Linking callosal structure to uni- and bilateral motor task performance in younger and older adults

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Introduction:

The corpus callosum (CC) as largest commissural fiber tract enables interhemispheric exchange of information. It is crucial for uni- and bilateral motor performance [1], which is known to decline with higher age [2,3]. However, the impact of altered structural integrity of the CC on age-related motor decline is not well understood. Gait disturbances and lower tapping rates have been associated with lower fractional anisotropy (FA) of CC subregions [4]. Yet, regions involved varied and most studies focused on single motor tasks in rather small or specific samples. We therefore examined several uni- and bilateral motor tasks in relation to diffusion-based imaging variables of the CC in two large groups of younger and older adults.

Methods:

From 555 eligible participants of the population-based 1000BRAINS cohort [5] the youngest and oldest (quartiles of age distribution, 93% right-handed) were split into an older (OA, >69 years, n=139) and a younger (YA, <49 years, n=138) age group. Analyzed motor tasks included (i) unilateral and alternating bilateral tapping at preferred and maximum pace; (ii) gait with and without a loaded tray plus a verbal or non-verbal cognitive task; (iii) balance on an oscillating platform after lateral displacement. After eddy current and motion correction, FA (FSL 5.0.9) and probabilistic streamline tractography (MRtrix3) was computed based on diffusion-weighted MR images, resulting in values of mean FA and number of streamlines passing through each subregion of the CC [6]. Imaging variables were corrected for intracranial volume; tapping and gait variables for body height by linear regression. Using the residuals, FA and streamlines of each subregion were correlated with each motor task separately for OA and YA (Spearman, Bonferroni-corrected p-value).

Results:

OA had poorer motor performance, e.g. OA tapped and walked slower, needed more steps and had a worse balance.
Higher FA in the anterior midbody of the CC, mostly comprising motor fibers, was related to higher frequency in bilateral tapping at maximum speed in YA and to left-handed tapping at maximum speed in OA (Fig. 1). Additionally, in OA more walking steps during the non-verbal task were associated with lower streamline counts, and better balance performance after a push from the left with higher FA in the rostrum, respectively. Here, no correlations in YA were found.

Conclusions:

In both groups tapping frequency at maximum speed was associated with CC anterior midbody microstructure. Only the specific task differed: this concerned bilateral in YA, but left-handed tapping in OA. Increasing tapping is related to greater motor overflow [7] that may lead to contralateral mirror movements, in particular during more demanding tapping with the non-dominant hand. Suppression of this overflow is facilitated by interhemispheric CC connections - obviously already required in OA for the left-handed tapping and for the even more demanding bilateral tapping in YA, where OA did not reach a sufficiently demanding speed.

Further, the relation between more steps in the non-verbal cognitive task and lower streamline counts in the rostrum of the CC possibly hints for less interhemispheric exchange. The rostrum connects premotor and prefrontal regions, which are relevant for higher cognitive tasks [8]. Thus, to remain able to solve the task while walking, OA may had to adapt by making more (shorter) steps.
Higher integrity (reflected by higher FA) within the rostrum of the CC also seems to help maintaining balance. Again, this was only found for the left, non-dominant body side.
Taken together, this emphasizes that structural integrity of the CC is in particular relevant in OA for more demanding motor tasks, e.g. performed with the non-dominant side. Additionally, in YA motor performance, i.e. tapping, was only linked to FA, but in OA also to streamline count, hence the latter may be of additional informative value for understanding the structural impact of CC regions on motor performance in OA.

