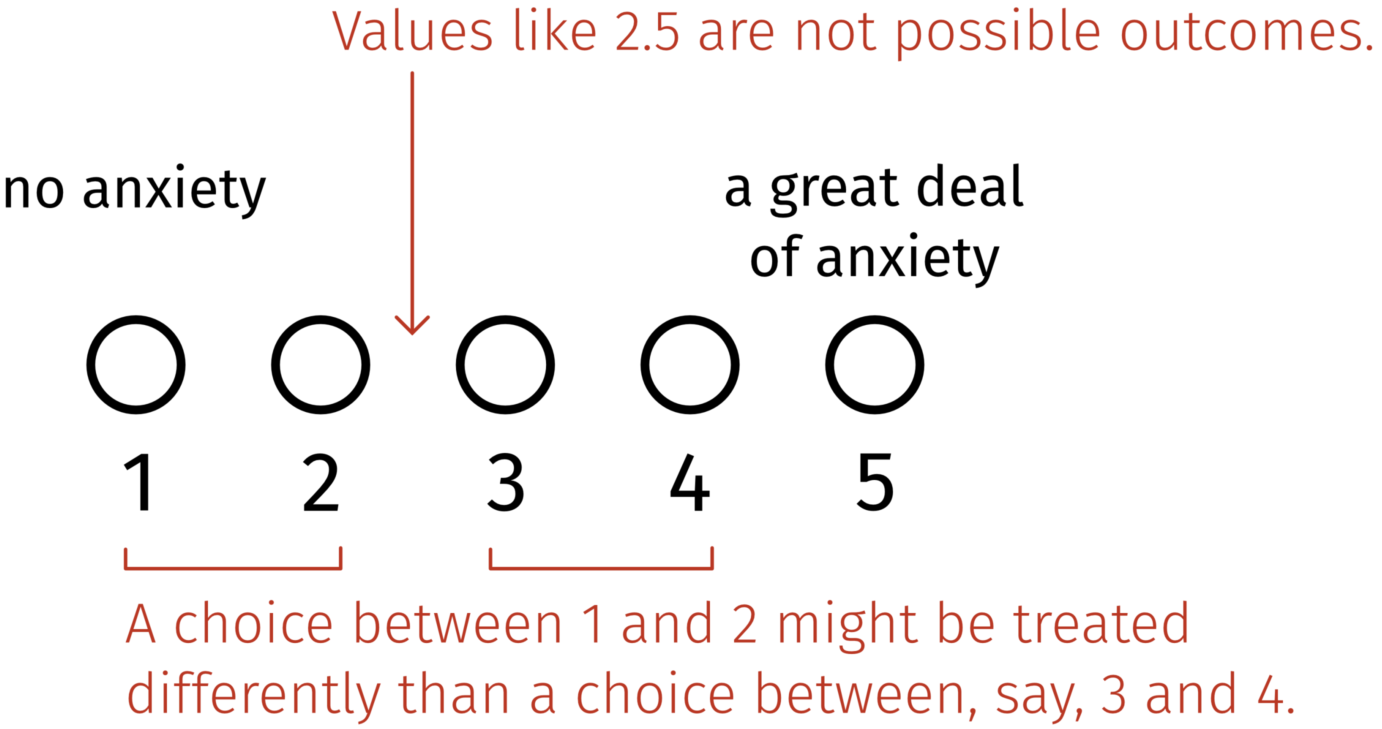

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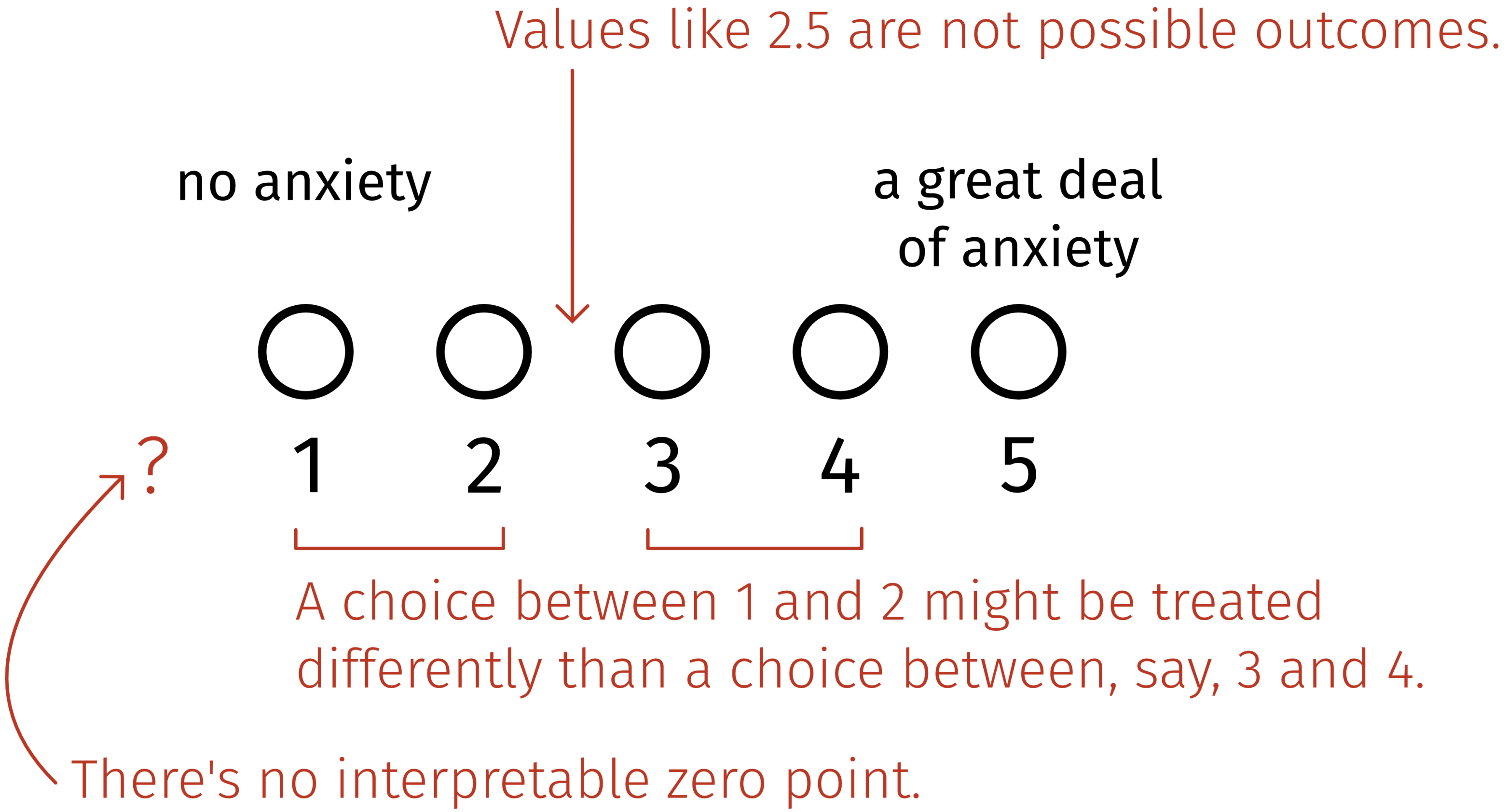

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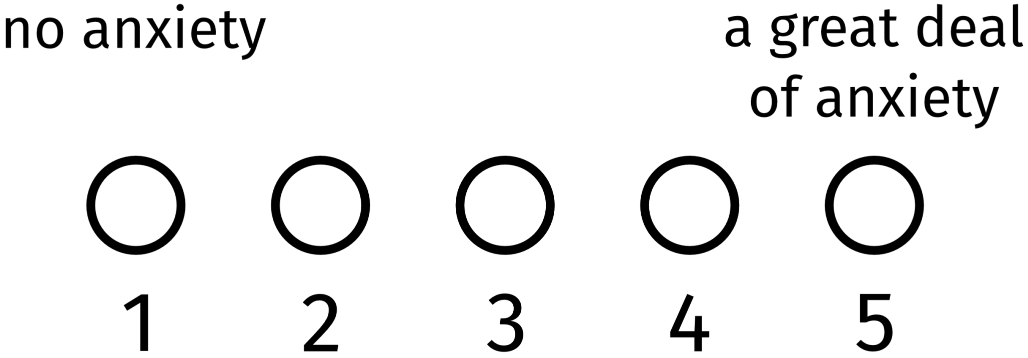

