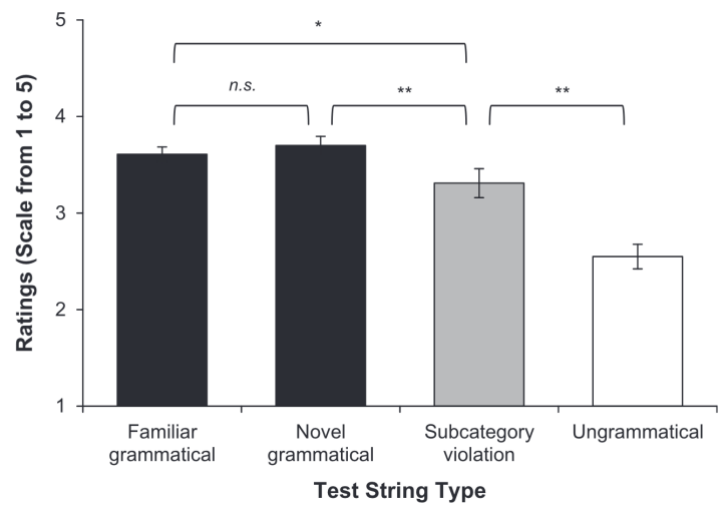


Three common mistakes in statistics and how to avoid them

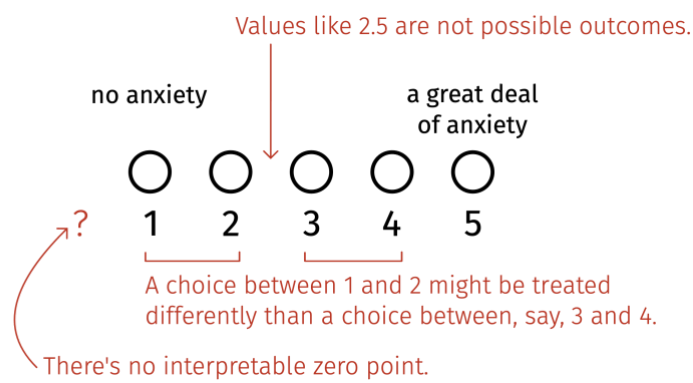
Elizabeth Pankratz, 26 March 2025

Something you won't be able to unsee

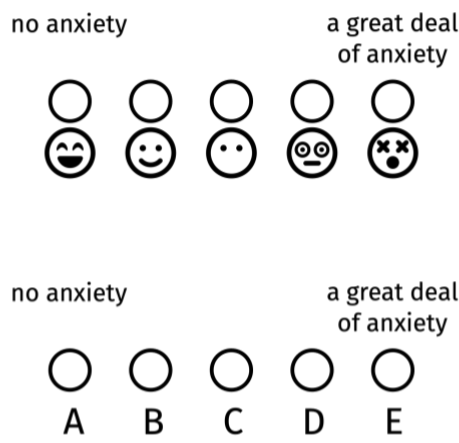


Taking the means of discrete ratings is very common—but a little strange!

Why Likert scale ratings aren't continuous numeric



Numbers on a Likert scale are just labels.



The mistake and how you'll avoid it

The mistake

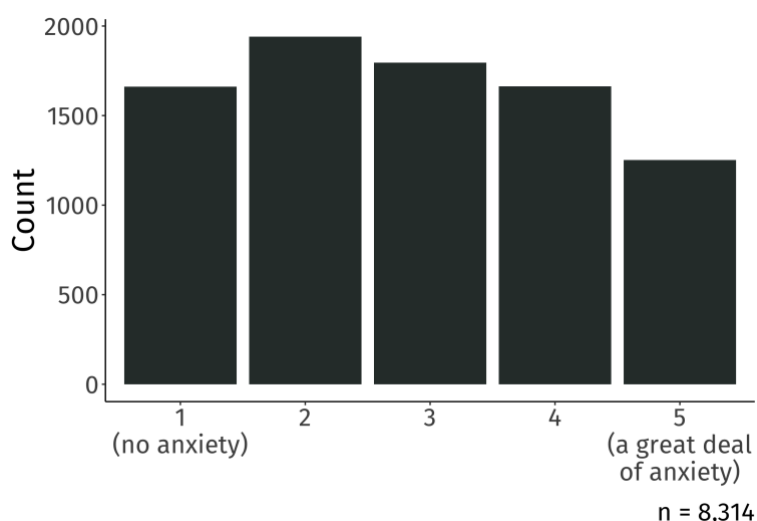
A common R mistake: Letting R treat all variables that look like numbers as continuous numeric.

