6. Estimating R2 values from mixed models

- Understand why mixed models don’t generate R2 values
- Learn how to estimate an R2 value for your mixed model
- Learn how to scale your data to generate standardized effect estimates

Regular linear model

```
> summary(mod1)

Call:
lm(formula = AFD ~ LENGTH, data = Clams)

Residuals:
      Min        1Q    Median        3Q       Max
-0.079253 -0.014092 -0.004987  0.008578  0.286588

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept) -0.1313364  0.0049097  -26.75   <2e-16 ***
LENGTH       0.0119844  0.0002598   46.13   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.03004 on 396 degrees of freedom
Multiple R-squared:  0.8431,    Adjusted R-squared:  0.8427
F-statistic:  2128 on 1 and 396 DF,  p-value: < 2.2e-16
```

What is this again?

Linear MIXED model

```
> summary(mod.final)
Linear mixed-effects model fit by REML
 Data: RIKZ
       AIC      BIC    logLik
  240.5538 249.2422 -115.2769

Random effects:
 Formula: ~1 | Beach
        (Intercept) Residual
StdDev:    1.907175 3.059089

Fixed effects: Richness ~ NAP + fExposure
                Value Std.Error DF   t-value p-value
(Intercept)  8.601088 1.0594875 35  8.118158  0.0000
NAP         -2.581708 0.4883901 35 -5.286160  0.0000
fExposure11 -4.532777 1.5755610  7 -2.876929  0.0238
 Correlation:
            (Intr) NAP
NAP         -0.136
fExposure11 -0.655 -0.037

Standardized Within-Group Residuals:
       Min         Q1        Med         Q3        Max
-1.5163203 -0.4815106 -0.1218700  0.2922854  3.8777562

Number of Observations: 45
Number of Groups: 9
>
```

R^2 of mixed model

- R^2 of LM tells how much total variance is explained by your model (ranges from 0 – 1)
  - Unit-less so comparable across models and offers a stand-alone measure of fit
- Mixed models do not provide this so how do you measure how good your model is?
  - AIC/BIC/DIC useful for model comparison (with the same data), but can tell us nothing about absolute fit and are not at all comparable across data sets.

Estimating R^2 of mixed model is not trivial

- LM: how much variance is explained by your model?

$$R^2 = 1 - \frac{\sigma_\varepsilon^2}{var(y_i)}$$

  - σ_ε^2 = residual variance of your final model (how much variance is unexplained by your model
  - $var(y_i)$ =(how much total variance is in your data)

- Mixed models: you have (at least) two error terms, residual error and error associated with your random effects. Are random effects explaining variance or what?

Marginal vs conditional R^2

- Marginal – variance explained just by the fixed effects
  - $R^2 = \frac{var(\widehat{y_i})}{var(y_i)} = \frac{\sigma_f^2}{\sigma_f^2+\sigma_g^2+\sigma_\varepsilon^2}$

- Conditional – variance explained by both the fixed and random effects
  - $R^2 = \frac{\sigma_f^2+\sigma_g^2}{\sigma_f^2+\sigma_g^2+\sigma_\varepsilon^2}$

Estimating R^2 in R

- RIKZ data set in R

Mis-use of p-values

- P-values say whether or not there is an effect of X on Y

BUT THEY SAY NOTHING ABOUT HOW STRONG/LARGE THAT EFFECT IS

Significant ….

