Inter- and intra-subject similarity in network functional connectivity under naturalistic stimulation

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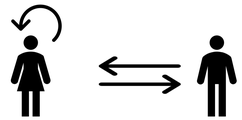
Introduction

- Recently increased interest in relationship between inter-individual differences in neuroimaging and phenotypical data
- Two important factors:



1. Variabiliy within subjects
2. Variabiliy between subjects

- Naturalistic stimuli assumed to benefit both intra- and inter-subject variability compared to resting-state-fMRI paradigms[1]
- Functional networks a priori informed data reduction

Aim

- Investigate inter- and intra- subject similarity in network functional connectivity (NFC) during naturalistic viewing (NV)

Meta-analytically defined networks:

- autobiographical memory (AM)[2]
- cognitive attention control (CogAC)[3]
- extended multiple demand network (eMDN)[4]
- emotional scene and face processing (EmoSF)[5]
- Empathy[6]
- theory of mind (ToM)[6]
- emotion regulation (ER)[7]
- extended socio-affective default (eSAD)[8]
- mirror neuron system (MNS)[9]
- Motor[10]
- reward (Rew)[11]
- semantic memory (SM)[12]
- vigilant attention (VigAtt)[13]
- working memory (WM)[14]

Methods

Sample:

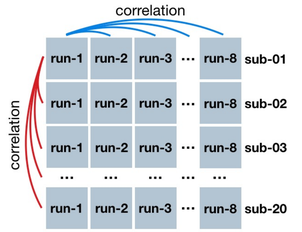
- 14 participants, 6 females, mean age 29.4 years

Functional imaging data:

- 2 hours of „Forrest Gump“ NV-fMRI split into 8 runs of ~15 min
- 3 Philipps Achieva dStream MRI scanner, 32 channel head coil
- T2*-weighted EPI images, TR = 2s, echo time = 30ms, flip angle = 90°, voxel size = 3mm, slices = 35
- Minimally preprocessed
- Extraction of functional connectivity as Pearson correlation between time courses of network nodes

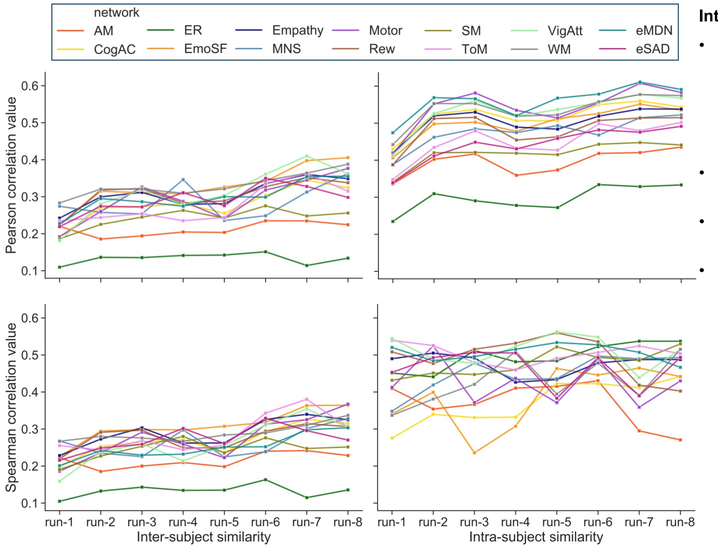
Variability in NFC

- Comparison of results based on Pearson and Spearman correlation



Calculation of inter- and intra-SC. Squares represent NFC matrices. Exemplary for one network, calculation of inter-SC and intra-SC of run-1 of sub-01 are shown. Inter-SC is calculated by averaging the correlation values (red) between run-1 of sub-01 and run-1 of all other subjects. Intra-SC is calculated by averaging the correlation values (blue) between run-1 of sub-01 and all other runs of sub-01.

Results



Inter-subject similarity:

- Pearson: two-way ANOVA: sign. **main effect of run** ($F(7,1456) = 62.035$, $p < .001$), **network** ($F(13,1456) = 75.83$, $p < .001$) and **interaction effect run*network** ($F(91,1456) = 2.611$, $p < .001$)
- Sign. increase after run 1 across all networks
- ER, AM and SM sign. different from all other networks
- Spearman: two-way ANOVA: sign. **main effects of run** ($F(7,1456) = 58.969$, $p < .001$), **network** ($F(13,1456) = 63.774$, $p < .001$) and **an interaction effect run*network** ($F(91,1456) = 2.908$, $p < .001$)

Intra-subject similarity:

- Pearson: two-way ANOVA: sign. **main effect of run** ($F(7,1456) = 18.291$, $p < .001$) **and network** ($F(13,1456) = 29.462$, $p < .001$), but no sign. run*network interaction effect ($F(91,1456) = 0.162$, $p = 1$)
- Sign. increase after run 1 across all networks
- ER network sign. different from all other networks, AM and SM networks sign. different from most networks
- Spearman: two-way ANOVA: sign. **main effects of run** ($F(7,1456) = 3.96$, $p < .001$), **network** ($F(13,1456) = 16.574$, $p < .001$) and **interaction effect run*network** ($F(91,1456) = 2.014$, $p < .001$)
- Different pattern in runs and networks, interaction only based on one network

Discussion

Runs

- Subjects' NFC get more similar to each other's and their own NFC after first run, but there is no sign. continuous, gradual increase
- Longer scanning time does not have universal effect on inter- and intra-subject similarity
- Differences between first and later runs might relate to familiarization with scanner environment and movie paradigm

Networks

- Emotion regulation (ER), autobiographical memory (AM) and semantic memory (SM) networks were most different from other networks in both inter- and intra-subject similarity; this might be related to subjective experience of movie and individual memories
- No clear pattern in regard to network domains (cognitive, emotional, mnemonic, social, motor)

Inter-subject similarity

- Similarity between subjects in different networks depends on run: run*network interaction might indicate relevance of movie content
- But no clear distinction between content of movie and runtime possible based on these data
- Annotation of movie content or features might enable more precise analyses on which features increase inter-subject similarity in which networks

Intra-subject similarity

- No run*network interaction in intra-subject similarity
- Similarity between subjects' own NFC plateaus after first run
- Different levels of similarity between networks
- Differences in the results pattern between Pearson- and Spearman-correlation -> variance in connectivity strength is better preserved via Pearson correlation in contrast to simple rank test

Conclusion:

- inter-subject similarity results indicate that movie content, but not length of the movie may induce relevant variance between subjects
- Intra-subject similarity in NFC seems more stable across runs within networks
- Rank-based correlation might be less suited when correlations on network node level are within small range

References

[1]Finn et al., 2017; [2]Spreng, Mar & Kim, 2008; [3]Cieslik, Mueller, Eickhoff, Langner, & Eickhoff, 2013; [4]Camilleri et al., 2016; [5]Sabatinelli et al., 2011; [6]Bzdok et al., 2012; [7]Buhle et al., 2014; [8]Amft et al., 2015; [9]Caspers et al., 2016; [10]Witt, Meyerand, & Laird, 2008; [11]Liu, Hairston, Schrier, & Fan, 2011; [12]Binder et al., 2009; [13]Langner & Eickhoff, 2013; [14]Rottschy et al., 2012

Acknowledgments

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