Differences in cortical thickness between musicians and non-musicians

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Introduction

A number of studies have investigated aspects of gross cerebral morphology associated with musical training (e.g. Gaser & Schlaug, 2003; Schneider et al., 2002), mainly with the use of manual segmentation and voxel-based morphometry of magnetic resonance images (MRIs). Automated methods for the extraction of cortical thickness from MRIs have been used successfully in experimental and descriptive studies of cerebral anatomy in various populations (e.g. Lerch et al., 2005). In the work described here, we use such a method to compare the cortical thickness of musicians and non-musicians with predicted differences in auditory, motor and dorsolateral frontal cortices.

Methods

Subjects and behavioural testing

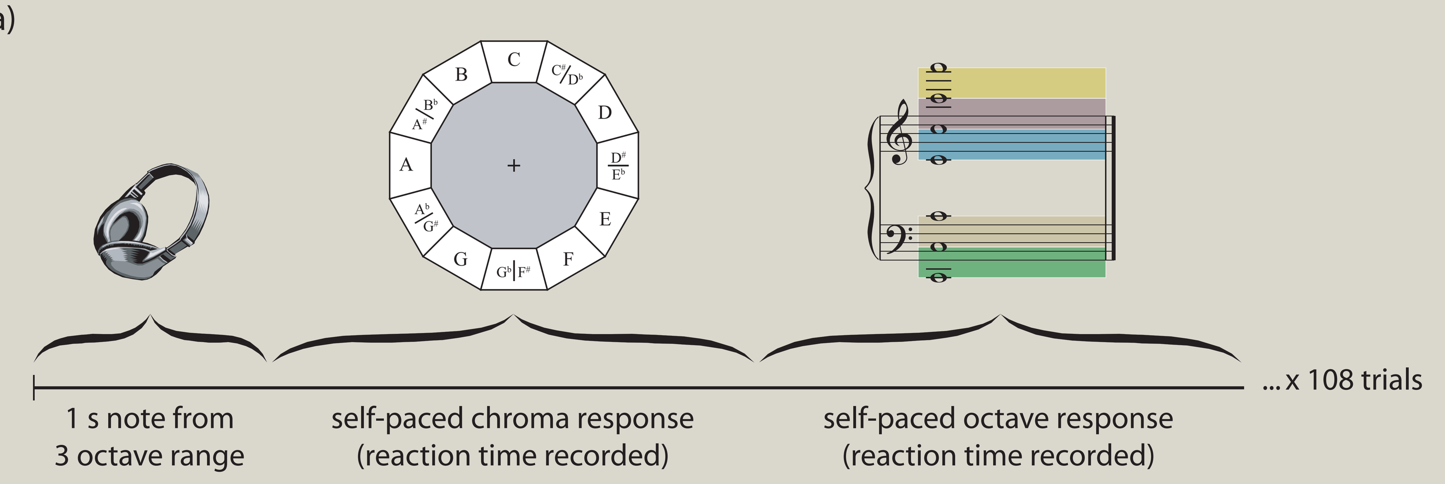
- 49 non-musicians (32f/17m) and 53 musicians (36f/17m, 10 years or more of musical experience, 19 with absolute pitch)
- test of absolute pitch (AP) administered to all musicians (figure 1), from which was derived an index of performance

Imaging and analyses

- T1 images linearly registered to the symmetric ICBM 152 template with a 9-parameter transformation (Collins et al., 1994)
- normalized images then RF inhomogeneity corrected (Sled et al., 1998) and tissue classified (Zijdenbos et al., 2002)
- deformable models used to first fit the white matter surface and then expand outward to find the gray matter/CSF intersection (MacDonald et al., 2000)
- cortical thickness defined as the distance between the linked vertices of the white and gray surfaces (Lerch & Evans, 2005)
- two analyses of cortical thickness: a musician vs. non-musician contrast (figure 2) and a regression of AP test performance across all musicians (figure 3)

Figure 1: a) schema of computer-based absolute pitch task and b) average performance of relative and absolute pitch musician subgroups

a)



b)

