Generalizability of connectome-based predictive models

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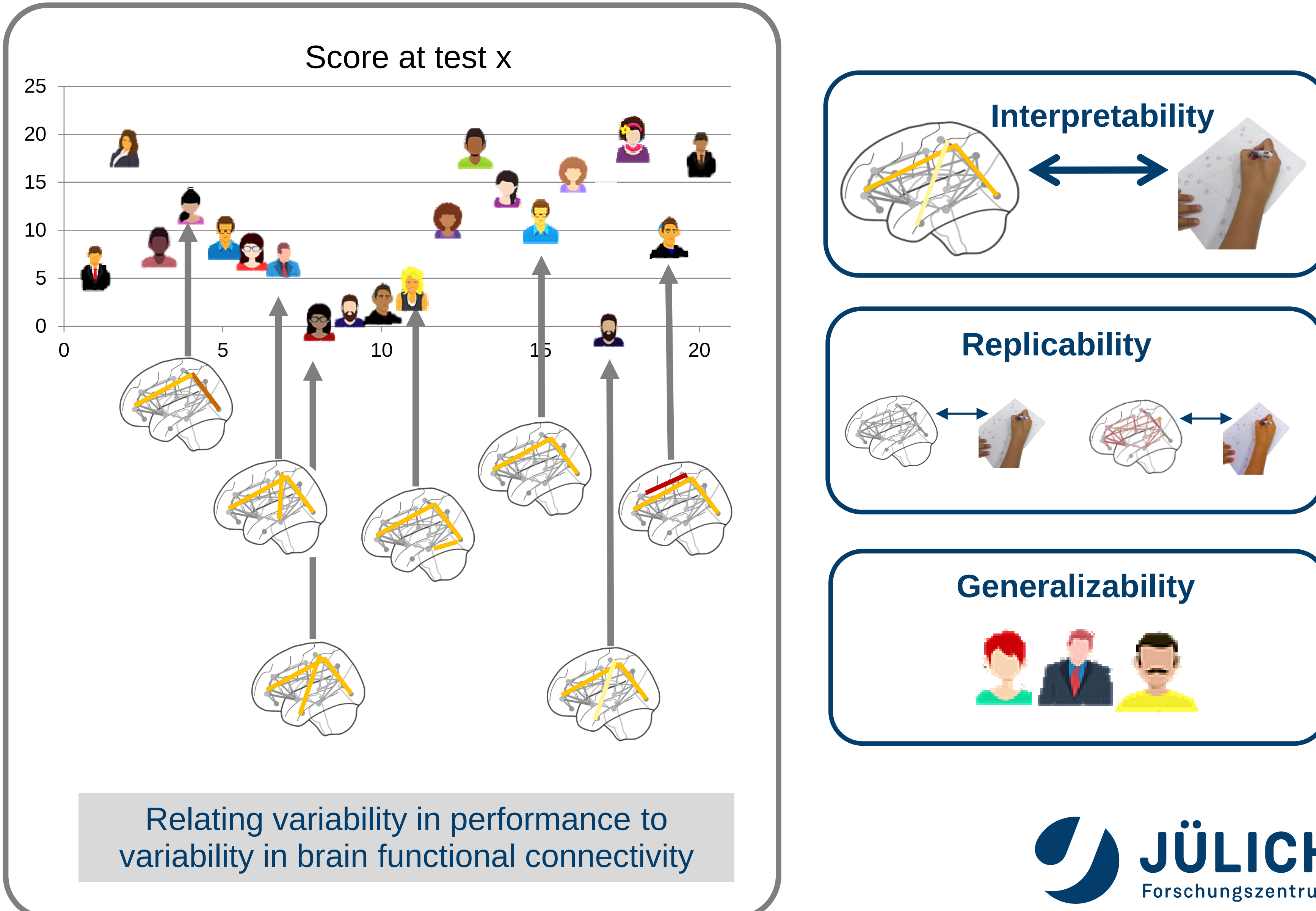
Connectivity-based psychometric prediction



Relating variability in performance to variability in brain functional connectivity

