Image-based vs Coordinate-based Meta-analysis

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Introduction

Neuroimaging meta-analyses are becoming increasingly common and are especially important for pooling data from under-powered studies. However, the standard meta-analysis methods are only based on reported peak coordinates, which suffer from threshold effects and convey no information about deactivations. We propose that image-based meta-analyses (IBMA) are to be preferred over coordinate-based meta-analyses (CBMA). While this does require full statistic maps, we find that IBMA has greater sensitivity and offers greater modeling flexibility. In this study we use 15 FMR1 studies of common pain activations to show that IBMA results are similar to CBMA, and that IBMA can be used to illustrate the potential of image-based meta-analysis.

Methods

Each study has standard FSL pre-processing and mixed-effects group-level modeling; per-study t-stat and hence passes up the effect size (contrast of parameter estimate, or COPE) images and their variance (variance of the contrast of parameter estimate, or VARCOPE). We compare 5 IBMA methods: weighted-group-model incorporating random intra-study variation (FLAME-MFX) or only considering intra-study variation (FLAME-FFX); unweighted least squares of each study’s COPEs (OLS-FFX); and the meta-analysis methods such as Fisher’s and Stouffer’s (Fisher’s-FFX & Stouffer’s-FFX).

Results

In order to illustrate each method, a hierarchical 1D dataset is simulated and used as input to both IBMA and CBMA (see Fig. 1). The aforementioned methods are also applied to real FMR1 data from 15 pain studies, all of which have a pain-perception contrast in common. The resulting activation maps are shown in Fig. 2, which shows the poor sensitivity of CBMA in localising the activation. In order to evaluate and quantify this shortcoming (which is probably primarily due to the information loss caused by summarisation of the statistic maps by a list of levels), Dice similarity measure (DSM) is used as a measure of information loss due to replacing the statistic maps by a list of coordinates. As inter-study variation is often considered a random effect, we use the (theoretically optimal) FLAME-FFX result as our gold-standard IBMA result.

Conclusions

Based on the differences between CBMA and IBMA results & possible maximization of the deactivation, CBMA maps, we find IBMA to be preferred over CBMA. We see this as motivation for sharing summary image data with publishers and colleagues. However, as a result of the lack of such data-sharing practice in the field of neuroimaging, CBMA is currently the only solution for most neuroimaging meta-analyses. In such cases, kernel size and statistical thresholding could be chosen using the results of this study. Also, the interpretation of the significance maps in the difference contrasts needs extra care, as it does not induce the deactivation phenomenon.

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References