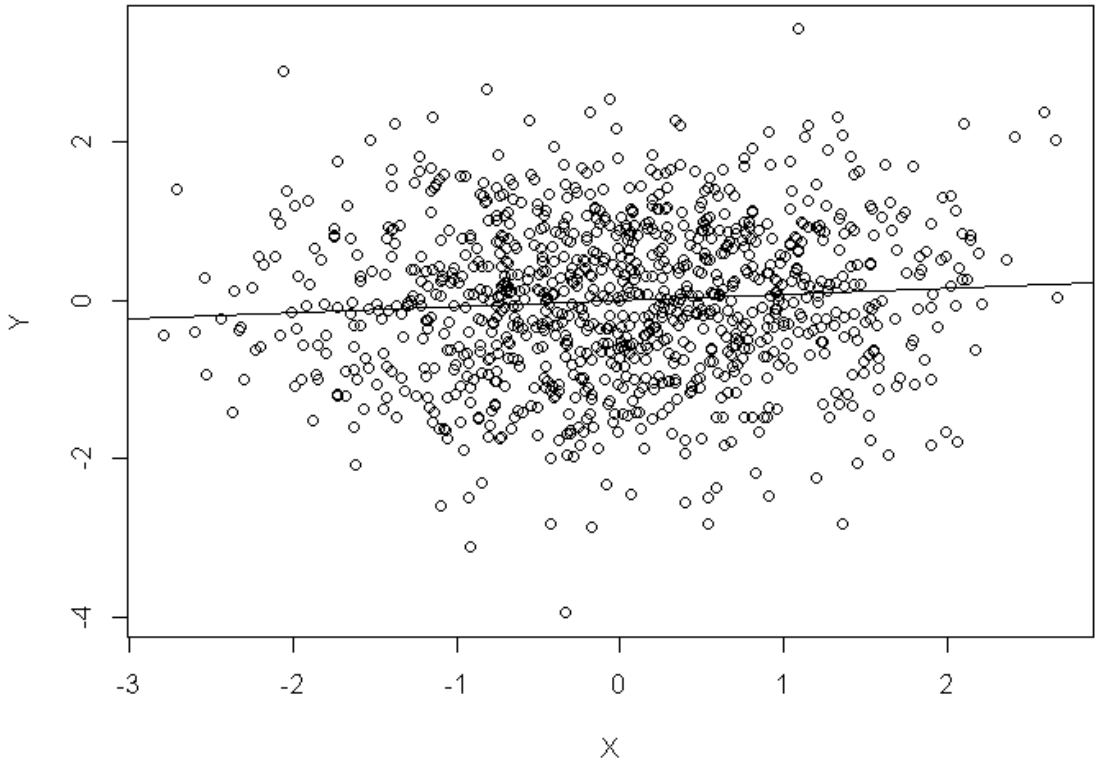
```
Call:
lm(formula = Y ~ X)

Residuals:
    Min      1Q  Median      3Q     Max
-3.9165 -0.6748  0.0267  0.7089  3.3358

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) 4.339e-17  3.154e-02   0.000   1.0000
X           8.000e-02  3.155e-02   2.535   0.0114 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

YAY!

p < 0.05!

Significant …. But not important

Correlation = 0.08



Correlations and R-squared values give you unitless values of how much variance is explained – how important is your variable?

Linear MIXED model

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How important are these factors? Which one is more important? P-value and estimates are not very informative!

Standardized coefficients (betas)

- This can easily be done by scaling all your response and predictors variables to standard deviation units
  - Divide all values by their standard deviation (variance = 1)
  - Now all factors on same scale
    - Increase of 1 standard deviation unit in the predictor results in an increase of x standard deviation units in the response

- Standardizing categorical predictors can be tricky! What is the standard deviation of gender (male, female), e.g.?
  - If both categorical and continuous variables are included in the same model, you may need to divide continuous variables by TWO stn.dev
  - Lots of different options for this, but this requires some research on your own part! (I put some good starting points in the “Further reading”)

R2 values and estimate standardization

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FURTHER READING on R2 & standardization for mixed models:

- Nakagawa & Schielzeth. 2013. A general and simple method for obtaining R2 from generalized linear mixed-effects models. Methods Ecol & Evol 4
- Nakagawa & Cuthill. 2007. Effect size, confidence interval and statistical significance: a practical guide for biologists. *Biol. Reviews 82*
- Schielzeth 2010. Simple means to improve the interpretability of regression coefficients. *Methods Ecol Evol*
- Gelman & Hill book. Chapter 4.
- http://www.stat.columbia.edu/~gelman/research/unpublished/standardizing.pdf