



Longitudinal Analysis of Gray-white Matter Contrast in Healthy Adults: A Uk Biobank Study

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Introduction

Regional analyses of healthy adult brain aging remain limited despite well-characterized patterns in neurodegenerative disease, such as Alzheimer's disease (AD). As brain regions are tied to specific cognitive functions, like the relationship between the hippocampus and memory, regional insights for healthy adults allow forecasts into how an individual's cognition is likely to progress with age in a widely applicable manner. To identify specific patterns of regional progression, individuals were categorized into two extreme groups: **"Contrast Decliners"** and **"Contrast Gainers"**. Jenrich's test assessed the similarity of gray-white matter contrast change (GWC) correlations between brain regions. Further analysis investigated correlations between gray-white matter contrast, demographic data, cognitive performance exams, and neural connectivity regions using resting-state MRI (rsfMRI) neural networks.

Data

UK Biobank Database

- UK Biobank participants with available demographic and MRI data were included ($N = 402$).
- Freesurfer 6.0 automatically parcellated and segmented T1-weighted volumes into Desikan-Killiany (DK) brain atlas regions.

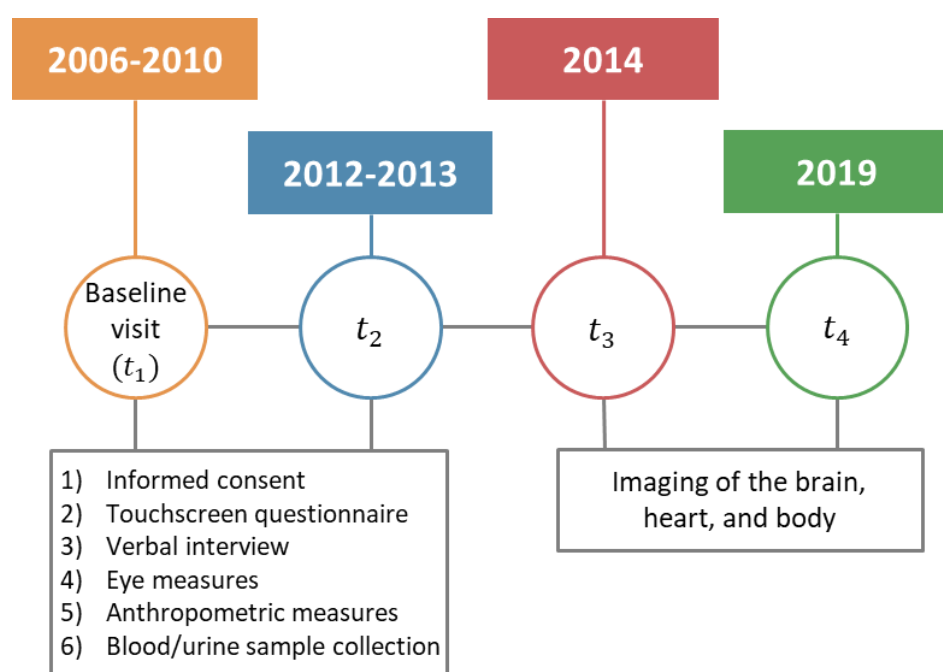


Fig 1. UK Biobank data collection timeline.

Brain Indices

- Gray/White Matter Contrast (GWC) is the difference in the intensity of gray and white matter for a particular brain region.
- We used the difference between matter/contrast between time points t_3 and t_4 .
- 65 brain regions of interest (ROIs) were used ($m = 65$) from DK atlas.
- 21 rsfMRI orthogonalized neural networks were derived.
- Fluid intelligence, reaction time, and the trail making test part A were used.

Mean Change in Gray-White Matter Contrast

Notations

For participant i :

O_i : Mean change in the gray-white matter contrast from t_3 to t_4 .

$C_{ij}^{t_3}$: Gray-white matter contrast value for brain region j at visit t_3 .

$C_{ij}^{t_4}$: Gray-white matter contrast value for brain region j at visit t_4 .

N : Total number of participants.

m : Total number of regions used from the brain atlas.

