Link between function and structure in the resting-state brain: an fMRI and VBM study

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Introduction

Resting-state fMRI reflects activity in the brain that is not related to an external stimulus. Although the intensity of this activity is often found to be strongest in the cuneus and precuneus [1], the fMRI signal strength in these areas varies considerably across individuals. One hypothesis is that this is due to variability in subject train of thought or consciousness level [8]. Alternatively, variations in the brains anatomical structure may also explain this result. We therefore investigated the relationship between grey-matter density and fMRI signal amplitude both across brain regions and subjects.

Methods

We used two publically-available data sets [2]. The description of the acquisition can be found on [2]. We first used FSL [3][4] and AFNI [5][6] to compute the fractional Amplitude of Low-Frequency Fluctuation (fALFF) signal between 0.01 and 0.1 Hz in 22 subjects (Dataset #1) and converted them to z-scores. We then used Voxel-Based Morphometry (VBM) to compute gray-matter probability (SPM8-VBM8 [7]) in each subject of the two data sets. fALFF and VBM datasets were registered to MNI space. The VBM results were divided into 10 equally-spaced bins (10%-100%) from which we extracted the mean fALFF. We computed the average best-fit curve between grey-matter density and fALFF across subjects, and used it to predict the fALFF from the second dataset using only the VBM results. The predicted and measured of the second dataset were then compared.

Result

We first found a negative polynomial relation between the quantification of grey matter and the amplitude of the fALFF signal across the brain. We were able to modelized the data with a 4^{th} degree polynomial equation. Then, we found that the relation was strong enough to obtain an accurate prediction with less than 10% error for every bin of grey matter probability on a second dataset (Dataset #2).

Conclusion

These preliminary results show a strong relation between structure and function in the brain. This suggests that variations in fMRI resting-state activity are not solely driven by the subjects state (e.g. level of vigilance), but also by inherent differences in the brains structural architecture. However, we also observed inter-regional differences, i.e. brain regions with high grey matter density that were not highly activated during resting-state scans. We are currently investigating other methods for more accurately establishing the link between the two components. A regional analysis could help us to be more accurate and efficient in our attempt to predict the fALFF signal in resting-state fMRI from a prior VBM analysis.

References

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