Marie Curie grant periodic report

• A summary description of the project objectives

1) Evolutionary: To investigate cranial asymmetries in humans and closely related hominid species in an adult sample. The main question addressed here will be:

a. Is there a left or right side bias in extant hominoid crania? And is the pattern constant across all taxa included in the study?

2) Development: (a) To examine the level and pattern of DA across an ontogenetic series of extant hominoids. The main question answered here will be:

- Do extant hominoids exhibit different patterns and levels of directional asymmetry at different age stages? And are these patterns similar or different across species.

(b) To investigate the level and pattern of DA in adult and sub-adult microcephalic human crania relative to non-pathological individuals. The main questions addressed here will be:

- What is the pattern and degree of DA in non-pathological and microcephalic humans?
- Does the pattern of DA influence patterns of cranial integration in microcephalic and non-pathological humans?

Thus, the overall objectives address two important aspects of asymmetry: evolutionary and developmental. Investigating the evolutionary aspects of asymmetry is essential to understand the origin of this trait, particularly in light of the recent *Homo floresiensis* finds. And the origin of the trait carries developmental significance, particularly in the context of modern humans. However, no research, thus far, has attempted to address the developmental aspects of this trait, nor have any studies addressed its evolutionary significance.

• A description of the work performed since the beginning of the project

The project was officially started February 2011 and requested to be terminated on January 31st, 2012 (a year prior to the official finish date). The following are the objectives accomplished thus far:

Data collection completed

1) Modern human sample at the University of Tuebingen
2) Microcephalic individuals at the Musée de l'Homme, Paris
3) Non-human ape sample

The data collection process entailed taking 3-D coordinates with a MicroScribe. The coordinates or landmarks were chosen according to repeatability and anatomical relevance across all the species and age categories included in the study.

Data processing completed

1) Modern human sample
2) Microcephalic humans
3) Non-human ape sample

The data processing includes sorting through the landmarks of all the individuals in the dataset, excluding specimens with missing data or accounting for missing data, correcting errors

such as mislabelled landmarks and removing variable landmarks.

• A description of the main results achieved so far

The data collected so far have not been analysed, but they will be done within the next few months and then written-up for publications.

Expected results
Publication 1: *Asymmetric variation in human and non-human apes*
We expect to find an evolutionarily conserved pattern of cranial asymmetry across humans and other apes. That is, we expect our results to suggest that directional asymmetry is similar among these species.
Publication 2: *Cranial asymmetry in microcephalic and non-pathological humans*
In this study we expect our results to show that the pattern of cranial asymmetry in pathological and non-pathological individuals is different.

• Potential impact and use (including the socio-economic impact and the wider societal implications of the project so far)

Asymmetric variation has its origin in genetic, developmental and environmental processes. Developmental-genetics data show that fluctuations in developmental pathways sometimes cause one side of a body part to diverge in ontogeny. Understanding the biological processes underlying overall phenotypic variation is fundamental in biology and also has implications for clinical studies. Even though the primary focus of this study is not on clinical aspects of asymmetry, the implications and outcome of this work will greatly inform medical research on cranio-facial asymmetries in humans. By incorporating an extensive ontogenetic sample of humans, including pathological individuals, this study will build a framework to evaluate possible cranio-facial asymmetries related to development; this will be done by comparing cranial components that exhibit maximum asymmetry in microcephalic and non-pathological individuals. Microcephaly is a result of stunted brain growth in certain regions. Size and shape of cranial components that encase the brain are directly affected by this condition. An in depth examination of this trait will provide insight into regions that are developmentally most susceptible to asymmetric growth. The inclusion of different taxa and a large modern human sample will provide important insight into the range of asymmetric variation not only in humans, but also in a comparative evolutionary context. Furthermore, prior to the advent of 3D geometric morphometric methods and virtual anthropological techniques, such comprehensive research on cranial asymmetry could not have been fully possible; this is linked to the timeliness of the project. Skeletal asymmetries are subtle and the previous non-invasive quantitative techniques were unable to evaluate the extent of these traits in their entirety. Thus, this study will not only be the first of its kind, but also build a framework for future research in anthropology, evolutionary developmental biology and possibly clinical studies on cranio-facial variation.