Opinion: Is consensus possible in neuroscience research?

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Brain scans involving functional magnetic resonance imaging (fMRI) have been a media darling for two decades. Images of brains lighting up to external stimuli have proved irresistible and have helped neuroscience achieve popular renown.

But fMRI has also received a battering. First, most famously, when used on a dead salmon, the technique appeared to show brain and spinal cord activity when subject to stimuli (in this case, images of people in social situations).

More recently, a *PNAS* paper reported a bug in one of the most widely used pieces of software for analysing data from fMRI scans. Again, this was widely reported.

The reason that fMRI works is due to the fact that increased neuronal activity leads to increased flow of blood in the brain. Of course, fMRI scans do produce a lot of data.

Consequently, trying to identify those areas where a section of the brain is activated more compared with other areas requires processing huge amounts of data. Rapidly, the multiple comparisons problem rears its head.

A possible consequence of this is that researchers may, and indeed do, opt for a limited or small sample size. There are then the limitations of small sample sizes. A recent study in *Nature Reviews Neuroscience* reports, "Here, we show that the average statistical power of studies in the neurosciences is very low. The consequences of this include overestimates of effect size and low reproducibility of results."

The broader question of how to analyse fMRI neuroimaging data has gradually attracted more attention over the question of how to collect the data.

Methods aiming to extract the interesting information directly from the data, contrary to the traditional approach based on testing the hypothesis proposed by researchers beforehand, have been introduced to the neuroimaging field.

These emerging data-driven methods provide more possibilities and perspectives of investigating and understanding the neuroimaging data that convey some crucial information for discovering brain mechanisms underlying cognitive behaviours.

Typically, an fMRI study on a certain stimulation paradigm would adopt a single method of analysis and statistical thresholding. This raises the question of the generalisability of the results from a single method of analysis. Yet, if a second study on the same stimulation paradigm would utilize another method of analysis, two different sets of divergent results would manifest. Considering that in this field methods of analysis and statistics have proliferated, it is inevitable that a somewhat confusing picture of the scientific progress gained by fMRI research would emerge.

We report on a collaborative study between Brunel and Aarhus Universities, with the data collected at the Advanced Magnetic Imaging center of Aalto university, Finland. What we have done, for the first time is to analyse fMRI data with the consensus clustering paradigm called binarisation of consensus partition matrices (Bi-CoPaM). This paradigm is capable of merging results from many analysis methods in order to obtain robust and reproducible clusters from various datasets. As a result, this can finally lead to a consensual landscape of neuroimaging results.

To validate the paradigm, we applied it to a complex fMRI experiment involving affective processing of hundreds of music clips. We found that brain structures related to visual, reward, and auditory processing have intrinsic spatial patterns of coherent neuroactivity.

The comparisons between the results obtained from our method and those from each individual clustering algorithm demonstrate that our paradigm has notable advantages over traditional single clustering algorithms in being able to evidence robust connectivity patterns even with complex neuroimaging data, involving a variety of stimuli and affective evaluations of them.

Our innovative use of the Bi-CoPaM paradigm allows us to find clusters including functionally and anatomically related neural networks consistently responding to emotional music, i.e. the basal ganglia, thalamus, insula, and other areas involved with processing of auditory features such as the Heschl's gyrus, the Rolandic operculum, and the superior temporal gyrus.

One of the pioneering aspects of this study is the employment of the Bi-CoPaM paradigm that explores fMRI data without any predetermined model, which is needed in classical model-based approaches.

The most important finding of this study is that our proposed approach was able to discover a single cluster, including the anatomically connected subcortical and cortical structures of the reward circuit, responding selectively to liked, enjoyed music. This is one of the few studies obtaining such finding with a data-driven approach.

Oh and that dead salmon reacting? Once the data underwent correction for multiple comparisons the false positives were eliminated – it really was a deceased fish!

More information: Chao Liu et al. Towards Tunable Consensus Clustering for Studying Functional Brain Connectivity During Affective Processing, *International Journal of Neural Systems* (2016). DOI: 10.1142/S0129065716500428

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