Mean Contrast Change

$$O_i = \frac{1}{m} \sum_{j=1}^m (C_{ij}^{t_4} - C_{ij}^{t_3}) \quad \forall i = 1, 2, \dots, N \quad (1)$$

Labeling

$$y_i = \begin{cases} \text{"Contrast Gainer"}, & O_i \geq D_8(O) \\ \text{"Contrast Decliner"}, & O_i \leq D_2(O) \end{cases} \quad \forall i = 1, 2, \dots, N \quad (2)$$

Mean Change in Gray-White Matter Contrast (Cont'd)

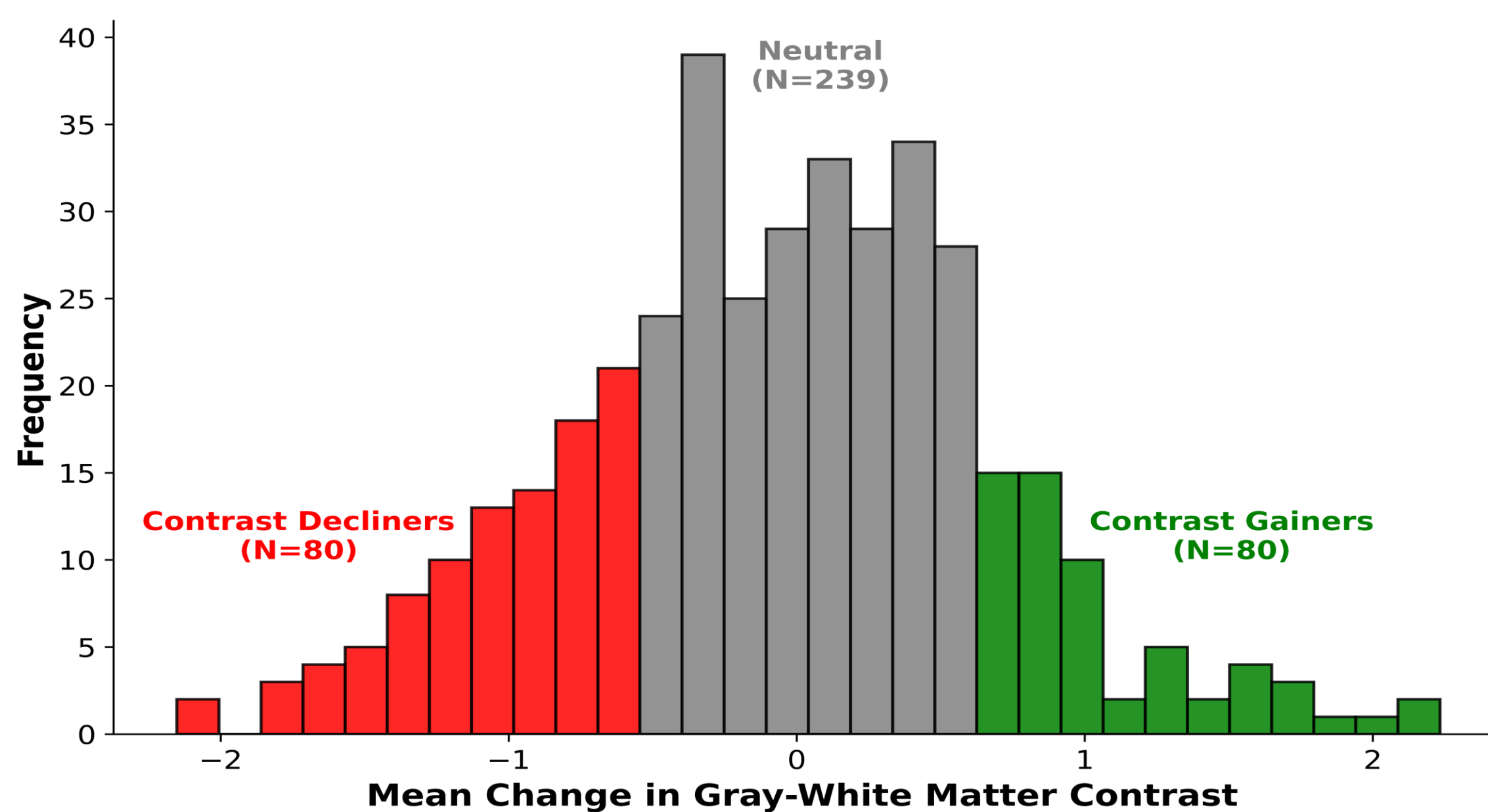


Fig 2. Histogram of Mean Overall Gray/White Matter Contrast Change.