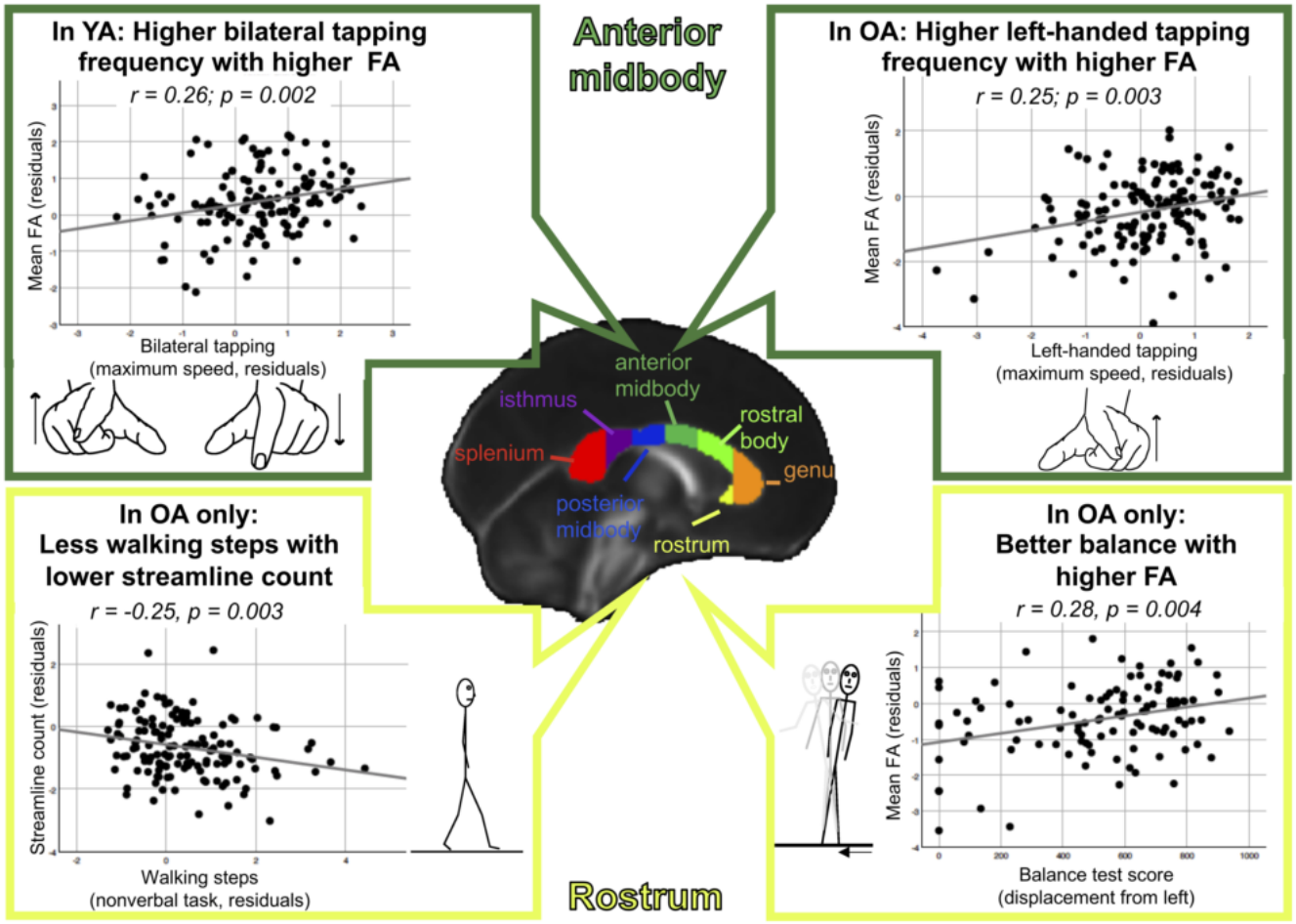

Fig. 1. Results from correlation analyses between FA and streamline count for each CC subregion and each motor task, obtained for YA and OA separately. The seven subregions of the CC [1] are depicted on the FMRIB58_FA (FSL 5.0.9) template. Values outside the range of four standard deviations around the mean were defined as outliers and excluded before analysis. Graphical icons: © C. Sproß

(https://files.aievolution.com/prd/hbm2101/abstracts/abs_1241/Figure1_Final.png)

Lifespan Development:

Aging [2]

Motor Behavior:

Motor Behavior Other [1]

Keywords:

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WHITE MATTER IMAGING - DTI, HARDI, DSI, ETC
Other - uni- and bilateral movements, corpus callosum, fractional anisotropy, gait, tapping, dual task

[1|2]Indicates the priority used for review

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No

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Not applicable

Please indicate which methods were used in your research:

Diffusion MRI
Other, Please specify - Motor performance testing

For human MRI, what field strength scanner do you use?

3.0T

Which processing packages did you use for your study?

FSL
Other, Please list - MRtrix3, ANTs

Provide references using author date format

[1] Eliassen (2000). Anterior and posterior callosal contributions to simultaneous bimanual movements of the hands and fingers. Brain: A Journal of Neurology, 123 Pt 12, 2501–2511. https://doi.org/10.1093/brain/123.12.2501
[2] Fujiyama, H. (2016). Age-Related Changes in Frontal Network Structural and Functional Connectivity in Relation to Bimanual Movement Control. The Journal of Neuroscience: The Official Journal of the Society for Neuroscience, 36(6), 1808–1822. https://doi.org/10.1523/JNEUROSCI.3355-15.2016
[3]Maes, C. (2017). Two hands, one brain, and aging. Neuroscience and Biobehavioral Reviews, 75, 234–256. https://doi.org/10.1016/j.neubiorev.2017.01.052
[4]Fling, B. W. (2011). Differential callosal contributions to bimanual control in young and older adults. Journal of Cognitive Neuroscience, 23(9), 2171–2185. https://doi.org/10.1162/jocn.2010.21600
[5]Caspers, S. (2014). Studying variability in human brain aging in a population-based German cohort-rationale and design of 1000BRAINS. Frontiers in Aging Neuroscience, 6, 149. https://doi.org/10.3389/fnagi.2014.00149
[6]Witelson, S. F. (1989). Hand and Sex Differences in the Isthmus and Genu of the Human Corpus

Callosum. Brain, 112, 799–8. https://doi.org/10.1093/brain/112.3.799
[7]Bodwell, J. A. (2003). Age and Features of Movement Influence Motor Overflow. Journal of the American Geriatrics Society, 51(12). https://doi.org/10.1046/j.1532-5415.2003.51557.x
[8]Ferrari, M. (2014). Prefrontal cortex activated bilaterally by a tilt board balance task: A functional near-infrared spectroscopy study in a semi-immersive virtual reality environment. Brain Topography, 27(3), 353–365. https://doi.org/10.1007/s10548-013-0320-z