Gray Matter Changes in Cerebral Development

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Abstract

Volumetric analysis is an essential neuroimaging tool for identifying and characterizing morphometric and connectivity brain changes. Due to the convenience of imaging processing software, such as FreeSurfer, standard practice is to rely on automated results. CAT12, an extension of the segmentation in SPM12, uses an internal interpolation to provide more reliable results even with low resolution images and anisotropic spatial resolutions. With data from Human Connectome Project Development(HCP-D) dataset, gray matter volume (GM_{vol}) and white matter volume (WM_{vol}) were investigated using FreeSurfer and CAT12 software. Volumetric analysis was performed on preprocessed T1 images of 20 healthy male subjects, ages 5-21. Results show that in comparison to FreeSurfer, CAT12 is regularly underestimating gray matter volumes and overestimating white matter volumes, with the exception of 2 subjects. Ages were also correlated with cerebral volumes for future work. Trends map a slight decline in gray matter volume and a slight increase in white matter volume as subject's age increases, for both CAT12 and FreeSurfer.

Introduction

Volumetric analysis is an essential neuroimaging tool for identifying and characterizing morphometric and connectivity brain changes. Due to the convenience of imaging processing software, such as FreeSurfer, standard practice is to rely on automated results. CAT12, an extension of the segmentation in SPM12, uses an internal interpolation to provide more reliable results even with low resolution images and anisotropic spatial resolutions.

The Human Connectome Project (HCP) is a major endeavor that will acquire and analyze connectivity data plus other neuroimaging, behavioral, and genetic data from 1,200 healthy adults. For this project, 20 healthy male subjects from the HCP Development dataset(HCP-D) are studied. Demographic data, including age, also accompanied the dataset.

Materials/Methods

Volumetric analysis was performed on preprocessed T1 images of 20 healthy male subjects, ages 5-21 from the Human Connectome Project Development Dataset. Volumetric data, including Gray Matter Volume(WM_{vol}), White Matter Volume(WM_{vol}), and Total Intracranial Volume(TIV) was collected using the algorithm CAT12 on MATLAB, and with FreeSurfer. GM volumes as calculated by CAT12 were compared to GM volumes as calculated by FreeSurfer.

