PHD MEETING - 11 OCTOBER 2016

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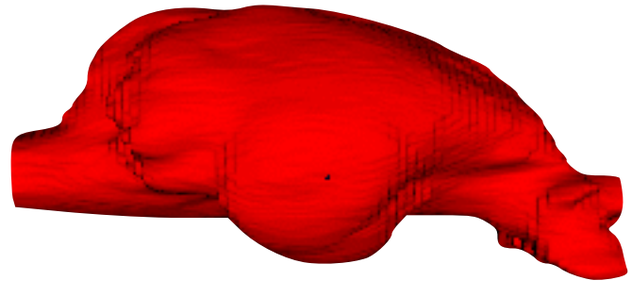
Aims:

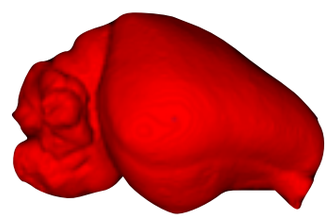
1 Sum up situation and potentiality of the “bunnies project”: Next goals, possible outcomes and questions.

2 Discuss possible methodological side project.

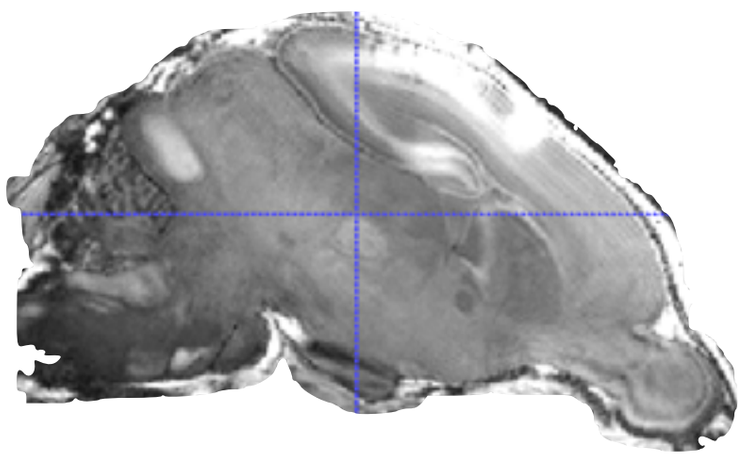
Barcelona adult model



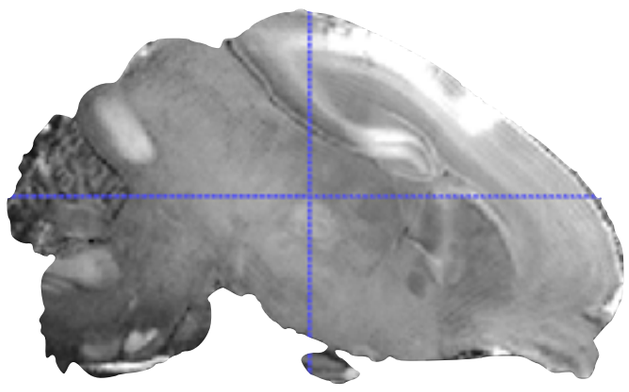
In skull1305 - pilot study
preliminary segmentation



In skull 1305 - pilot study

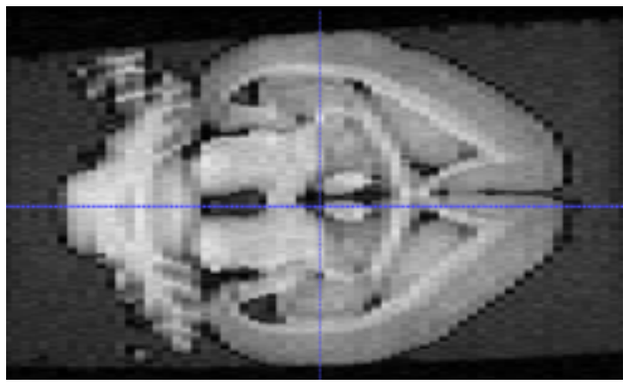


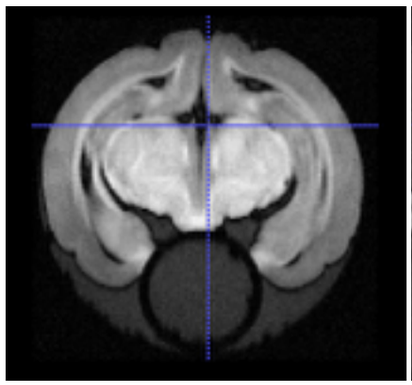
Skull-stripped 1305
landmark based registration using ex skull template

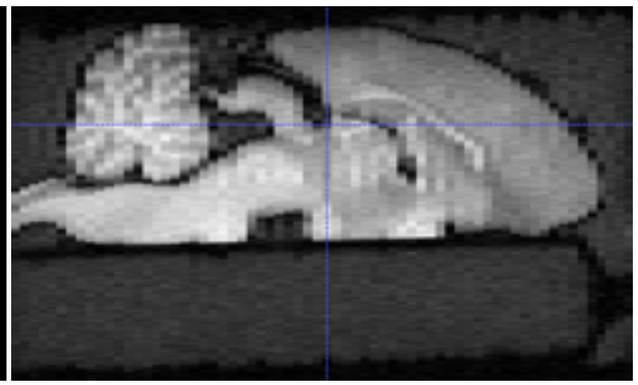


Sum up:

