



A Cross-cultural Perspective on Upper Palaeolithic Hand Images with Missing Phalanges

Brea McCauley¹ · David Maxwell¹ · Mark Collard¹

Published online: 21 November 2018
© Springer Nature Switzerland AG 2018

Abstract

Hand images with missing phalanges occur at a number of Upper Palaeolithic rock art sites in Europe. It has been argued that they represent hand signals or a counting system, but there are reasons to believe they were actually produced by hands from which finger segments had been removed. Here, we report a cross-cultural study designed to shed light on this phenomenon. Our review of the ethnographic literature identified 121 societies from Africa, Asia, the Americas, and Oceania that engaged in finger segment amputation, and we were able to distinguish ten distinct amputation practices within this sample. When the contexts and what we can infer about the participants are taken into account, the scenario that best fits the rock art hand images is removal of finger segments during life in order to appeal for supernatural assistance. This has potentially interesting implications for social life in the Upper Palaeolithic because traumatic religious rituals have been found to foster strong interpersonal bonds among group members and hostility towards members of other groups.

Keywords Upper Palaeolithic · Rock art · Hand images · Finger amputation · Ritual · Religion

Introduction

The study reported here concerns an enigmatic feature of the rock art at a number of Upper Palaeolithic (UP) cave sites in Western Europe—hand images that are missing phalanges, i.e. finger segments (Fig. 1).

Electronic supplementary material The online version of this article (<https://doi.org/10.1007/s41982-018-0016-8>) contains supplementary material, which is available to authorized users.

✉ Mark Collard
mcollard@sfu.ca

¹ Department of Archaeology, Simon Fraser University, 8888 University Drive, Burnaby, British Columbia V5A 1S6, Canada

A)**B)**

Fig. 1 Examples of Upper Palaeolithic hand images, including some with missing phalanges. **a** Negative hand images from Grotte de Gargas (Hautes-Pyrénées, France). **b** Negative hand images on calcite draperies in Cosquer Cave (Calanque de Morgiou, France). (Photos: © Jean Clottes, used with permission)

The term “hand image” encompasses both handprints and hand stencils. These can be thought of as positive or negative forms of hand image (Janssens 1957; Snow 2006). To create a positive hand image, an individual would have dipped their hand in pigment and then pressed it on the cave wall (Janssens 1957; Snow 2006). The creation of negative hand images would have involved an individual pressing their hand to the cave wall and then applying pigment around it by, for example, blowing (Janssens 1957; Snow 2006).

Hand images are a common feature of rock art (Anati 1993; Bahn 1998; Lundborg 2014). They are present at one of the earliest known rock art sites, Leang Timpuseng in Indonesia (Aubert et al. 2014), and have been found in numerous other caves with rock art, including some of the most famous and intensively studied ones. Examples include

Altamira (Pike et al. 2012), Chauvet (Clottes and Arnold 2001), and Pech-Merle (Leroi-Gourhan 1968).

Over 200 of the hand images that have been found at UP rock art sites in Europe have missing finger segments.¹ Currently, it is thought that all these images date to the Gravettian (ca. 22–27 Ka BP) (Jaubert 2008). The caves that contain the UP incomplete hand images are located in France and Spain. Numerous hand images with missing phalanges are present at Grotte de Gargas in Hautes-Pyrénées, France (Barrière 1976). In total, 231 hand images have been recorded at this site (Hooper 1980). It has been estimated that their production involved 40–50 individuals (Barrière 1976). Based on the size of the images, these individuals are thought to have included men, women, adolescents, and infants (Barrière 1976). Of the 231 images, 114 have at least one finger segment missing, ten are complete, and 107 are insufficiently well preserved to determine whether they originally were complete (Hooper 1980). Some of the Grotte de Gargas hand images are shown in Fig. 1.

Cosquer Cave is another French cave site that has hand images with missing phalanges (Clottes et al. 2005). Cosquer Cave is located in the Calanque de Morgiou, which is a sheltered inlet that lies between Marseille and Cassis in southern France. There are 49 negative hand images at the site, 28 of which have one or more fingers with missing phalanges (Clottes et al. 2005). Three of these have only the thumb complete; six have the thumb and first finger complete; 14 have the thumb and first two fingers complete, and five have the thumb and first three fingers complete (Clottes and Courtin 1994; Clottes et al. 2005). Examples of the hand images in Cosquer Cave can be seen in Fig. 1.

