Training induces changes in white-matter architecture

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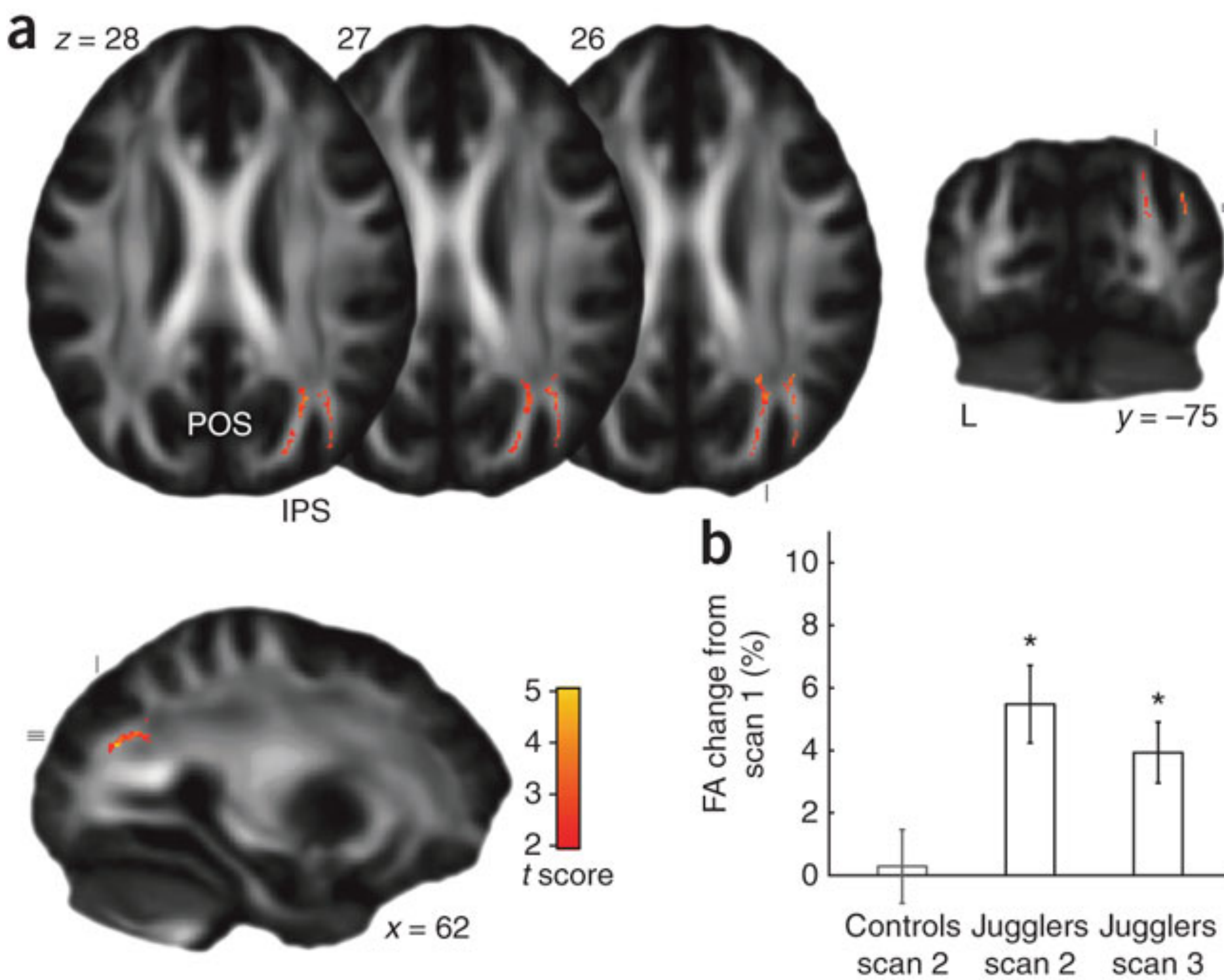
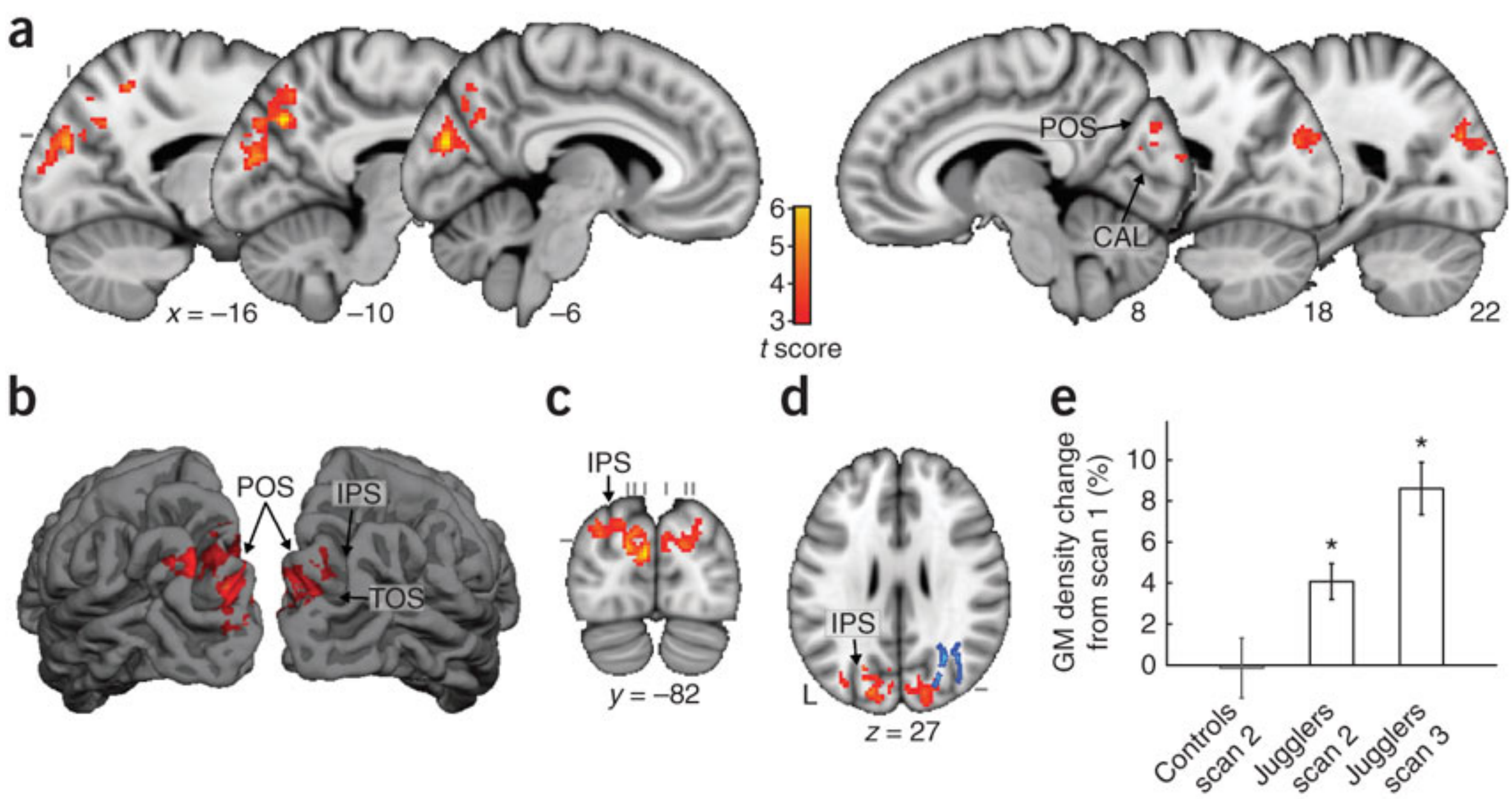
Although experience-dependent structural changes have been found in adult gray matter, there is little evidence for such changes in white matter. Using diffusion imaging, we detected a localized increase in fractional anisotropy, a measure of microstructure, in white matter underlying the intraparietal sulcus following training of a complex visuo-motor skill [JUGGLING]. This provides, to the best of our knowledge, <u>the first evidence for training-related changes in white-matter structure in the healthy human adult brain</u>.
http://www.nature.com/neuro/journal/v12/n11/full/nn.2412.html