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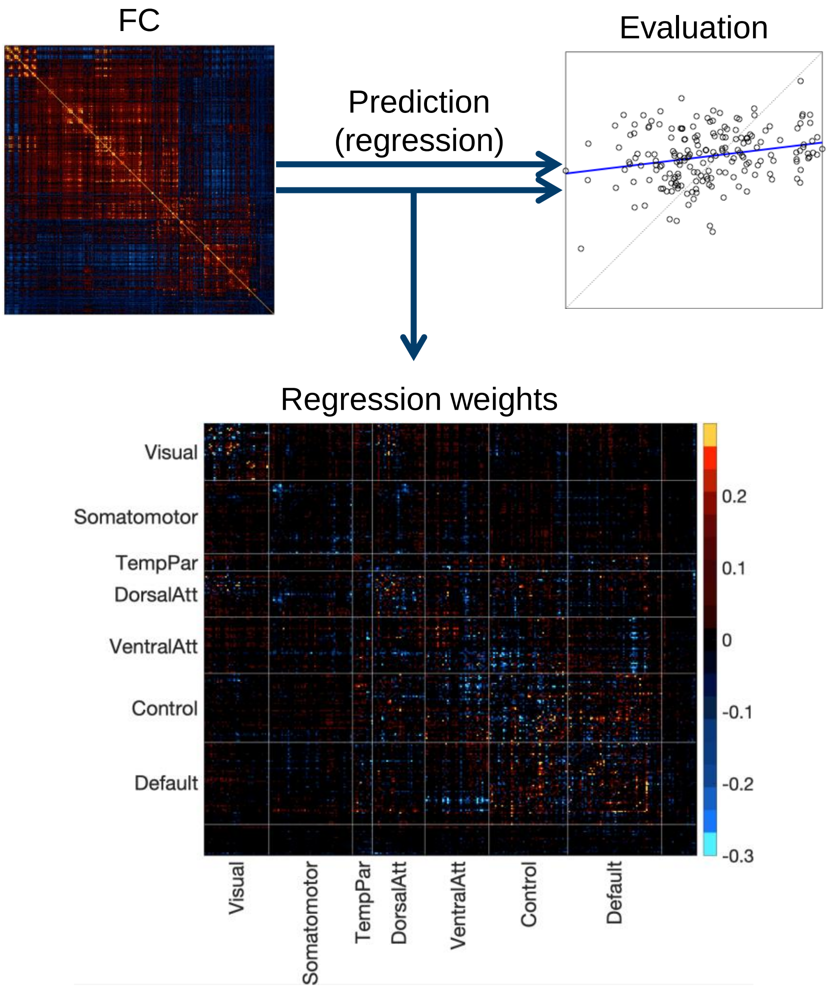
Predictive models of psychometric data

Interpretability /neurobiological validity issue

- Hypothesis-driven approach: a priori selection of specific regions/networks for the prediction
- **Data-driven approach**: How do we characterize each region/parcel's association to a psychometric variable?
- **Weight magnitude does not reflect** the regions' **association strength** with the psychometric variable
- Hard to get neurobiological insights

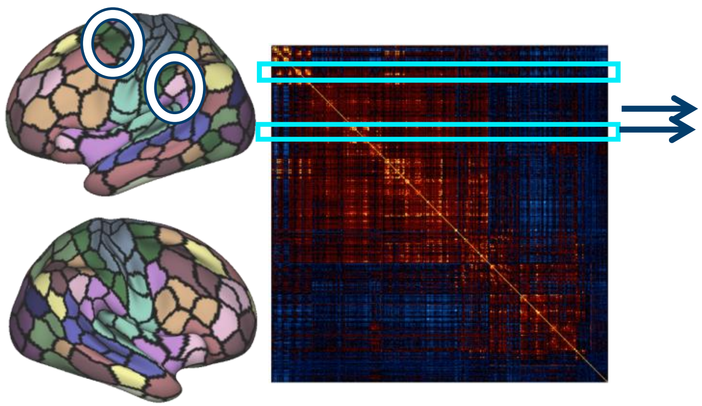


Wu,…,& Genon, 2021, Cerebral Cortex

Predictive models of psychometric data: interpretability

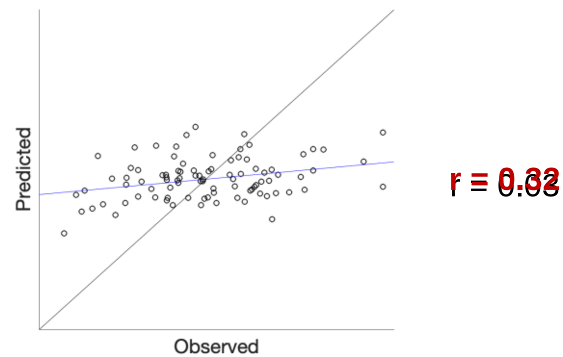
A region-based approach

- One predictive model for each brain region/parcel



(Schaefer et al., 2019)

	FC features	Total cognition composite score
Subject 1		133.76
Subject 2		106.85
Subject 3		72.15
…	…	…
Subject N		122.99