Small numbers of hand images with missing finger segments have been found at three other French UP rock art sites—Tibiran, La Grande Grotte, and Margot. Tibiran is located in the department of Hautes-Pyrénées and has ten hand images, all of which have missing phalanges (Sahly 1966; Hooper 1980). Located in Burgundy, La Grande Grotte d'Arcy-sur-Cure has nine hand images, one of which is incomplete (Baffier and Girard 1998; Baffier et al. 2005). The cave of Margot is located in the department of Mayenne and has a total of five hand images (Pigeaud et al. 2006). One of these images has missing finger segments (Pigeaud et al. 2006).

Hand images with missing finger segments have also been found at two caves in Spain. These sites are Fuente del Trucho and Maltravieso. Located in the province of Huesca in northeast Spain, Fuente del Trucho has a total of 50 hand images (Utrilla et al. 2013). Five of these are missing phalanges (Utrilla et al. 2014). Maltravieso is in the province of Cáceres in western Spain. A total of 71 hand images have been documented at this site (López et al. 1999). Sixty-one of these are missing one or more finger segments (López et al. 1999).

Currently, the significance of the hand images that are missing phalanges is unclear. Some researchers have argued that the individuals who produced them had all their fingers and simply manipulated their hands in such a way that certain

¹ During the review process, our attention was drawn to the so-called crooked thumb images, which are negative stencils of isolated thumbs that are bent at the interphalangeal joint (Clottes 2008). It was suggested that they may be a variant of the hand images with missing finger segments. While we accept this is possible, we think there are sufficient differences between the two sets of images for it to be reasonable to treat them separately for the time being. Most importantly it is unclear whether the hands to which the crooked thumbs belonged were intact or missing phalanges.

fingers were not included in the prints. It has been proposed, for example, that the incomplete hand images reflect the use of a sign language (Leroi-Gourhan 1967; Barrière and Suères 1993; Delluc and Delluc 1993; Clottes and Courtin 1994). Proponents of this hypothesis have argued that the incomplete hand images resemble hand signals used by some San groups to communicate silently while hunting (Leroi-Gourhan 1967). They have also argued that the frequencies of the different finger patterns are consistent with the ease with which they can be achieved (Leroi-Gourhan and Michelson 1986). Van den Broeck (1950) and Rouillon (2006) have put forward alternative hypotheses. Van den Broeck (1950) suggested that the hand images are a signature or “visiting card”, while Rouillon (2006) argued that the missing phalanges are found in five different configurations and suggested that these represent the numbers one through five.

Although the idea that the incomplete hand images are signs or a counting system is intriguing, there are several reasons for thinking that the images actually involved hands from which finger segments had been removed. To begin with, there is independent evidence that individuals with missing phalanges visited at least one of the caves in which incomplete hand images have been found. Barrière (1976) reported the discovery of impressions of human limbs in hardened mud at Grotte de Gargas, and some of them are of hands with stumps of fingers instead of complete fingers. The limb impressions are thought to be the same age as the rock art at the site. Thus, we have reason to believe that phalangeal amputation was not just practiced in UP Europe but practiced by groups that used the cave with the greatest number of incomplete hand images.

Gilligan (2010) outlined additional reasons for thinking that the incomplete hand images reflect phalangeal amputation rather than a sign language or counting system. He argued that individuals using sign language likely would have created a greater variety of patterns than is seen in the UP incomplete hand images. In support of this, Gilligan highlighted Walsh's (1979) work investigating the link between rock art hand stencils and sign language in Australia. Gilligan (2010) pointed out that Walsh (1979) documented a much wider range of finger patterns than is seen in the UP incomplete hand images. Gilligan (2010) also highlighted the fact that the representation of thumbs and fifth fingers differ markedly between the Australian hand stencils examined by Walsh (1979) and the UP incomplete hand images. The former frequently lack the thumb but often have a complete fifth finger, whereas the latter typically have the thumb but often lack one or more segments of the fifth finger (Clottes and Courtin 1996)@@. The difference in the presence/absence of the thumb is particularly significant, Gilligan (2010) explained, because the thumb is the easiest digit to fold out of view and therefore should be one of the most frequently missing digits if the UP incomplete hand images reflect a sign language. This undercuts one of the main arguments put forward in support of the sign language hypothesis—namely, that the frequencies of the different finger patterns are consistent with the ease with which they can be achieved (Leroi-Gourhan and Michelson 1986).

There is a further reason for thinking that the UP incomplete hand images reflect phalangeal amputation rather than a sign language or counting system. In the late 1950s, Paul Janssens noted that most of the Grotte de Gargas hand images that are missing fingers have clear outlines (Janssens 1957). This, he argued, implies that the hands were not prevented from lying flat by folded fingers. Attempts to test this hypothesis experimentally have yielded conflicting findings (Lorblanchet 1980; Wildgoose et al.

