News Using the length of the 2nd to 4th digit ratio (2D:4D) to sex cave art hand stencils: factors to consider

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1 Introduction

Authorship is often the starting point for discussions of art history, but an area of some doubt for the study of the earliest painted art. Some authors ignore completely the subject of who painted the images (Bahn 1998). Others argue that that men and women of all ages must have been present underground in the caves (White 2003: 120). Another approach is to assume that we simply cannot determine who made the Palaeolithic images that decorate caves in Europe (Bahn & Vertut 1997:189). Whilst other specialists have assumed that cave art from Europe was created by adult or sub-adult males (Canby 1961; Prideaux 1973), and, finally, reconstruction images usually portray these artists as male (Moser 1998:159).

Determining the sex of the makers of Palaeoltihic art is a matter of some uncertainty, but correct sex determination of handprints painted in caves could reveal whether there were both male and female artists at work in the caves, and possibly whether these artists were sub-adult or fully mature in age. Painted handprints and stencils are one of the most common representations to be recorded in prehistoric art, with examples to be found in France, Spain, the Americas, Australia, South Africa, amongst other places. Sometimes hundreds of such images can be found in a single site such as Gargas cave in southern France, and the Cueva de los Manos in Argentina. Handprints, and hand stencils, therefore, provide the best resource available for addressing the question of the sex of the artist in prehistoric times.

Recently two research teams have made use of the relative length of the 2nd (index) to 4th (ring) digit ratio or 2D:4D (Manning et al1998) to sex hands represented in cave art. There are currently two articles addressing this; a published news item (Chazine & Noury 2006) and the other, an unpublished paper (Snow in press). Here we comment on the news item by Jean-Michel Chazine and Arnaud Noury which considers their preliminary results for determining sexual identity of hand stencils from Gua Masri II Cave, East Kalimantan in Borneo (Chazine 1999; Chazine & Fage 1999a; 1999b) dated at over 9,900 years BP (Plagnes et al 2003).

Sexing the hand from negative or positive representations can be done to an extent by simply comparing size alone; adult males tend to have hands that are globally bigger and fingers that are longer when compared to females (Napier 1993). However, it must be borne in mind that there will always be overlap in size ranges between males at the lower end of the size spectrum and females at the upper end. Serious difficulties arise when the representations are made by sub-adult males as these would simply get subsumed into the female category without a further, more discriminatory, process to separate out the sexes. This is where 2D:4D may be of use.

2D:4D is likely to be a negative correlate of prenatal testosterone (PT) (Lutchmaya et al 2004; Van Anders et al 2006) and in humans, mean 2D:4D differs between males and females, with males having lower ratios (higher PT) than females (Manning 2002; figure 1a,b). Sexual differences in 2D:4D occur around 9 weeks of foetal development (Malas et al in press) and may result