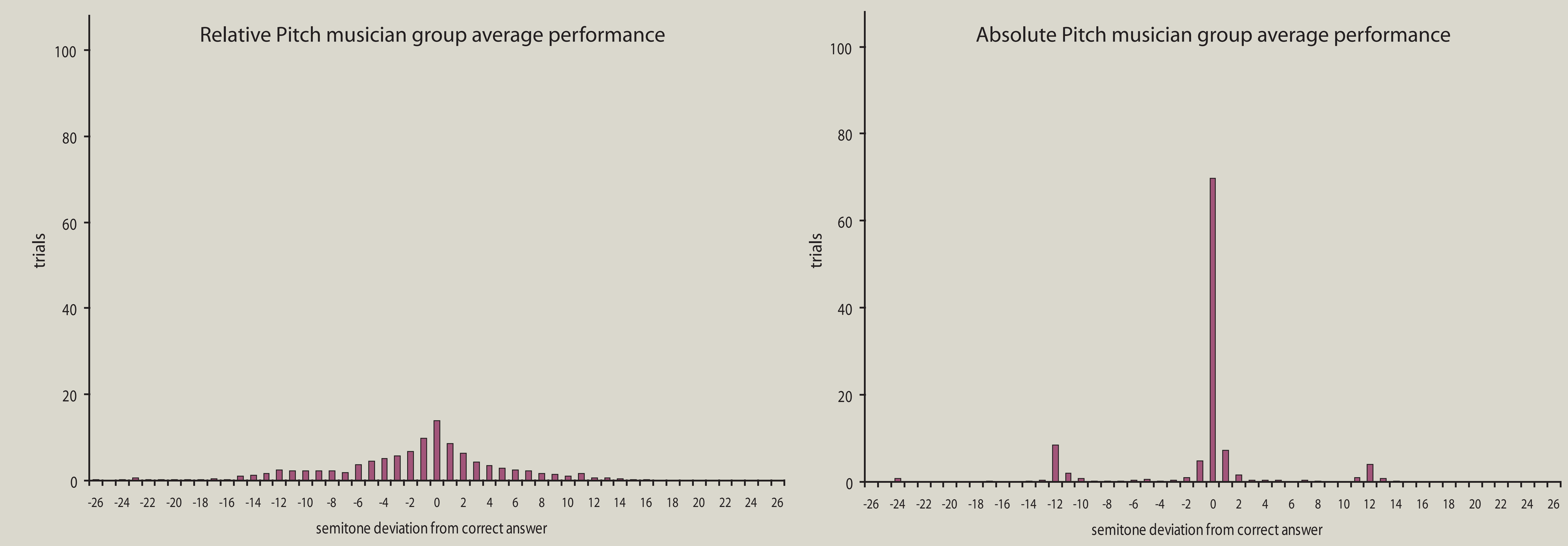


Figure 2: musicians > non-musicians (a, b, d: $p < .05$; c: $p < .01$)

