Predicting Personality from Structural-Functional Brain Network Coupling

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Introduction

Personality traits

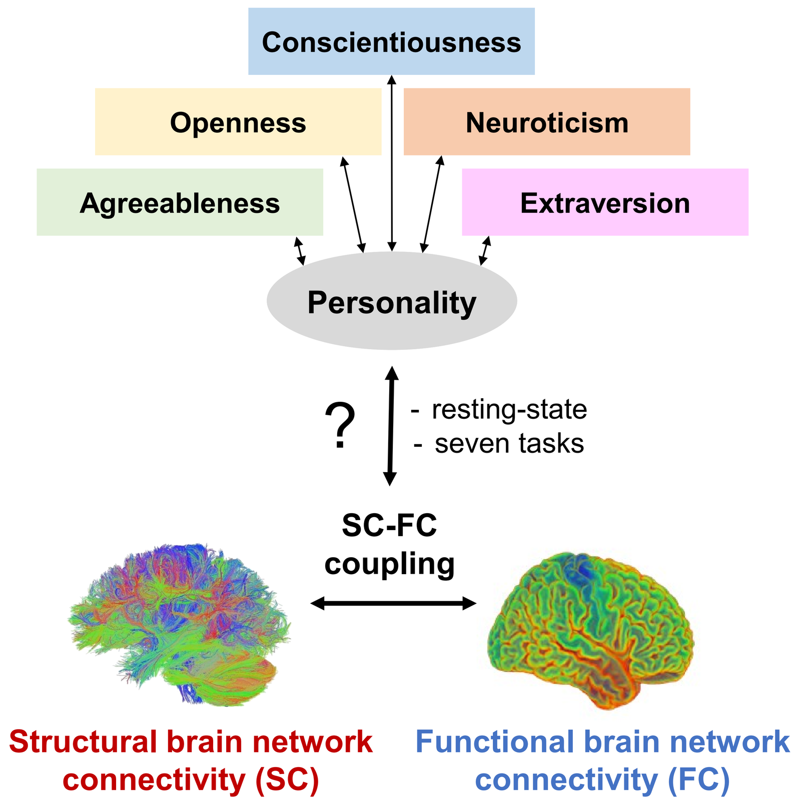
- Stable individual tendencies in behavior, motivation, emotion and cognition [1]
- Big-Five Personality Model [2,3]
- Traits particularly visible in trait-relevant situations? [4]

Neural basis of personality

- Neurobiological correlates of personality in **structural brain networks** and **functional brain networks** [4]
- No investigation of **structural-functional brain-network coupling**

Research goals

- **Investigation** of how general (group-average) SC-FC **coupling** depends on **coupling measures** and **fMRI conditions**
- **Prediction of personality traits** from intrinsic and task-induced SC-FC coupling
  - **Better prediction** from **trait-relevant** tasks?



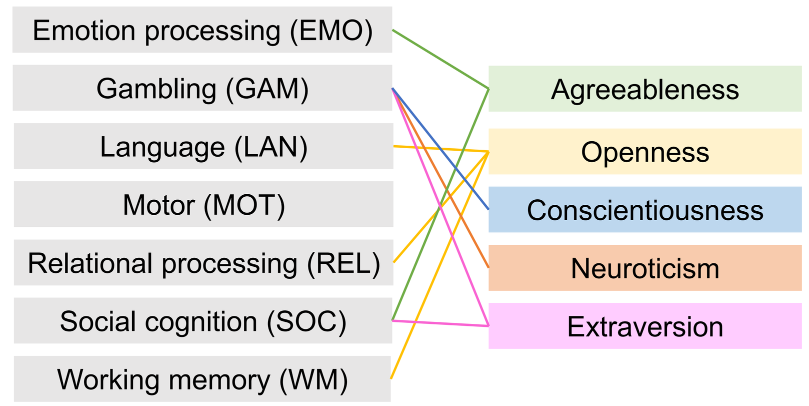
Methods

Preregistered

Sample (N_{main} = 532; $N_{replication}$ = 232)

- Human Connectome Project (HCP) [5]
- Personality: NEO-FFI [6]
- **Functional connectivity (FC)**
  - resting-state fMRI (RES)
  - seven fMRI tasks
- **Structural connectivity (SC)**
  - DWI
- Confounds: Age, gender, handedness, and head motion

