MT898

Multivariate Analysis of Cortical Morphometry across Human Brain Development

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Introduction

- Here we propose a framework that leverages neurodevelopmental structural covariance, cross-sectionally and longitudinally, across measures of cortical thickness [CT], surface area [SA], local gyrification index [GI], and mean curvature [MC] that allows for interpretation of dimensions of anatomy using an implementation of nonnegative matrix factorization [1]. We further relate these patterns to age and sex, socioeconomic background, and cognitive ability to better understand inter-individual differences in cortical patterning and maturation.

Methods & Workflow

Data: we used data from the National Institute of Mental Health (NIMH) from youth aged 5-25 years; from two subsets of: 1) Cross-sectional: N=776, 357F, mean age:12.4 SD:3.4 | and 2) Longitudinal: N=183, 77F, 3 time-points over ~3yrs interval, mean age:11.2, SD:2.7).

A. Extracting vertex-wise morphometric features and slopes

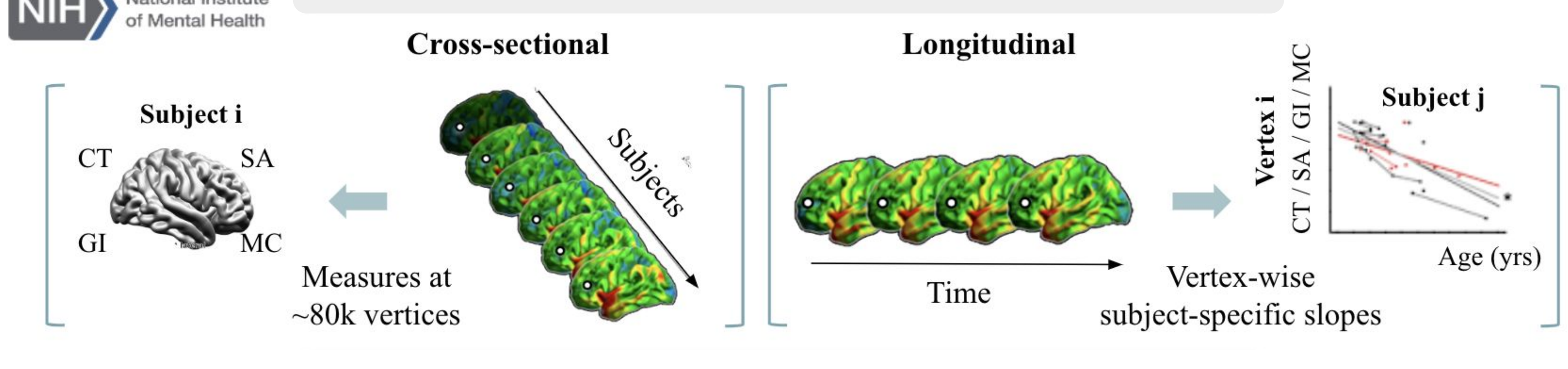

Fig1.A) Cortical metrics were extracted using CIVET pipeline [2]. Cortical vertices of all subjects were concatenated in columns to build an input morphometry matrix. For longitudinal analysis, age-related slopes were extracted, using linear mixed effect modeling, as a proxy of change.

