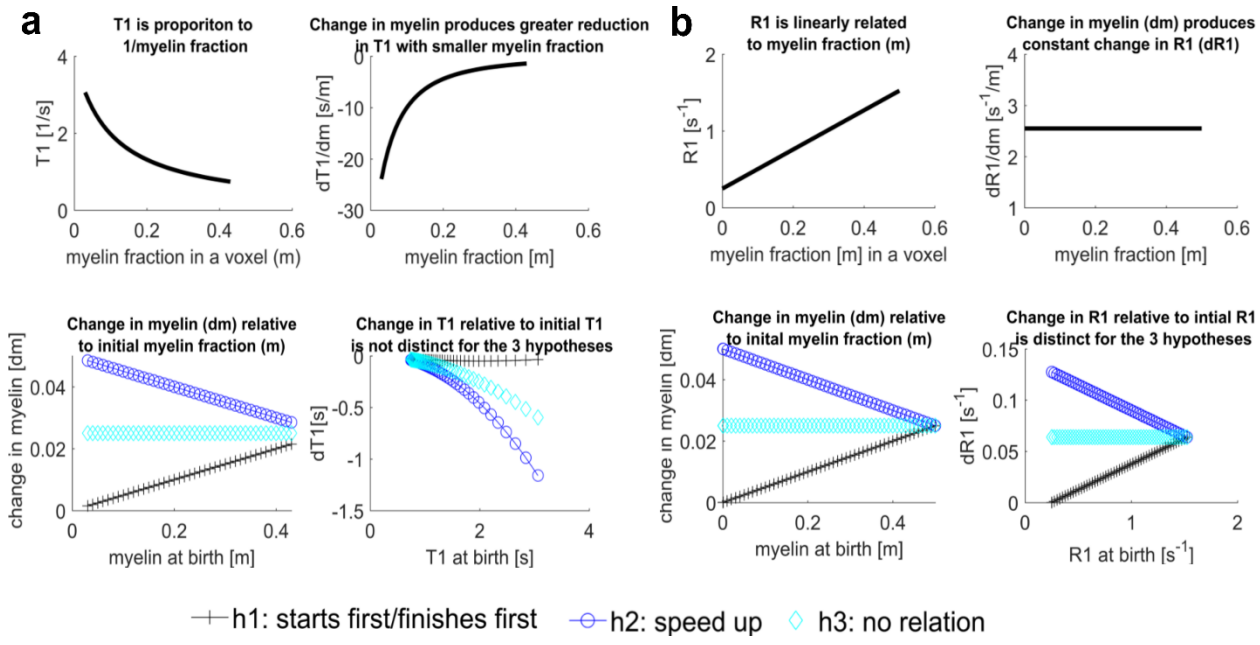
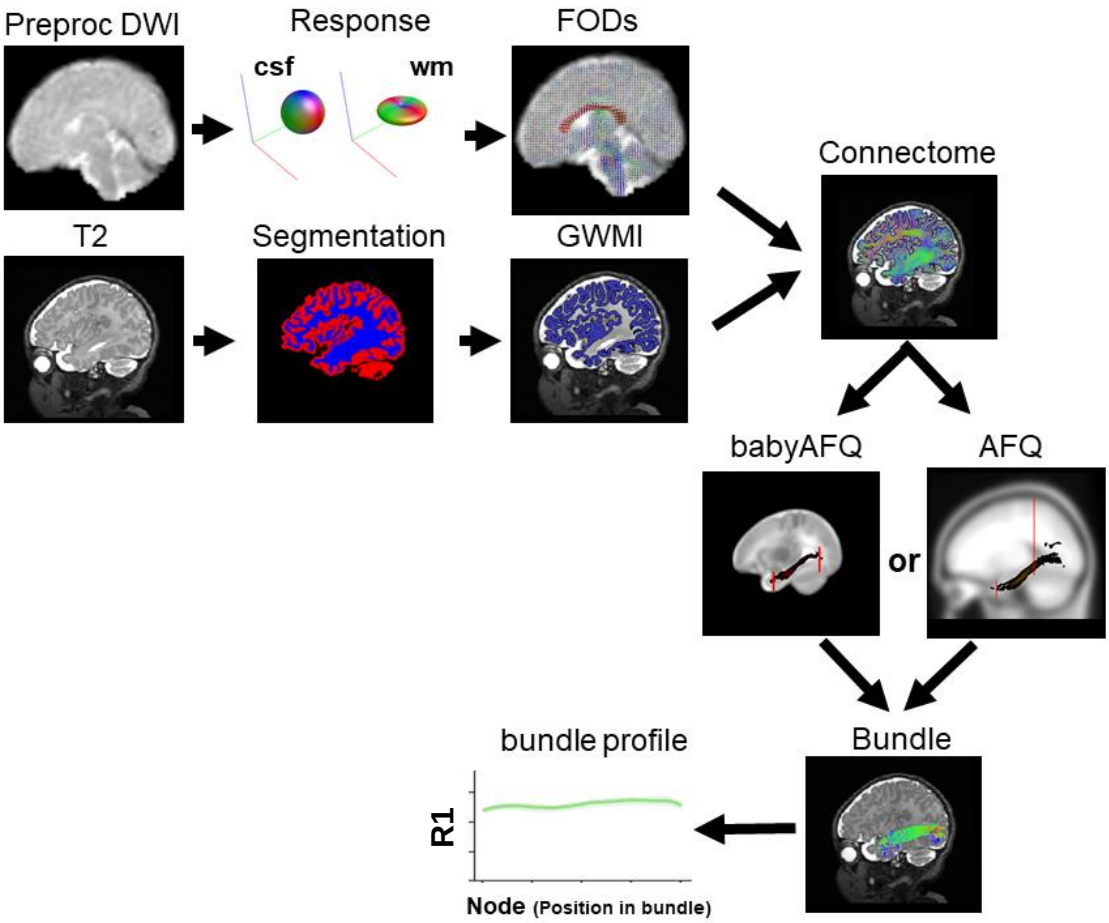
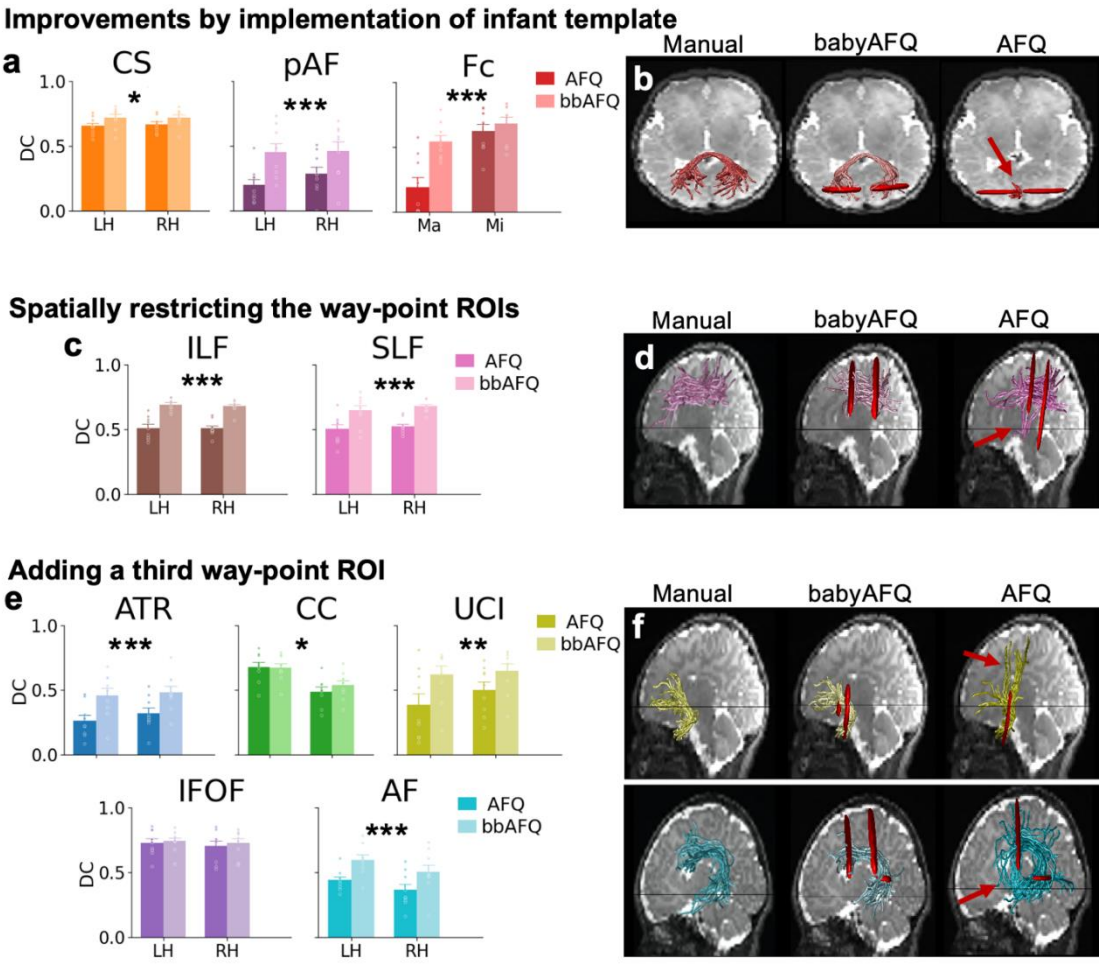


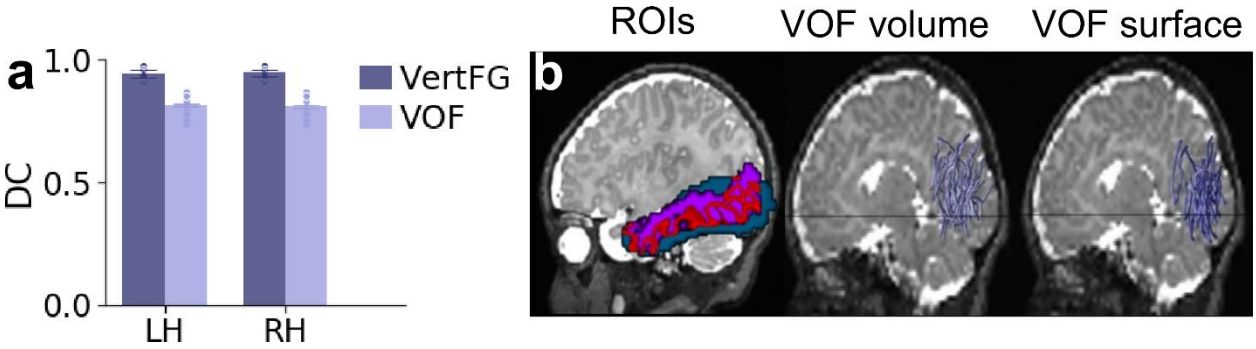

**Supplementary Figure 1.** Quantitative MRI measures of R1 (b) but not T1 (a) are linearly related to myelin content. As such, R1 is a suitable metric to distinguish between developmental hypotheses.



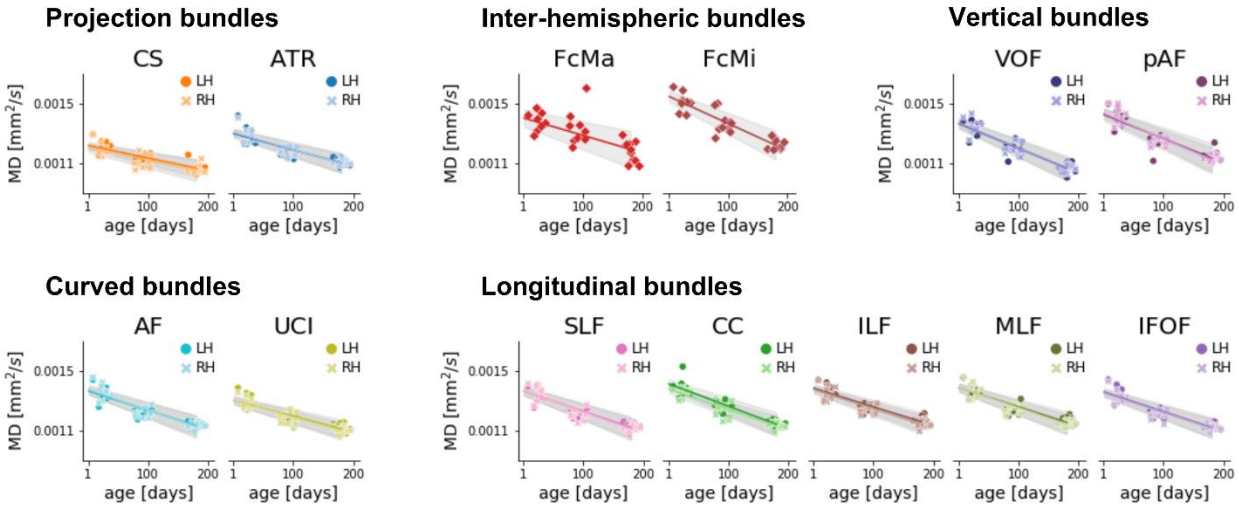

**Supplementary Figure 2.** A schematic representation of our processing pipeline. DMRI data is preprocessed and fiber density functions (FODs) are generated separately for white matter and CSF using multi-shell/multi-tissue constrained spherical deconvolution (CSD). A tissue segmentation is generated from anatomical data and used for anatomically constrained tractography (ACT). Seeds for tractography are placed at the gray/white matter interface (GWMI) and whole brain connectomes with 2 million streamlines are created for each infant and timepoint. Bundles are delineated from the whole brain connectome using either babyAFQ, which was developed here and optimized for infant data or AFQ, which was developed from adult data and serves as a benchmark. R1 development is then evaluated across the length of each bundle identified with babyAFQ.



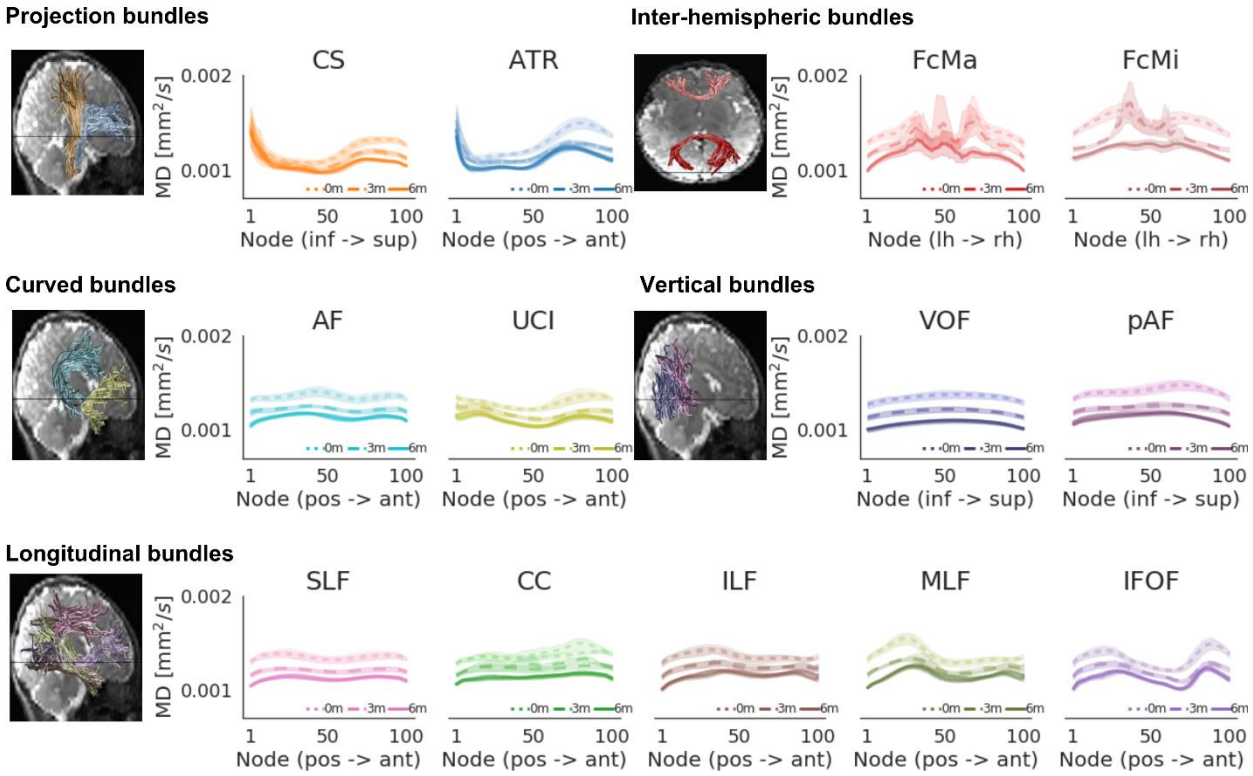

**Supplementary Figure 3.** Adapting AFQ for the infant brain (babyAFQ) improves the identification of white matter bundles in newborns. Infant-specific adaptations included the usage of an infant template brain for definition of way-point ROIs for all tracts, spatially restricted way-point ROIs for the ILF and SLF and the introduction of a third way-point ROIs for "curvy" bundles. a,c,e: Bar graphs compare AFQ and babyAFQ to manually delineated "gold-standard" bundles in newborns (N=9). Higher dice coefficients (DCs) indicate more spatial overlap with manual tracts. Repeated measures ANOVAs (factors: AFQ and hemisphere / anteriority) show main effect of AFQ for most bundles: CS: $F(8)=11.45$, $p=0.01$, pAF: $F(8)=56.82$, $p=0.0001$, Fc: $F(8)=20.80$, $p=0.0007$, ILF: $F(8)=159.63$, $p<0.0001$, SLF: $F(8)=99.46$, $p<0.0001$, ATR: $F(8)=123.11$, $p<0.0001$, CC: $F(8)=9.70$, $p=0.01$, UCI: $F(8)=21.34$, $p=0.008$, IFOF: $F(8)=1.06$, $p=0.33$, AF: $F(8)=36.25$, $p=0.0003$. Bars show mean DCs ± SEM. *p<0.05, **p<0.01, ***p<0.001. Circles indicate individual infants' data. b,d,f: Examples of bundles delineated manually as well as with AFQ and babyAFQ presented in individual subject's left hemisphere. Abbreviations: LH: left hemisphere, RH: right hemisphere, CS: cortico-spinal tract, pAF: posterior arcuate fasciculus, Fc: forceps (Ma=forceps major; Mi=forceps minor), ILF: inferior longitudinal fasciculus, SLF: superior longitudinal fasciculus, ATR: anterior thalamic radiation, CC: cingulum cingulate, UCI: uncinate fasciculus, IFOF: inferior frontal occipital fasciculus, AF: arcuate fasciculus.



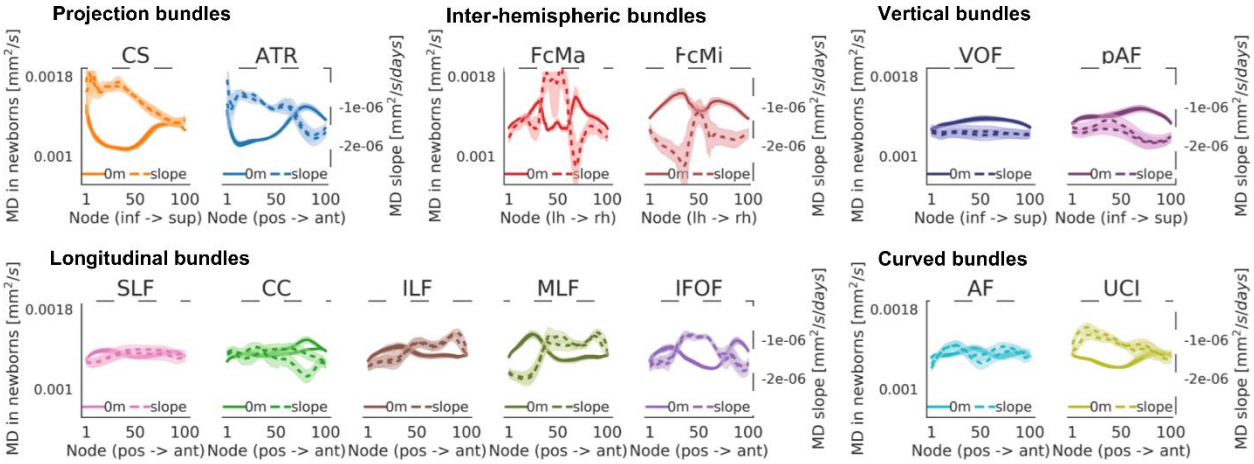

**Supplementary Figure 4.** Tracts identified as being part of the VOF are similar regardless of whether surface or volume waypoint ROIs are used. While AFQ uses surface ROIs to define the VOF, babyAFQ offers both surface and volume ROIs to define this bundle, as to date it is difficult to generate cortical surfaces in infants. a. Bar graph shows DC for tracts identified using surface ROIs and volume ROIs. Dark bars indicate overlap of all vertical tracts and light bars indicate overlap of the VOF bundle identified with both approaches. Bars show mean DC ± SEM separately for both hemispheres. Circles indicate individual infants' data. b. ROIs and identified VOF bundles in an example subject. Left panel: purple outline shows an example surface ROI, blue box shows an example volume ROI and red outline indicates gray-white matter interface within volume ROI. Middle panel: VOF identified using a volume ROI. Right panel: VOF identified using a surface ROI. Abbreviations: LH: left hemisphere, RH: right hemisphere, VertFG: vertical fiber group, VOF: vertical occipital fasciculus.




