Assignment 1 - Language Development in ASD - Power and simulations

Eyes of Kasparov

2020-09-29

Welcome to the third exciting part of the Language Development in ASD exercise

In this part of the assignment, we try to figure out how a new study should be planned (i.e. how many participants?) in order to have enough power to replicate the findings (ensuring our sample size is adequate, our alpha at 0.05 and our beta at 0.8): 1- if we trust the estimates of the current study. Report the power analysis and comment on what you can (or cannot) use its estimates for. 2- if we are skeptical of the current study. Report the power analysis and comment on what you can (or cannot) use its estimates for. 3- if we only have access to 30 participants. Identify the power for each relevant effect and discuss whether it's worth to run the study and why The list above is also what you should discuss in your code-less report.

Learning objectives

- Learn how to calculate statistical power
- Critically appraise how to apply frequentist statistical power

Exercise 1

How much power does your study have (if your model estimates are quite right)? - Load your dataset (both training and testing), fit your favorite model, assess power for your effects of interest (probably your interactions). - Report the power analysis and comment on what you can (or cannot) use its estimates for. - Test how many participants you would have to have to replicate the findings (assuming the findings are correct)

N.B. Remember that main effects are tricky once you have interactions in the model (same for 2-way interactions w 3-way interactions in the model). If you want to test the power of main effects, run a model excluding the interactions. N.B. Check this paper: https://besjournals.onlinelibrary.wiley.com/doi/full/10.1111/2041-210X.12504 You will be using: - powerSim() to calculate power - powerCurve() to estimate the needed number of participants - extend() to simulate more participants

Loading data

```
pacman::p_load(tidyverse, lmerTest, simr)

data_train <- read_csv("super_clean_train.csv") %>%
```

```
  select(CHI_MLU, Visit, Diagnosis, MOT_MLU, verbalIQ1, Child.ID) %>%
  drop_na()

## Parsed with column specification:
## cols(
##   .default = col_double(),
##   Ethnicity = col_character(),
##   Diagnosis = col_character(),
##   Gender = col_character()
## )

## See spec(...) for full column specifications.

data_test <- read_csv("test_cleaned.csv") %>%
  select(CHI_MLU, Visit, Diagnosis, MOT_MLU, verbalIQ1, Child.ID) %>%
  drop_na()

## Parsed with column specification:
## cols(
##   .default = col_double(),
##   Child.ID = col_character(),
##   Ethnicity = col_character(),
##   Diagnosis = col_character(),
##   Gender = col_character()
## )
## See spec(...) for full column specifications.
```

Doing power calculations

```
# Defining model from last time
library(broom.mixed)

## Registered S3 method overwritten by 'broom.mixed':
##   method      from
##   tidy.gamlss broom

m3 <- lmer(CHI_MLU ~ (Visit + Diagnosis + MOT_MLU + verbalIQ1)^2 + (1|Child.ID),
                    data=data_train)

sig_inter_terms <- m3 %>%
  tidy() %>%
  # Get all interaction terms
  filter(str_detect(term, ":")) %>%
  pull(term)

power_test_interact <- function(interact, model=m3) {
  simr::powerSim(model, test = fixed(interact, "z"), nsim=50)
}

interaction_list <- purrr::map(sig_inter_terms, power_test_interact)
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## Warning in observedPowerWarning(sim): This appears to be an "observed power"
## calculation

interaction_list

## [[1]]
## Power for predictor 'Visit:DiagnosisTD', (95% confidence interval):
##       100.0% (92.89, 100.0)
##
```

```
## Test: z-test
##       Effect size for Visit:DiagnosisTD is 0.39
##
## Based on 50 simulations, (0 warnings, 0 errors)
## alpha = 0.05, nrow = 352
##
## Time elapsed: 0 h 0 m 6 s
##
## nb: result might be an observed power calculation
##
## [[2]]
## Power for predictor 'Visit:MOT_MLU', (95% confidence interval):
##        8.00% ( 2.22, 19.23)
##
## Test: z-test
##       Effect size for Visit:MOT_MLU is -0.0072
##
## Based on 50 simulations, (0 warnings, 0 errors)
## alpha = 0.05, nrow = 352
##
## Time elapsed: 0 h 0 m 6 s
##
## nb: result might be an observed power calculation
##
## [[3]]
## Power for predictor 'Visit:verbalIQ1', (95% confidence interval):
##       16.00% ( 7.17, 29.11)
##
## Test: z-test
##       Effect size for Visit:verbalIQ1 is 0.022
##
## Based on 50 simulations, (0 warnings, 0 errors)
## alpha = 0.05, nrow = 352
##
## Time elapsed: 0 h 0 m 6 s
##
## nb: result might be an observed power calculation
##
## [[4]]
## Power for predictor 'DiagnosisTD:MOT_MLU', (95% confidence interval):
##       64.00% (49.19, 77.08)
##
## Test: z-test
##       Effect size for DiagnosisTD:MOT_MLU is 0.13
##
## Based on 50 simulations, (0 warnings, 0 errors)
## alpha = 0.05, nrow = 352
##
```

```
## Time elapsed: 0 h 0 m 6 s
##
## nb: result might be an observed power calculation
##
## [[5]]
## Power for predictor 'DiagnosisTD:verbalIQ1', (95% confidence interval):
##       100.0% (92.89, 100.0)
##
## Test: z-test
##       Effect size for DiagnosisTD:verbalIQ1 is -0.43
##
## Based on 50 simulations, (0 warnings, 0 errors)
## alpha = 0.05, nrow = 352
##
## Time elapsed: 0 h 0 m 6 s
##
## nb: result might be an observed power calculation
##
## [[6]]
## Power for predictor 'MOT_MLU:verbalIQ1', (95% confidence interval):
##       76.00% (61.83, 86.94)
##
## Test: z-test
##       Effect size for MOT_MLU:verbalIQ1 is 0.097
##
## Based on 50 simulations, (0 warnings, 0 errors)
## alpha = 0.05, nrow = 352
##
## Time elapsed: 0 h 0 m 7 s
##
## nb: result might be an observed power calculation
```