B. Nonnegative Matrix Factorization (NMF)

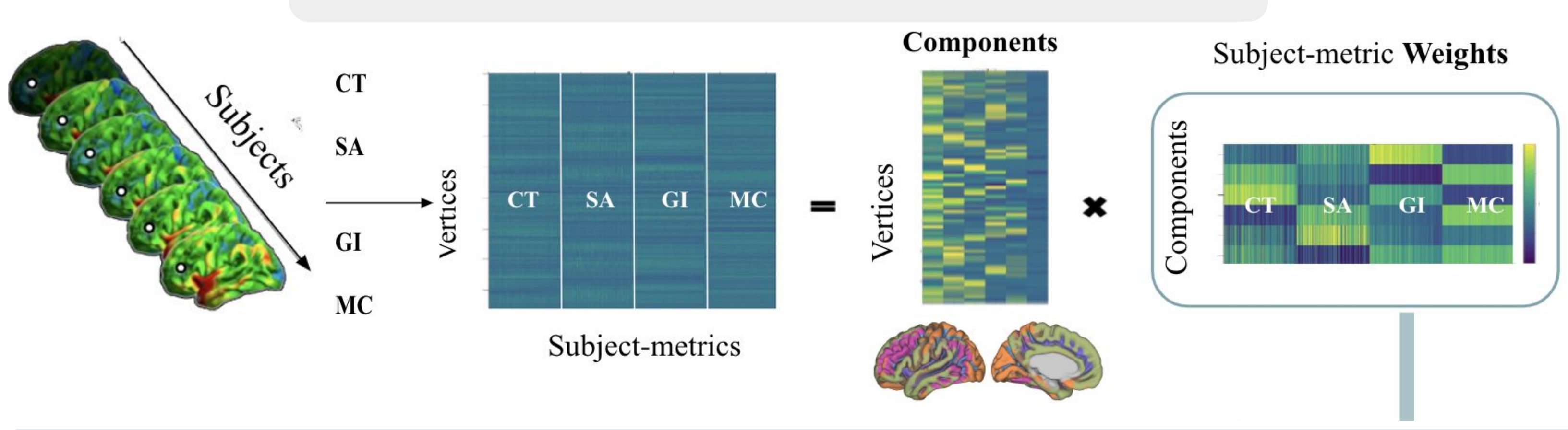

Fig1.B) NMF (orthogonal projective variant) decomposes the input matrix into a components matrix, representing spatially distinct components of covariance across subjects and metrics, and a weights matrix, , representing the extent to which each subjects' vertex loads onto the identified components.

B2. Longitudinal implementation of NMF

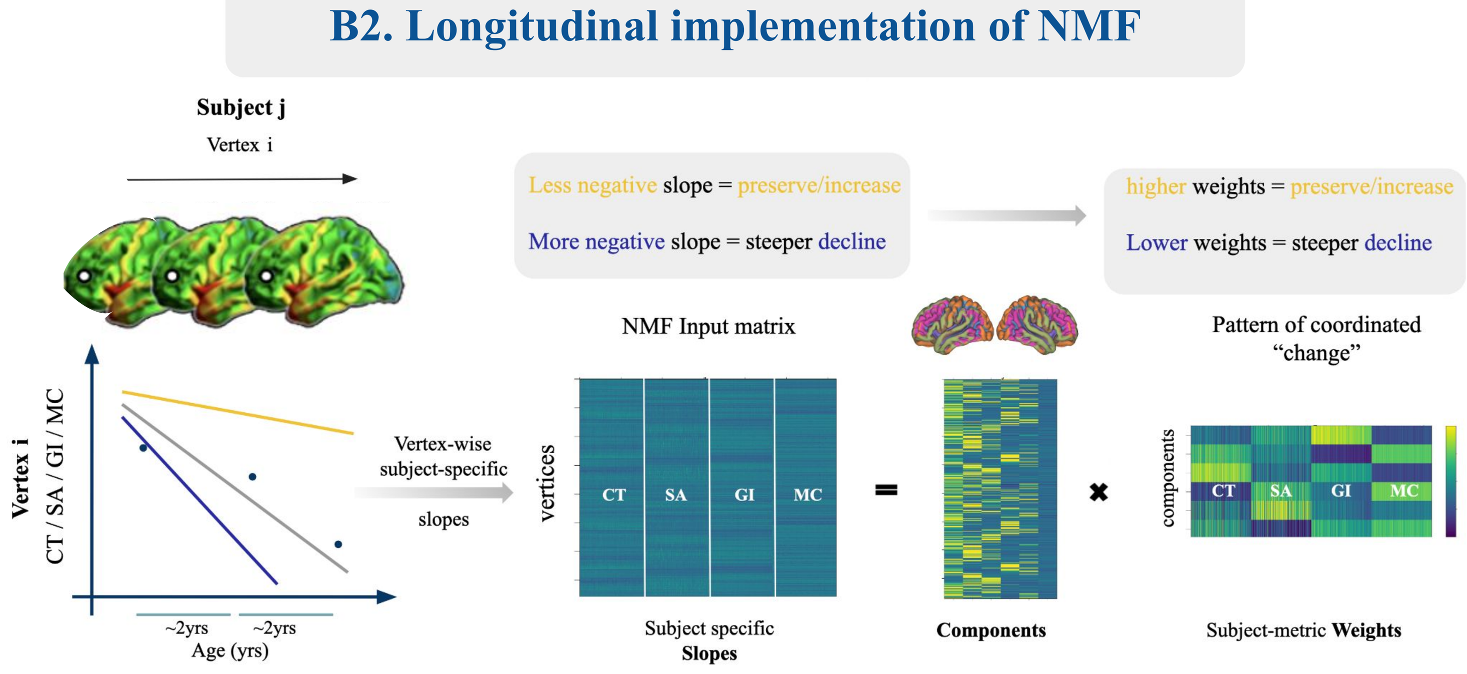

Fig1.B2) Longitudinal NMF implication and interpretation. While higher NMF weights indicate relative preservation of a metric, a lower weight indicates a steeper decline over time.