**Supplementary Figure 5.** MD of white matter bundles linearly decreases from birth to 6 months of age. Mean MD of each bundle as a function of age in days. Each point is a participant; markers indicate hemisphere; lines indicate LMM prediction; lines for both hemispheres fall on top of each other; gray shaded regions indicate 95% confidence intervals. Abbreviations: MD: mean diffusivity, LH: left hemisphere, RH: right hemisphere, CS: cortico-spinal tract, ATR: anterior thalamic radiation, FcMa: forceps major; FcMi: forceps minor, VOF: vertical occipital fasciculus, pAF: posterior arcuate fasciculus, AF: arcuate fasciculus, UCI: uncinate fasciculus, SLF: superior longitudinal fasciculus, CC: cingulum cingulate, ILF: inferior longitudinal fasciculus, MLF: middle longitudinal fasciculus, IFOF: inferior frontal occipital fasciculus.



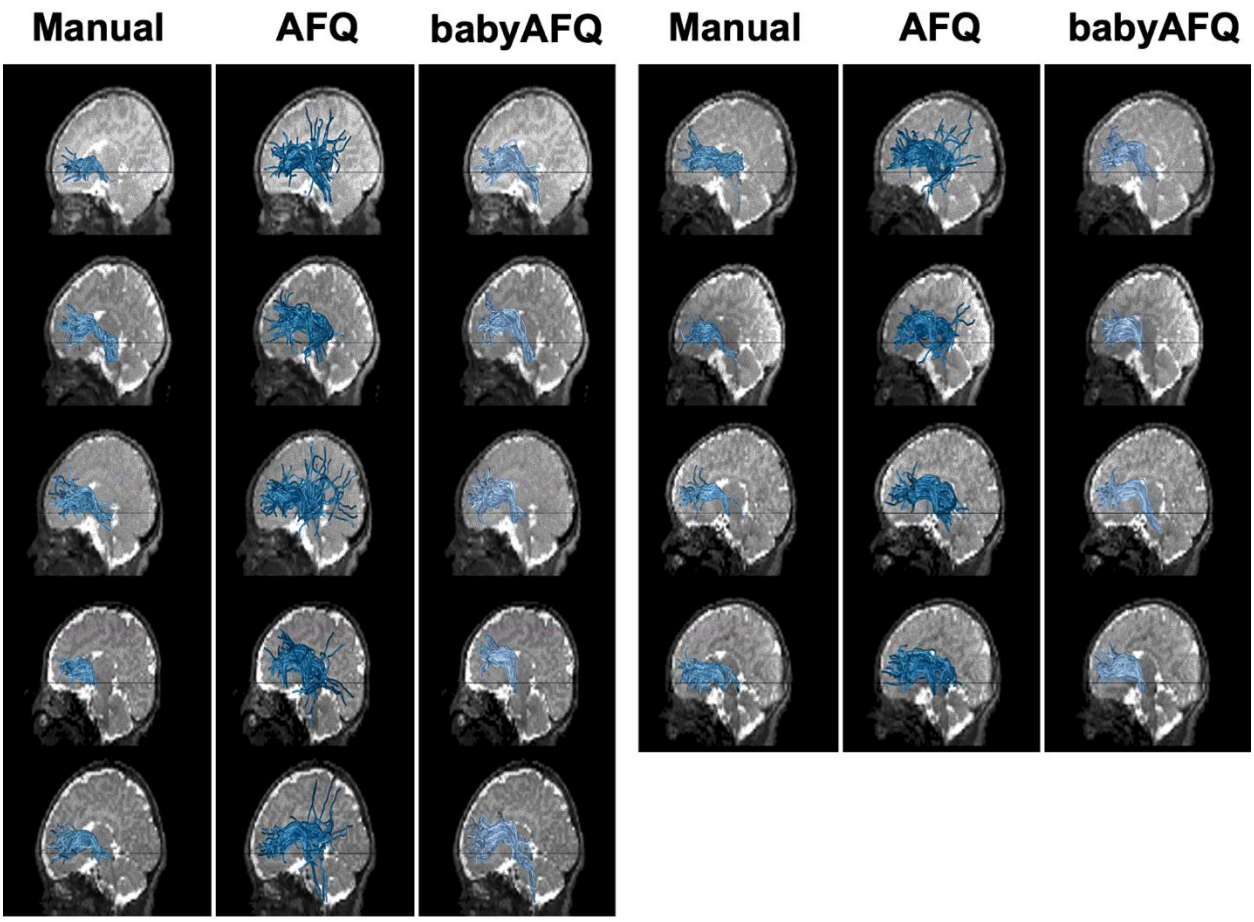

**Supplementary Figure 6.** Development of MD along each bundle. Mean MD across infants is displayed in both hemispheres (lines for the two hemispheres fall on top of each other) along the length of each bundle in newborns (0m, dotted line), 3-months-olds (3m, dashed line), and 6-months-olds (6m, solid line). Shaded regions: 95% confidence intervals. Left panels show the bundles in a representative newborn. Abbreviations: MD: mean diffusivity, CS: cortico-spinal tract, ATR: anterior thalamic radiation, FcMa: forceps major; FcMi: forceps minor, VOF: vertical occipital fasciculus, pAF: posterior arcuate fasciculus, AF: arcuate fasciculus, UCI: uncinate fasciculus, SLF: superior longitudinal fasciculus, CC: cingulum cingulate, ILF: inferior longitudinal fasciculus, MLF: middle longitudinal fasciculus, IFOF: inferior frontal occipital fasciculus.



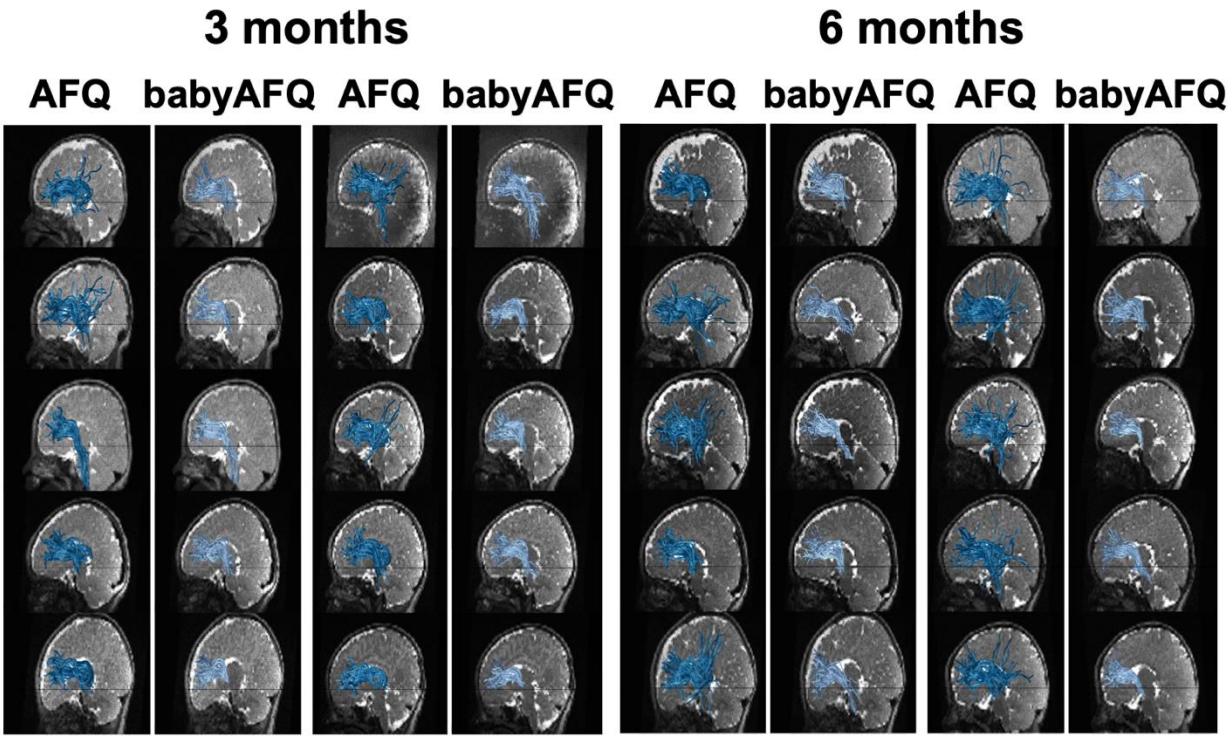

**Supplementary Figure 7.** MD development rate varies along the length of each bundle. Each panel jointly shows the measured MD in newborns (left y axis, solid line) and the slope of MD development (right y axis, dashed line) at each node along the bundle. Faster development (more negative slope) corresponds to lower values of dashed lines. Higher MD in newborns correspond to higher values in solid lines. Lines from both hemispheres are presented separately but fall on top of each other. Shaded regions indicate standard error of measured MD in newborns or slope of MD development, respectively. Abbreviations: MD: mean diffusivity, CS: cortico-spinal tract, ATR: anterior thalamic radiation, FcMa: forceps major; FcMi: forceps minor, VOF: vertical occipital fasciculus, pAF: posterior arcuate fasciculus, AF: arcuate fasciculus, UCI: uncinate fasciculus, SLF: superior longitudinal fasciculus, CC: cingulum cingulate, ILF: inferior longitudinal fasciculus, MLF: middle longitudinal fasciculus, IFOF: inferior frontal occipital fasciculus.

**Supplementary Figure 8.** BabyAFQ successfully identifies all bundles in all infants and timepoints. On the following pages, we show each individual's bundles identified with babyAFQ as well as AFQ and manually (where applicable). Data is sorted by bundle. Bundles identified with babyAFQ show the expected spatial extent and trajectory across all participants.

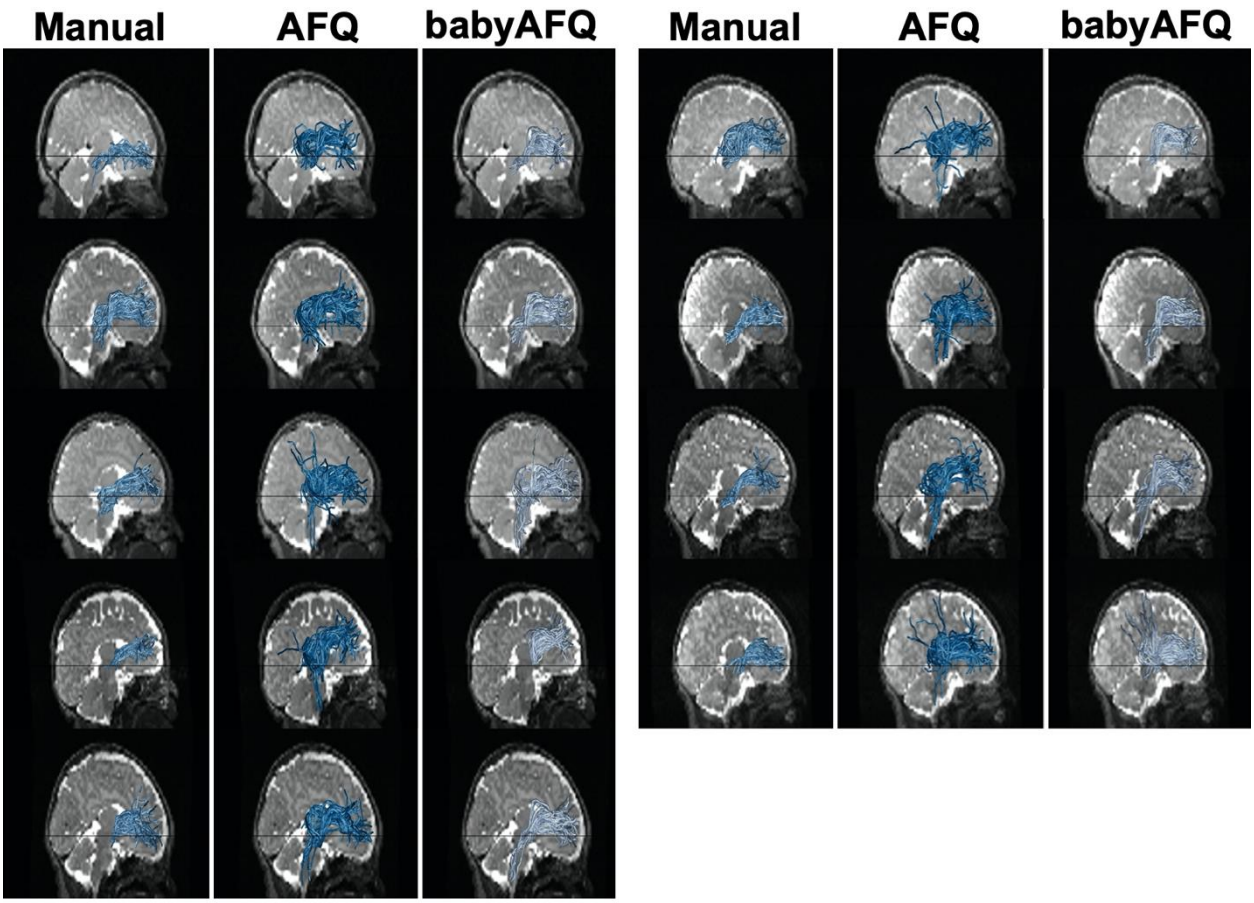
# Left Anterior Thalamic Radiation
# Newborn



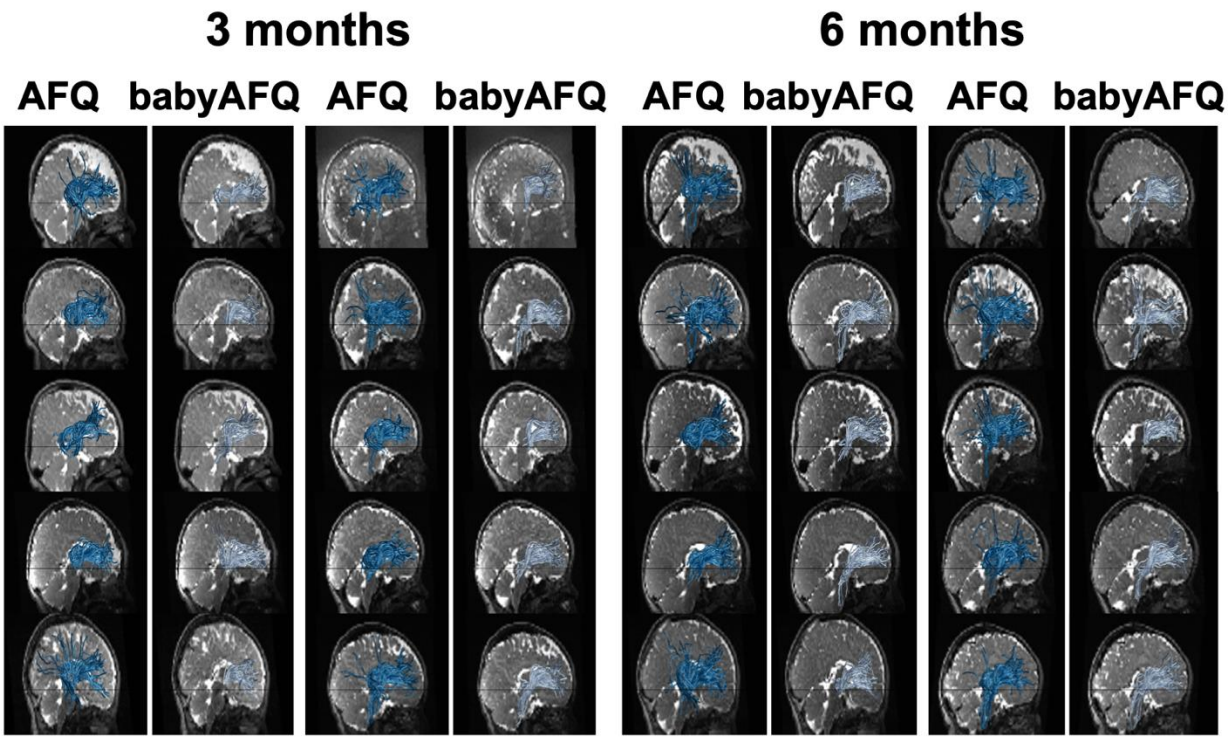
# Left Anterior Thalamic Radiation



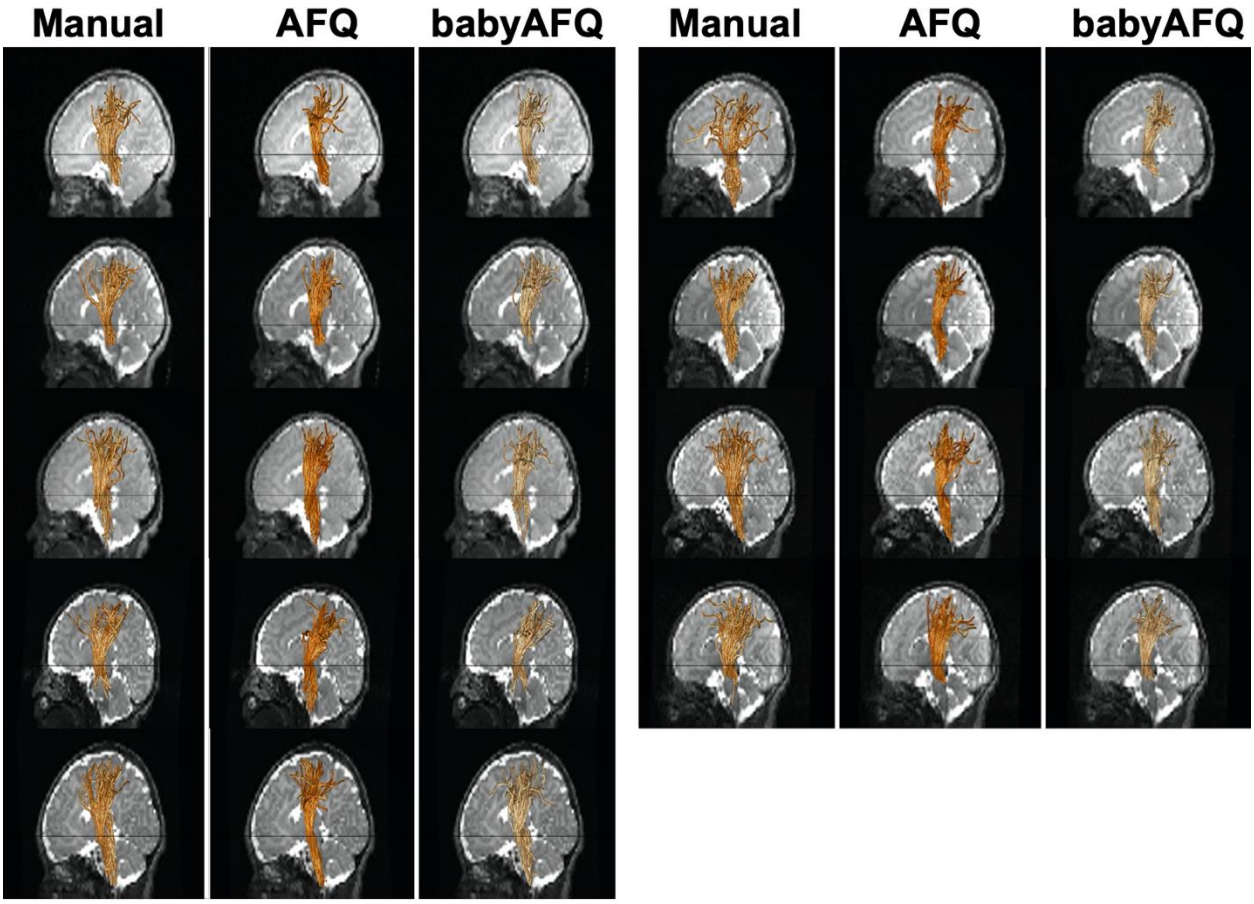
# Right Anterior Thalamic Radiation
# Newborn



