Four-dimensional Mapping of Dynamic Subcortical Development of Infant Brains

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GOAL

To investigate the **dynamic early developmental patterns** of the **thalamus, caudate, putamen, pallidum, hippocampus, and amygdala**, during the **first two postnatal years** by exploring both the **gross volumetric development** and **spatiotemporally-detailed surface areal expansion**.

• Significance

1. Revealing early subcortical developmental patterns
2. Better understanding early brain disorders (e.g., autism)

• Challenges

1. Low spatial resolution
2. Low and dynamic tissue contrast
3. Rapid growth

RESULTS

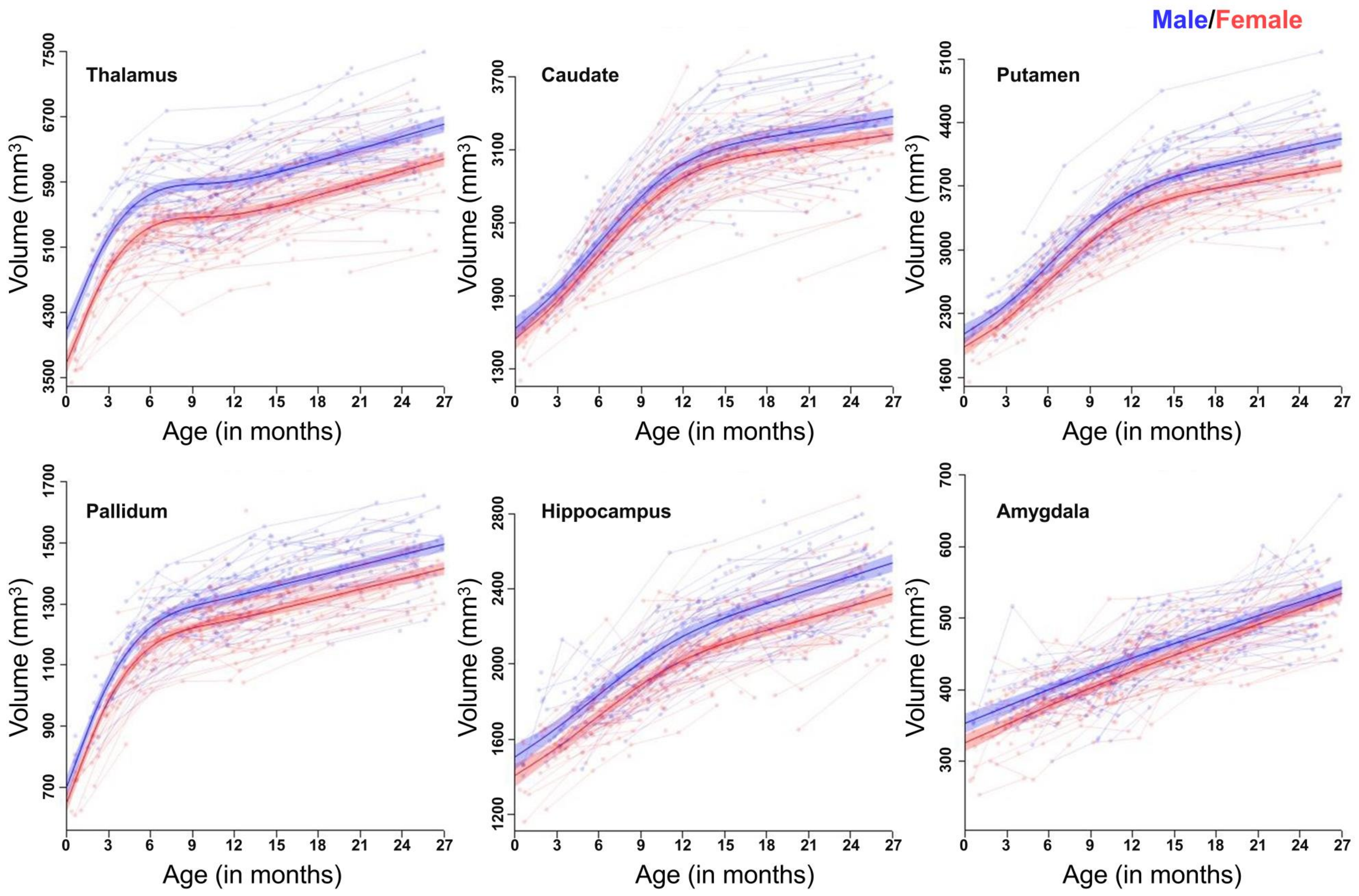

Fig. 1. Longitudinal volumetric developmental trajectories of different subcortical structures. Plots show both the individual-level (thin lines) and fitted population-level (solid curves) developmental trajectories of the bilaterally averaged volumes of the thalamus, caudate, putamen, pallidum, hippocampus, and amygdala structures. The shaded ribbon around each curve denotes 95% confidence intervals.

