



Verbal Training Improved the Gray Matter Volume and Neurocognitive Performance

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INTRODUCTION

Background

--- Previous research has suggested that elders who receive articulation training has shown increased connectivity in the right frontotemporal regions and improved performance in a sentence reading task.

--- This study employs VBM, involves a voxel-wise comparison of the local concentration of gray matter between two group of subjects, to examine shifts in grey matter volume and density responding to articulation training in the healthy elders.

Purposes

--- Can verbal training induce changes in the volume of gray matter in language related area?

--- Is the change in gray matter volume associated with participants' articulation performance in sentence reading?

METHODS

Participants

--- Forty subjects were randomly divided into the training group and the control group.

Procedures

(1) At Day 1, subjects 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

--- Data were acquired using a 3 T Siemens MR scanner, with a 12- channel head coil receiver. A high-resolution T1-weighted 3D MPRAGE scan covering the whole brain (TR = 2,500 ms, TE = 2.63 ms, flip angle = 7°, FOV = 256 mm, and isotropic voxels 1 × 1 × 1 mm) was obtained for all participants.

Data Analysis

--- Image converting --- dcm2nii
--- Image preprocessing --- CAT12 toolbox for SPM
--- Paired t-test and Pearson's correlation test --- SPM12
--- Spatially normalizing single-subject high- resolution T1 volume --- AAL3 toolbox for SPM

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] [はわせず]"

RESULTS: Paired t-test

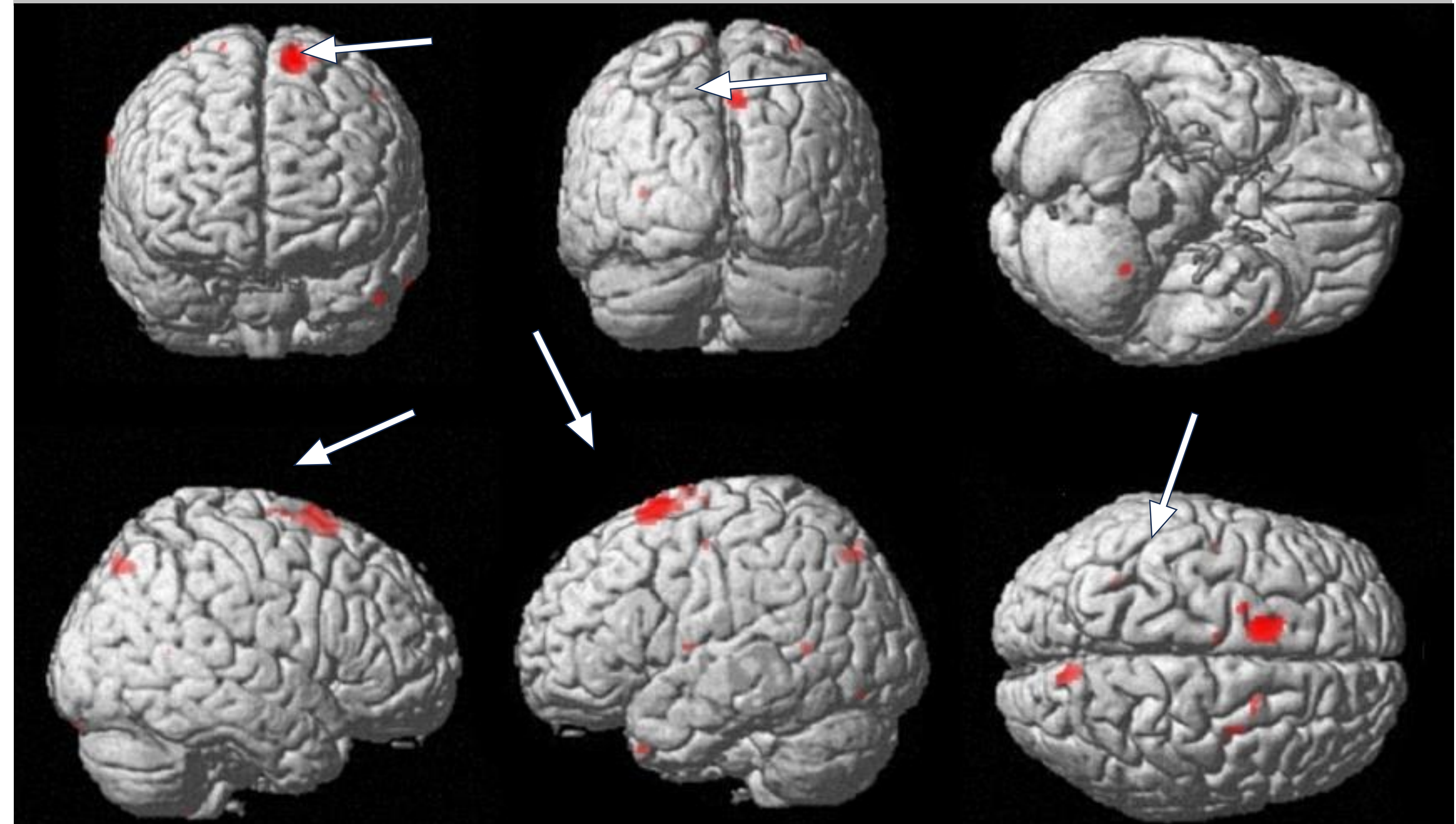


Figure 1. Paired T-Test Between Pre-Training Group and Post-Training Group ($p < 0.001$)

The result of post- and pre-training paired t-test revealed increased gray matter volume in the left supplementary motor area, the left postcentral gyrus, the left and right superior frontal gyri. ($p < 0.001$) (Figure 1).