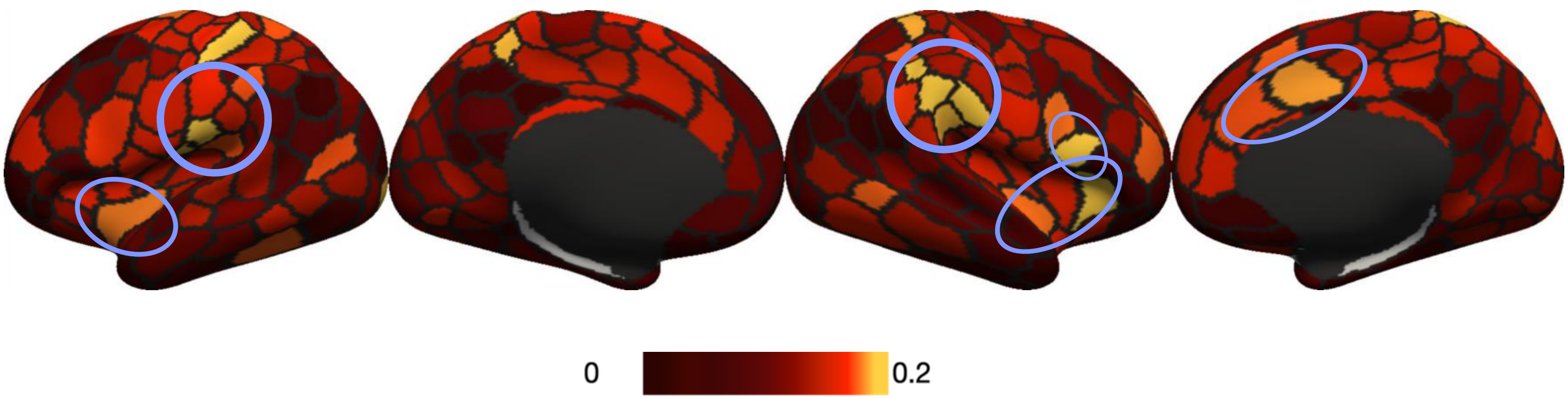


Wu,…,& Genon, 2021, Cerebral Cortex

Predictive models of psychometric data: interpretability

Prediction Performance Distribution

(working memory) 2-back task accuracy

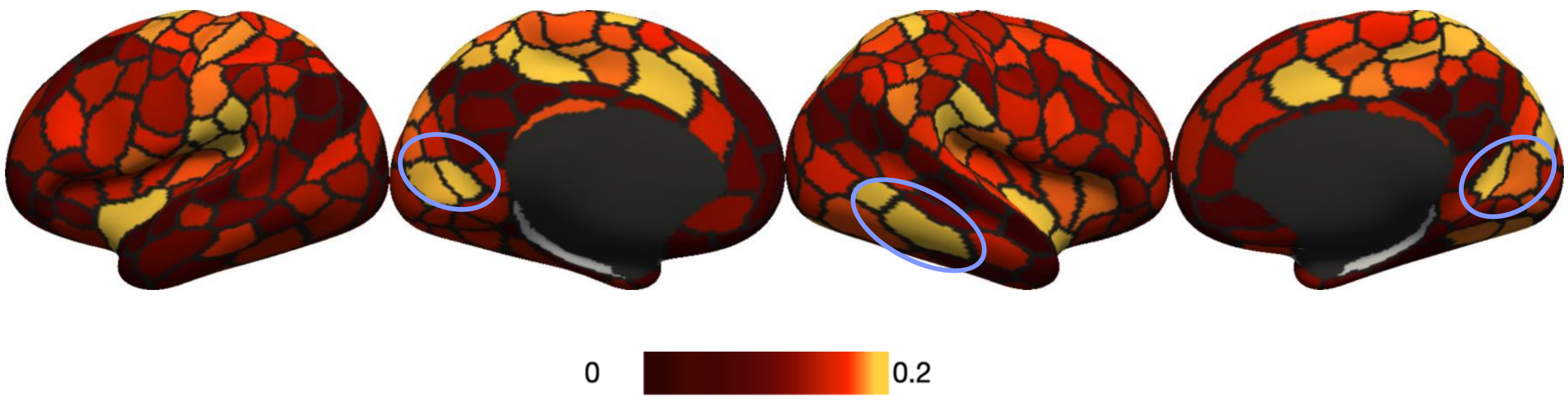


Wu,…,& Genon, 2021, Cerebral Cortex

Predictive models of psychometric data: interpretability

Prediction Performance Distribution

(working memory) 2-back **face** task accuracy



Wu,…,& Genon, 2021, Cerebral Cortex

Predictive models of psychometric data: replicability of brain-behavior patterns

