Maternal deprivation and milk replacement affect the integrity of gray and white matter in the developing lamb brain

Scott Love, Emmanuelle Haslin, Manon Bellardie, Frédéric Andersson, Laurent Barantin, Isabelle Filipiak, Hans Adriaensen, Csilla Lea Fazekas, Laurène Leroy, Dóra Zelena, et al.

Morphometric and microstructural MRI data indicate that maternal deprivation and milk replacement affect and delay lamb brain maturation from as early as 1.5 weeks of age.

FENS Forum 2022 - Poster S07-373

Maternal Deprivation and Milk Replacement Affect the Integrity of Gray and White Matter in the Developing Lamb Brain

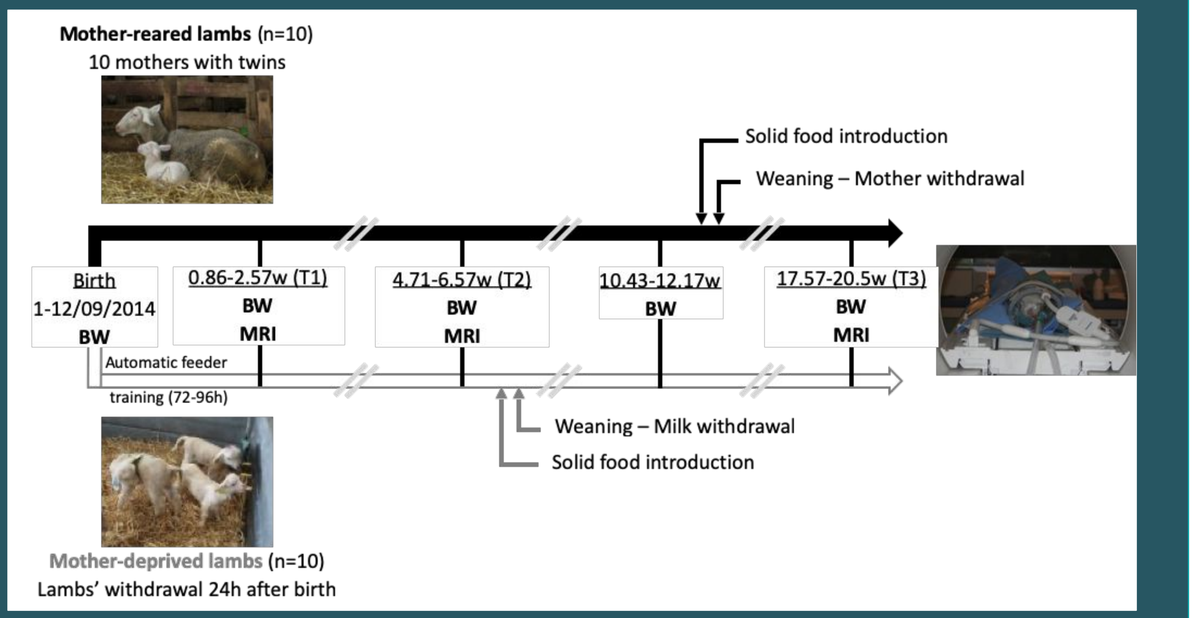
Scott Love[1], Emmanuelle Haslin[1], Manon Bellardie[1], Frédéric Andersson[2], Laurent Barantin[2], Isabelle Filipiak[2], Hans Adriaensen[1], Csilla Lea Fazekas[3], Laurène Leroy[1], Dóra Zelena[3], Mélody Morisse[1], Frédéric Elleboudt[1], Christian Moussu[1], Frédéric Lévy[1], Raymond Nowak[1], Elodie Chaillou[1]