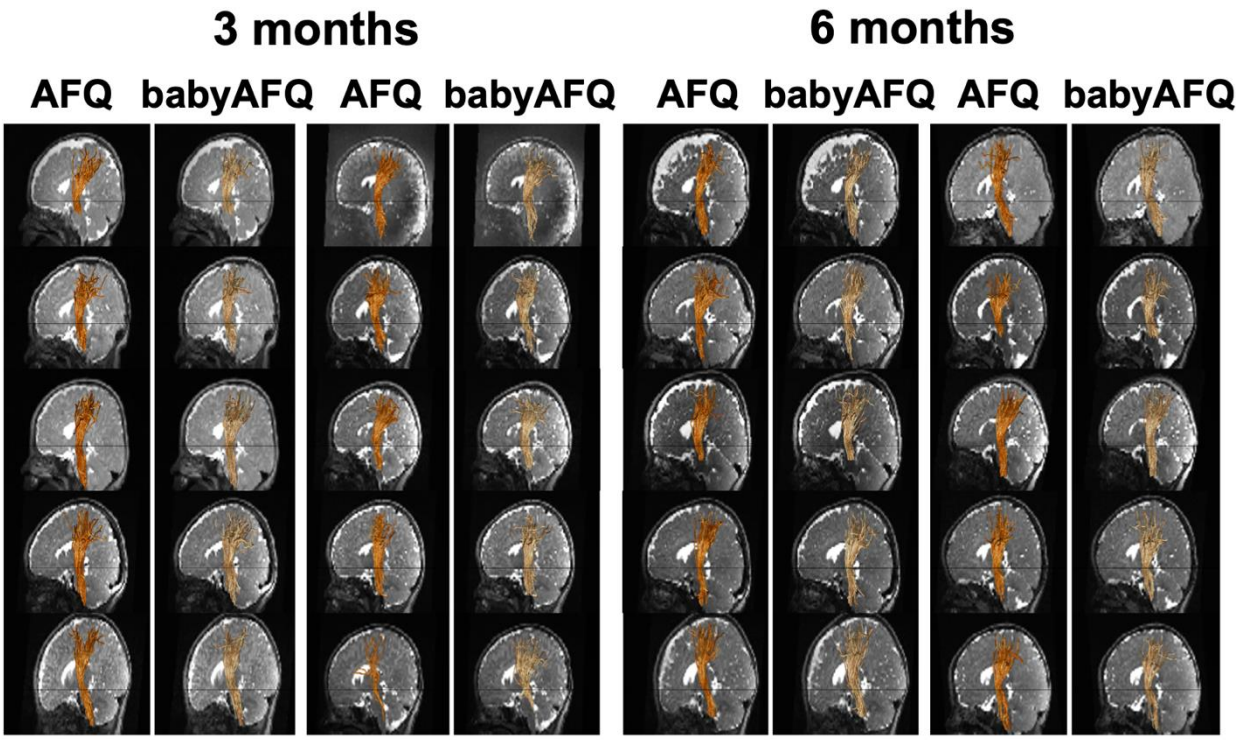
# Right Anterior Thalamic Radiation



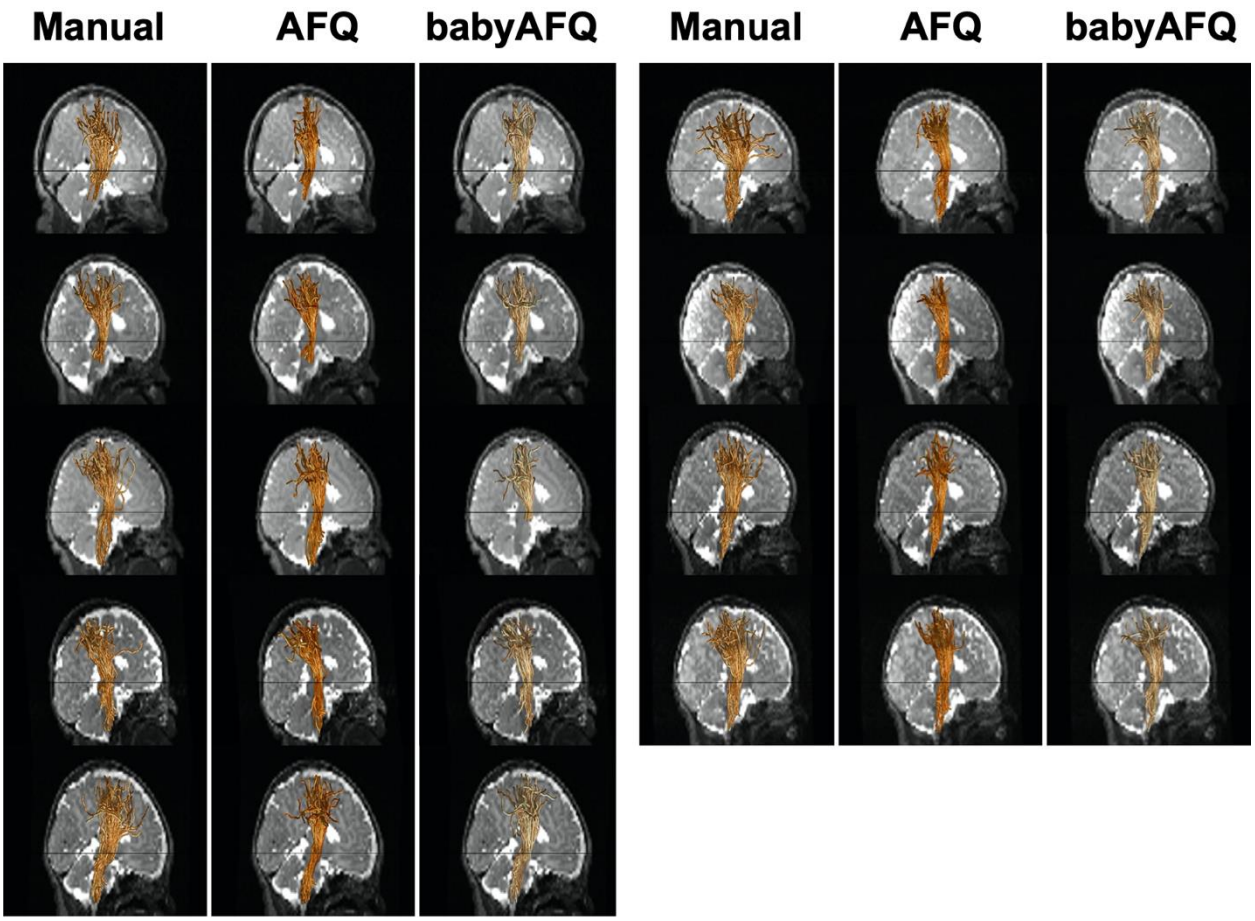
# Left Corticospinal Tract
# Newborn



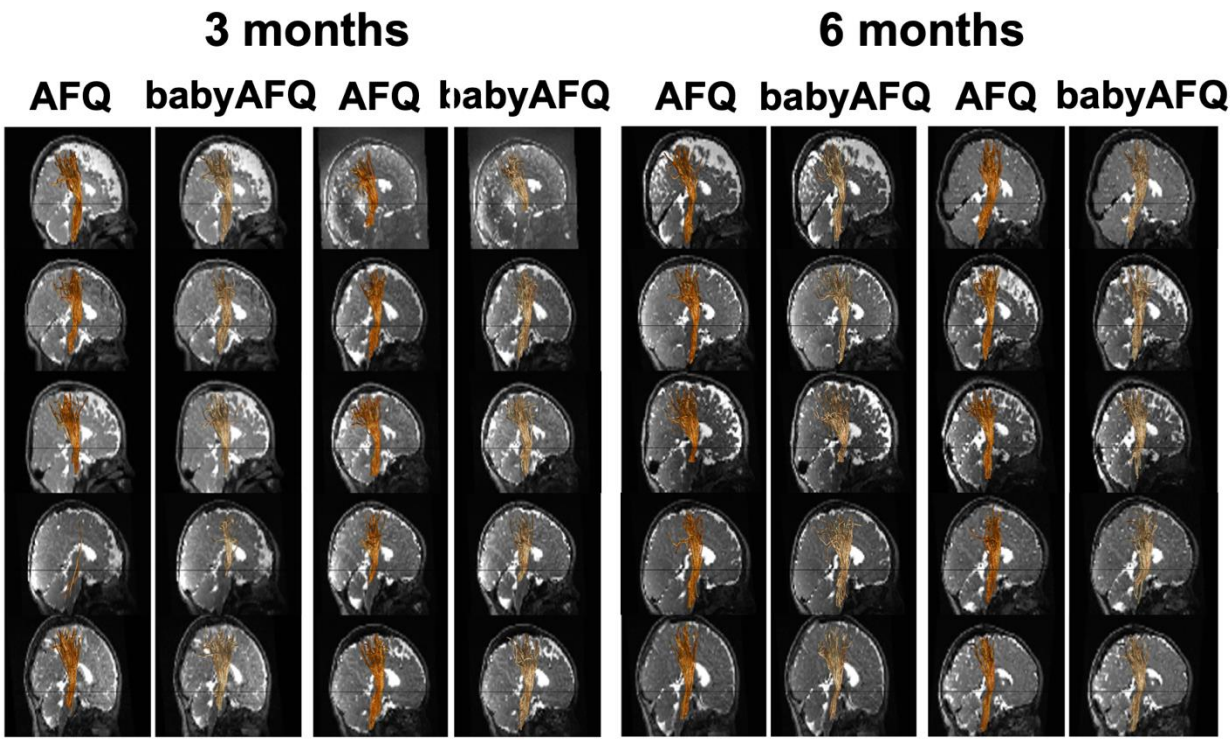
# Left Corticospinal Tract



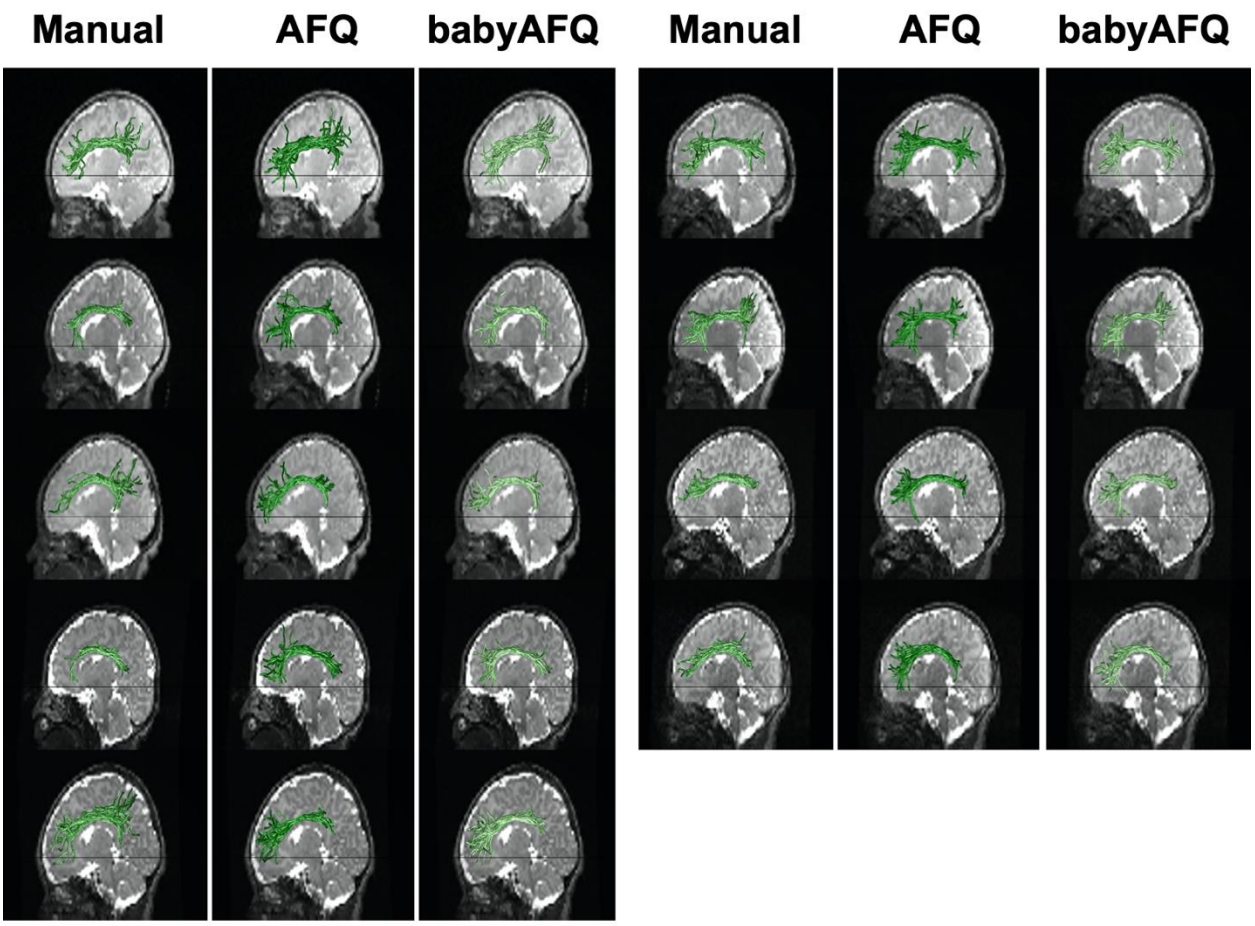
# Right Corticospinal Tract
# Newborn



# Right Corticospinal Tract



# Left Cingulum Cingulate
# Newborn



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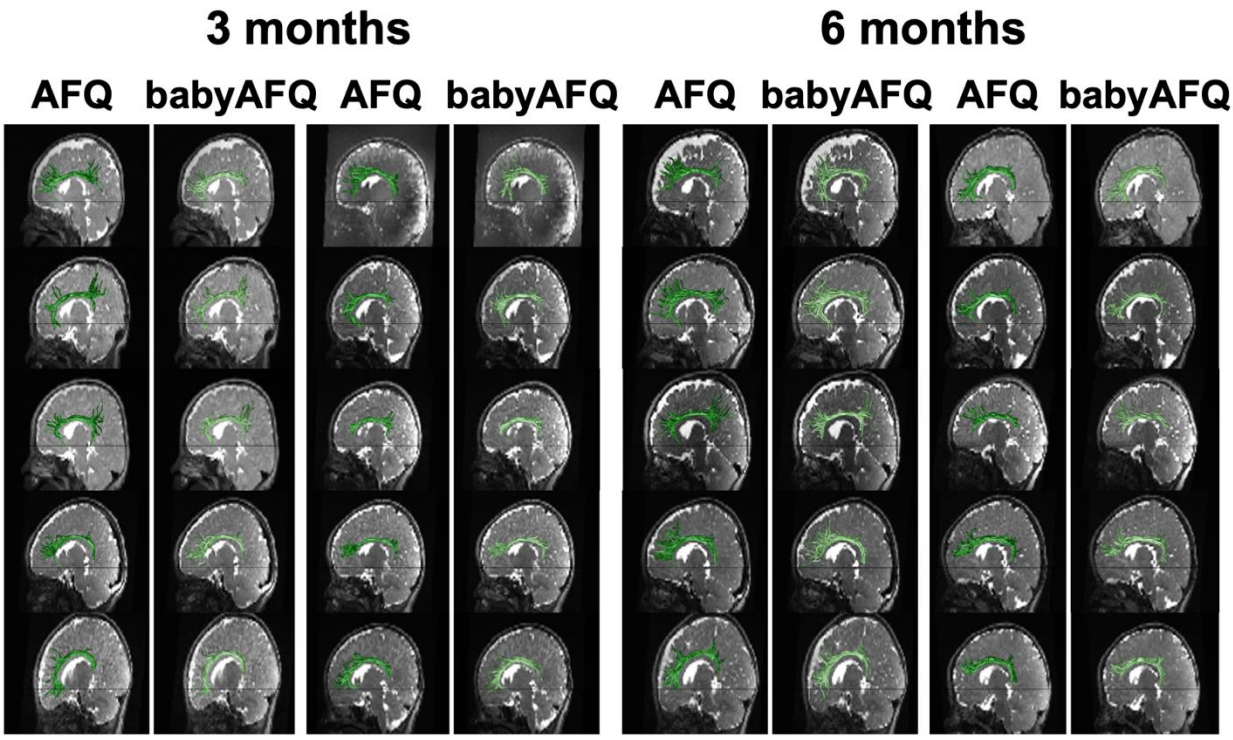

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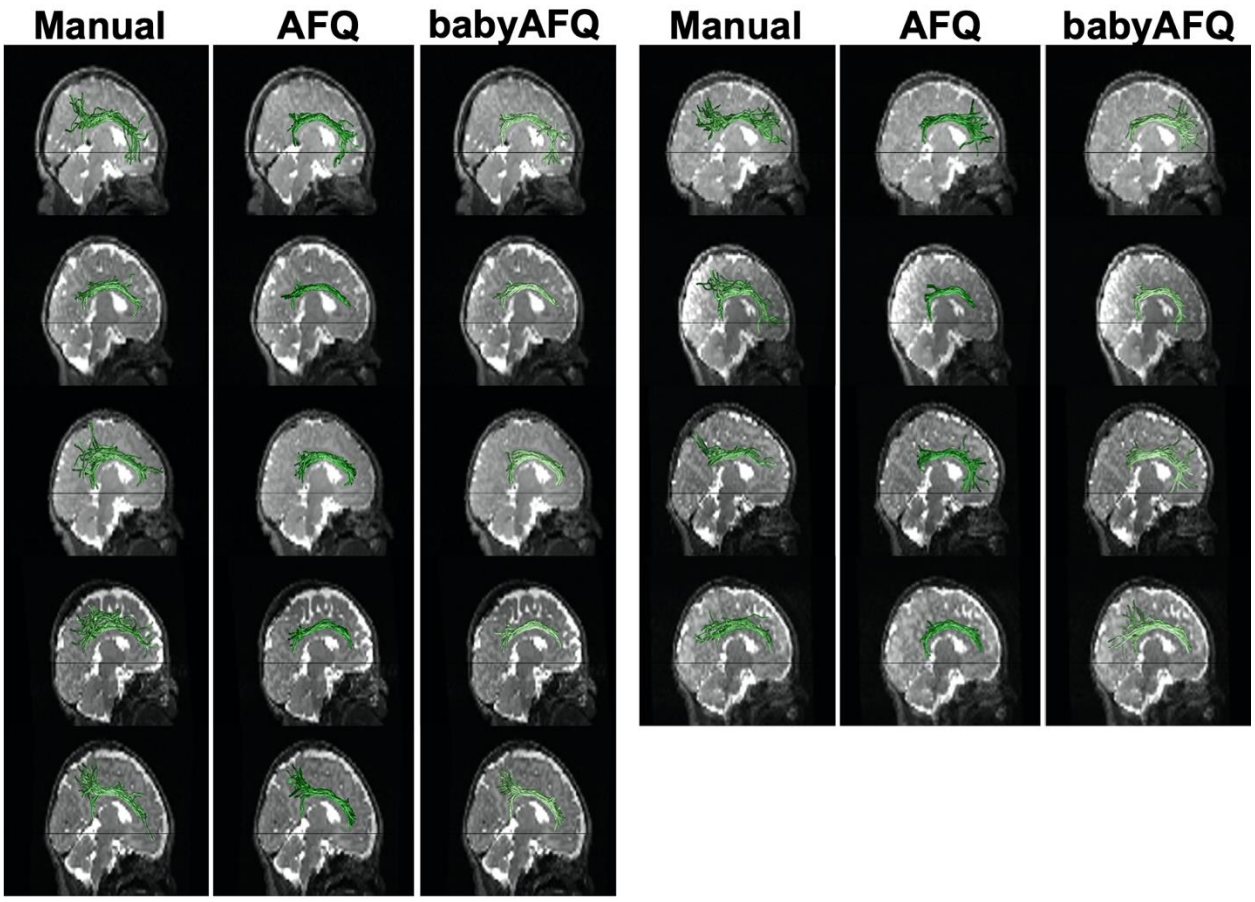
# Newborn