Cross-dataset replicability of brain predictive patterns for fluid cognition

HCP-YA

HCP-A

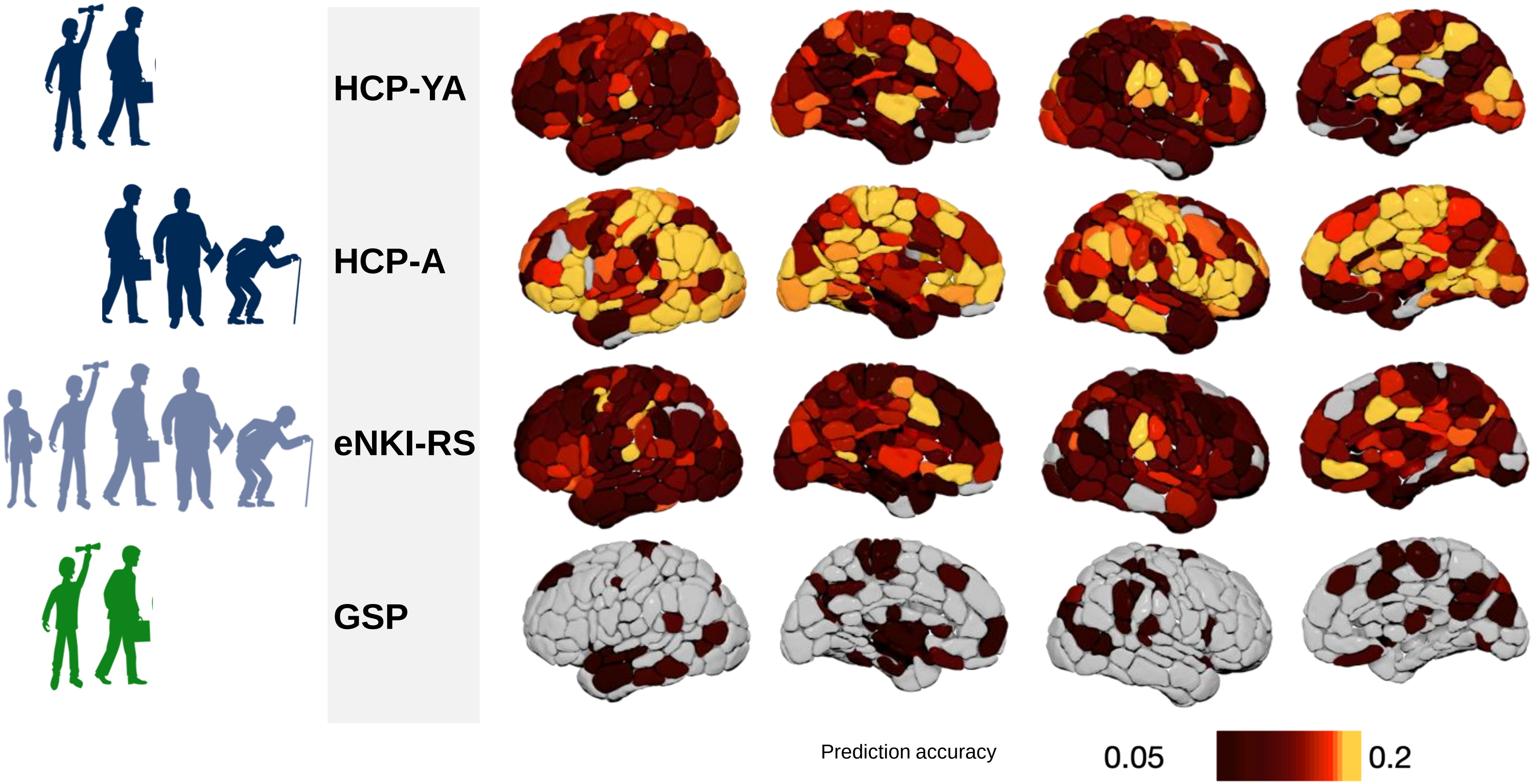
eNKI-RS

GSP

Wu,…,& Genon, in press, NeuroImage

Predictive models of psychometric data: replicability of brain-behavior patterns

Cross-dataset replicability of brain predictive patterns for fluid cognition



Wu,…,& Genon, in press, NeuroImage

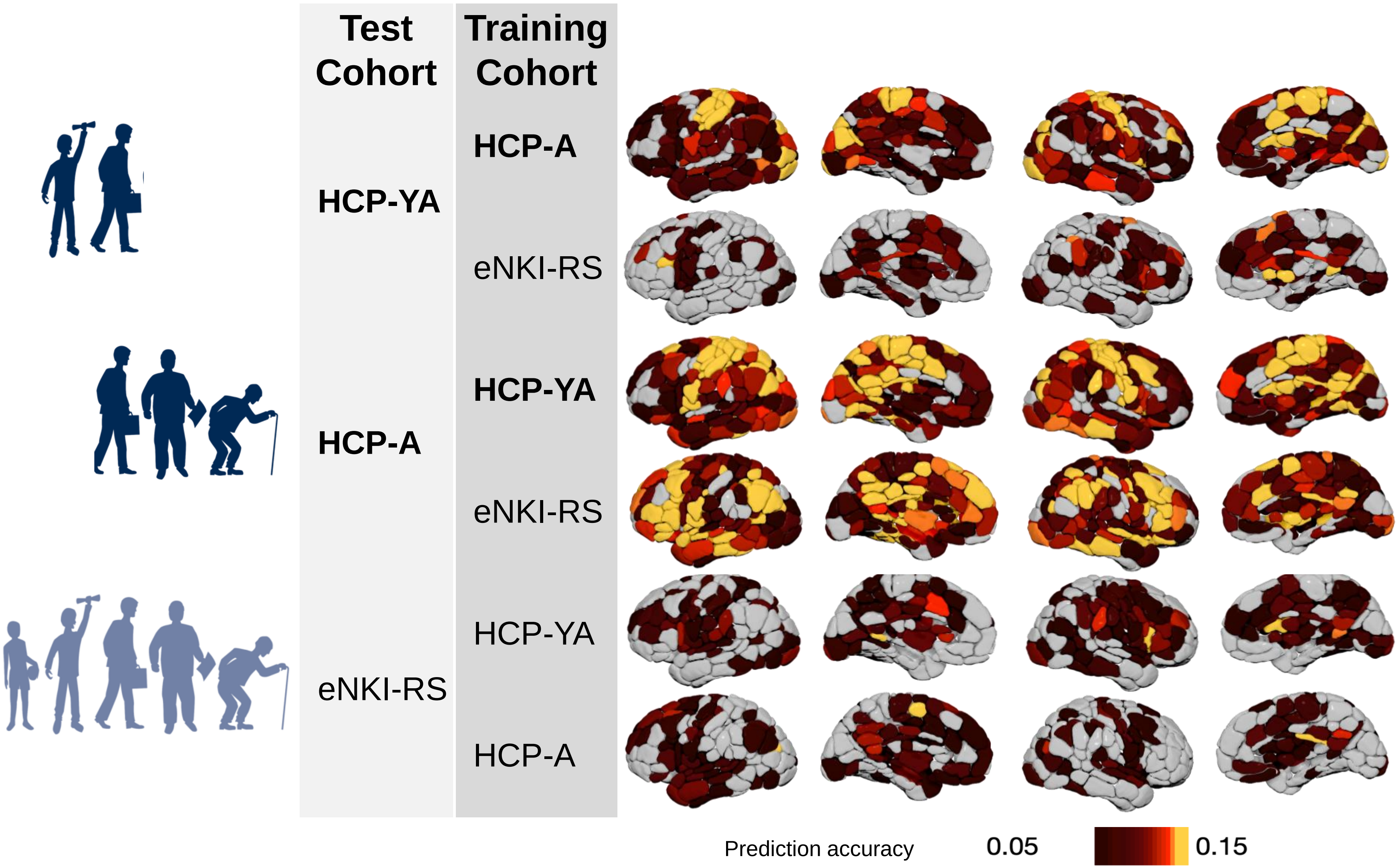
Predictive models of psychometric data: cross-dataset generalizability