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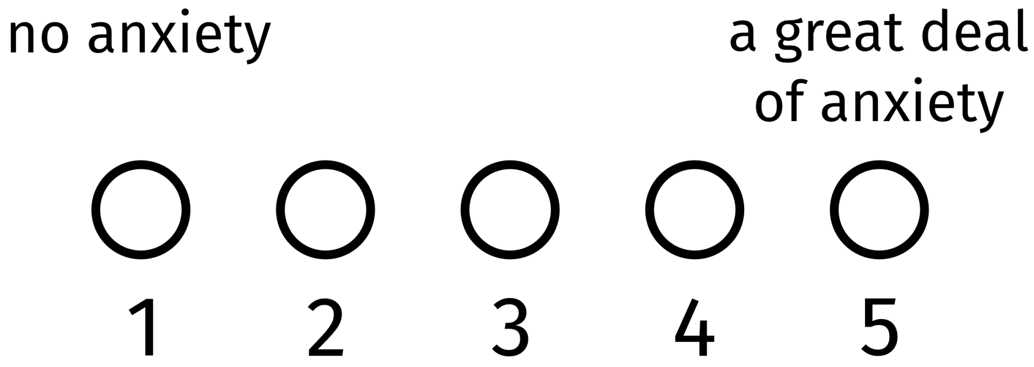
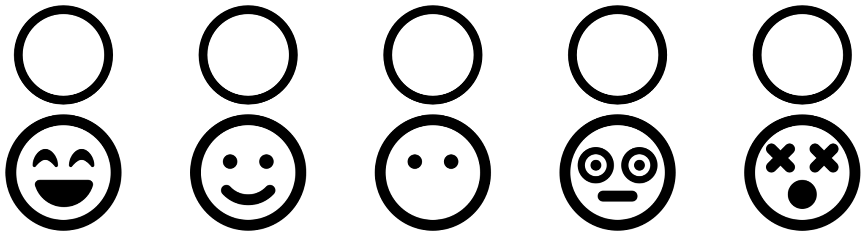


Numbers on a Likert scale are just labels.

Why Likert scale ratings aren’t continuous numeric

no anxiety

a great deal of anxiety



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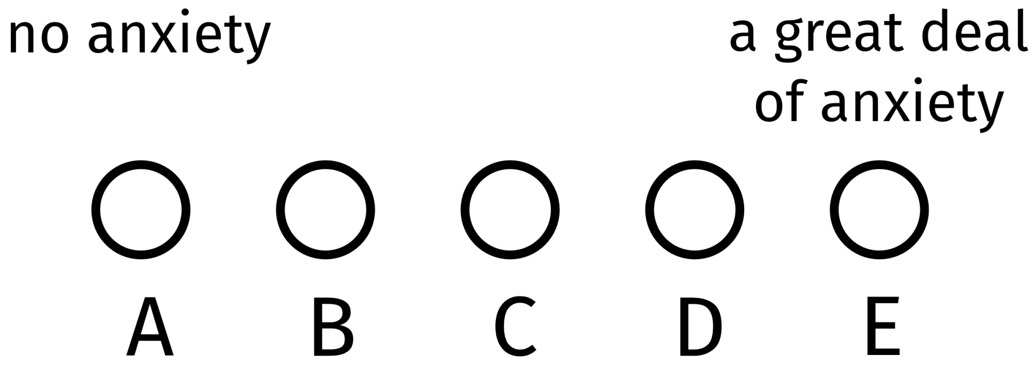

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The mistake

How you'll avoid it

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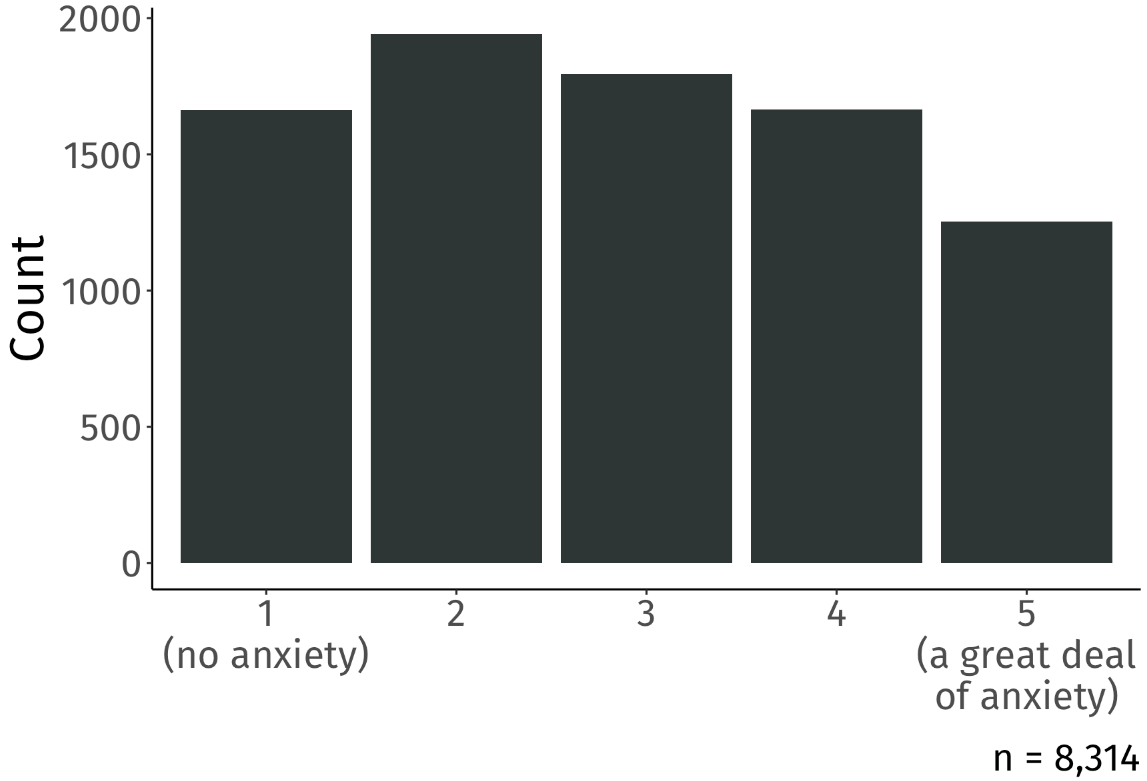

The data: Students' anxiety ratings for "Going to ask my statistics teacher for individual help with material I am having difficulty understanding".

```r
slice(anx, 45:50)
```

```
## # A tibble: 6 × 3
##   unique_id gender          rating
##   <chr>     <chr>            <dbl>
## 1 7d28c303  Female/Woman         4
## 2 7d55383a  Another Gender       4
## 3 8116550a  Female/Woman         1
## 4 83491ff9  Female/Woman         4
## 5 8450f8ad  Male/Man             2
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```

`rating` looks like numbers, and R treats it like numbers, as `dbl`.

So it's tempting to manipulate it like numbers.

```r
mean(anx$rating)
```

```
## [1] 2.868054
```

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Store categorical variables as factors.

```
anx <- anx |>
  mutate(rating = factor(rating))
```

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Store categorical variables as factors.

```
anx <- anx |>
  mutate(rating = factor(rating))
```

Now it’s impossible to incorrectly treat them as if they're numeric!

