BrainHealth.power

Power calculation for human models (WP1 and WP2)

Q1.1 Stability in repeated measures of brain health over three time points

Pilot data

In my pilot research, I showed that brain age is accelerated by three years in individuals with schizophrenia and by two years in adolescent patients with Anorexia (Figure 1A and 1B).

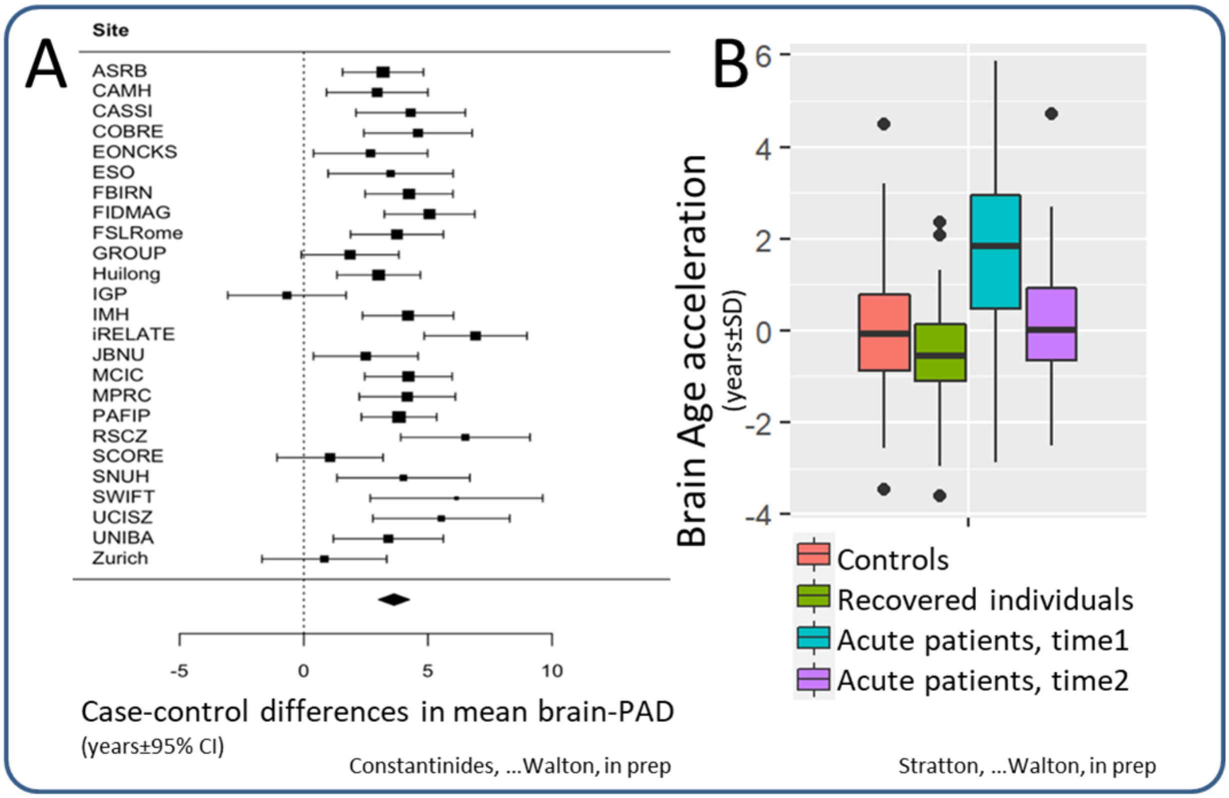

Figure 1. Pilot data on brain health in A) schizophrenia and B) anorexia nervosa.

Power calculations

These power calculations were done using GPower and were informed by the `Superpower` R package, as described here.

We are interested in both stability and change in brain health over time, across three repeated measures. However, for this power calculation, we were mainly interested in the smallest change (rather than stability), we will be able to detect.

Therefore, we assume a 'most-stable' scenario (highest correlation between repeated measures of brain health, based on our previous research, r=0.9; Figure 1B).

