BraiNY Bunch Presentation
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Brain Structures Differ between Musicians and Non-Musicians

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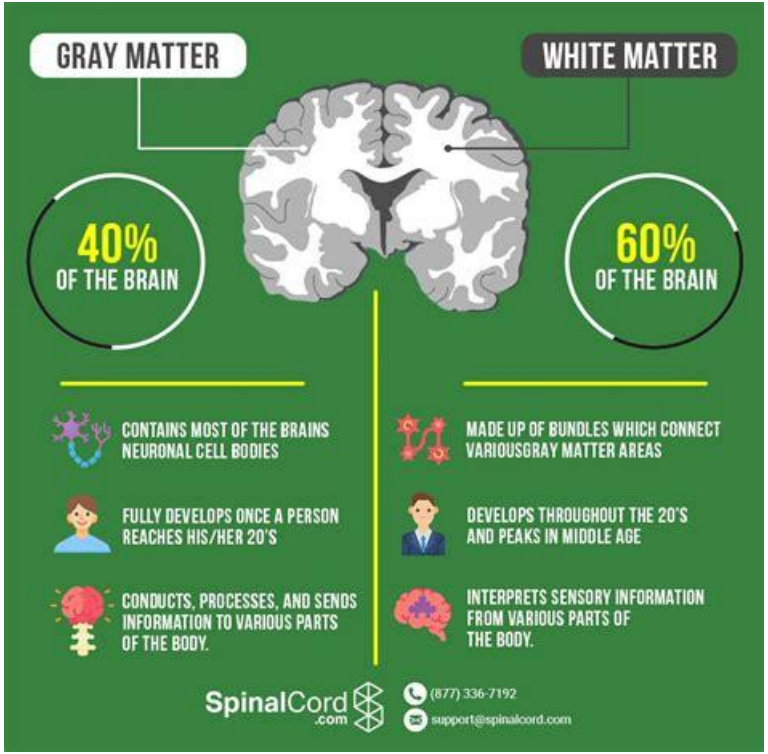
IMPORTANT TERMS

Gray matter: nerve tissue, especially of the brain and spinal cord, that contains fibres and nerve cell bodies and is dark reddish-gray.

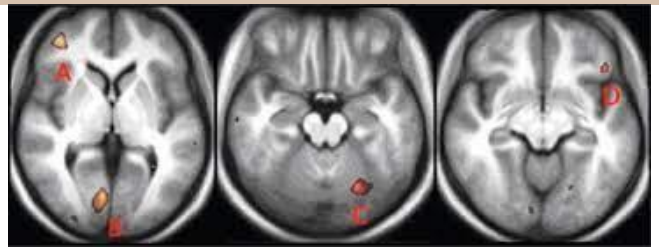
White matter: nerve tissue, especially of the brain and spinal cord, which primarily contains myelinated fibres and is nearly white.

Differences:
White matter contains both glial cells and long axons that are often myelinated while grey matter is composed of neuronal cell bodies, glial cells, and capillaries that are mostly unmyelinated except the neuropil, which is composed of myelinated axons and dendrites.

The majority (60%) of the brain is composed of white matter which conveys pulses between regions of the brain. Grey matter is responsible for sensory perception, memory, emotions, speech, and for almost all the muscle control.



IMPORTANT TERMS

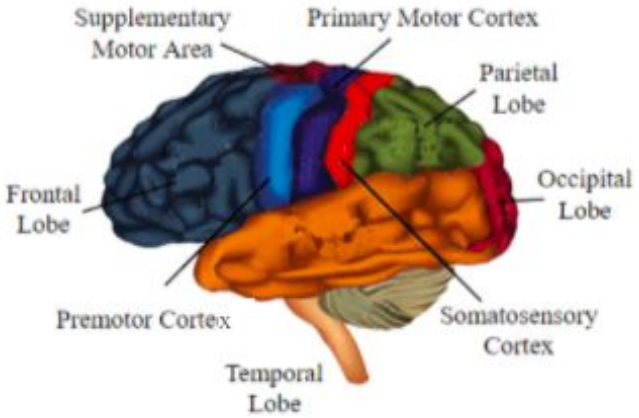


Voxel-based morphometry (VBM): a fully automatic technique for computational analysis differences in local gray matter volume

Primary motor: provides the most important signal for the production of skilled movements