Figure 1 - Fractional anisotropy increases after juggling training.



(**a**) Colored voxels represent clusters (corrected $P < 0.05$) of significant fractional anisotropy increase from scan 1 to scan 2, superimposed on the mean fractional anisotropy map. POS, parieto-occipital sulcus. (**b**) Mean fractional anisotropy (FA) change from scan 1 in the cluster shown in **a**. Error bars represent standard errors. * indicates significance relative to baseline at $P < 0.05$.

Figure 2 - Gray-matter density increases after juggling training.



(**a**–**d**) Red and yellow voxels represent clusters ($P < 0.05$, corrected) of significant gray-matter density increase from scan 1 to scan 2, superimposed on the Montreal Neurological Institute template. Sagittal (**a**), coronal (**c**) and axial (**d**) slices, and a surface rendering (**b**) are shown. The white-matter changes (blue, thickened for visibility) are shown in **d** for comparison. CAL, calcarine sulcus; TOS, transverse occipital sulcus. (**e**) Mean gray-matter (GM) density changes from scan 1 in the clusters shown in **a**–**d**. Error bars represent standard errors. * indicates significant at $P < 0.05$ relative to scan 1.
http://www.nature.com/neuro/journal/v12/n11/fig_tab/nn.2412_F2.html

In response to 6 weeks of juggling training FA changed in white matter underlying the intraparietal sulcus of previously naïve adults (21–32 years) (Figure 5). These white matter changes were accompanied by structural changes in overlying gray matter regions. This suggests that brain matter continues to be malleable during adulthood and that learning might rely on reorganization of specific brain regions and their connections.

Juggler, postgraduate student at FMRIB*, and first author on the paper, Jan Scholz, said: ‘We challenged half of the volunteers to learn to do something entirely new. After six weeks of juggling training, we saw changes in the white matter of this group compared to the others who had received no training. The changes were in regions of the brain which are involved in reaching and grasping in the periphery of vision, so that seems to make a lot of sense.’

After the training, there was a great variation in the ability of the volunteers to juggle. All could juggle three balls for at least two cascades, but some could juggle five balls and perform other tricks. All showed changes in white matter, however, suggesting this was down to the time spent training and practicing rather than the level of skill attained.
http://www.physorg.com/news174490349.html

*FMRIB: Oxford Centre for Functional MRI of the Brain

Calories Burned per Hour

Juggling	**280**
Picking Up	865
(or per drop)	~1
Walking Slow	175
Walking Moderate	232
Watching TV	70