Cross-dataset generalizability of fluid cognition

Test Cohort	Training Cohort
HCP-YA	**HCP-A**
	eNKI-RS
HCP-A	**HCP-YA**
	eNKI-RS
eNKI-RS	HCP-YA
	HCP-A

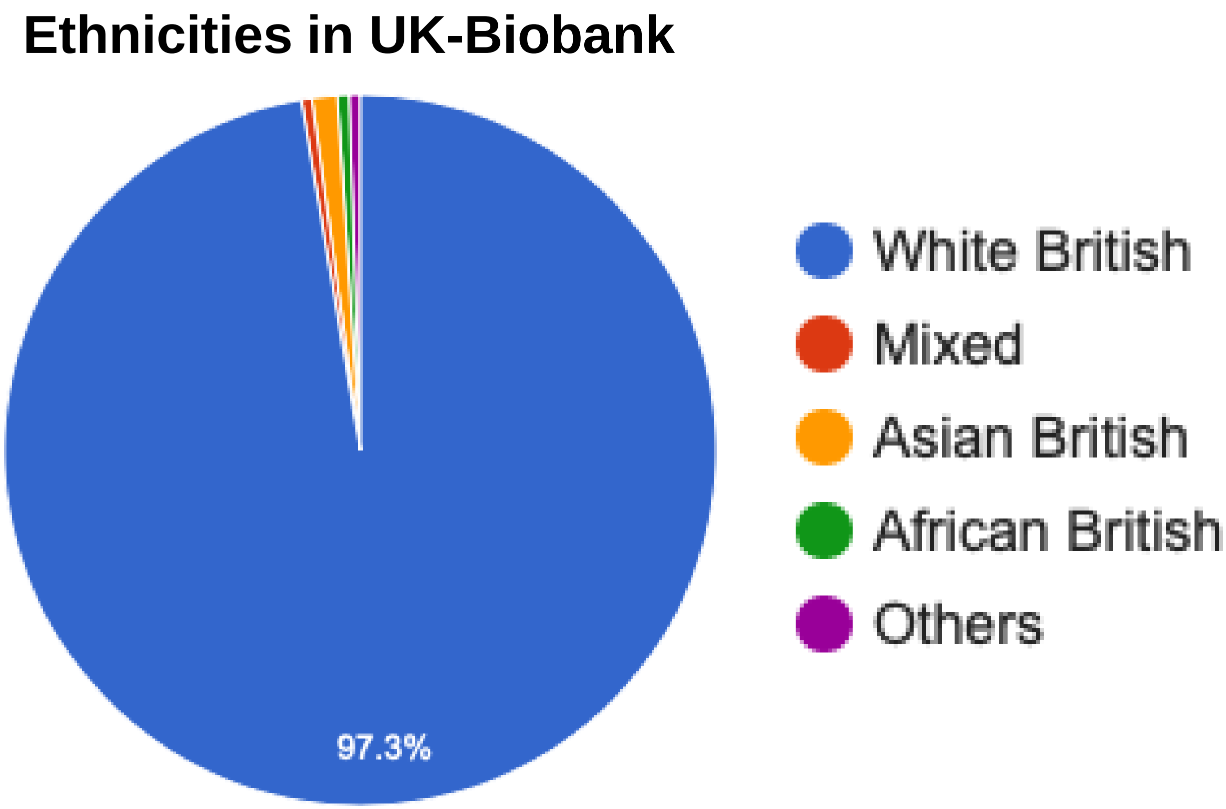
Predictive models of psychometric data: cross-dataset generalizability