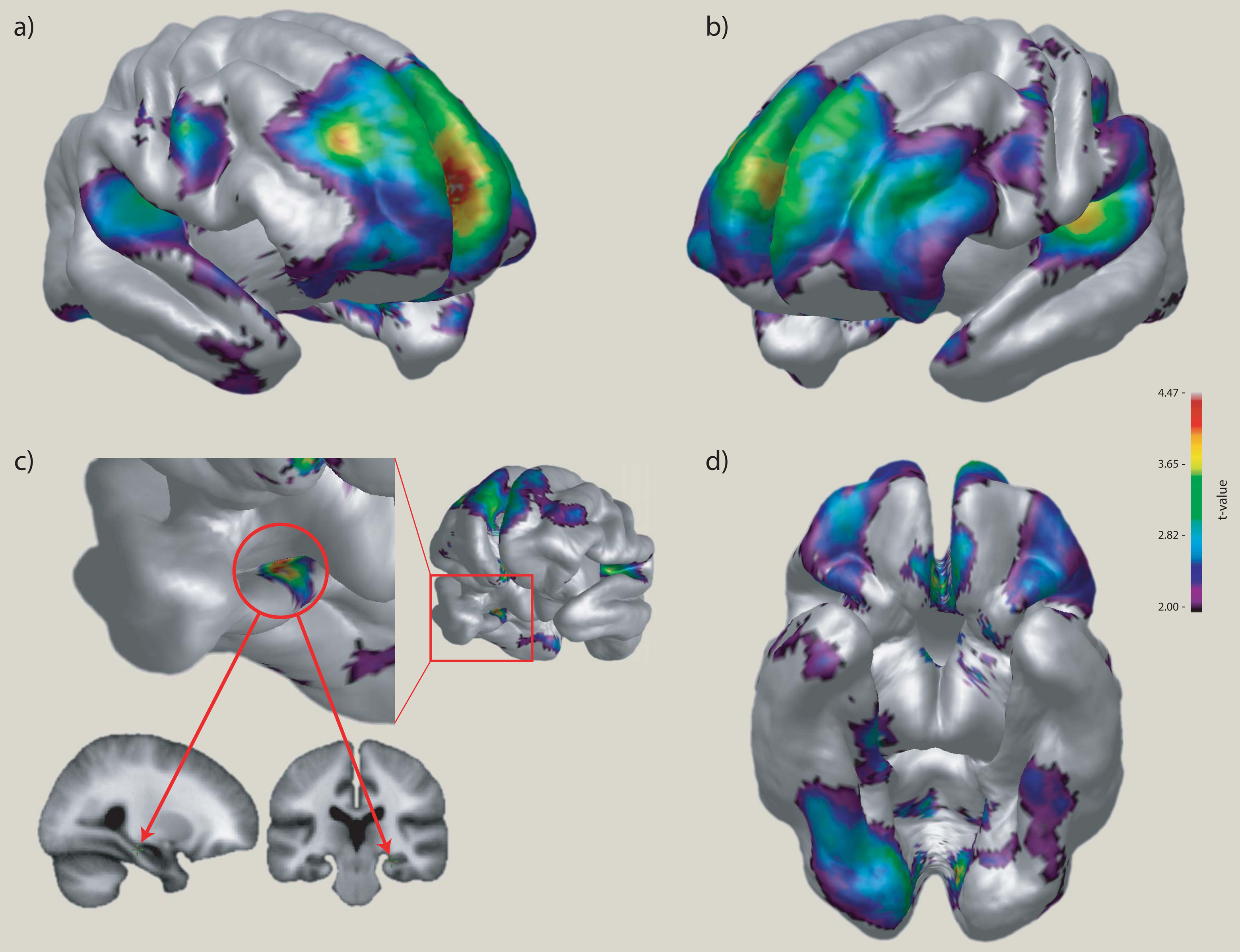
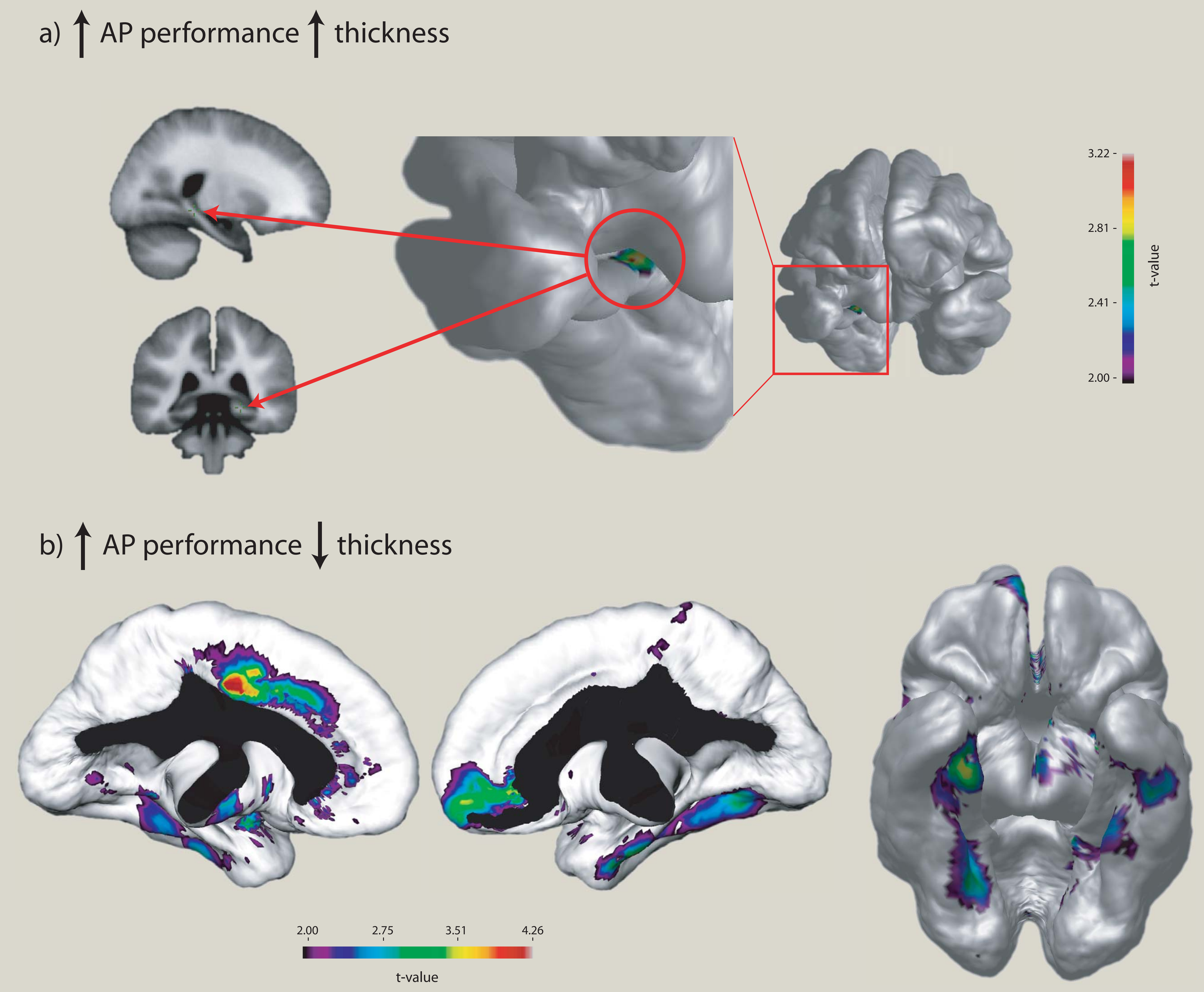