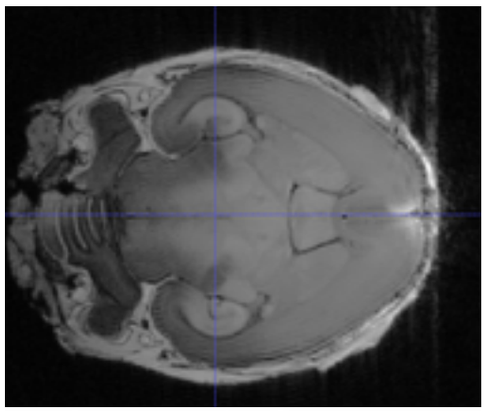
Subject 012
Barcelona study

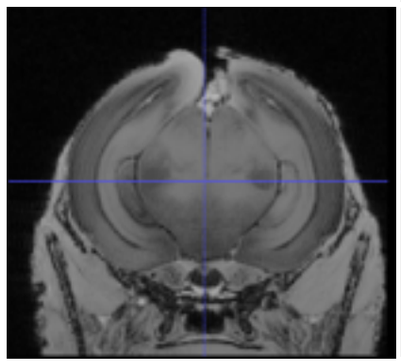


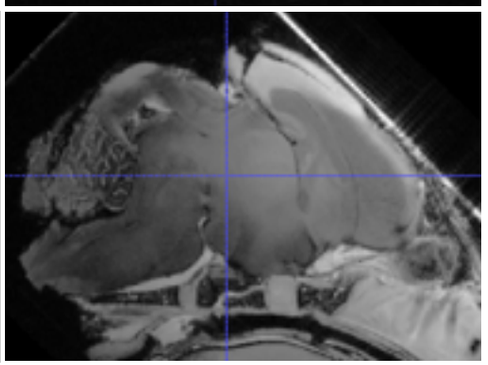




Subject 602
Pilot study







1. Subjects in hands at the moment:
   5 subjects ex skull (3 term, 2 pre-term),
   2 ex vivo, in skull, open skull perfusion, pre-term
   4 ex vivo, in skull, no open perfusion, pre-term
   2 subjects in vivo.
   + Barcelona adult study
2. Upcoming data - pilot study:
   7 in vivo / ex vivo subjects arriving the next week + ~6 new subjects, double scans for three of them (pilot study).
3. The study will involve a longitudinal study with three datasets
   Control dataset - Preterm with corticosteroid - Preterm without corticosteroid
   Histological sections, pictured before and after resection.
   Neurobehavioral assessments.

Main goal, side goals.

MAIN GOAL IS: Prediction of the neurocognitive consequences of Preterm Birth and Corticosteroid administration.

Main next steps:

1. Template construction and probabilistic atlas (expert neuroanatomist supervised).
2. Template-free skull stripping method robust to noise.
3. Statistical analysis.

Main next steps for me:

1. Doing homeworks: state of the art literature and neuroanatomy of the brain rabbit.
2. Doing homeworks 2: improve in programming.
3. Have the pipeline ready for when the data will come and familiarity with software for registration and segmentation (semi-automatic and automatic).

Main goal, side goals.

MAIN GOAL IS: Prediction of the neurocognitive consequences of Preterm Birth and Corticosteroid administration.

Possible side project:

1. Pediatric rabbit atlas and template publication. ISMRM 2017
2. Possible new template-free skull stripping method robust to noise. Later…
3. Possible new statistical analysis methods. Later…
4. Possible Histology-MRI registration. Later…

Main priority is the pipeline with the pre-term in skull from the Pilot study.

Main Questions:

1. Can we use the pilot data to create a template that is publishable afterwards? Yes, a pre-term atlas with pipeline explanation, to make the results reproducible.
2. Does it make sense to invest time in the creation of a new skull stripping method for our purposes? No, but it is worth try existing methods, starting from Guotai and ImageJ
3. Which statistics is better for our main aim? Still an open question for DWI.

Question 1

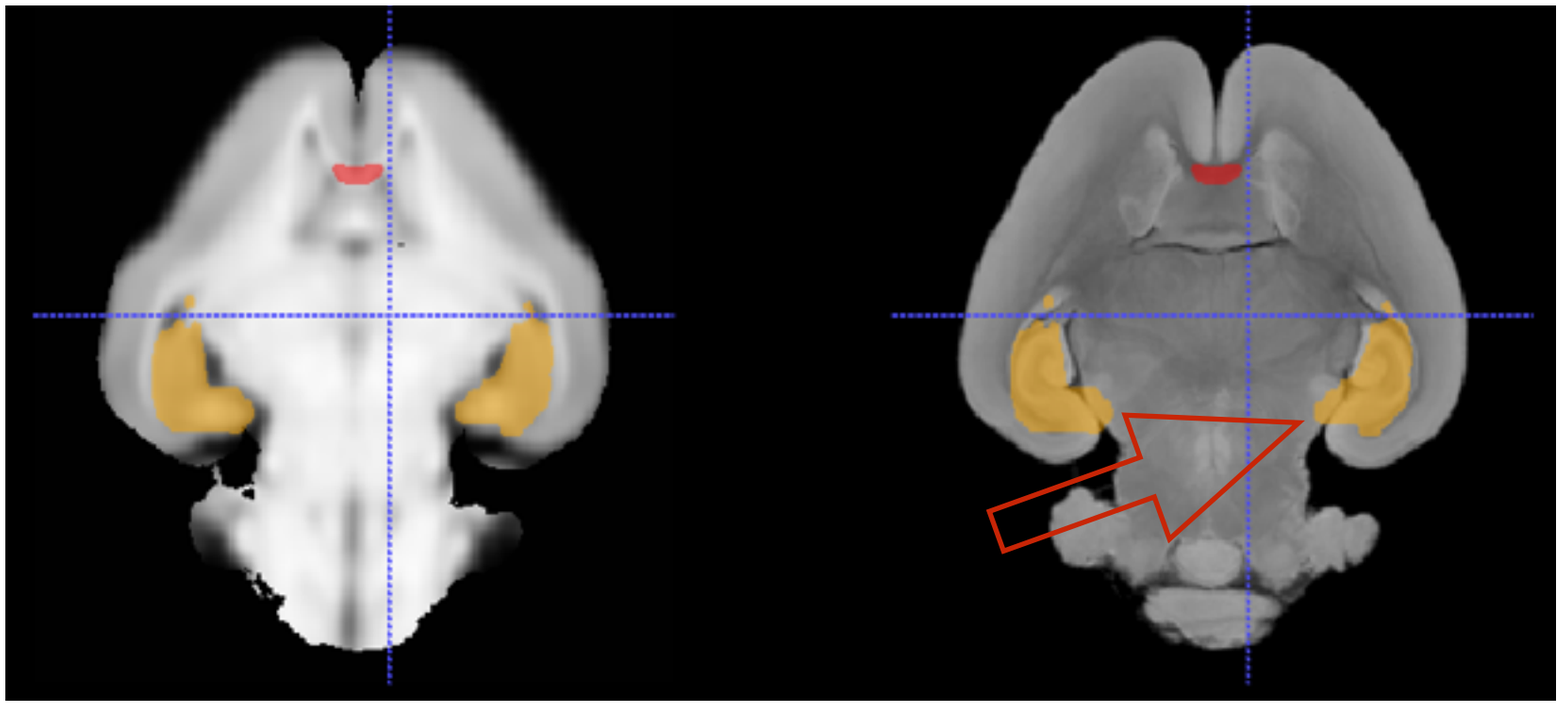
- Can we use the pilot data to create a template that is publishable afterwards?