Results

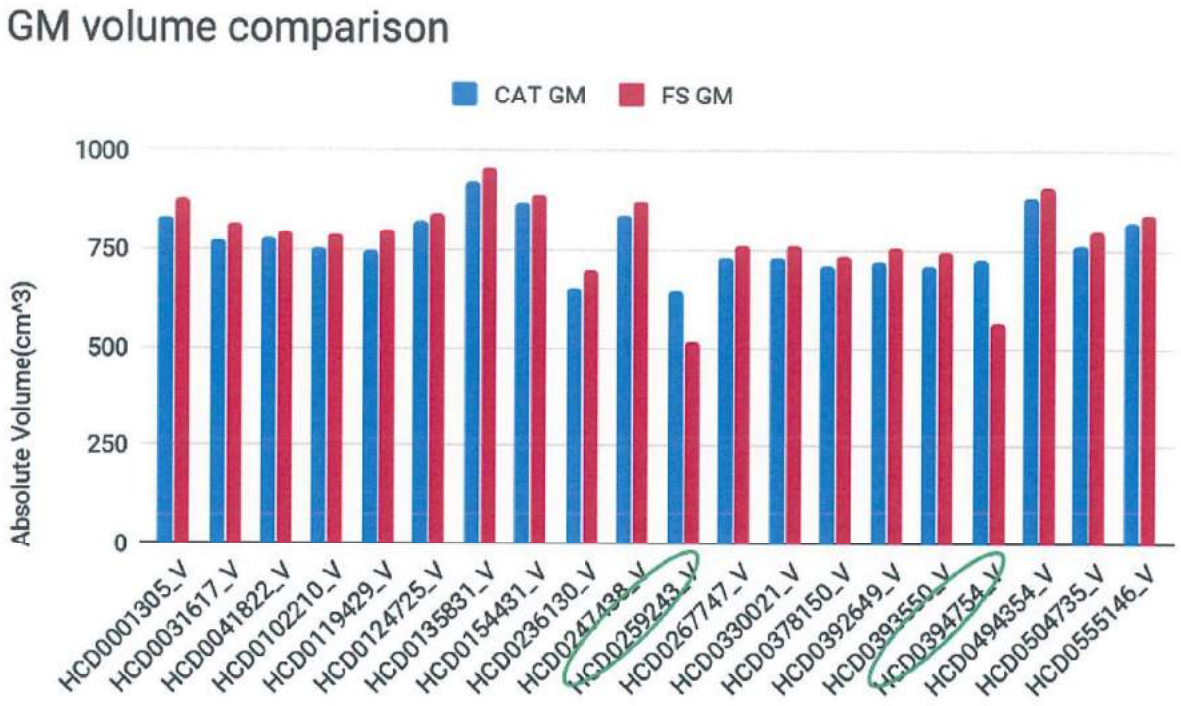

Figure 1: In comparison to FreeSurfer, CAT12 is regularly underestimating GM Volumes, with the exception of 2 subjects.

p=0.2001251396

p>0.001

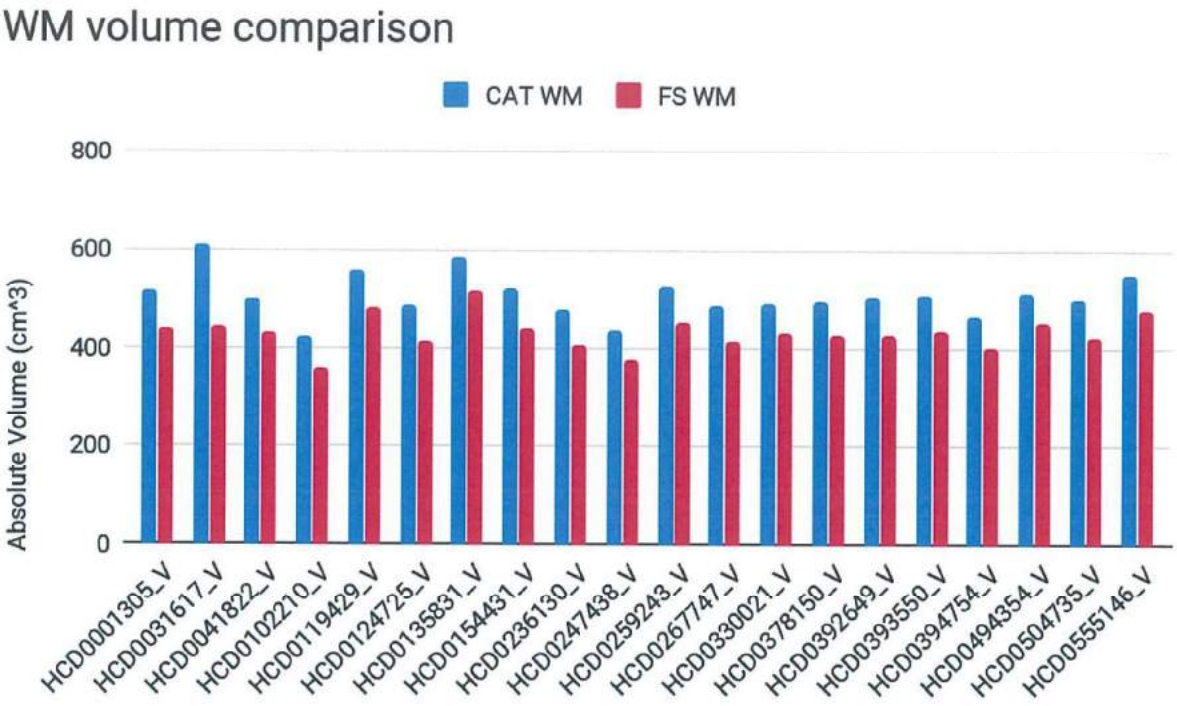

Figure 2:In comparison to FreeSurfer, CAT12 is regularly over-estimating WM Volumes

