Targeted audience: clinicians and researchers in pediatric neurology. Purpose: Epilepsy is one of the most common neurologic disorders and impacts the quality of life of affected individuals. Surgical removal of the epileptogenic brain tissue is an option for children (and adults) whose seizures cannot be controlled with medications. Thereby, the primary motor areas have to be identified and preserved. The current gold standard for identifying the primary motor areas in young children who cannot follow functional tasks in functional MRI (fMRI) is electrical stimulation mapping (ESM) which, however, is invasive and often inadequately sensitive in young children. Diffusion weighted imaging (DWI) is a powerful technique that does not require patient cooperation and may be used to investigate the white matter tracts such as cortico-spinal tract (CST), of which damage would result in deficits of contralateral motor function. We determined whether DWI tractography can provide automatic localization of cortical areas and white matter pathways associated with movement of mouth/lip, fingers, and ankle/legs, by testing a new method: a maximum a posteriori probability (MAP) classification using neural connectivity of the cortico-spinal tract (CST) between the precentral gyrus (PCG) and posterior limb of internal capsule (PLIC). Methods: Subjects included 17 normally developing children (age: 10.0±3.3 years, 4.3-17.8 years, 9 boys) and 10 children with focal epilepsy (age: 12.3±4.9 years, 2.4-17.1 years, 6 boys). MRI scans were performed on a 3T GE-Signa scanner (GE Healthcare, Milwaukee, WI) equipped with an 8-channel head coil and ASSET. DW-MRI was acquired with a multi-slice single shot diffusion weighted echo-planar-imaging (EPI) sequence at TR = 12,500ms, TE = 88.7ms, FOV = 24cm, 128x128 acquisition matrix (nominal resolution = 1.89mm), contiguous 3 mm thickness in order to cover axial slices of the whole brain using 55 isotropic gradient directions with b=1000s/mm², one b=0 acquisition, and number of excitations (NEX)=1. Whole brain fMRI data, to map the areas of mouth/lips, fingers, and ankle/legs, were also acquired from normally developing children using T2*-weighted EPI sequence at TR=2000ms, TE=30ms, matrix=64x64, FOV=24cm, thickness=4mm. An independent component analysis tractography combined with ball-stick model (ICA+BSM) tractography was performed to identify unique CST pathways originating from mouth/lip, finger, and ankle/leg areas determined by fMRI. Group averaging of these pathways was performed across subjects in MNI space to construct homunculus representations of primary motor areas in PCG and PLIC, P_{PCG}(x,y,z|C_i) and P_{PLIC}(x,y,z|C_i), which represents the estimate of probability that a given fiber penetrates to a voxel (x,y,z) in PCG and PLIC of C_i = "mouth/lip", C_2 = "finger", C_3 = "ankle/leg", respectively. We designed a maximum a posteriori (MAP) classifier that can make a classification of a given tract of CST pathways into four classes of interest, "mouth/lip", "finger", "ankle/leg", and "others", by transferring the maps of P_{PCG}(x,y,z|C_{i=1,2,3}) and P_{PLIC}(x,y,z|C_{i=1,2,3}) into individual subject’s space via spatial deformation obtained between the subject’s b0 image and MNI b0 template. The resulting maps were then used to approximate the conditional probability of a given voxel (x,y,z), P(x,y,z|C_i) for i=1,2,3 for "mouth/lip", "finger", and "ankle/leg", respectively. Also, to decrease ambiguous classification, we defined an “other” class, C_{i=4} for unnecessary false fibers. Since the conditional probability map, P(x,y,z|C_i) of the fiber_j into four classes of interest, C_1 = "mouth/lip", C_2 = "finger", C_3 = "ankle/leg", and C_4 = "other". P(fiber_j|C_i) represents the estimate of probability that a given fiber penetrates to a voxel (x,y,z) in PCG and PLIC of C_i = "mouth/lip", C_2 = "finger", C_3 = "ankle/leg", and C_4 = "other". P(fiber_j|C_i) is defined by the probability of voxel (x,y,z) belonging to the i-th class, the MAP classifier makes a decision of a given tract of CST pathways, fiber, into four classes of interest, C_1 = "mouth/lip", C_2 = "finger", C_3 = "ankle/leg", and C_4 = "other". The 2\frac{P_{PCG}(x,y,z|C_i)+P_{PLIC}(x,y,z|C_i)}{C_i=1,2,3,4} if \ P(fiber_j|C_{i=1,2,3})\geq P_{fiber_j} MAP(fiber_j)=\text{argmax} P(fiber_j|C_i) else, MAP(fiber_j)=4, where P_{PCG}(x,y,z|C_i) and P_{PLIC}(x,y,z|C_i) represent the locations of electrodes used for ESM. C_1: ‘mouth/lip pathway’, C_2: ‘finger pathway’, C_3: ‘leg pathway’ were obtained at P_{th}=0.30.

Discussion and Conclusion: This study provides preliminary evidence that an integrative tool can delineate not only the primary motor cortices but also visualize the underlying CST fibers for presurgical planning.