A Comparison of FreeSurfer, HippUnfold, and Automatic Segmentation of Hippocampal Subfields (ASHS) for Estimating Hippocampal Volumes in Early Childhood

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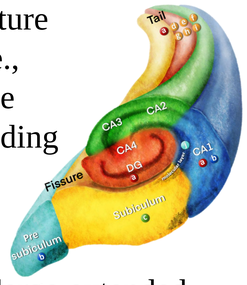
INTRODUCTION

- The hippocampus (Hc) is a complex structure comprised of multiple internal circuits (i.e., subfields) that subserve memory across the lifespan (Amaral & Lavenex, 2007), including
  - Cornu Ammonis (CA) fields 1-4,
  - Dentate Gyrus (DG)
  - Subiculum



- Hippocampal subfields are thought to undergo extended postnatal development (Lavenex & Lavenex, 2013), however studies with human children are limited, partially due to methodological limitations.
- Existing studies on Hc subfields employ a range of publicly available segmentation software packages, which have different input resolution thresholds. Yet, scarce research has investigated the performance and reliability across these packages, especially among young children.
- **AIM:** To compare Hc subfield volumes (CA1, CA2-4/DG, subiculum) extracted by three automated software packages — FreeSurfer, HippUnfold, and Automatic Segmentation of Hippocampal Subfields (ASHS), among a sample of 4-8 years old children.

METHODS

Sample: We utilized a subset of 19 children from a larger study (M_{age} = 6.85±1.59; 47.4% female)

Image Acquisition and Processing

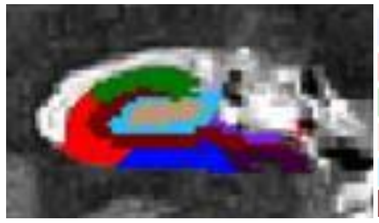
- Whole-brain T1-weighted .9mm isotropic scans were acquired for processing in FreeSurfer 7.1.1 (Fischl, 2012) and HippUnfold 1.4.1 (DeKraker et al., 2022).
- T2-weighted scans (.4mm x.4mm x 2mm) of the medial temporal lobe were acquired for ASHS processing (Yushkevich et al, 2014).

Analysis

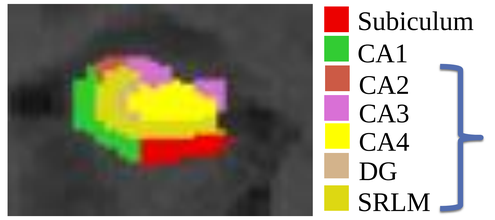
- Pearson correlations and intraclass correlations were run to investigate similarities and differences in subfield volumes extracted using the three methods.

RESULTS

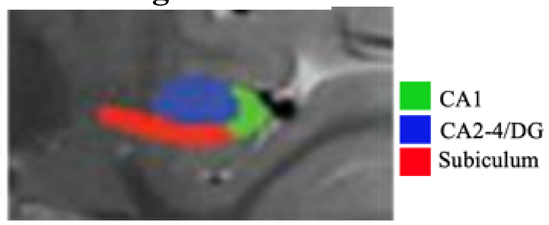
FreeSurfer Segmentation



HippUnfold Segmentation



ASHS Segmentation



Pearson Correlation Analyses

Left Hippocampus Total Volume

	FreeSurfer	HippUnfold	ASHS
FreeSurfer	--		
HippUnfold	.72**	--	
ASHS	.67**	.80***	--

Right Hippocampus Total Volume

	FreeSurfer	HippUnfold	ASHS
FreeSurfer	--		
HippUnfold	.89***	--	
ASHS	.68**	.75***	--

Left CA1

	FreeSurfer	HippUnfold	ASHS
FreeSurfer	--		
HippUnfold	.79***	--	
ASHS	.72***	.73***	--

Right CA1

	FreeSurfer	HippUnfold	ASHS
FreeSurfer	--		
HippUnfold	.88***	--	
ASHS	.67**	.63**	--

Left CA2-4/DG

	FreeSurfer	HippUnfold	ASHS
FreeSurfer	--		
HippUnfold	.58**	--	
ASHS	.68**	.55*	--

Right CA2-4/DG

	FreeSurfer	HippUnfold	ASHS
FreeSurfer	--		
HippUnfold	.75***	--	
ASHS	.64**	.70**	--

Left Subiculum

	FreeSurfer	HippUnfold	ASHS
FreeSurfer	--		
HippUnfold	.53*	--	
ASHS	.31	.58**	--

Right Subiculum

	FreeSurfer	HippUnfold	ASHS
FreeSurfer	--		
HippUnfold	.67**	--	
ASHS	.29	.45	--

- Total Hc and subfield volumes ($r_{mean\text{-}left}$ = .61; $r_{mean\text{-}right}$ = .63) derived from all methods were overall comparable bilaterally.
- Volumes of the bilateral CA1 extracted by the different packages showed the highest mean correlation (r_{mean} = .74), followed by the bilateral CA2-4/DG (r_{mean} = .65), and subiculum volumes (r_{mean} = .47).
- HippUnfold and FreeSurfer showed the strongest correlation in estimating the mean volumes across each bilateral subfield

Intraclass Correlation Analyses

- Intraclass correlations in terms of absolute agreement indicated:
  - ❑ **GOOD reliability** for left $CA1_{ICC(2,1)}$ = .75, right $CA1_{ICC(2,1)}$ = .81;
  - ❑ **MODERATE reliability** for left $total_{ICC(2,1)}$ = .71, right $total_{ICC(2,1)}$ = .62, right $CA2\text{-}4/DG_{ICC(2,1)}$ = .59;
  - ❑ **POOR reliability** for left $CA2\text{-}4/DG_{ICC(2,1)}$ = .36, left $subiculum_{ICC(2,1)}$ = .41, right $subiculum_{ICC(2,1)}$ = .12.

CONCLUSION AND NEXT STEPS

- Our analyses revealed considerable variability in the estimations of subfield volumes between the methods, especially for the bilateral subiculum. Our next steps are to:
  - ❑ Compare the three packages to our manual tracing and calculate spatial overlap between methods;
  - ❑ Investigate similarities and differences between the methods in estimating subfield volumes in the Hc head and body;
  - ❑ Test if relations between subfield volumes and memory performance differ as a function of package used.