Increased gray matter volume and cortical surface area of left pars opercularis in male orchestral musicians correlated positively with years of musical performance

I. Abdul-Kareem[1], A. Stancak[2], L. Parkes[3], and V. Sluming[1]

[1]School of Health Sciences, Magnetic Resonance and Image Analysis Research Centre, University of Liverpool, Liverpool, United Kingdom, [2]Department of Psychology, University of Liverpool, Liverpool, United Kingdom, [3]Department of Imaging Science and Biomedical Engineering, School of Cancer and Imaging Sciences, University of Manchester, Manchester, United Kingdom

Background and purpose

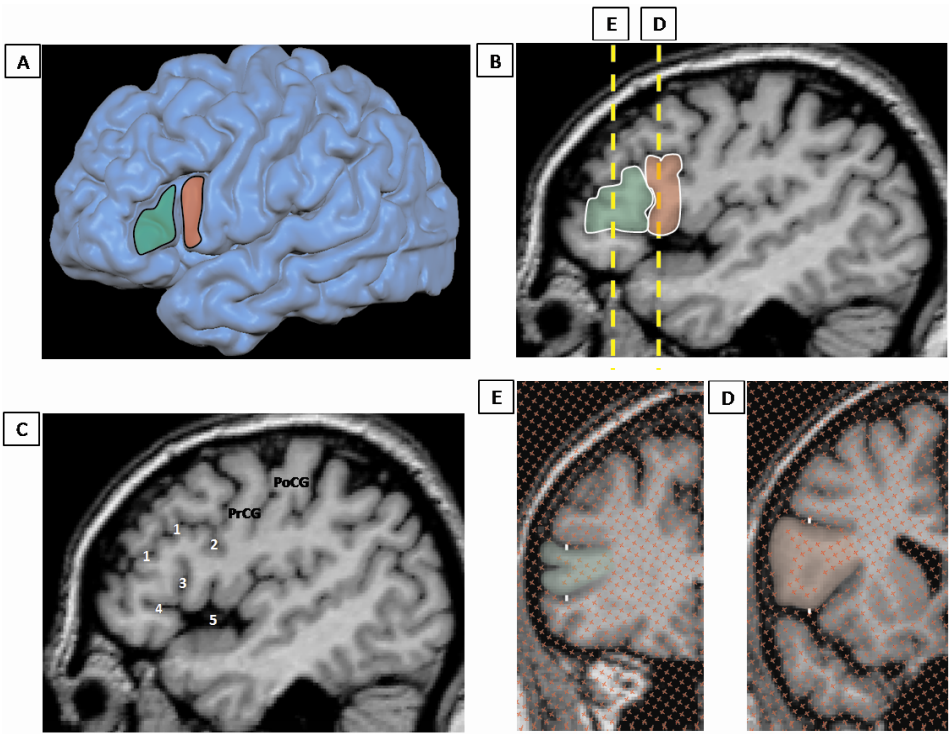
Environmental challenges may result in structural adaptive changes in the brain. Musicians' brains have long been studied for possible structural neuroplasticity in response to early, intensive and prolonged skill acquisition. In addition to language, Broca's region is crucial for several musically relevant abilities, notably audiomotor integration. In a previous study (1), it has been shown that musicians have significantly increased gray matter density in Broca's region in the left hemisphere which was positively correlated with years of musical performance. Here we use the same cohort (1) to compare gray and white matter volumes and cortical surface area measurements of Broca's region subparts: pars opercularis (POP)(BA 44) and pars triangularis (PTR)(BA45) between musicians and non-musicians.

Materials and method

The cohort includes twenty six right handed male orchestral musicians and twenty six musically naive age-, sex- and handedness-matched subjects. Musicians were all members of a major British symphony orchestra. T1-weighted MRI images were obtained at 1.5 T. Gray and white matter volumes of POP and PTR were measured manually using stereology through applying the Cavalieri method in combination with point counting (FIGURE 1). Cortical surface area of these regions was measured automatically in normalized brains using Brain Voyager software.

Result Results show that musicians have significantly increased gray matter volume of left POP ($F_{1,49}$=14.4, p<0.0001), no significant results were detected in gray matter volume of right POP, left and right PTR and white matter volumes for all regions. There was a positive correlation between left POP gray matter volume and years of musical performance (r=0.7, p=0.0001). In addition, musicians have significantly increased cortical surface area of left POP ($F_{1,49}$ = 4.13, p<0.01) with no significant results in left PTR, right POP/PTR. There was a positive correlation between cortical surface area of left POP and years of musical performance (r=0.5, p<0.01).

Conclusion Recent functional studies have shown that POP of the dominant hemisphere is involved in polymodal processing, audiomotor and visuomotor integration being part of the mirror neuron system (2).The surface area in particular may be correlated with neuronal density (3). We hypothesize that early and prolonged skill acquisition in the form orchestral musical performance is an environmentally enriching activity resulting in structural neuroplasticity through increased gray matter volume and cortical surface area of left POP which is essential for performance by ensemble musicians.



References

1- Sluming et al., 2002. Voxel-based morphometry reveals increased gray matter density in Broca's area in male symphony orchestra musicians. Neuroimage 17(3):1613-1622.

2- Baumgaertner et al., 2007. Polymodal conceptual processing of human biological actions in the left inferior frontal lobe. Eur J Neurosci 25(3):881-889.

3- Rockel et al., 1980. The basic uniformity in structure of the neocortex. Brain 103(2):221-244.

Fig. 1. A, Depiction of POP (red) and PTR (green) on a three dimensional hemispheric display and a sagittal section of the same subject **B**; **C**, anatomical boundaries of POP and PTR; 1, inferior frontal sulcus; 2, inferior precentral sulcus; 3, anterior ascending ramus of lateral fissure; 4, anterior horizontal ramus of lateral fissure; 5, lateral fissure; PrCG, precentral gyrus and PoCG, postcentral gyrus; **D** and **E** are coronal sections taken at the level of POP and PTR, respectively showing point counting method used in this study to estimate volume (gray matter in this example). Superior and inferior boundaries were identified by markers (white dots) and only crosses overlying gray matter were counted.