

A Comparison of Individualized Behaviour Prediction Across Modalities in MRI

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Abstract

Several studies have investigated the correlation of structural and functional brain variations, as captured by brain imaging, to behavioural and demographic variation (e.g. Llera et al.). However, there have not been many direct comparisons between the ability of these variations to predict behavior at an individual level. Furthermore, the ability of these findings to generalize across datasets has scarcely been explored.

Here, we compared imaging features derived from structural, diffusion and functional MRI in predicting behavioural scores derived from the Human Connectome Project [HCP] (Van Essen et al, 2013) and the Adolescent Brain Cognitive Development study [ABCD] (Volkow et al., 2018). Additionally, we investigate whether using a combination of imaging features can result in an improved prediction.

We found that in both datasets, functional MRI outperforms other modalities in the prediction of behaviour, especially in the field of cognition. Furthermore, we find that combining task and resting state functional MRI gives an increase in prediction accuracy equivalent to combining all features from all modalities.

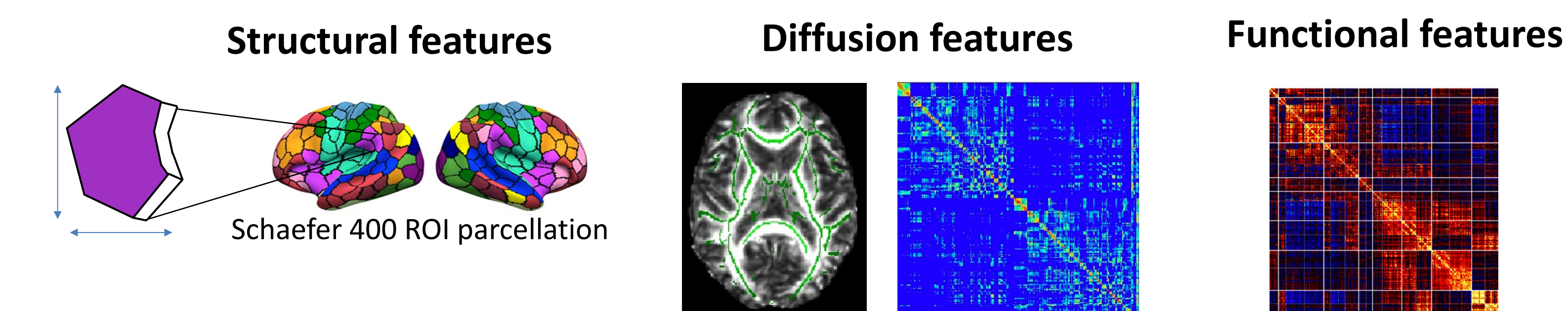
Methods

• Stage 1: Dataset

- ❖ HCP: n=753; 53.1% male; mean age 28.6
- ❖ ABCD: n=1506; 45.6% male; mean age 10.1

• Stage 2: Processing imaging features

- ❖ Structural features: Cortical area, thickness and volume were calculated for each ROI of the Schaefer parcellation (Schaefer et al., 2018)
- ❖ Diffusion features: A DTI and relaxed NODDI model (Dadducci et al., 2015) were fitted to the diffusion data. Probabilistic tractography was run for each subject. The metrics of the models were sampled using the TBSS skeleton (Smith et al., 2006), and along the tracts generated by the tractography.
- ❖ Functional features: A functional connectivity matrix was calculated by finding the pairwise correlation of each ROI for task and resting fMRI



• Stage 3: Processing behavioural features

- ❖ A factor analysis was conducted for each dataset, and we predicted 3 resulting components