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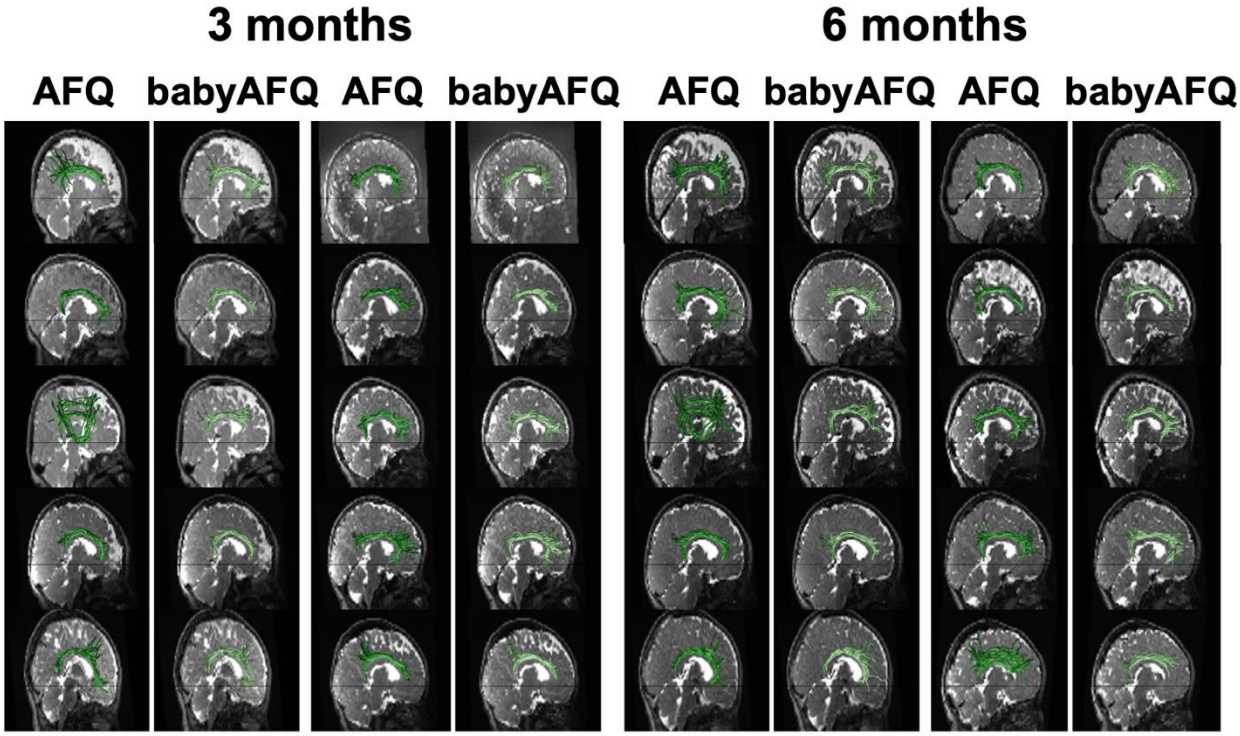
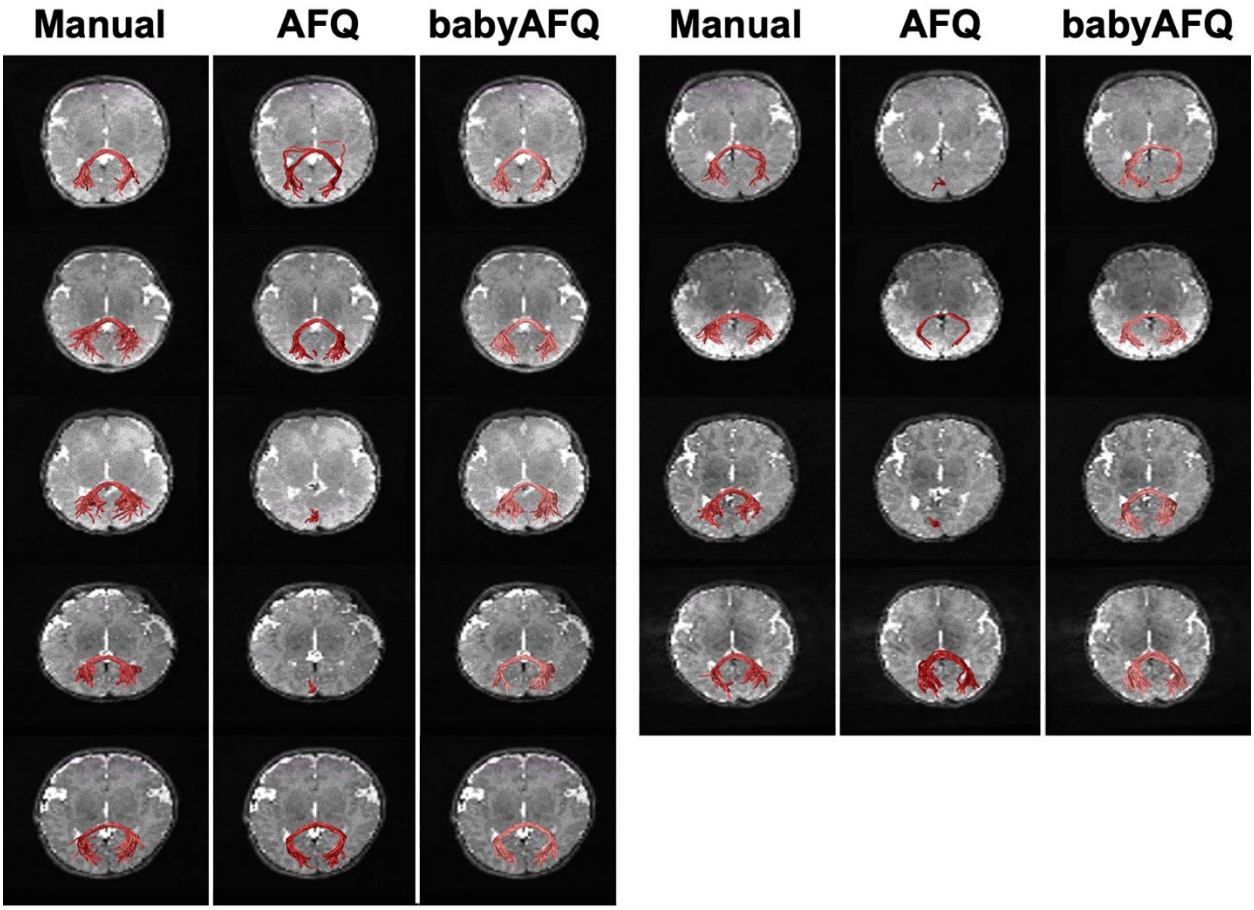
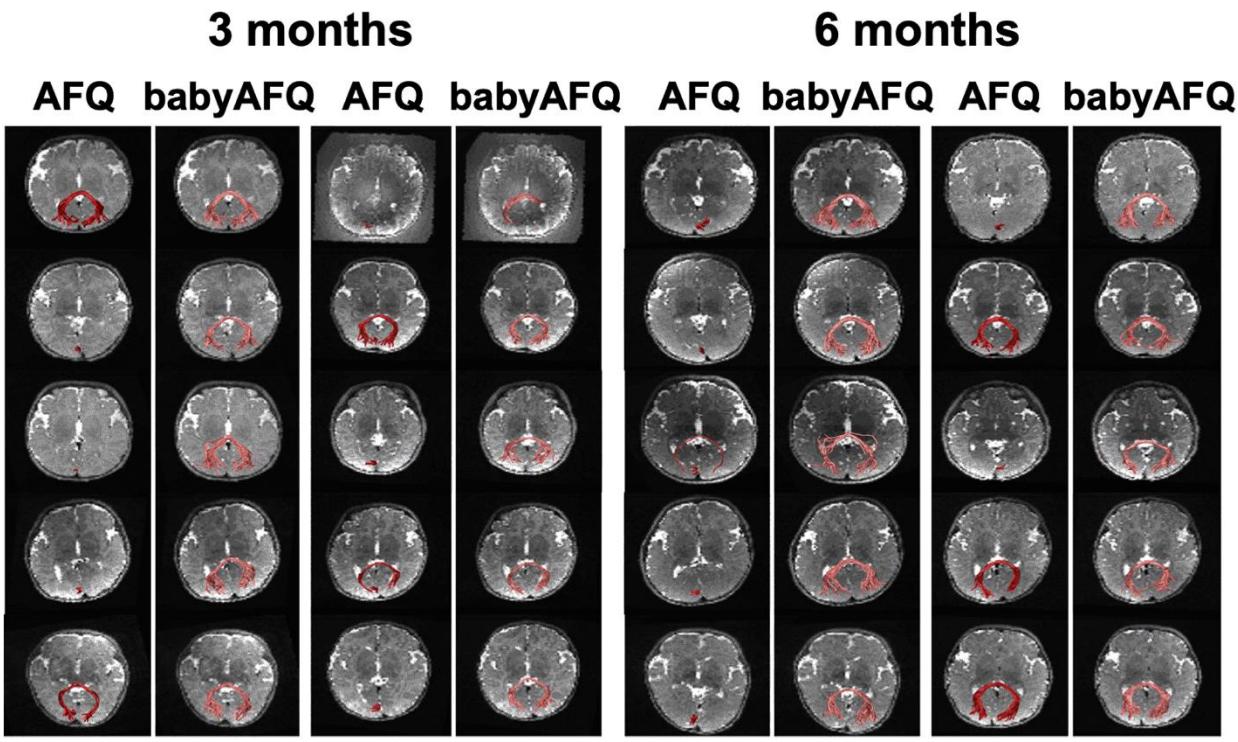


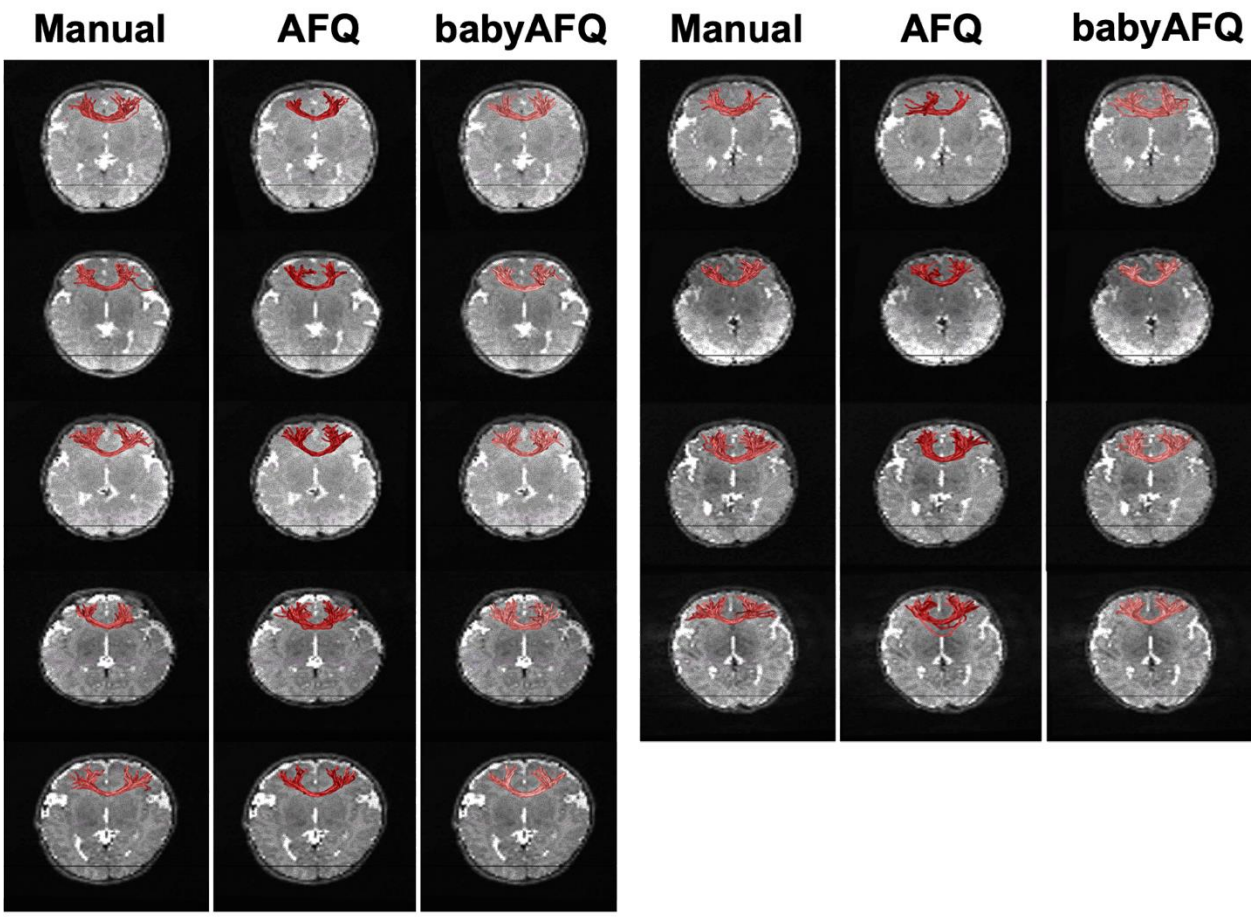
# Forceps Major
# Newborn



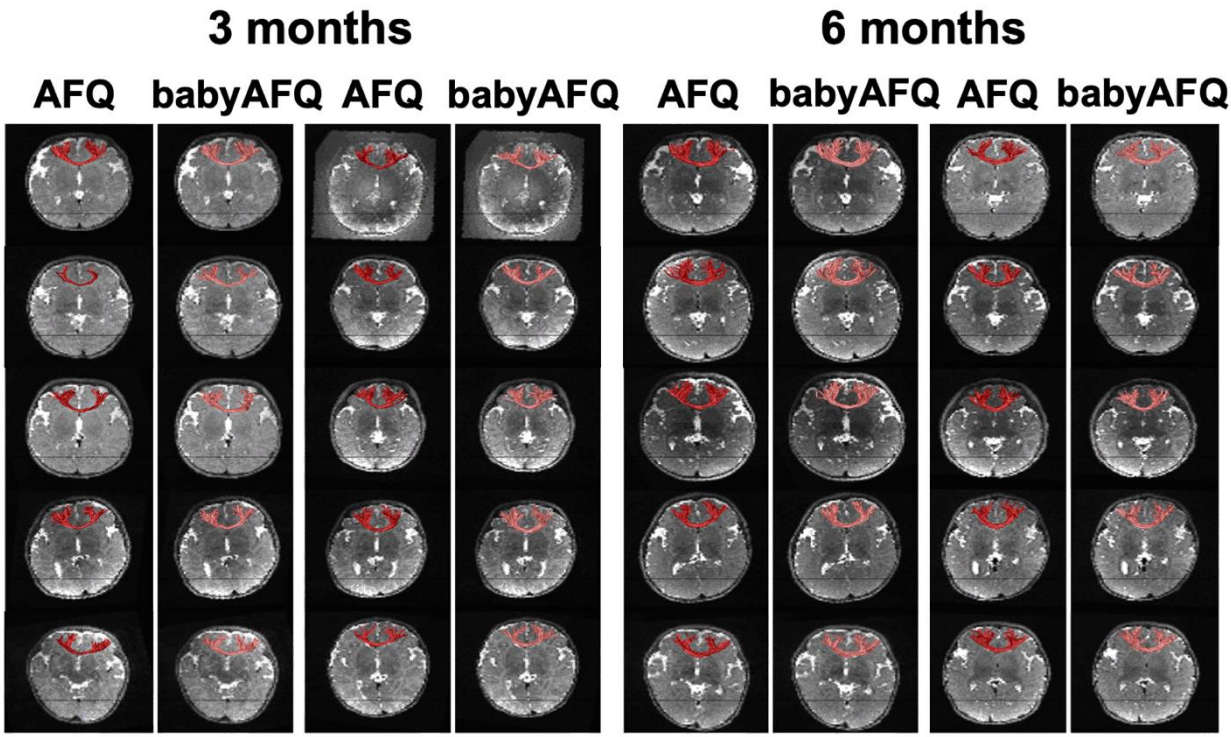
# Forceps Major



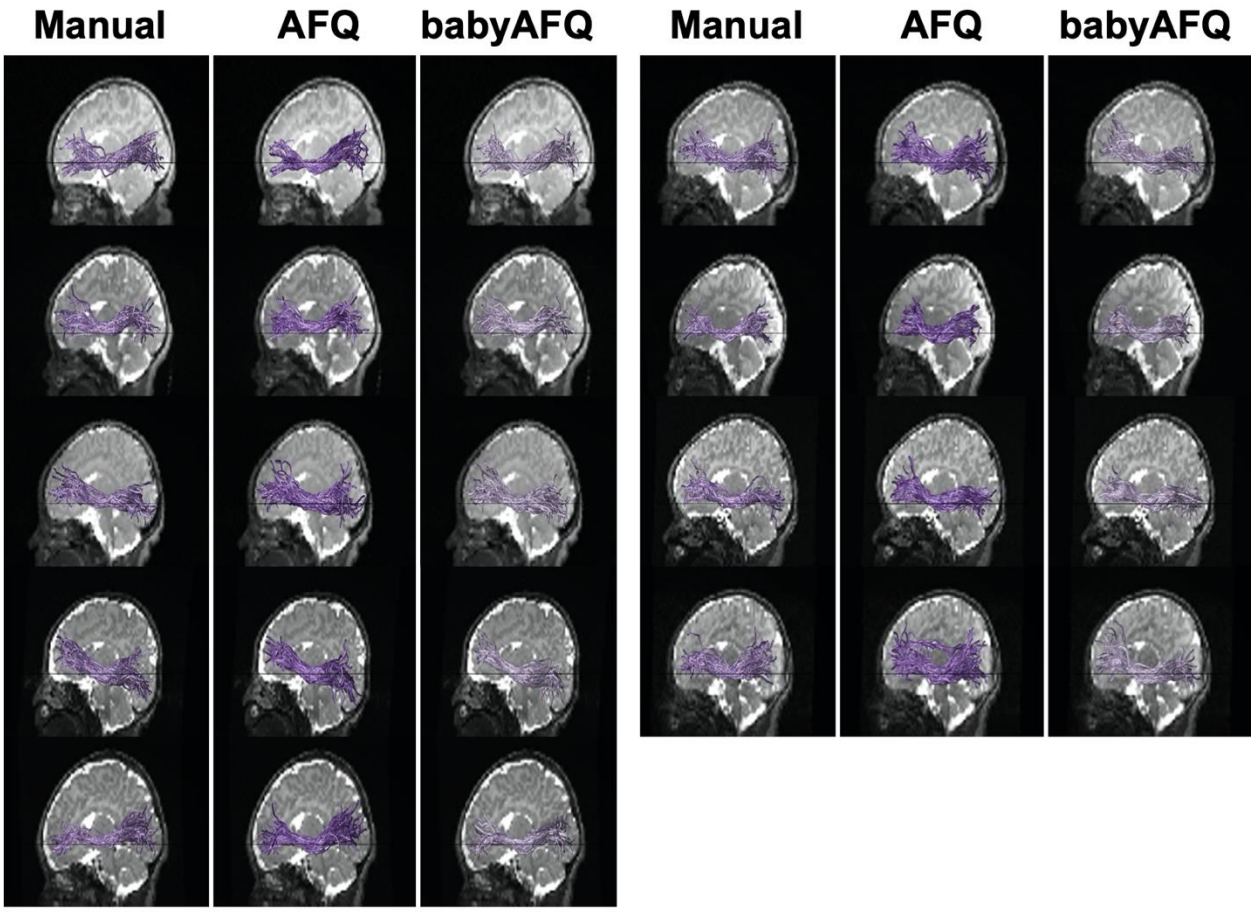
# Forceps Minor
# Newborn



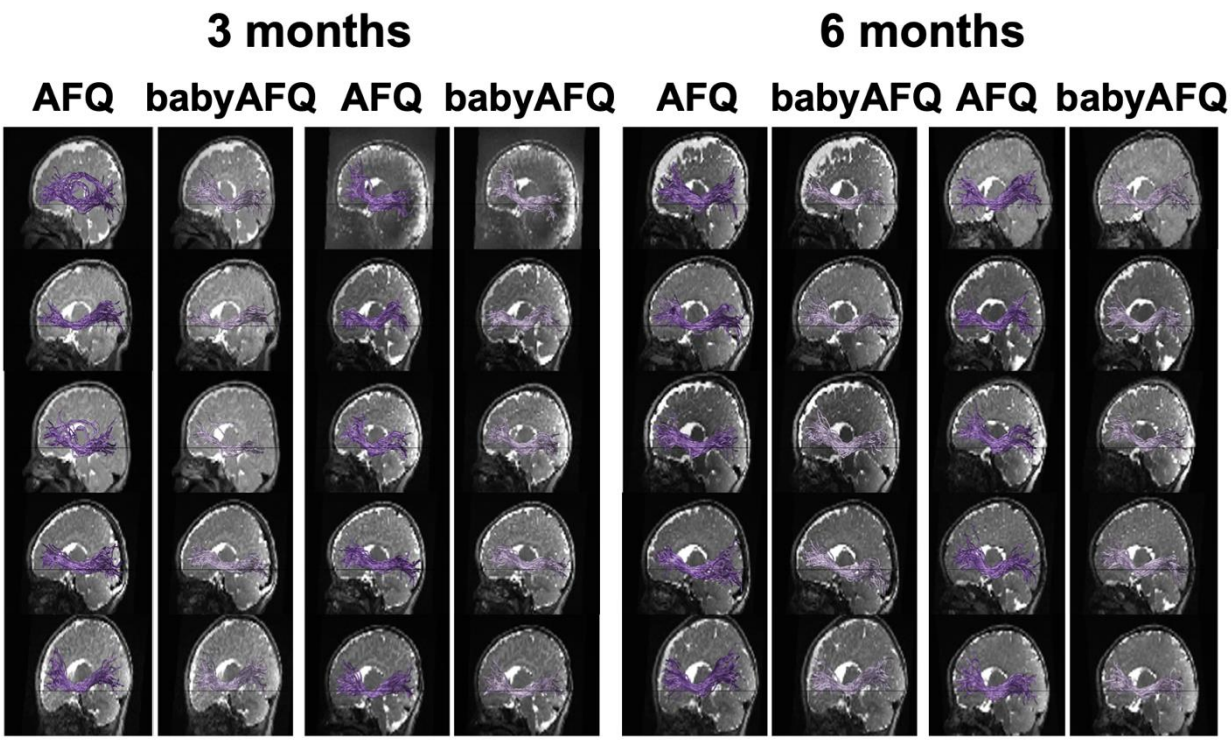
# Forceps Minor



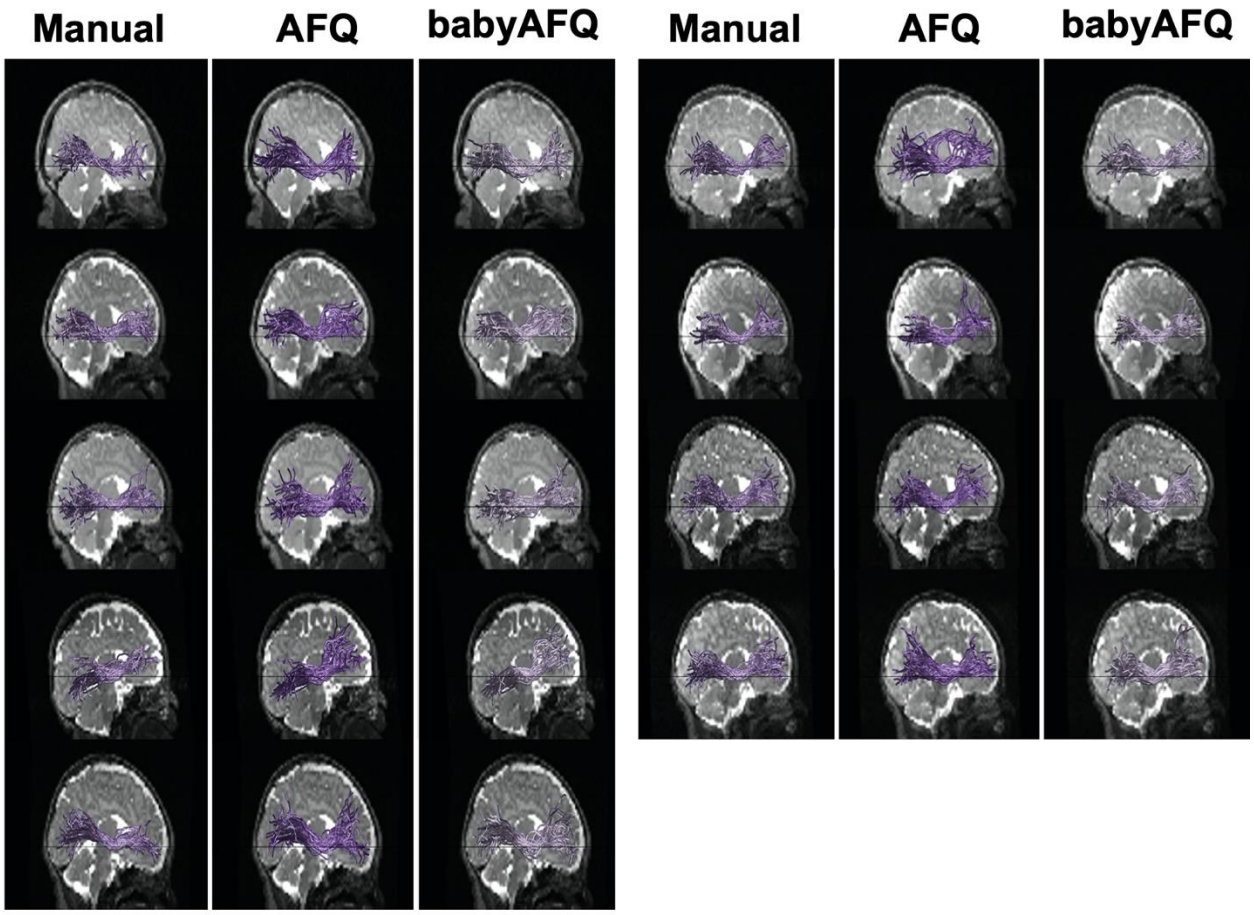
# Left Inferior Frontal Occipital Fasciculus
# Newborn