Testing underpowered interactions

```
underpowered_interactions <- c('Visit:MOT_MLU',
'Visit:verbalIQ1','DiagnosisTD:MOT_MLU', 'DiagnosisTD:MOT_MLU',
'MOT_MLU:verbalIQ1')

# testing powercurve for 161 (the magic number of participants)
m3_large <- extend(m3, along="Child.ID", n=161)

power_curve_testy <- function(param, model=m3_large) {
  powerCurve(model, test=fixed(param, "z"), along = "Child.ID", nsim=100)
}


test_curve <- power_curve_testy('Visit:MOT_MLU')

## Calculating power at 10 sample sizes along Child.ID
```

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## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient

## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient

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## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient

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## boundary (singular) fit: see ?isSingular

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## boundary (singular) fit: see ?isSingular

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## Warning in observedPowerWarning(sim): This appears to be an "observed power"
## calculation
```

```
non_signif_interaction_power_curves <- purrr::map(underpowered_interactions,
power_curve_testy)
```

```
## Calculating power at 10 sample sizes along Child.ID

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## boundary (singular) fit: see ?isSingular

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## Warning in observedPowerWarning(sim): This appears to be an "observed power"
## calculation

## Calculating power at 10 sample sizes along Child.ID

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## boundary (singular) fit: see ?isSingular

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## Warning in observedPowerWarning(sim): This appears to be an "observed power"
## calculation

## Calculating power at 10 sample sizes along Child.ID

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## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient
## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient

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## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient
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## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient
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## boundary (singular) fit: see ?isSingular

## ( 1/10) Simulating: |===
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## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient
## boundary (singular) fit: see ?isSingular

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## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient

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## boundary (singular) fit: see ?isSingular

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## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient

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## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient

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## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient
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## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient
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## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient

## boundary (singular) fit: see ?isSingular

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## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient
## boundary (singular) fit: see ?isSingular

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## Warning in observedPowerWarning(sim): This appears to be an "observed power"
## calculation

## Calculating power at 10 sample sizes along Child.ID

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## boundary (singular) fit: see ?isSingular

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## Warning in observedPowerWarning(sim): This appears to be an "observed power"
## calculation

## Calculating power at 10 sample sizes along Child.ID

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## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient

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## boundary (singular) fit: see ?isSingular

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## boundary (singular) fit: see ?isSingular
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## boundary (singular) fit: see ?isSingular

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## boundary (singular) fit: see ?isSingular

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## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient

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## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient

## boundary (singular) fit: see ?isSingular

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## boundary (singular) fit: see ?isSingular

