Development of Right Hemispheric Dominance in Self-Body Recognition Tasks

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Introduction:

The human right cerebral cortex has traditionally been considered as the "non-dominant" hemisphere; yet, a growing body of evidence indicates that one of its assigned functions is deeply involved in bodily recognition. In our previous study, we have shown in the adult brain that both visual self-face recognition and somatic recognition of one's own limb posture (proprioceptive illusion) commonly activate inferior parietal lobule (IPL) and inferior frontal cortices that are likely connected by the inferior branch of the superior longitudinal fasciculus tract (SLF III), in a right dominant manner (Morita et al. 2017). In the present study, we examine when and how the brain develops such functional lateralization to the right hemisphere and its common recruitment between these two self-body recognition tasks in typically developing humans.

Methods:

We measured blood oxygenation level-dependent (BOLD) signals with functional magnetic resonance imaging (fMRI) in 60 right-handed healthy children (aged 8–11 years; CH), adolescents (aged 12–15 years; ADO), and young adults (aged 18–23 years; AD, 20 per group) during a self-face recognition task. In this task, we presented visual images of the participant's own face (Self) and those of others' (Others), and asked the participants to judge whether the face they saw was their own or someone else's. We also conducted fMRI while the same participants performed a proprioceptive illusion task (Naito et al. 2017), where the blindfolded participants experienced a proprioceptive illusion of flexion of the right stationary wrist. In the imaging analysis, we first examined developmental change of self-face-related activity (Self vs. Others) in each group. Then, we conducted a flip analysis to examine when adult-like right-dominant use of SLF III network emerges. We also performed a conjunction analysis to see when adult-like common use of right-sided SLF III structures between two self-body recognition tasks emerges. Finally, we investigated whether the degree of right-lateralization of brain activity in the common region is associated with each other between self-face recognition and proprioceptive illusion.

Results:

All participants performed the self-face recognition task with high accuracy. Patterns of self-face-related activity were different across groups, though some similarities were also observed between groups (Figure 1). In AD and ADO group, self-face-related activity was identified in the inferior frontoparietal regions of the right hemisphere. However, unlike AD group, right middle occipital and bilateral inferior occipitotemporal activity was not observed in ADO group. In contrast, in CH group, no adult-like robust activity was observed in these cortices. We also found that right IPL develops predominantly for self-face processing without being substantially involved in processing of others' faces. The flip analysis revealed that adult-like right-side dominant use of SLF III network emerges during adolescence but not yet in childhood. Adult-like common brain activation between self-face recognition and proprioceptive illusion also emerges in the right IPL (areas PFt and PF) during

adolescence (Figure 2A). Finally, the degree of right-lateralization of self-face-related IPL activity positively and significantly correlated with that of illusion-related IPL activity in ADO group (r = 0.546, Figure 2B).
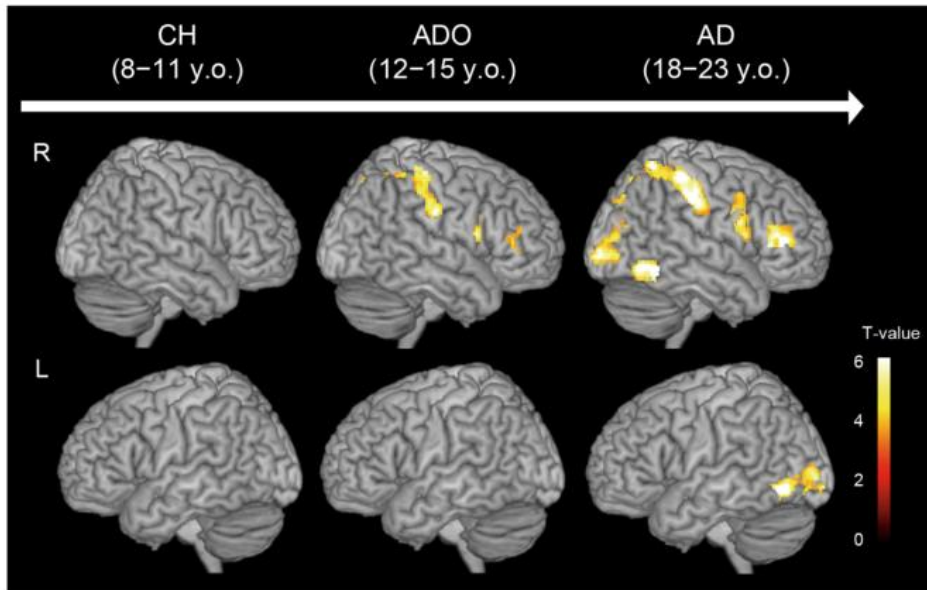

