A global perspective on the neural bases of intelligence

Maria Bringas Vega, Dr. Co Organizer
Cuban Neuroscience Center
La Habana, CUBA
Cuba

Pedro Valdes Sosa, Dr. Organizer
University of Electronic Sciences and Technology of China UESTC
Chengdu
China

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Symposium

All current global brain initiatives are gathering biological data concurrently with psychometric measures of intelligence. As mentioned above such studies crucially need diversification in terms of domains of intelligence studied, geographical representativeness and use of different imaging modalities. This symposium will provide an introduction to network neuroscience studies of intelligence that will be illustrated by studies from Cuba, China, and Canada as examples of the desired diversification. This considerations will aid in the improvement of new projects as well as the improvement of ongoing ones, with an emphasis of standardization and homogenization.

Objective

- How to design and analyze concordant validation between neuroimaging modalities
- How to extend the results from high income countries to other settings
-How to include more cognitive domains into studies of intelligence

Target Audience

Neuroimagers, psychologists, cognitive neuroscientists, neurologists and psychiatrists who wish to understand the limitations of current studies and how to circumvent them from countries in all economic settings.

Presentations

Network Neuroscience Theory of Human Intelligence

An enduring aim of research in the psychological and brain sciences is to understand the nature of individual differences in human intelligence, examining the stunning breadth and diversity of intellectual abilities and the remarkable neurobiological mechanisms from which they arise. In this presentation, I survey recent neuroscience evidence to elucidate how general intelligence (g) emerges from individual differences in the network architecture of the human brain. The reviewed findings motivate new insights about how network topology and dynamics account for individual differences in g, represented by the Network Neuroscience Theory. According to this

framework, g emerges from the small-world topology of brain networks and the dynamic reorganization of its community structure in the service of system-wide flexibility and adaptation. Rather than attribute individual differences in general intelligence to a single brain region, network, or the overlap among specific networks, the proposed theory instead suggests that general intelligence depends on the dynamic reorganization of brain networks – modifying their topology and community structure in the service of system-wide flexibility and adaptation. This framework sets the stage for new approaches to understanding individual differences in general intelligence, examining the global network topology and dynamics of the human brain – from the level of molecules and synapses to neural circuits, networks, and systems. By investigating the foundations of general intelligence in global network dynamics, the burgeoning field of network neuroscience will continue to advance our understanding of the cognitive and neural architecture from which the remarkable constellation of individual differences in human intelligence emerge.

Presenter

Aron Barbey, Dr., University of Illinois at Urbana-Champaign Urbana, IL
United States

Brain activity markers of intelligence in children: from intellectual disability to giftedness

Brain activity show maturational patterns of neurodevelopment. Recent researches suggest EEG brain activity is a marker of intellectual development, from intellectual disability to giftedness. While some markers are correlated to the continuum of intellectual quotient, others are relevant to either intellectual disability or giftedness. More precisely, while several intellectual disability syndromes including Fragile X Syndrome, Down Syndrome, Syngap1 mutation, copy number variant deletions and duplications, and idiopathic low IQ children show abnormal amplitude in the signal, gifted individuals show advantages in latencies of processing. Developmental data from resting-state and tasks evoked activity will be presented, with a particular focus on our results suggesting habituation and anticipation paradigms are particularly sensitive to cognitive development in infants.

Presenter

Sarah Lippé, Université de Montréal Montreal, Quebec
Canada

Gender Differences in Connectome-based Predictions of Individualized Intelligence Quotient and Sub-domain Scores

Scores on intelligence tests are strongly predictive of various important life outcomes. However, the gender discrepancy on intelligence quotient (IQ) prediction using brain imaging variables has not been studied. To this aim, we predicted individual IQ scores for males and females separately using whole-brain functional connectivity (FC). Robust predictions of intellectual capabilities were achieved across three independent data sets (680 subjects) and two intelligence measurements (IQ and fluid intelligence) using the same model within each gender. Interestingly, we found that intelligence of males and females were underpinned by different neurobiological correlates, which are consistent with their respective superiority in cognitive domains (visuospatial vs verbal ability). In addition, the identified FC patterns are uniquely predictive on IQ and its sub-domain scores only within the same gender but neither for the opposite gender nor on the IQ-irrelevant measures such as temperament

traits. Moreover, females exhibit significantly higher IQ predictability than males in the discovery cohort. This finding facilitated our understanding of the biological basis of intelligence by demonstrating that intelligence is underpinned by a variety of complex neural mechanisms that engage an interacting network of regions —particularly prefrontal–parietal and basal ganglia—whereas the network pattern differs between genders

Presenter

Jing Sui, PhD, Brainnetome Center and National Laboratory of Pattern Recognition, Chinese Academy of Sciences
Beijing, Beijing
China

Crystallized and fluid intelligence are predicted by microstructure of specific white-matter tracts

The relation of neuroimaging with intelligence measures is usually based on simple correlations. While useful in exploratory analyses, they do not provide information about causal pathways that require more complex multivariate analyses. Specific statistical methods for causal analysis must be used. On the other hand, there is an inconsistent exploration of cognitive domains. Some studies rely on specially designed cognitive scales, then summarized to reflect a single latent variable. Even when widely available scales, such as the Wechsler Adult Intelligence Scale (WAIS), are used, they are often also reduced to a single score, such as the general or “g” factor, or “fluid intelligence” using different procedures. It is better to explore the individual indices of the WAIS, those related to performance intelligence: Perceptual Organization (PO) and Processing Speed (PS), as well as verbal Intelligence: Verbal Comprehension (VC) and Working Memory (WM). Here, the relation between mean tract-based fractional anisotropy (mTBFA) and intelligence indices was explored. Deterministic tractography was performed using a regions of interest approach for 10 white-matter fascicles along which the mTBFA was calculated. The study sample included 83 healthy individuals from the second wave of the Cuban Human Brain Mapping Project, whose WAIS-III intelligence quotients and indices were obtained. Inspired by the “Watershed model” of intelligence, we employed a regularized hierarchical Multiple Indicator, Multiple Causes model (MIMIC), to assess the association of mTBFA with intelligence scores, as mediated by latent variables summarizing the indices. Regularized MIMIC, used due to the limited sample size, selected relevant mTBFA by means of an elastic net penalty and achieved good fits to the data. Two latent variables were necessary to describe the indices: Fluid intelligence (Perceptual Organization and Processing Speed indices) and Crystallized Intelligence (Verbal Comprehension and Working Memory indices). Regularized MIMIC revealed effects of the forceps minor tract on crystallized intelligence and of the superior longitudinal fasciculus on fluid intelligence. The model also detected the significant effect of age on both latent variables.

Presenter

Maria Bringas Vega, Dr., Cuban Neuroscience Center La Habana, CUBA
Cuba