RESULTS: Pearson's correlation test

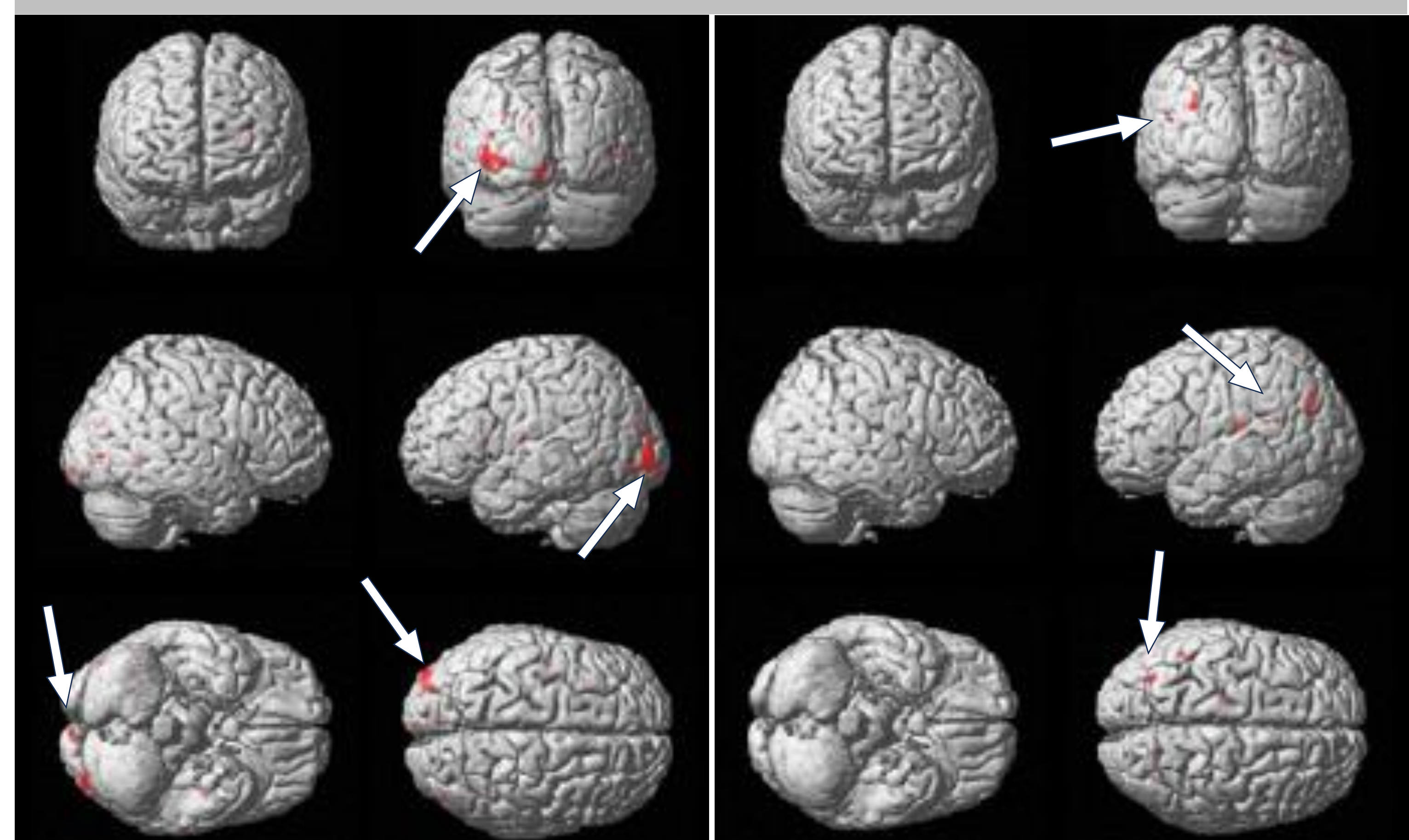


Figure 2. Correlation Between Easy Meaningful Sentences and Training Group ($p < 0.001$)

Figure 3. Correlation Between Difficult Meaningful Sentences and Training Group ($p < 0.001$)

The result of Pearson's correlation analysis revealed the positive correlation between the increase of gray matter and meaningful sentences, primarily in bilateral SFG, MFG, MTG, IFG, and MOG.

DISCUSSION and CONCLUSION

(1) The paired t-test revealed that articulation training can lead to significant increase in gray matter volumes, especially in the left SMA, the left PoCG, and the bilateral SMG. These findings are consistent with previous research on these areas, suggesting their plastic adaptations to support language production. (Boisgueheneuc et al., 2007; Ookawa et al., 2017).

(2) The correlation analysis showed negative correlations between the reading speed of the sentences with real words and increased gray matter volumes, primarily in the bilateral SFG, MFG, MTG, IFG, and MOG. Previous studies have suggested the MTG is associated with semantic retrieval. The MTG shows functional connectivity with the IFG during tasks and at rest, forming a semantic control network. (Davey et al., 2016). The MOG has been linked to object recognition, including the functional properties and perception of said objects. (Grill-Spector et al., 2001). Significant correlations in these regions following training suggest the positive effects on coordination of different networks.

(3) In conclusion, only 30-minute articulatory training per day for a month proved effective on increase of the local brain volumes. Such enhancement in turn bolsters language processing abilities. This change could also potentially subserve the interconnections among various regions of the brain, resulting in improvement in cognitive functions.