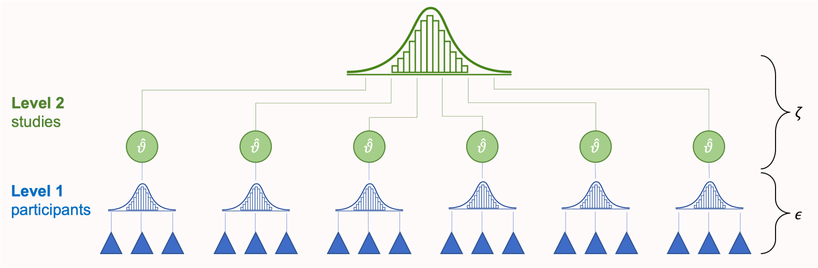
Do musicians have better short-term memory than nonmusicians? A multi-lab study

Power analysis and data management

The starting point

Multilab structure



The starting point

We started with the meta-analysis by Talamini et al. (2018)

PLOS | ONE

RESEARCH ARTICLE

Musicians have better memory than nonmusicians: A meta-analysis

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The model for the main hypotheses

We have a between-groups comparison for each unit i. Thus we can simplify the model to a random-effects meta-analysis model.

$$y_i = \mu_\theta + \delta_i + \epsilon_i$$

$$\delta_i \sim \mathcal{N}(0, \tau^2)$$

$$\epsilon_i \sim \mathcal{N}(0, \sigma^2_{\epsilon_i})$$

The model for the main hypotheses

Within this parametrization:

- τ^2 is the between-units heterogeneity thus the expected variability in the true effects among different units
- μ_θ is the mean of true effects
- $\theta_i = \mu_\theta + \delta_i$ is the unit-specific true effect

Power analysis

For this simple scenario we can use the Borenstein et al. (2009) approach.

$$Z^\star = \frac{M^\star}{\sqrt{V_{M^\star}}}$$

$$V_{M^\star} = \frac{\sigma_\epsilon^2 + \tau^2}{k}$$

$$Z_c = \Phi(1 - \alpha/2)$$

$$\text{Power} = 1 - \Phi(Z_c - Z^\star) + \Phi(-Z_c - Z^\star)$$

Power analysis

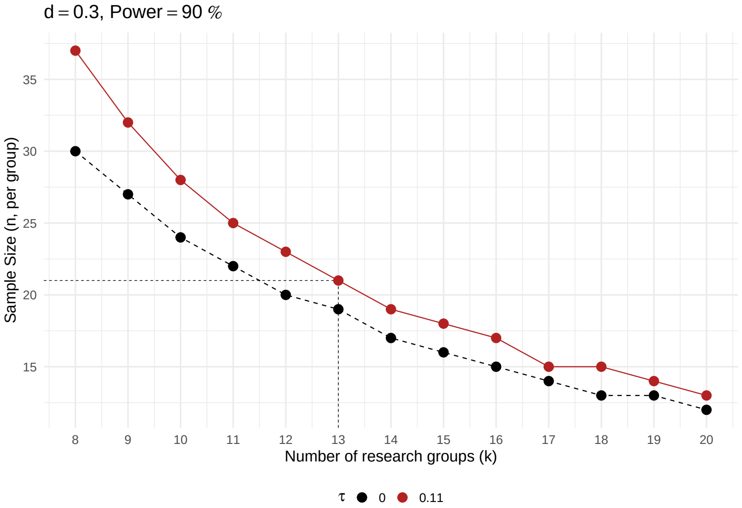
We fixed $\tau^2 = 0.11$ (half the estimated value from the meta-analysis) and $d = 0.3$. The idea was to

- target a small but plausible effect size
- assume a non-zero heterogeneity (for a conservative approach) but lower than a meta-analysis on the topic without experimental control
- minimize the effort on the single lab (lower sample size) increasing the number of labs

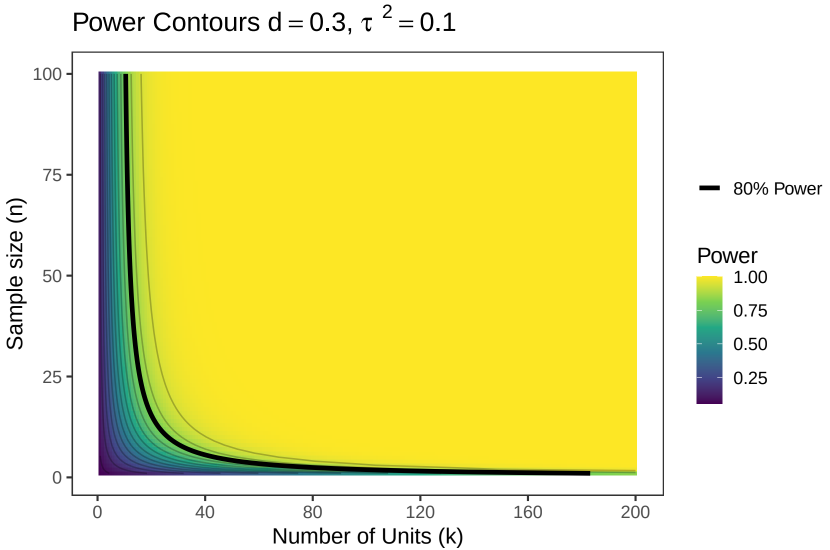
Crucially, for multi-lab studies the power is a function of both sample size and number of units.

