

Resting-state cognition is associated with resting-state network activation

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Introduction

The human brain generates complex patterns of activity and cognition during wakeful rest, but the question is: how are they related?

In 2008, we developed a self-report Resting-State Questionnaire (RSQ) of 50 five-point Likert items for rating feelings and thoughts during the classical eyes-closed resting-state (RS) condition.¹

Here, we investigate links between cognition and brain activity during the resting state using the RSQ and functional magnetic resonance imaging (fMRI).

Methods

68 participants underwent RS-fMRI twice. Immediately after each session they completed the RSQ while still in the bore.

- Philips Intera 3T MRI machine with 8-channel head coil.
- 2 blocks of 140 volumes RS-fMRI (axial, TR 2200 ms, TE 30 ms, flip angle 80°, 2.75 mm isotropic with 10% inter-slice gap) separated by 30 minutes of task-based fMRI.
- Instructions: "Please relax, lie still with eyes closed and try not to fall asleep".
- RSQ scores analysed using PCA with VARIMAX rotation.
- fMRI data analysed with FSL using standard pre-processing.
- ICA with PCA-driven dimensionality reduction on temporally concatenated fMRI data to identify large-scale patterns of functional connectivity within the full group.²
- Dual-regression to determine scan-specific temporal dynamics and associated spatial maps.³
- Spatial maps divided into 2 groups for each RSQ factor; scores below vs. above the median.
- Non-parametric voxel-wise analysis of differences between groups (5,000 permutations, TFCE, $p < 0.05$ FWE-corrected).

Results

The participants reported no problems remembering or rating their thoughts and feelings on the RSQ (Fig. 1A).

The data revealed large and often stable inter-individual differences in the quality and content of thoughts and feelings during RS-fMRI (Fig. 1B to F).

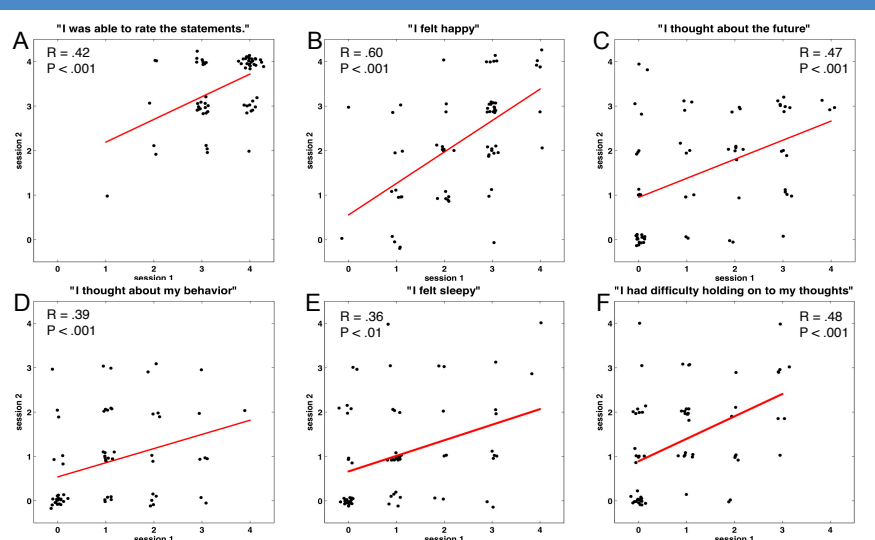


Fig. 1. Test-retest reliability of representative items from the 5 RSQ factors.

PCA identified 5 different RSQ factors with high loadings for items pertaining to feelings (e.g. item in panel B), self projection (C), self reflection (D), sleepiness (E) or discontinuity of mind (F).

ICA identified 21 components, of which 10 represent well-known RS networks of brain regions with temporally correlated BOLD signals (Fig. 2).⁴

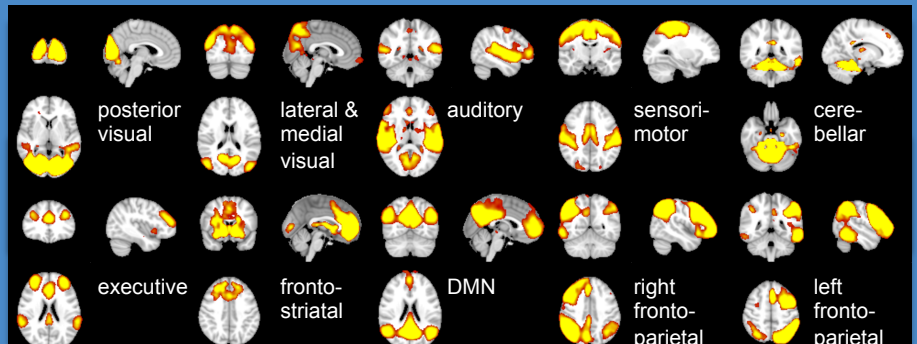


Fig. 2. Well-known resting-state networks from the ICA analysis. Figure shows most informative orthogonal slices. RSN's displayed in red-yellow superimposed on the MNI brain (left = right).

Surprisingly, we found that high scores on 'self projection' were associated with *less* functional connectivity in posterior parts of the default mode⁵, executive and left fronto-parietal networks when compared to low scores (Fig. 3A).

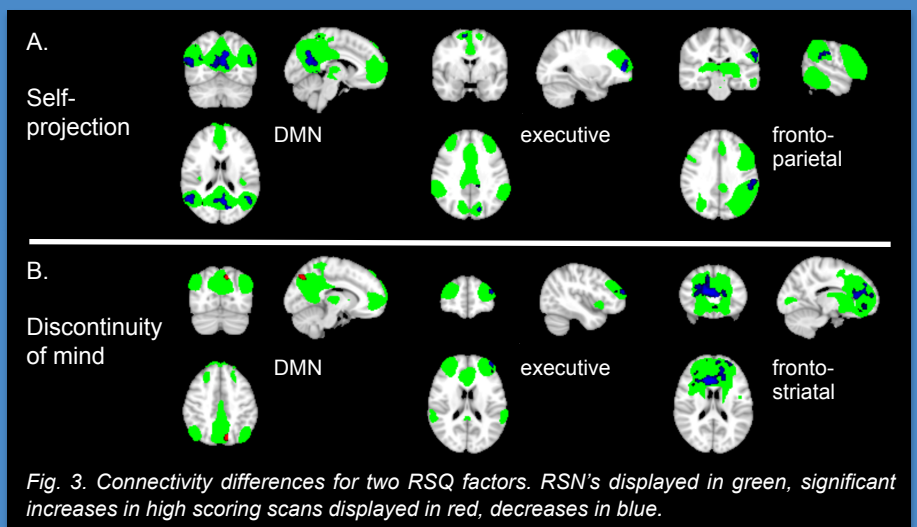


Fig. 3. Connectivity differences for two RSQ factors. RSN's displayed in green, significant increases in high scoring scans displayed in red, decreases in blue.

In contrast, high scores on 'discontinuity of mind' were associated with *more* connectivity within the default mode network, and less connectivity in the executive and fronto-striatal networks (Fig. 3B). Functional connectivity differences could also be demonstrated for the other three RSQ factors (not illustrated).

Conclusion

Individual variation in RS cognition is associated with differential activation of resting-state networks. The RSQ could prove useful for shedding light on functional implications of genetic or disease-related variation in RS brain activity.

References

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