ABSTRACT

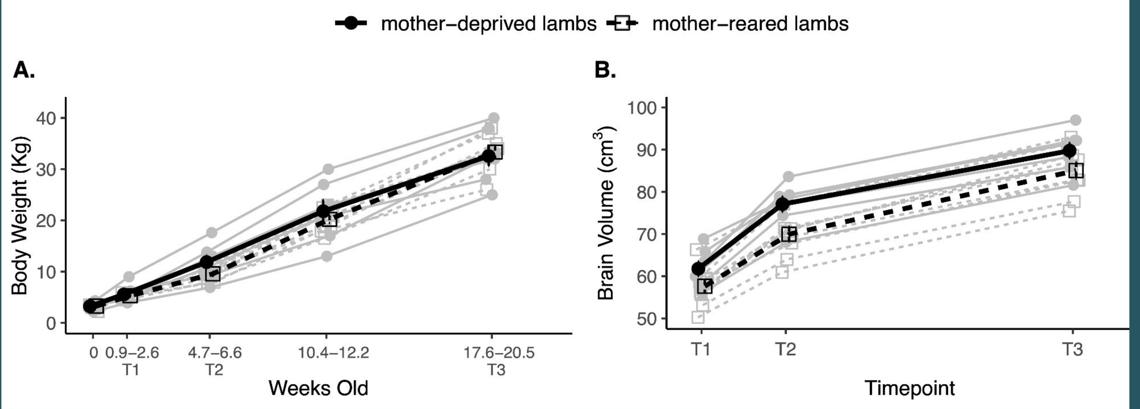
The psychoendocrine evaluation of lamb development has demonstrated that maternal deprivation and milk replacement alters health, behavior and endocrine profiles. While lambs are able to discriminate familiar and non-familiar conspecifics (mother or lamb), only lambs reared with their mother develop such clear social discrimination or preference. Lambs reared without mother display no preference for a specific lamb from its own group. Differences in exploratory and emotional behaviours between mother-reared and mother deprived lambs have also been reported. As these behavioural abilities are supported by the brain, we hypothesize that rearing with maternal deprivation and milk replacement leads to altered brain development and maturation. To test this hypothesis, we examined brain morphometric and microstructural variables extracted from *in-vivo* T1-weighted and diffusion-weighted magnetic resonance images acquired longitudinally (1 week, 1.5 months and 4.5 months of age) in mother-reared and mother-deprived lambs.

From the morphometric variables the caudate nuclei volume was found to be smaller for mother-deprived than for mother-reared lambs. T1-weighted signal intensity and radial diffusivity (RD) were higher for mother-deprived than for mother-reared lambs in both the white and gray matters. The fractional anisotropy (FA) of the white matter was lower for mother-deprived than for mother-reared lambs. Based on these morphometric and microstructural characteristics we conclude that maternal deprivation delays and affects lamb brain growth and maturation.