Cross-dataset generalizability of fluid cognition



Predictive models of psychometric data

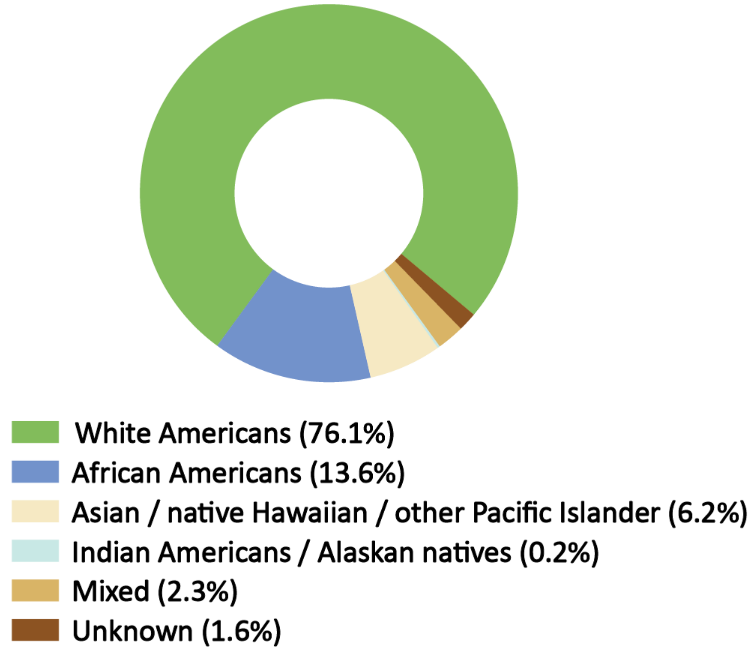
Underrepresented populations in neuroimaging datasets



Predictive models of psychometric data: biases in population minority

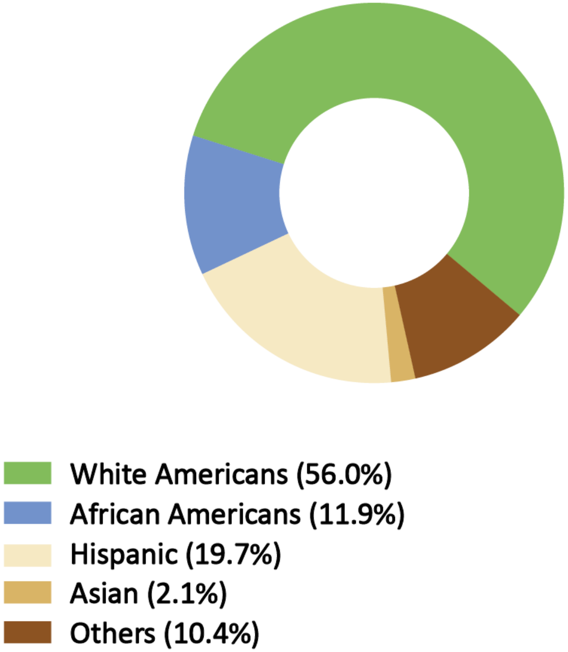
Human Connectome Project (HCP)

- N = 948; 22-37years
- 58 behavioral measures
- #WA = 721, #AA = 129



Adolescent Brain Cognitive Development (ABCD)