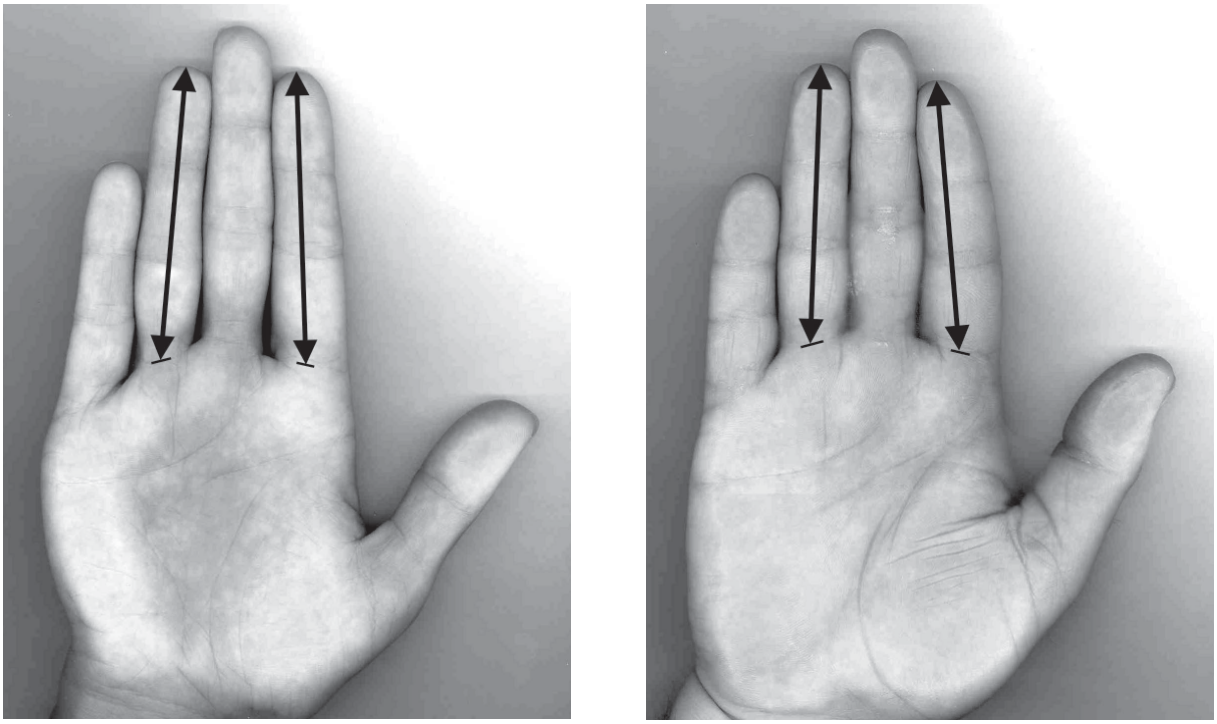

Figure 1 (a) The right hand of a Caucasian female with a digit ratio of 1.00 **(b)** The right hand of a Caucasian male with 2D:4D of 0.95

from an interplay between foetal sex steroid levels and the genes that code for the patterning of both the digits and reproductive system (Kondo et al 1997; Peichel et al 1997; Manning 2002; McFadden & Bracht 2005). These mechanisms appear highly conserved in vertebrates (Brown et al 2002; McFadden & Bracht 2003; Romano et al 2005) and it therefore seems appropriate to use 2D:4D as part of a methodology to establish the sex of cave art hand stencils.

To address this question a software programme (Kalimain©) had been designed by Arnaud Noury and tested on a selection of hand stencils from a panel situated in Gua Masri II Cave (Chazine & Noury 2006). Preliminary results look promising. Evidence of hypo- (high 2D:4D) and hyper-masculinised (low 2D:4D) hands do suggest that that both sexes may have been involved in creating the hand stencils (figure 2). The authors draw attention to the fact that patterning of the stencils appear to fall into sexually differentiated clusters, with some panel areas seemingly more favoured by males, while female-like hands predominate in other areas. The sexes also seem to exhibit their own distinct styles of patterning. However, as the authors acknowledge, hypotheses associated with planning, patterning and the utilisation of the space are only valid when viewing the panel as being created in one synchronic event. These theories become less plausible, however, once it is known that the frieze was probably created in two or more phases.

In the preliminary analysis, only 34 of the total number of 140 hand images were deemed suitable for the application of the sexing software. It is stated that the programme was able to sex a stencil by assessing the size and shape of the image and then applying the ratio formula. Although the methodology of the programme was not detailed, the outline implies that some form of digitising or digital imaging was used. If this is the case, measurements from digital images may create another set of problems for the calculation of the ratio and this may affect sex identification (see below). Procedures used to validate Kalimain© were not made clear in the article and some features of the application are still being developed, such as the identification of hand stencils from the same individual.

We do appreciate that these results are preliminary and this publication was in the form of a newsletter rather than a formal paper. Although we are by no means experts in the analysis of cave art, our studies with contemporary human populations might augment and help refine this work. There are some factors and methodological issues we feel should be considered when attempting to sex a hand from a print or stencil using 2D:4D.