5 subjects ex skull - 2 term 3 pre-term.

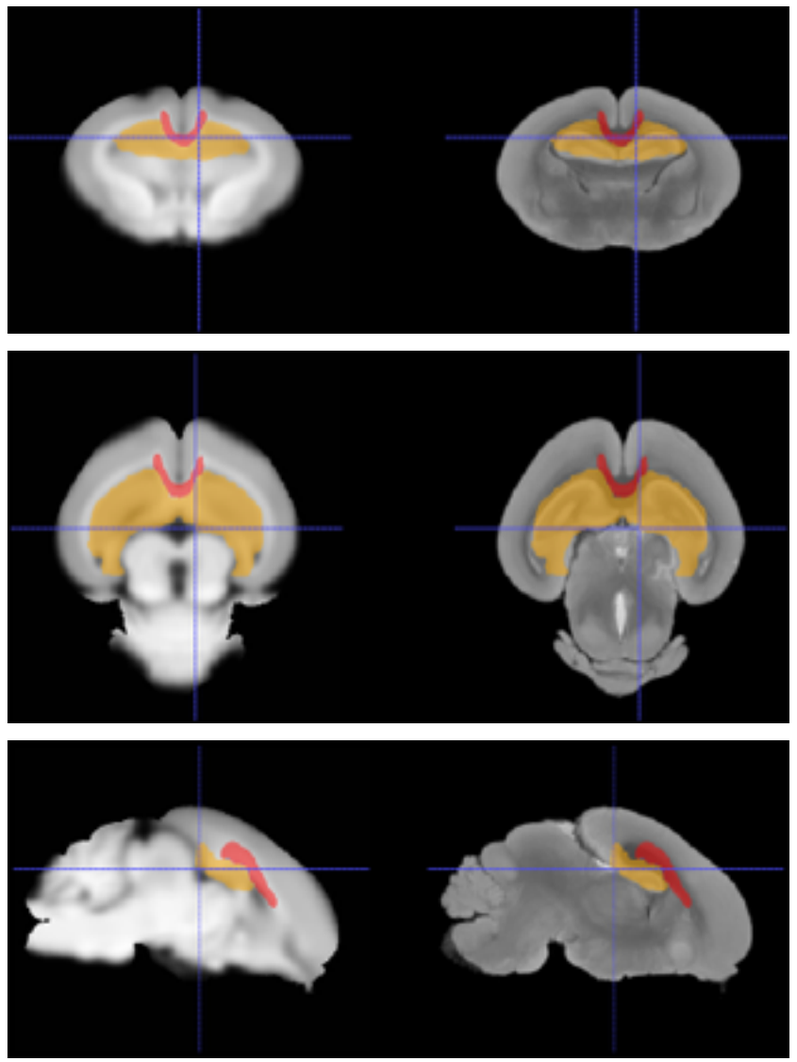
6 in skull - 2 open skull perfusion pre-term, 4 closed skull perfusion pre-term

2 in vivo term.

Problem in creating a “probabilistic” atlas from the registration of the Barcelona atlas. Is there a way of computing a probability based on a measure on the SVF?