1982; Groenen 1988). However, Janssens' (1957) hypothesis is supported by the above-mentioned analysis of Australian rock art hand images by Walsh (1979). In addition to the results discussed in the previous paragraph, Walsh (1979) found that the stencilling was usually indistinct in the area of the missing phalanges and concluded that this was due to the fingers being folded over rather than pressed firmly against the rock surface.

While the case for favouring the amputation hypothesis is not airtight, we are of the opinion that it is strong enough to warrant treating the hypothesis as if it is correct for the purposes of further investigation, and this is what we did in the study reported here.

The study addressed the most obvious question raised by the amputation hypothesis—namely, why would individuals have had their phalanges removed? One possibility that has been raised is that the amputations were carried out for medical reasons. Janssens (1957), for example, argued that the incomplete hand images reflect instances of Raynaud's disease. This disease involves a narrowing of the arteries that reduces blood flow to the fingers and toes and can, in severe cases, require amputation of the affected parts (Wigley 2002). In a similar vein, Gilligan (2010) recently suggested that the UP incomplete hand images reflect amputation in response to frostbite. However, the sheer number of incomplete hand images at Grotte de Gargas and Cosquer Cave suggests that other reasons for amputation should be considered.

Several non-medical explanations for the putative phalangeal amputations have been put forward. Casteret (1951), for instance, argued that the incomplete hand images in Gargas Cave were made by hands from which phalanges had been removed as sacrificial offerings. The following year, Breuil (1952) proposed that caves with rock art were used in connection with hunting magic and suggested that the incomplete hand images reflect ritual amputations carried out to ensure a successful hunt. More recently, Lundborg (2014) argued that the phalanges were removed during initiation rites. However, it is unclear whether these are the only plausible alternative explanations.

The goal of the study reported here was to provide a cross-cultural or ethnological perspective on the range of possibilities. We began by reviewing a large sample of ethnographic texts to identify societies that engage in or used to engage in phalangeal amputation. Subsequently, we used the data collected in the literature review to develop a taxonomy of amputation practices. As we will show in the “**Discussion**” section of this report, one of these practices is a particularly good match for the UP incomplete hand images when we take into account the locations of the images and what we can infer about the individuals whose hands produced them.

Materials and Methods

To identify finger amputation practices among ethnographically documented societies, we used the electronic version of the Human Relation Area Files (eHRAF) as well as hard copy texts. eHRAF is a keyword-searchable database of ethnographies (World Cultures Ethnography Database 2008). To search eHRAF, we used the keywords “amputation” and “amputate”. We also searched within the category “ritual” using the keywords “finger”, “amputation”, and “amputate”.

For each finger amputation practice, we recorded data on a number of variables. We noted whether the participants were alive or deceased at the time of amputation and whether it was carried out voluntarily or involuntarily by the participant themselves or

by their kin or non-kin. We also made a note of the age and sex distribution of the practice. In addition, we sought information on several variables that are specific to the amputation itself: which hand was mutilated, which finger or set of fingers was amputated, and how many phalanges of those fingers were removed. Lastly, we recorded the method of amputation.

Results

Finger amputation practices were mentioned in 188 sources pertaining to 121 groups. The sources included ethnographic documents, travel journals, and expedition archives. Sufficiently detailed information was available for 104 of the 121 groups; 46 from Africa, seven from Eurasia, 11 from Oceania, 36 from North America, and three from South America. Some of the groups relied on hunting and gathering at the time they were visited by the ethnographer, while others relied on small-scale food production. The vast majority of the groups indicated that finger amputation practices had died out or were in the process of dying out. Details of the groups and relevant sources are provided in the [supplementary online material](#).

We identified ten distinct amputation practices (Table 1). These can be divided into those where the individual is alive at the time of amputation and those where they are dead. Within the former category, the practices can be divided into those that are voluntary and those that are involuntary. Here, "voluntary" means that the practice was assented to by the participant or, in the case of a child, by their parents, whereas "involuntary" means that the practice was forced on the participant. Voluntary practices include removing phalanges to appeal to a deity for assistance (*sacrifice*), to express extreme grief (*mourning*), to mark group membership (*identity*), to attempt to heal sickness (*medical*), and to signal marital status (*marriage*). There are two involuntary practices: amputation to punish a bad deed (*punishment*) and amputation to produce a magical object or worshiping device (*veneration*). Among the post-mortem practices, there is one that was carried out by close relatives: amputation to appeal to a deity for assistance (*offering*). There are also two practices that were carried out by members of another group. In one, phalanges were removed and kept to mark victory over a deceased enemy (*trophy*). In the other, phalanges were removed and kept to assist with worship or magic (*talisman*).