C. behavioural Partial Least Squares

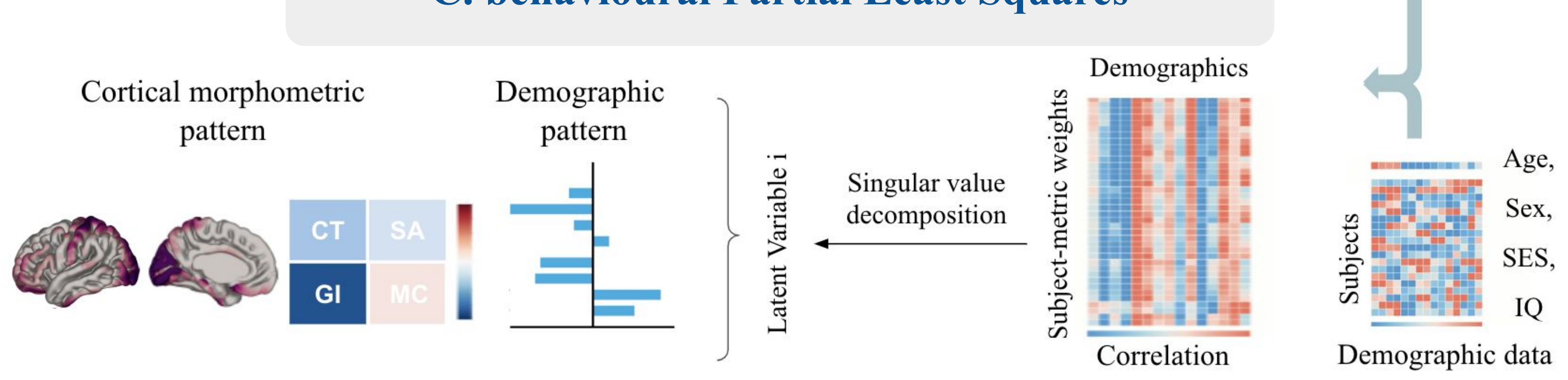

Fig1.C) PLS analysis [3] was used to identify patterns of association between variability in morphometry and interindividual differences in demographic data and cognitive ability through Latent Variables (LVs).

Conclusions

- We identified patterns of covariation across integrated measures of cortical morphometry and their synchronized rate of maturation in typically developing youth. The non-uniform relationship between these measures, underlys fundamental neurodevelopmental processes that covary together.
- The identified patterns were age-related, sexually differentiated, influenced by individual differences in socioeconomic factors, and associated with cognitive ability.
- This novel characterization of cortical morphometric features maturation provides an important understanding of the interdependencies between morphological measures, their coordinated development, and their relationship to critical factors impacting development.