$p<0.001$

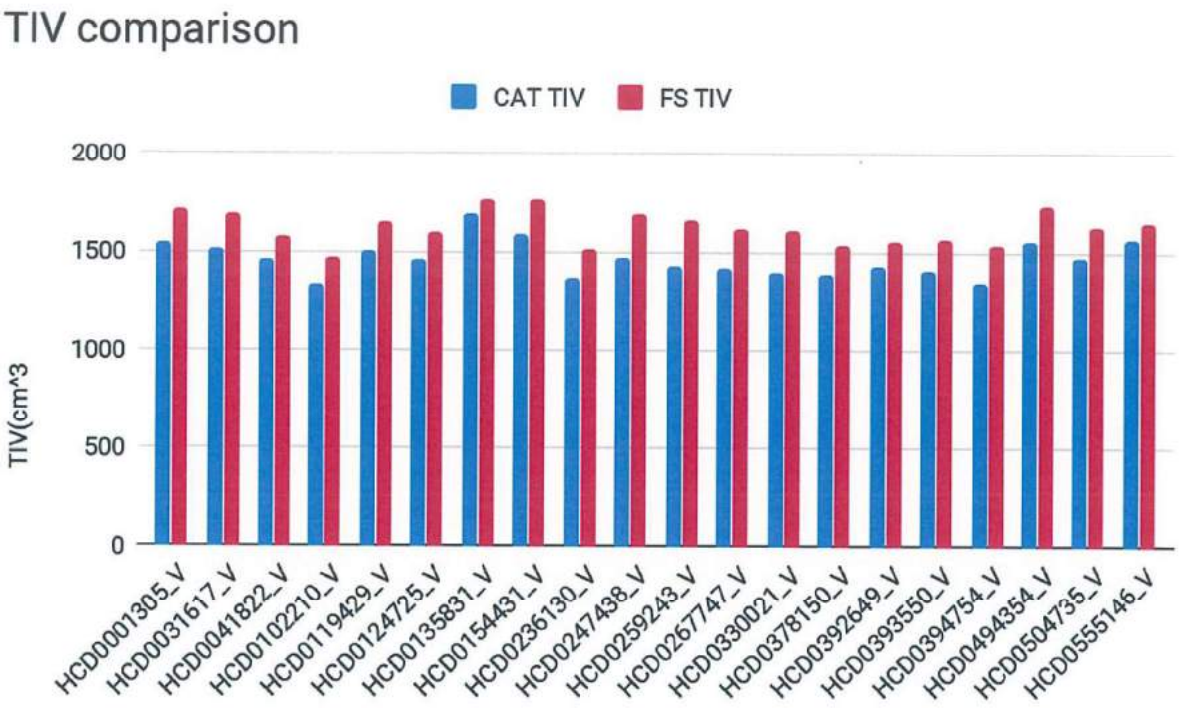

Figure 3:In comparison to FreeSurfer, CAT12 is regularly under-estimating TIV

$p<0.001$

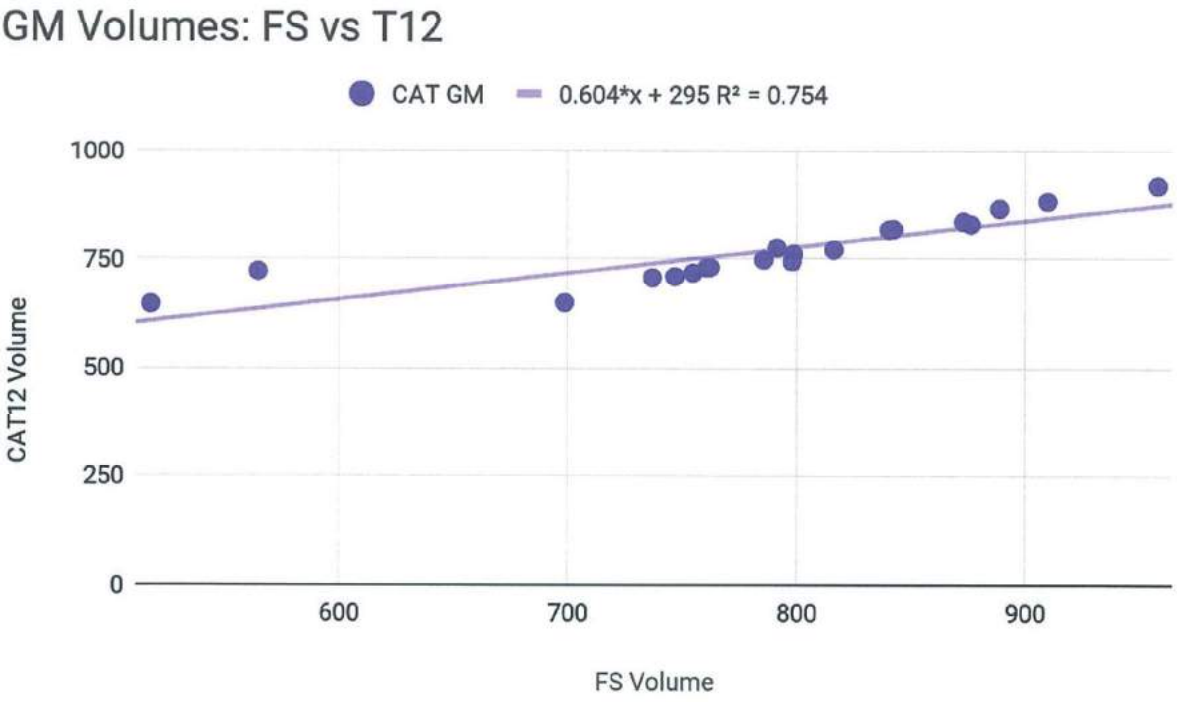

Figure 4: The greater the deviation is from a slope of 1, the greater the difference is in Volume.