A foundational stats mistake: Modelling categorical, ordinal data as if it were numeric.

A foundational stats mistake: Interpreting a significant p -value as evidence that an effect exists in the real world.

How you'll avoid it

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



```
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
## 6 876547d6 Female/Woman      3
```

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

So it's tempting to manipulate it like numbers.

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

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

Remember: We are smarter than R is

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
```

The mistake and how you'll avoid it

The mistake

A common R mistake: Letting R treat all variables that look like numbers as continuous numeric.

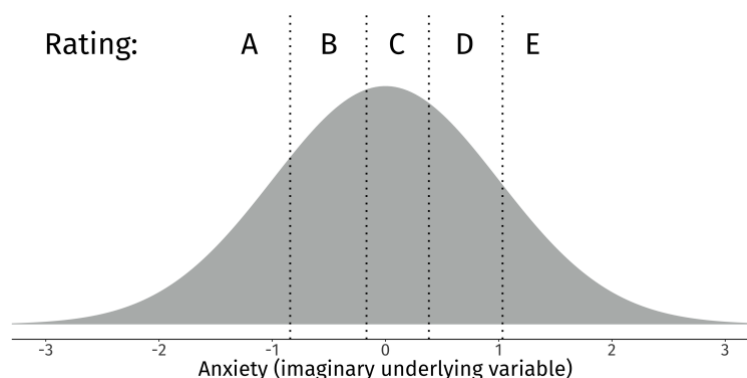
A foundational stats mistake: Modelling categorical, ordinal data as if it were numeric.

A foundational stats mistake: Interpreting a significant p -value as evidence that an effect exists in the real world.

How you'll avoid it

When a variable comes from a Likert scale, tell R it's categorical using `factor()`.

What ordinal regression models do



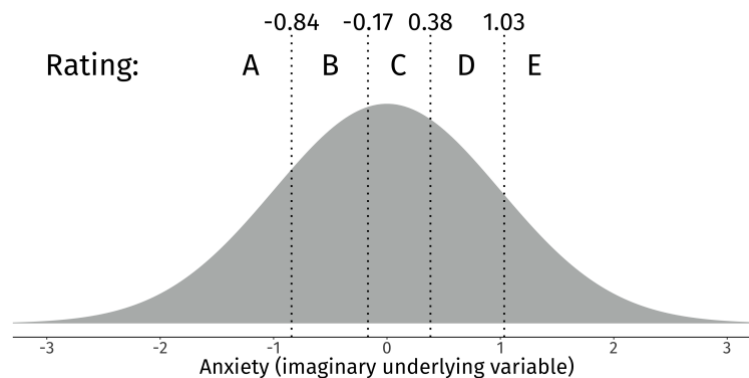
Fit ordinal regression models with `polr()`

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

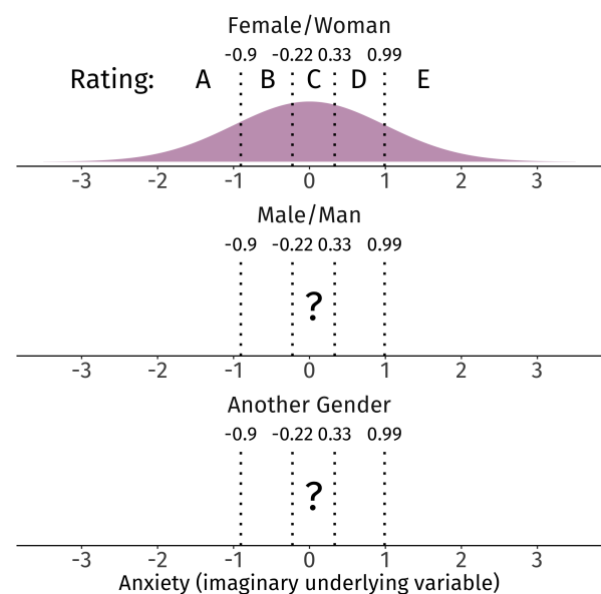
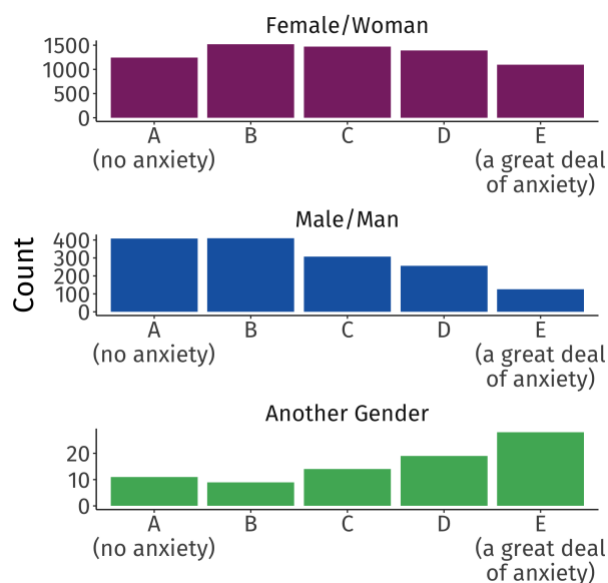
anx_fit1 <- polr(
  rating ~ 1, # intercept-only model, to start
  data = anx,
  Hess = TRUE, method = 'probit' # ask me in the Q+A!
)
```

```
summary(anx_fit1)
```

