# From M1 to Cerebellum: What effect does hand-preference have on the local volumes of motor related structures?

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## *Introduction*

People preferentially choose one of their hands to perform tasks and there is a strong bias towards dominance of the right hand (90% of population). This bias develops early and is stable throughout the lifetime. Is this hand preference associated with asymmetries throughout the brain regions associated with motor control?

## *Primary Motor Cortex (M1)*

To estimate the extent of the hand area of M1 the sulcal ribbon along the hand-knob (Yousry et al. 1997) was manually labelled in 31 subjects taken from the International Consortium for Brain Mapping (ICBM) (Mazziotta et al. 1995). There were 14 lefthanders (LH) (7f, 29y +/-4.9y) and 17 righthanders (RH) (6f, 29y +/-4.9y).

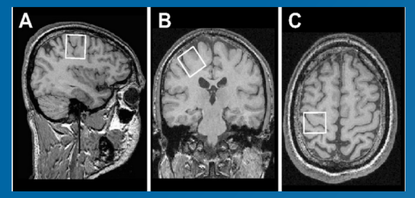
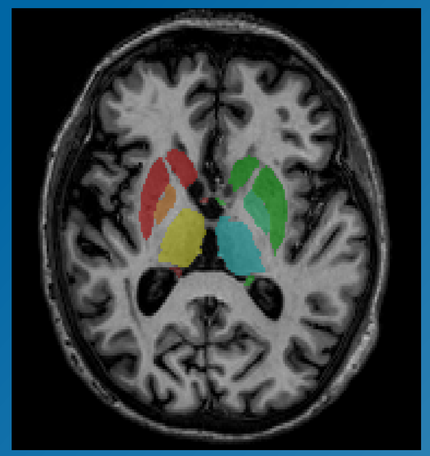



Illustration of the handknob in the human brain in sagittal (A) coronal (B) and horizontal (C) view (Illustration from Tremblay et al. 2012)

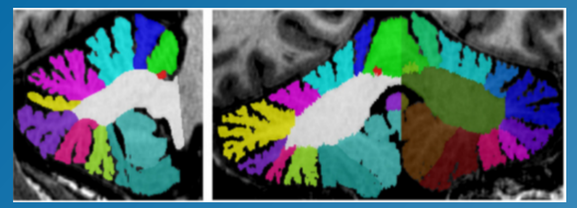
## *Subcortical structures and Cerebellum*

For the analysis of possible asymmetries associated with hand preference in the basal ganglia, thalamus and cerebellum we automatically extracted local volumes using multiple automatically generated templates of different brains (MAGeT Brain) (Chakravarty et al. 2013, Pipitone et al. 2014, Park et al. 2014). This method allows for the reliable and robust extraction of the volumes (and shape) of a large number of predefined anatomical areas. As this can easily and reliably be done in large datasets we did this for both the ICBM dataset and the Human Conectome Project (HCP) (Van Essen et al. 2012). After post-processing QC the ICBM dataset included 169 subjects (91f, 43y +/- 15.4y); the HCP dataset included 511 subjects (302f, 29y +/- 3.5y). Both datasets measure hand preference on a continuous scale (0-10 ICBM, 0=LH, 10=RH)(-100 to 100 in HCP negativ=LH, postiv=RH).

On the right is an example showing an axial slice of one subjects' brain with subcortical regions identified and labelled.



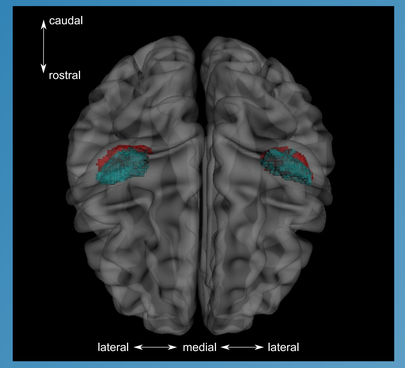
The illustration on the right shows a sagittal and coronal slice through the manually labelled cerebellar atlas that delineates the various grey and white matter regions in great detail.