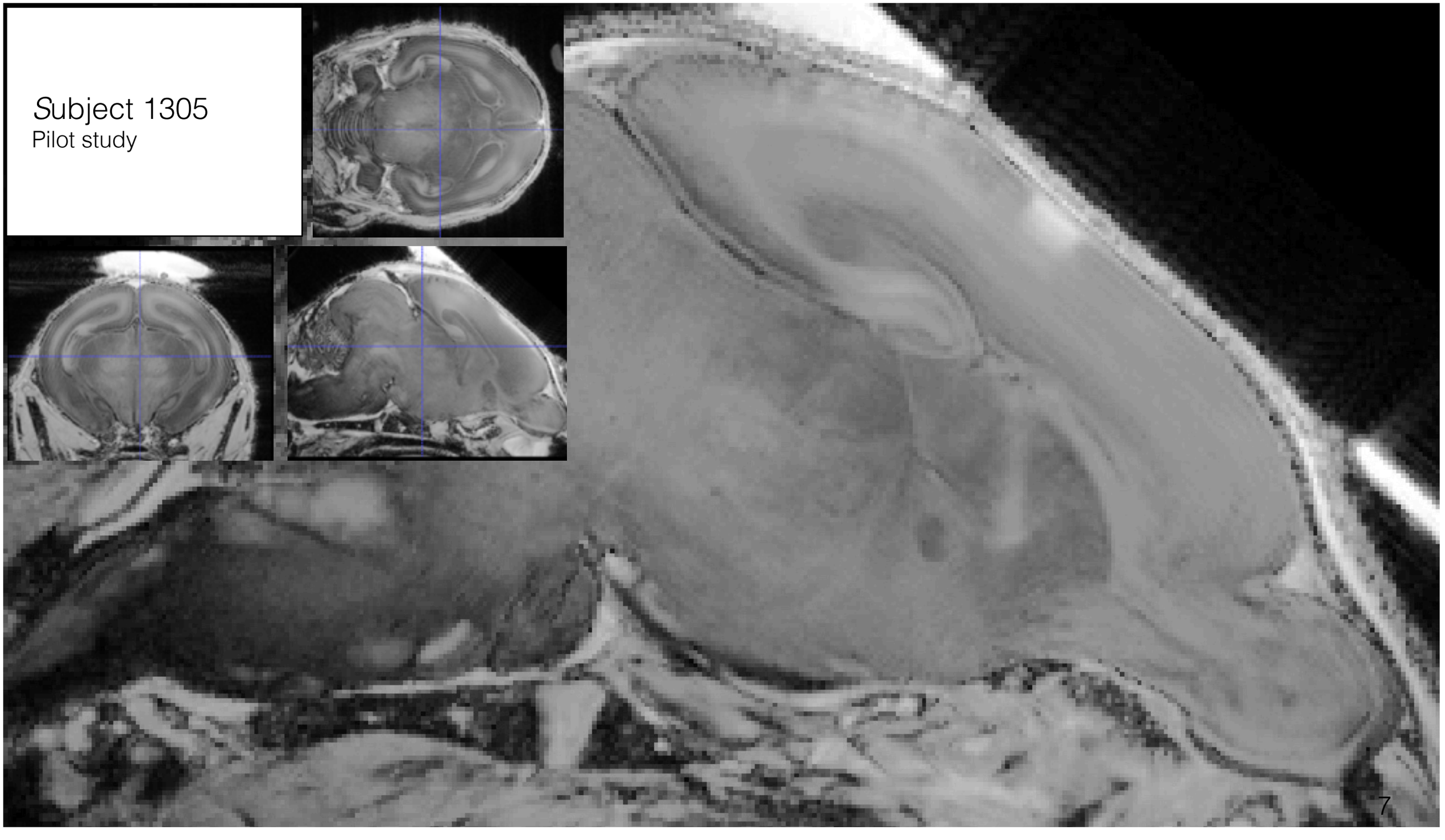


Adultino and Subject 1305
Propagation corpus callosum and hippocampi.

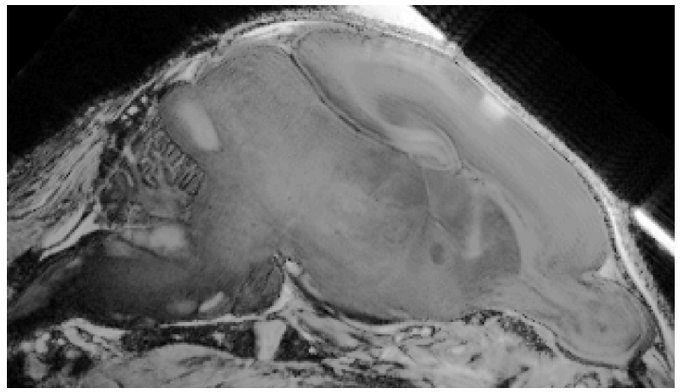


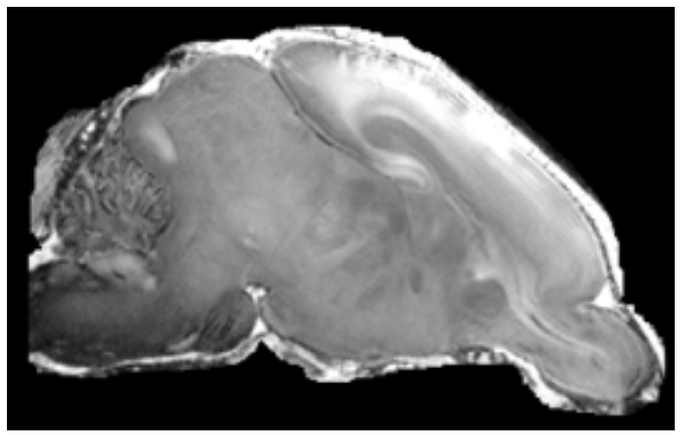
Question 2

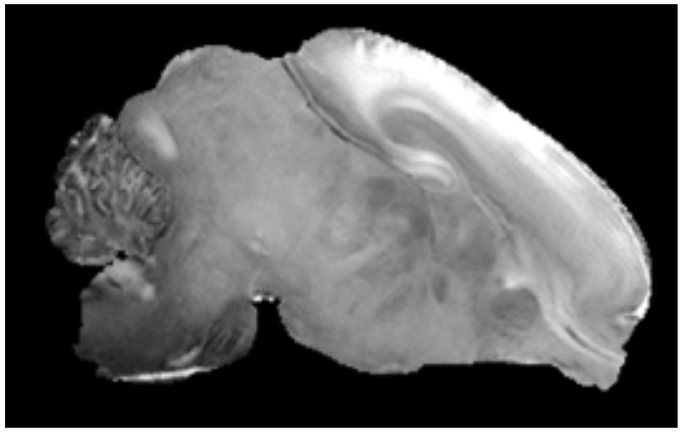
- Does it make sense to invest time in the creation of a new skull stripping method for our purposes?