Regional Patterns of GWC Change

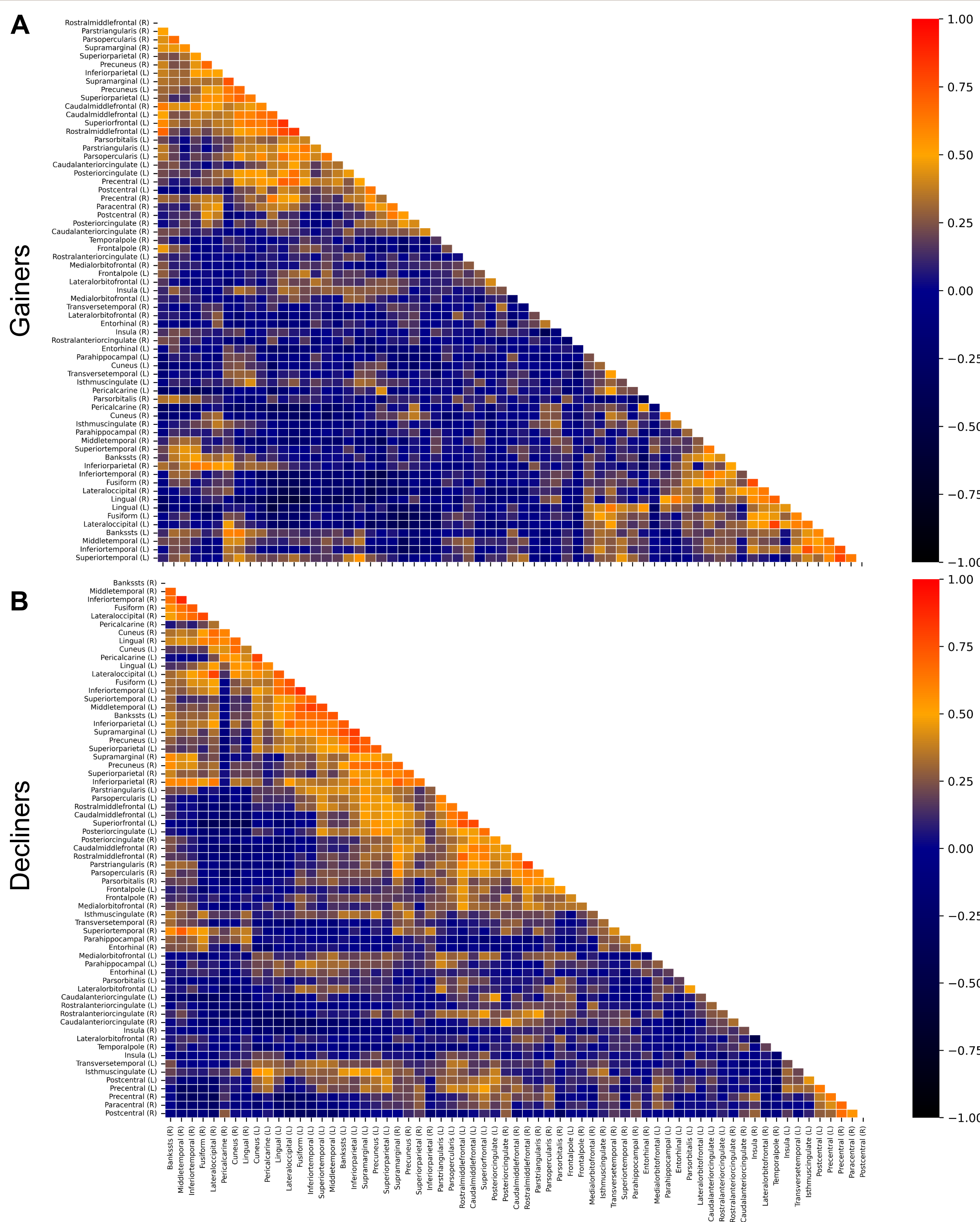


Fig 3. Heatmaps of Correlation between GWC Change of Different Brain Regions for Contrast Gainers (A) and Contrast Decliners (B).

Comparison of Correlation Patterns

Statistical Analysis of Correlation Matrices

- Used Jenrich's Test to compare the similarity of correlation matrices between the two groups:

$$\begin{cases} H_0: R_{Decliner} = R_{Gainers} \\ H_a: R_{Decliner} \neq R_{Gainers} \end{cases}$$

- Resulting p-value < 0.0001
- Conclusion: The patterns of GWC change is not the same between the two groups.