# Left Inferior Frontal Occipital Fasciculus



# Right Inferior Frontal Occipital Fasciculus
# Newborn



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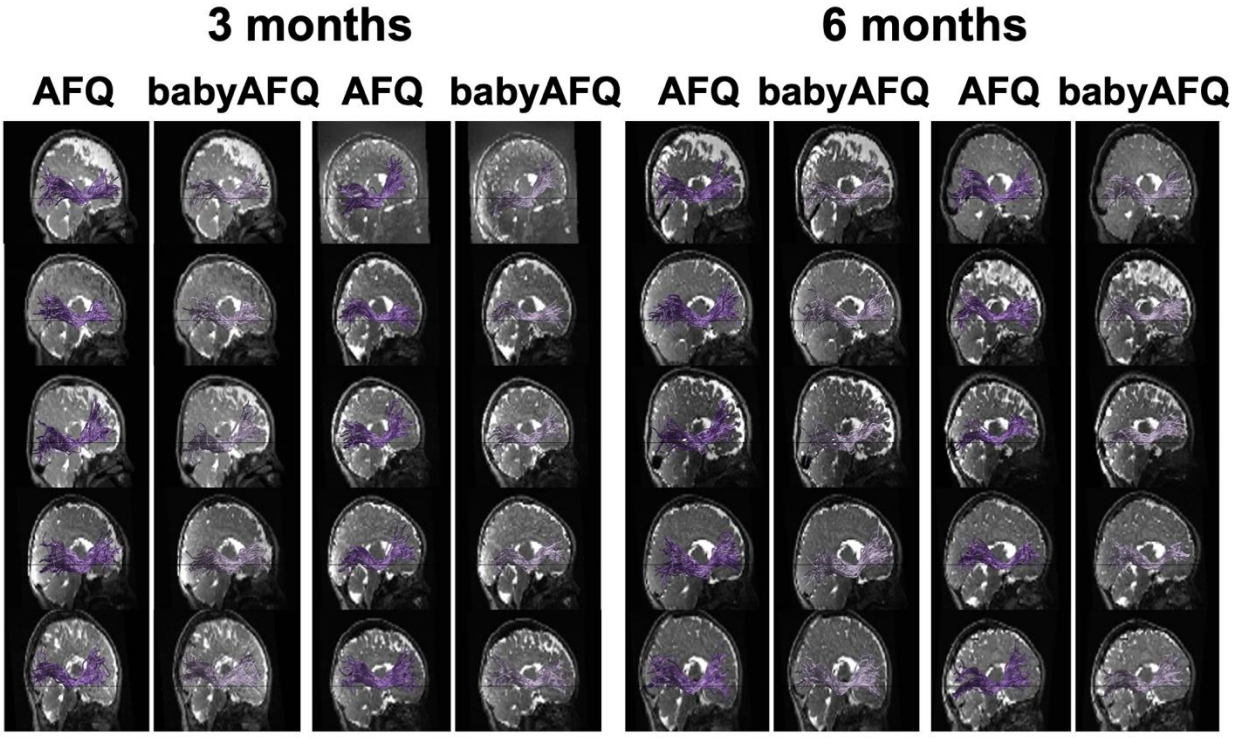
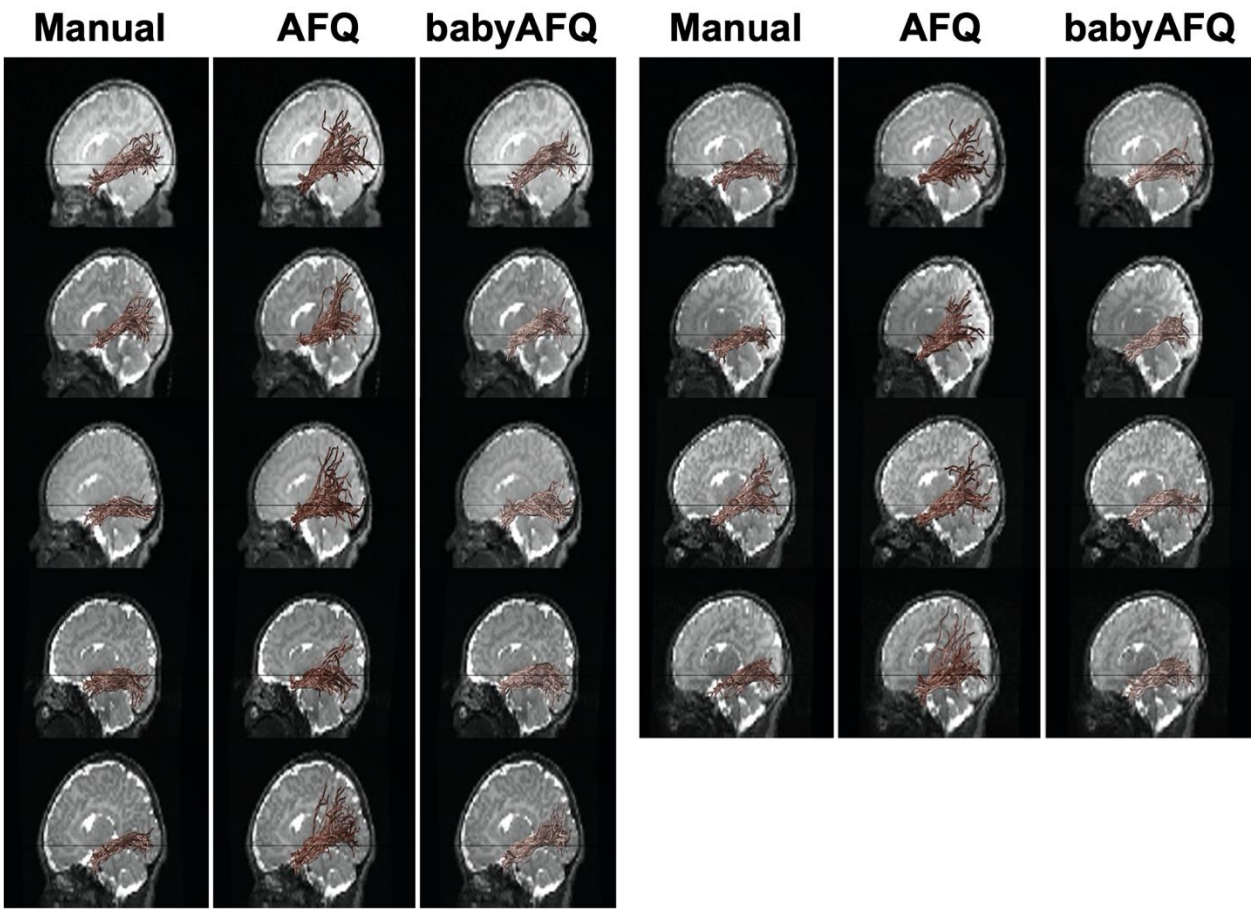


# Left Inferior Longitudinal Fasciculus
# Newborn



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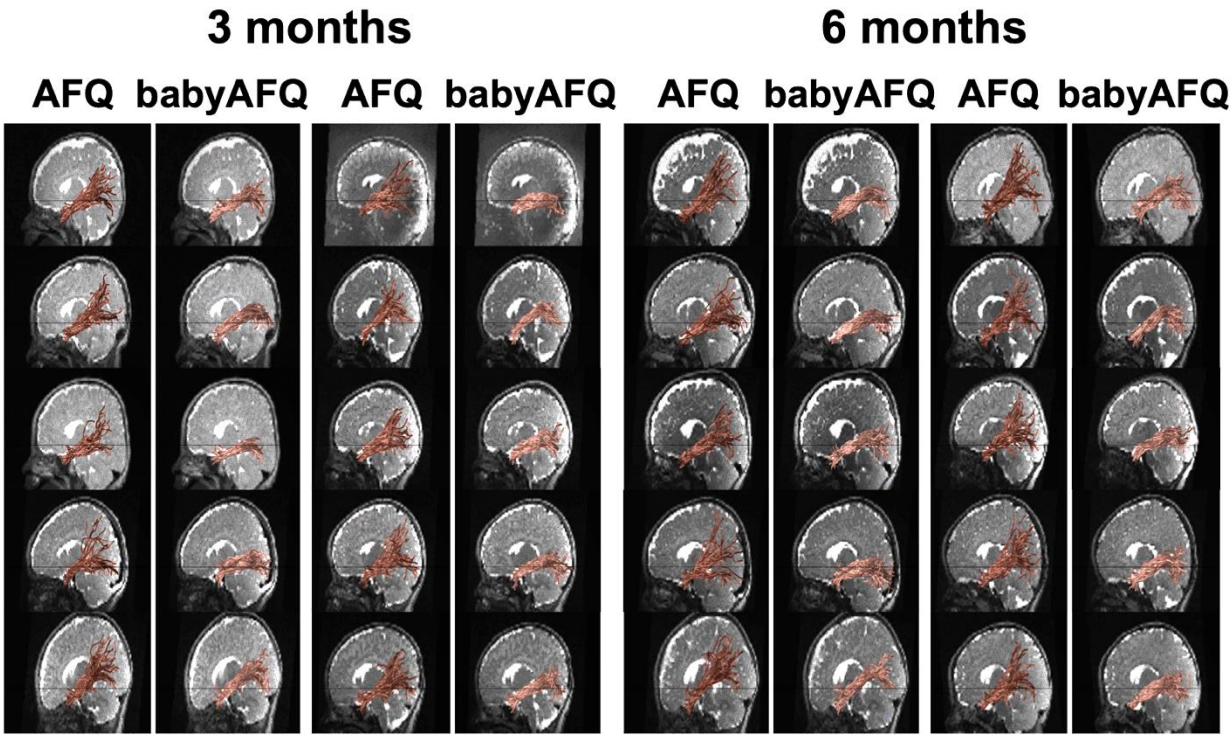

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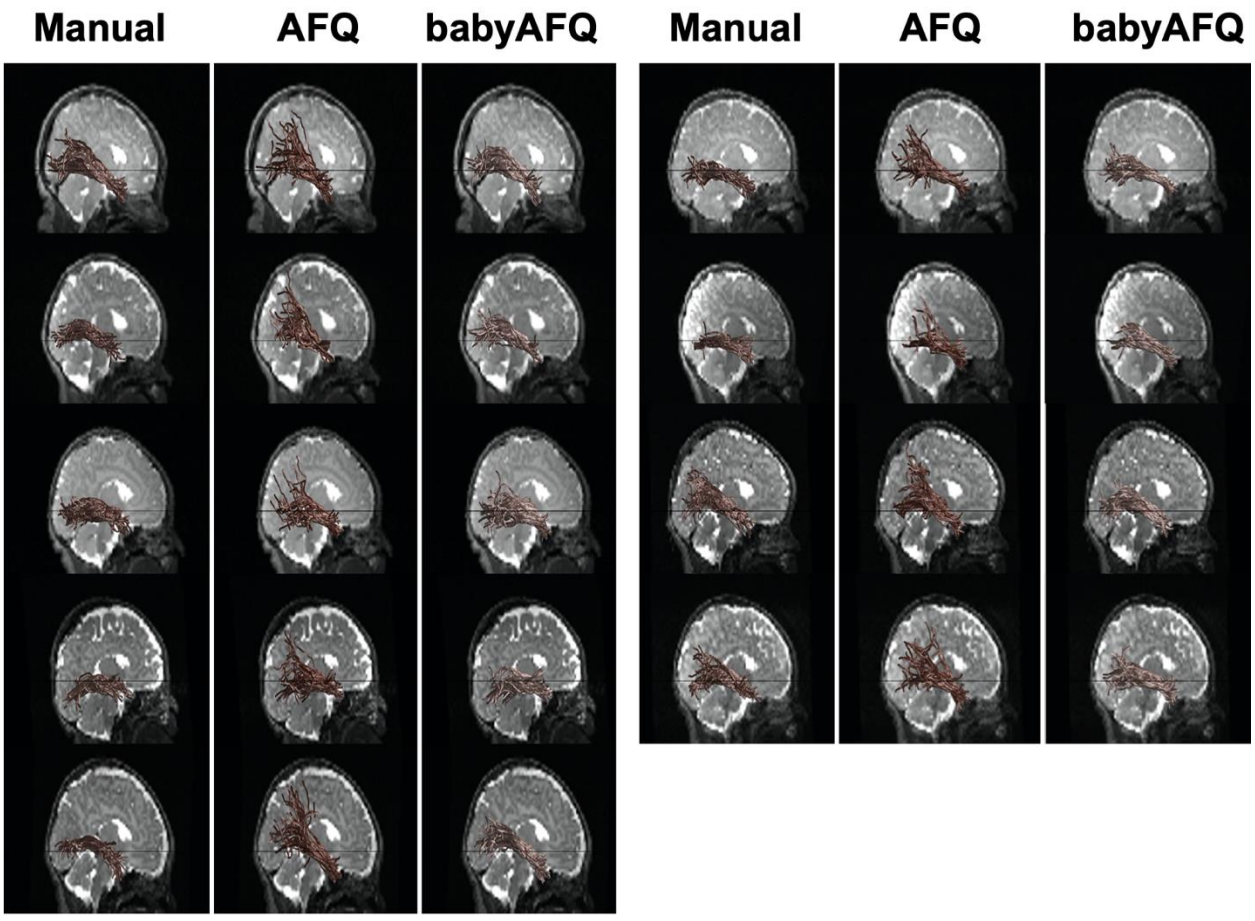

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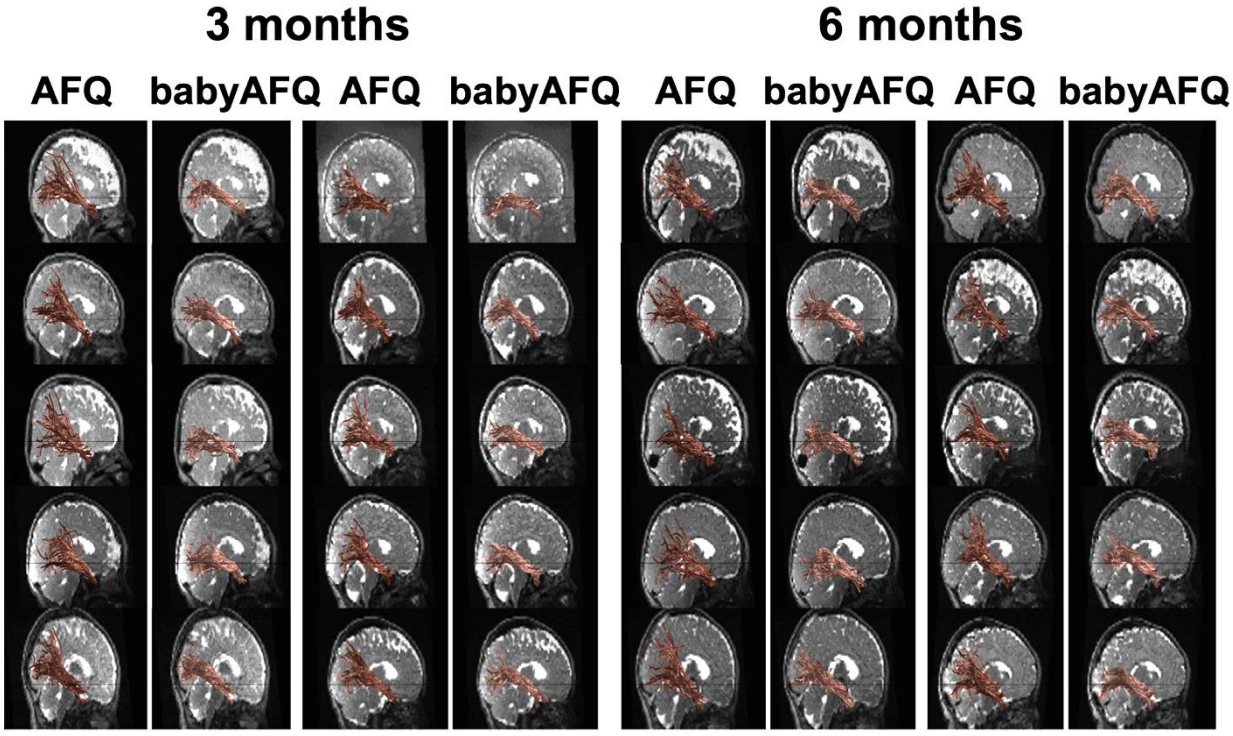
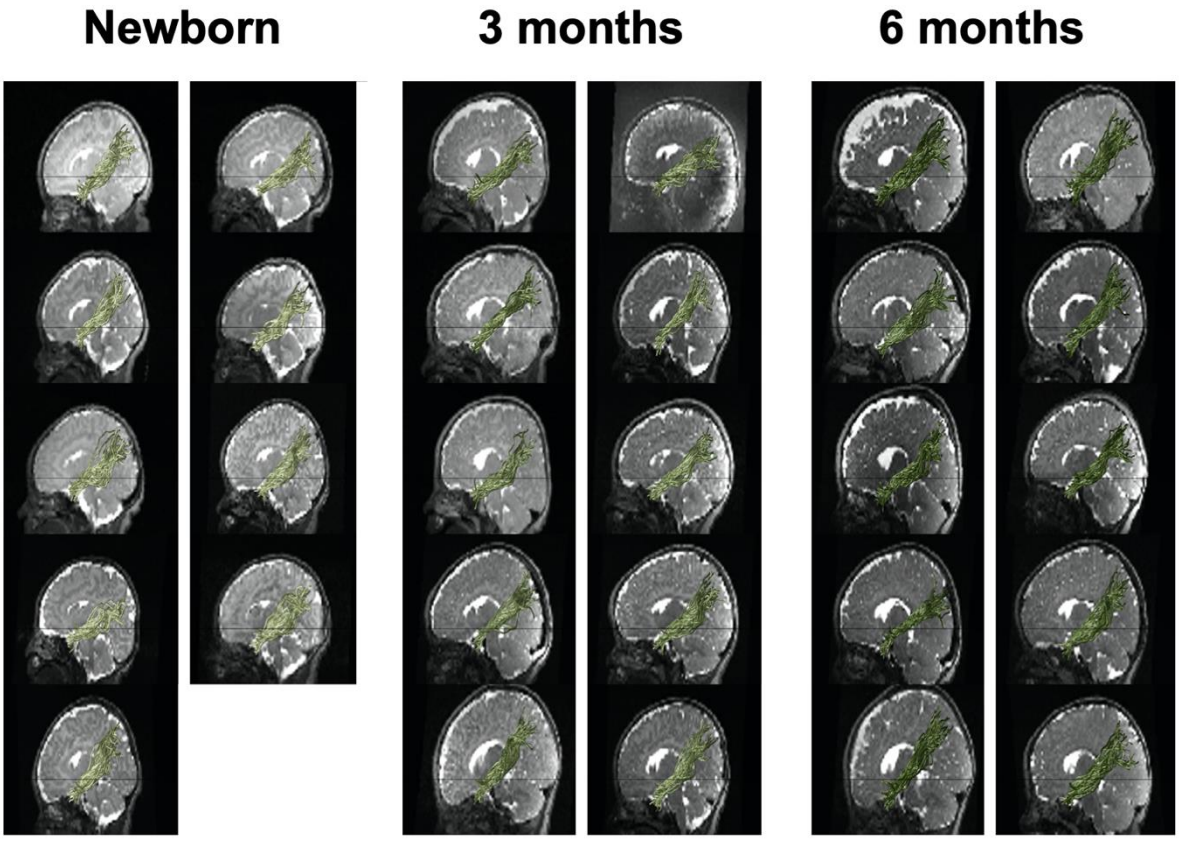