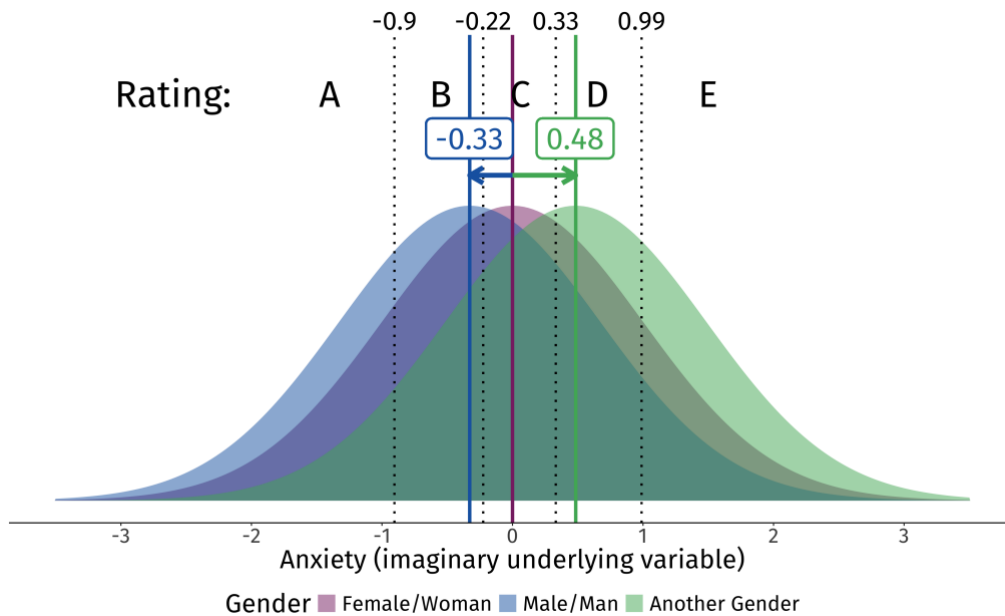
```
## Intercepts:
##      Value Std. Error t value
## 1|2 -0.8420  0.0157  -53.7268
## 2|3 -0.1678  0.0138  -12.1462
## 3|4  0.3833  0.0141   27.1512
## 4|5  1.0339  0.0168   61.6193
```



How does a student's gender affect ratings for "Going to ask my statistics teacher for individual help with material I am having difficulty understanding"?



Don't flip the page until after the activity!



The mistake and how you'll avoid it

The mistake

A common R mistake: Letting R treat all variables that look like numbers as continuous numeric.

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A foundational stats mistake: Interpreting a significant p -value as evidence that an effect exists in the real world.

How you'll avoid it

When a variable comes from a Likert scale, tell R it's categorical using `factor()`.

Apply and interpret ordinal regression models (e.g., `polr()` from MASS).

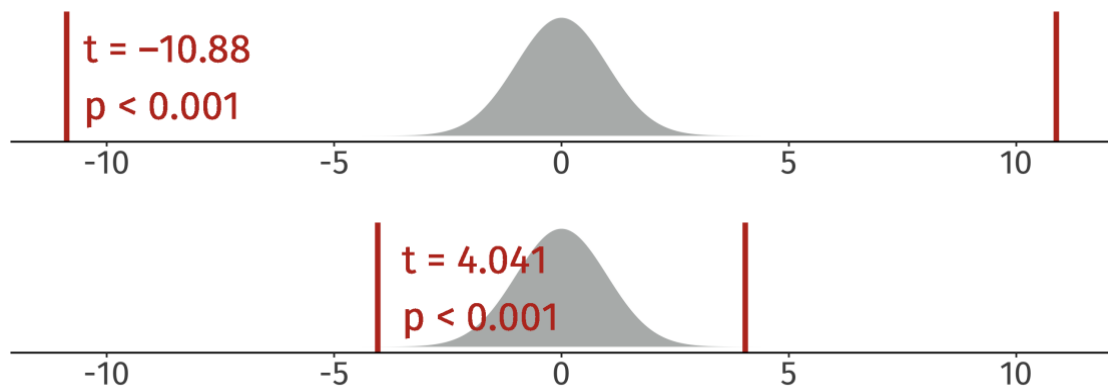
Are the effects of gender significant?

```
summary(anx_fit2)
```

```
## Coefficients:
##              Value Std. Error t value
## genderMale/Man   -0.3280    0.03015 -10.880
## genderAnother Gender  0.4846    0.11992   4.041
```