Results

- **NMF identified spatially stable components of Morphometric Covariance**

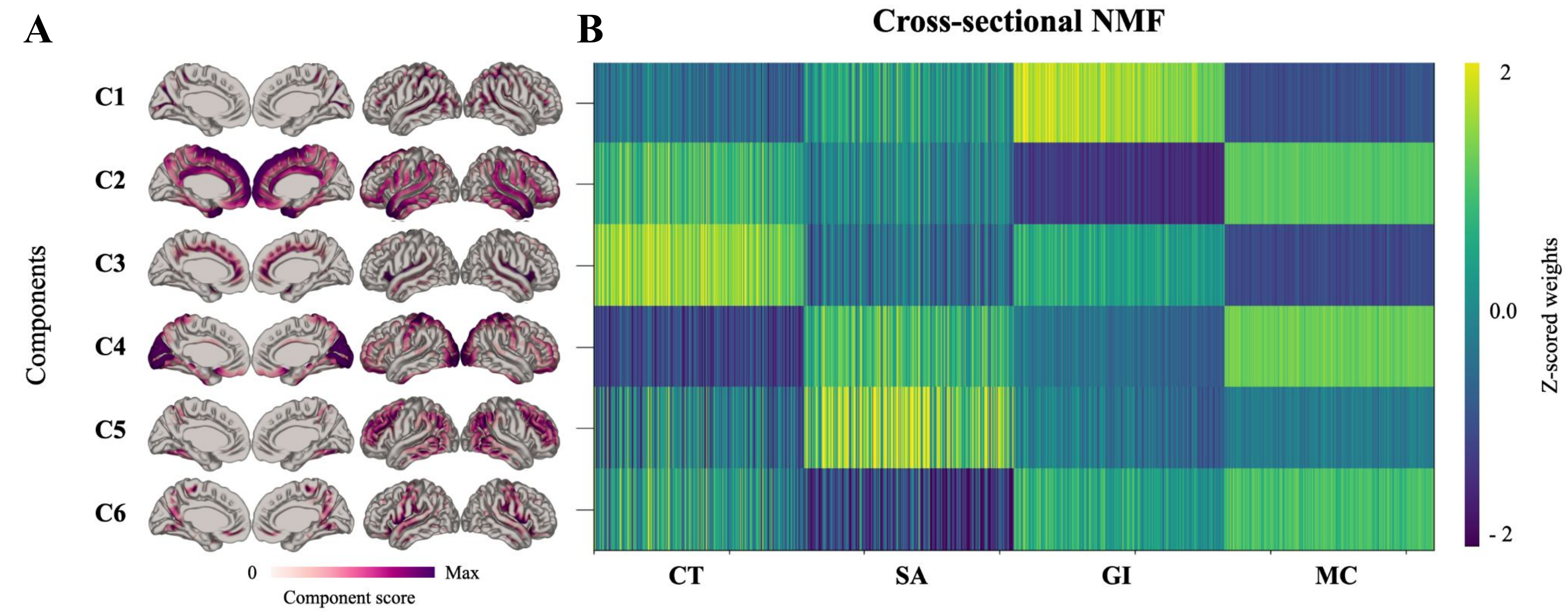

Figure 2. Cross-sectional NMF Results. A) Spatial cortical components of 6 component decomposition solutions (chosen by performing half-split stability analysis), and B) their corresponding weights. Subjects' weights matrix (z-scored within each row) shows each component's comparative morphometric pattern. The components and weight matrix together show the component-specific description with respect to multiple measures in each spatial component: i.e., component 2 (C2), is characterized by higher values of CT and MC, moderate variation in SA, and lower values of GI.

- **NMF identified spatially stable components of Morphometric synchronized rate of change**