- N = 5351; 9-11years
- 36 behavioral measures
- #WA = 2997, #AA = 642



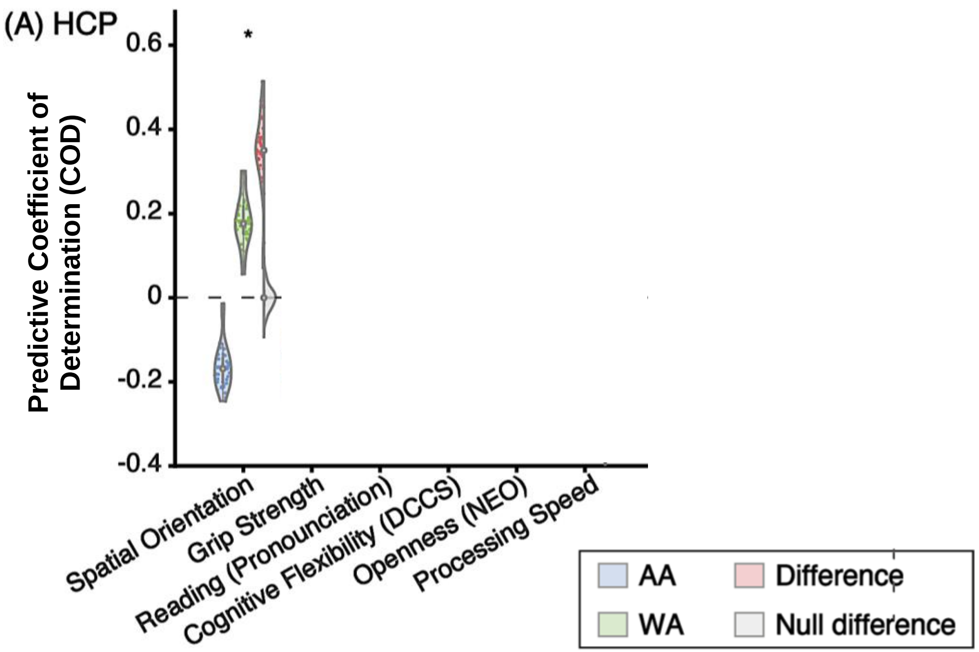
Li,…, & Genon, 2022, Science Advances

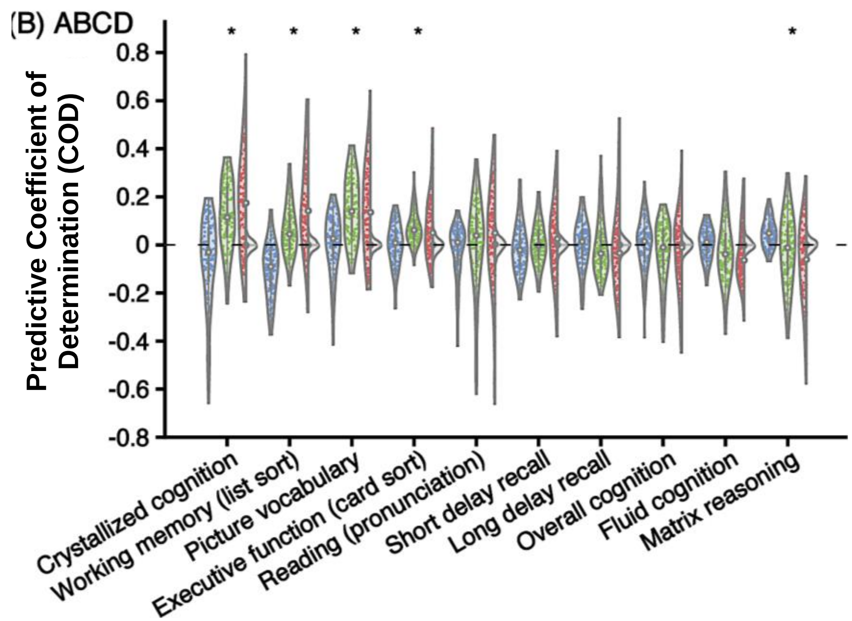
Predictive models of psychometric data: biases in population minority

LARGER PREDICTION ERROR IN AFRICAN AMERICANS THAN MATCHED WHITE AMERICANS

Human Connectome Project (HCP)

Adolescent Brain Cognitive Development (ABCD)





Only predictable behavioral measures are shown here.

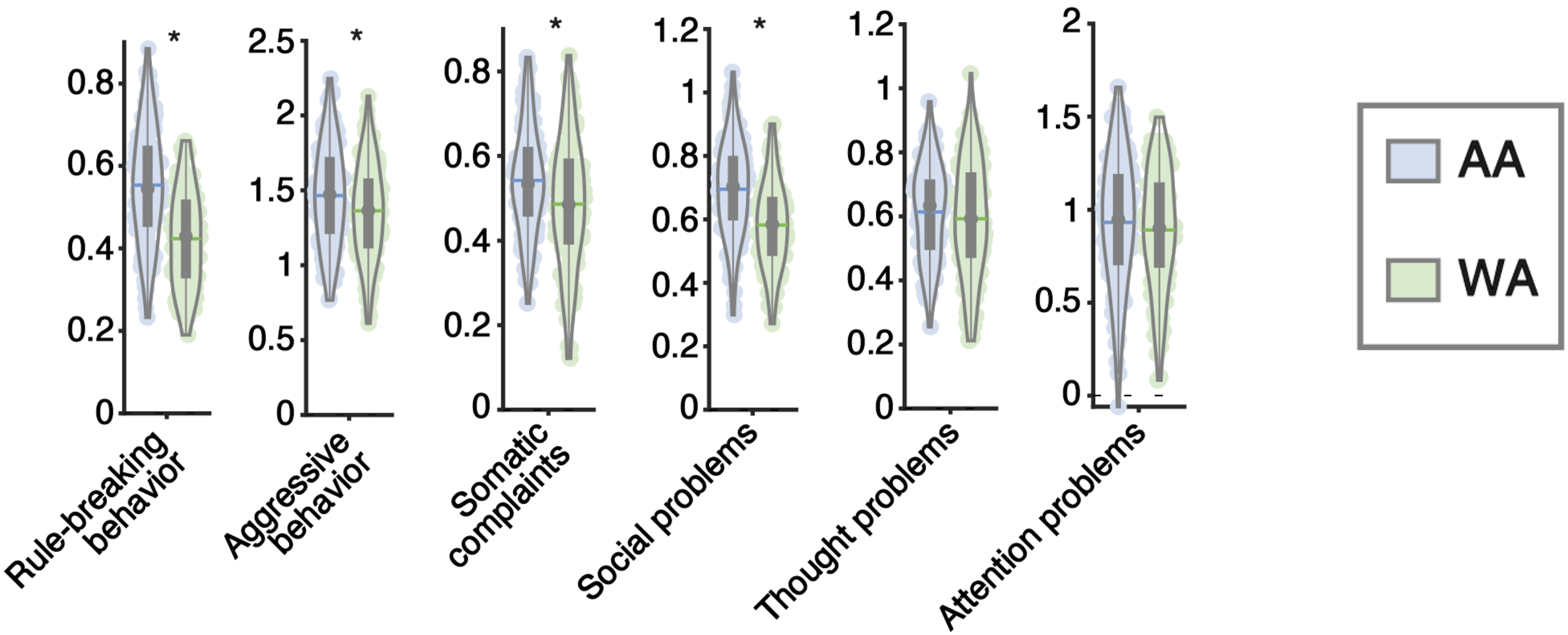
Similar pattern by looking into all behavioral measures, or regressing different confounds, or modelling with a different algorithm.