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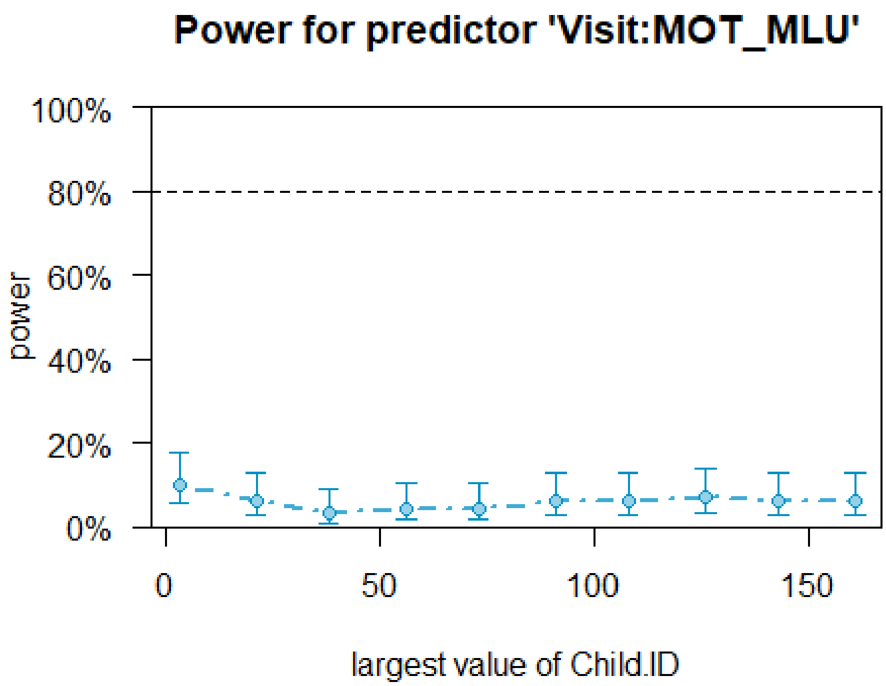
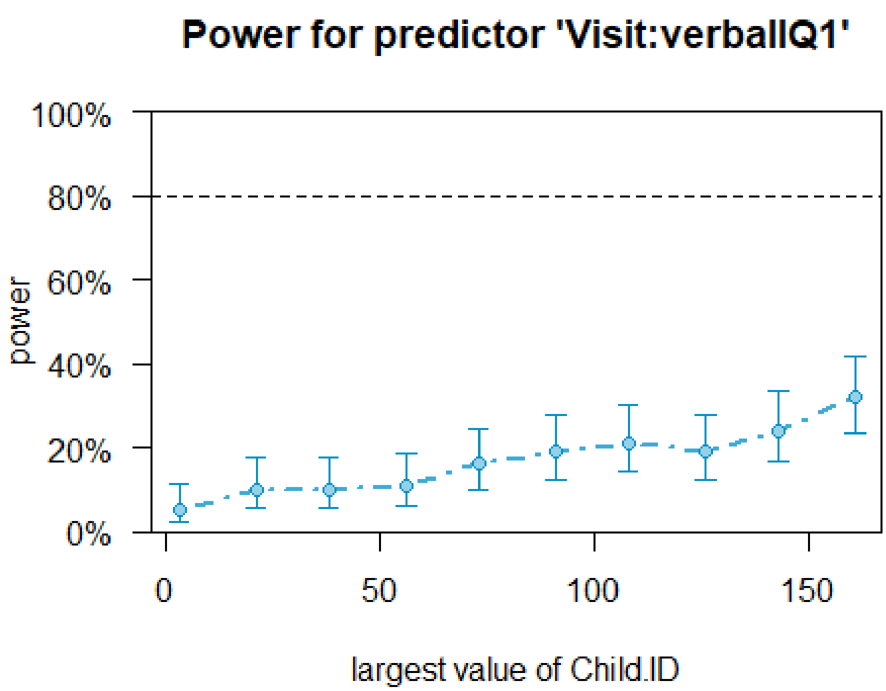
## Warning in observedPowerWarning(sim): This appears to be an "observed power"
## calculation

plot_pcurves <- function(pcurves) {
  for (curve in pcurves) {
    plot(curve)
    title(main = curve$text)
  }
}