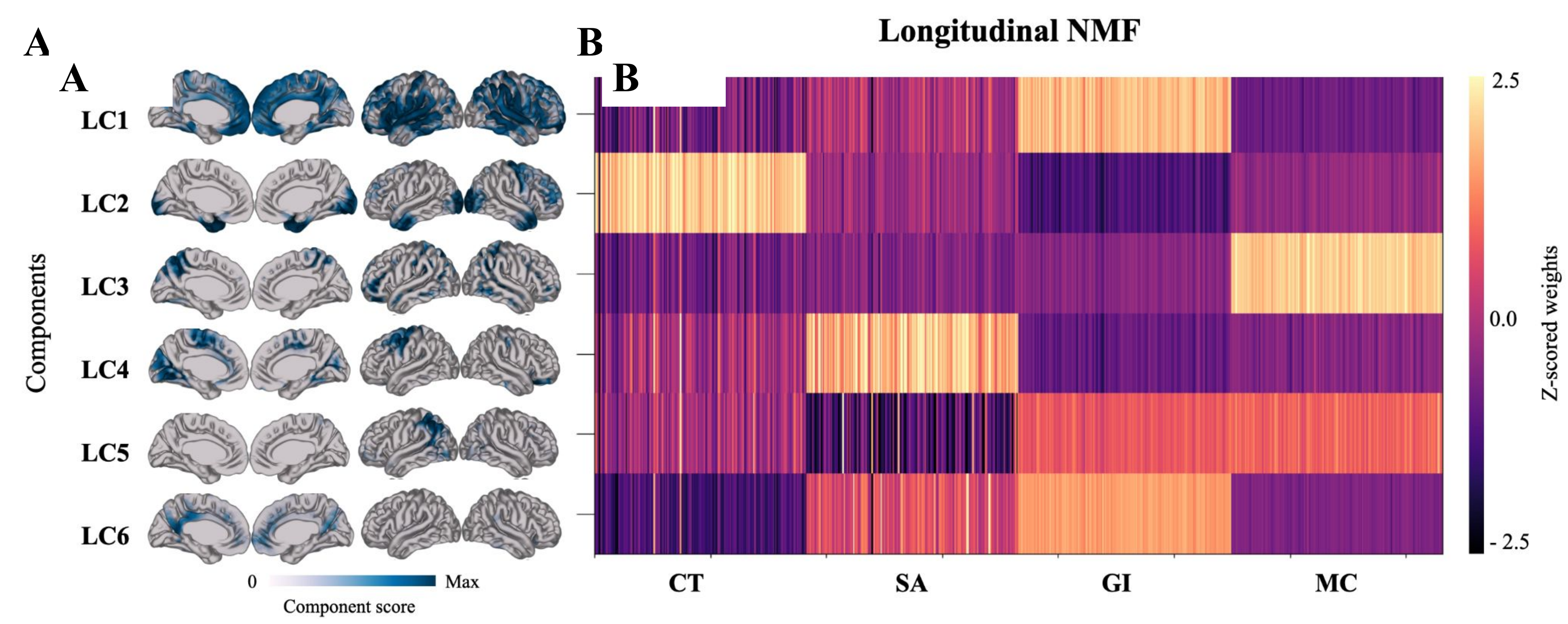

Figure 3. Longitudinal NMF Results. The components (A) and weight matrix (B) together show the component-specific description with respect to coordinated change of multiple measures in each spatial component. i.e., Longitudinal component 1 (LC1) describes a dominant decline of CT, and a moderate decline of MC and SA and a relative preservation of GI across much of the cortex.

- **Variability in cortical morphometry is influenced by variability in demographics and cognitive ability**

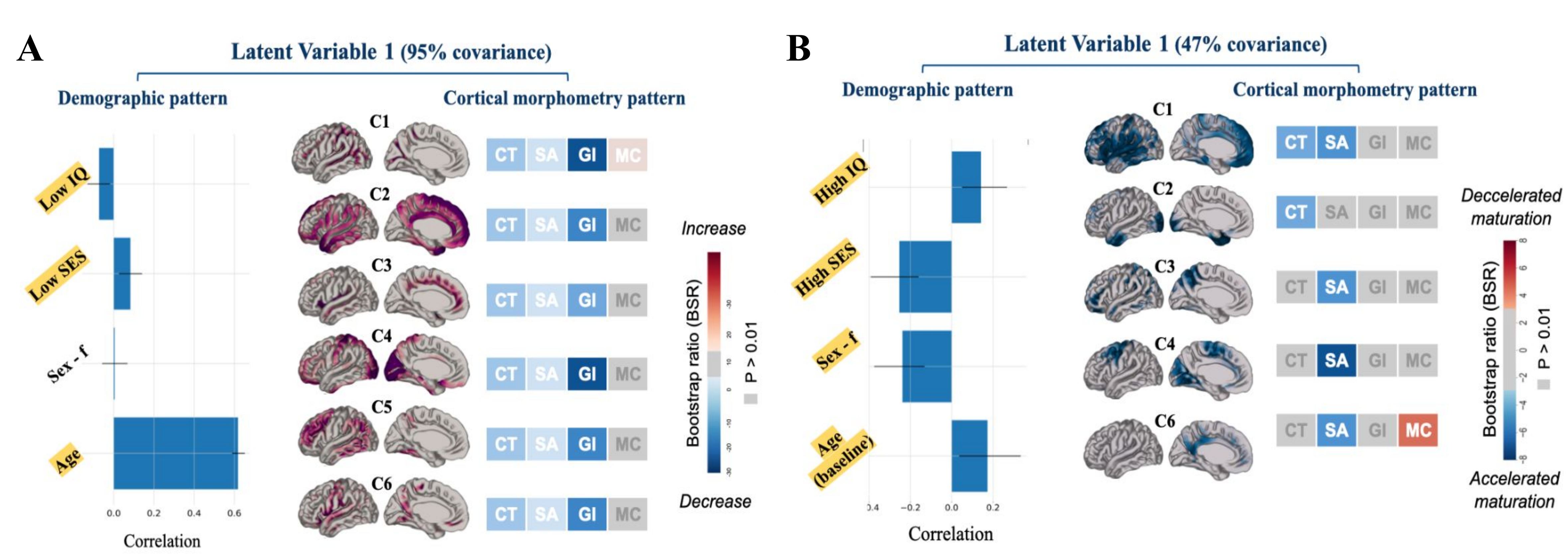

Fig 4. PLS Results. LVs relating **A)** morphometric variability (cross-sectional NMF results), and **B)** variability in coordinated cortical maturation (longitudinal NMF results; three LV, one is shown) to inter-individual differences. For each LV, cortical components are summarized with their morphometric profiles. For each significant morphometric feature contributing to the LV, the bootstrap ratios are displayed on the components morphometry profile. The Bar plot describes the contribution of demographic variables to the identified LV in which significant variables with a non-zero overlapping confidence interval are highlighted in yellow.

References

1- Patel et al, *Neuroimage,* 2020 | 2- Ad-Dabbagh et al, *Neuroimage,* 2006 | 3- Krishnan et al, *Neuroimage,* 2011