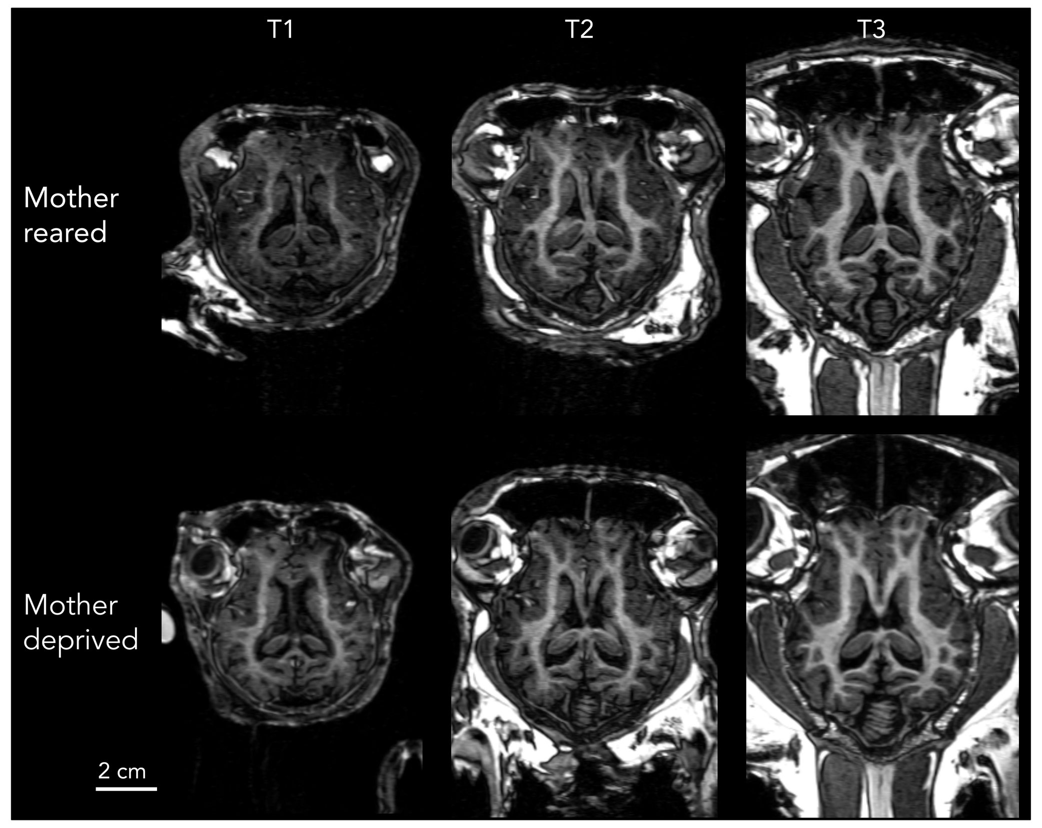
EXPERIMENTAL PROTOCOL



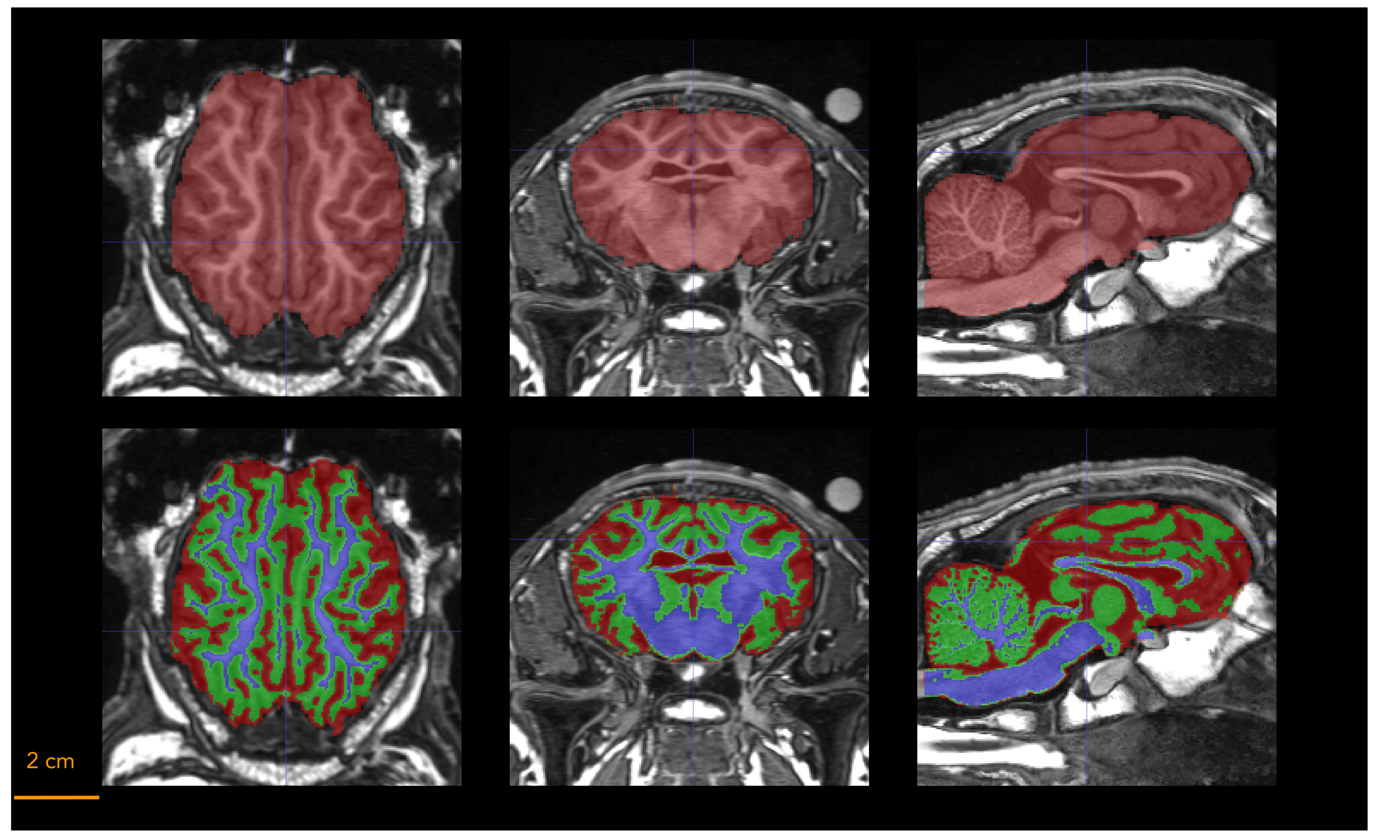
Rearing condition did not impact body weight but did impact brain volume



