

# All-Resolutions Inference for Brain Imaging

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**Abstract:** Modern data analysis can be highly exploratory. Rather than a single well-defined research question there are tens of thousands of micro-questions, leading to tens of thousands hypothesis tests and tens of thousands of micro-inferences. These can be aggregated to larger-scale inferences in countless ways.

In brain imaging, for example, the brain is partitioned into tens of thousands of voxels, each of which may show activity as a response to stimulus. However, the unit of a voxel is arbitrarily determined by the measurement technique and does not represent a primary neural entity. The real research questions relate to patterns of activity at larger scales of aggregation, i.e. brain regions.

Researchers often highlight the patterns of brain activation suggested by the data, but false discoveries are likely to intrude into this selection. It is well-known that humans are very good at finding seemingly convincing patterns even in pure noise. How confident can the researcher be about a pattern that has been found, if that pattern has been selected from so many potential patterns?

We propose a novel approach - termed 'All Resolutions Inference' (ARI) - that delivers strong FWER control in any selected set of voxels. ARI allows a truly interactive approach to selective inference, that does not set any limits on the way the researcher chooses to perform the selection. The selection process does not have to be declared beforehand; it may be data-driven or knowledge-driven, or any mix of the two. Regardless of the selection process used, the researcher obtains a valid confidence bound for the proportion of truly active voxels in the final selected region.