We have a within-subject design, with:

- 3 repeated measures
- smallest sample size n=420
- correlation among repeated measures: 0.9 (based on pilot data on accelerated brain ageing in Anorexia, Figure 1B)
- alpha 0.05/7 for seven different ageing measures
- one group

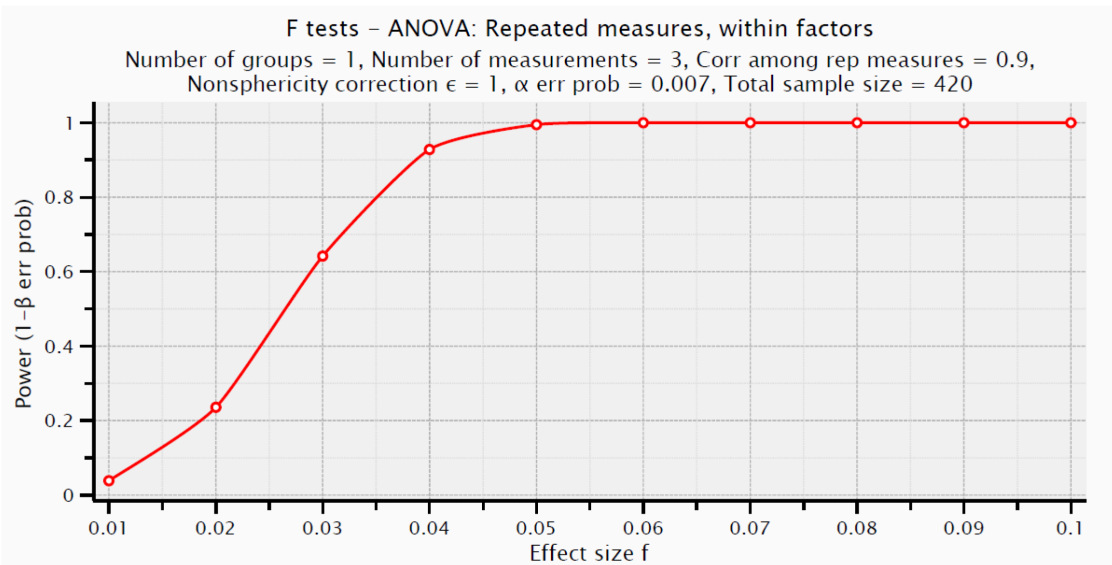

Figure 2. Power Q1.1

In the 'most-stable' scenario, we have 95% power to detect longitudinal changes as small as 0.04 (Cohen's f) or an R^2 of 0.1%.

Q1.2/1.3/2.1 and 2.2 Power calculation for multivariate regressions (main and interaction / moderation effects)

Main effect

We assume:

- smallest sample size n=420
- 2 groups (above-median versus below-median brain health)
- 3 covariates (age, age^2, sex)

- alpha 0.05/7 for seven different ageing measures

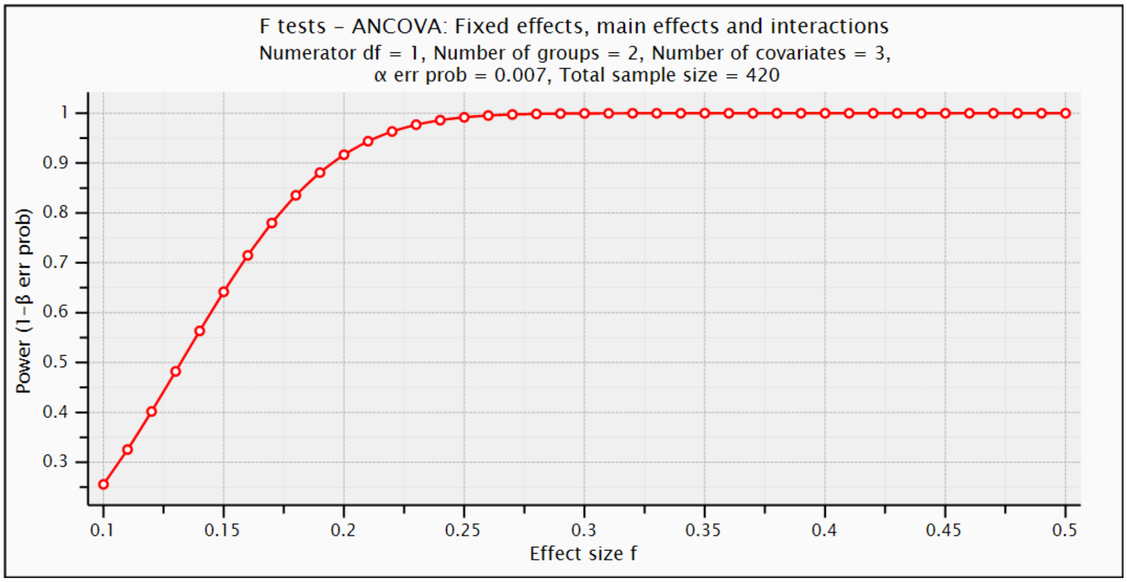

Figure 3. Power Q1.2 and Q1.3

We have 95% power to detect an effect as small as 0.21 (Cohen's f) or an R^2 of `0.04`%.