2 2D:4D and hand sexing: factors to consider

Mean 2D:4D differs between males and females within

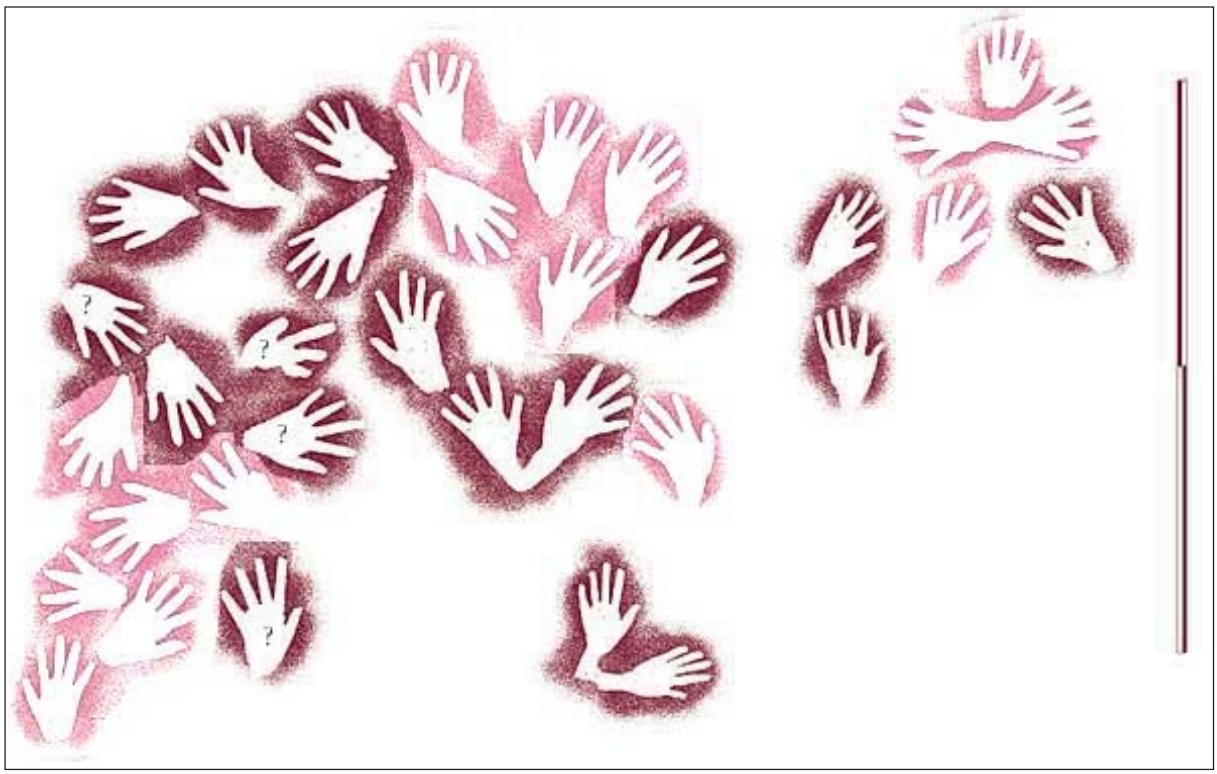

Figure 2 Negative hand stencils from Gua Masri II Cave. Dark hands allotted to females. Reproduced from Chazine & Noury 2006 with permission of the authors

a population. However, there is often considerable overlap between the sexes in terms of individual values (figure 3). Thus a proportion of the females will have masculine-like (low) digit ratio and a proportion of males will have values within the female range for that population (Manning 2002). This is normal human variation. It is therefore unwise to determine the sex of a hand stencil using ratios alone or to assume that 2D:4D is a definitive marker of an individual's sex. Mean 2D:4D can also vary quite markedly between ethnic