# Left Middle Longitudinal Fasciculus



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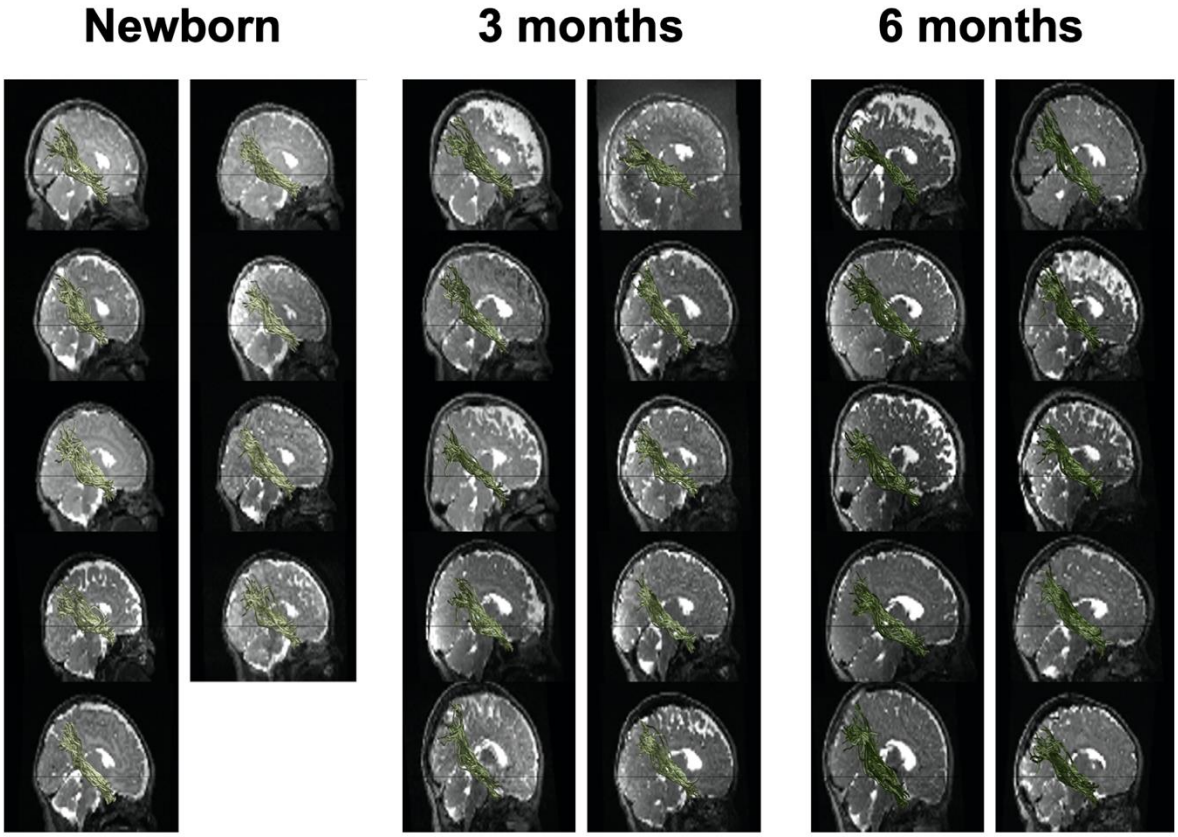
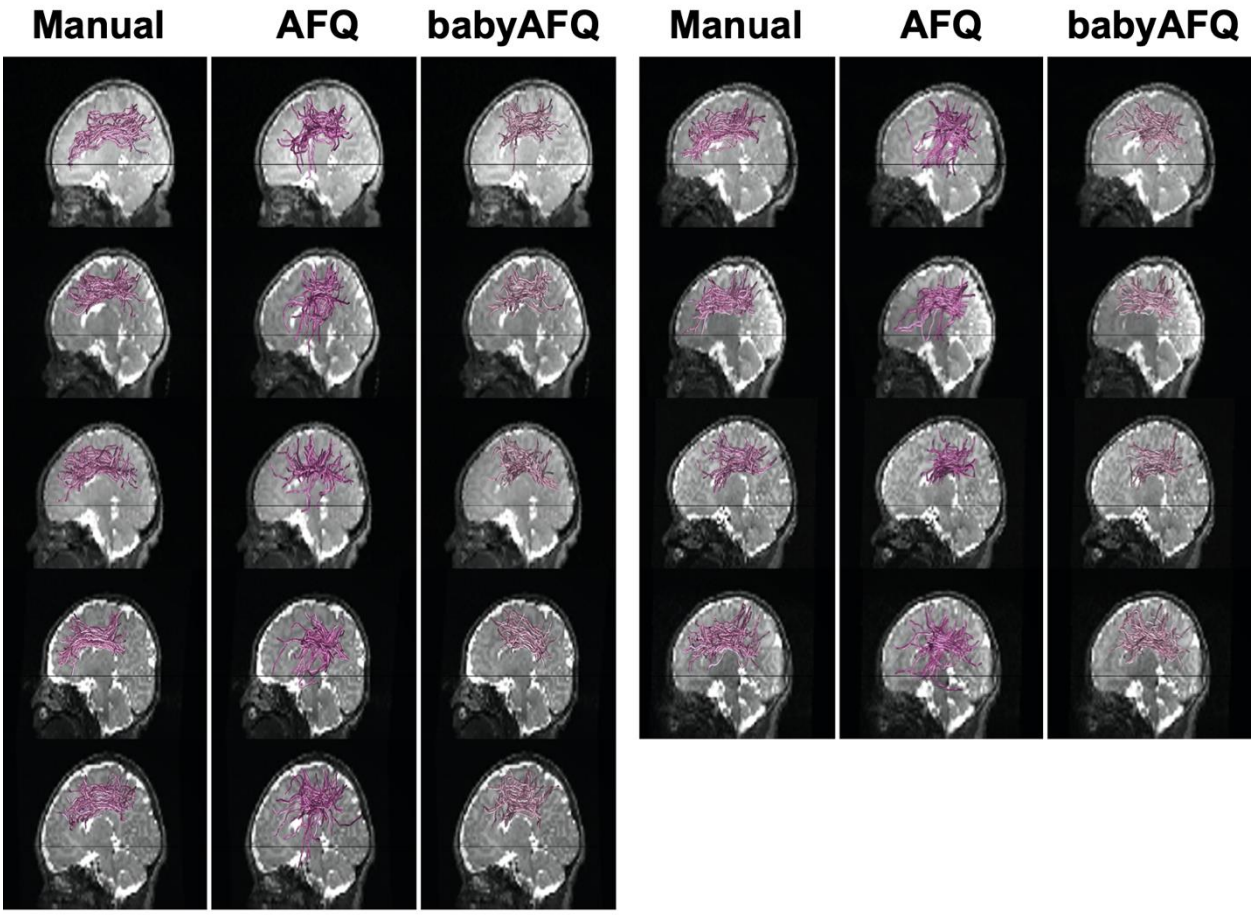


# Left Superior Longitudinal Fasciculus
# Newborn



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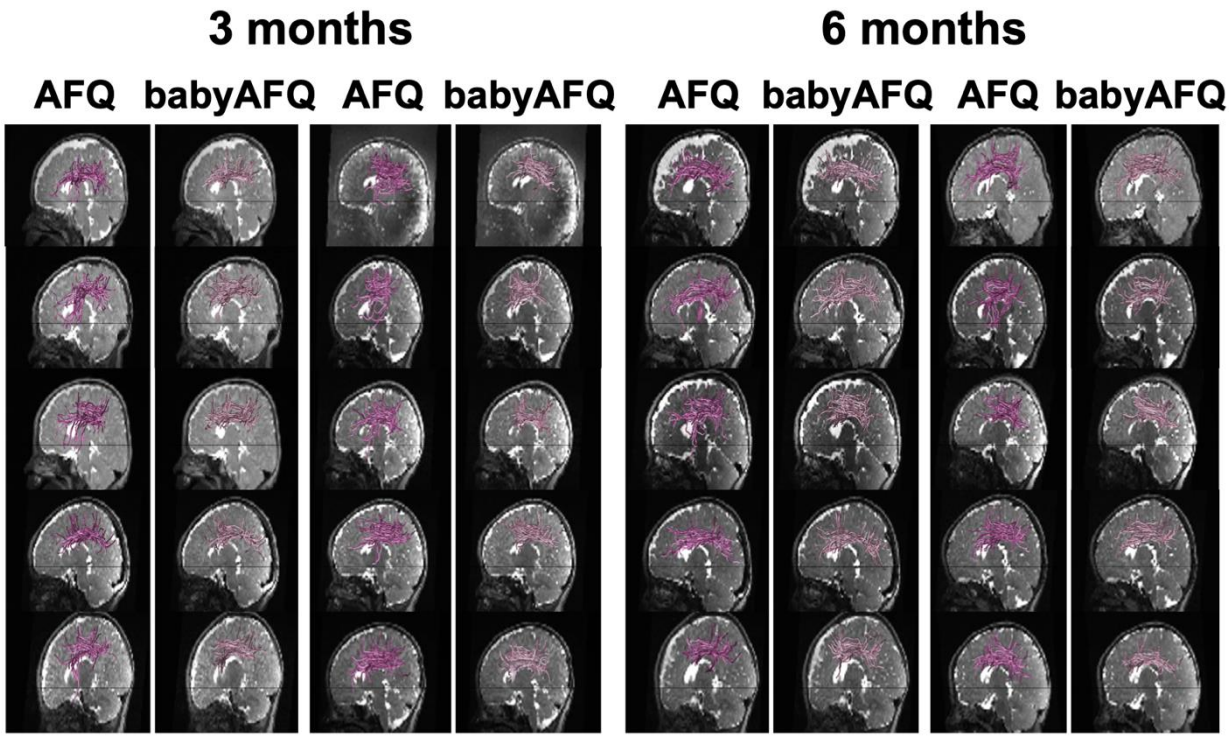

# Right Superior Longitudinal Fasciculus
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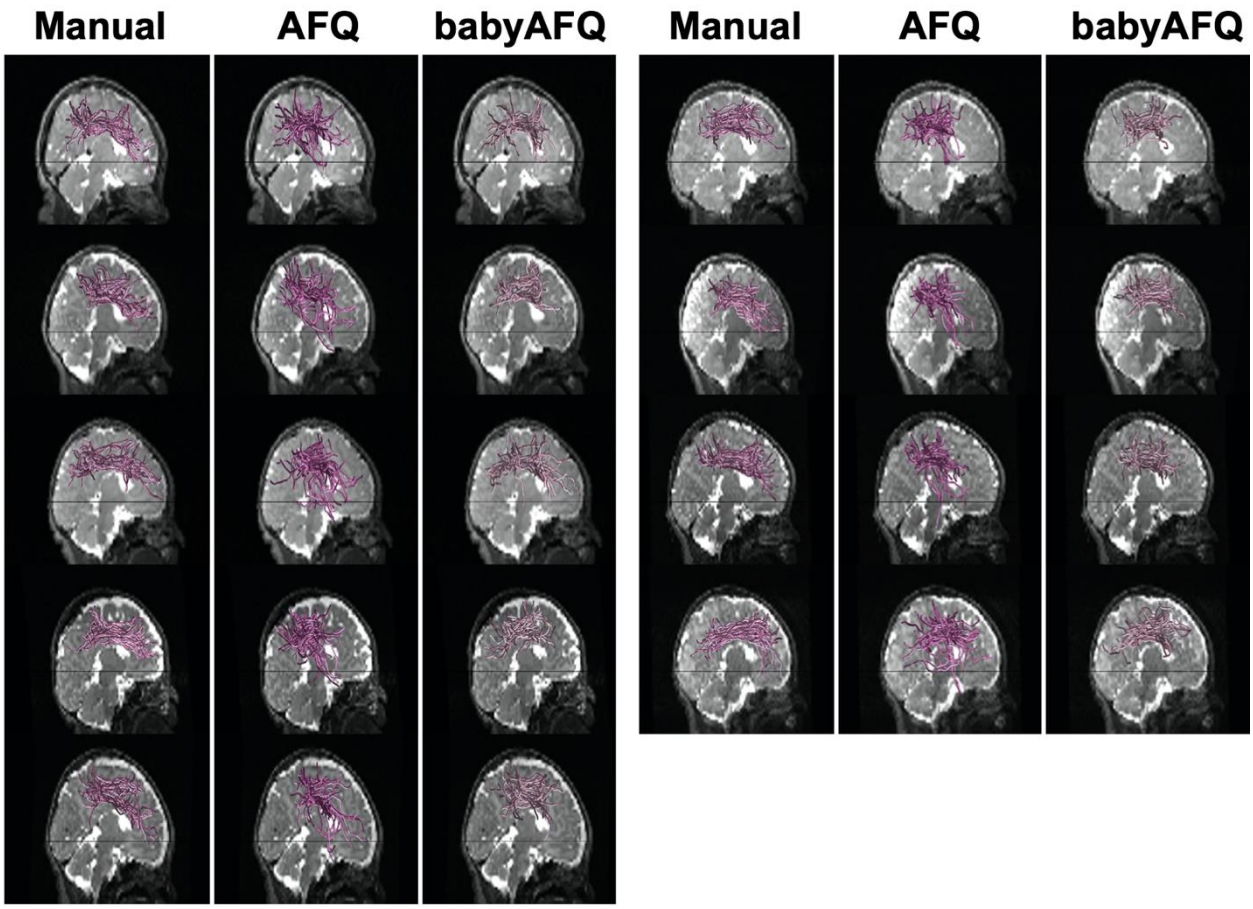

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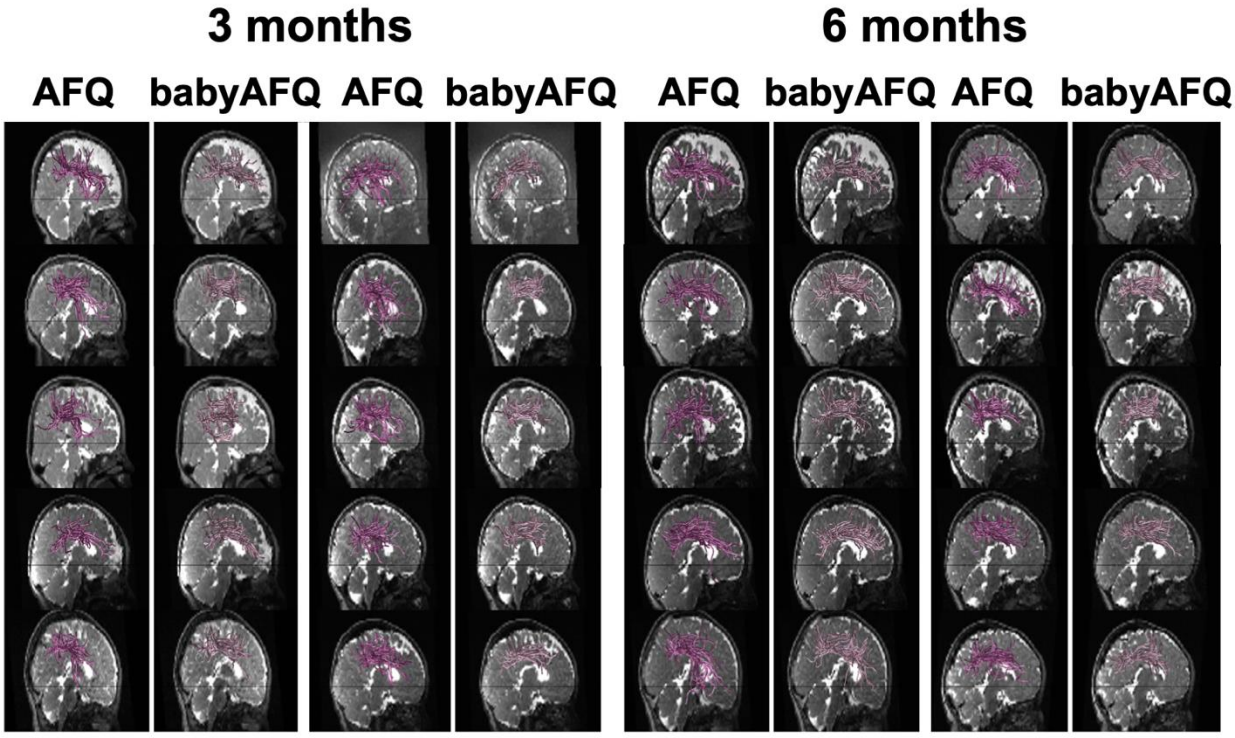
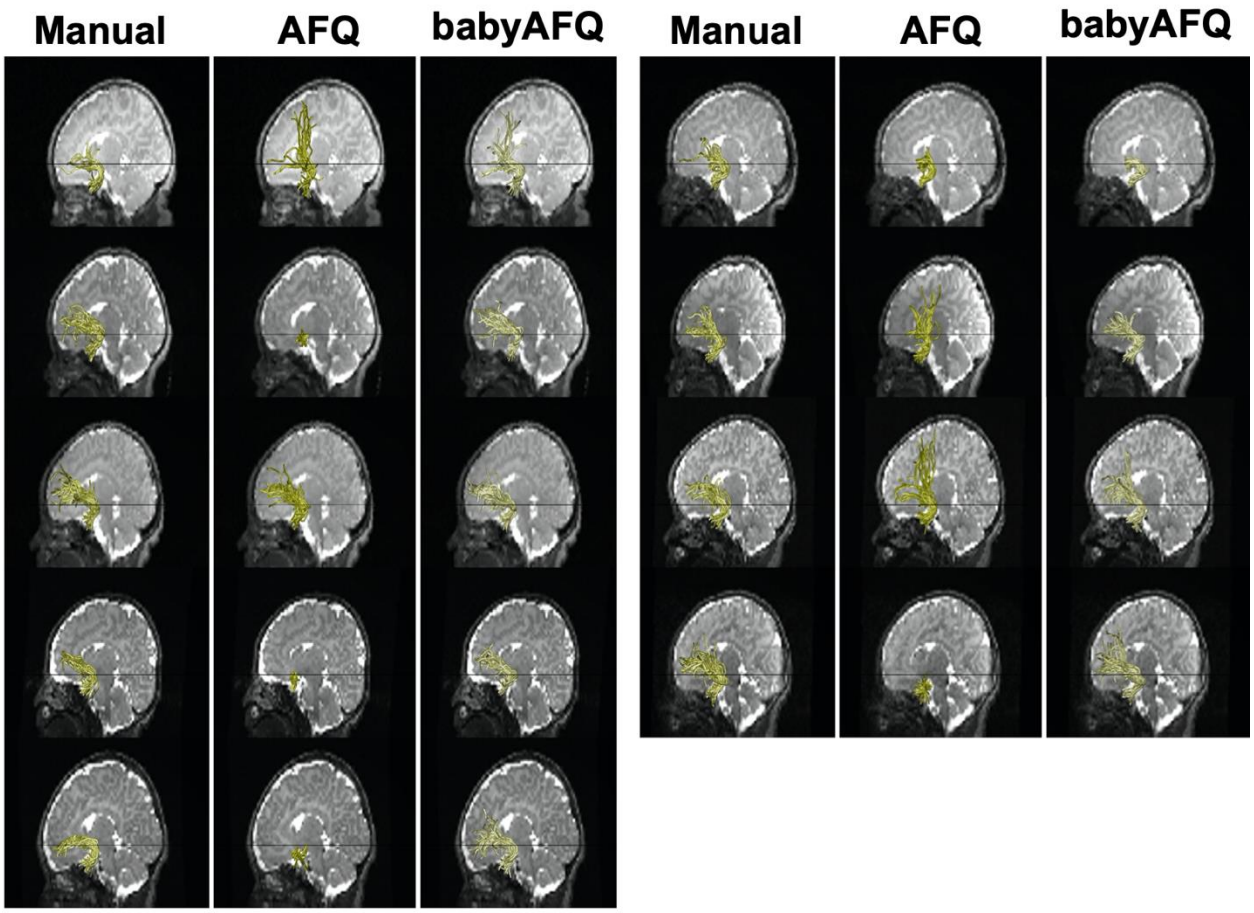
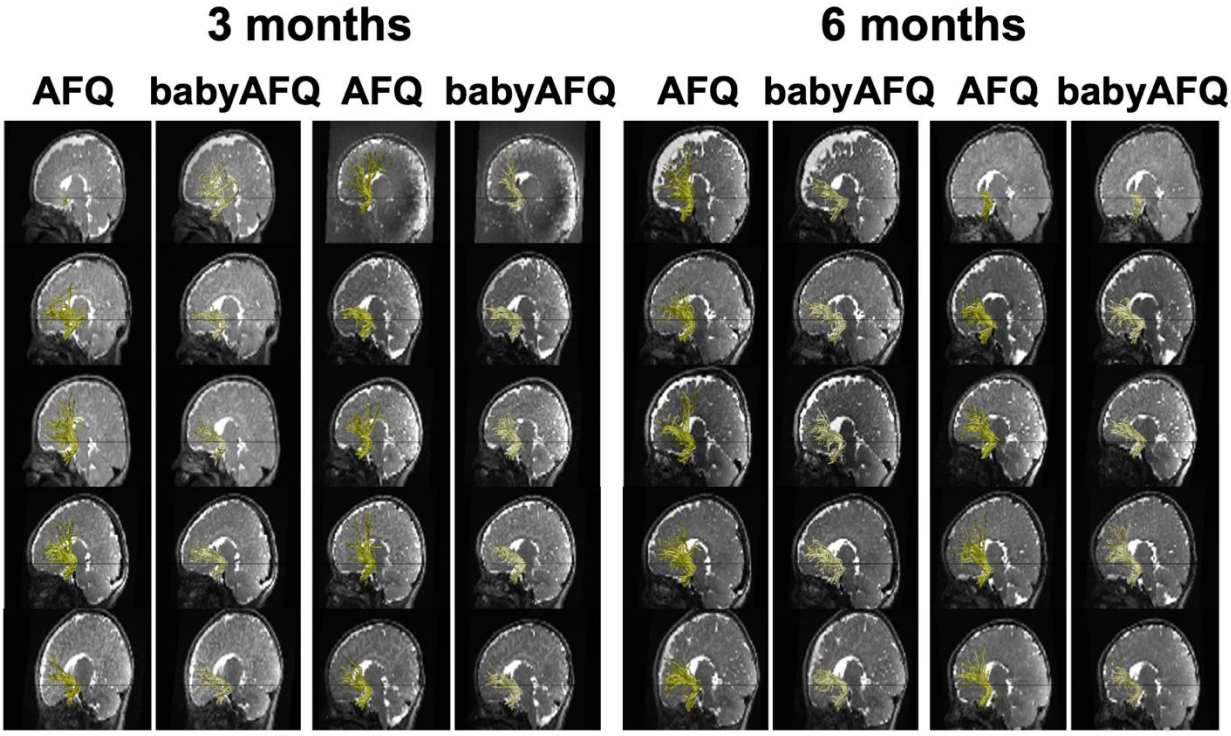