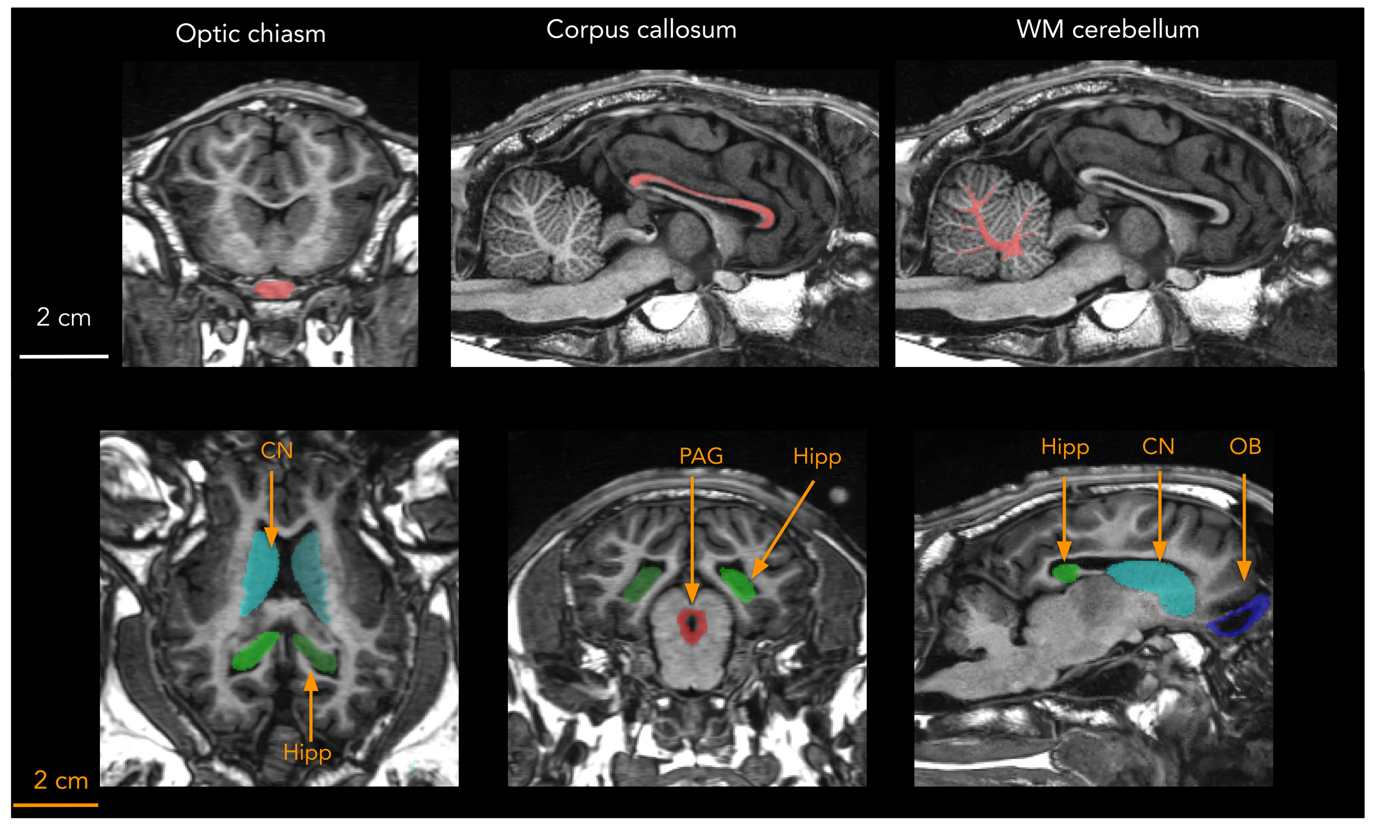
Example T1-weighted images from each group at each timepoint (approx. 1 week, 1.5 months & 4.5 months)