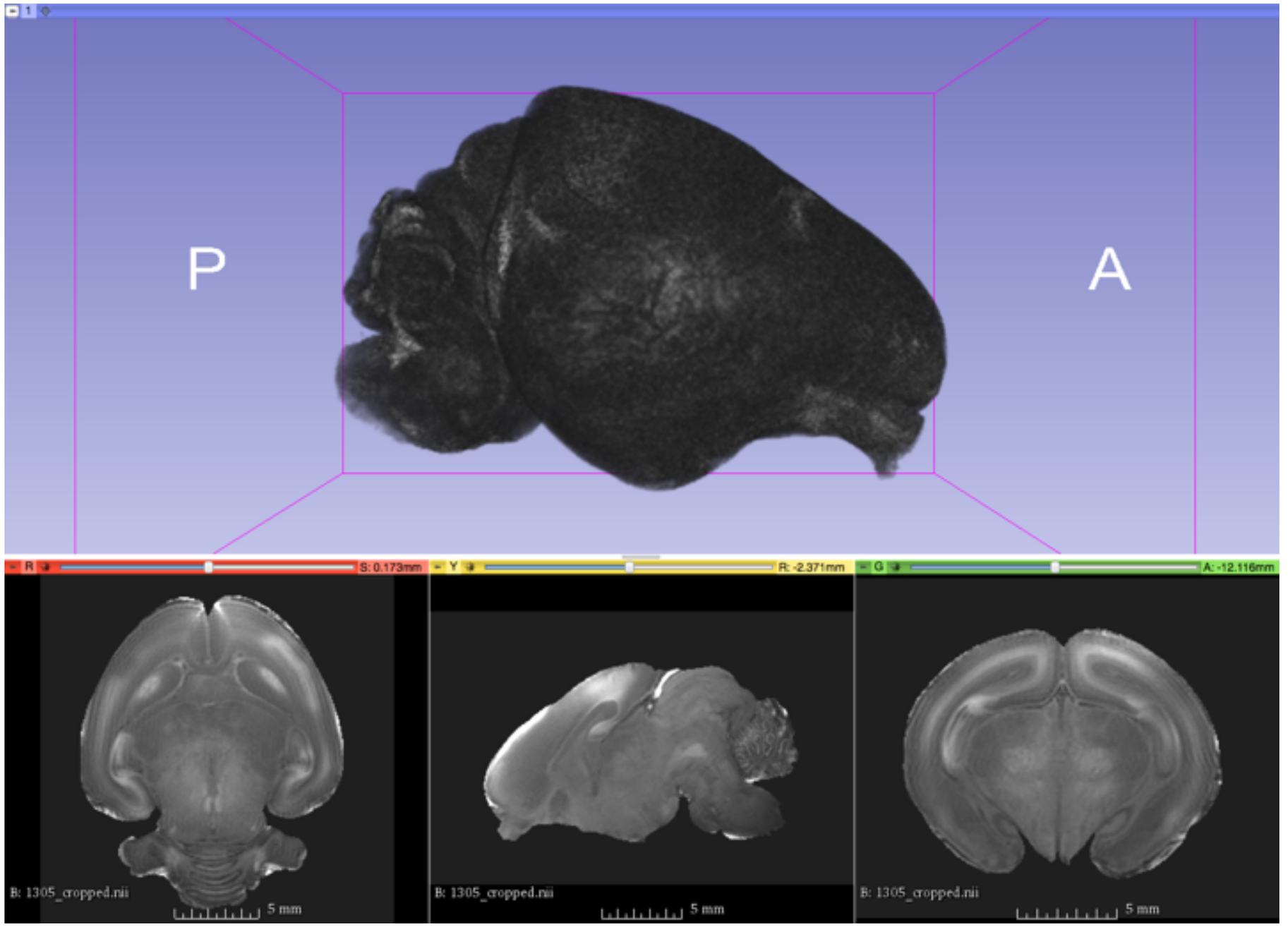


Question 2



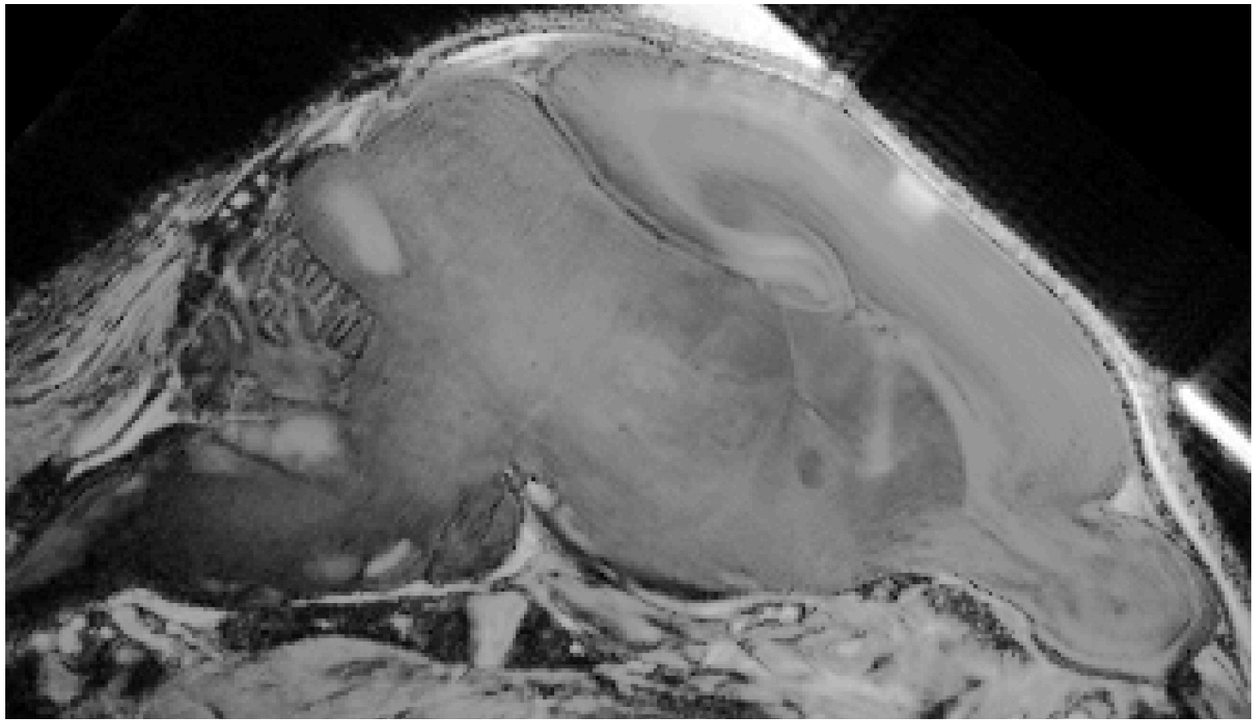


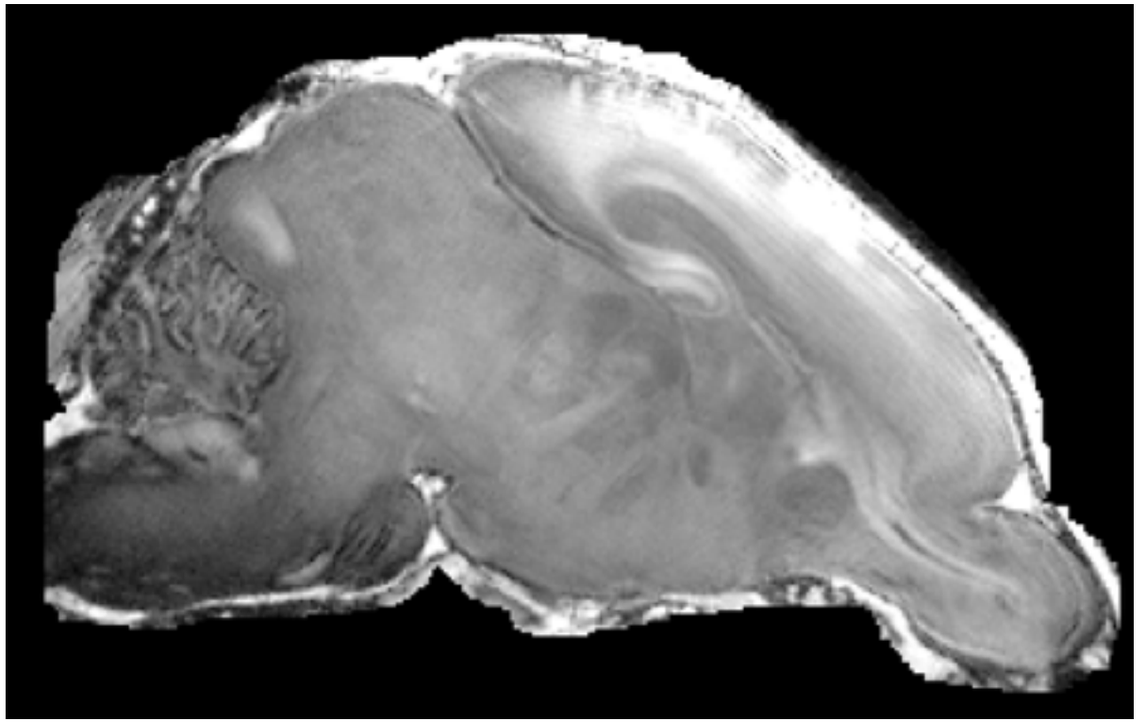




Subject 1305

Preliminary results: segmentation obtained