R-squared=0.75

Slope: 0.604

CAT12 generally underestimates GM volume, in relation to FreeSurfer

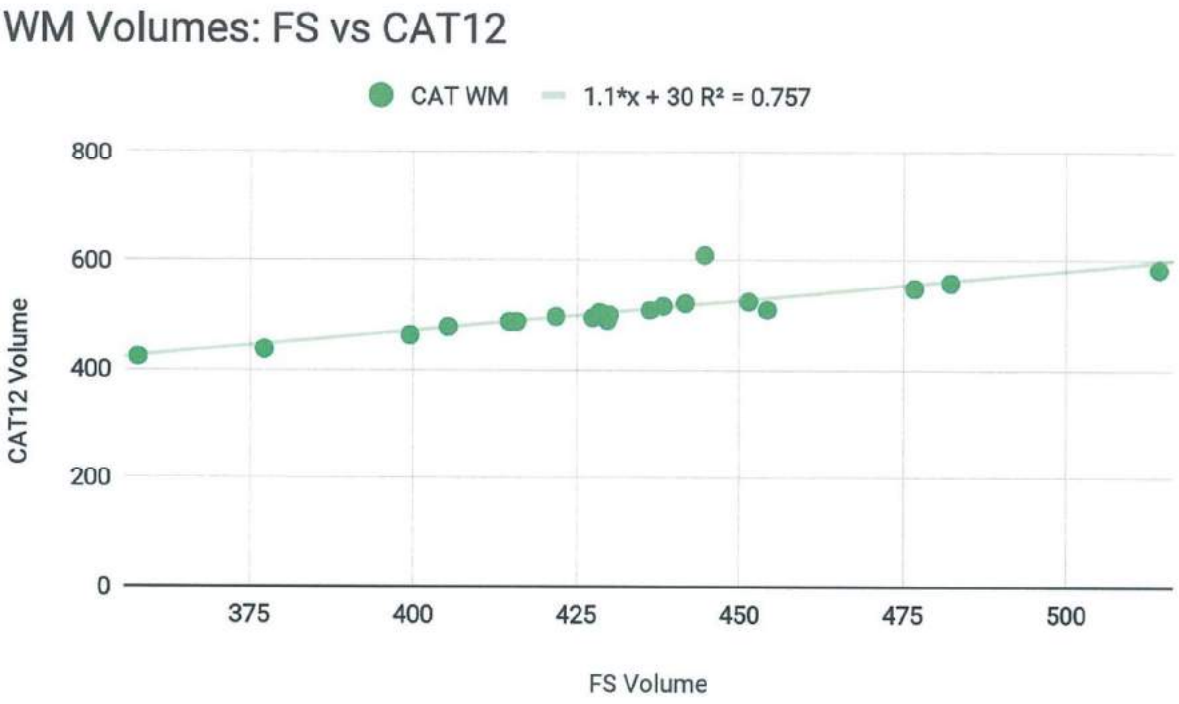

Figure 5:The greater the deviation is from a slope of 1, the greater the difference is in Volume.

