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# Same Data Meta Analysis for Neuroimaging Multiverse Data

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Researchers using brain MRI data have a wide range of analysis tools to model brain structure and function. This diversity of analytical approaches means there are many possible variations of the same imaging result (Bowring et al., 2019). Analyzing a dataset with a single approach can thus be misleading. Alternatively, a multiverse analysis can be used, where multiple sets of results are obtained from running different pipelines on the same dataset. Such a setting produces multiple outputs in the form of a statistical map. Meta-analysis approaches can then help to effectively extract a unique result from these maps.

Traditional meta-analyses require an assumption of independence among input datasets. This assumption is no longer true in a multiverse setting, and treating dependent studies as independent may lead to inflated false positives.

We have developed a suite of same data meta-analysis (SDMA) models that account for dependence among multiple multiverse results from a single dataset. The validity and accuracy of these models were assessed in a set of simulations as well as on two real-world multiverse outputs originating from the same data: the "NARPS" multiverse analysis (Botvinik-Nezer et al., 2020) and the "HCP Young Adult" multiverse analysis (Germani et al., 2023) which generated respectively 70 and 24 different statistical maps.

We have two variants of SDMA models, one based on the average of inputs ("Stouffer"), one based on generalized least squares (GLS) that optimally combine the correlated data. From simulation we find all of our approaches are valid under the null hypothesis. On real data we find that the Stouffer methods are all consistent and closely correspond to a naive average of inputs; the GLS method can be very unstable if there are complex patterns of correlation among the inputs.

These sort of SDMA approaches will be an important tool as more researchers conduct multiverse analyses.

## References

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