plot_pcurves(non_signif_interaction_power_curves)
```


Power for predictor 'Visit:MOT_MLU'
100%
80%
60%
40%
20%
0%
power
0
50
100
150
largest value of Child.ID


Power for predictor 'Visit:verbalIQ1'
100%
80%
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40%
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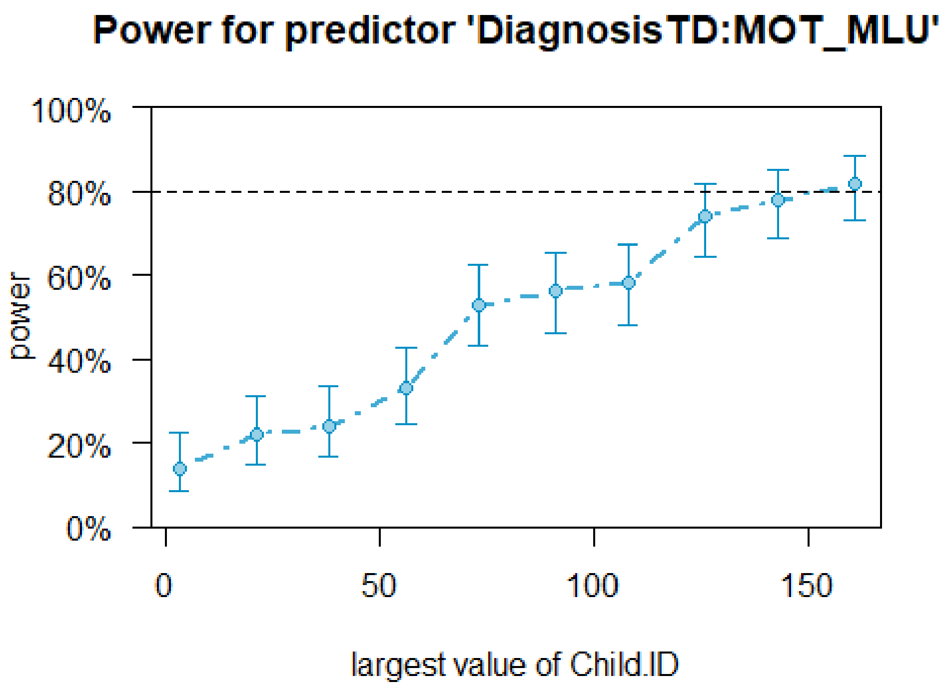
largest value of Child.ID


Power for predictor 'DiagnosisTD:MOT_MLU'
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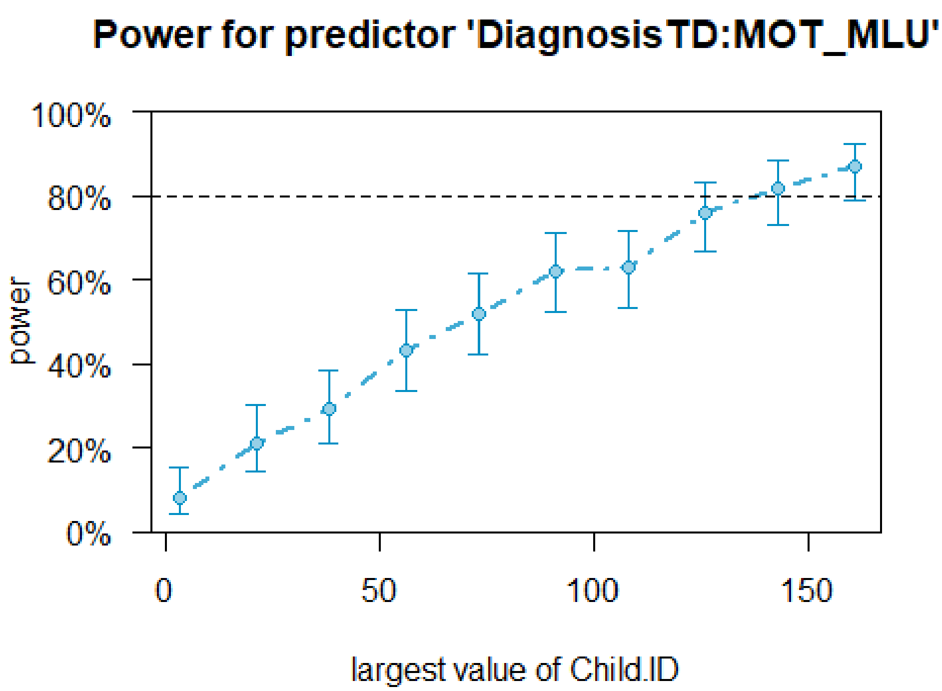
Power for predictor 'DiagnosisTD:MOT_MLU'
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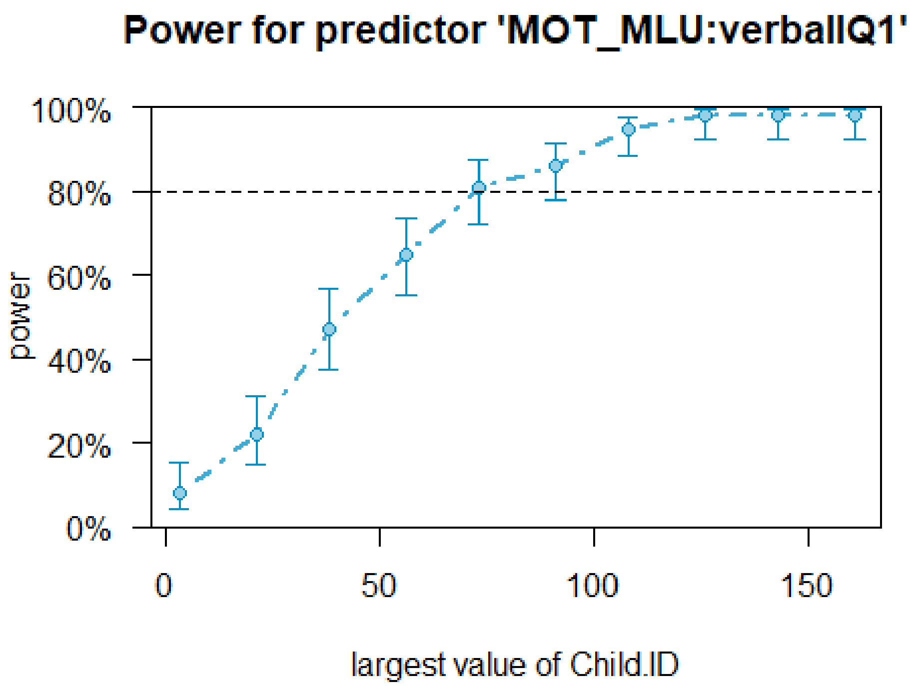
largest value of Child.ID



Exercise 2

How would you perform a more conservative power analysis? - Identify and justify a minimum effect size for each of your relevant effects - take the model from exercise 1 and replace the effects with the minimum effect size that you'd accept. - assess the power curve by Child.ID, identifying an ideal number of participants to estimate each effect - if your power estimates do not reach an acceptable threshold simulate additional participants and repeat the previous analysis - Report the power analysis and comment on what you can (or cannot) use its estimates for.

