Asymmetries of the temporo-parietal cortex in common chimpanzee: functional correlates and comparison with human

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Introduction - Patterns of asymmetry in the human brain are matched by neuroanatomical asymmetries in non-human primates. In particular, the Planum Temporale (PT), an area on the posterior superior temporal gyrus within the sylvian fissure has been the subject of numerous studies which consistently described a left larger than right PT in humans. Several studies have subsequently shown leftward asymmetry of the PT in common chimpanzee (Gannon et al., 1998; Hopkins et al., 1998; Gilissen, 2001; Hopkins and Nir, 2010).

In humans, there is a general agreement that right–handed individuals have a significant leftward PT asymmetry compared to left-handed individuals. In contrast, handedness for non-communicative functions in chimpanzee appears to be associated with other brain areas, such as the motor-hand area of the precentral gyrus (Hopkins and Cantalupo, 2004; Sherwood et al., 2007).

The parietal operculum (PO), a brain region located just above the PT, shows a pattern of asymmetry comparable to the PT in humans. The distribution of right- and left-handed individuals according to the degree of parietal operculum and planum temporale asymmetries is similar. Right-handed individuals show more marked leftward asymmetry for both the PT and PO than left-handed individuals. PT and PO asymmetries are not correlated to each other at the population level but their convergence toward the left side is strongly associated with right-handedness in humans (Habib et al., 1995, 1999).

The primary aim of this study was to assess whether the combination of PT and PO asymmetries observed in humans by Habib et al. (1995, 1999) also exists in common chimpanzee and, if it occurs, what are its potential functional correlates.

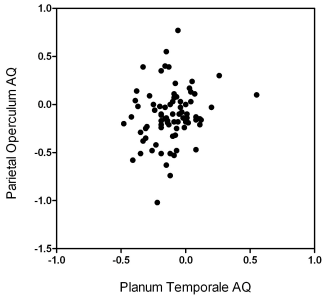

Fig.3. PO AQ versus PT AQ in common chimpanzees. Pearson r = 0.195 (not significant).

AQ = asymmetry quotient

Results – There was no effect of sex or age in the direction of asymmetry neither for PT nor for PO. For both PT and PO, chimpanzees showed significant leftward asymmetries but a Pearson r failed to reveal any significant association between the measures (r (80)=0.195, p > 0.05) (fig.3), as has been reported in human (Habib et al.,1995, 1999). Finally, handedness effect was identified only for tool use (termite fishing) ($F(1, 63) = 4.18$, $p < 0.05$). Right-handed chimpanzees had significantly lower PO and PT AQ scores than non-right-handed chimpanzees (fig. 4-6).

The four types of combinations of PT and PO asymmetries and their respective occurences of right- (RH) and non right- (NRH) handed individuals are summarized below. In humans, the convergence of PT and PO asymmetries toward the left side is strongly associated with right handedness. This convergence is the most frequent In both chimpanzee and humans, but in chimpanzees, it is not associated with right handedness.

Pan troglodytes (N=71)

Left PT > Right PT [72 %]

Left PO > Right PO **(N=36)**		Left PO < Right PO **(N=15)**	
RH	NRH	RH	NRH
17	***19***	***7***	***8***

Left PT < Right PT [28 %]

Left PO > Right PO **(N=12)**		Left PO < Right PO **(N=8)**	
RH	NRH	RH	NRH
5	***7***	***1***	***7***

Homo sapiens (N=40) (Habib et al., 1995)

Left PT > Right PT [63 %]

Left PO > Right PO **(N=19)**		Left PO < Right PO **(N=6)**	
RH	NRH	RH	NRH
16	***3***	***3***	***3***

Left PT < Right PT [27 %]

Left PO > Right PO **(N=9)**		Left PO < Right PO **(N=6)**	
RH	NRH	RH	NRH
3	***6***	***2***	***4***

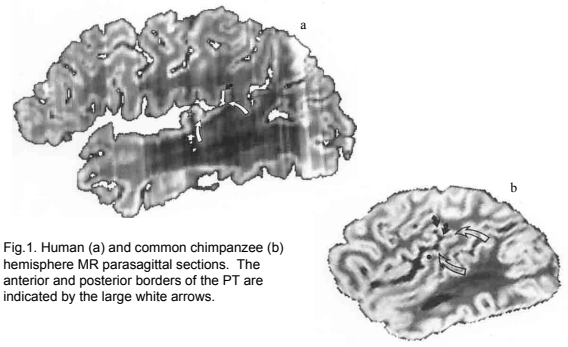

Fig.1. Human (a) and common chimpanzee (b) hemisphere MR parasagittal sections. The anterior and posterior borders of the PT are indicated by the large white arrows.

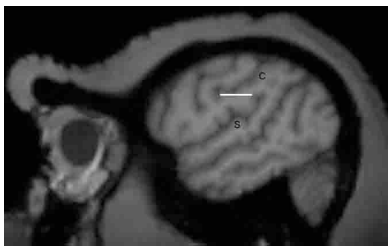

Fig.2. In vivo common chimpanzee head MR parasagittal section. PO was defined as the maximal linear distance between the end point of the sylvian fissure (S) and the central sulcus (C) (see methods).

Material - Magnetic resonance imaging (MRI) scans were obtained in 83 captive common chimpanzees (55 females and 28 males, age range 6 to 50 years) housed at the Yerkes National Primate Research Center in Atlanta, Georgia. A sub-sample of 71 specimens is used in this study.

Methods – PT was quantified following procedures previously employed (Cantalupo et al., 2003; Hopkins, 2007) (fig.1) and PO was defined as the maximal linear distance between the end point of the sylvian fissure and the central sulcus on parasagittal sections (Habib et al., 1995) (fig.2). Two tasks with different motor demands were designed to simulate the termite fishing and anvil use behavior of wild chimpanzees. For both the PT and PO, asymmetry quotients were derived following the formula [AQ = (R – L) / R + L) *.5)] where R and L indicated the surface area (for the PT) and length (for the PO) measures of the right and left hemispheres, respectively. Negative AQ values = left hemisphere asymmetries, positive AQ values = right hemisphere asymmetries. For the handedness tasks, binomial z-scores were calculated for each subject based on the total frequency of left and right hand use.

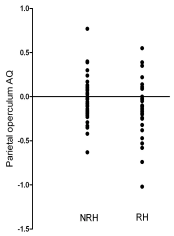

Fig.4. Distribution of right- (RH) and non right- (NRH) handed individuals for tool use according to the degree of PO asymmetry in common chimpanzees.

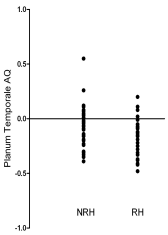

Fig.5. Distribution of right- (RH) and non right- (NRH) handed individuals for tool use according to the degree of PT asymmetry in common chimpanzees.

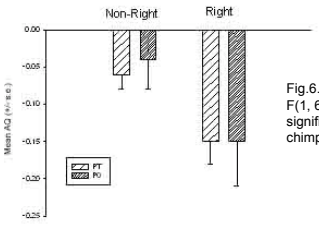

Fig.6. Main effect for handedness in tool use is significant $F(1, 63) = 4.18$, $p < .05$. Right-handed chimpanzees had a significantly lower AQ scores than non-right-handed chimpanzees. mixed model ANOVA.

Conclusion –Overall, this study suggests that in spite of a comparable distribution of PT and PO structural asymmetries, functional correlates such as handedness effects are not similar in humans and chimpanzees. This study was funded by NIH grant NS-42867 (WDH) and by the European Commission, contract number 029023 (EG).

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