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Default mode network compensates for immature brain executive function network during childhood

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Introduction

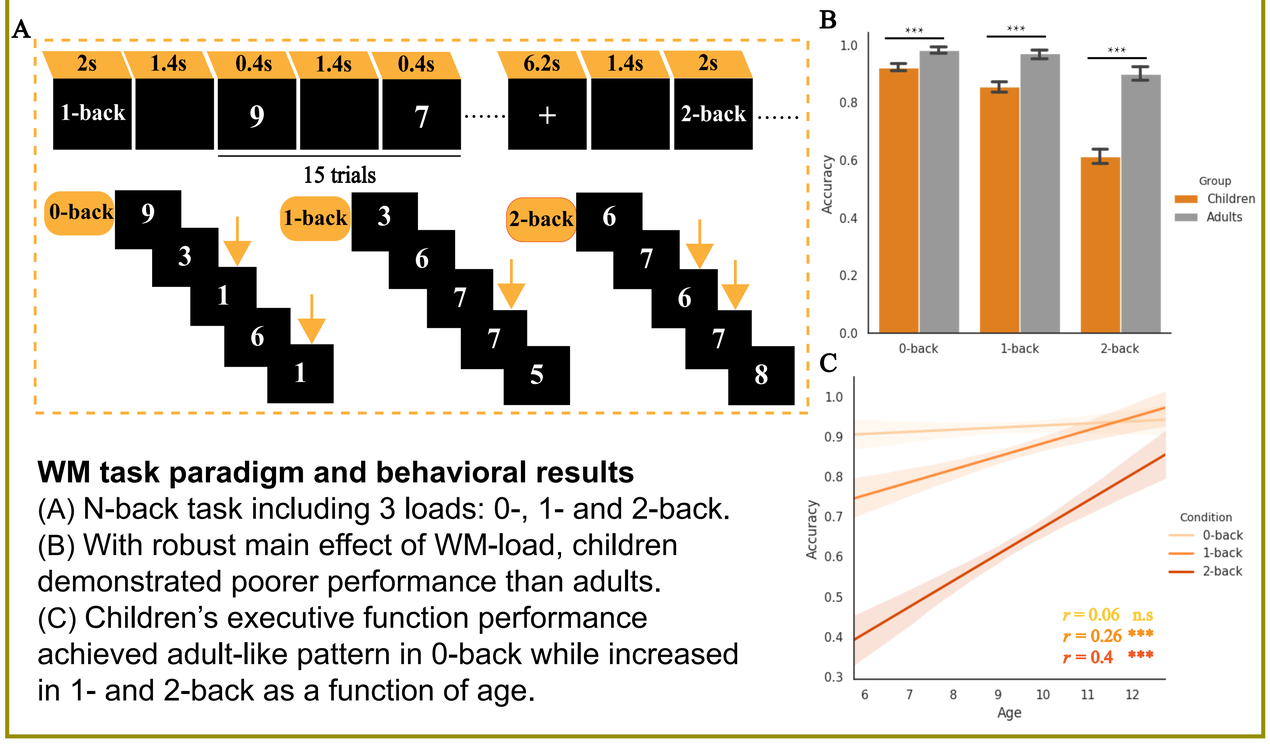
- From childhood to adulthood, the maturation of brain functional networks underlies the improvement of cognitive abilities. Working memory (WM), as a foundation of high order cognitive functions undergoes a protracted development[1].
- Studies have found that the activated frontal parietal network (FPN)[2] and deactivated default mode network (DMN)[3] are responsible for WM performance[4]. How these two networks collaborate to support WM performance from childhood to adulthood remains unclear.
- Here we conducted a resting and WM task fMRI study in a large sample of healthy children and adults to investigate the development trajectories of these two networks and how they interact to support the executive function development.

Methods & Behavioral Results

Participants

- 253 children (6-12 years old) and 93 young adults (18 to 28 years old).