• Stage 4: Single modality behavioural prediction

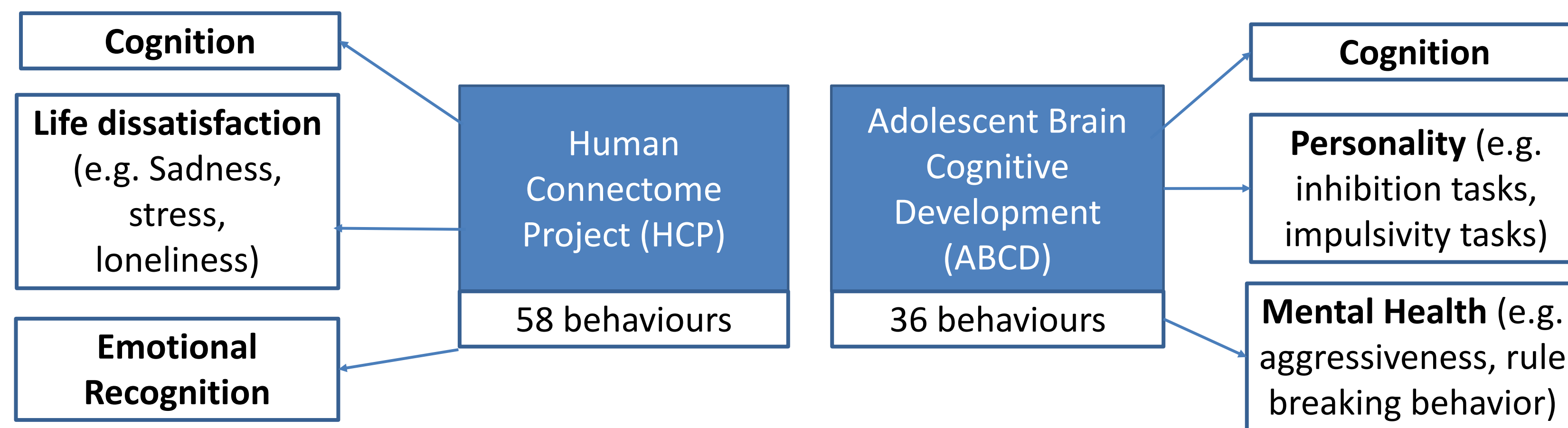
- ❖ Imaging features from each modality were used as predictors in a Kernel Ridge Regression [KRR] (Kong et al., 2019) and their resulting accuracies were compared over 600 splits in the HCP and 120 splits in the ABCD

• Stage 5: Multiple modality behavioural prediction

- ❖ Modalities were combined in a 1) multiKRR model (Chen et al., 2020) and 2) stacking model and compared to the best performing single modality model