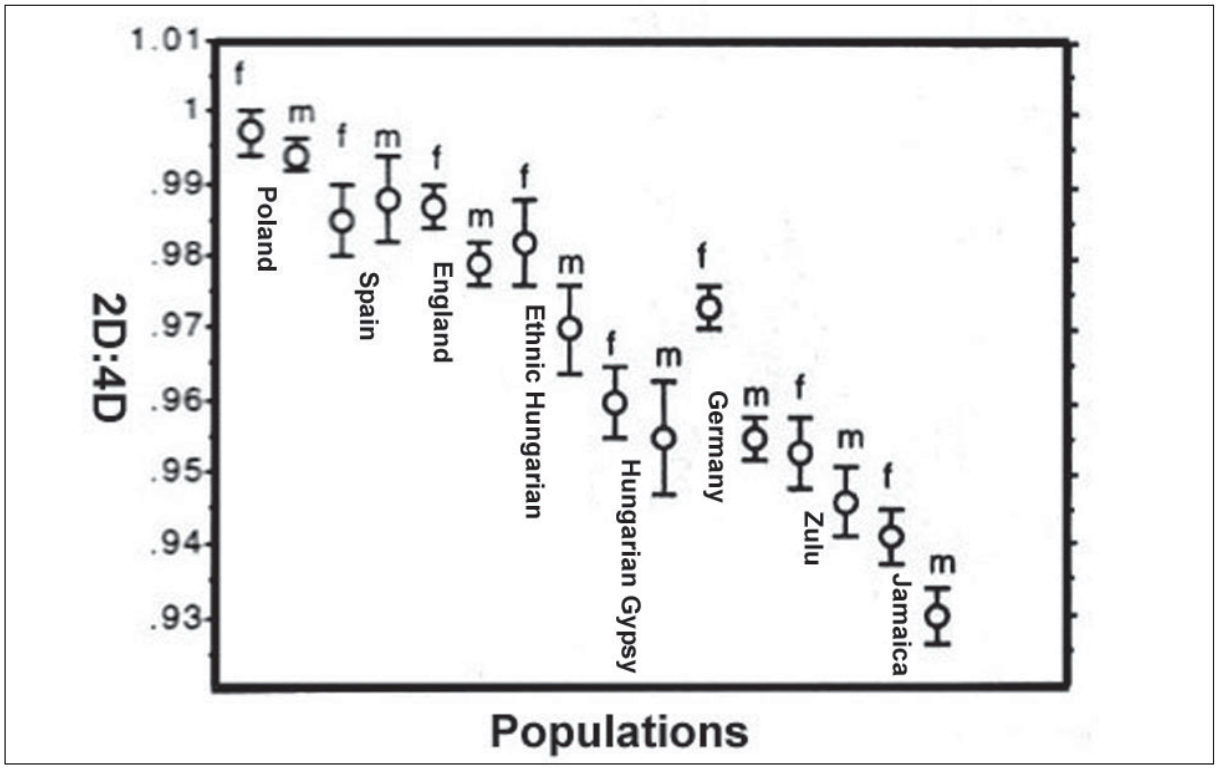

Figure 3 Mean 2D:4D with standard error bars for selected ethnic and national groups (f = female, m = male). Adapted from Manning et al 2000

groups and group differences must be controlled for (Manning et al 2000; Manning et al 2004a,b). For example, the males of Poland have a more feminised 2D:4D than German females and both of these groups are more feminised than Jamaicans (figure 3). It is also possible that the ratio changes over relatively short geographical distances within the same ethnic group.

Within a population or ethnic group there may only be a few millimetres that distinguish male from female means (4 millimetres in Europeans), it is therefore important to use the most appropriate reference sample. It is assumed here, but it is not clear, that Chazine and Noury used mean 2D:4D ratios taken from European populations (0.96 for males and 1.0 for females). If they did use these values, they are unlikely to be appropriate for discriminating the sex of the Borneo hand stencils. It may be more valid to use mean 2D:4D taken from indigenous populations, as their gene pool is likely be closer to that of the cave artists and is also likely to differ from the ratios of present day Europeans.