Fig. 1

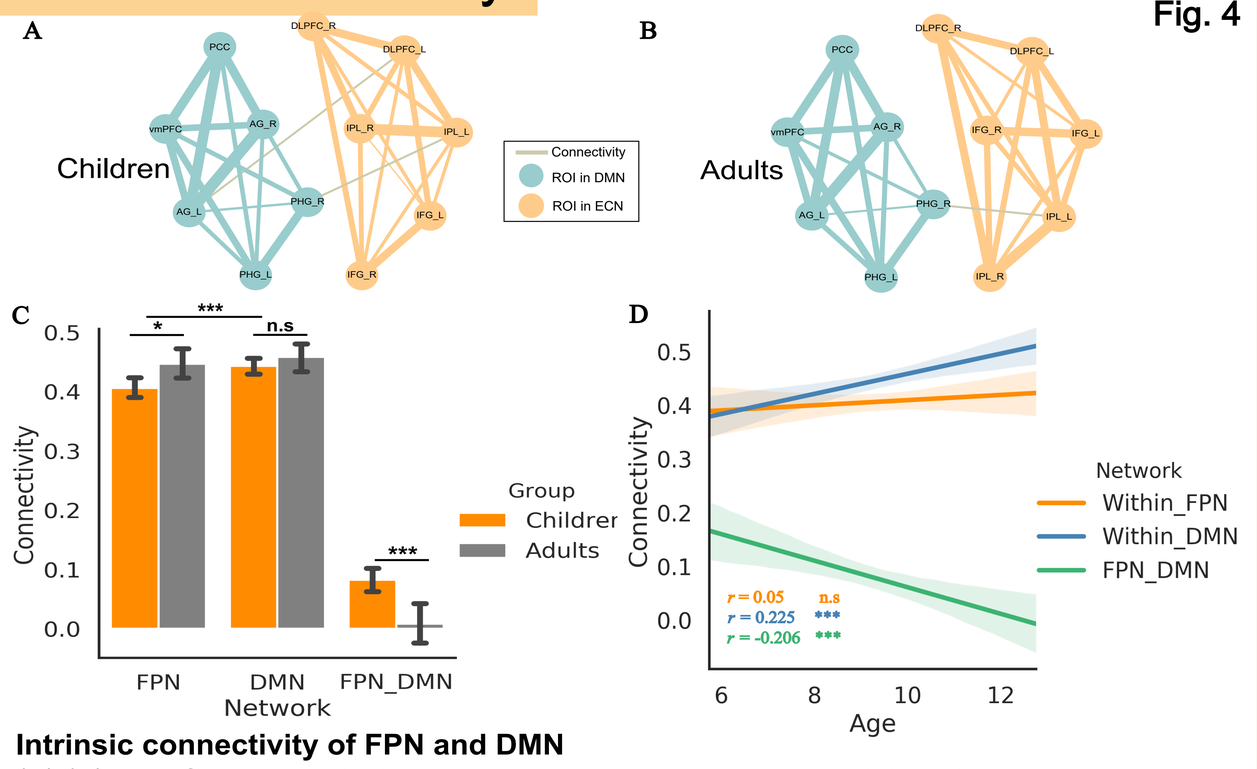


WM task paradigm and behavioral results

(A) N-back task including 3 loads: 0-, 1- and 2-back.
(B) With robust main effect of WM-load, children demonstrated poorer performance than adults.
(C) Children's executive function performance achieved adult-like pattern in 0-back while increased in 1- and 2-back as a function of age.