No p -values in the model summary.

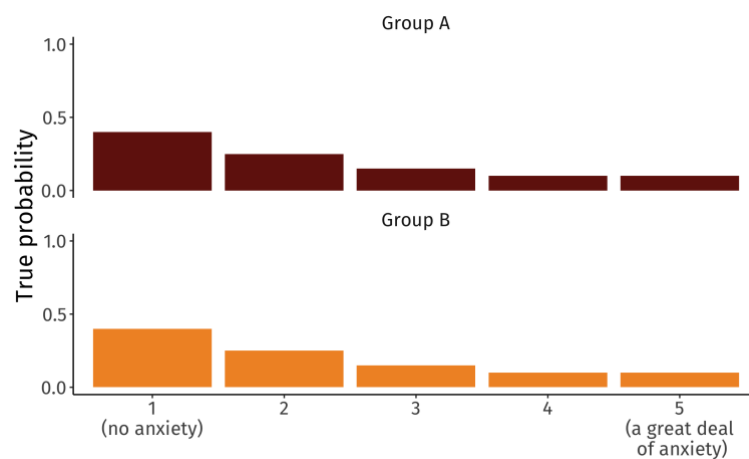
But it's common practice to compare these t -values to a standard normal distribution.



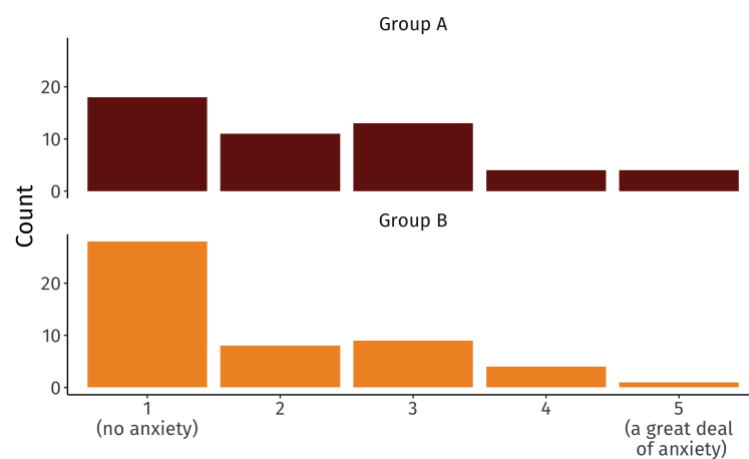
Why don't significant p -values mean an effect exists?

Because we can also get significant p -values when there really is *no* effect.

No difference in the true population:

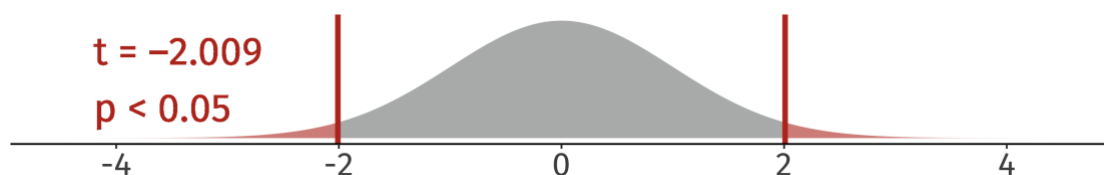


A possible random sample ($n = 50$ per group):



```
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
```



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

The mistake and how you'll avoid it

The mistake

A common R mistake: Letting R treat all variables that look like numbers as continuous numeric.

A foundational stats mistake: Modelling categorical, ordinal data as if it were numeric.

A foundational stats mistake: Interpreting a significant p -value as evidence that an effect exists in the real world.

How you'll avoid it

When a variable comes from a Likert scale, tell R it's categorical using `factor()`.

Apply and interpret ordinal regression models (e.g., `polr()` from MASS).

Understand that significant p -values can arise even if no effect exists in the real world.

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.