Power analysis

We did the calculation implementing the equations in R and solving them for different combination of k and n that produced 90% power.



Power Contours



Shiny Power

We have a little shiny (thanks GPT) for visualize the power in different conditions.

https://stat-teaching.github.io/statshiny/shiny/power-meta.html

Why using a meta-analysis?

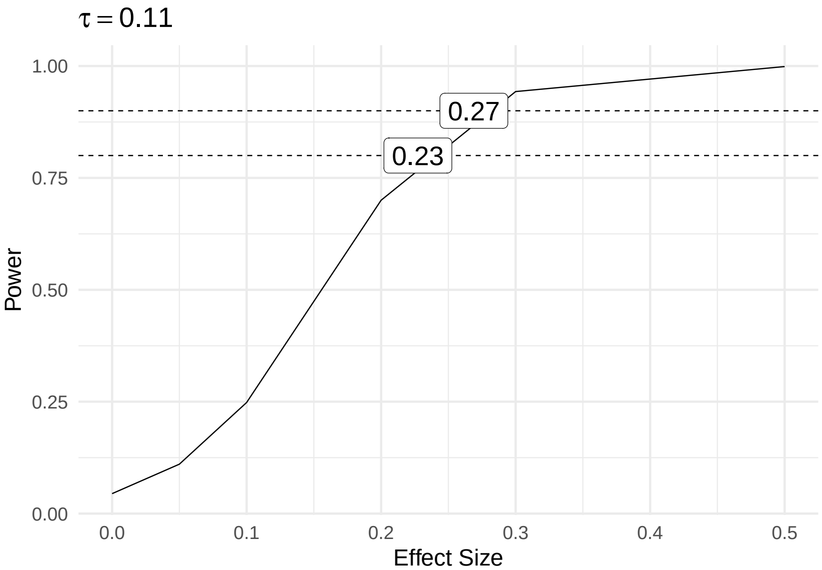
- easier to compute power given the fixed n and k
- easier to calculate interesting heterogeneity statistics τ^2, I^2, H^2, etc.
- main hypotheses are just groups comparisons, no covariates
- results on a standardized scale (i.e., Hedges' g)
- no clear advantages of using a multilevel model (`lme4`)

Post-hoc power

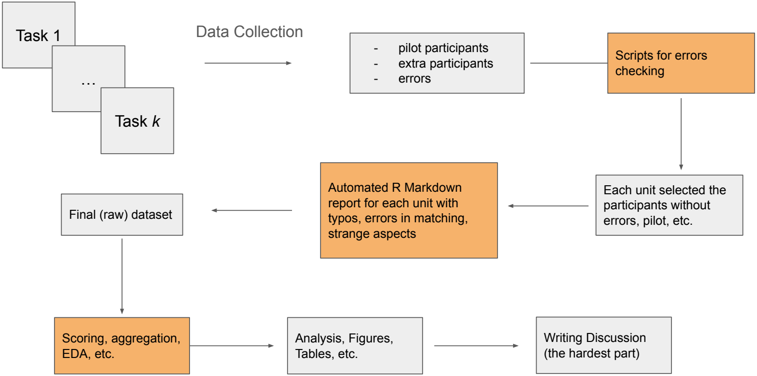
We also computed a post-hoc power without changing the assumed d and τ^2 but using the actual number of units k and sample size per unit n. Not all units collected the full sample size and we had more units than planned. This required a Monte Carlo simulation but given the number of units, the power is not affected.

[extra] Sensitivity analysis

We can also estimate the minimum detectable effect size given the final design.



The big picture



Scripts for errors checking

The process of finding and solving errors was the most difficult and stressful.

We wrote more than 1174 lines of code just to check for errors, solve them and pre-process the data.

Errors, Errors, Errors...

The coolest nerd-stuff for errors checking!

IT_Padova

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Description

This is an automated report for a sanity check of collected data.

Checks

Missing data

Here we check if all participants have all data.

There are **0** participants with at least one missing task.

Duplicated IDs

The following table reports all the participants that seem to have taken the task more than once. They might be participants of other units with the same ID as your participants. In the case you do not see the table means that there are no problems.

Groups

The number of observations is 42 (should be 42). The number of musicians is 21 and the number of non-musicians is 21.

Sex

In the musicians group there are 11 males (10 females) and in the non-musicians group there are 11 males (10 females).

Age

0 participants are out the age range (18-30). The average age is 23.9047619. For the musicians group the average age is 24 and for the non-musician group is 23.8095238.

Errors, Errors, Errors...

We founds a lot of amazing stuff:

- people changing the country between one task and the other
- people aging 10 years after doing the verbal memory task
- Lab located in UK but collecting data in Brazil
- ...

The most important lesson is that, errors are there, you are just failing to find them.

References

Borenstein, M., Hedges, L. V., Higgins, J. P. T., & Rothstein, H. R. (2009). *Introduction to Meta-Analysis*. https://doi.org/10.1002/9780470743386

Talamini, F., Altoè, G., Carretti, B., & Grassi, M. (2018). Correction: Musicians have better memory than nonmusicians: A meta-analysis. *PloS One*, *13*, e0191776. https://doi.org/10.1371/journal.pone.0191776