We will now discuss each practice in more detail. We will begin by outlining the practices that were carried out when the amputee was alive at the time of amputation. Subsequently, we will focus on the practices that were conducted post-mortem. To save space, we will use examples to illustrate each practice rather than discussing all the societies that practiced it. The names of the societies that engaged in a given practice are given in Tables 2 and 3.

Amputation While Alive

Sacrifice In this practice, individuals engaged in phalangeal amputation to appeal to a deity for assistance. It is the commonest type of finger amputation practice in the sample. Thirty-three groups practiced this type of finger amputation: 16 from North America, ten from Africa, six from Oceania, and one from Asia. *Sacrifice* involved

Table 1 Finger amputation practices identified in cross-cultural sample

Practice	Carried out while alive/post-mortem?	Performed by in-group or out-group?	Voluntary or involuntary?	Age distribution	Sex distribution	Purpose
<i>Sacrifice</i>	Alive	In-group	Voluntary	All, most common children	Both, more common females	To appeal to a deity for assistance
<i>Mourning</i>	Alive	In-group	Voluntary	All	Females	To express extreme grief
<i>Identity</i>	Alive	In-group	Voluntary	Children	Females	To mark group membership
<i>Medical</i>	Alive	In-group	Voluntary	All, commonly children	Both	To heal sickness
<i>Marriage</i>	Alive	In-group	Voluntary	Marrying age and older	Females	To signal marital status
<i>Punishment</i>	Alive	In-group	Involuntary	All	Commonly men	To punish a bad deed
<i>Veneration</i>	Alive	In-group	Involuntary	Children	Both	To produce a magical object or worshiping device
<i>Offering</i>	Post-mortem	In-group	N/A	Children	Both	To appeal to a deity for assistance
<i>Trophy</i>	Post-mortem	Out-group	N/A	War fighter and older	Commonly men	To mark victory over the deceased enemy
<i>Talisman</i>	Post-mortem	Out-group	N/A	Not listed	Female	To produce a magical object or worshipping device

Table 2 Groups with finger amputation practices in which the amputee is alive

	Africa	Eurasia	Oceania	North America	South America
<i>Sacrifice</i>	Babongo Barotse Bushman Darama Fengu Khoikhoi Kimwani Pygmy Sakalava Shambaa	Hindu	Dugum Dani Fijian Futuna Papuan Tongan 'Uvea	Arapaho Arikara Assiniboine Blackfoot Cheyenne Crow Gros Ventre Haida Hidatsa Kootenay Mandan Plains Cree Sioux Tlingit Tsimshian Western Dakota	
<i>Mourning</i>	Babongo Bushman Eynicqua Khoikhoi Maasai Pygmy		Dugum Dani Fijian Kanak Papuan Rotuman Tongan	Assiniboine Beaver Blackfoot Cheyenne Chipewyan Cree Crow Eastern Dakota Mandan Maya Omaha Plains Ojibwa Ponca Sekani Tsuu T'ina	Charrúa Minuane Pampas
<i>Identity</i>	Bomvu Bushman Dama Fengu Kabba Khoikhoi Pondo West Africa		Dalibura Eastern Australia Ginum Gweagal Maryborough New South Wales Turrbal Worimi Wulwulam	Amahami Hidatsa Mandan	
<i>Medical</i>	Bushman Damara Igbo Khoikhoi Koranna Nama Shambaa South Africa	Serbs	Tongan	Chipewyan Inuit	
<i>Marriage</i>	Khoikhoi		Copmanhurst		
<i>Punishment</i>	Azande Babongo Baluba Banjangi	Cambodian Iran Malay Mongol	Fijian	Aleut Maya	

Table 2 (continued)

Africa	Eurasia	Oceania	North America	South America
Chewa				
Herero				
Ila				
Lamba				
Mabudu				
Pare				
Rwanda				
Shona				
Somali				
Sumbwa				
Uganda				
Walenje				
Wamba				
Xhosa				
<i>Veneration</i>			Sioux	

both males and females, but it was more common among females (Een 1872; Scott 1911). Children were the most common amputees, although the practice was not restricted to that age category (Grinnell 1923; Trilles 1932). Therefore, female children were the most common participants. Typically, individuals would have the distal phalanx of their fifth finger removed from one or the other hand (Boas 1889; Dinitz

Table 3 Groups with post-mortem finger amputation practices

	Africa	Eurasia	Oceania	North America	South America
<i>Offering</i>	Abarambo Ashanti Azande Manyema Manyika Shona Wamba West Africa				
<i>Trophy</i>	Bagisu Yao			Apache Assiniboine Blackfoot Cheyenne Chinook Cree Crow Maya Middle Missouri Ojibwa Pawnee Sioux Ute	
<i>Talisman</i>	Sakalava Yao			Aztec	

1925). The phalanx was cut off with an axe or adze, or it was bitten off (Grinnell 1923; Majno 1975). The Blackfoot of North America are one of the groups that engaged in sacrifice (Grinnell 1923). Both sexes sometimes sacrificed finger segments in the sun dance. There were also sex-specific versions of the practice. A man would sometimes sacrifice a phalanx to the moon and stars, while a woman might cut off and swallow a piece of her finger in order to become pregnant. A woman might also cut off the tip of her baby's finger and swallow it, to give the baby good luck.