```
# Interpretable model
m_int <- lmerTest::lmer(CHI_MLU ~ Visit + Diagnosis + MOT_MLU + verbalIQ1 +
Visit:Diagnosis + Diagnosis:verbalIQ1 + (1 + Visit|Child.ID), data = data_train)

# Relevant effects: MOT_MLU, Visit:Diagnosis, DiagnosisTD:verbalIQ1
# Testing the value 0.1 out of my butt
fixef(m_int)["MOT_MLU"] <- 0.2
fixef(m_int)["Visit:DiagnosisTD"] <- 0.2
fixef(m_int)["DiagnosisTD:verbalIQ1"] <- -0.2

relevant_effects <- c("MOT_MLU", "Visit:DiagnosisTD", "DiagnosisTD:verbalIQ1")

tested_effects <- map(relevant_effects, ~power_test_interact(.x, model = m_int))
```

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```
m_int_large <- extend(m_int, along="Child.ID", n=161)
tested_power_curve <- map(relevant_effects, ~power_curve_testy(.x, model =
m_int_large))
```

```
## Calculating power at 10 sample sizes along Child.ID
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## Calculating power at 10 sample sizes along Child.ID

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## Calculating power at 10 sample sizes along Child.ID

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## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient

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## boundary (singular) fit: see ?isSingular

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plot_pcurves(tested_power_curve)
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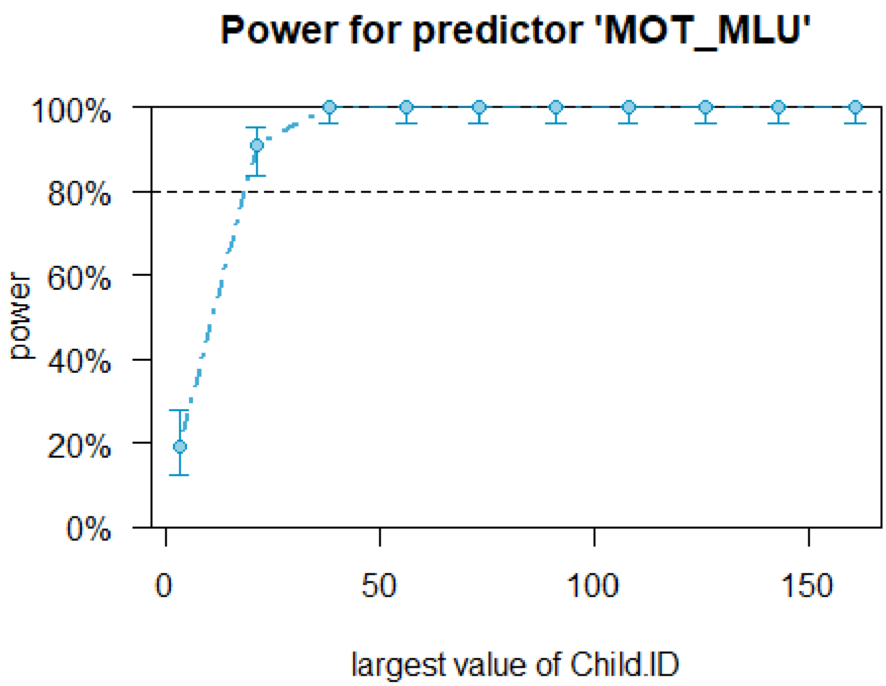
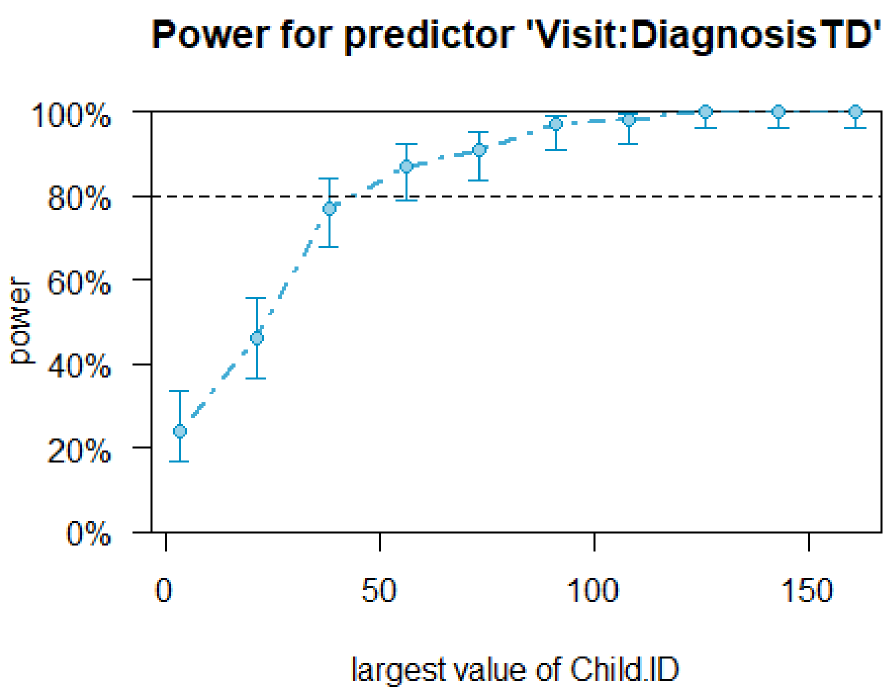

Power for predictor 'MOT_MLU'
100%
80%
60%
40%
20%
0%
power
0
50
100
150
largest value of Child.ID


Power for predictor 'Visit:DiagnosisTD'
100%
80%
60%
40%
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0%
power
0
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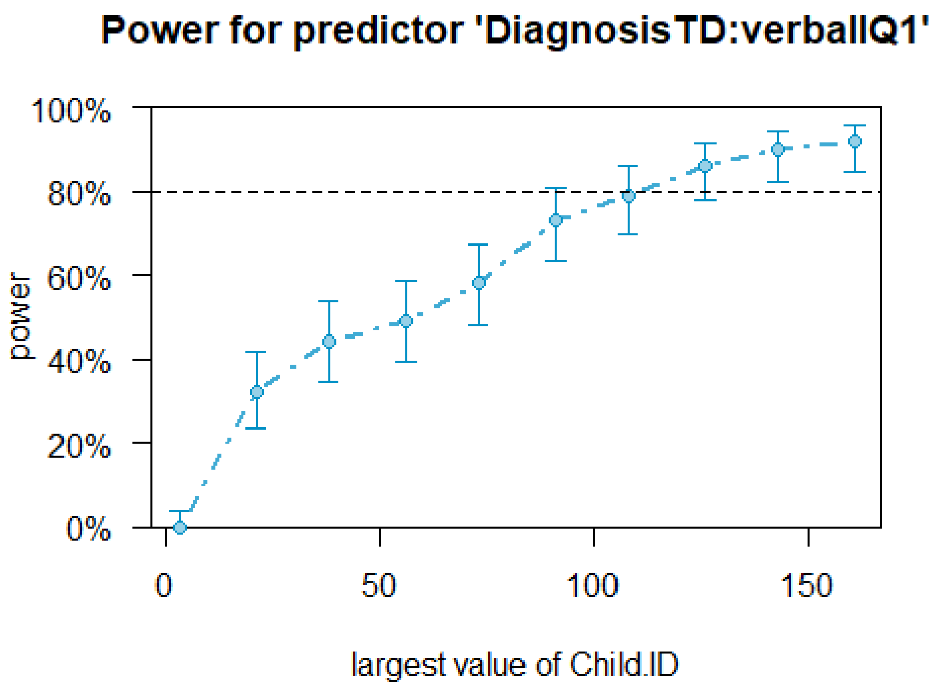
largest value of Child.ID



Exercise 3

Assume you have only the resources to collect 30 kids (15 with ASD and 15 TDs). Identify the power for each relevant effect and discuss whether it's worth to run the study and why