Li,…, & Genon, 2022, Science Advances

Predictive models of psychometric data: biases in population minority

DIRECTION OF PREDICTION ERROR & POTENTIAL CONSEQUENCES

Predicted – observed behavioral scores



ABCD data - Achenbach Child Behavior Checklist

Li,…, & Genon, 2022, Science Advances

Predictive models of psychometric data: biases in population minority

EFFECTS OF TRAINING POPULATION

ABCD dataset

Compare 3 types of models, trained on:

a. AA only
b. WA only (same sample size as AA)
c. Half AA, half WA (combination of *a.* & *b.*)

Li,…, & Genon, 2022, Science Advances

Predictive models of psychometric data: biases in population minority

EFFECTS OF TRAINING POPULATION

ABCD dataset

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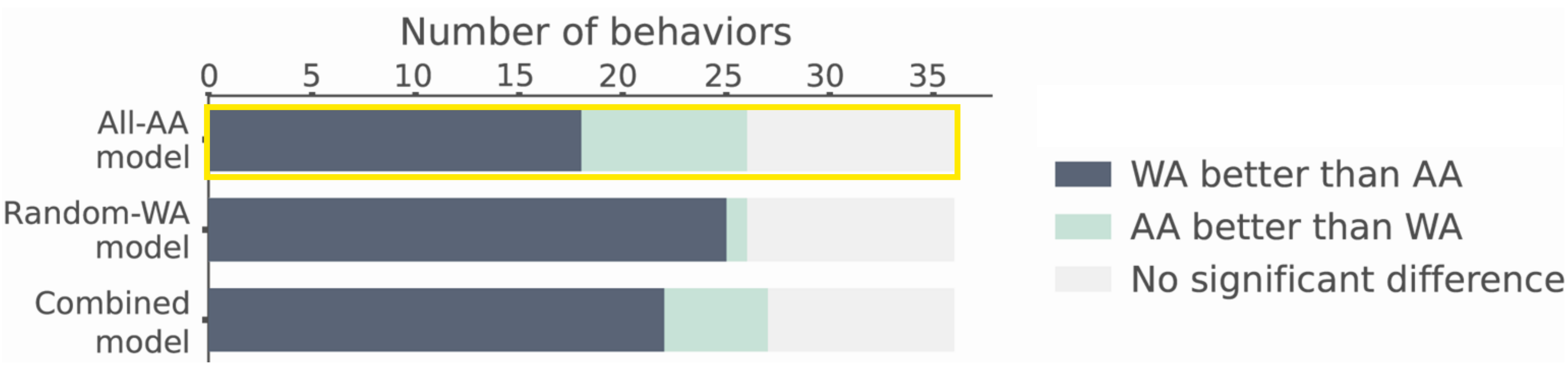

Li,…, & Genon, 2022, Science Advances

- Training only on AA helped to reduce prediction bias against AA

- Prediction accuracy was still in favor of WA

  - Brain Imaging side:
    preprocessing strategies/parameters were optimized on white-dominated samples (e.g. brain templates, functional atlases)

  - Behavioral side:
    standard measures (or tools) suitable / valid for minorities?

- Call for more data collection from non-European-descendant / non-white populations, to learn better representation of minor populations.
  Consider even more minor groups (e.g. native Americans in the US population)
  Africans in Africa ≠ African Americans

- Subgroups in the currently defined ethnic/racial categories (e.g. Chinese vs Indian, both as "Asian")
  Be aware of similar issue in other countries (e.g. Chinese datasets dominated by Han)
  Other minority groups, e.g. lower social class

- Assess & promote fairness of future artificial intelligence applications across populations.

JÜLICH Forschungszentrum

Thank you

HEINRICH HEINE UNIVERSITÄT DÜSSELDORF
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Mitglied der Helmholtz-Gemeinschaft

Helmholtz Portfolio Theme SMHB Supercomputing and Modeling for the Human Brain

HBP

DFG