Right hand 2D:4D seems to be more responsive to PT than the left 2D:4D (Manning et al 1998; Manning 2002; Cattrall et al 2005) and this may need to be taken into account in studies such as this. Right and left hand 2D:4D are similar within individuals (approximately r=0.60), but marked differences are not uncommon. If the diagrams of Chazine and Noury are accurate it would seem that there is equal representation of both the left and right hands on this panel; our estimation, using the thumb as a guide to identify left or right hands and assuming the palm is placed downwards, was 17 right hands, and 16 left, 1 indeterminate (figure 2). Thus, if the software is estimating the ratio with some precision, the right hands may be exhibiting slightly lower 2D:4Ds compared to the left hand and this may cause some error in sexing the hands. This may also be an important factor when attempts are being made to identify multiple hand stencils from the same individual. For example, the software is programmed to seek out the same, or similar ratios from all fingers within a +/- 10% variance range and was able to identify six stencils from the panel that, according to this criterion, were from the same individual. Caution is required in interpreting this type of result.

When 2D:4D is measured on a living person the length of the digit is taken from the proximal crease on the palm of the hand at the base of the digit to the finger tip in the mid-line; excluding the nail and without compressing the finger pad (figure 4a). The length of the index finger (2D) is then divided by the length of the ring finger (4D) to obtain 2D:4D. Obviously these soft-tissue features are not available on the hand stencils so other points of measurement need to be established. It is not stated how the Kalimain© programme calculates digit ratio from the hand images or where the points of measurement are taken from, but as 2D:4D is a measure of index finger length relative to the ring finger length, it does not matter where the

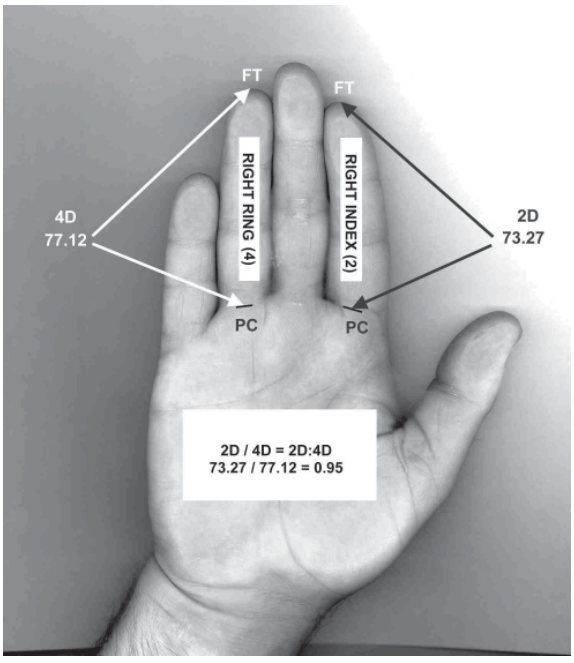

Figure 4 (a) Conventional method for measuring digit length and calculating 2D:4D (FT = finger tip, PC = proximal crease)

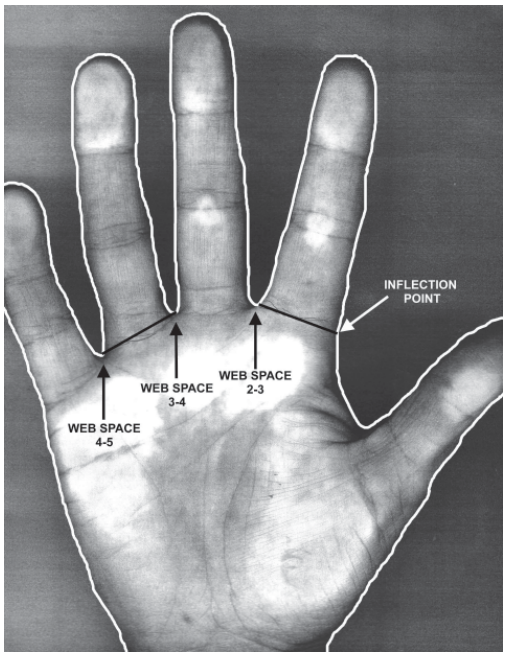

Figure 4 (b) Measuring digit length from hand outlines

proximal point of measurement is taken from as long as the same anatomical point is used on each finger. We would suggest obtaining the proximal point for the 2nd digit (index finger) by drawing a straight line from the inflection point on the lateral aspect of the hand close to the base of the 2nd digit, to the web space between digits 2 and 3. Then measure to the tip of the stencil from this line, up the mid-line of the digit. A similar process can be used for calculating the length of the 4th digit (ring finger), but in this case a line should be drawn between the web spaces of digits 3 and 4 (see figure 4b). This technique appears to be similar to that used by Gruning (1886).