```
mean(anx$rating)
```

```
## [1] NA
```

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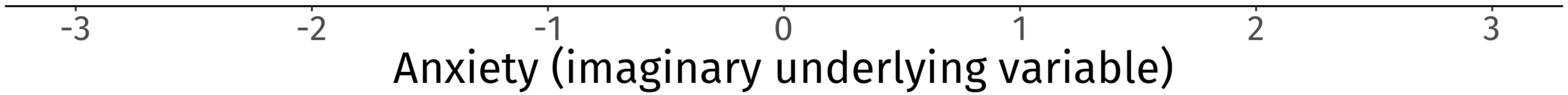

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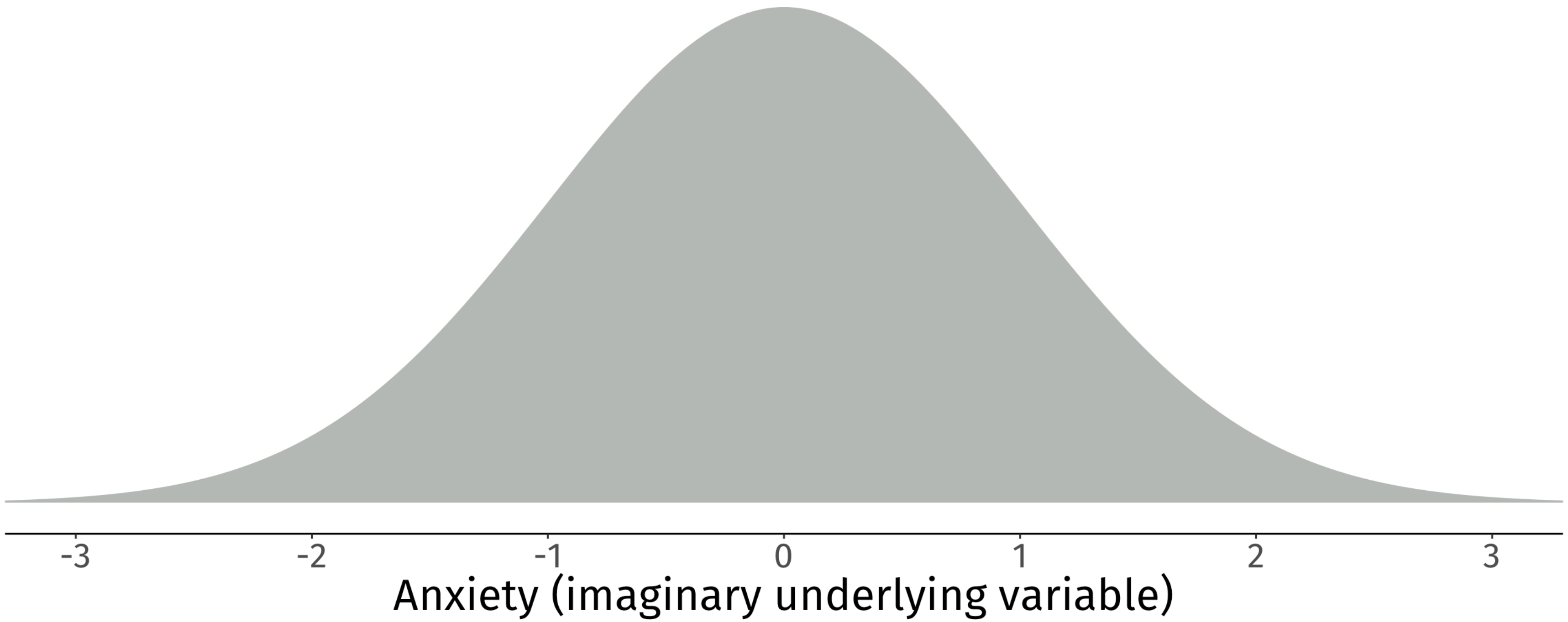

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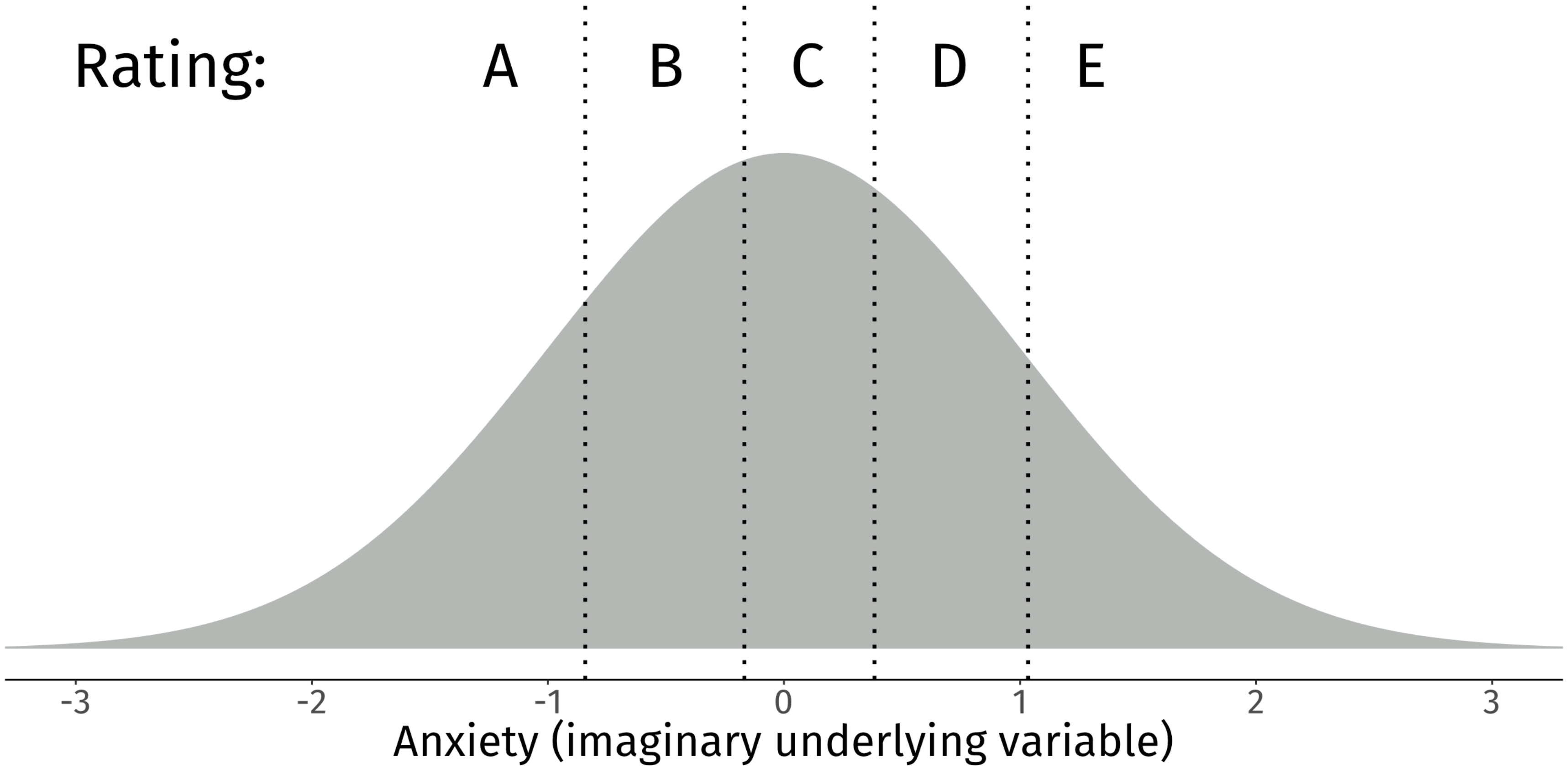

Fit ordinal regression models with `polr()`

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```
library(MASS)         # MASS contains the polr() function

anx_fit1 <- polr(
  rating ~ 1,         # intercept-only model, to start
  data = anx,
  Hess = TRUE, method = 'probit'   # ask me in the Q+A!
)
```

