Power Analysis

Are there unconscious visual images in aphantasia? Development of an implicit priming paradigm

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# 1. Rationale

We hypothesised that difference in reaction times (RT) between congruent and incongruent trials (the congruence effect) in the tasks would be modulated by the visual imagery ability of participants, and therefore that we would observe between-group differences in the magnitude of this effect. In a statistical model with categorical predictors, evidence in favour of our hypothesis would be provided by a significant two-way interaction between Group and Congruence condition. Estimating the statistical power to capture such an effect, given an experimental design, a sample size and an effect size, requires simulations from a model close to the one that will be used for the analysis of real data, as well as assumptions about the structure of data. The power estimation procedure requires 3 steps:

1. Specifying the structure and coefficients of a generative model
2. Generating a synthetic dataset using the generative model and an expected effect size
3. Fitting the same model on the simulated data and test the statistical significance of the interaction of interest

Steps 2 and 3 are then repeated as many times as necessary to reach a desired precision of estimation. The proportion of synthetic datasets for which the effect of interest is significant is an estimation of power. Steps 2 and 3 can also be repeated for a range of effect sizes, if the expected effect size is not known exactly which is what we have done here. We detail and justify below every assumption made for the generative model.

# 2. Generative model

In real datasets, the distributions of RTs are right-skewed and can be modelled with transformations using Gamma or inverse Gaussian distributions. However, such a modelling choice is only an approximation as RTs do not follow exactly any distribution of the exponential family for which generalized models can be fitted. It is difficult to evaluate the impact of such approximation on type I and type II errors. Thus, for power calculation, we generated normally distributed RT and modelled them with a regular mixed model, which simplifies the model parametrization as well as alleviates the computational burden.

The generative model has been created using the simr R package.

* Fixed effects: We included the ***Group*** (aphantasic, control), ***Congruence*** condition (congruent or incongruent) and ***Color*** condition (color or uncolored) along with all their two and three way interactions as fixed categorical predictors. Regression coefficients were set in such a way as to produce a pattern of means roughly following our hypotheses, where the control group would be faster solely in the congruent condition.
* Random intercepts: We included a random intercept for participants with a standard deviation of 150ms. This number was derived from the literature (see Fucci et al., 2023) - however, previous simulation studies have shown that the magnitude of random intercepts has no effect on statistical power whatsoever (Brysbaert & Stevens, n.d.), a result that we could verify in our own simulations.
* Random slopes: We included random by-participant slopes for Congruence and Color, thus specifying the *full model* given our factors and resulting in the most conservative power estimates. Standard deviations of random slopes are virtually never reported in scientific publications; we set them at 50ms, which is in the same range as the maximum expected population-average effect size.
* Correlations between random effects were all set to 0, but an alternative value (0.5) produced similar results.

This random effect structure has been specified and provided to a simr modelling function to simulate the models that will be fitted on our data.

# 3. Simulations

* Effect sizes: For the interaction Group x Congruence, the effect size can be defined as the double difference (aphantasics - controls) x (congruent - incongruent). Assuming, based on previous works, that the strongest difference would not exceed 50-60ms, and that differences below 10ms would hardly be meaningful, we ran simulations for differences between 10 and 60ms, by steps of 5ms. As the power reached the ceiling of 100% after 40ms effect sizes, we report here the results up to this size.
* Number of simulations: For each effect size, we ran as many simulations as were needed to obtain a confidence interval below ±10 points around the mean. Going by steps of 50, we eventually ran 200 simulations for each effect size. These simulations ran for more than 8 hours, therefore their results are stored in .RDS R objects for ease of access: data/r-data-structures/power-analyses-list.RDS and data/r-data-structures/power-analyses-table.RDS.

# 4. Results

The analysis yielded a power of 82% starting at effect sizes around 25ms, going up to 91% at 30ms and 97% at 35ms. Every effect size equal and above 40ms reached a ceiling of 100% power. The complete results are summarized in [Table S4.1](#supptbl-simulations-table) and [Figure S4.1](#suppfig-simulations-plot).

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| Table S4.1: Results of the power analysis through simulation.   | Effect size (difference in ms) | Successes | Simulations | Power | 95% CI | | --- | --- | --- | --- | --- | | 10 | 46 | 200 | 0.23 | [ 0.17, 0.29 ] | | 15 | 78 | 200 | 0.39 | [ 0.32, 0.46 ] | | 20 | 136 | 200 | 0.68 | [ 0.61, 0.74 ] | | 25 | 164 | 200 | 0.82 | [ 0.76, 0.87 ] | | 30 | 182 | 200 | 0.91 | [ 0.86, 0.95 ] | | 35 | 195 | 200 | 0.97 | [ 0.94, 0.99 ] | | 40 | 200 | 200 | 1.00 | [ 0.98, 1 ] | |

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| Figure S4.1: Results of the power analysis using simulations. 200 simulations have been computed for each effect size. |

Brysbaert, M., & Stevens, M. (n.d.). Power Analysis and Effect Size in Mixed Effects Models: A Tutorial. *Journal of Cognition*, *1*(1), 9. <https://doi.org/10.5334/joc.10>

Fucci, E., Abdoun, O., Baquedano, C., & Lutz, A. (2023). Ready to help, no matter what you did: Responsibility attribution does not influence compassion in expert Buddhist practitioners. *Preprint*. <https://doi.org/10.31234/osf.io/d6y4w>