

Statistics and Data Science Seminar

Brain Regions Identified as Being Associated With Verbal Reasoning Through the Use of Imaging Regression via Internal Variation

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Abstract: Brain-imaging data have been increasingly used to understand intellectual disabilities. Despite significant progress in biomedical research, the mechanisms for most of the intellectual disabilities remain unknown. Finding the underlying neurological mechanisms has proved difficult, especially in children due to the rapid development of their brains. We investigate verbal reasoning, which is a reliable measure of an individual's general intellectual abilities, and develop a class of high-order imaging regression models to identify brain subregions which might be associated with this specific intellectual ability. A key novelty of our method is to take advantage of spatial brain structures, and specifically the piecewise smooth nature of most imaging coefficients in the form of high-order tensors. Our approach provides an effective and urgently needed method for identifying brain subregions potentially underlying certain intellectual disabilities. The idea behind our approach is a carefully constructed concept called internal variation (IV). The IV employs tensor decomposition and provides a computationally feasible substitution for total variation, which has been considered suitable to deal with similar problems but may not be scalable to high-order tensor regression. Before applying our method to analyze the real data, we conduct comprehensive simulation studies to demonstrate the validity of our method in imaging signal identification. Next, we present our results from the analysis of a dataset based on the Philadelphia Neurodevelopmental Cohort for which we preprocessed

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the data including reorienting, bias-field correcting, extracting, normalizing, and registering the magnetic resonance images from 978 individuals. Our analysis identified a subregion across the cingulate cortex and the corpus callosum as being associated with individuals' verbal reasoning ability, which, to the best of our knowledge, is a novel region that has not been reported in the literature. This finding is useful in further investigation of functional mechanisms for verbal reasoning.

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