Task free connectivity

Fig. 4

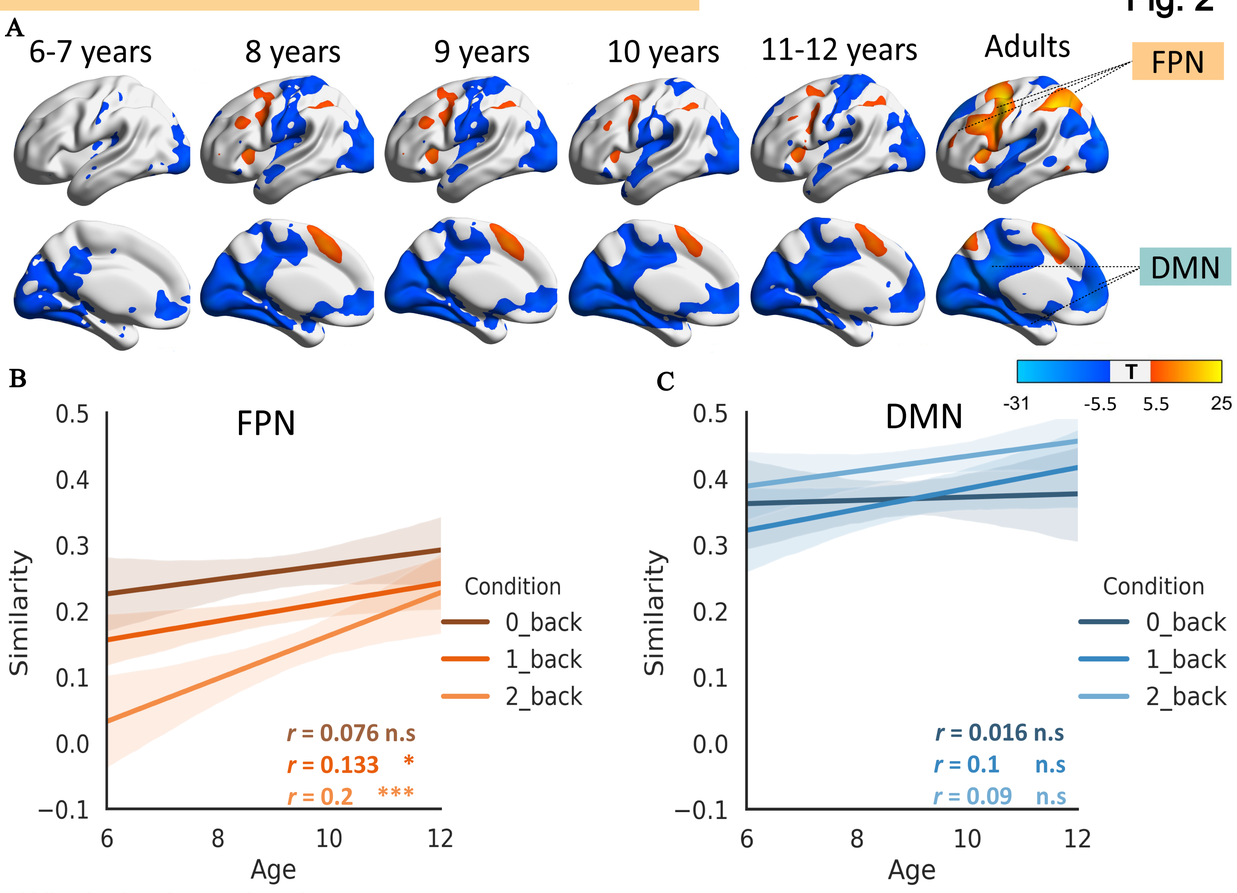


Intrinsic connectivity of FPN and DMN

(A) (B) Task free connectivity was measured based on resting state data.
(C) The intrinsic connectivity between children and adults was significantly different in FPN but not in DMN.
(D) Trajectories of children's intrinsic connectivity development showed that maturation in FPN was slower than DMN.