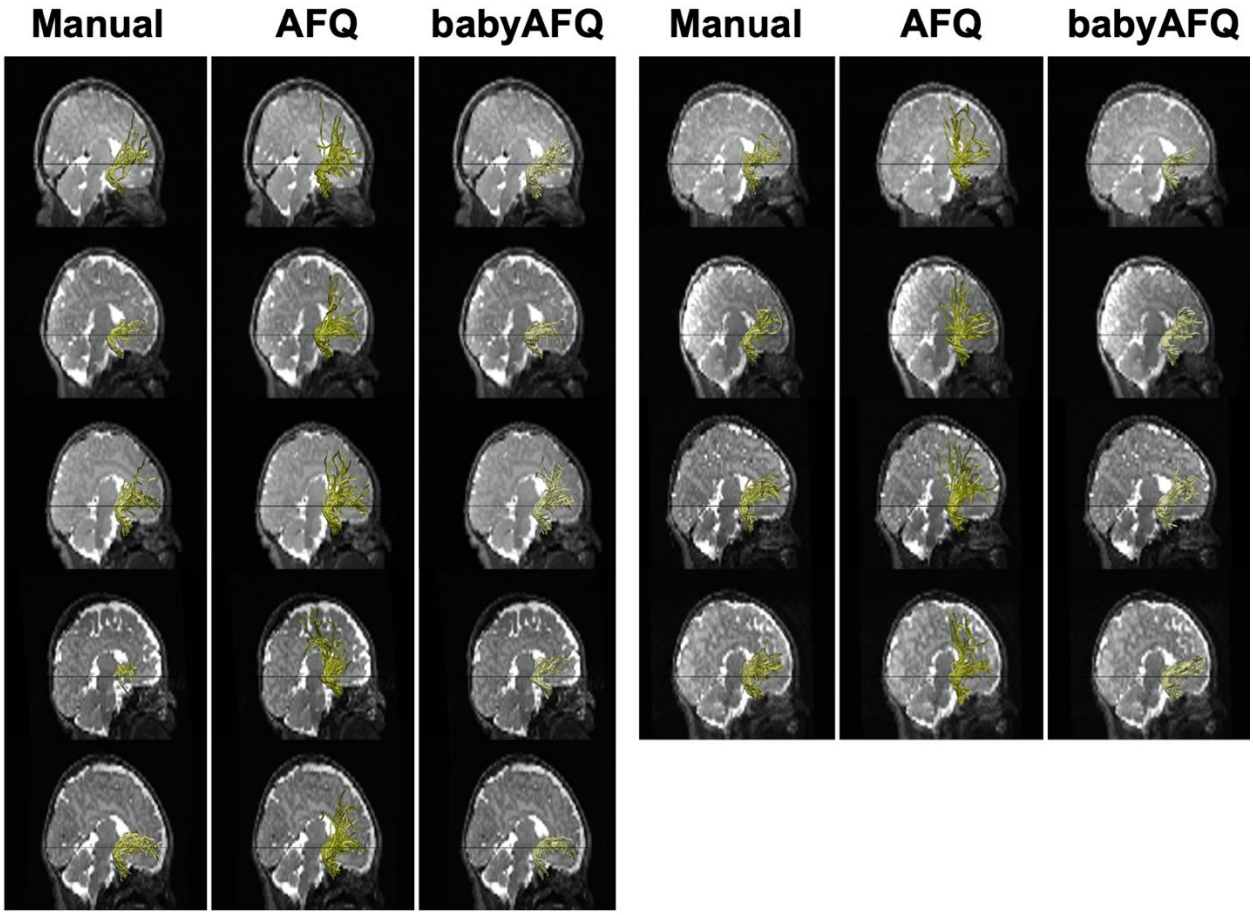
# Left Uncinate Fasciculus
# Newborn



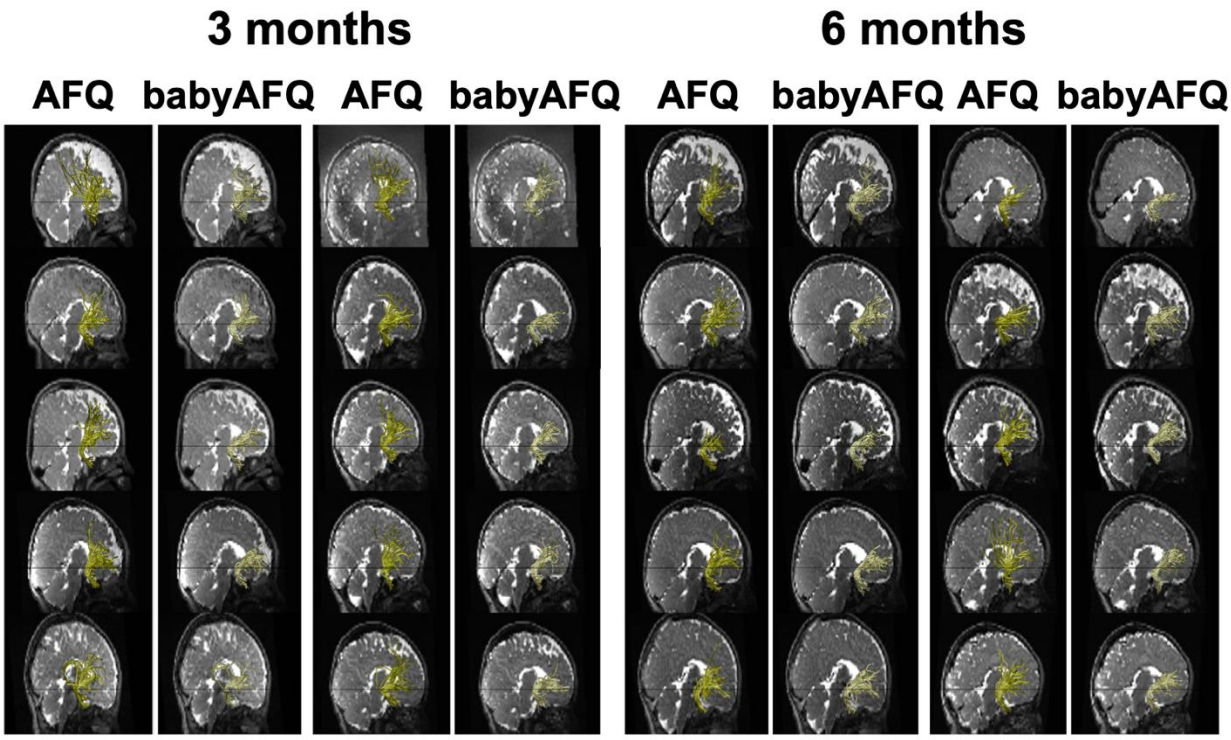
# Left Uncinate Fasciculus



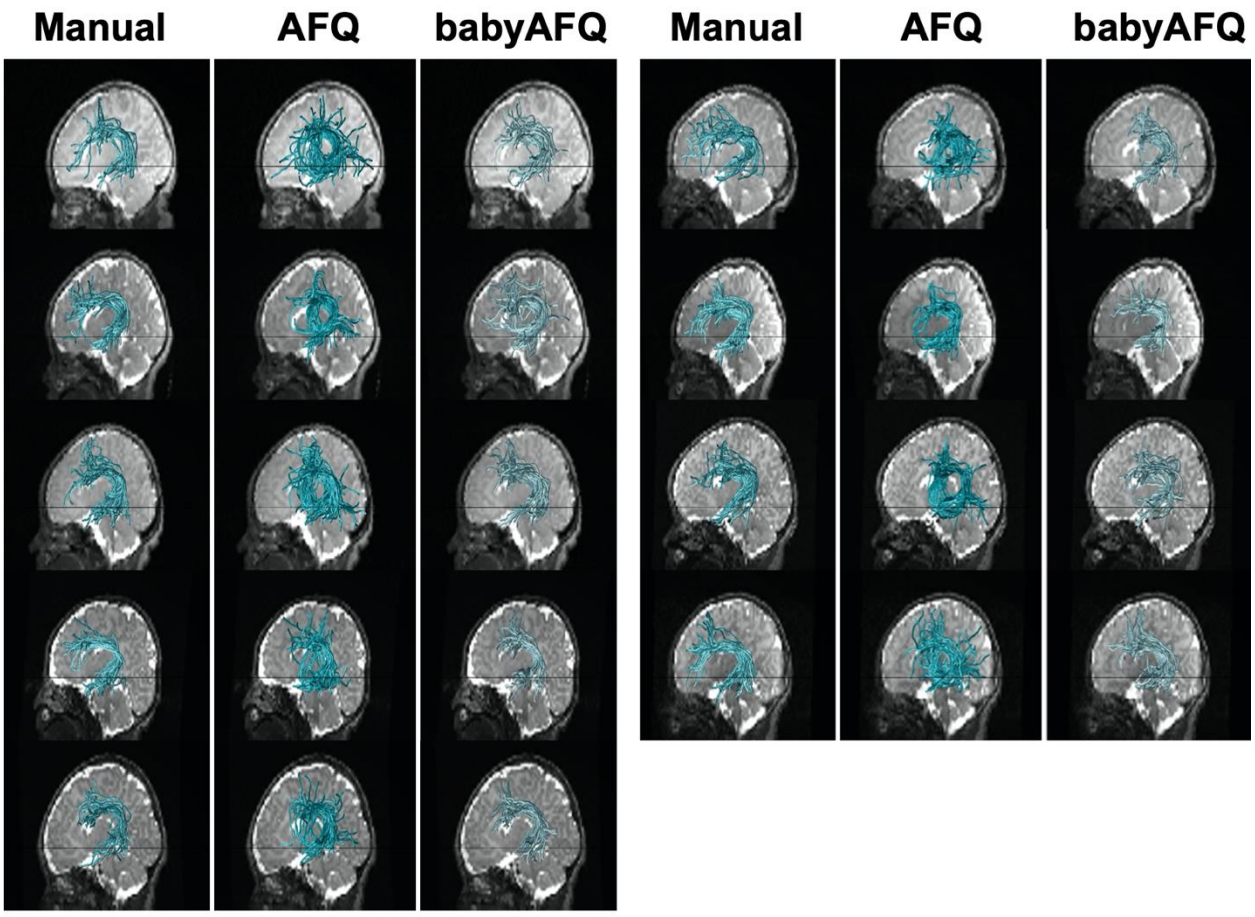
# Right Uncinate Fasciculus
# Newborn



# Right Uncinate Fasciculus



# Left Arcuate Fasciculus
# Newborn



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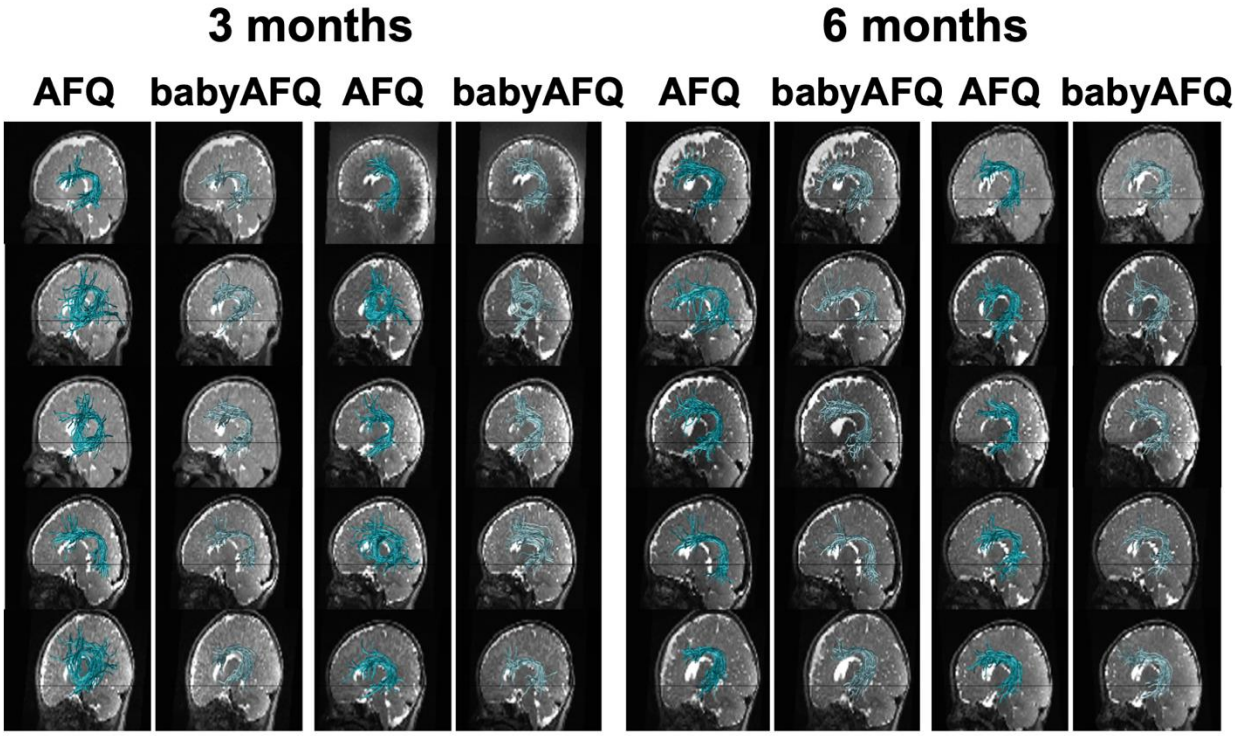
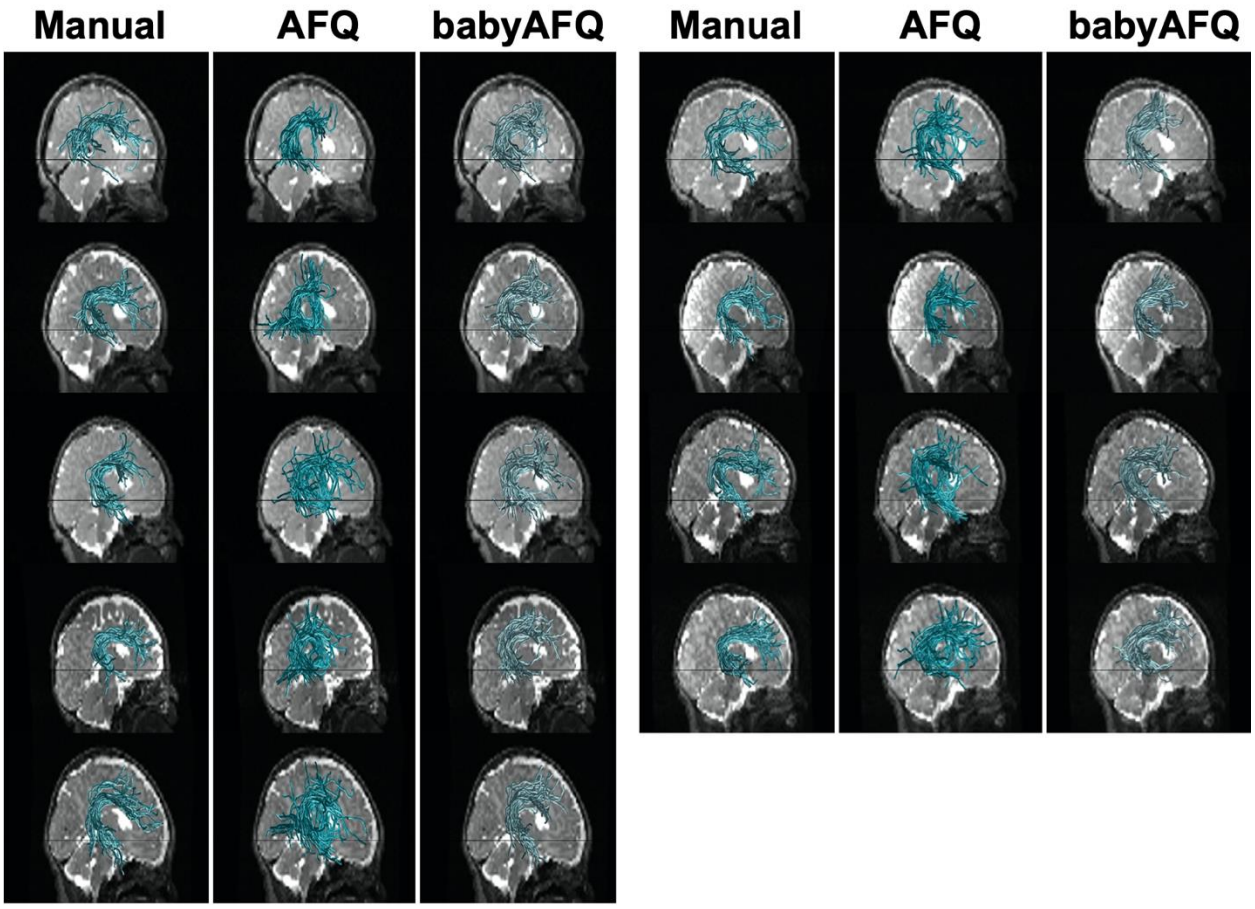
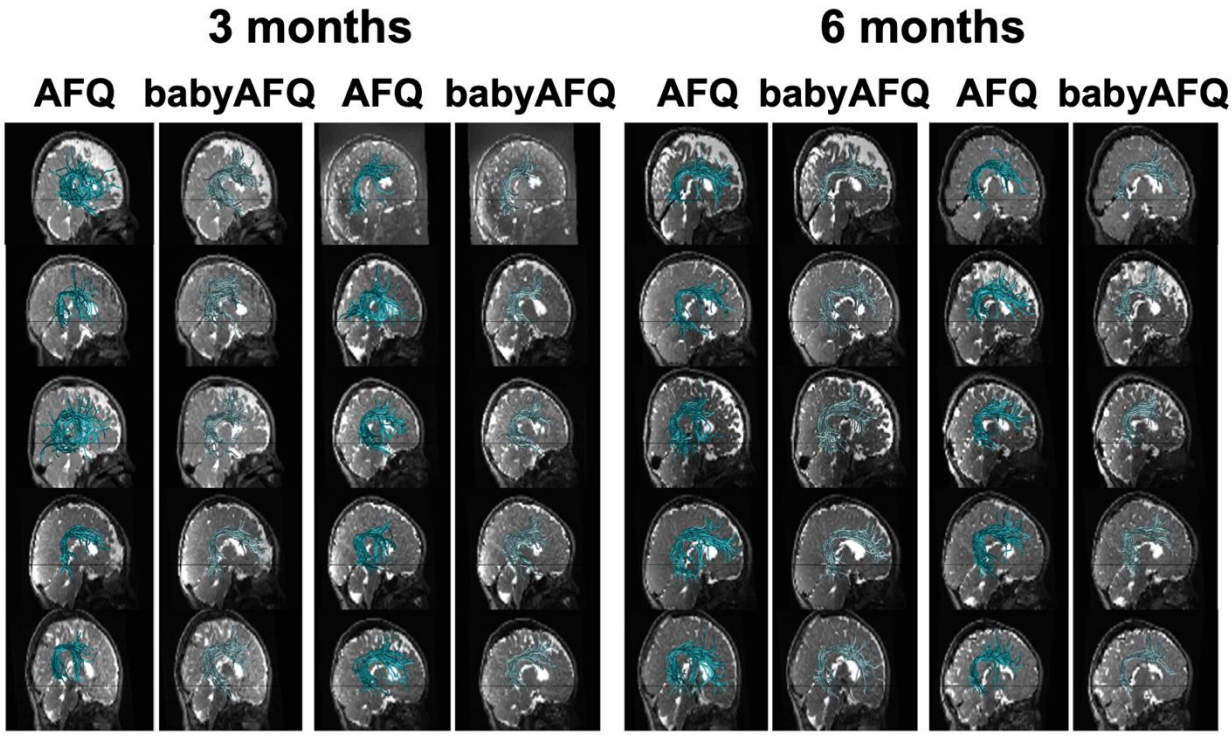


