

Verbal training improved the white matter integrity and reading performance



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INTRODUCTION

Background

--- Deterioration of the brain structure is thought to be the cause of cognitive decline in the aging population; therefore, studies comparing changes to structural integrity and function are increasingly applied.

--- Previous studies suggested that verbal training could modulate brain activity in regions associated with language.

--- The study aims to investigate whether verbal training could enhance the integrity of language-related white matter tracts in older adults. A group of 40 healthy elders participated in a 4-week program during which they practiced a daily verbal articulation task.

Purposes

--- Can 4 weeks' verbal training induce changes in the white matter integrity of language-related tracts?

--- Is the change in white matter integrity associated with participants' articulation performance in sentence reading?

METHODS

Participants

--- 40 subjects were divided, including the control group (n=20, age=70.3, SD=3.6, m/f=10/10) and experimental group (n=20, age=69.7, SD=4.2, m/f=12/18).

Procedures

(1) At Day 1, participants underwent scanning and a neuropsychological battery including the Verbal fluency test (5min), Stroop task (10min), Bochumer Matrices Test (BOMAT) (15min), WAIS III digit span (backwards only, 5 min), WAIS III digit symbol (5min), MMSE (10min), GDS (3min), H.N. Handedness (3min) and sentence reading task (10min).

(2) At Day 28, the training group underwent the procedure again. The control group only received the tests of the neuropsychic battery from Day 1 to Day 28.

(3) The training lasted 20-25 minutes per day, with a one-day break after the three-day training.

Image Conversion

--- T1-weighted 3D MPRAGE and Diffusion Tensor Images (DTI) were acquired in a 3 Tesla MR scanner (TIM Trio, Siemens, Erlangen, Germany).

Data Analysis

--- Image converting --- dcm2nii

--- Image preprocessing --- FSL (<https://fsl.fmrib.ox.ac.uk/fsl/fslwiki/FDT>)

--- Analysis --- Tract-Based Spatial Statistics (TBSS) (<https://fsl.fmrib.ox.ac.uk/fsl/fslwiki/TBSS>)

SENTENCE READING TASK

(1) We created 4 conditions (10 items in each condition) totaling 40 sentences for the reading task. All sentences were presented in the order of Subject-Adjective-Object-Verb.

(2) The definition of difficult or easy to articulate was determined by the consonants which were late or early acquired by Japanese children.

(3) Participants in experimental group were instructed to complete the verbal articulation of 40 sentences. They were required to read sentences 10 times as fast and accurately as possible.

--- 4 conditions

(1) Easy-to-articulated sentence with real words:
"[マキは] [棚の刀を] [磨く] (Maki polishes a sword on the shelf)."

(2) Difficult-to-articulated sentence with real words:
"[シホは] [私費の] [施設を] [保守する] (Shiho protects a private facility)."

(3) Easy-to-articulated sentence with pseudowords:
"[コペメは] [グテの] [テビミを] [ぐぼねく]"

(4) Difficult-to-articulated sentence with pseudowords:
"[チリヨサは] [ルヒャの] [ズラシュを] [はわせす]"

RESULTS: Tract-Based Spatial Statistics Analysis

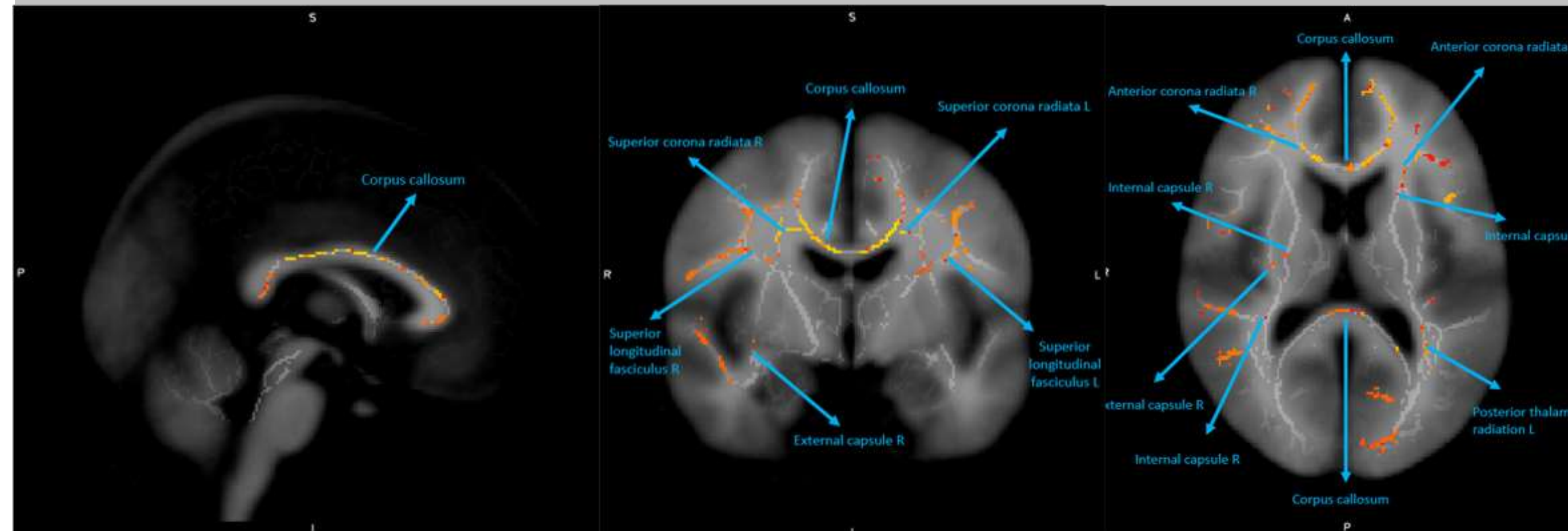


Figure 1. (1) Two Sample T-Test Between Post-Control Group and Post-Experimental Group ($p < 0.001$, TFCE):

