Functional Neuroimaging of General Fluid Intelligencein Prodigies

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Understanding how and why people differ is a fundamental, if distant, goal of research efforts to bridge psychological and biological levels of analysis. General fluid intelligence (gF) is a major dimension of individual differences and refers to reasoning and novel problemsolving ability. A conceptual integration of evidence from cognitive (behavioral) and anatomical studies suggeststhat gF should covary with both task performance and neural activity in specific brain systems when specific cognitive demands are present, with the neural activity mediating the relation between gF and performance. Direct investigation of this possibility will be a critical step toward a mechanistic model of human intelligence. In turn, a mechanistic model might suggest ways to enhance gF through targeted behavioral or neurobiological interventions.

We formed two different groups as subjects based on their scholarly attainments. Each group consists of 20 volunteers(aged 16-17 years, right-handed males) from the National Gifted School and a local high school respectively. To test whether individual differences in general intelligence are mediated at a neural level, we first assessed intellectual characteristics in 40 subjects using standard intelligence tests (Raven's Advanced Progressive Matrices, Wechsler Adult Intelligence Scale, Torrance Tests of Creative Thinking) administered outside of the MR scanner. We then used functional magnetic resonance imaging (fMRI) to measure task-related brain activity as participants performed three different kinds of computerized reasoning tasks that were intended to activate the relevant neural systems.

To examine the difference of neural activity according to discrepancy in general intelligence, we compared the brain activity of both extreme groups (each, n=10) of the participants based on the standard intelligence

test scores. In contrast to the common expectation, there was no significant difference of brain region involved in high-g tasks between both groups. Random effect analysis exhibited that lateral prefrontal, anterior cingulate and parietal cortex are associated with gF. Despite very different task contents in the three high-g-low-g contrasts, recruitment of multiple regions is markedly similar in each case. However, on the task with high gF correlations, the prodigy group, (intelligence rank: >99%) showed higher task-related neural activity in several brain regions. These results suggest that the relationship between gF and brain activity should be stronger under high-g conditions than low-g conditions.