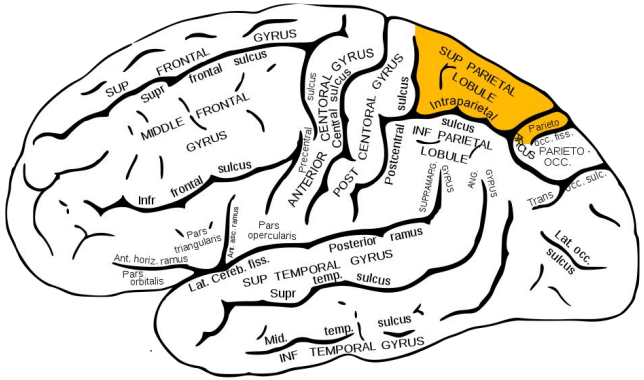
Somatosensory areas: receives and processes the sensory information from the entire body

Premotor areas: prepares the body's muscles for the exact movements it will make; helps you control your movements

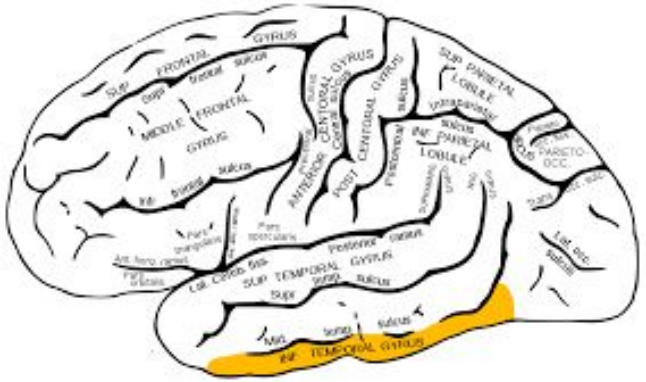


IMPORTANT TERMS

Anterior Superior parietal areas: helps with determining your own and other object's orientation in space, and receives significant visual input and sensory input from your hands



Inferior temporal gyrus bilaterally: responsible for visual object recognition and receives processed, visual information

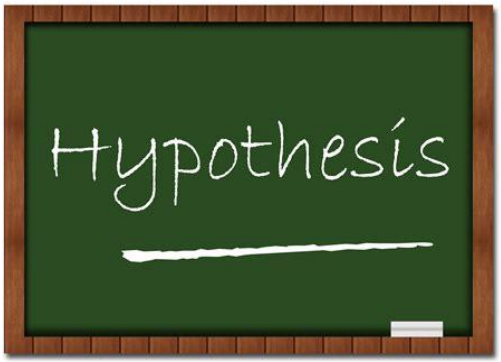


PREVIOUS RESEARCH

Several behavioural, neurophysiological, and neuroimaging studies have explored these exceptional and highly specialized sensorimotor, auditory, auditory-spatial, and memory often colorated to skills of musicians. Several functional imaging studies have shown differences between musicians and non-musicians while performing motor, auditory, or somatosensory tasks. However, no study has searched across the whole brain space for structural differences between musicians and non-musicians that are linked to musicians' specialized skills and the extensive, long-term refinement of those skills. The differences have always fascinated researchers, a common finding across most skill acquisition studies is the functional enlargement of the representative area that underlies that particular skill.

HYPOTHESIS

”We applied an optimized method of voxel-based morphometry (VBM) (Ashburner and Friston, 2000, Good et al., 2001a, b) to explore whether structural brain differences exist between three matched groups of subjects (professional musicians amateur musicians, and non-musicians) that differed in musician status and practice intensity.“



PARTICIPANTS

Sample Size: 20 male professional musicians and 20 male amateur musicians were compared to a matched control group of 40 male non-musicians.

Age range: 18 –40 years.

To control confounding variables, all the musicians selected were

- Male
- Right-handed
- Keyboard players

The subjects also underwent a brief IQ test to assess their verbal intelligence.

Table 1. Demographic characteristics of the samples

	Professional musicians ($n = 20$)	Amateur musicians ($n = 20$)	Non-musicians ($n = 40$)
Age (year)	23.05 (3.83)	25.95 (5.61)	26.92 (4.90)
Verbal IQ	119.23 (7.06)	122.57 (2.57)	118.18 (5.08)
Age of commencement (year)	6.00 (1.81)	7.65 (4.17)	
Average practice time per day (hr)	2.23 (0.91)*	1.15 (1.0)*	
Average practice time per day × duration of practice (hr × year)	39.1 (21.24)*	17.88 (9.74)*	

Data are mean (SD).