WM-related brain maturation

Fig. 2



Whole brain activation map

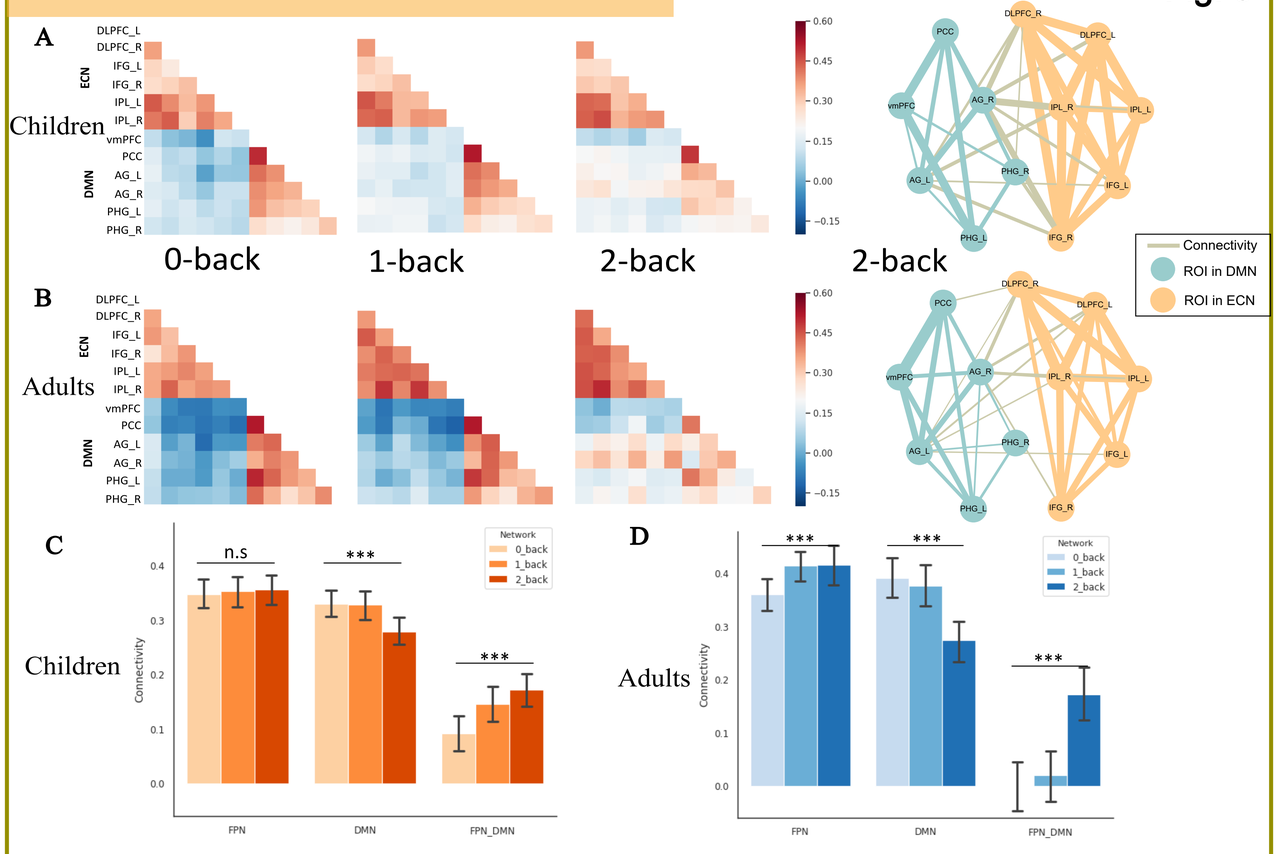
(A) Whole brain maturation in 2-back of children from 6 - 12 years old and adults.

Developmental trajectories of WM-related brain networks

(B)(C) Children's activation pattern similarity in FPN and DMN with adults showed distinct developmental tracjories. (Methods refer to Ref. 5)