Fit ordinal regression models with `polr()`

```
summary(anx_fit1)
```

```
## Intercepts:
##      Value    Std. Error t value
## A|B  -0.8420   0.0157   -53.7268
## B|C  -0.1678   0.0138   -12.1462
## C|D   0.3833   0.0141    27.1512
## D|E   1.0339   0.0168    61.6193
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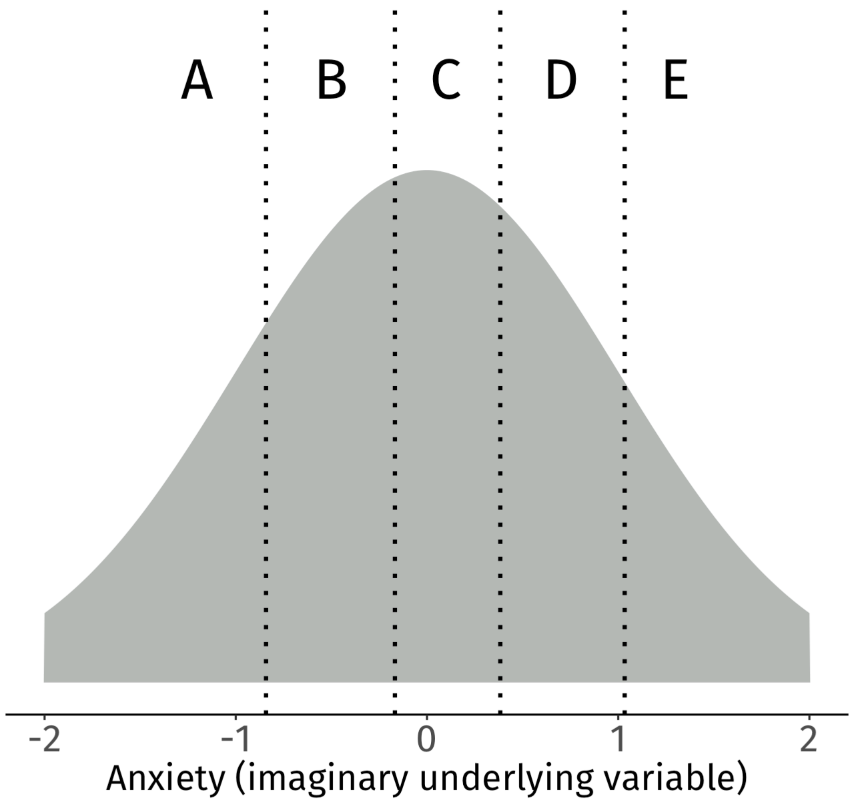

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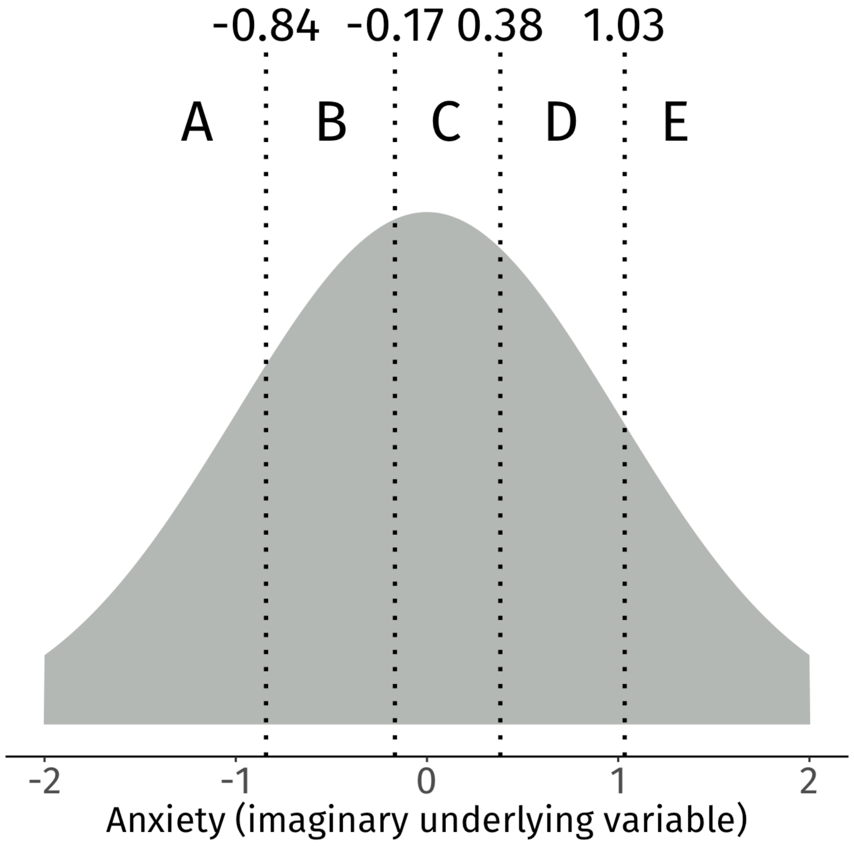

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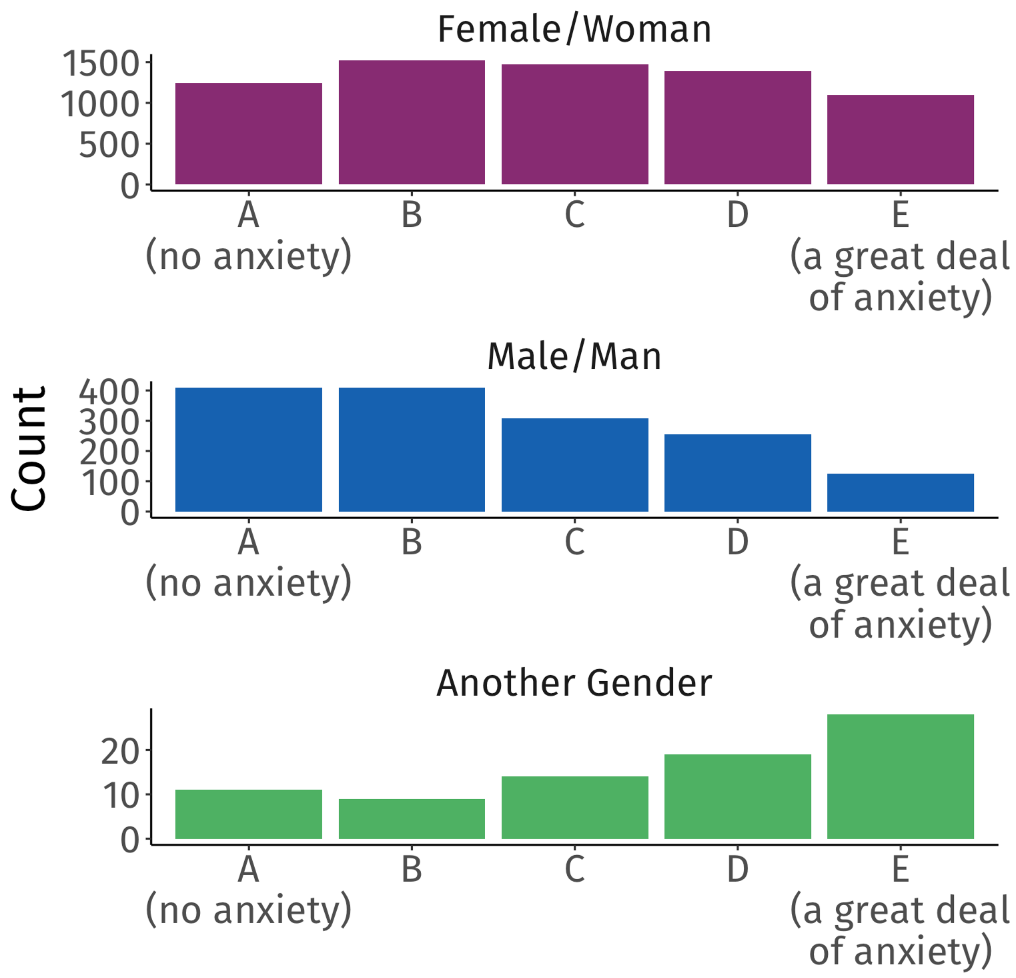

