Tractometry of the subcortical motor network using SHORE-based indices

Introduction

In this work we aim at investigating the 3D Simple Harmonic Oscillator based Reconstruction and Estimation (3D-SHORE) derived numerical indices for quantitative tractography. In particular, we target the cortico motor network (SC-MN) of a cohort of ten healthy subjects. Using diffusion spectrum imaging (DSI) we reconstructed the network connections and compared the resulting information about white matter (WM) density and structure to that provided by Generalized Fractional Anisotropy (GFA) and Magnetization Transfer Ratio (MTR). The SC-MN gathers the connections between the cortical motor area, the basal ganglia and the thalamus, and it essentially consists of three major subcortical networks (Figure 1).

Methods

Ten healthy subjects (age 56±17.8 years old, mean±SD) went through a DSI scan twice one month apart (±1 week, tp1 and tp2, see [1] for more details). The Ensemble-Average Propagator (EAP) was reconstructed using the SHORE model [6] and the orientational (ODF) and microstructural indices (±1 week, tp1c and tp2c, see [1] for more details). Comparative analysis revealed that the applied 3D-SHORE indices are highly correlated to anisotropy measures like GFA and much less with MTR (Table 1).

Results and Discussion

The Ensemble-Average Propagator (EAP) was derived including Return to zero (RTOP), Return to axis (RTAP) and Return to plan (RTPP) probability and propagator anisotropy (PA) as in [6]. From RTAP, an estimation of the mean ensemble value of the axons' radius (R) can be inferred [5]. This might suggests that the applied 3D-SHORE indices are highly correlated to anisotropy measures like GFA and much less with MTR (Table 1).

Comparative analysis revealed that 1) the indices are not normally distributed along the bundles for any pair of regions (Jargue-Bera, p<0.001); 2) histograms are stable across time points for all indices (GFA, MTR, RTAP, R, PA) (Table 1); 3) RTAP, R and PA absolute percent changes on mean is highly correlated with those of GFA as well as histogram distances; 4) PA has the highest correlation with GFA, while R has the highest correlation with MTR and is highly correlated with GFA; 5) the distributions of the estimated axons radius is consistent across the fiber bundles and the values reported in literature [7,8] (Figure 2: average distribution across subjects).

Conclusions

Our results confirm that all the indices are reproducible over time in the SC-MN of normal subjects. Last, our data show that 3D-SHORE indices are highly correlated to anisotropy measures like GFA and much less with measures of myelin presence (i.e. MTR) with the exception of R. This might suggests that the applied 3D-SHORE can be sensitive enough to detect the effect of myelin on axonal diameter.