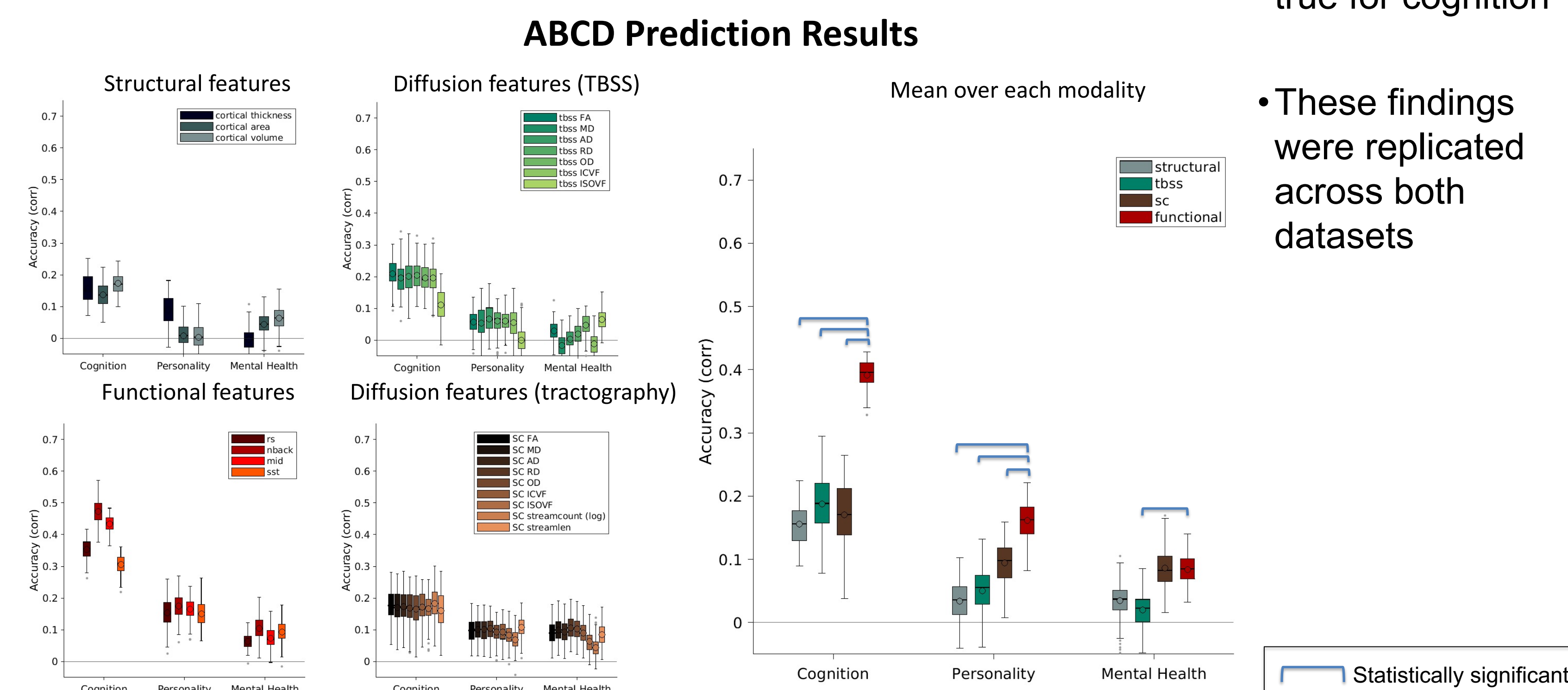
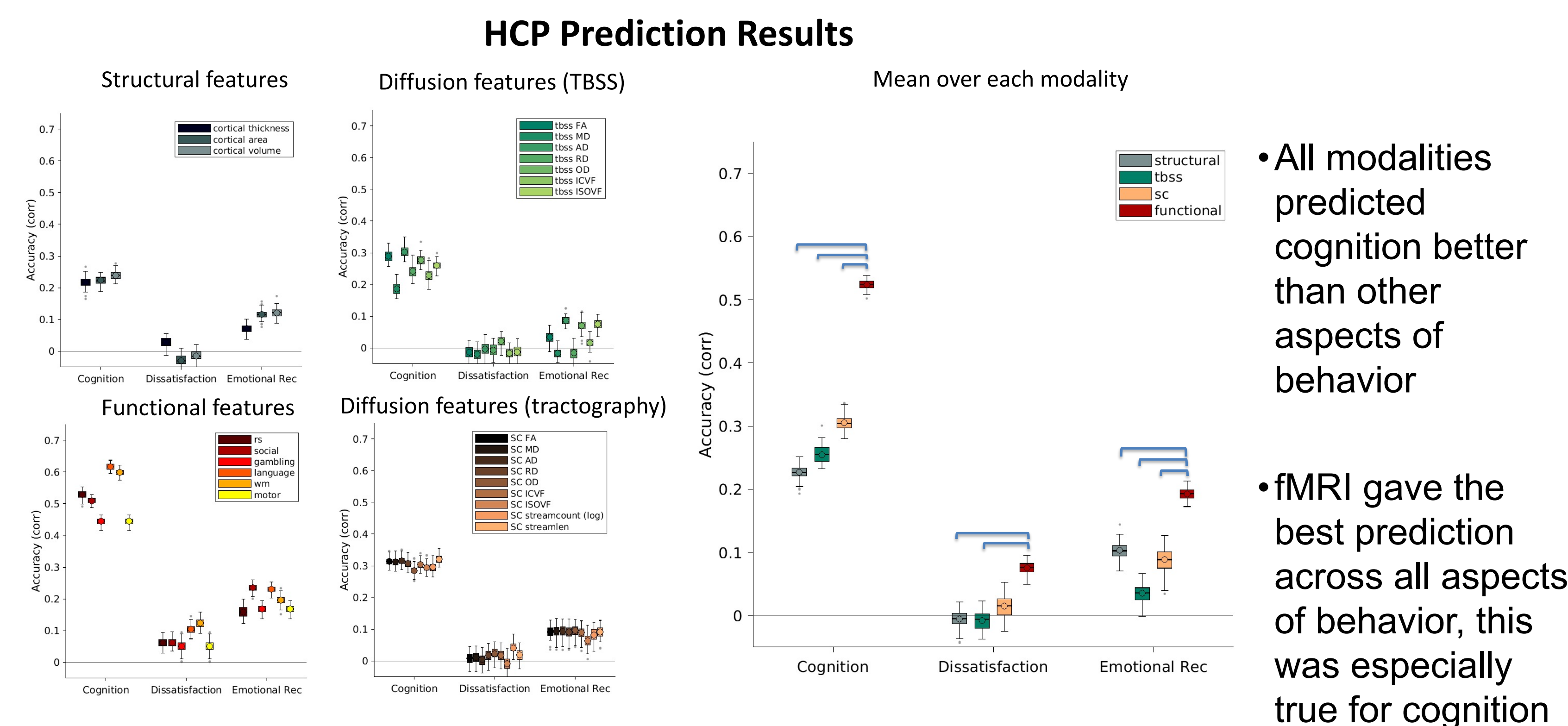
Behavioural Components of the HCP and ABCD

- Scores in each dataset under went a principal component analysis and varimax rotation