Task dependent connectivity

Fig. 5

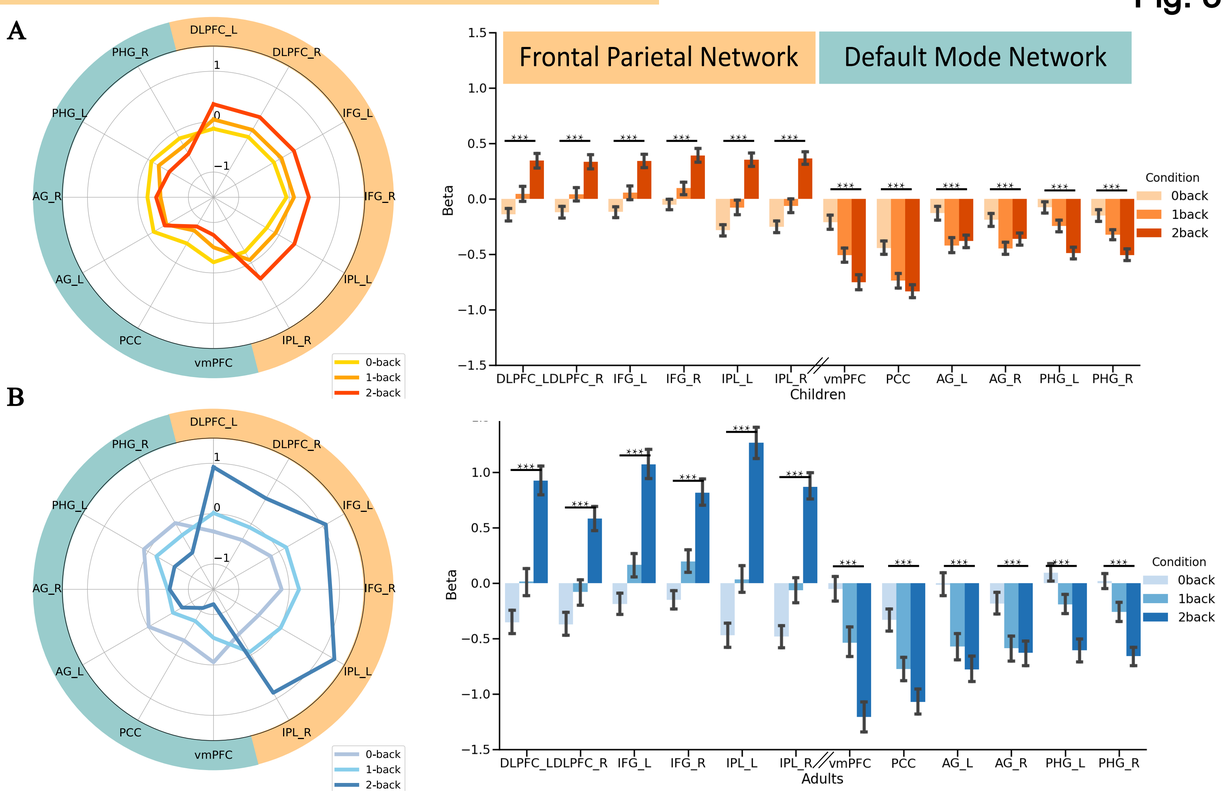


WM-related functional connectivity maturation over development

(C) (D) While the modulation in FPN of adults increased in high load condition, there was no difference among loads in children which reflecting the immature connectivity pattern in FPN in childhood during WM task. Integration of DMN had a similar pattern between children and adults.
The integration between FPN and DMN increased with task load both in children and adults.

Brain functional dissociation

Fig. 3



Activation in WM-related brain systems during development

(A) (B) Activation of ROIs in both FPN and DMN showed dissociation among 3 loads conditions in children and adults. Children showed a less pronounced activation association compared to adults.

Conclusions

- Behavioral data suggests WM ability undergoes a protracted development during childhood with adult-like performance in 0-back and successively increasing in 1- and 2-back.
- Children show different developmental trajectories of two networks with adult-like similarity in DMN and continuously increasing in FPN in 1- and 2-back. Indicating the immaturation of FPN.
- The intrinsic connectivity shows DMN is matured earlier and faster than FPN. While task dependent connectivity reveales DMN and it's interaction with FPN support children's cognitive function (WM) when FPN is immature.
- Our finding demonstrates DMN mature faster to compensate for protracted development of FPN function to support WM during childhood.

References

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