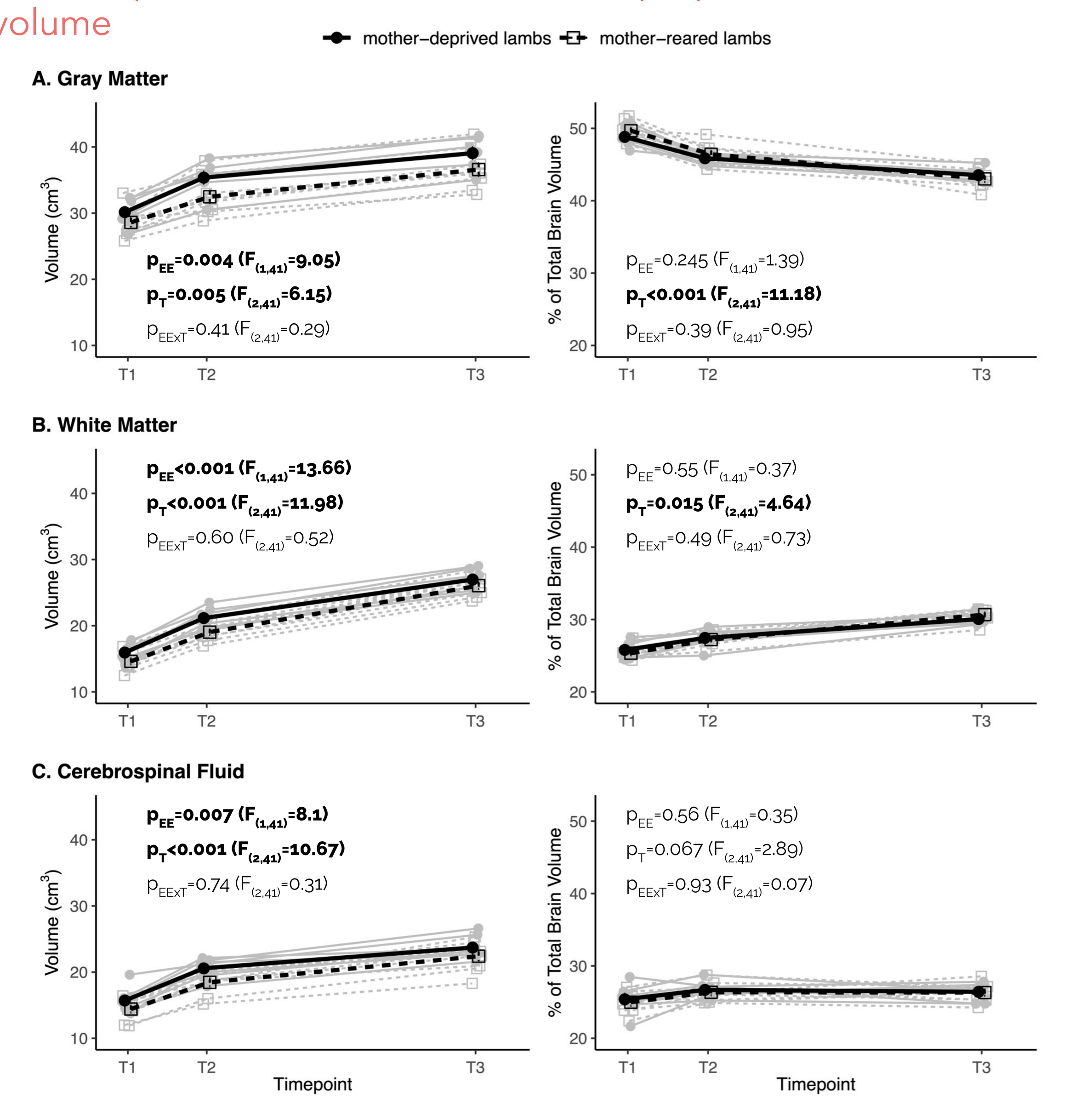
Example brain mask, white matter (blue), gray matter (green) & cerebrospinal fluid (red) segmentations