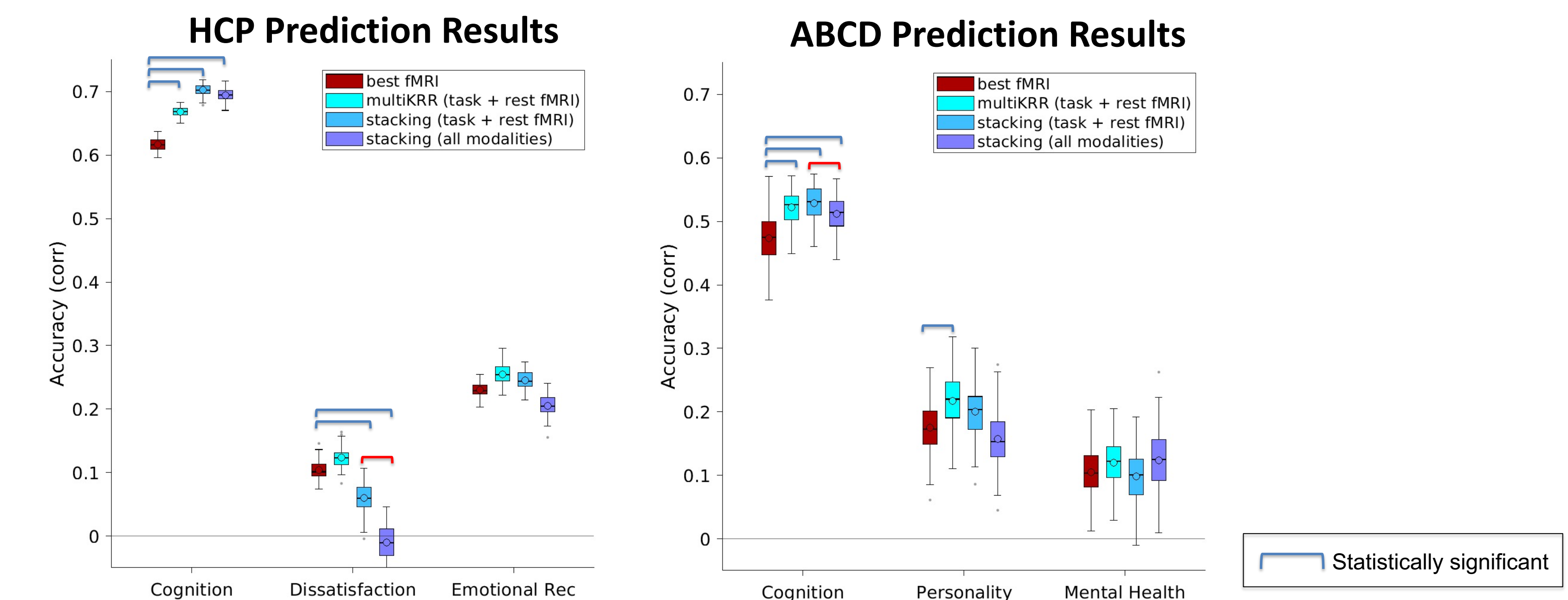
- The resulting scores from these components were used as the target variables for prediction

fMRI gives the best prediction of behaviour



Combining fMRI states is just as good as combining across all modalities

- The best performing single model for each dataset (HCP: fMRI language / ABCD fMRI nback) was compared to 2 methods of combining modalities – multiKRR and stacking



- Combining information across modalities always improved prediction of cognition
- Combining information from resting and task fMRI had an equivalent or better performance than combining all features from all modalities

Conclusion

- 1) Cognition is predicted more accurately compared to other aspects of behavior, regardless of the modality
- 2) We show that fMRI outperforms other modalities in predicting behavior, especially in the field of cognition
- 3) Combining information from different modalities increases prediction accuracy for cognition
- 4) Combining task and rest fMRI gives an improvement to prediction of cognition, that is equivalent to or better than combining all modalities

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Support

Our research is currently supported by the Singapore National Research Foundation (NRF) Fellowship (Class of 2017), the NUS Yong Loo Lin School of Medicine (NUHSRO/2020/124/TMR/LOA), the Singapore National Medical Research Council (NMRC) LCG (OFLCG19May-0035), the Singapore Ministry of Defense (Project CURATE) and the USA NIH (R01MH120080). Our computational work was partially performed on resources of the National Supercomputing Centre, Singapore (<https://www.nsc.sg>). Any opinions, findings and conclusions or recommendations expressed in this material are those of the authors and do not reflect the views of the Singapore NRF or the Singapore NMRC.