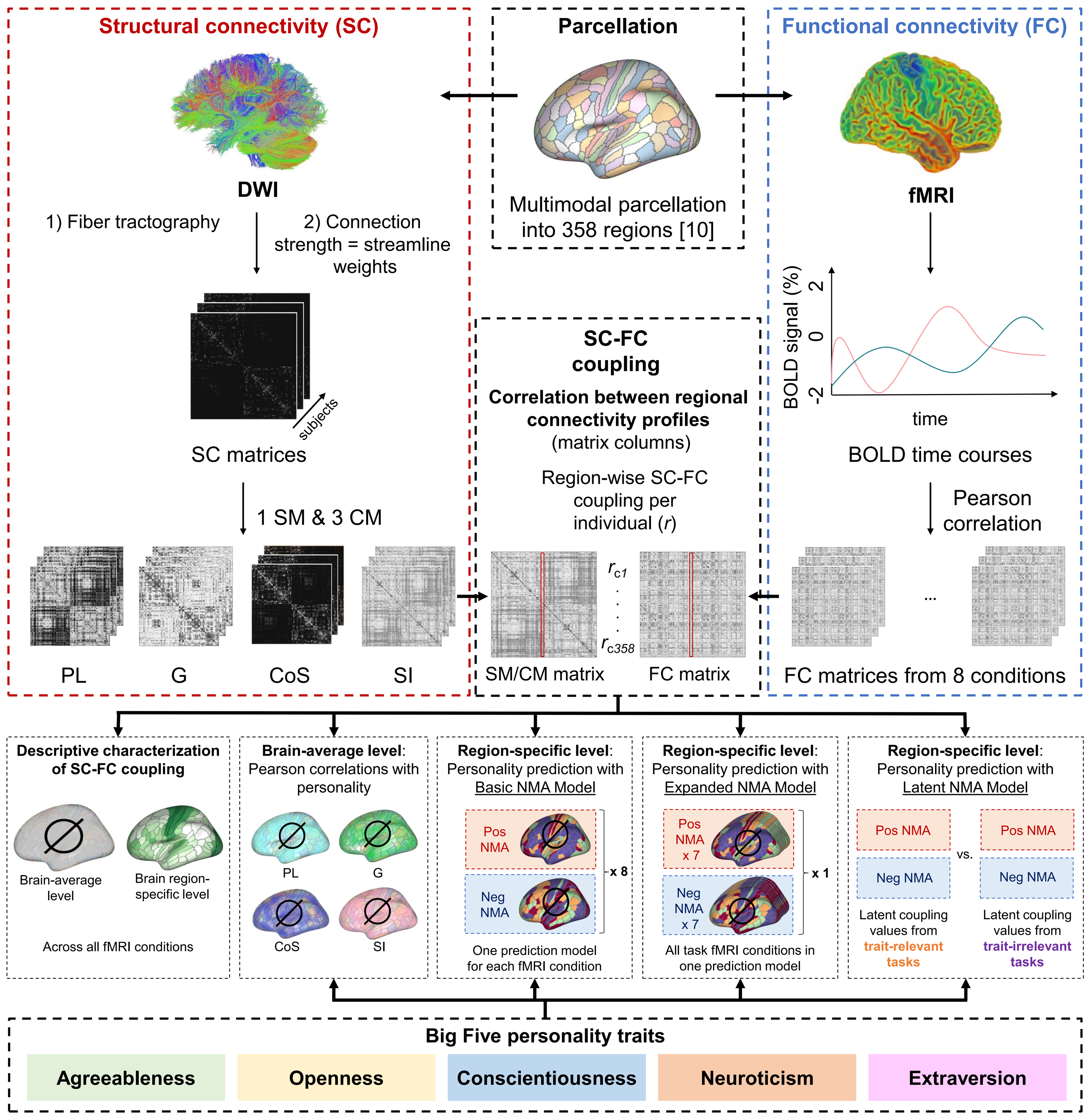
Trait-relevance of fMRI tasks



Network communication measures (CM) & similarity measures (SM)

- **CM** model potential functional interactions on top of SC [7,8,9]
- Distinct CM: different communication strategies from routing to diffusion
- **SM** depict similarity of connectivity profiles
- Computation based on weighted SC matrices