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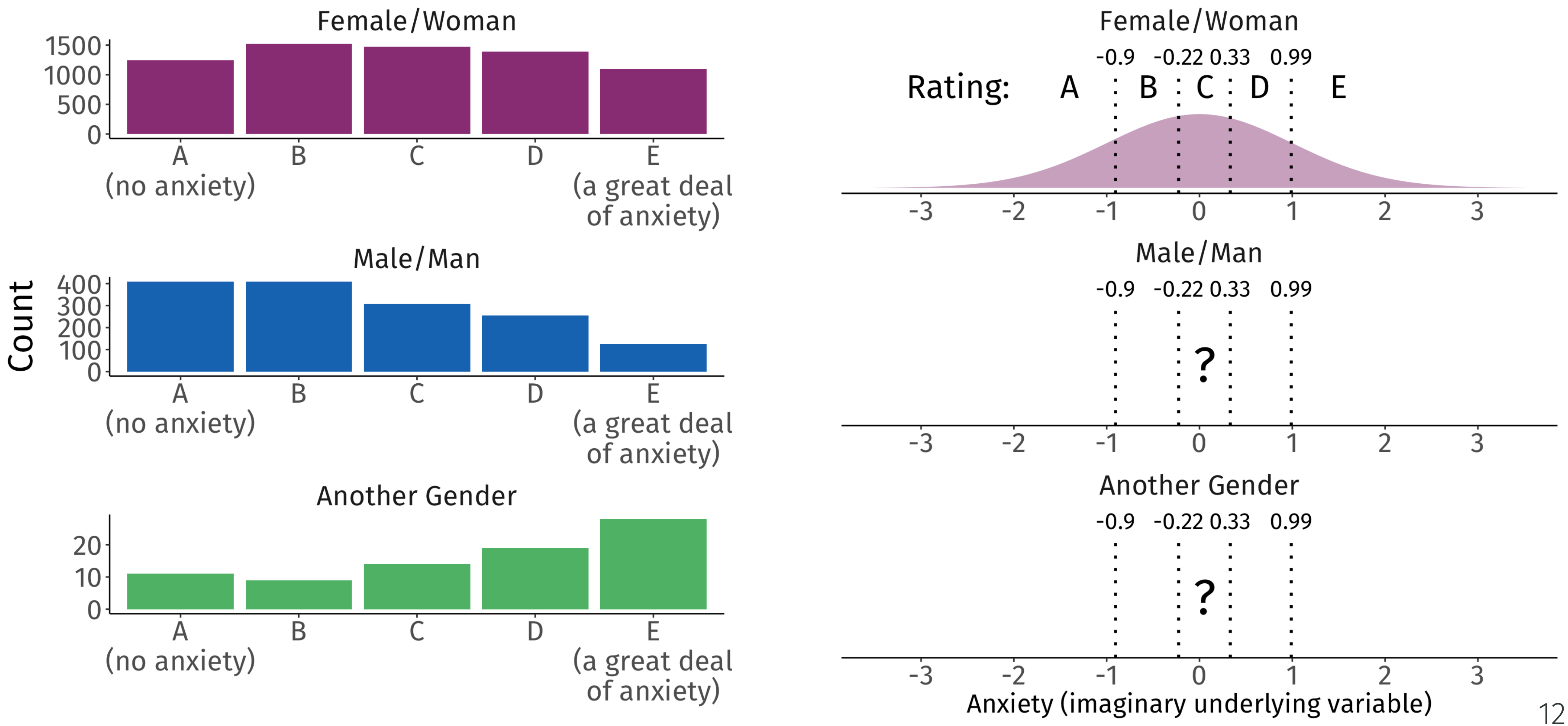
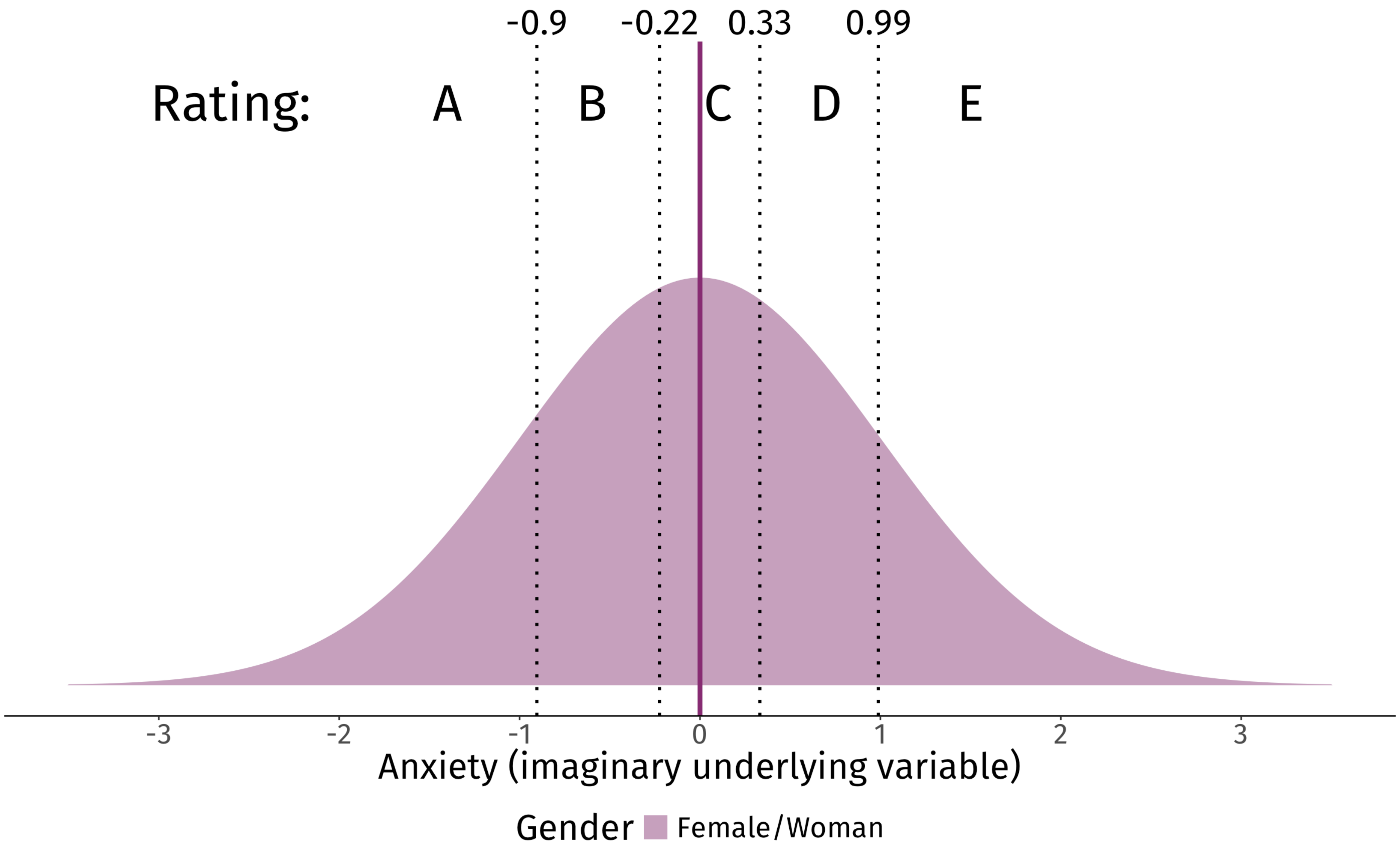
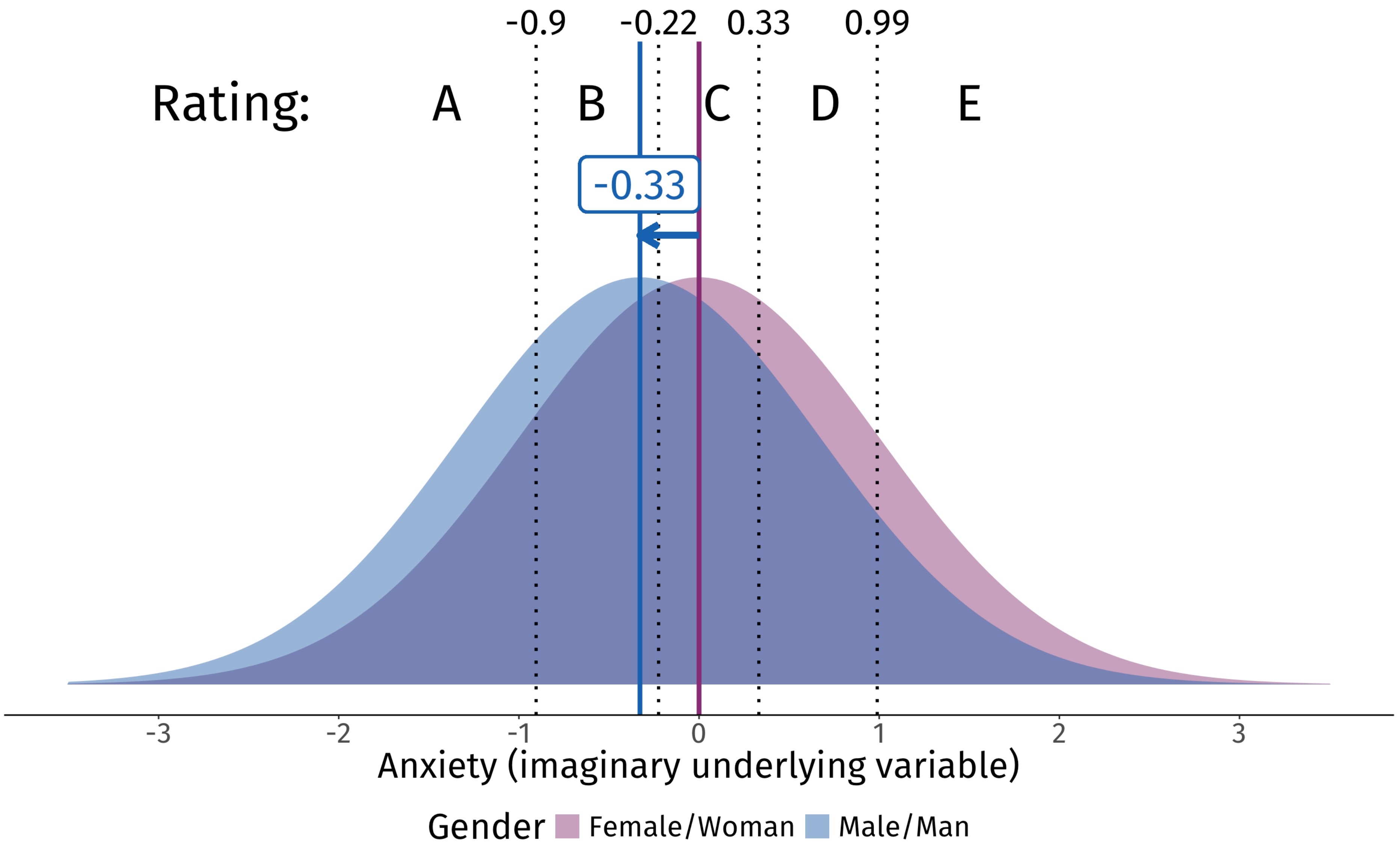



-0.9
-0.22
0.33
0.99
Rating:
A
B
C
D
E
-3
-2
-1
0
1
2
3
Anxiety (imaginary underlying variable)
Gender
Female/Woman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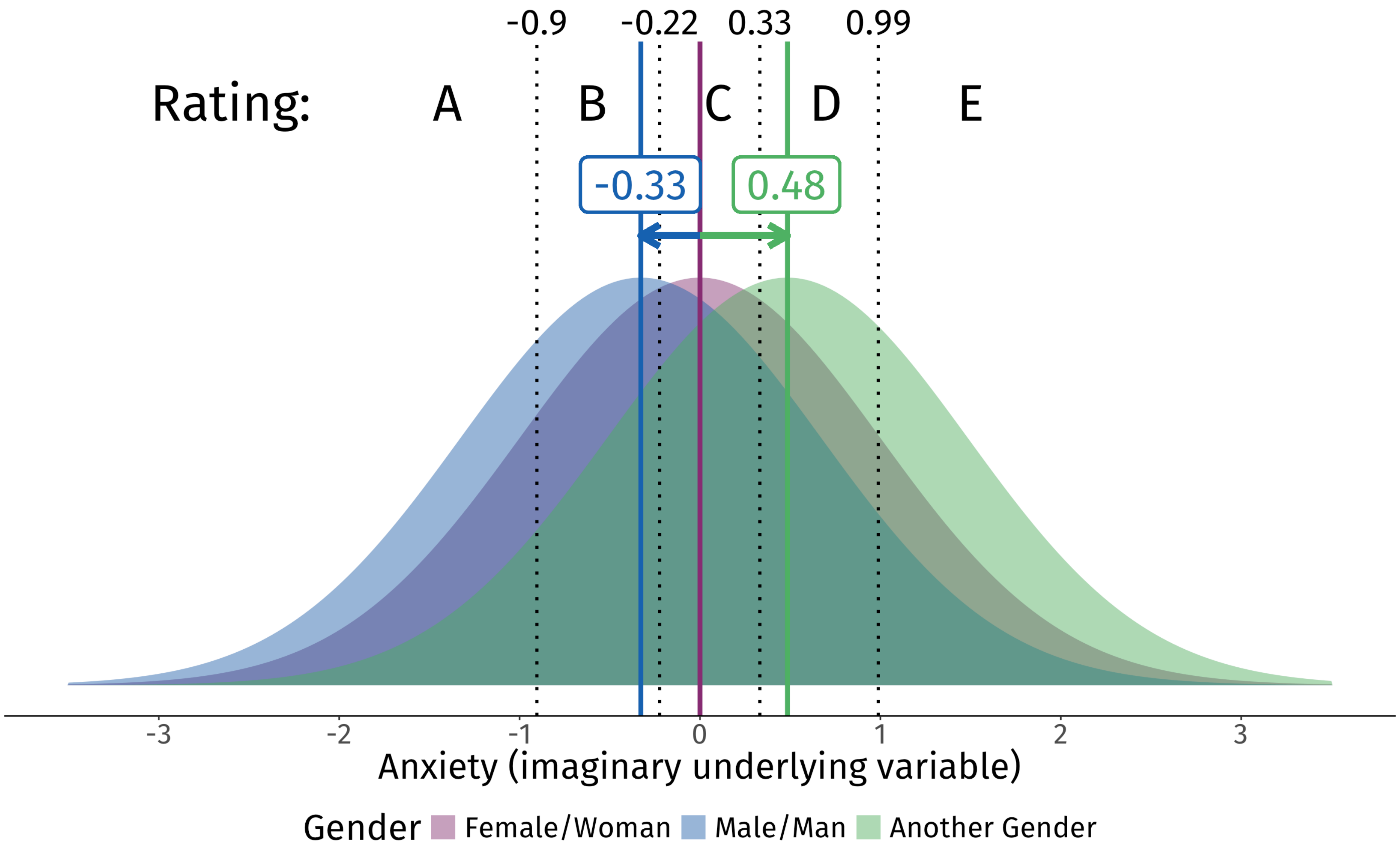
-0.9
-0.22
0.33
0.99
Rating:
A
B
C
D
E
-0.33
0.48
-3
-2
-1
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Are the effects of `gender` significant?

