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The length of the 2nd to 4th digit ratio (2D:4D) is a recognised bio-marker for prenatal testosterone (PT) and correlates with sex-linked traits in a number of vertebrate taxa. In humans variations in mean 2D:4D have been shown to correspond to differences in fertility, sexual selection and social bonding within and between populations.

This study uses 2D:4D to see how variations in PT early in development can affect the expression of social behaviour within and between non-human anthropoid species. This work has implications for understanding temporal and spatial changes in human and pre-human social systems.



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Highfield, Avenue Campus  
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**Grant Award  
Application  
2007**

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## RESEARCH PROPOSAL

### 1. Name of applicant

Title:
First name: Emma
Surname: Nelson

### Address for correspondence

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### 2. Present position

Present appointment and employer (If student, please indicate degree in progress, name of supervisor and institution)

PhD student, School of Archaeology, Classics and Egyptology (SACE), University of Liverpool Supervisors, Dr. A.G.M. Sinclair (SACE), Dr. S. Shultz (Biological Sciences)
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### 3. Details of grant requested

Title of project (not more than 15 words)

Using digit length ratios (2D:4D) to investigate non-human anthropoid social behaviours.
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Sum requested  
to the nearest £

£500
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### 4. Project summary

Information on your research project may be placed upon the BABAO website. Please use this space to provide a description of your research in a way that could be used for a general – i.e. non-expert - readership. (Maximum 100 words.)

The length of the 2 <sup>nd</sup> to 4 <sup>th</sup> digit ratio (2D:4D) is a recognised bio-marker for prenatal testosterone (PT) and correlates with sex-linked traits in a number of vertebrate taxa. In humans variations in mean 2D:4D has been shown to corresponds to differences in fertility, sexual selection and social bonding within and between populations. This study uses 2D:4D to see how variations in PT early in development can affect the expression of social behaviour within and between non-human anthropoid species. This work has implications for understanding temporal and spatial changes in human and pre-human social systems.
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## 5. Project information

Please provide concise details of your planned research project in the following boxes in order that the research validity and potential of your project can be assessed. (Maximum 500 words in **each** box.)

Research question(s) or problem	<p>Social brain research has largely focussed on linking brain size to overt expressions of primate sociality such as group size (See Dunbar, 2003; Whiten and Byrne, 1997). This has led to the belief that large brains are necessary for socially complex behaviours and are most common in species with large social groups and high levels of sexual selection (Pawlowski <i>et al.</i> 1998; Sawaguchi; 1996). Recently, however, large brain size has been associated with socially monogamous, pair-bonded species (Shillaci, 2006; Shultz and Dunbar in press). On this evidence it seems that brain size may be related more to the complexities of maintaining stable relationships within a social group than to group size <i>per se</i>. It also suggests that there may be qualitative aspects to sociality that we are failing to access but could be highly informative in understanding social bonding and the evolution of primate and human sociality.</p> <p>Adult circulating sex hormones underpin many aspects of mammalian species sexual behaviour (Klein, 2000; Gray, 2003). Recent evidence from studies of foetal and infant programming (Philips, 2002; Wallen, 1996) and social cognition (Baron-Cohen <i>et al.</i> 2004) are showing that differing levels of foetal sex hormones appear to pre-set endocrine pathways affecting behaviour and health later in life (Carter, 1998). It would seem that some aspects of social behaviour are pre-set <i>in utero</i>. The ability to investigate this phase of development may provide us with a new avenue for social brain research.</p> <p>The length ratio of the 2<sup>nd</sup> and 4<sup>th</sup> digits (2D:4D) is an easy to measure bio-marker that correlates negatively with prenatal testosterone (PT); males have lower 2D:4D compared to females. There is a genetic link, via the <i>Hoxa-d</i> group of genes, between the development of the digits and the reproductive system. <i>Hox</i> genes are highly conserved in vertebrate taxa and correlations between digit ratios and foetal sex hormones have been demonstrated in mammals, reptiles and birds (see Saino <i>et al.</i> 2007). The fact that 2D:4D indicates, to some extent, early sexual differentiation and has been linked to social behaviour in humans and birds (Manning <i>et al.</i> 2000; Connellan <i>et al.</i> 2000; Navarro <i>et al.</i> 2006) means 2D:4D could potentially inform us about the organisation of sociality in non-human primates (Roney <i>et al.</i> 2004). Furthermore, 2D:4D is reflected in the underlying bones. The potential therefore exists for predicting some social behaviours in past human groups and possibly fossil hominins (McFadden and Bracht, 2003).</p> <p>Questions: Does variation in 2D:4D reflect differences in social behaviour within (e.g. sex differences) and between species? If so, how do these results fit within our current understanding of the Social Brain Hypothesis? Can 2D:4D be used to predict social behaviour?</p>
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<p>Aims &amp; objectives</p>	<p>A. Make a cross-species comparison of non-human primate 2D:4D to investigate how variations in PT early in development may influence a species' social system and how these behaviours may differ between the sexes.</p> <p>B. To quantify the relationship between soft- and hard-tissue measures of 2D:4D in order to produce formulae to estimate 2D:4D from disarticulated primates skeletal remains. This should then allow social system to be predicted.</p>
<p>Research methods</p>	<p><b>1. 2D:4D data collection.</b> Primate digit length data will form the framework of this project and allow cross-species analysis of 2D:4D.</p> <p><b>Methods and analysis.</b> Data is collected by consenting zoos and primate institutions. Measurements are collected from primates when they are anaesthetised for a routine procedure. Protocols follow those used for humans (Manning <i>et al.</i> 1998). Repeated measurements are obtained for each digit. Supplementary data is required; genus, species, sex, age and weight. Data is downloaded via a web site portal. Measurement error will be estimated using intraclass correlation coefficient (<math>r_1</math>). Means will be calculated at the species and sub-species (sex) level. Brain size data and social behaviour categories will be culled from the literature (e.g. categories of intra-male competition Plavcan and Van Schaik, 1992). Multivariate statistical techniques will be used for cross-species analysis. Body weight, substrate and phylogenetic effects will be controlled for using Phylogenetic Generalised Least Squares Analysis.</p> <p><b>Status.</b> Data analysis was completed in March (sample size: 1300 individuals from 68 species). Results will be written up as a chapter and paper. Co-authors: Dr. S. Shultz and Prof. R.I.M. Dunbar, University of Liverpool).</p> <p><b>2. 2D:4D data collection from dissected specimens.</b> Comparisons of soft- and hard-tissues of the digits will enable formulae to be devised to allow estimates of 2D:4D to be calculated from disarticulated phalanges.</p> <p><b>Methods and analysis.</b> Soft-tissue digit length measurements are taken from deceased primates as per protocol, the hands are dissected and maximum length measurements are taken from the digital phalanges (Susman, 1979). Proximal phalangeal curvature is also calculated (Stern <i>et al.</i> 1995). Multivariate regression analysis will be used to devise formulae. Formulae will be tested on bone data from primate skeletal material and the results will be compared against the 2D:4D species database.</p> <p><b>Status:</b> Data collection will be completed in September.</p>