with landmark based registration from the average ex_skull preliminary template to the subject 1305.





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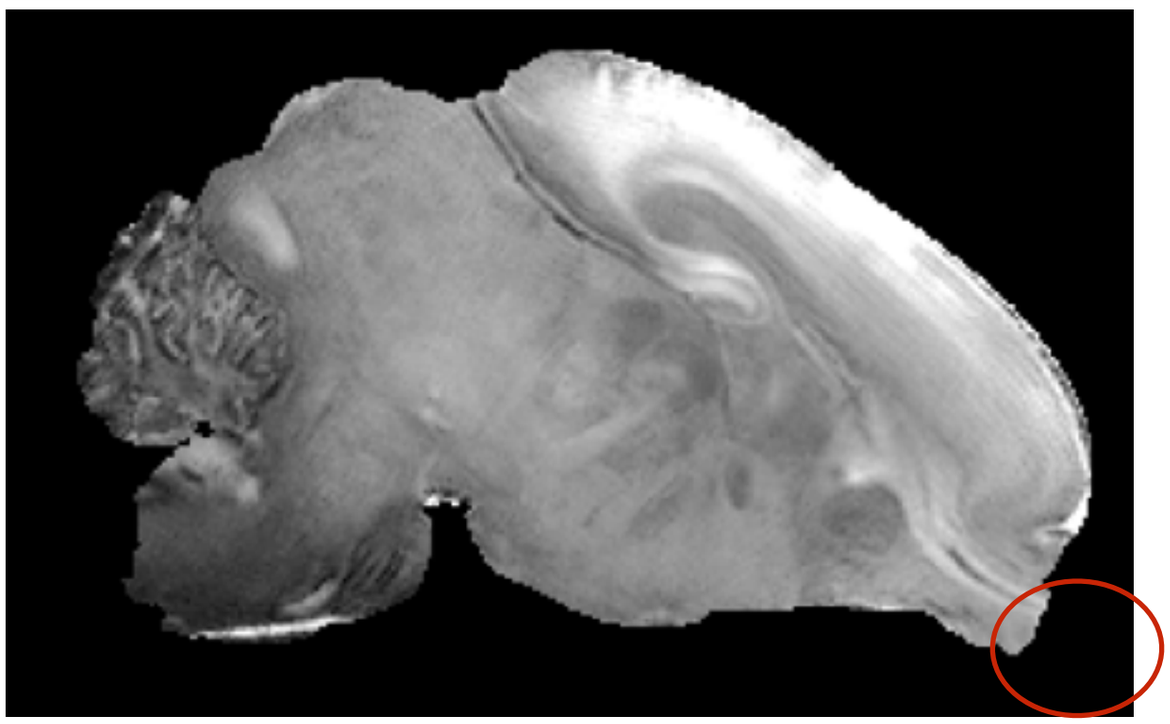