```
## Coefficients:
##                         Value Std. Error t value
## genderMale/Man        -0.3280    0.03015 -10.880
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No *p*-values in the model summary.

Are the effects of `gender` significant?

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## Coefficients:
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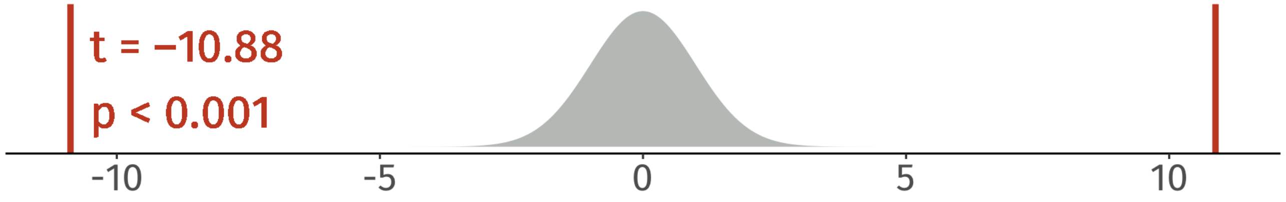

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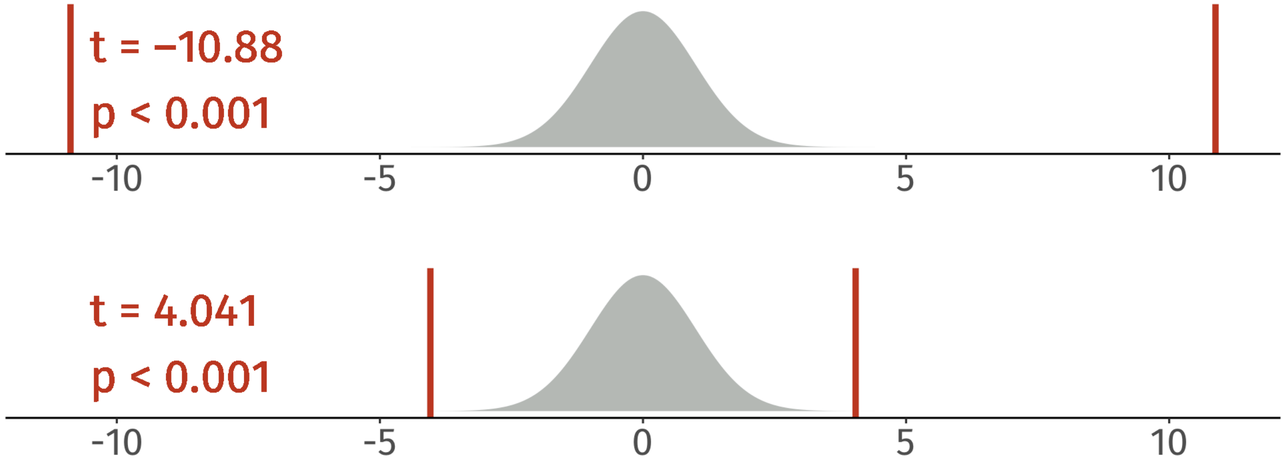