R-squared=0.76

Slope: 1.1

CAT12 generally overestimates GM volume, in relation to FreeSurfer

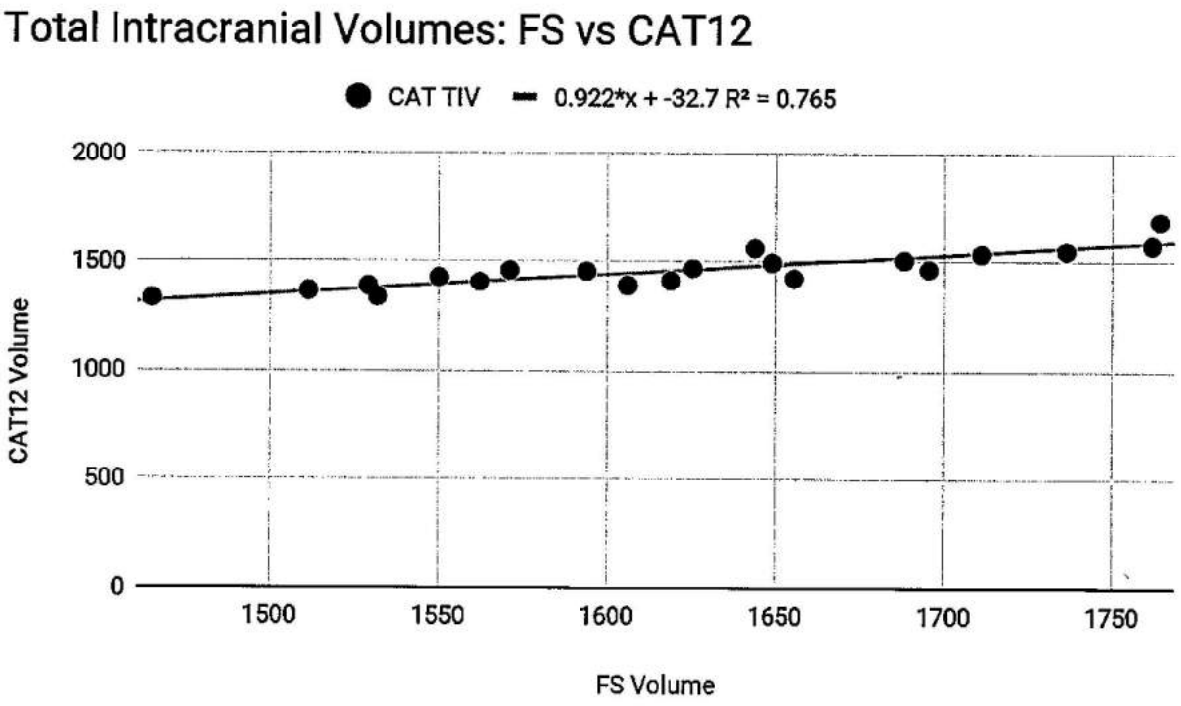

Figure 6:The greater the deviation is from a slope of 1, the greater the difference is in Volume.