```
# Extend it backwards y'all!
m_int_small <- extend(m_int, along="Child.ID", n=30)

lil_powercurves <- map(relevant_effects, ~power_curve_testy(.x, model =
m_int_small))

## Calculating power at 10 sample sizes along Child.ID

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## Calculating power at 10 sample sizes along Child.ID

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## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient

## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient

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## boundary (singular) fit: see ?isSingular
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## boundary (singular) fit: see ?isSingular

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## boundary (singular) fit: see ?isSingular

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## boundary (singular) fit: see ?isSingular

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## boundary (singular) fit: see ?isSingular

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## boundary (singular) fit: see ?isSingular

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## boundary (singular) fit: see ?isSingular

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## boundary (singular) fit: see ?isSingular

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## boundary (singular) fit: see ?isSingular
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## boundary (singular) fit: see ?isSingular

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## boundary (singular) fit: see ?isSingular

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## boundary (singular) fit: see ?isSingular

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## boundary (singular) fit: see ?isSingular

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## boundary (singular) fit: see ?isSingular
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## boundary (singular) fit: see ?isSingular

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## boundary (singular) fit: see ?isSingular

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## boundary (singular) fit: see ?isSingular

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## boundary (singular) fit: see ?isSingular

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## boundary (singular) fit: see ?isSingular
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## boundary (singular) fit: see ?isSingular

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## boundary (singular) fit: see ?isSingular

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## boundary (singular) fit: see ?isSingular

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## boundary (singular) fit: see ?isSingular

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## boundary (singular) fit: see ?isSingular

