



SUBCORTICAL BRAIN DEVELOPMENT DURING ADOLESCENCE: DEVELOPMENTAL TRAJECTORIES, HERITABILITY AND IQ



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Aims

Brain structures follow various developmental trajectories during adolescence. For most structures, initially there is growth, followed by a decrease in volume (with exception for white matter volume). The peak of this trajectory is different for structures, and for boys and girls. These trajectories are often studied cross-sectionally, and rarely in a longitudinal setting.

- ❖ Investigate subcortical volume change during adolescence

Most global brain volumes are 70-90% heritable. The heritability of global brain structures in childhood/adolescence is well established. This is less so for subcortical structures, in adults their heritability is estimated between .44 (accumbens) and .88 (caudate).

- ❖ Estimate heritability of subcortical structures in adolescence

Total brain size correlates around .25 with IQ. This association comes from shared genetic factors.

- ❖ Explore association subcortical structures with IQ

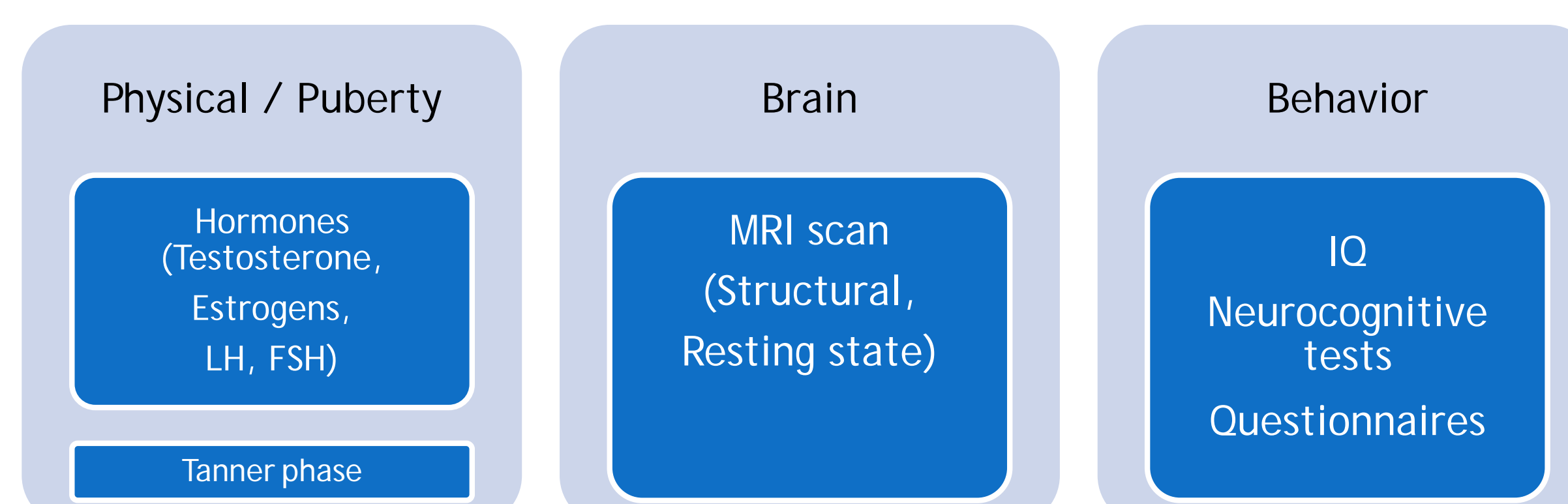


BrainSCALE

Brain Structure and Cognition:
an Adolescent Longitudinal Twin Study into
the Genetic Etiology of Individual Differences

Methods and Sample: Netherlands Twin Register

Baseline (T1)	Follow up (T2)
112 families	89 families
96 MZ & 128 DZ twins, 9.2 yrs	80 MZ & 98 DZ twins
103 siblings 11.8 yrs (9-14)	83 siblings, 14.8 years old (14-17)
91% MRI scan	74% MRI scan



- ❖ Automatic segmentation (in Freesurfer) was used for volume measurement of the thalamus, caudate, putamen, pallidum, amygdala, hippocampus and nucleus accumbens.
- ❖ IQ: total, verbal, performal, index scores (verbal comprehension, perceptual organization, processing speed)

RESULTS

Volume change

Increase:
thalamus
pallidum
amygdala
hippocampus

Decrease:
caudate
putamen
n. accumbens

Different for boys/ girls and left/ right

Genetic architecture of subcortical volumes

- ❖ Heritability: most over 50% (not n. accumbens)
- ❖ Same genetic factors over time

Association with IQ

- ❖ Subcortical volumes correlate between .05 and .32 with total IQ.
- After correction for IC only the left thalamus (.13) and left hippocampus (.15) correlate significantly with IQ.
- Shared genetic factors explain this association.

	Girls		Boys	
	L	R	L	R
Thalamus	+3.8%	+1.9%	+3.4%	+2.6%
Caudate	-0.7%	-1.0%	-1.7%	-1.2%
Putamen	+0.5%	-0.8%	-0.4%	-1.2%
Pallidum	+1.7%	+2.4%	+2.5%	+2.5%
Amygdala	+2.7%	+2.5%	+2.4%	+2.9%
Hippocampus	+1.7%	+1.0%	+2.2%	+3.6%
Accumbens	+0.3%	-3.2%	-3.0%	-4.5%

	h ² 9 yrs	h ² 12 yrs
Thalamus L/R	72 / 76	63 / 72
Caudate L/R	69 84 / 72 80	75 89 / 78 76
Putamen L/R	91 / 87	88 / 81
Pallidus L/R	60 / 61 41	63 / 70 29
Amygdala L/R	61 / 70	73 / 52
Hippocampus L/R	69 / 68 79	72 / 74 66
Accumbens L/R	33 / 53	22 / 58

	Total	Verbal	Perform	VCI	POi	PSi
Thalamus	.28/.21	.23/.14	.26/.24	.23/.12	.29/.27	.05/-.02
Caudate	.19/.14	.17/.12	.15/.13	.18/.12	.19/.16	-.08/-.03
Putamen	.23/.22	.17/.18	.23/.20	.18/.18	.26/.23	-.06/-.07
Pallidus	.24/.16	.21/.14	.19/.14	.21/.14	.21/.14	0/.05
Amygdala	.21/.19	.15/.16	.23/.17	.14/.16	.26/.19	0/-.04
Hippocampus	.32/.23	.29/.21	.25/.18	.29/.23	.27/.19	-.05/-.04
Accumbens	.05/.12	.06/.11	.01/.09	.07/.12	.06/.12	-.18/-.15

Subcortical brain development is a dynamic process, following different trajectories of growth or volume reduction. However, heritability estimates over a 3-year interval are relatively similar. In general, heritability is high.

Only volume of the left thalamus and hippocampus correlate with IQ.

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