Mourning In this practice, close relatives of a deceased individual would voluntarily remove parts of their fingers as an act of extreme grief. Thirty groups in the sample engaged in this practice: 15 from North America, six from Africa, six from Oceania, and three from South America. Close female family members of the deceased were the most common participants in this practice (Moritz 1915; Andrews 1959). Typically, one finger segment was removed per deceased individual, starting with the distal phalanx of the fifth finger (Bijlmer 1923; Schapera and Farrington 1933). Fingers from both hands were targeted, and it was normally carried out with an axe or adze (Forster 1787). The practice does not appear to have been a religious ritual. Deities were not named or alluded to in any of the accounts we examined. The Bushmen of South Africa were one of the groups that engaged in *mourning*. Burchell (1825:79) recounts meeting an elderly woman who had lost two phalanges on her right fifth finger and one phalanx on her left fifth finger. She explained that they had been cut off at different times to express grief over the death of three of her daughters. After this encounter, Burchell noted many other women and some men with similarly mutilated hands.

Identity In this practice, finger amputation was carried out to mark group membership. Nineteen groups in the sample engaged in this practice: nine from Australia, eight from Africa, and two from North America. Most commonly, the distal phalanx of the fifth finger was amputated from the left hand (Fritsch 1894). Female children were most often the amputee, and the phalanx was removed with an axe or adze (Jung 1883; Mathew 1899). In southwestern Australia, women would often have two phalanges of one of their fifth fingers amputated. In some groups, the left hand was used, while in others, the right was targeted. In some cases, the practice was carried out to mark membership of a particular occupation. Among the Aborigines of Port Stephens, for example, a mother would mark her infant daughter as a fisherwoman by cutting off two phalanges from the fifth finger of the right hand. The Dalibura engaged in the same practice but amputated the fifth finger of the left hand (Howitt 1904; Sollas 1911).

Medical In this practice, finger amputation was carried out to resolve a health problem. It includes not only amputation of damaged fingers (e.g. fingers damaged as a result of frostbite) but also amputation of undamaged fingers to bleed sickness out of the amputee or to bleed healthy blood into another, sick individual. Eleven groups in the sample engaged in *medical*: eight from Africa, two from North America, one from Eurasia, and one from Oceania. Similar to the categories already listed, the distal phalanx of the fifth finger of the left hand was the main target for removal (Barrow 1801; Moritz 1915). However, for ailments that directly related to the fingers, the affected finger would be targeted (Densmore 1928; Weyer 1932). Children of both sexes were often the amputee (Scherzer 1864). No information on the method of

amputation was available. The Griqua of southern Africa were one of the groups for which *medical* was recorded. They would sometimes remove the distal phalanx of the fifth finger in case of illness. The disease was believed to disappear via the blood from the wound (Campbell 1882:48; Lagercrantz 1935).

Marriage In this practice, a phalanx was removed prior to the amputee getting married. This practice was found in two groups: one from Africa and one from Australia. In both groups, finger amputation for marriage was female specific, and in both cases, it was the distal phalanx of the fifth finger on the left hand that was amputated (Kolbe 1745). The amputation was carried out by tying a cord tightly around the finger until the phalanx fell off (Etheridge 1904). The Khoikhoi of southern Africa were one of the groups that engaged in *marriage*. Among the Khoikhoi, a woman could experience this practice more than once. Widows who wished to re-marry were required to have another phalanx amputated in order to release her from the spirit of her deceased husband (Thunberg 1789:215; Lagercrantz 1935).

Punishment In this practice, finger amputation was carried out as a form of punishment. Twenty-three groups in our sample practiced this type of finger amputation: 16 from Africa, four from Asia, two from North America, and one from Oceania. The amputation would often be of the distal phalanx of the fifth finger (Dohne 1844). How the amputation was carried out (i.e., cutting, tying, or biting the finger off) was not described in any of the books and papers we consulted. Males were the most likely to be subjected to this type of amputation, and there does not seem to have been a norm regarding the hand from which the finger was removed (Le Marinel 1893; Westermarck 1906). *Punishment* was carried out by the Ila of Zimbabwe. Finger amputation was the punishment for persistent adulterers, thieves, and arsonists (Smith and Dale 1920:358; Lagercrantz 1935). Interestingly, they would sometimes also amputate toes for these offences.

