Multiple-demand systems contribute to math academic performance during childhood and adolescence

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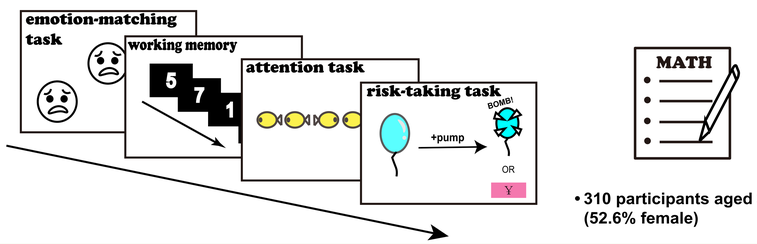
Introduction

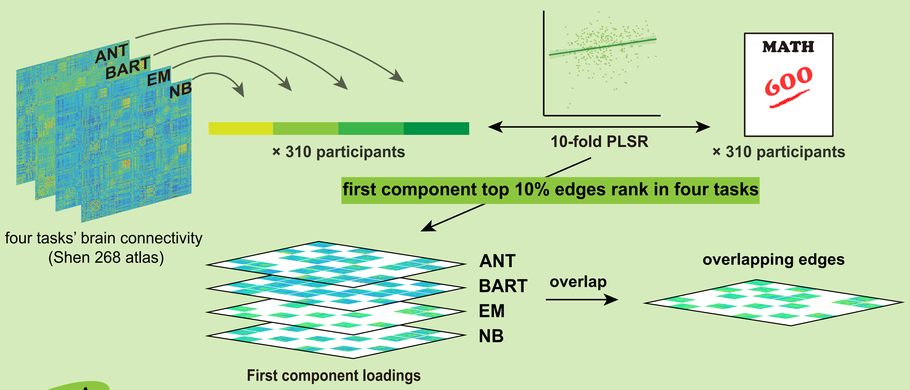
1. **Mathematics** is a form of human high-order cognition, associated with multiple cognitive factors, including executive functions and fluid intelligence.
2. **Multiple-demand(MD) system** is a basic brain network that is activated across a range of cognitive tasks and is considered a potential neural mechanism underlying executive functions and fluid intelligence.
3. However, there is currently no solid evidence elucidating the relationship between mathematical academic performance and the multiple-demand system.

Analysis1: static analysis

Multiple MRI tasks and test

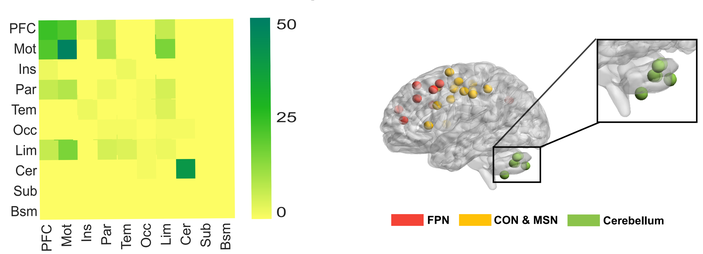


• 310 participants aged 6 to 12 (52.6% female)