Interaction (moderation) effect

We assume an ordinal interaction terms, which has been shown to display poorer power properties compared to a disordinal interaction terms (ref).

We also assume:

- an ANOVA design with two main effects:
- a measure of ageing ('a' in Figure 4)
- a moderator (e.g. exercise; 'b' in Figure 4)
- the interaction between these two
- smallest sample size n=420
- SD=0.7 (taken from brain age pilot data, Figure 1)
- effect sizes effect of the moderator (e.g. exercise) of 4 months (0.3 years)
- alpha 0.05/7 for seven different ageing measures

```
design = ANOVA_design(
  design = "2b*2b",
  n = 420,
  mu = c(0.3, 0, 0, 0),
  sd = 0.7)
```

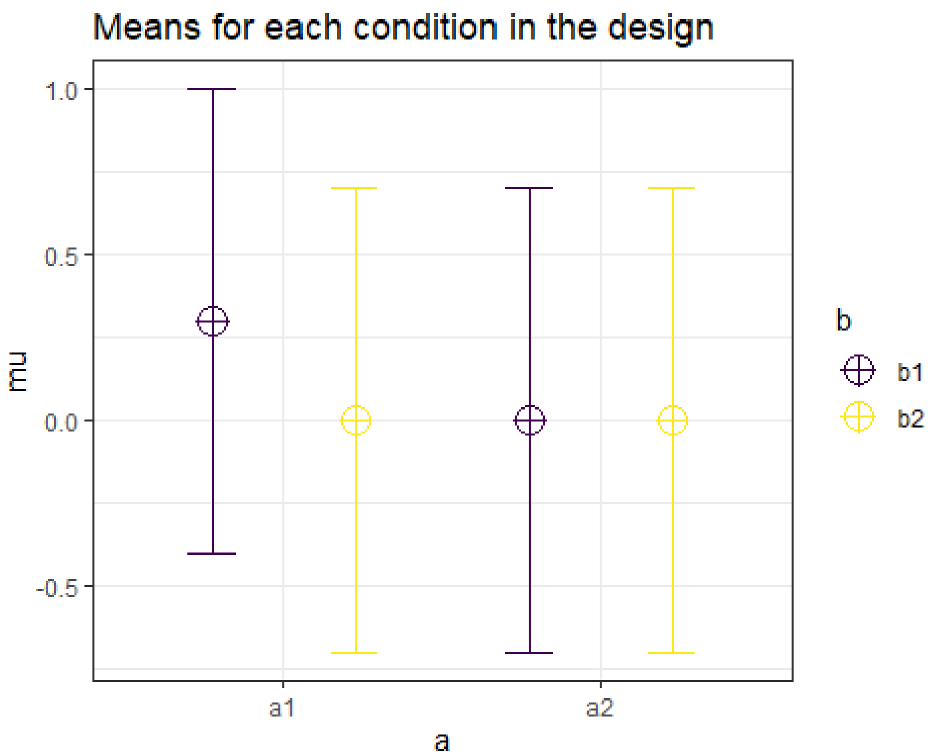

Figure 4. Design Q2.1 and 2.2.

```
out=ANOVA_exact(design, alpha_level = 0.05/7)$main_result

## Power and Effect sizes for ANOVA tests
##         power partial_eta_squared cohen_f non_centrality
## a   95.5123              0.0114  0.1073        19.2857
## b   95.5123              0.0114  0.1073        19.2857
## a:b 95.5123              0.0114  0.1073        19.2857
##
## Power and Effect sizes for pairwise comparisons (t-tests)
##                       power effect_size
## p_a_a1_b_b1_a_a1_b_b2 99.98       -0.43
## p_a_a1_b_b1_a_a2_b_b1 99.98       -0.43
## p_a_a1_b_b1_a_a2_b_b2 99.98       -0.43
## p_a_a1_b_b2_a_a2_b_b1  0.71        0.00
## p_a_a1_b_b2_a_a2_b_b2  0.71        0.00
## p_a_a2_b_b1_a_a2_b_b2  0.71        0.00

f2=out["a:b","cohen_f"]^2
```

We have `95.51` power to detect a univariate effect as small as Cohen's f of `0.11` or R^2 of `0.01`.