SHAP Values of a Logistic Regression Contrast Grouping:

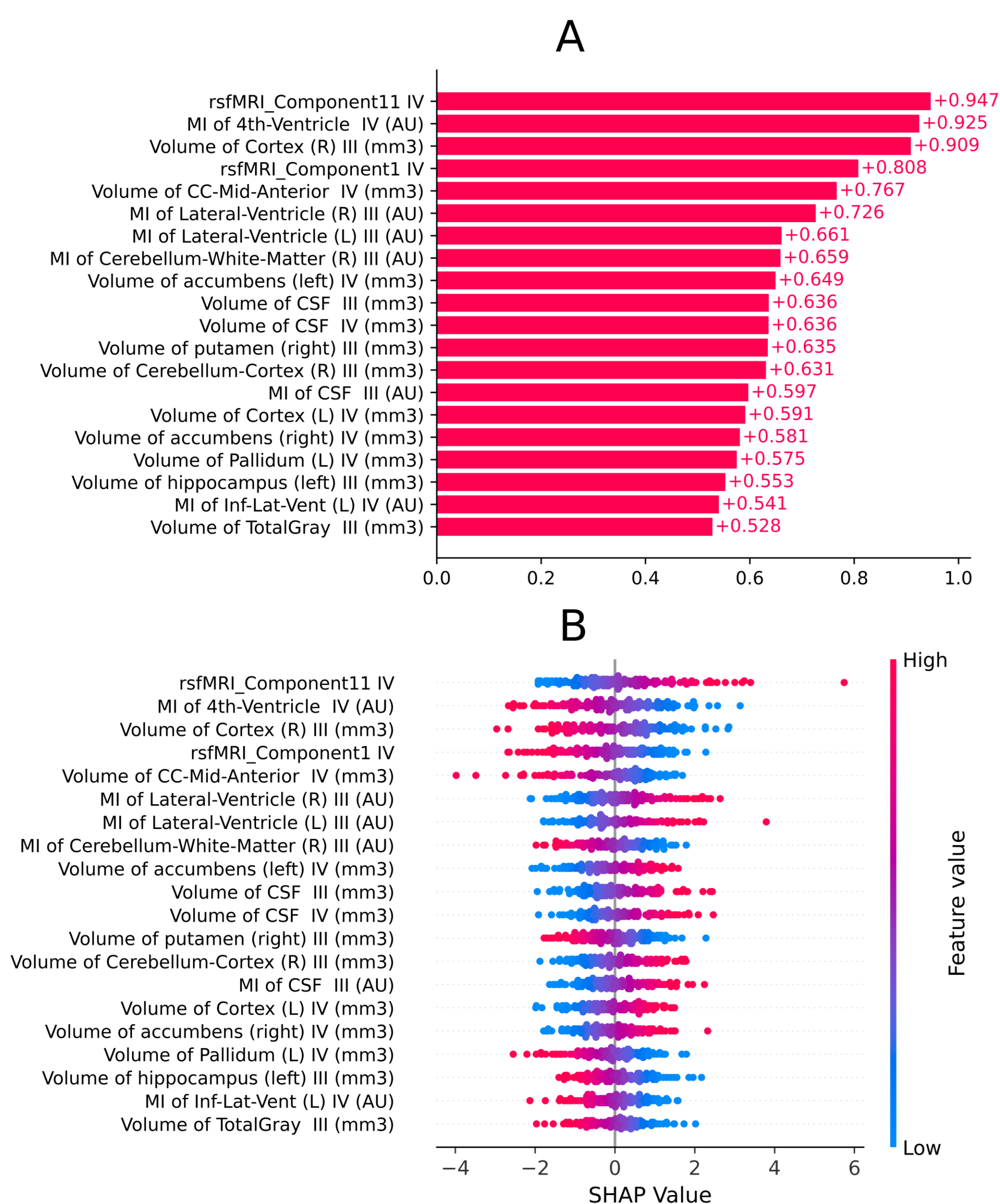


Fig 4. SHAP Values of Logistic Contrast Grouping Predictive Model using A) Bar Plot and B) Beeswarm plot

Summary & Next Steps

Summary

- Major contributors included an affective salience resting network (#11), the Default Mode Network (#1), and degree of whole brain atrophy
- The distinction between "Contrast Decliners" and "Contrast Gainers" was useful for establishing correlations between certain biomarkers and overall contrast change
- Clusters of highly correlated regions differed across "Contrast Decliners" and "Contrast Gainers" groups.

Next Steps

- Exploration of contrast groupings for younger age groups
- Designing studies to determine causal relationships between features and contrast grouping