R-squared=0.77

Slope: 0.922

CAT12 generally underestimates TIV volume, in relation to FreeSurfer

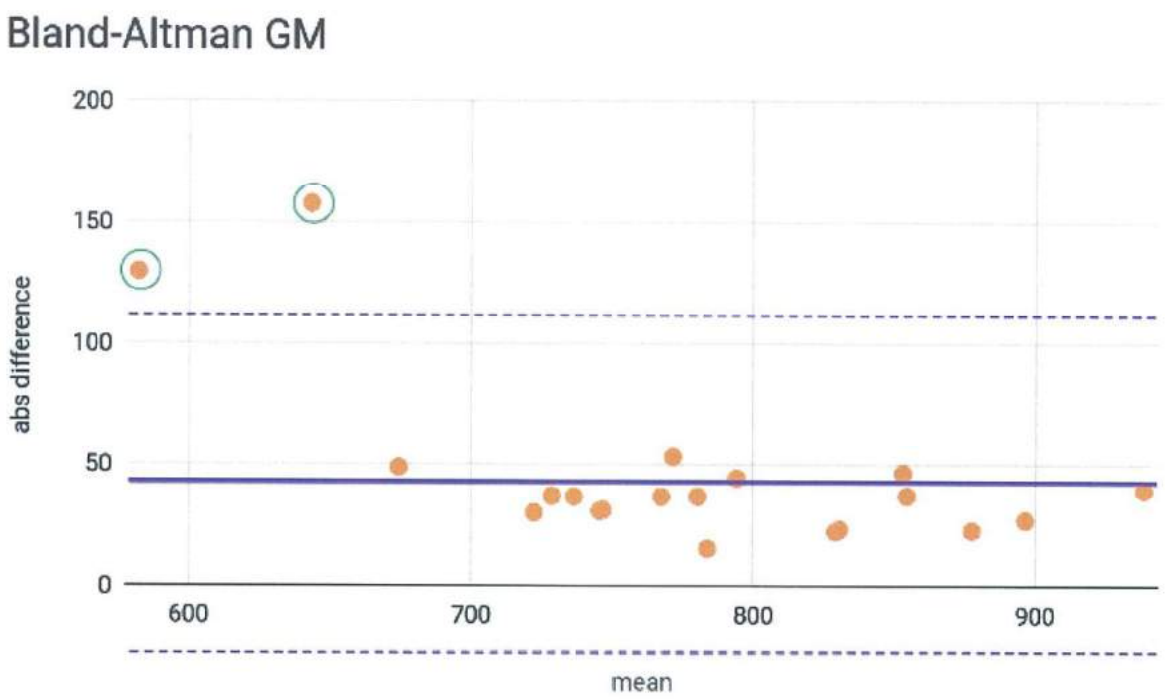

Figure 7:Used to evaluate agreement/ define outliers

Shows if the difference of volumes between algorithms for each subject is constant/proportional

Bias(mean): 45.23075917

Limits of Agreement(~95% of data):

Upper: 114.2158321

Lower: -23.75431376

Figure 8:Used to evaluate agreement/ define outliers

Shows if the difference of volumes between algorithms for each subject is constant/proportional

Bias(mean): 75.08264665

Limits if Agreement(~95% of data):

Upper: 118.7053095

Lower: 31.4599831

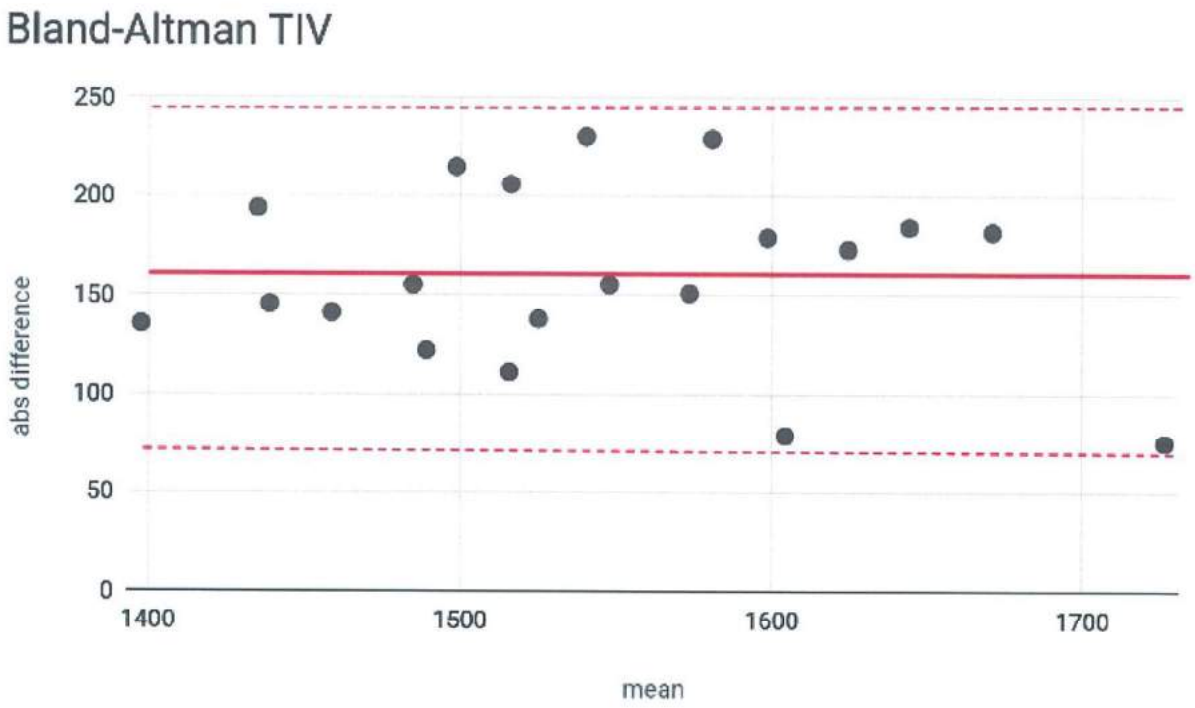

Figure 9:Used to evaluate agreement/ define outliers

Shows if the difference of volumes between algorithms for each subject is constant/proportional

Bias(mean): 160.0264306

Limits if Agreement(~95% of data):