The improved association fiber tracts included the superior longitudinal fasciculus (SLF). The enhanced projection fiber tracts included the superior and anterior corona radiata, the right external capsule, the posterior limb of the right internal capsule, the retro-lenticular part of the right internal capsule, the anterior limb of the left internal capsule, and the left posterior thalamic radiation. One of the commissural fiber tracts, the corpus callosum, showed improvement after the training sessions.

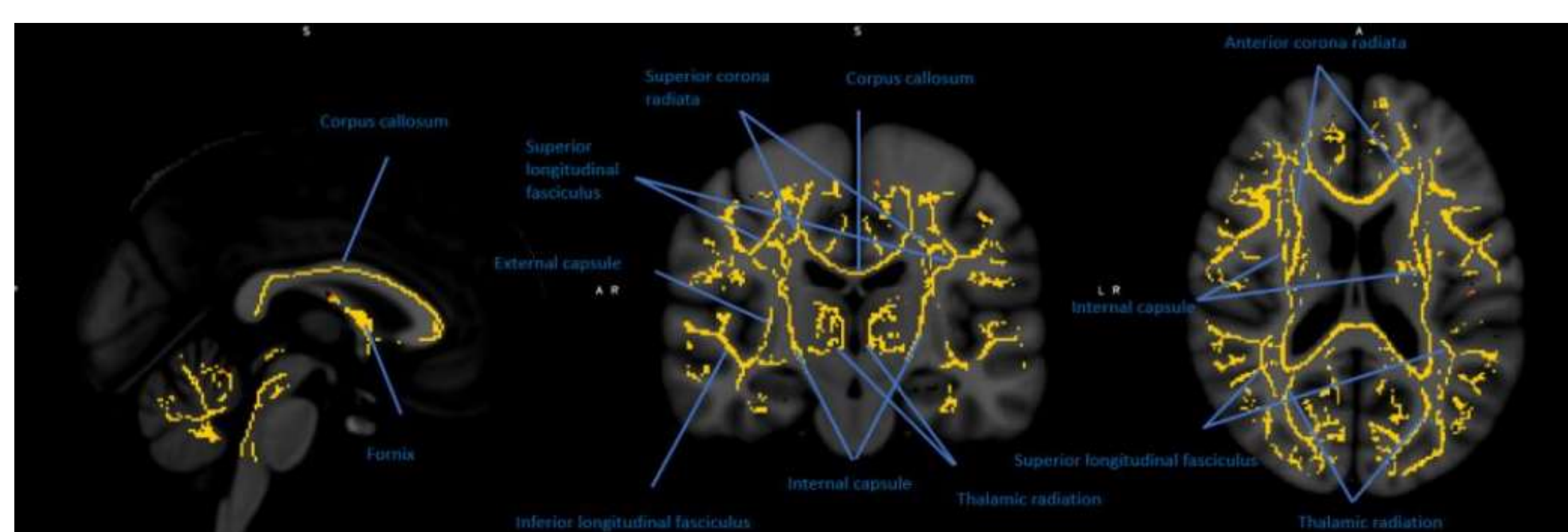


Figure 2. Correlation Between FA and Difficult-to-Articulated Sentences with Real Words ($p < 0.001$, TFCE):

Significant correlations between FA of the fiber tracts and difficult-to-articulated sentences with real words were observed. The improved association fiber tracts included the superior longitudinal fasciculus (SLF) and inferior longitudinal fasciculus (ILF). The enhanced projection fiber tracts included the superior and anterior corona radiata, the right external capsule (EC), the internal capsule (IC), the thalamic radiation. The commissural fiber tracts, represented by the corpus callosum (CC) and fornix, also showed correlation with the sentences.

Correlation between neuropsych scores and both groups ($p < 0.001$, TFCE):

No significant correlation was observed between any neuropsych scores and white matter change in either group.

DISCUSSION and CONCLUSION

(1) Our findings has demonstrated that a 4 weeks' verbal intervention could lead to significant improvement in white matter integrity. These results are consistent with previous studies that have linked these tracts to various aspects of language, such as vocabulary development, syntactic processing, phonological awareness, and semantic-lexical mapping.

(2) We have observed a significant correlation between the FA values in certain fiber tracts and the production of difficult-to-articulated sentences with real Japanese vocabularies. Targeting these fiber tracts in therapeutic interventions may lead to more effective treatments for individuals with speech production difficulties or language disorders.

(3) No significant difference were observed in the neuropsychic scores of pre- and post-training groups. This suggests that an articulation-based intervention could not affect the executive functions over a short period of time.

(4) Future studies should consider :

--- A larger sample size

--- Conducting long-term follow-up assessments

--- Incorporate other DTI metrics such as MD and AD

--- Groups including patients with language disorders