Figure 3: regression of AP performance for musicians ($p < .05$)



Results

In the *musicians vs. non-musician contrast*, there was significantly greater thickness for musicians in superior temporal surfaces, motor cortices, broad areas of the prefrontal lobes, the left lingual gyrus and the right parahippocampal area. In the *regression of AP test performance* onto thickness, there was a positive correlation in the right parahippocampal area and negative correlations in medial temporal areas, left posterior cingulate and right medial frontal gyrus.

Discussion

The auditory and motor cortices have previously been shown to be morphologically distinct in musicians with the use of other techniques (e.g. Bermudez & Zatorre, 2005; Gaser & Schlaug, 2003). As a measure, cortical thickness is complementary yet more specific and constrained than typical VBM analyses which usually convey information about extent, shape and position concurrently. The mid-dorsolateral frontal areas are thought to be of particular importance in subserving working memory function, an aspect of cognition very heavily relied upon in music perception and production. The bilateral peaks of significance over areas 9/46 (figure 2a, 2b; Petrides & Pandya, 2001; Owen et al., 1998) in the musician/non-musician contrast are interpreted as a reflection of the extra-ordinary demands placed on these abilities during many years of musical training. The parahippocampal areas accept multi-modal input and are thought to play important roles in various types of memory formation. Musicians showed greater cortical thickness in these areas of the right hemisphere (figure 2c), which were also positively correlated with performance on a test of absolute pitch in musicians (figure 3a). The interpretation of relative decreases in thickness with increasing AP test performance (figure 3b) is not yet clear. The microstructural and functional significance of cortical thickness remains somewhat uncertain. Many factors influence this measure, including cell size, number, packing density and number of connections and their myelination (Eickhoff et al., 2005; Gittins & Harrison, 2004), all of which interact with MRI acquisition and subsequent processing. A better understanding of these contributions will serve towards more confident interpretations of cortical thickness results.

References & acknowledgements

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