Upper: 246.6067931

Lower: 73.4460682

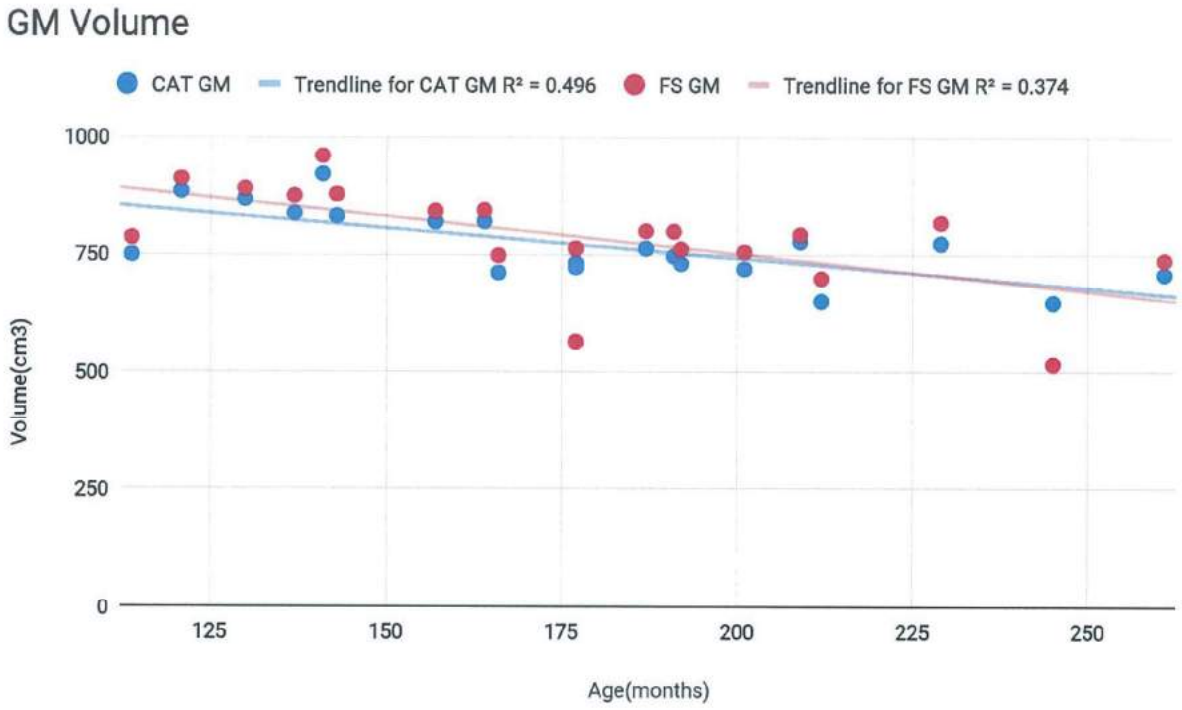

Figure 10:Trends map a general decline in GM volume as subject's age increases, for both CAT12 and FreeSurfer