## *Results M1*

The sulcal region of the hand shows a strong asymmetry and is enlarged in the dominant (for fine motor tasks) hemisphere in both LH and RH: the area is 12% larger on the left for RH and a full 40% larger on the right for LH. This relatioship between hand-preference and M1 asymmetry is significant ($p<0.01$). There is no effect of gender. The average sulcal ribbons in MNI space of LH (green) and RH (red) and illustrated on the right in a MNI152 glass brain (top view).

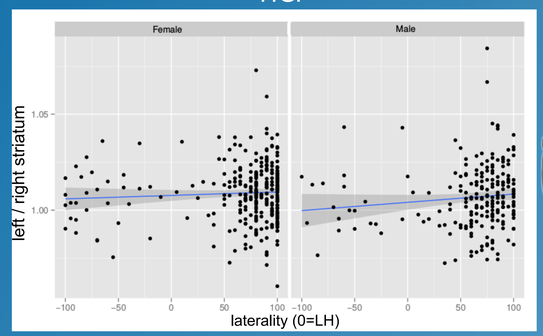
| Sulcal ribbon (depth x length) of hand-knob | Left | Right |
|---|---|---|
| Lefthanders | 450 $mm^2$ | 620 $mm^2$ |
| Righthanders | 558 $mm^2$ | 494 $mm^2$ |

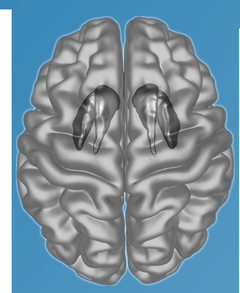



## *Results: Basal Ganglia*

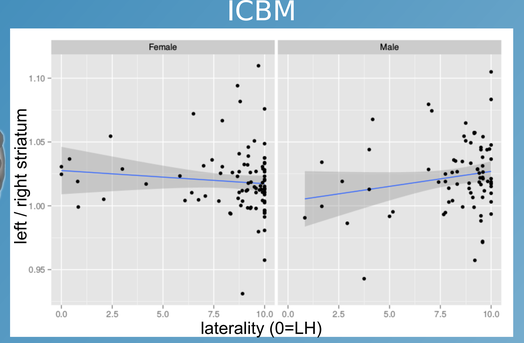
A linear relationship between asymmetry of the striatum and laterality is found in the males in both datasets. It is significant with $p<0.01$ in the ICBM data and with $p<0.05$ in the HCP data. While the left striatum is always bigger in the left hemisphere this difference is more pronounced in RH.

HCP



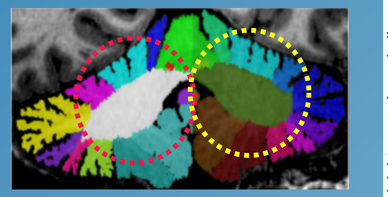



ICBM

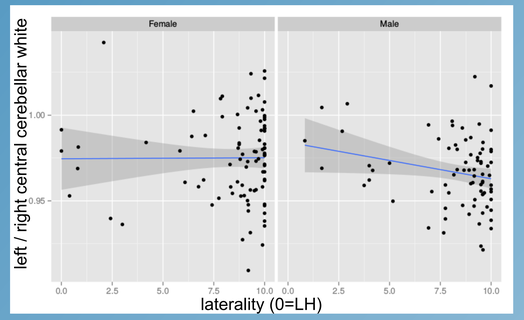



## *Results: Cerebellum*

Asymmetries in the cerebellum associated with hand preference are found in the relative white matter volume in the ICBM dataset ($p<0.05$) again only in males.



ICBM




*Two possible processes might be involved in the local area and volume differences demonstrated in this study: plastic changes associated with practise and differences in neuronal development that -among others- give rise to hand preference. The asymmetries found in the M1 region, striatum and cerebellum combined with findings that training has a marked effect (e.g. Musso et al. 1999, Zatorre 2005) on local volumes leads us to believe that life-long practise and brain plasticity is a work here.*

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