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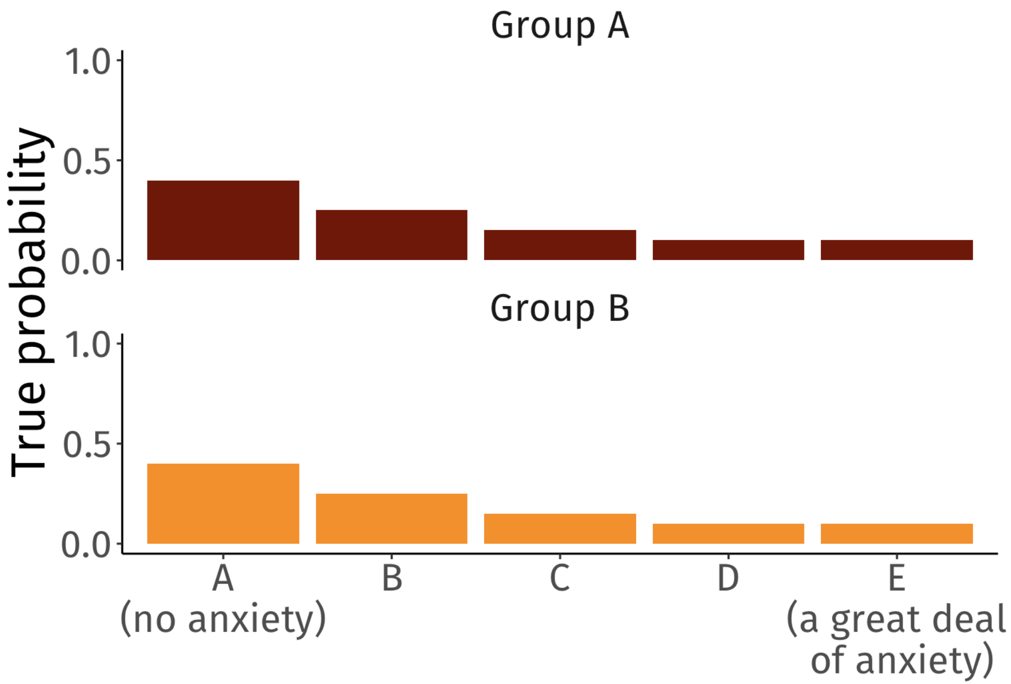

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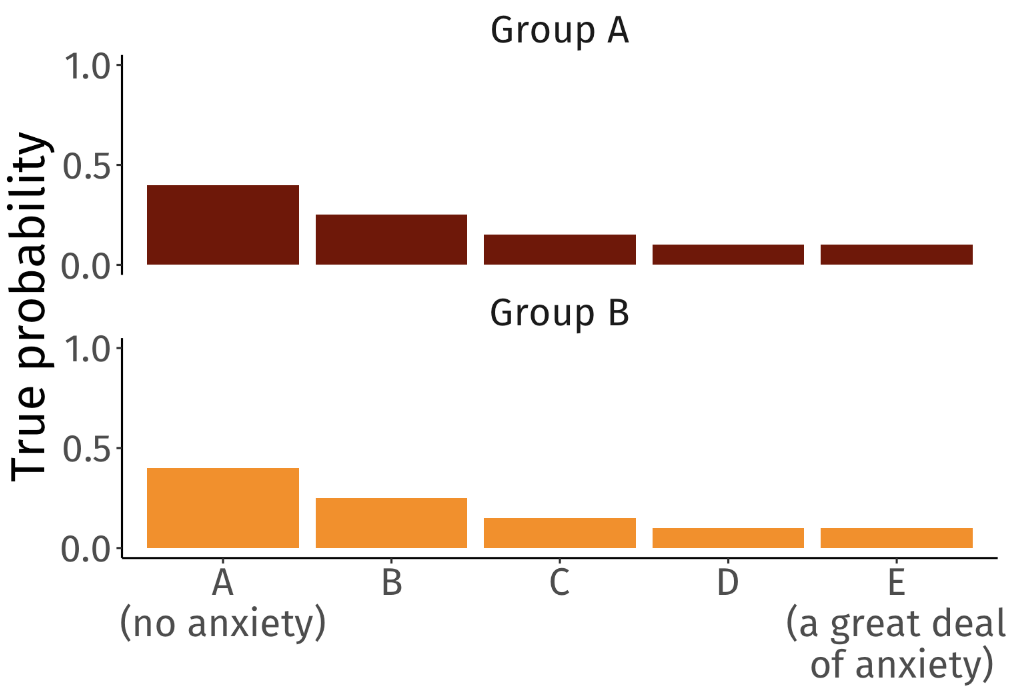
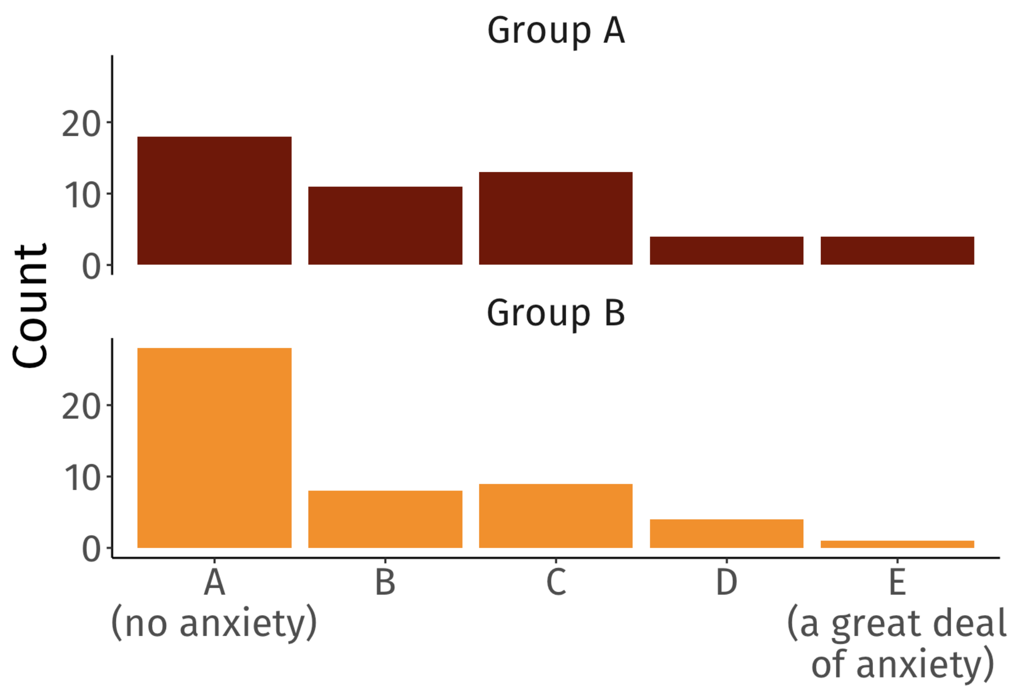


A possible random sample (n = 50 per group):



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```
sim_fit <- polr(rating ~ group, data = simdat, method = 'probit', Hess = TRUE)
summary(sim_fit)
```

```
## Coefficients:
##                 Value Std. Error t value
## groupGroup B -0.4479     0.2229  -2.009
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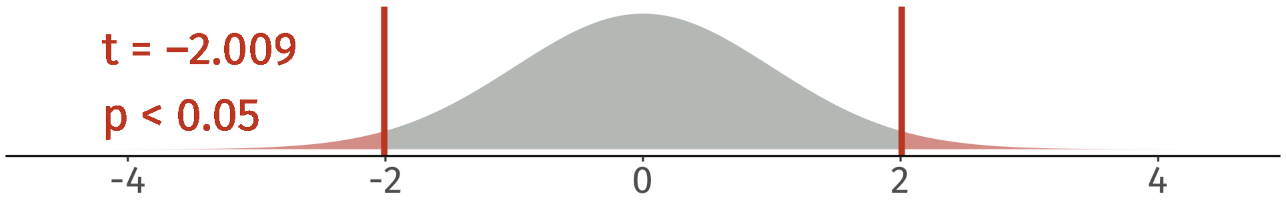

So *p* is significant, but in the true population, Group A and Group B were identical!