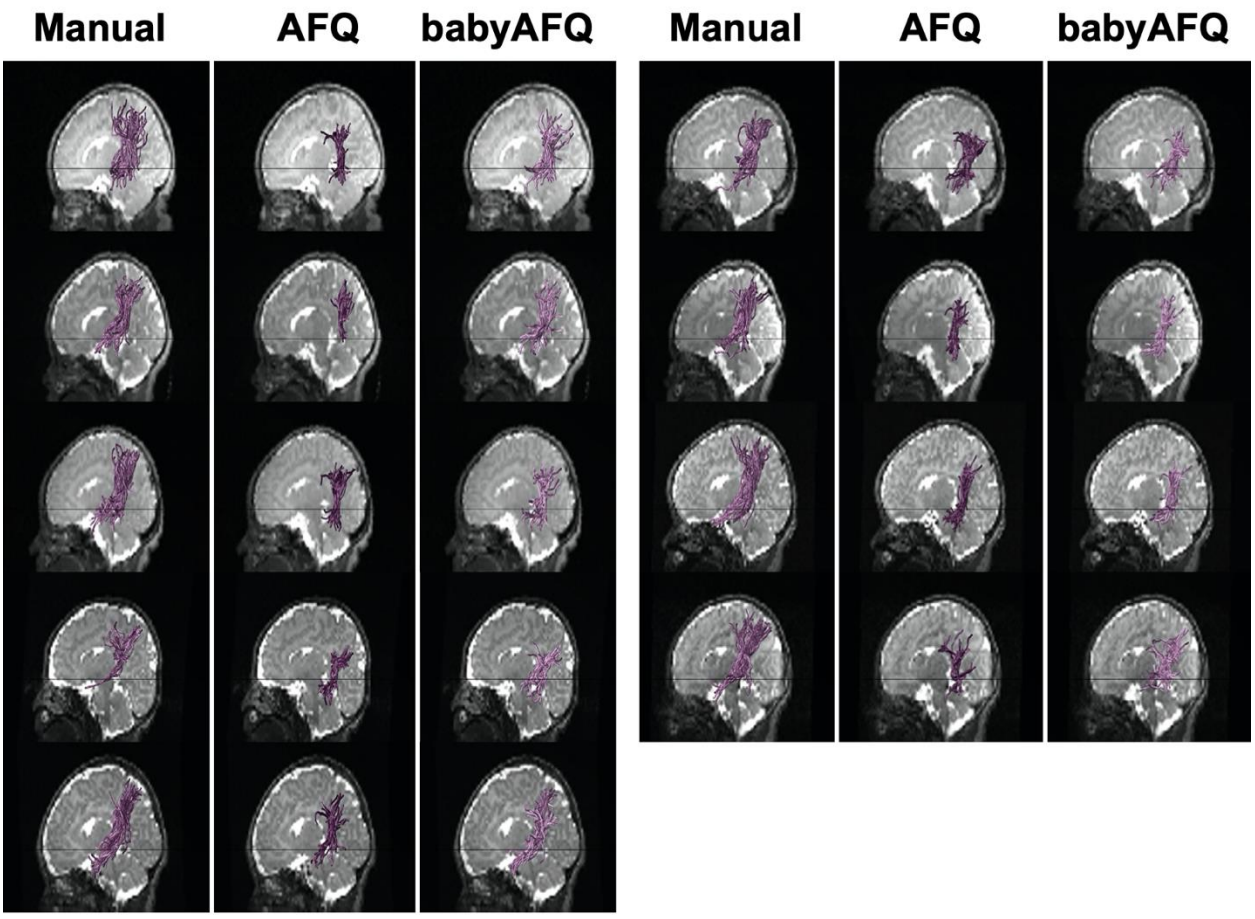
# Right Arcuate Fasciculus
# Newborn



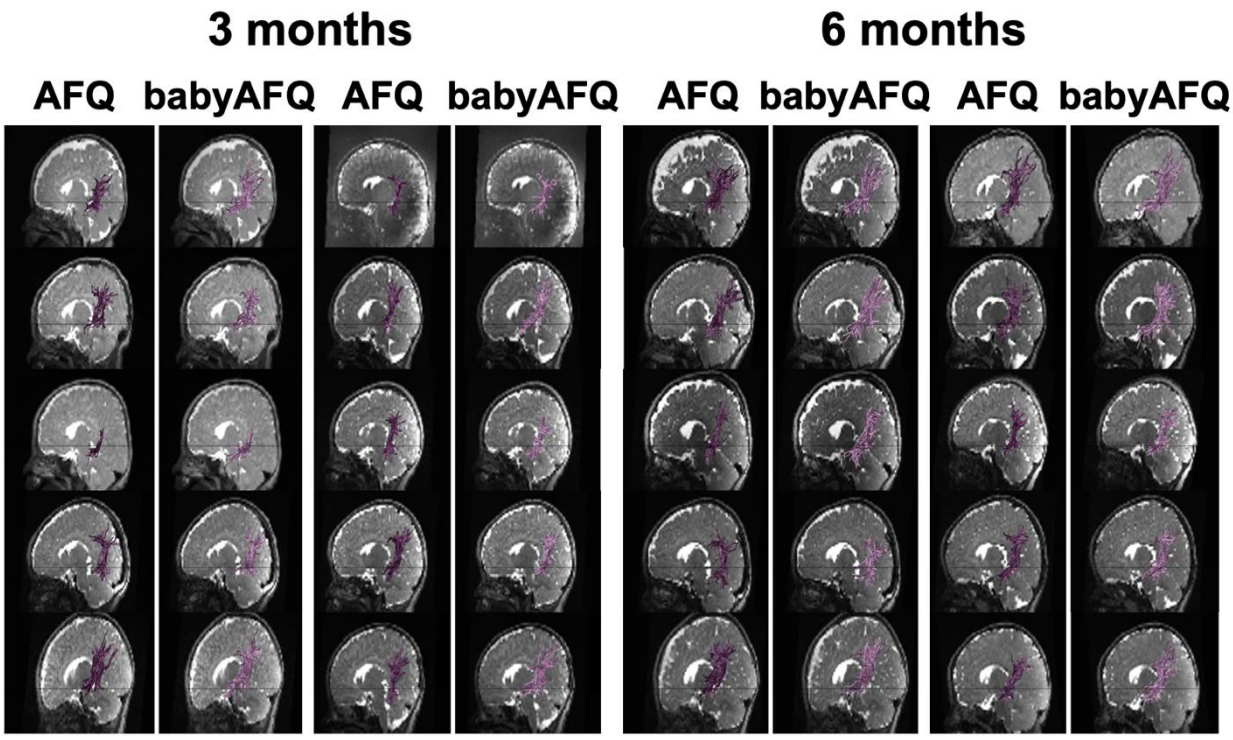
# Right Arcuate Fasciculus



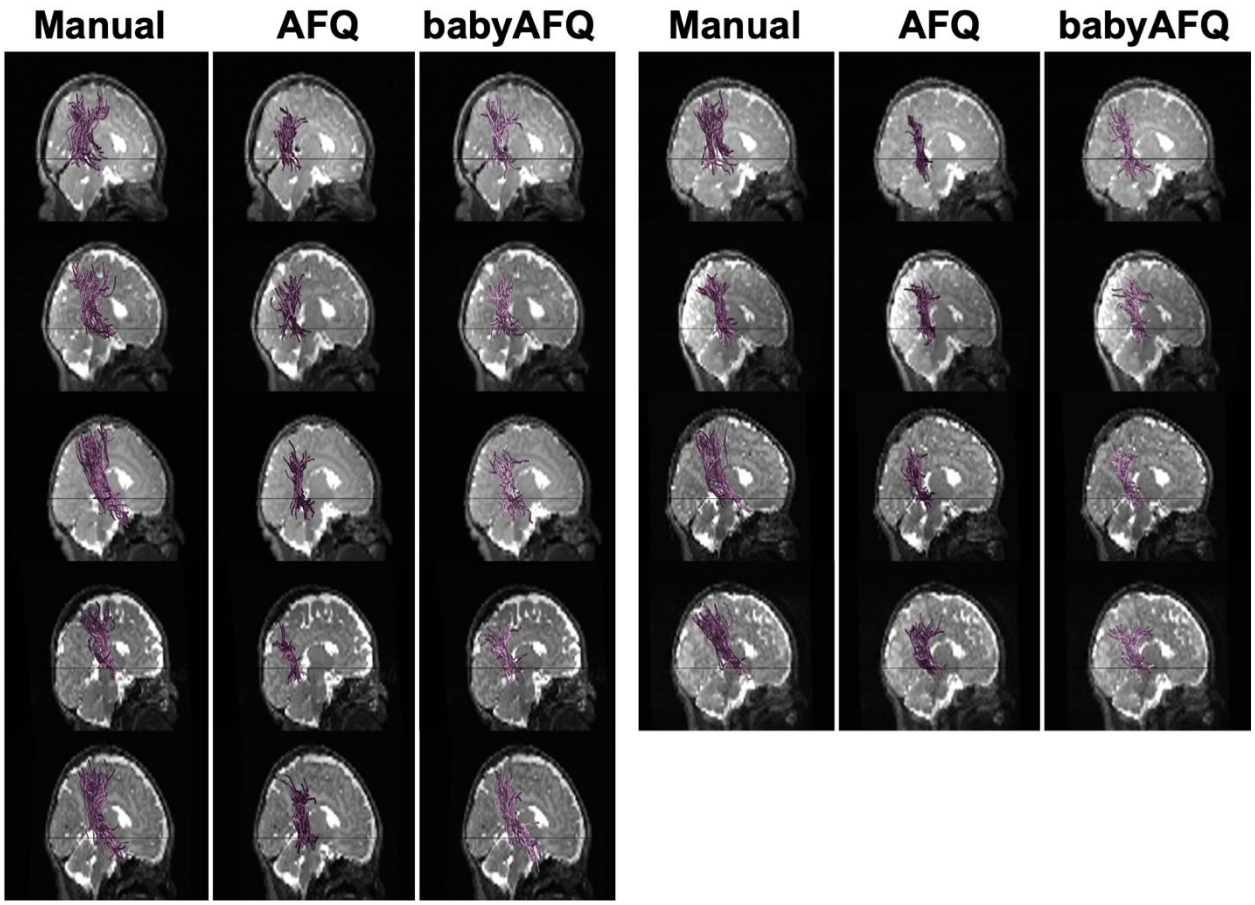
# Left Posterior Arcuate Fasciculus
# Newborn



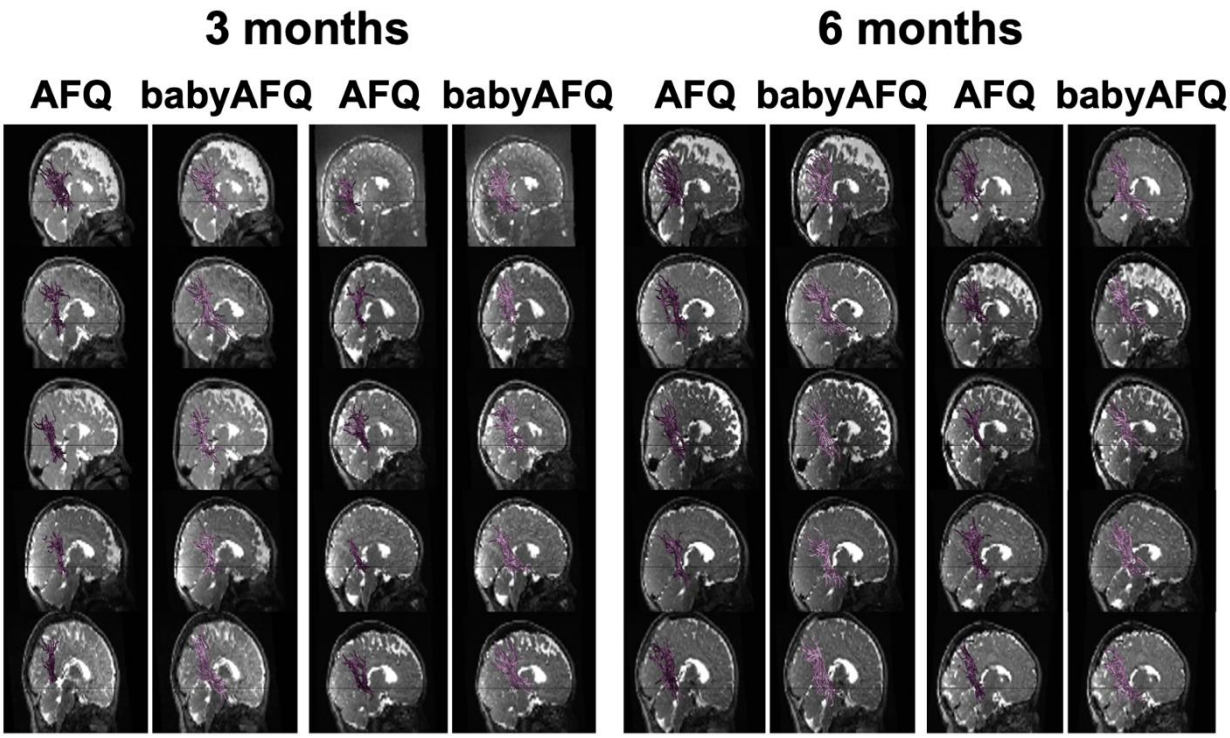
# Left Posterior Arcuate Fasciculus



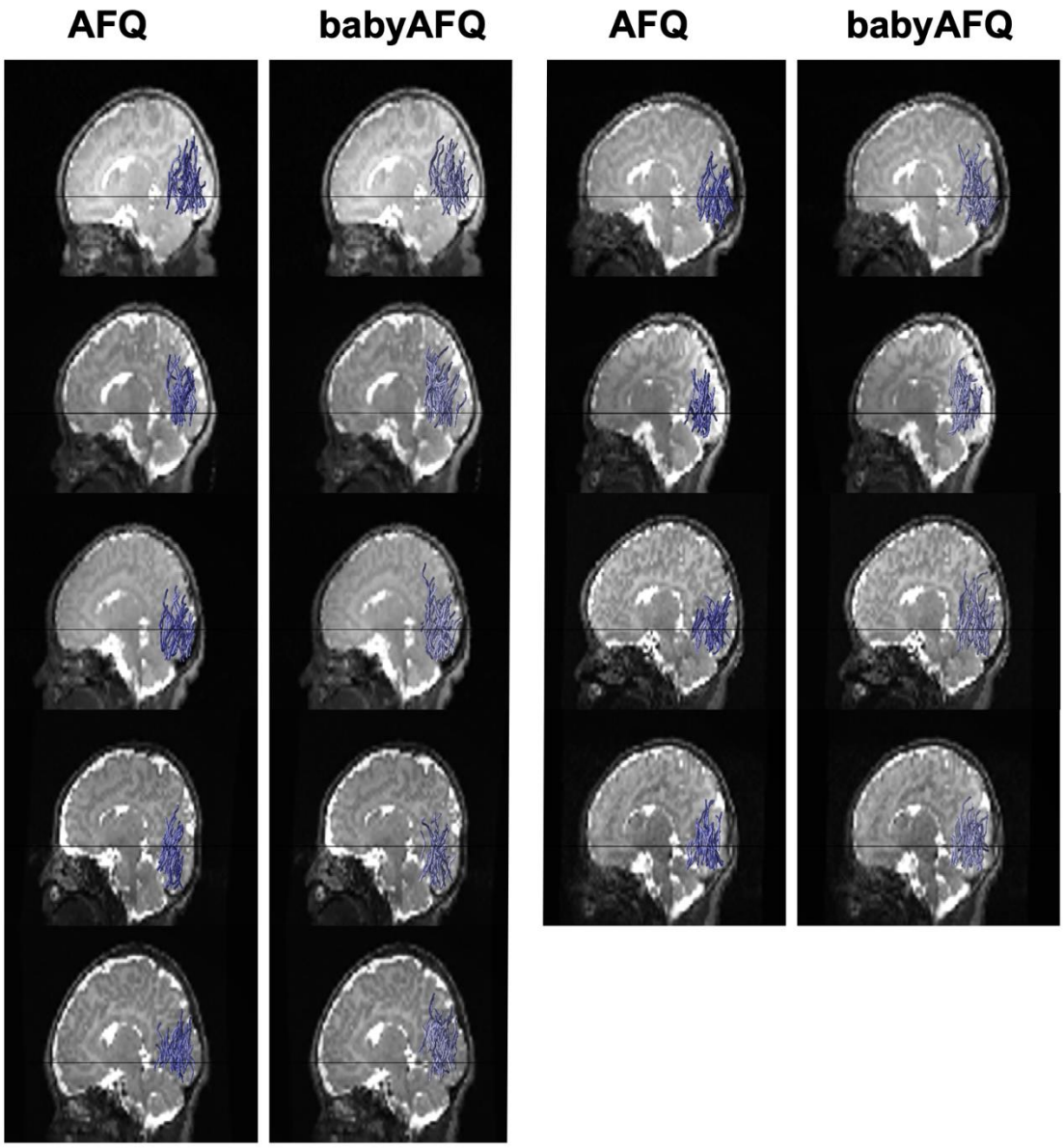
# Right Posterior Arcuate Fasciculus
# Newborn



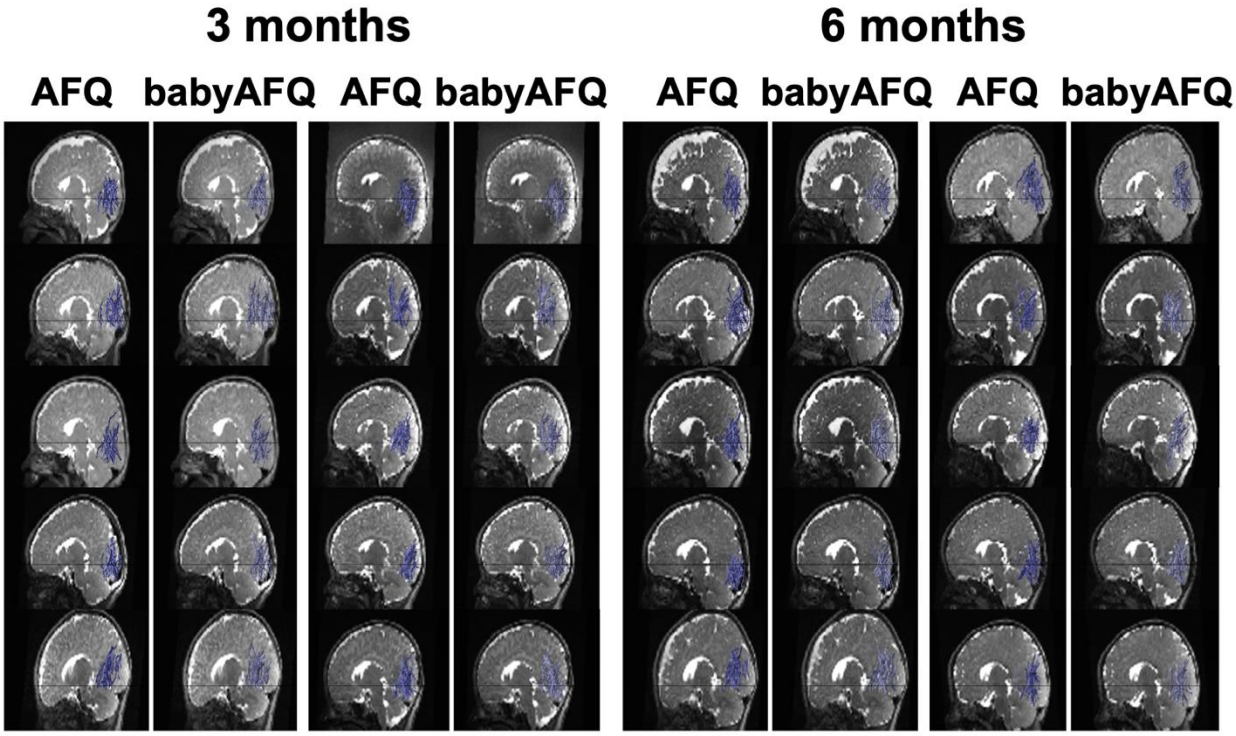
# Right Posterior Arcuate Fasciculus



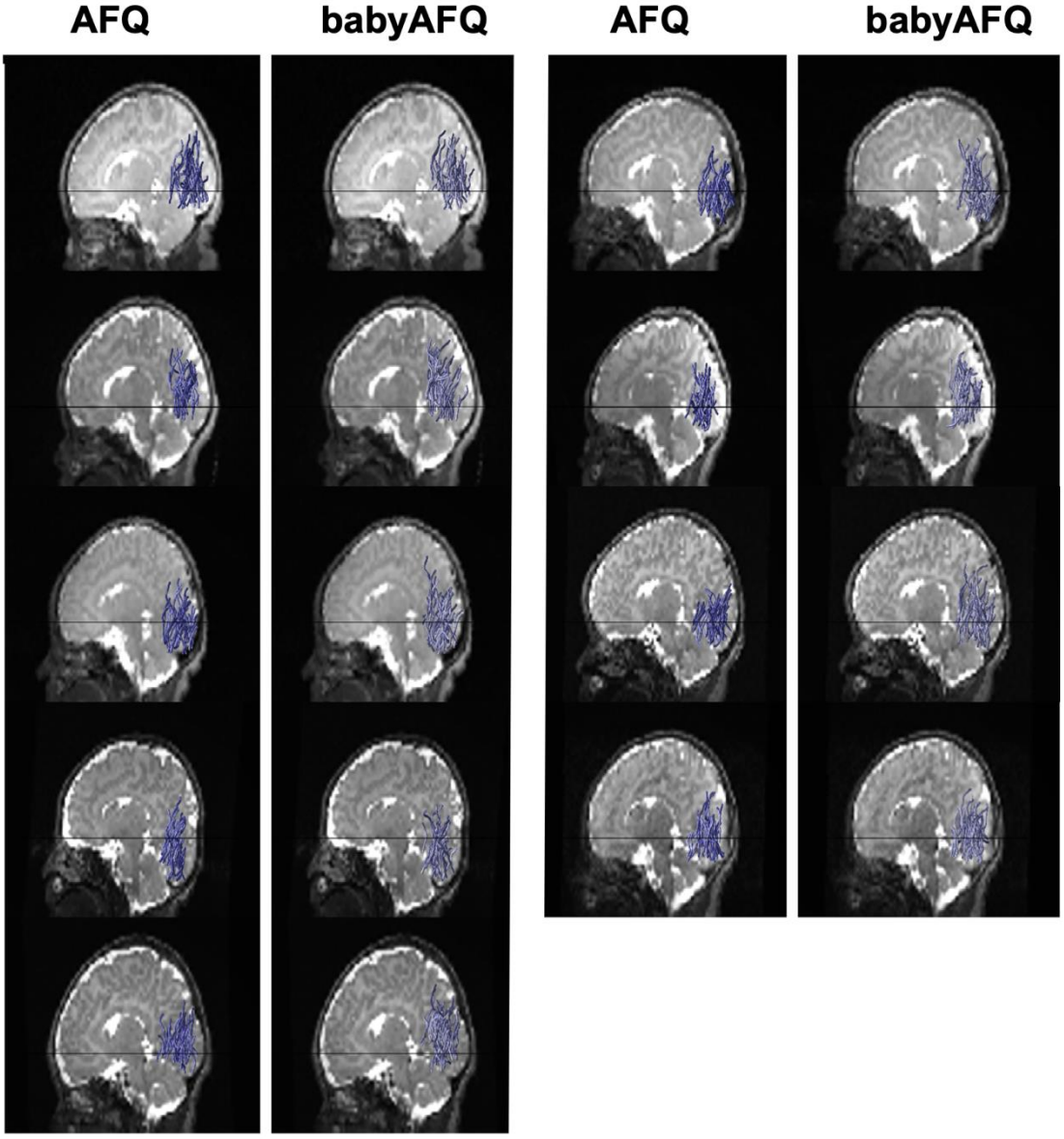
# Left Vertical Occipital Fasciculus
# Newborn



# Left Vertical Occipital Fasciculus



# Right Vertical Occipital Fasciculus
# Newborn



# Right Vertical Occipital Fasciculus