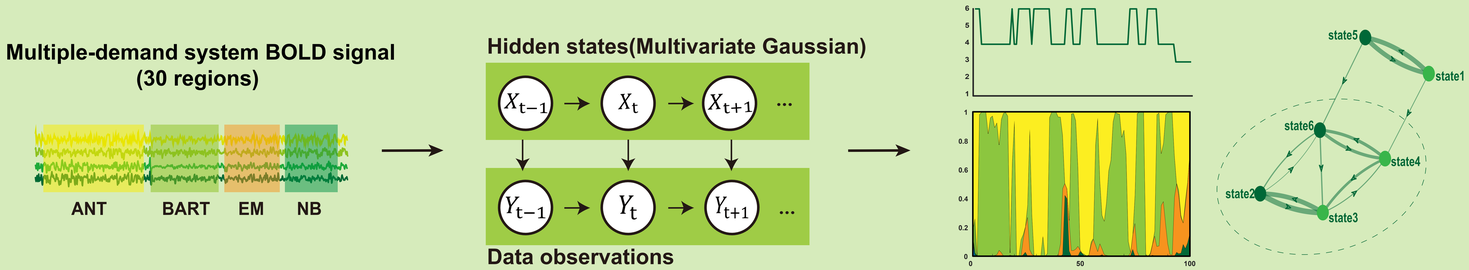


results1

Multiple-demand system across multiple tasks related math performance

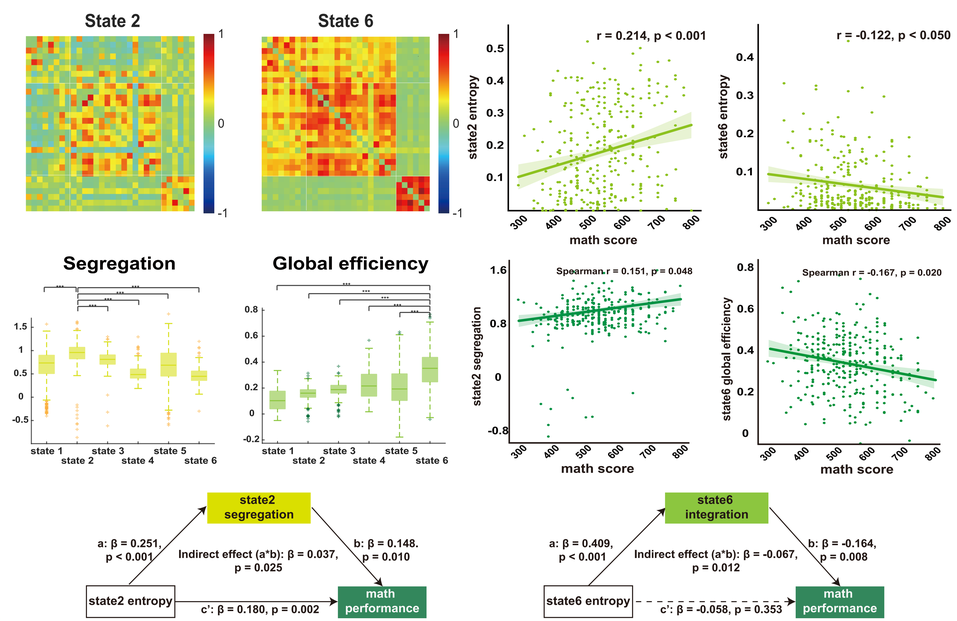


Analysis2: dynamic analysis



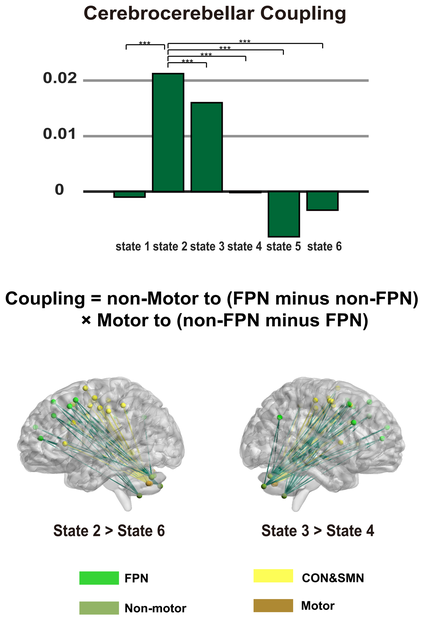
results2

The spatial features of the multiple-demand system in the cerebral cortex mediate the link between brain state's neural entropy and math performance



results3

Cerebro-cerebellar coupling in math-related brain states



Conclusions

1. Mathematical academic performance is associated with the multiple-demand system during children and adolescence.
2. During basic cognitive tasks, the multiple-demand system in participants with higher math performance tends to remain in segregated states for the majority of the time, exhibiting greater temporal flexibility as well.
3. The spatial characteristics of the multiple-demand system in the cerebral cortex mediate the relationship between the temporal characteristics of several states and mathematics performance.
4. Cerebrocerebellar coupling might play a significant role in math cognition.

References
The multiple-demand (MD) system of the primate brain: mental programs for intelligent behaviour. Duncan,. 2010. Direct and indirect influences of executive functions on mathematics achievement. Crag,. 2017. Relations between measures of Cattell-Horn-Carroll (CHC) cognitive abilities and mathematics achievement across the school-age years. Floyd,. 2003. Entropy, complexity, and maturity in children's neural responses to naturalistic video lessons. Amalric,. 2023.

This study has been supported by the Scientific and Technological Innovation (STI) 2030-Major Projects 2021ZD0200500, the National Natural Science Foundation of China (32130045, 32361163611, 82021004, 62077010)

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