Power calculation for WP3 (mouse model)

Previous work:

- wild type (n = 11) and Grb10 pat KO (n = 7) brains at three different ages and found overall means of 473.722+/-8.584 (wt) and 509.401+/-10.761 (KO)

Get the effect size (Hedge's g to account for sample size < 20):

```
esc_mean_sd(grp1m = 473.722, grp1sd = 8.584, grp1n = 11,
grp2m = 509.401, grp2sd = 10.761, grp2n = 7, es.type = "g")

##
## Effect Size Calculation for Meta Analysis
##
##      Conversion: mean and sd to effect size Hedges' g
##     Effect Size:  -3.5922
##  Standard Error:   0.7931
##        Variance:   0.6290
##        Lower CI:  -5.1466
##        Upper CI:  -2.0379
##          Weight:   1.5899

ES=esc_mean_sd(grp1m = 473.722, grp1sd = 8.584, grp1n = 11,
grp2m = 509.401, grp2sd = 10.761, grp2n = 7, es.type = "g")$es
```

Given the sample size, what's the smallest effect size we would be able to detect?

Calculate minimum detectable effect size

- significance level = 5%
- power = 85%
- sample size of n=10 per group

```
pwr.t.test(n=10, sig.level = 0.05, power = 0.85, type=c("two.sample"))

##
##      Two-sample t test power calculation
##
##               n = 10
##               d = 1.417362
##       sig.level = 0.05
##           power = 0.85
##     alternative = two.sided
##
## NOTE: n is number in *each* group

ES.out=pwr.t.test(n=10, sig.level = 0.05, power = 0.85,
type=c("two.sample"))$d
```

Given a sample size of n=10 per group, a significance level of 5% and power of 85%, we are adequately powered to detect effect sizes as low as 1.42.

```
# range of effect sizes
r <- seq(.5,4,.5)
nr <- length(r)
# range of sample size
p <- seq(2,18,2)
np <- length(p)
# obtain power estimates
pow <- array(numeric(nr*np), dim=c(nr,np))
for (i in 1:np){
  for (j in 1:nr){
    pow[j,i] = pwr.t.test(n=p[i], sig.level = 0.05, d = r[j],
type=c("two.sample"))$power
  }
}
# set up graph
xrange <- range(r)
yrange <- round(range(pow))
colors <- rainbow(length(p))
plot(xrange, yrange, type="n",
     xlab="Effect size (Hedge's g)",
     ylab="Power" )
# add power curves
for (i in 1:np){
  lines(smooth.spline(r,pow[,i]), type="l", lwd=2, col=colors[i])
}
# add annotation (grid lines, title, legend)
abline(v=0, h=seq(0,yrange[2],50), lty=2, col="grey89")
abline(h=0, v=seq(xrange[1],xrange[2],.02), lty=2,
       col="grey89")
title("Power curves for different sample sizes")
legend("bottomright", title="Sample size per group", as.character(p),
       fill=colors)
```

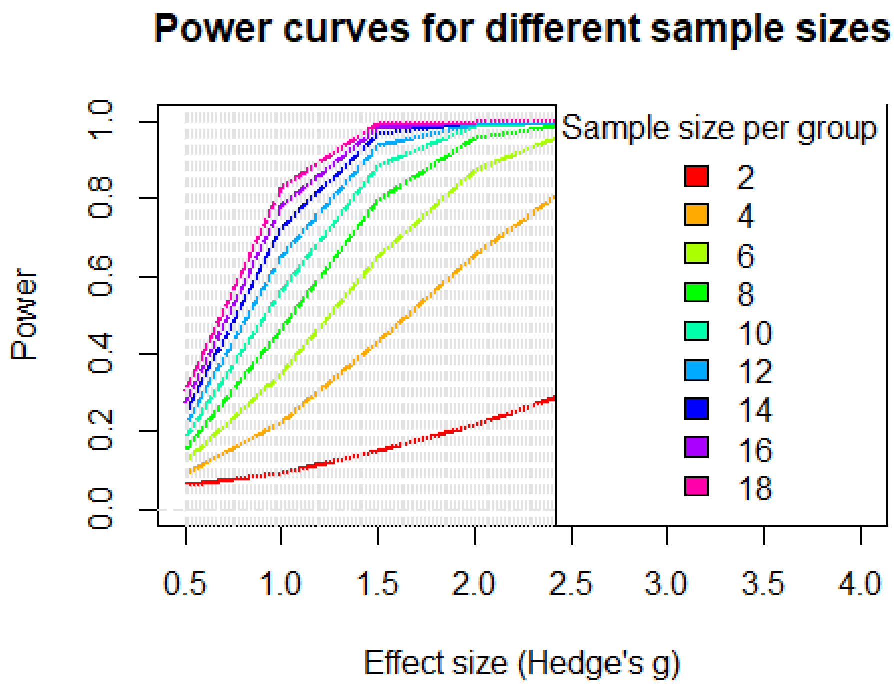

Figure 5. Power WP3 (mouse model).