Veneration In this practice, fingers were amputated to serve as a worshipping object or magical tool. As with *punishment*, the amputation was involuntary. One group from North America engaged in this practice—the Sioux. In the case described, a Sioux elderly woman cut off all the fingers of some Chippeway children and then strung the fingers in order to form a ritual necklace (Eastman 1849:47; Owsley et al. 2007).

Post-mortem Amputation

Now, we turn to finger amputation that was carried out post-mortem. In these practices, individuals were newly deceased when their fingers were amputated rather than their phalanges being removed from their place of internment.

Offering In this practice, the finger segment was amputated by a close relative of the deceased. Similar to voluntary sacrifice of living individuals, this type of phalangeal amputation was carried out to appeal to a deity for assistance. Eight groups in our sample engaged in this practice. All of them are from Africa. The distal phalanx of the fifth finger on either hand could be amputated from either sex (Bullock 1927). This practice tended to target children after they had died and involved use of an axe or adze (Rattray 1927). The Abarambo from central Africa are one of the groups that engaged

in this practice. They would cut off the fifth finger of the left hand after death. It was hoped that by removing the finger, the spirits would help them determine whether the death was caused by magical or natural causes (Larken 1923:6, 204; Lagercrantz 1935).

Trophy This practice was carried out post-mortem by an individual from another group who had defeated the amputee in combat. The finger was taken to mark triumph over the deceased enemy. Fifteen groups in our sample engaged in this practice, 14 from North America and one from Africa. *Trophy* was not restricted to the fifth finger as was the case with many of the other practices. It was common to take more than one finger (Powell 1969). There was little other information about this practice, but as most of the instances occurred during war time, it is reasonable to assume that the majority of the amputees would have been males and that the fingers would have been cut off (Macdonald 1882). One of the more detailed accounts we located concerns a Chinook chief who carried 14 amputated fingers in his medicine bag. When asked about them, he explained that they were the fingers of enemies he had defeated in combat (Moulton 1989:351; Owsley et al. 2007).

Talisman This is another type of finger amputation practice that was performed after death by individuals from another group. The goal of this practice was to produce objects with which to engage in worship or magic. Four groups in our sample carried out this practice, two from Africa and two from North America. Typically, the amputee was a female of unknown age, and she would have one or two fingers removed from her left hand, either the fifth finger or the thumb (Sahagún 1961). The method of amputation was not reported for any of the cases. The Aztecs were one group that engaged in this practice. Aztec warriors would seek out hair, bones of the forearms, and fingers of women who died in childbirth to increase their bravery in battle (Sahagún 1969:161–162; Miller 2007).

Discussion

Hand images with missing finger segments are a feature of the UP rock art in a number of caves in France and Spain. It has been argued that they represent hand signals or a counting system produced with intact hands, but there are reasons to believe that they were actually produced by individuals whose fingers had been amputated. The aim of the present study was to address the obvious question that the incomplete hand images raise—why would individuals have had portions of their fingers amputated? To shed light on this question, we carried out a review of the ethnographic literature. We sought to identify societies that engage or engaged in finger amputation on a regular basis, and we also attempted to determine the groups' motives for doing so. We found reports of finger amputation practices occurring in 121 societies. For 104 of these groups, the information provided was sufficiently detailed for us to compare and contrast the practices. We identified a total of ten distinct practices among the 104 groups (Table 1).

Given the results of the review, are there any finger amputation practices that could account for the UP incomplete hand images? We think it is reasonable to rule out instances where the individual was deceased before the finger segment was removed. It would have been necessary to carry deceased individuals into the caves to have their

hands painted, and that would have been difficult. Considering the number of individuals who are postulated to have made the hand images at some sites (e.g. 40–50 at Grotte de Gargas), it seems more likely that the individuals were alive when the hand images were created. Therefore, we think it is reasonable to discount the three practices where the amputation was carried out after death—*offering*, *trophy*, and *talisman*.

We also think the two involuntary finger amputation practices—*punishment* and *veneration*—can probably be discounted. To reiterate, it is estimated that 40–50 people were involved in the production of the hand images at Grotte de Gargas. Such a large number of people undergoing finger amputation is inconsistent with the ethnographic data, which indicates that *punishment* and *veneration* are both rare phenomena.