Figure 1. Brain regions that showed self-face-related activity (Self > Others) in each group. Adult-like self-face-related activity emerged in the right inferior frontoparietal cortices during adolescence. The color bar at the bottom right indicates T-values. Abbreviations: CH, children; ADO, adolescents; AD, adults.
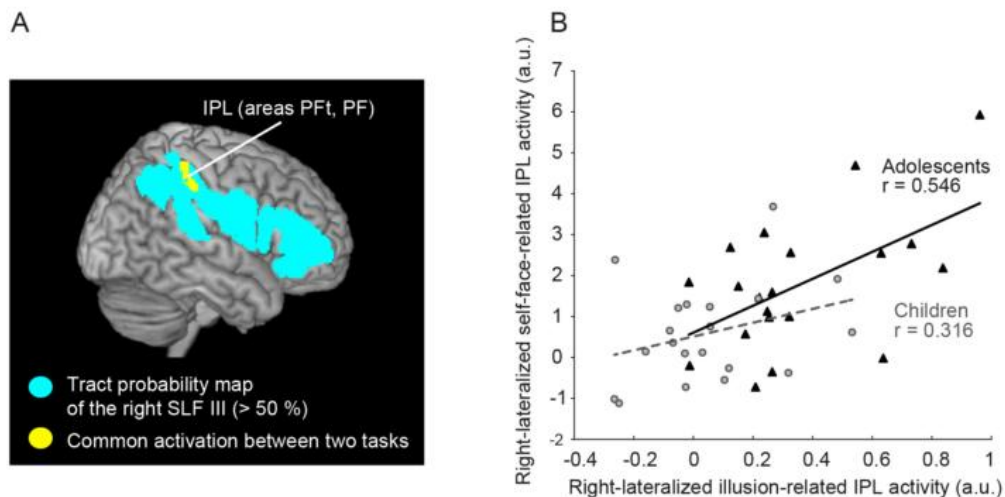

Figure 2. A: Right IPL region (areas PFt and PF) commonly activated during both self-face recognition and proprioceptive illusion in adolescents (yellow, left panel). Blue sections indicate cortical regions likely connected by the right SLF III in the adult brain (putative SLF III regions in adolescents). B: Correlation between the degree of right-lateralization of self-face-related IPL activity and that of illusion-related IPL activity in adolescents (triangle dots) and children (circle dots). The horizontal axis indicates values for differences in parameter estimates between the right and the left IPLs (right−left) for illusion-related activity and the vertical axis indicates the same for self-face-related activity. A significant positive correlation was observed in adolescents. Abbreviation: r, correlation coefficient; a.u., arbitrary unit.

Conclusions:

The right-hemispheric dominant use of IPL and its sharing between two self-body recognition (self-face recognition and limb proprioception) tasks emerge during adolescence. This implies the possibility that dominant use of the right cerebral cortex for certain brain functions emerges during adolescence. Self-face recognition directly contributes to recognition (awareness) of the bodily self, and thus co-development of right IPL activation for self-face recognition and limb proprioception may indicate the importance of the right IPL in self-body recognition that may lead to bodily self-awareness.

Higher Cognitive Functions:

Higher Cognitive Functions Other

Imaging Methods:

BOLD fMRI [2]

Lifespan Development:

Normal Brain Development: Fetus to Adolescence [1]

Perception and Attention:

Consciousness and Awareness
Perception: Visual

Keywords:

Consciousness
Cortex
Development
FUNCTIONAL MRI
NORMAL HUMAN
Perception
Other - Self

[1][2]Indicates the priority used for review

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Please indicate which methods were used in your research:

Functional MRI

For human MRI, what field strength scanner do you use?

3.0T

Which processing packages did you use for your study?

SPM

Provide references using author date format

Morita, T. (2017), 'Self-face recognition shares brain regions active during proprioceptive illusion in the right inferior fronto-parietal superior longitudinal fasciculus III network', Neuroscience, vol. 348, pp. 288-301
Naito, E. (2017) 'Development of right-hemispheric dominance of inferior parietal lobule in proprioceptive illusion task', Cerebral Cortex, vol. 27, pp. 5385-5397