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## boundary (singular) fit: see ?isSingular

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## boundary (singular) fit: see ?isSingular
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## boundary (singular) fit: see ?isSingular
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## boundary (singular) fit: see ?isSingular
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## boundary (singular) fit: see ?isSingular
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## boundary (singular) fit: see ?isSingular

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## boundary (singular) fit: see ?isSingular

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## boundary (singular) fit: see ?isSingular

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## boundary (singular) fit: see ?isSingular

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## boundary (singular) fit: see ?isSingular

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## boundary (singular) fit: see ?isSingular

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## boundary (singular) fit: see ?isSingular

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## Calculating power at 10 sample sizes along Child.ID

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## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient

## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient

## boundary (singular) fit: see ?isSingular

## ( 1/10) Simulating: |=
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## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient

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## boundary (singular) fit: see ?isSingular

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## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient
## boundary (singular) fit: see ?isSingular

## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient

## boundary (singular) fit: see ?isSingular
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## ( 1/10) Simulating: |===
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## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient

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## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient

## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient

## ( 1/10) Simulating: |=====
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## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient

## boundary (singular) fit: see ?isSingular

## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient

## boundary (singular) fit: see ?isSingular

## ( 1/10) Simulating: |======
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## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient

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## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient

## boundary (singular) fit: see ?isSingular

## ( 1/10) Simulating: |========
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## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient

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## boundary (singular) fit: see ?isSingular

## ( 1/10) Simulating: |=========
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## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient
## boundary (singular) fit: see ?isSingular

## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient
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## ( 1/10) Simulating: |==========
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## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient

## boundary (singular) fit: see ?isSingular

## ( 1/10) Simulating: |===========
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## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient

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## boundary (singular) fit: see ?isSingular

## ( 1/10) Simulating: |============
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## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient
## boundary (singular) fit: see ?isSingular

## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient

## ( 1/10) Simulating: |=============
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## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient
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## boundary (singular) fit: see ?isSingular

## ( 1/10) Simulating: |================
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## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient
## boundary (singular) fit: see ?isSingular

## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient

## boundary (singular) fit: see ?isSingular
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## ( 1/10) Simulating: |=================
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## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient

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## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient

## boundary (singular) fit: see ?isSingular

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## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient
## boundary (singular) fit: see ?isSingular

## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient

## boundary (singular) fit: see ?isSingular

## ( 1/10) Simulating: |====================
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## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient
## boundary (singular) fit: see ?isSingular

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## boundary (singular) fit: see ?isSingular

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## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient

## boundary (singular) fit: see ?isSingular
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## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient

## ( 1/10) Simulating: |=======================
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## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient

## boundary (singular) fit: see ?isSingular

## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient

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## boundary (singular) fit: see ?isSingular
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## boundary (singular) fit: see ?isSingular

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## boundary (singular) fit: see ?isSingular

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## boundary (singular) fit: see ?isSingular

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## boundary (singular) fit: see ?isSingular

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## boundary (singular) fit: see ?isSingular

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## boundary (singular) fit: see ?isSingular

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## boundary (singular) fit: see ?isSingular

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## boundary (singular) fit: see ?isSingular

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## boundary (singular) fit: see ?isSingular
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## boundary (singular) fit: see ?isSingular