*$p < 0.001$.

Table 2. Brain regions with positive correlation between gray matter and musician status

x	y	z	t value	Region (Brodmann area)
−62	−40	−16	5.45	Left inferior temporal gyrus (20)
60	−40	−20	4.69	Right inferior temporal gyrus (20)
−28	−21	63	4.63	Left precentral gyrus (4, 6)
27	−50	60	4.55	Right superior parietal cortex (5, 7)
28	−22	62	4.32	Right precentral gyrus (4, 6)
−39	−28	3	4.32	Left Heschl's gyrus (41)
−42	50	0	4.10	Left inferior frontal gyrus (46)
10	−21	57	3.86	Right medial frontal gyrus (6)
−32	−56	−30	3.58	Left anterior cerebellar lobe (Larsell lobes HV/HVI)

$p < 0.05$ corrected for multiple comparisons; extent threshold, $p < 0.1$. Coordinates (given in millimeters for the maximum value in the cluster) refer to the template space and correspond only approximately to the space of the Talairach atlas.

PARTICIPANTS

”Professional musicians“ were defined as performing artists, full-time music teachers, or full-time conservatory students having an average daily practice time of at least 1 hr.

”Amateur musicians“ were defined as those who played a musical instrument regularly but whose profession was outside the field of music.

”Non-musicians“ were defined as those who had never played a musical instrument.

Musicians were recruited through advertisements in newspapers and local music schools, while non-musicians were recruited from local universities and medical institutions and matched to the two musician groups for gender, age, and IQ score.

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METHODS

Steps for VBM:

1) Spatial normalization of all images to a standardized anatomical space by removing differences in overall size, position, and global shape
2) Extraction of gray and whte matter from the normalized images
3) Analysis of differences in local gray and white matter volume across the whole brain

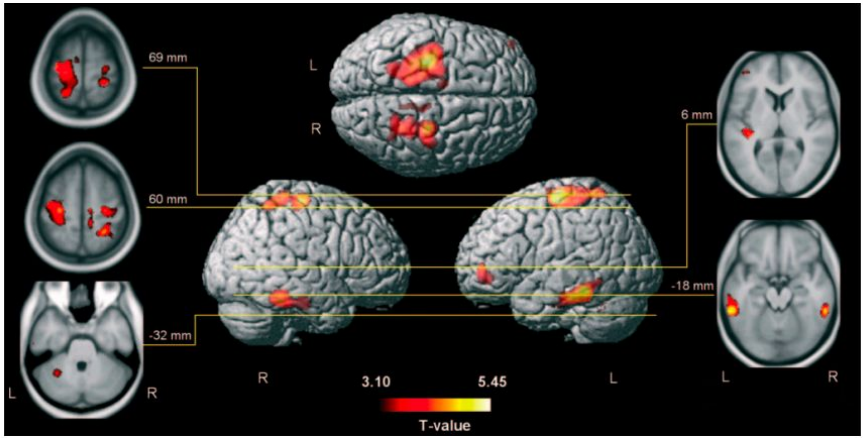

Figure 1. Brain regions with gray matter differences between professional musicians, amateur musicians, and non-musicians. The musician status was modeled as a three-level gradation ir which professional musicians were ranked highest, amateur musicians were intermediate, and non-musicians were ranked lowest (see Materials and Methods for details). Only those voxels with a significant positive correlation between musician status and increase in gray matter volume are shown ($p < 0.05$; corrected for multiple comparisons). Only clusters of voxels consisting of at leas 225 voxels are displayed, corresponding to a spatial extent threshold of $p < 0.1$. These clusters were overlaid on the rendered cortex surface of a selected single subject. Yellow lines indicate selected cuts through this brain, and the corresponding axial slices are shown in the left and right panels. These axial slices show the overlay of the results onto the average of all 80 single anatomical images

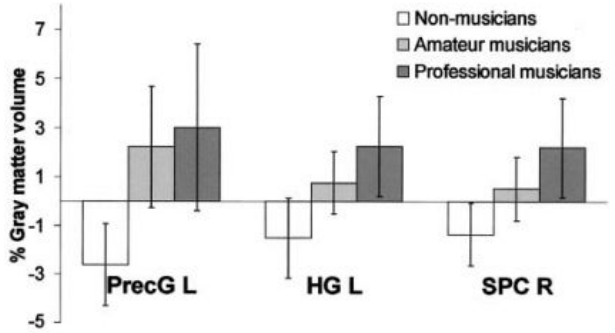

Figure 2. Relative differences in gray matter volume (mean and SD) between professional musicians, amateur musicians, and non-musicians in three selected regions. Regional differences in the left precentral gyrus (PrecG L), left Heschl's gyrus (HG L), and right superior parietal cortex (SPC R) using a spherical region of interest with a radius of 8 mm centered at the local maximal difference are shown.

