3.4 How does adonis2 do it?

The adonis2 function (in the vegan package in R) will provide a partitioning of the total sum of squares according to a given ANOVA design. *However*, adonis2 constructs pseudo-F ratios for **all** of the terms in **any** model **using the residual mean square** (MS_{Res}$) **as the denominator** (yikes!). In many cases, this will (clearly) give you incorrect results.

Thus, adonis2 has two fundamental drawbacks:

- It does **not** use expectations of mean squares to construct the correct F tests.
- It does **not** identify the correct permutable units for tests of individual terms in the model.

This means there are really important **limits** on what kinds of ANOVA models adonis2 can actually (safely) be used for. Specifically, adonis2 will not handle correctly any designs that have random factors or nested factors. It also may be problematic for cases where there are continuous covariates and/or imbalance in the study design, whenever these features affect the EMS (i.e., almost always).

In effect, adonis2 assumes everything is a fixed factor, and a sequential (Type I) SS is done. This function is therefore also quite limiting for analysing unbalanced ANOVA designs or designs with quantitative covariates. In contrast, PERMANOVA in PRIMER offers partitioning using Type I, Type II or Type III SS (your choice).

Are there cases when it might be ok to use adonis2?

An analysis done using adonis2 in R should be ok if you have a single factor (a simple one-way ANOVA design). It **might** be ok(?) if you happen to have all fixed factors in a fully balanced, fully crossed design, with no random factors, covariates or nested terms. (*Caveat:* I can make no promises about that)!

Clearly, as previously articulated in Chapter 2 above, R is a wonderful statistical programming language, with loads of packages that are constantly evolving, and with many amazing contributors, so maybe in the future the functionality of adonis2 will be improved, or a new package will be written. At the moment, however, you cannot trust R to analyse PERMANOVA models correctly except (perhaps?) in some very special cases (i.e., crossed fixed factors only, fully balanced designs).

In contrast, **you can completely trust** the implementation and resulting output provided by PERMANOVA in PRIMER **for any design**.

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