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plot_pcurves(lil_powercurves)
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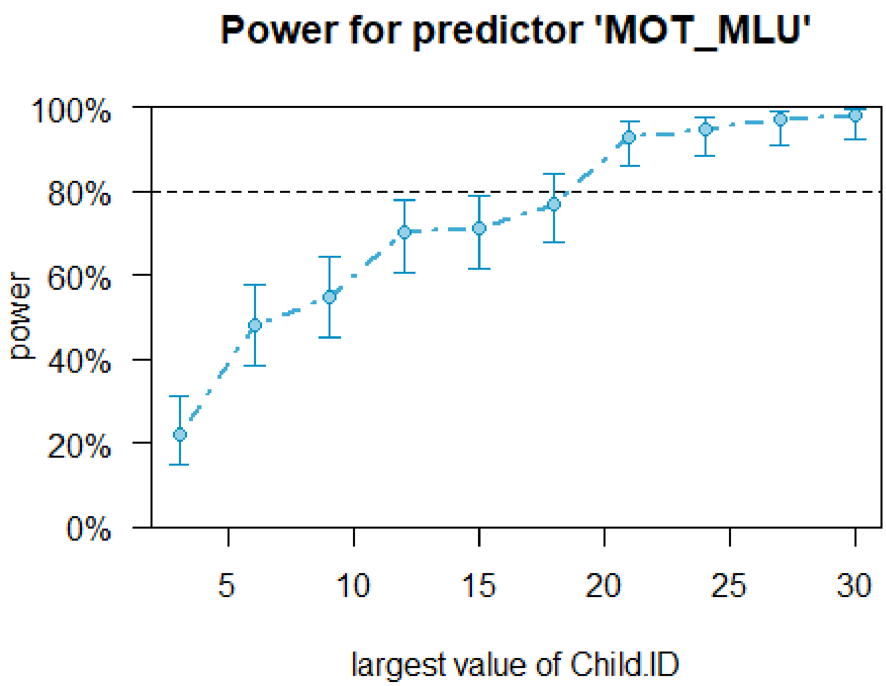
Power for predictor 'MOT_MLU'
100%
80%
60%
40%
20%
0%
power
5
10
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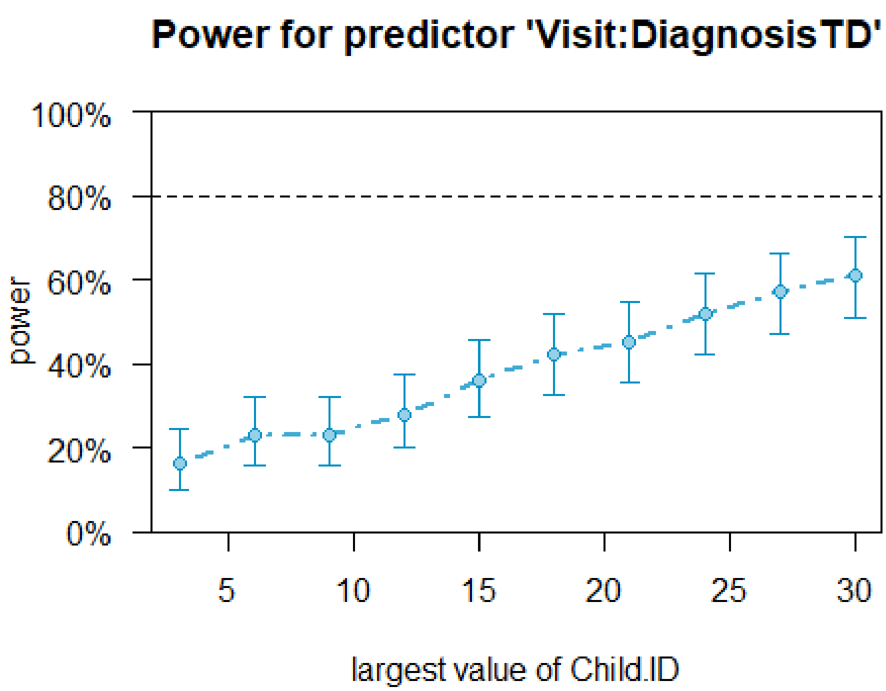
25
30
largest value of Child.ID


Power for predictor 'Visit:DiagnosisTD'
100%
80%
60%
40%
20%
0%
power
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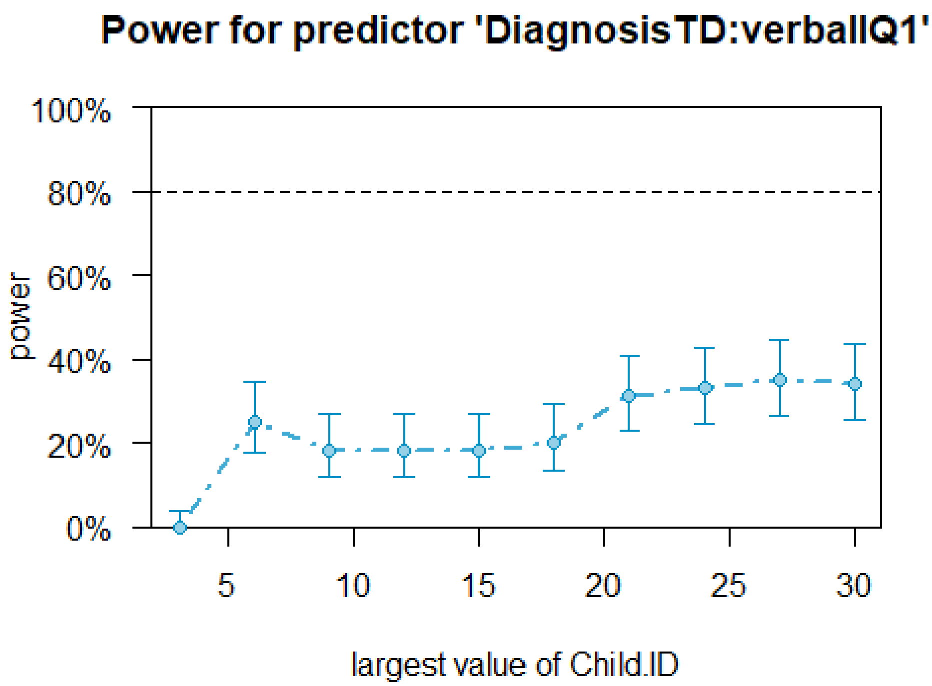
largest value of Child.ID


Power for predictor 'DiagnosisTD:verbalIQ1'
100%
80%
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power
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largest value of Child.ID