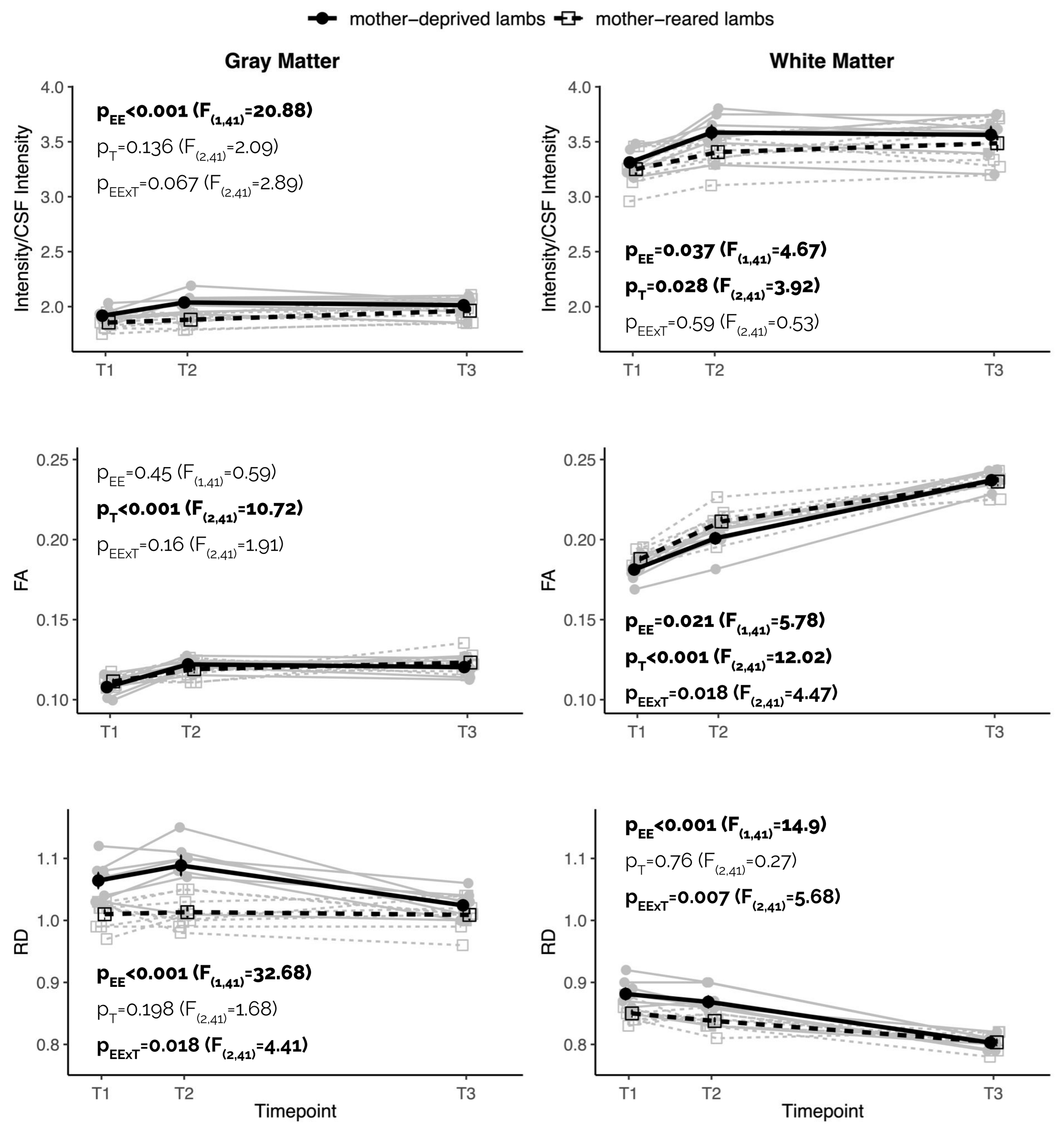
Example gray and white matter regions of interest