If published means from contemporary populations are used to sex hand stencils it is worth noting that finger length is usually measured with the digits extended and together (figure 4a), whilst all the hand stencils have their digits abducted to some degree. It is possible that the splaying out of the fingers as happens in the making of hand stencils may alter digit length in some way. The problem may be solved to some extent by creating a new reference sample by measuring a group of people, possibly local to the cave, and calculating mean 2D:4D from splayed-out fingers (see Snow in press). Hand stencils could also be obtained from this same sample to test the accuracy of the software programme. These issues should be addressed in the validation process.

Other errors could be introduced by the finger nails, adding length to one or both of the digits, perhaps changing the ratio. Non-homogeneity of the cave wall and the way the paint is applied could affect the quality of the stencils or distort the web space regions so as to confound measurement. Some experimental work on this has been carried at Cheddar Gorge (UK) by Barham (pers comm), who compared finger length measurements taken from hand stencils made on the rock walls by student volunteers to measures taken from the same 'artists' on flat paper surfaces. In these comparisons, the topography of the cave surface, type of rock and the method used to apply pigment all contributed to error in 2D:4D. It has also been show that photocopied images of the hand can distort images in ways that systematically reduce 2D:4D (Manning et al 2005) and it is possible that similar processes could affect digital methods used to image the cave hand stencils. Again, these types of issues should be addressed in the validation process; replication studies may be of particular importance in understating how the rock surface and methods of paint application distort finger length.

The overall aim here is to use hand size and *average* measures of 2D:4D taken from contemporary populations to identify the sex of an *individual* from a hand stencil created thousands of years ago. The objective is confounded by the fact that we are dealing with such small differences in mean 2D:4D between males and females. It is therefore very important to ensure the methodologies are as consistent and as accurate as possible. Error will inevitably occur; the objective is to minimise this and using a specifically adapted software programme such as Kalimain© may be the way forward.

3 Conclusion

Our main concerns with the use of 2D:4D as a method of sexing hand stencils must be firstly to draw attention to the overlap in values that occurs between males and females and secondly to emphasise our inability to identify the normal range of 2D:4D for males and females in the population under study. Nevertheless, we do feel that 2D:4D is a useful tool to sex hand stencils and would be most effectively employed in identifying hands whose size is indicative of sub adult male or female status. We emphasise that it is not sufficient to use 2D:4D alone to sex hand stencils, and would strongly recommend the ratio to be used to determine sex only after more robust methods, such as hand size have been employed. This seems to be the method employed by the Kalimain© programme and is similar to the technique outlined by Snow (In press).

The authors state that sexual determination of the hand stencils could reveal something about social organisation of the cave artists, however, we feel that any hypotheses about social organisation, based upon this technique, be made with caution. What it does tell us is that the hand stencils in Gua Masri II Cave appear to have been produced by both males and females and, therefore, cave art may not have been a purely male dominated activity as popular images have so often projected. Studies of more hand stencils from other caves in Borneo and around the world need to be carried out before we can say for sure whether it was common for both sexes to participate in hand stencilling. If this is found to be a general trend, it would obviously

change some of our ideas about gender roles in these societies. After all it is an understanding of the people, rather than the art *per se*, that is the goal of archaeologists and any theories formulated must be underpinned by science not mere assumption.

This area of research also offers prospects for our own work; hand images such as those found in abundance in caves of East Kalimantan, could provide us with a novel mode of studying temporal and spatial changes in digit ratio in prehistoric groups, which is particularly intriguing from the evolutionary and bio-behavioural perspective. It is also of interest that two groups are currently making use of digit ratio to help disentangle some of the ambiguities surrounding cave art, and preliminary results outlined in the article by Chazine and Noury are encouraging. This work is inspiring and we look forward to learning more about the software programme and hope the factors outlined here will be useful in refining the methodologies of sexing hands represented in cave art using 2D:4D.

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