	<p><b>3. Chimpanzee study (<i>Pan troglodytes</i>).</b> Primate Foundation of Arizona (PFA) have provided data on 74 animals. This study aims to look at links between 2D:4D, male dominance and testes size. Hypothesis: Higher ranking males will have bigger testes and lower 2D:4D (high PT) than non-dominant animals of the same age.</p> <p><b>Methods and analysis.</b> Observational studies are used to assess dominance rank, digit data collected as per protocol, testes measurements follow Muehlenbein <i>et al.</i> 2002. Statistical methods as above.</p> <p><b>Status:</b> Data collection was completed in March. Data analysis will be completed by September. Co-authors, Dr. S. Shultz and Dr. E. Videan (PFA).</p> <p><b>4. Macaque study (<i>Macaca mulatta</i>)*.</b> This study aims to look at links between 2D:4D, female dominance rank and parity. Hypothesis: Dominant females will have lower 2D:4D (higher PT) and more offspring than non dominant females of the same age.</p> <p><b>Methods and analysis.</b> Data will be obtained from a group of macaques from Cayo Santiago, Puerto Rico. Digit measurements as per protocol. Observational studies used to assess rank. Parity data taken from medical records.</p> <p><b>Status:</b> Data will be collected this winter. Co-authors, Dr. M. Gerald (Scientific Director of Cayo Santiago) and Dr. S. Shultz.</p> <p><b>*BABA O funding will facilitate travel to Cayo Santiago.</b></p>
<p><b>Timetable</b> (Research is expected to be presented at the BABA O conference [either paper or poster] in the year following the award.)</p>	<p>Writing up the project has already begun and will start in earnest in September. The data for the macaque study is still outstanding, but will be collected in the winter; data will be analysed in the spring and will be ready for presenting and publishing by summer (2008).</p>

## 6. Ethical aspects of the proposal

a) Are there any ethical implications arising from the proposed research?

Yes  No

If yes, please give details below of what they are and how you intend to address them.

Ethical approval for this project was given by the School of Archaeology, Classics and Egyptology Research Committee.

Data collection was also reviewed and ethically approved by each zoo and facility's Institutional Animal Care and Use Committee.

## 7. Budget summary

Give a summary of the total costs that will be incurred; then complete the detailed breakdown below.

Summary	Cost (£)
Travel and subsistence	£700
Equipment	

Please itemise and justify expenditure requested for travel and subsistence, and equipment and materials.

Description	Justification	Cost (£)
Flights	Return flight to Puerto Rico to obtain macaque data. Cayo Santiago Field Station, Caribbean Primate Research Center, Puerto Rico, U.S.A	£700
Accommodation	Free	-