Impact of early experience on gray matter, white matter and cerebrospinal fluid volume & their proportion of total brain volume



Impact of early experience on the maturation of gray and white matter microstructure



Impact of early experience on the morphometry of gray matter regions of interest

Brain structure	Timepoint	Mother-reared lambs	Mother-deprived lambs	ANCOVA analyses results
Caudate nucleus	n	9	7	**p_{EE}<0.001 ($F_{(1,27)}$=14.86)**
	T2	675.47±72.17	600.64±29.33	**p_{T}=0.014 ($F_{(1,27)}$=6.97)**
	T3	859.87±102.11	763.91±48.03	p_{EExT}=0.41 ($F_{(1,27)}$=0.69)
Hippocampus	n	7	7	p_{EE}=0.89 ($F_{(1,23)}$=0.02)
	T2	519.36±38.26	518.13±14.59	**p_{T}=0.001 ($F_{(1,23)}$=39.09)**
	T3	616.65±56.88	629.49±64.05	p_{EExT}=0.56 ($F_{(1,23)}$=0.35)
Olfactory bulb	n	6	6	p_{EE}=0.42 ($F_{(1,19)}$=0.68)
	T2	221.54 ±49.98	246.58±33.73	p_{T}=0.88 ($F_{(1,19)}$=0.68)
	T3	346.27±52.19	354.23±54.93	p_{EExT}=0.73 ($F_{(1,19)}$=0.73)
Periaqueductal gray	n	9	7	p_{EE}=0.13 ($F_{(1,27)}$=2.45)
	T2	223.88±21.54	199.96±15.74	p_{T}=0.79 ($F_{(1,27)}$=0.07)
	T3	250.63±21.11	244.51±35.64	p_{EExT}=0.23 ($F_{(1,27)}$=1.36)

Abbreviations: CN, caudate nucleus; RD, radial diffusivity; EE, early experience; FA, fraction of anisotropy; HIPP, hippocampus; OB, olfactory bulb; PAG, periaqueductal gray; T, timepoint.

[1]CNRS, IFCE, INRAE, Université de Tours, PRC, Nouzilly, France
[2]UMR 1253, iBrain, Université de Tours, Inserm, Tours, France
[3]Centre for Neuroscience, Szentágothai Research Centre, Institute of Physiology, Medical School, University of Pécs, Pécs, Hungary

Contact
Scott Love
scott.love@inrae.fr

This work was partially supported by funding from the Conseil Régional du Centre-Val de Loire (Ovin2A 2013 00083140), SFR Neuroimagerie Fonctionnelle FED4426 & French National Research Agency (ANR-20-CE20-0001-01)

GET THE PAPER