Probing Gray Matter Microstructure in Alzheimer's Disease using Diffusion MRI

Popular scientific summary

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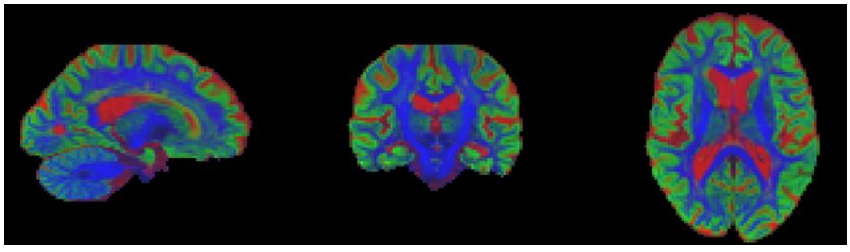
Alzheimer's disease is a neurodegenerative disease affecting 50 million people and is the most common cause of dementia. With an aging population, this number is expected to rise up to 130 million, making Alzheimer's and dementia research indispensable. For the development of a treatment for Alzheimer's disease, the ability to diagnose the disease and track its progression is of utter importance. In my thesis, new methods for tracking microstructural changes in the brain caused by Alzheimer's will be investigated.

What causes Alzheimer's disease and what happens in the brain?

It is not completely understood what causes Alzheimer's and how it progresses, but we do know some processes that appear during the disease. In early stages, two pathological processes appear. Two proteins, namely amyloid-beta and tau, start misfunctioning and accumulate in the brain. This leads to cell death and neurodegeneration, which leads to atrophy (shrinking) of the brain. In later stages of the disease, symptoms like cognitive impairment and dementia appear.

How can we measure these early changes in the brain?

Using MRI we can detect this atrophy and use it to track the progression of the disease. Before the atrophy can be detected, however, microstructural changes take place. Due to the pathological processes, like the aggregation of proteins in plaques and cell death, the composition of the tissue changes. These changes can be detected using diffusion MRI. Diffusion MRI can measure the movement of particles (so-called diffusion), which depends on the environment. For example, diffusion can be hindered by cells. By measuring the speed and direction of diffusion, we can draw conclusions about the microstructure. In my thesis, the MT-CSD model (multi-tissue constrained spherical convolution) was used to separate three main tissues in the brain (gray matter, white matter and free water), like in the picture below, and investigate how the ratio of these tissues changes with Alzheimer's disease.



How can we use this model to help Alzheimer's research?

In my work, I found that for patients with Alzheimer's the faction of free water contents in the gray matter is higher than for healthy people. This can be caused for example by cell death, which leads to more free space for the particles to move, i.e. higher diffusion. My work is of course just a first step in testing the potential of this model, but the first results seem promising. If it proves useful and reliable in the future, it could be used to track how the microstructure changes with the progression of the disease and more importantly how medication can change this – hopefully leading to a treatment of Alzheimer's disease in the future.