Barrière's (1976) finding that the individuals whose hands produced the hand images at Grotte de Gargas included men, women, and children suggests that we can also discount *marriage*. As we explained earlier, in the ethnographic cases, *marriage* is restricted to women. Thus, *marriage* is inconsistent with the existence of incomplete hand images of men and children at the UP rock art sites.

Identity is unlikely as well, we think. The reason for this is that the ethnographic data indicate that individuals typically only had one finger segment amputated to mark their group identity. In contrast, as we noted earlier, a large portion of the incomplete hand images in the UP rock art sites are missing multiple phalanges.

It has been argued that the incomplete hand images reflect finger amputation due to ailments such as Raynaud's disease (Janssens 1957) and frostbite (Sahly 1966; Gilligan 2010). However, there are reasons to be sceptical about this hypothesis. To begin with, it seems unlikely that medical amputation can account for the fact that the distribution of mutilated hands is so patchy. As we explained earlier, incomplete hand images only occur at a few of the UP cave sites that have hand images. The majority of such sites do not have any incomplete hand images; they only have complete ones. It seems likely that if finger amputation was carried out for medical reasons, incomplete hand images should be much more common among the UP cave sites with hand images. Moreover, if frostbite or some other conditions was common enough to account for the numerous incomplete hand images at Grotte de Gargas and Cosquer Cave, then hand images with missing fingers probably should occur at other cave sites with UP hand images. With regard to an ailment such as Raynaud's disease, Clottes (1998) argued that it is improbable that groups living at roughly the same time but hundreds of miles apart would have developed the same severe condition, engaged in finger amputation, and immortalised their damaged hands on the walls of caves. Given these points, we think we can probably rule out *medical* as the primary explanation.

This leaves two possibilities—*mourning* and *sacrifice*. These were the most common finger amputation practices in our cross-cultural sample. They both resulted in multiple finger segments being amputated over an individual's lifetime and were voluntary. In addition, neither was age or sex dependent, which fits with Barrière's (1976) finding that the size of the incomplete hand images at Grotte de Gargas is consistent with their production having involved men, women, and children.

On the basis of the hand images alone, it is not possible to choose between *mourning* and *sacrifice* as the practice most likely to have resulted in the mutilated hands that produced the UP incomplete hand images. However, *sacrifice* fits well with one of the major hypotheses concerning the nature of UP rock art—namely, that they are remnants of religious rituals. A number of scholars have posited that the caves with UP rock art

represent sanctuaries, shrines, or even churches (e.g. Eliade 1978; González 1985). The religion of the people who produced the art has been argued to have been animistic (Glory 1964; Sax 1994) and to have involved shamans (Lommel 1967; Davenport and Jochim 1988; Clottes and Lewis-Williams 1998; Lewis-Williams 2002; Whitley 2009). *Sacrifice* is ritualistic in nature and carried out to appeal to a supernatural power for assistance. In contrast, *mourning* was not associated with higher powers among the groups in our sample who engaged in it. Thus, we think that, of the ten finger amputation practices revealed by our review of the ethnographic literature, *sacrifice* is the one that is most likely to be reflected by the incomplete hand images at UP sites.

Of the existing explanations for the incomplete hand images, those proposed by Casteret (1951), Breuil (1952), and Lundborg (2014) are closest to our interpretation. As we explained in the “Introduction”, Casteret (1951) argued that the incomplete hand images in Gargas Cave were made by hands from which phalanges had been removed as sacrificial offerings, while Breuil (1952) suggested that the incomplete hand images reflect ritual finger amputations carried out to ensure a successful hunt. Lundborg (2014) proposed that the incomplete hand images reflect finger segment amputation in connection with initiation rites. It is worth noting that our conclusion is also in line with Valde-Nowak’s (2009) interpretation of Oblazowa Cave, a Gravettian-variant site in southern Poland. Two human finger bones were found in this cave (Valde-Nowak et al. 1987; Valde-Nowak 2003). These are the only human remains that have been recovered from the site and the few accompanying objects found in the same layer are argued to be objects of symbolic significance including three Arctic fox tooth pendants, a needle, and what has been claimed to be the world’s oldest boomerang (Valde-Nowak 2003). Valde-Nowak (2009) suggested that these findings indicate that ritual activities were carried out at the site and argued that the presence of isolated human phalanges may represent ritual finger amputation at the time the incomplete hand images were created.