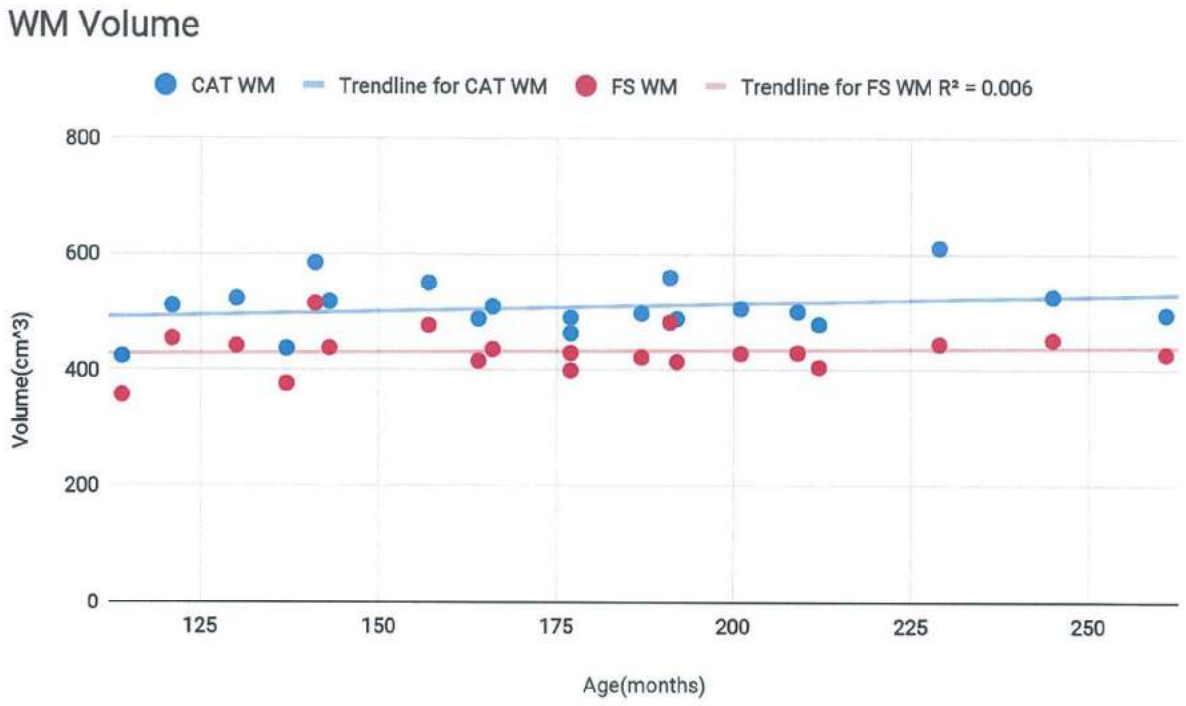

Figure 11:Trends map a slight increase in WM volume as subject's age increases, for both CAT12 and FreeSurfer

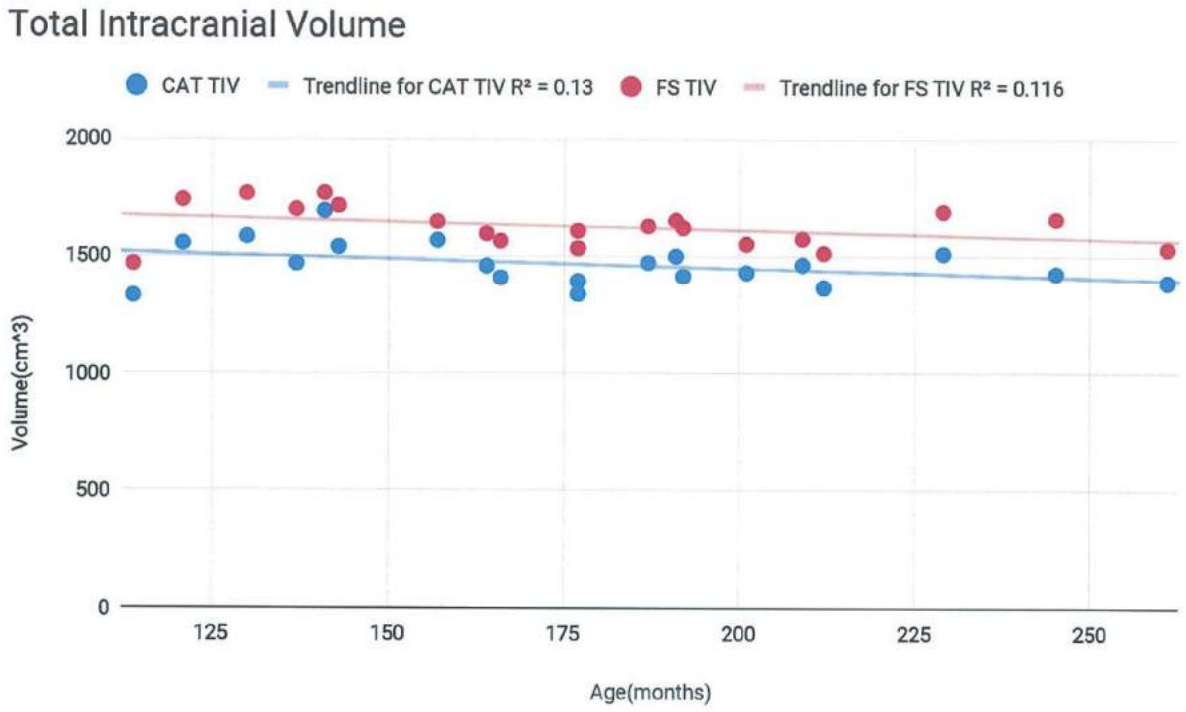

Figure 12: Trends map a general decline in TIV as subject's age increases, for both CAT12 and FreeSurfer

Discussions/Conclusions

In comparison to FreeSurfer, CAT12 is regularly underestimating gray matter volumes and overestimating white matter volumes, with the exception of 2 subjects. Ages were also correlated with cerebral volumes for future work. Trends map a slight decline in gray matter volume and a slight increase in white matter volume as subject's age increases, for both CAT12 and FreeSurfer.

References

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