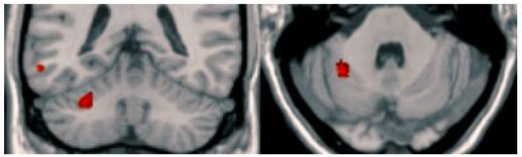

Figure 3. Location of cerebellar gray matter effects. The significant gray matter differences in the cerebellum in a selected coronal and axial section are shown. Orientation of these sections has been performed according to the coordinating system described by Grodd et al. (2001). The cluster in the cerebellar region corresponds to the area of the cerebellar finger–hand representation, as shown in functional imaging studies, and is located in the lobes HV/HVI according to the classification of Larsell and Jansen (1971).

RESULTS

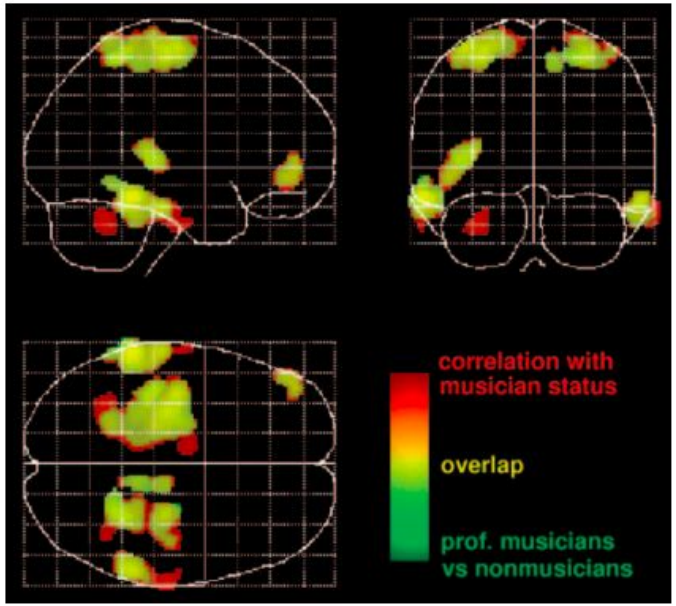

Figure 4. Overlap between different types of statistical analyses. This figure shows the results of the direct comparison between professional musicians and non-musicians (green) and the correlation with musician status (red) using the same statistical thresholds as in Figure 1. The overlap between both results is shown in yellow (as a result of mixing red and green). Results are displayed as maximum intensity projections ("glass brain"), which show highest values within each orientation.

In comparing these three groups, areas with a significant positive correlation between musician status and increase in grey matter volume were found in perirolandic regions including primary motor and somatosensory areas, premotor areas, anterior superior parietal areas, and in the inferior temporal gyrus bilaterally. Additional positive correlations with musician status were seen in the left cerebellum, left Heschl's gyrus, and left inferior frontal gyrus. When the spatial extent threshold was changed, there were no areas showing a significant decrease in grey matter volume in relation to musician status.

DISCUSSION

Summary:

The results suggest a pattern of differences in the grey matter distribution between the groups that involve motor, auditory, and visual regions. The cluster of cerebellar gray matter differences in our study is located in the lobes HV/HVI according to the classification of Larsell and Jansen (1971) and to regions V and VI in the new three-dimensional MR imaging atlas of the cerebellum by Schmahmann et al. (1999). These results also support structural differences found in the left Heschl's gyrus (Figs. 1, 2) support the results of a recent study showing higher grey matter volume in this region in musicians, which was associated with neurophysiological source activity differences between professional musicians, amateur musicians, and non-musicians while listening to tones (Schneider et al., 2002). No differences were found in the planum temporale in this study.

DISCUSSION

Limitations:

- Paper never specified the location of the experiment
- Participants were limited to only males
- Participants were limited to only right-handed people
- The methods could not be replicated
- The musicians (participants) were limited to only keyboard players
- The main hypothesis focuses on the detection of effects in gray matter
- The VBM method is insensitive to white matter differences

Possible Future Experiments:

➔ Determining the relative contribution of predisposition and practice