Draft algorithm (when watershed transform is not robust enough):

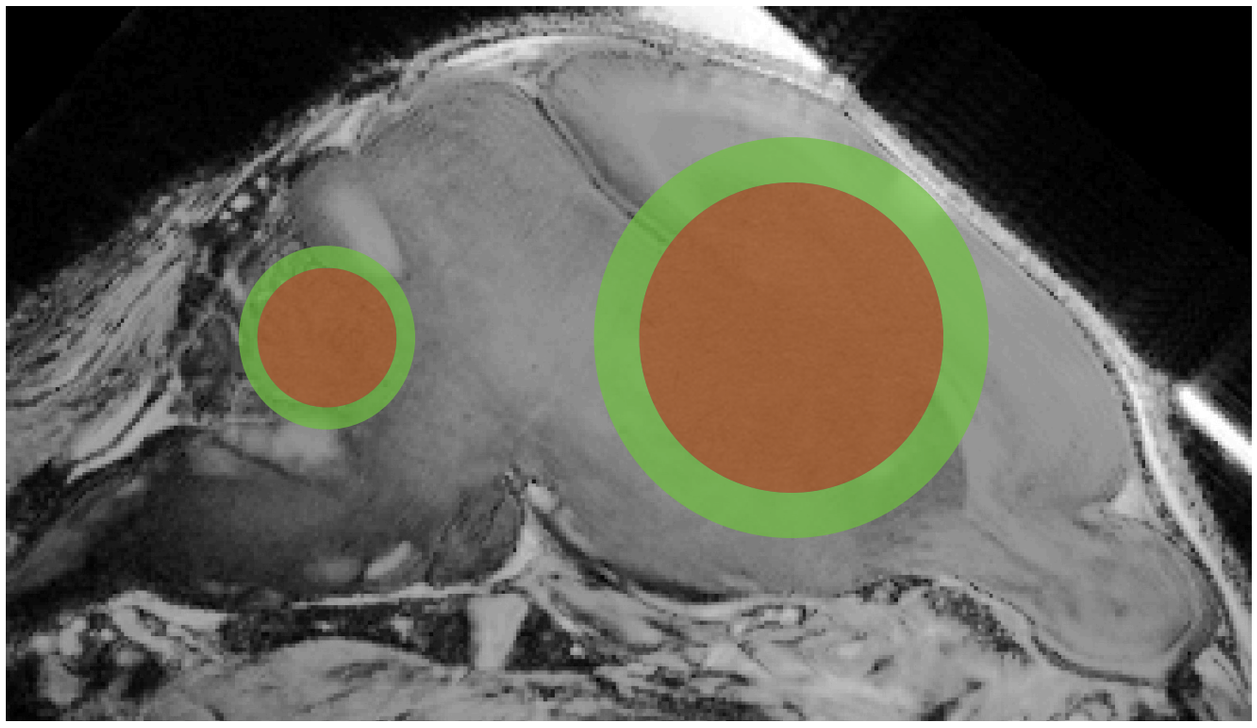
Try before ImageJ and Guotai method!

1. Set manually one or more initial seed.
2. At each iteration:

   The seeds are dilated by a radius proportional to the radius of the manual segmentation and the image size.

   Each voxel is scored inside or outside the segmentation according to the value collected inside the segmentation at the previous step.

   Remove the components that are not connected.



Score function at the voxel $\mathbf{x}$: $S(\mathbf{x}) = \lambda_i s_i(\mathbf{x}) \qquad i = 1, 2, 3$

$s_1(\mathbf{x})$ Difference of the normalised intensities of the voxel considered and the previous area

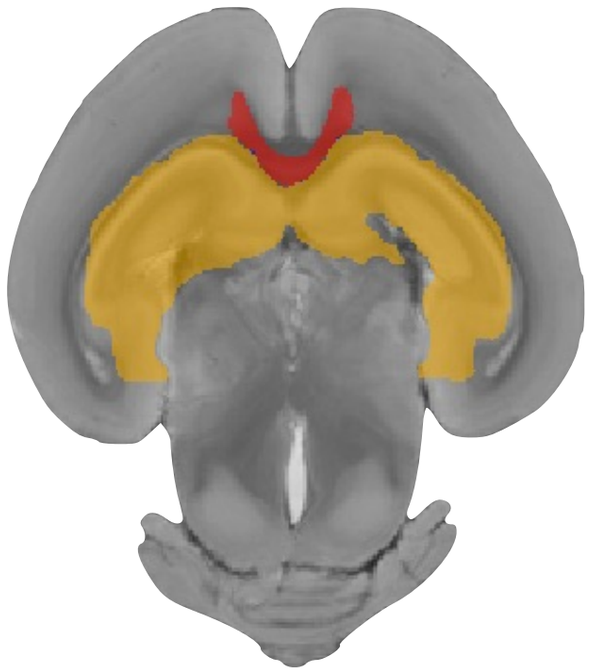
$s_2(\mathbf{x})$ Difference between spherical mean of the gradient vectors inside the area and the gradient vector at the considered voxel

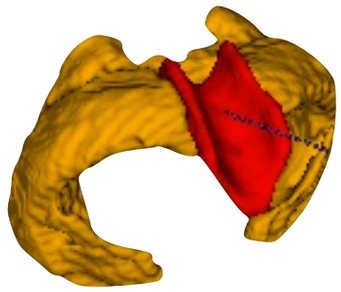
$s_3(\mathbf{x})$ Difference between the fractal dimension of the inside area and the neighbour of the considered voxel.