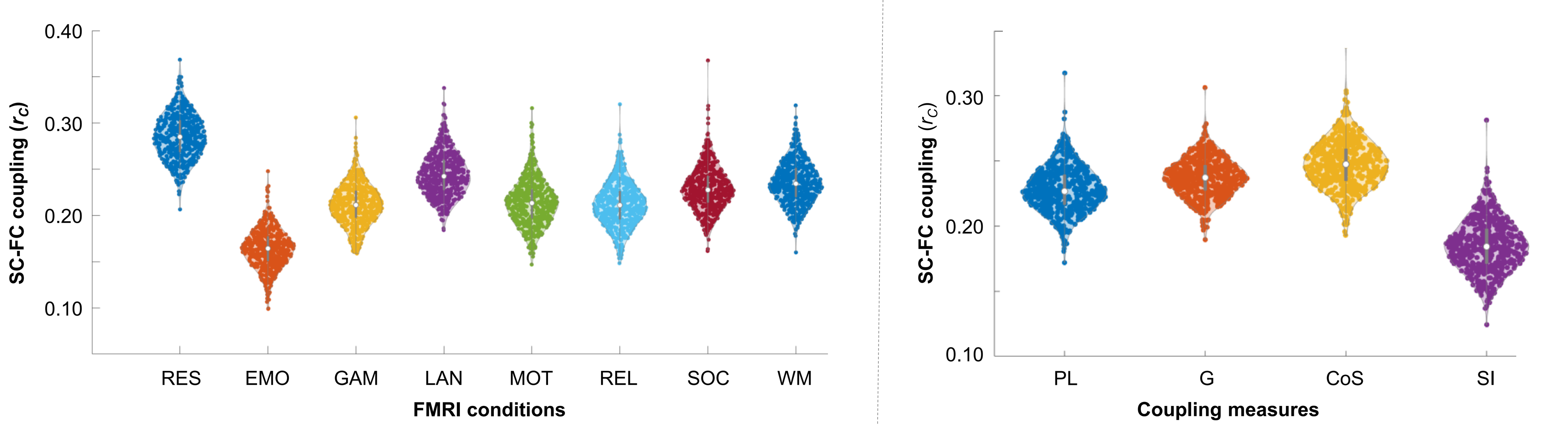
Path length (PL):
Length of the shortest possible path between brain regions
Communicability (G):
Weighted sum of walks of all lengths between pairs of brain regions
Cosine similarity (CoS):
Similarity between connectivity profiles based on vector orientation
Search information (SI):
Amount of information needed to discover a path in a network



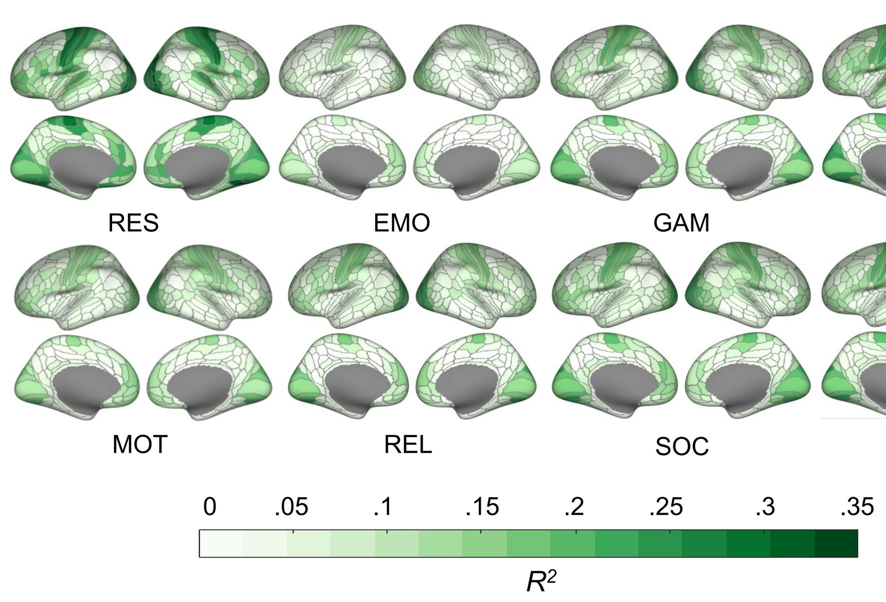
Results

1. Task- and measure-specific differences in SC-FC coupling

Brain-average SC-FC coupling varies between coupling measures and fMRI conditions

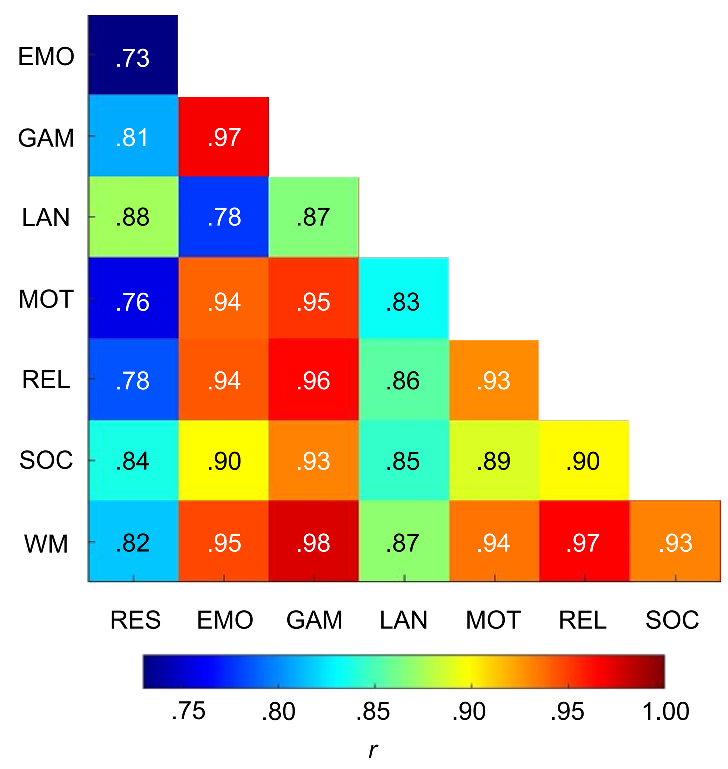


Group-average SC-FC coupling



- High coupling strength in unimodal areas
- Low coupling strength in multimodal areas