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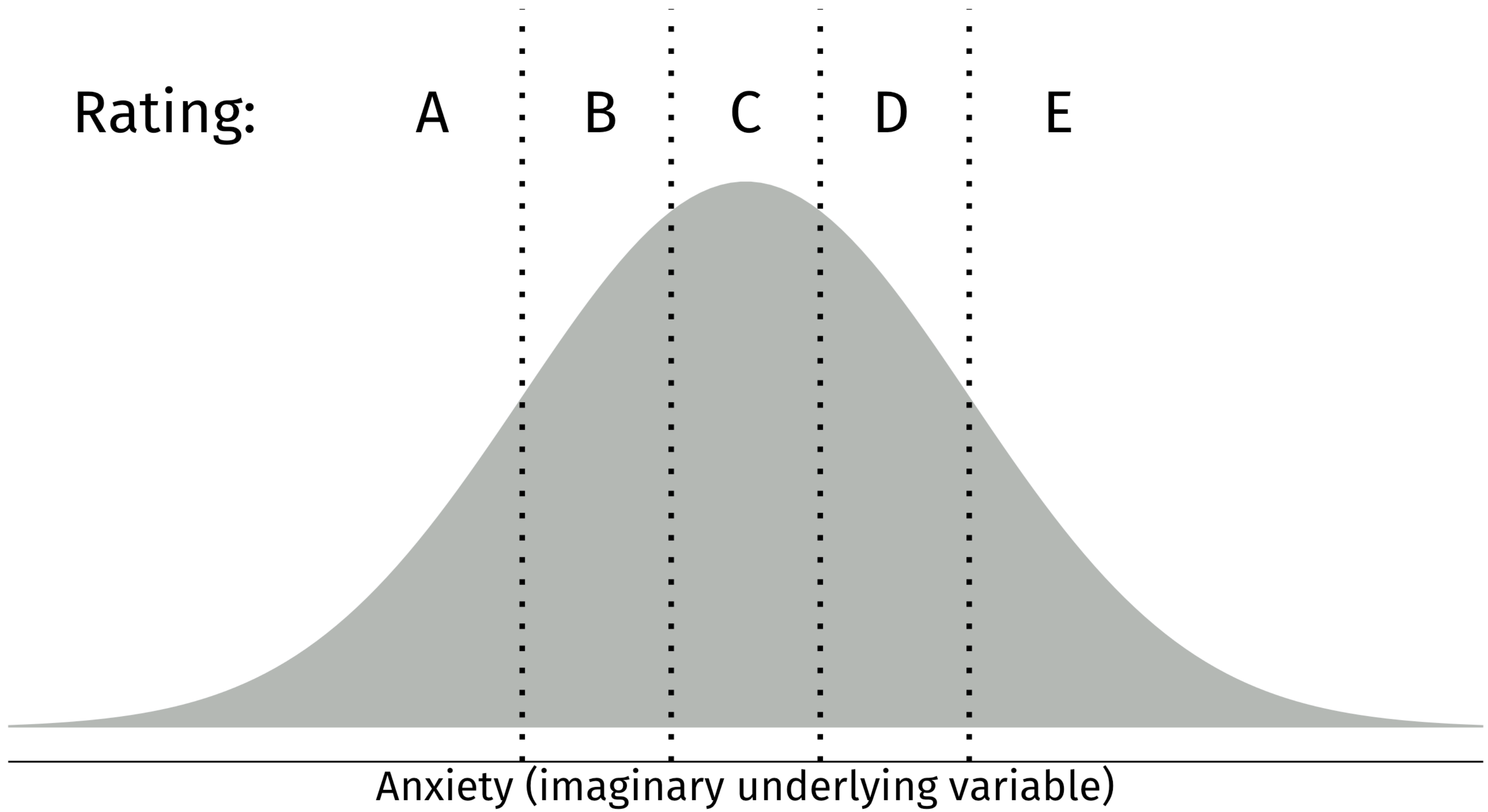
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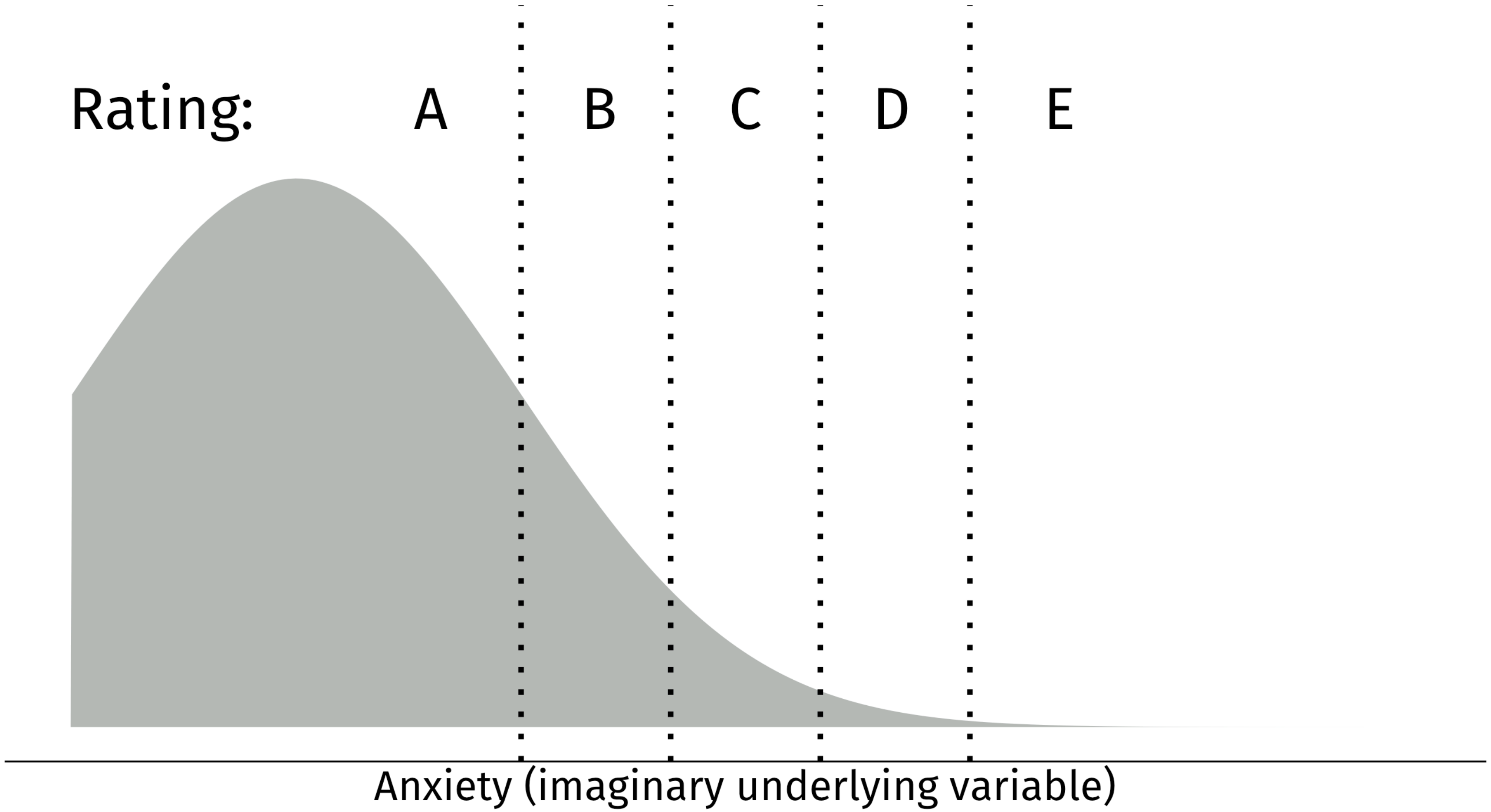

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Thank you! 😊 Time for questions!

Some really nice resources

- Jamieson's (2004) paper **Likert scales: How to (ab)use them.**
- UCLA Statistical Methods and Data Analytics's web page **Ordinal Logistic Regression.**
- Kurz' (2021) blog post **Notes on the Bayesian cumulative probit.**
- Vasishth and Nicenboim's (2016) paper **Statistical Methods for Linguistic Research: Foundational Ideas – Part I.**
- Gelman and Hill's (2007) book **Data Analysis Using Regression and Multilevel/Hierarchical Models.**

Plot on Slide 2 from

Reeder, P. A., Newport, E. L., & Aslin, R. N. (2017). Distributional learning of subcategories in an artificial grammar: Category generalization and subcategory restrictions. *Journal of Memory and Language*, 97, 17–29.

Data from

Terry, J., Ross, R. M., Nagy, T., Salgado, M., Garrido-Vásquez, P., Sarfo, J. O., Cooper, S., Buttner, A. C., Lima, T. J. S., Öztürk, İ., Akay, N., Santos, F. H., Artemenko, C., Copping, L. T., Elsherif, M. M., Milovanović, I., Cribbie, R. A., Drushlyak, M. G., Swainston, K., … Field, A. P. (2023). Data from an International Multi-Centre Study of Statistics and Mathematics Anxieties and Related Variables in University Students (the SMARVUS Dataset). *Journal of Open Psychology Data*, 11(1), 8.