

## 28.7: Appendix

### 28.7.1 The paired t-test as a linear model

We can also define the paired t-test in terms of a general linear model. To do this, we include all of the measurements for each subject as data points (within a tidy data frame). We then include in the model a variable that codes for the identity of each individual (in this case, the ID variable that contains a subject ID for each person). This is known as a *mixed model*, since it includes effects of independent variables as well as effects of individuals. The standard model fitting procedure `lm()` can't do this, but we can do it using the `lmer()` function from a popular R package called *lme4*, which is specialized for estimating mixed models. The `(1|ID)` in the formula tells `lmer()` to estimate a separate intercept (which is what the `1` refers to) for each value of the `ID` variable (i.e. for each individual in the dataset), and then estimate a common slope relating timepoint to BP.

```
# compute mixed model for paired test

lmrResult <- lmer(BPsys ~ timepoint + (1 | ID),
                  data = NHANES_sample_tidy)
summary(lmrResult)

## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: BPsys ~ timepoint + (1 | ID)
## Data: NHANES_sample_tidy
##
## REML criterion at convergence: 2895
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.3843 -0.4808  0.0076  0.4221  2.1718
##
## Random effects:
## Groups Name Variance Std.Dev.
## ID      (Intercept) 236.1    15.37
## Residual          13.9     3.73
## Number of obs: 400, groups: ID, 200
##
## Fixed effects:
##              Estimate Std. Error    df t value Pr(>|t|)
## (Intercept)    121.370      1.118 210.361  108.55  <2e-16 ***
## timepointBPSys2  -1.020      0.373 199.000   -2.74  0.0068 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##              (Intr)
## tmpntBPSys2 -0.167
```

You can see that this shows us a p-value that is very close to the result from the paired t-test computed using the `t.test()` function.

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