Tracking Age-Related Changes using NOE_{MTR} in Brain Subregions at 3T

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INTRODUCTION: The aging brain is a complex entity that undergoes significant change over the course of one's lifespan. The human brain encompasses a multitude of neural structures, each contributing to human cognition and behavior. Among these structures, the thalamus, caudate nucleus, hippocampus, pallidum, and putamen are pivotal in shaping our sensory perception, motor control, and memory functions[1]. Brain is the most lipid rich organ and contains 50% of its dry weight as lipids[2]. Nuclear Overhauser Effect Magnetization Transfer Ratio (NOE_{MTR}) is an emerging technique to study mobile macromolecules such as lipids and proteins in the brain[3]. In this study, we evaluate NOE_{MTR} as a function of age in 15 participants (ages 24Y-76Y) in various sub-regions, that may improve our understanding of age-related lipid metabolism among these specific brain regions. This is the first time this has been observed using NOE_{MTR}.

METHODS: All human studies were conducted under an approved University of Pennsylvania Institutional Review Board protocol. Fifteen healthy volunteers (13 males, 2 females) aged 24-to-76years old participated in the study. All imaging was performed on a 3T whole body scanner (MAGNETOM Prisma, Siemens Healthcare, Erlangen, Germany) with a body transmit/32-channel receive proton phased-array head coil. The 3D-NOE acquisition parameters are: number-of-slices=12, slice thickness=2 mm, in-plane resolution=1x1x2mm^3, matrix-size=240x196, gradient-echo readout TR=3.5ms, TE=1.79 ms, read-out flip-angle=10°, averages=1, SHOT-TR = 8000ms, and saturation pulse of $B_{1,rms}$=0.62μT with a saturation length of 3s.

RESULTS: We observed noteworthy correlations between age and NOE_{MTR} across the thalamus, caudate, putamen and pallidum (**Figure 1**). In the thalamus, a significant negative correlation was identified (Pearson's correlation coefficient, pcc = -0.77, p = 0.0006), indicating a reduction in NOE_{MTR} with advancing age. Similarly, a significant negative correlation was found in the caudate (pcc = -0.75, p = 0.0008), and in the putamen (pcc = -0.67, p = 0.004). The pallidum also exhibited a negative correlation (pcc = -0.38) with age, suggesting potential age-related changes; however, this association was not statistically significant (p = 0.15). Lastly, the hippocampus displayed a negative correlation (pcc = -0.65, p = 0.006), which was statistically significant. Illustrated in **Figure 2** are representative NOE_{MTR} maps from the 24 and 76 y/o within the cohort. Here we observe a significant drop in the caudate, thalamus, hippocampus, and pallidum.

DISCUSSION: Results from this study collectively suggest that NOE_{MTR} in the thalamus, caudate, putamen, and hippocampus is significantly influenced by age, with a clear decline in NOE_{MTR} as subjects grow older. While the pallidum showed some evidence of age-related trends, further investigations with larger sample sizes may be necessary to establish statistical significance in these subregions. These findings contribute to our understanding of age-related changes in brain tissue microstructure and may have implications for future studies examining the role of NOE_{MTR} in healthy aging, neurodegenerative processes, and cognitive decline.

REFERENCES:

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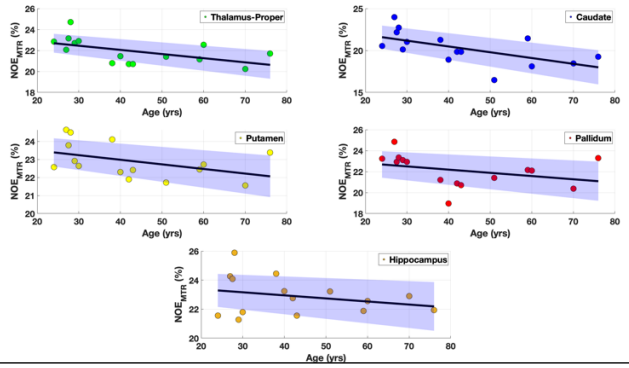

Figure 1: This figure displays scatter plots illustrating the relationship between age and NOE_{MTR} in different brain subregions. Each subregion, including thalamus, caudate, putamen, pallidum, and hippocampus, is represented by a distinct scatter plot surrounded by its respective 95% confidence interval. These plots visually depict there is a negative correlation between NOE_{MTR} as a function of age for each subregion.

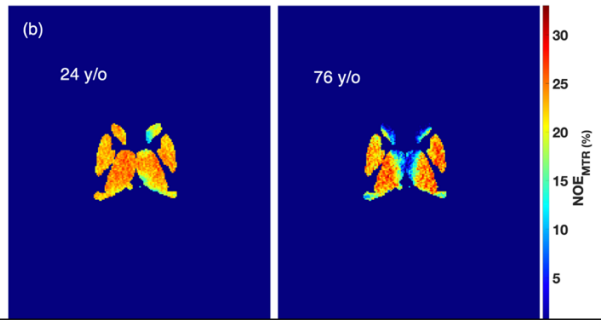

Figure 2: NOE_{MTR} maps overlayed onto the respective segmentation maps of the 24- and 76-year-old subject. The NOE_{MTR} map shows a significant drop in signal in the caudate, hippocampus and thalamus regions for the 76-year-old subject (b).