**Exploring Diffusion MRI: Phantom & Human Analyses**

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**Introduction**

Diffusion weighted imaging (DWI) is used as an approximation to detect anisotropic diffusion reflecting brain white matter tracts in vivo. There exist two major tracking reconstruction methods for DWI: Diffusion Tensor Imaging (DTI) and High Angular Resolution Diffusion Imaging (HARDI). The aims were threefold: (1) explore DSIstudio's and diffusion imaging using a controllable standard, an anisotropic diffusion phantom, as a model for extra-cellular restricted diffusion. (2) assess the practical differences of the two reconstruction methods, and (3) incorporate fMRI regions of interest (ROIs) for tracking analysis in human subjects.

For the phantom and human analyses, images were acquired using a 3T Siemens MR whole body scanner with 32-channel headcoil using a double spin echo pulse sequence to reduce eddy current distortion. Slices were ordered in an interleaved fashion with a voxel size of 2.4 mm
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**Phantom Analysis**

**Aim 1:** explore diffusion imaging parameters using an anisotropic diffusion phantom (Brain Innovation BV, Maastricht, The Netherlands), as a model for extra-cellular restricted diffusion (Pullens et al., 2010).

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**Aim 2:** practical differences between DTI and HARDI.

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**Aim 3:** phantom analysis

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**Human Analysis**

**Design:** Six subjects (3 male, 3 female; ages 20-30 yrs.) were used in human analysis. One subject was left handed and five subjects were right handed.

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**Analysis 1:** MRI data processing was carried out using FEAT (FMRI Expert Analysis Tool).

**Version 5.98**, part of FSL (FMRI’s Software Library, www.fmrib.ox.ac.uk/fsl).

For processing, the following were applied: (1) non-brain removal using BET (brain extraction tool) (Smith 2002), (2) motion correction using MCFLIRT (Jenkinson 2002), (3) time-series statistical analysis was carried out using FSLFM with local autocorrelation correction (prewhitening) (Woolrich 2001), (4) grandmean intensity normalization of the entire 4D dataset by a single multiplicative factor; (5) GLM fitting for the robust and accurate linear registration and motion correction of brain images. NeuroImage 17(2):825-841.

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**Analysis 2:** Motion and image drift cannot be estimated from DW images due to lower signals and contrast variations of anisotropic diffusion at different directions of DW gradients. Motion correction in diffusion imaging needs to address two aspects: (1) registration of intensity and (2) rotation of the diffusion vector.

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Motion correction comparison is shown for global comparison and for cingulate ROI comparison. The anterior portion and edges of the brain are most affected.

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**Conclusions**

**Phantom Analysis:**

In the diffusion phantom, DTI accurately resolved more tracts when scanning for more directions performed better than HARDI at a lower b value. However, DTI was unable to resolve crossing fiber tracts in the phantom and was limited in resolving lateral projections.

**Human Analysis:**

White bilateral DLPFC activation was found, the right DLPFC typically exhibited larger activation. Tracking revealed connections between active DLPFC cortical areas and connections from active DLPFC regions to inactive, but spatially analogous, regions. Therefore, asymmetrical BOLD activation may be unrelated to connective tracks.

**Overall:**

1. Diffusion imaging dependent on: ROI, b-value, & directions, & orientation.
2. Diffusion imaging particularly susceptible to subject motion.
3. Subject comparisons in diffusion imaging not trivial.
4. Tracking is a useful exploratory technique.

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**References**

1. Diffusion tensor imaging tutorial (tutorialbrainglobe.org)

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