Question 3

- Which statistics is better for our main aim?

1. Tensor Based Morphometry (TBM)
2. Voxel Based Morphometry (VBM)
3. “Rough” Volumes Analysis
4. Boundary Shift Integral in the Volumetric Study (BSI)
5. Deformation Based Morphometry (DBM)
6. Deformation Based Morphometry for Divergence Free fields (DivFree-DBM)
7. Multivariate Pattern Analysis (MVPA)
8. Geodesics transformation for Pseudo-Longitudinal Statistics (Marco)
9. DWI: NODDI, Apparent Diffusion Coefficient, Fractional Anisotropy.





Summary after the meeting 1/2 - Next aims.

Propose a Pre-term rabbit template at ISMRM 2017.

The paper will contain:
0) Literature review.
1) Pipeline and methods + code on git-hub.
2) Template + atlas manually adjusted by Alberto Prats-Galino (from Barcelona Group)
3) Each individual subject manually adjusted.
4) Reoriented DWI and field maps.

Summary after the meeting 2/2 - Next moves

Reorient and crop each image manually.
Extract ROI of each of the in skull closed perfusion pre-term subject using the dilated preliminary template mask.
Reorient DWI with current orientations and extract ROI.

-> We have all the subjects manually oriented, cropped, and with the ROI extracted + DWI.

Manually segment lesion masks of each subject (black holes artefacts and disturbance intensities).
In paint the lesion masks with Ferran method.
Pairwise registration of the ROI subjects in-painted, rigid and non-rigid.
Remove the in-painting and average the subjects for the sum of the masks of the subjects, excluding the lesions - If a zone is lesioned for all the subjects we will have a “nan”, being a missing information in the template.

-> We have the average in the Region Of Interest.

Manually skull-strip the average, using landmarks + preliminary atlas (with the skull stripped).
Back-propagate the brain mask to each subject from the average on and skull strip each of them.

-> We have each subject skull stripped and the average skull stripped.

Register the template from the Barcelona study on the average, affine and landmark-based non-rigid.
Propagate the atlas of the Barcelona study on the average with the same transformations, and obtain the probabilistic map for each region.
Back-propagate atlas and probabilistic map from the average to each single subject.

-> We have the average with a first approximation of the template and a probabilistic map. We have it on all of the subjects.

Send all to Alberto for the manual corrections and start writing the paper.
Submit.
… Wait!

People:

Phd Project

supervisor
Tom Vercauteren

Co-supervisors
Marco Lorenzi, Marc Modat

Clinical supervisor
Jan Deprest

Project

Hannes Van Der Merwe,
Willy Gsell
Zach Eaton-Rosen,
Andrew Melbourne,
Ferran Pardos,
Alberto Prats-Galino

Possible side project MRI/Histology:

Eugenio Iglesias
Roberto Annunziata

Main thread resources:

Volpe, Joseph J., et al. "Reprint of “The developing oligodendrocyte: key cellular target in brain injury in the premature infant”." International Journal of Developmental Neuroscience 29.6 (2011): 565-582.

Drobyshevsky, Alexander, et al. "Unmyelinated axon loss with postnatal hypertonia after fetal hypoxia." Annals of neurology 75.4 (2014): 533-541.

Muñoz-Moreno, Emma, et al. "A magnetic resonance image based atlas of the rabbit brain for automatic parcellation." PloS one 8.7 (2013): e67418. - (**Barcelona study)**

Drobyshevsky, Alexander, et al. "Developmental changes in diffusion anisotropy coincide with immature oligodendrocyte progression and maturation of compound action potential." The Journal of neuroscience 25.25 (2005): 5988-5997.

Lim, Seong Yong, et al. "New Insights into the Developing Rabbit Brain Using Diffusion Tensor Tractography and Generalized q-Sampling MRI." PloS one 10.3 (2015): e0119932.

Müllhaupt, Désirée, et al. "Magnetic resonance imaging anatomy of the rabbit brain at 3 T." Acta Veterinaria Scandinavica 57.1 (2015): 1.

Batalle, Dafnis, et al. "Long-term reorganization of structural brain networks in a rabbit model of intrauterine growth restriction." Neuroimage 100 (2014): 24-38.

Stats initial resources

Friston, Karl J. "Statistical parametric mapping." (1994).

Lorenzi, Marco, Nicholas Ayache, and Xavier Pennec. "Regional flux analysis of longitudinal atrophy in Alzheimer's disease." International Conference on Medical Image Computing and Computer-Assisted Intervention. Springer Berlin Heidelberg, 2012.

Jones, Derek K., Thomas R. Knösche, and Robert Turner. "White matter integrity, fiber count, and other fallacies: the do's and don'ts of diffusion MRI." Neuroimage 73 (2013): 239-254.

Ashtari, Manzar, et al. "White matter development during late adolescence in healthy males: a cross-sectional diffusion tensor imaging study." Neuroimage 35.2 (2007): 501-510.

Thompson, Paul M., et al. "Mathematical/computational challenges in creating deformable and probabilistic atlases of the human brain." Human brain mapping 9.2 (2000): 81-92.

Skull stripping initial resources

Hahn, Horst K., and Heinz-Otto Peitgen. "The skull stripping problem in MRI solved by a single 3D watershed transform." International Conference on Medical Image Computing and Computer-Assisted Intervention. Springer Berlin Heidelberg, 2000.

Ségonne, Florent, et al. "A hybrid approach to the skull stripping problem in MRI." Neuroimage 22.3 (2004): 1060-1075.

Park, Jong Geun, and Chulhee Lee. "Skull stripping based on region growing for magnetic resonance brain images." NeuroImage 47.4 (2009): 1394-1407.