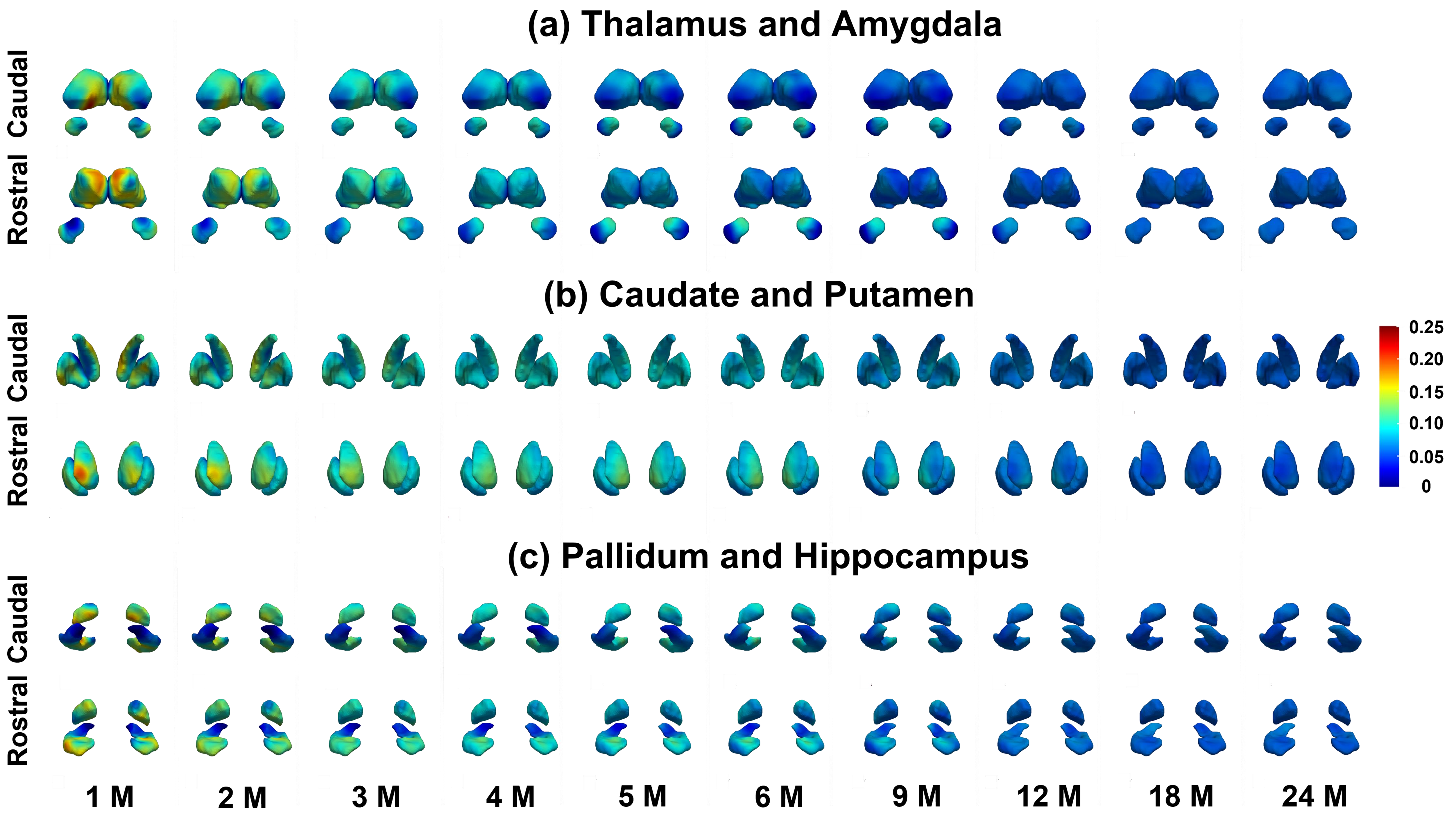

Fig. 2. 4D monthly growth rate maps of surface area. M: Month.

• Volumetric Developmental Trajectory

- Each subcortical structure (except for the amygdala) exhibits a distinct rapid volumetric growth after birth, then its growth rate slows down starting from a structure-specific age.
- Amygdala presents an approximately linear increase.
- Males consistently exhibit a larger volume than females in each subcortical structure during the age range examined.

• Surface Area Growth Rate

- The areal expansion of each subcortical structure exhibits distinct, age-dependent, region-specific, and bilaterally quasisymmetric patterns, with the growth rates initially being high and gradually slowing down.

MATERIALS & METHODS

- 513 longitudinal MRI scans from 231 subjects (including 105 males with 233 scans and 126 females with 280 scans) up to 27 months of age from the UNC/UMN Baby Connectome Project (BCP) [1].
- Preprocessing using iBEAT V2.0 Cloud (http://www.ibeatcloud.com) [2]
- Learning-based infant subcortical segmentation [3]
- UNC-BCP 4D Infant Brain Volumetric Atlas (https://www.nitrc.org/projects/uncbcp_4d_atlas/) [4]
- ANTs registration software [5]
- Generalized additive mixed model (GAMM) [6]

CONCLUSIONS

Our study has revealed volumetric developmental trajectories and spatiotemporally high- and low-growth subregions of six subcortical structures during infancy.

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