Similarity of SC-FC coupling across fMRI conditions



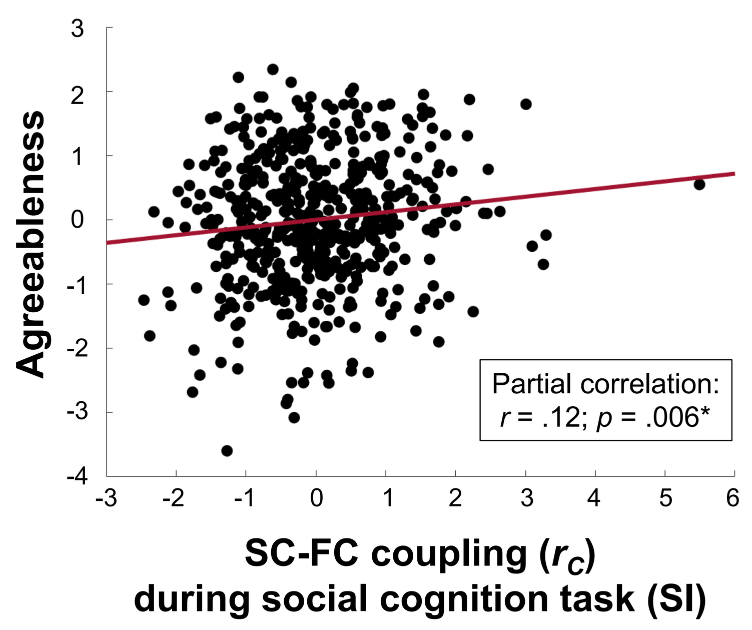
2. Resting-state: No relationship between intrinsic SC-FC coupling and personality

Prediction performance Basic NMA Model

Personality	r (p)
Agreeableness	- .01 (.617)
Openness	- .03 (.725)
Conscientiousness	.07 (.072)
Neuroticism	- .01 (.637)
Extraversion	.06 (.109)

- No significant association between brain-average SC-FC coupling & individual differences in personality traits during resting-state
- Individual personality scores can not be predicted from region-specific SC-FC coupling

3. Social cognition task: Positive relationship between agreeableness and brain-average SC-FC coupling



* $p < .05$ uncorrected for multiple comparisons

4. SC-FC coupling across tasks outperforms intrinsic SC-FC coupling for all personality traits

Prediction performance Expanded NMA Model

Personality	r (p) - RES	r (p) - All task fMRI conditions
Agreeableness	-.01 (.617)	.04 (.187)
Openness	-.03 (.725)	.06 (.085)
Conscientious-ness	.07 (.072)	.14 (.001)**
Neuroticism	-.01 (.637)	.02 (.346)
Extraversion	.06 (.109)	.06 (.051)

5. No difference in predictive performance between trait-relevant and trait-irrelevant tasks

Prediction performance Latent NMA Model

Personality	r (p) Trait-relevant task	r (p) Trait-irrelevant task
Agreeableness	.06 (.098)	.02 (.336)
Openness	.06 (.088)	.07 (.068)
Conscientious-ness	.10 (.032)*	.08 (.066)
Neuroticism	-.03 (.723)	-.00 (.545)
Extraversion	.09 (.046)*	.02 (.294)

* $p < .05$ uncorrected for multiple comparisons; ** $p < .05$ corrected for five comparisons

Summary and Conclusions

- **Consistent pattern of SC-FC coupling** across resting-state and different tasks
- Brain-average and brain region-specific **SC-FC coupling** is **higher during resting-state** as compared to task fMRI
- **Intrinsic SC-FC coupling** is **not associated** with individual differences in **personality**
- **Task-induced SC-FC coupling** can **predict** individual **conscientiousness** scores, suggesting that behaviorally relevant information becomes **more visible** during **active task demand**
- Confrontation with **"trait-relevant" situations** did **not improve prediction performance** in our sample

Personality traits shape human behavior and are manifested in **brain structure** and **brain function**. Investigating **multimodal brain properties** – such as **SC-FC coupling** – in **trait-relevant situations** may present a promising further development. However, conceptual study design and feasability of data acquisition encounter specific challenges that need to be overcome by future research.

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