Multidimensional diffusion MRI: From colloid science to learning studies

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The structure of the brain is changing during learning processes such as language acquisition. The structural changes take place on a range of length scales: from the formation of new connections between individual neurons to the growth of entire brain regions. Magnetic resonance imaging (MRI) gives information on brain structure through measurements that can be completely non-invasive, a fact that is of particular importance for learning studies. The fundamental limits to the spatial resolution in MRI unfortunately prohibit the acquisition of images where single nerve cells can be resolved. Still, one can get microstructural information averaged over millimeter-size volume elements. This presentation gives an overview of our new diffusion MRI methods utilizing the micrometer-scale translational motion of water to map the shape, density, orientation, and membrane permeability of the cells. In the methods development work, we make extensive use of materials from the world of colloid science, having structures closely resembling the ones in the living brain. Since the new methods are both non-invasive and give previously inaccessible information, they have great potential for providing answers to the questions about what happens to the brain on the microstructural level when acquiring new knowledge.