If the incomplete hand images do indeed indicate that some UP groups engaged in *sacrifice*, there are some interesting implications for our understanding of UP society. In recent years, a number of researchers in the field of the cognitive science of religion have investigated the psychological and social effects of “dysphoric rituals.” These are rituals that arouse intensive negative emotions through practices like collective possession, homicide, cannibalism, and the use of mind-altering substances (Whitehouse 2002, 2018; Xygalatas et al. 2013; Fischer et al. 2014). It has been found that such rituals are capable of creating strong bonds among the participants (Xygalatas et al. 2013). Dysphoric rituals have been argued to be important in the creation of cults, military units, and terrorist cells (Whitehouse et al. 2014; Raffield et al. 2016; Whitehouse 2018).

In certain circumstances, dysphoric rituals can result in a phenomenon that has been dubbed “identity fusion” (Kinzer Stewart 1991; Swann et al. 2009, 2012; Whitehouse and Lanman 2014; Whitehouse 2018). Identity fusion involves members of a group identifying with one another as if they are kin. While identity fusion can happen as a result of a similar worldview within the group, it can also occur through shared experiences, especially if these are traumatic. In some cases, the bonds that develop between group members can be stronger than those between kin. In a study of identity fusion among revolutionary battalions taking part in the Libyan Civil War in 2011, for example, Whitehouse et al. (2014) found that 97% of participants felt fused to their

battalion and that 45% of frontline fighters felt more fused to their battalion than to their own family. The idea that identity fusion can be caused by shared experience of a traumatic event is further supported by the fact that in the Whitehouse et al. (2014) study, only 28% of non-combatants attached to battalions reported feeling more fused to their colleagues than to their family.

Identity fusion can have a number of consequences. One is that members of a group can develop a strong sense of obligation and commitment to the group, leading them to act altruistically, sometimes to the point of sacrificing their lives for other members. Another potential consequence is that individuals can come to perceive the in-group as not only superior to others but also as invulnerable, motivating them to engage in extreme pro-group behaviour (Swann et al. 2009). This can have repercussions. Most notably, members of groups can become less trusting of, and even hostile to, non-members (Lindeman 1997; McDonald et al. 2012; Whitehouse 2012, 2018).

It seems reasonable to suppose that having a finger segment amputated is a dysphoric experience even when effective anaesthetic and pain relief are employed. Thus, if the incomplete hand images indicate that some UP groups engaged in *sacrifice*, then it is likely that the groups in question would have had unusually strong interpersonal bonds and may even have undergone identity fusion. The corollary of this is that the members of the groups may have been exceptionally cooperative with each other and overtly hostile towards other groups.

It is possible that the UP groups that produced the incomplete hand images were not alone in seeking out dysphoric experiences. Pfeiffer (1982) argued that rituals during the UP likely involved the revelation of startling images in conditions of extreme emotional and sensory arousal. He focused on caves as the most common surviving evidence of UP ritual activity. These environments, he averred, would be ideal for the transmission of traumatic and mystical experiences. Caves, with lowered temperatures, lack of light, and winding tunnels, can be distressing in their own right. This reaction would have been heightened with the addition of cave paintings. Whitehouse (1995) also argued that cave art images were designed to provide an emotionally stimulating experience. According to this author, many of the images were placed in locations where they would appear abruptly out of the darkness. A link between UP painted and engraved images and ritual has also been proposed by Davidson (2012). He argued that there was a difference between the eastern and western Mediterranean regions such that there was little arousal in the rituals in the former region but high arousal rituals in the western Mediterranean. Lewis-Williams raised the possibility that UP groups were engaged in another dysphoric ritual practice (Lewis-Williams and Dowson 1982; Lewis-Williams 1997). He suggested that much of the imagery used in UP cave paintings reflects the consumption of mind-altering substances. Thus, it could be that it was common for the members of UP groups to engage in dysphoric rituals and therefore to be both intensely bonded to one another and hostile towards members of other groups. We think it is worth considering whether this might help explain not only the ability of UP groups to outcompete non-modern hominins like the Neanderthals but also the emergence of the ethnolinguistic groups that appear to be reflected in the personal ornaments of the UP (Vanhaeren and d'Errico 2006). Another interesting possibility is that finger amputation and other dysphoric rituals played a role in the evolution of what seems to be our psychological propensity for tribalism (Haidt 2012).

With regard to further research, there are some obvious possibilities. Given how widespread finger amputation practices were in the recent past, it seems likely that additional examples of hand images reflecting this practice could be found. Thus, a global survey of hand images in caves and rock shelters with a focus on missing finger segments could be a profitable undertaking. Such a study might also help us further evaluate the hypothesis that folded fingers lead to indistinct areas at the tip of the shortened finger whereas amputated fingers result in a clear outline. A second possibility for future work is to look for other evidence of finger amputation in the UP. The most obvious additional line of evidence is skeletal remains. Missing finger bones would normally be explained by taphonomic processes, but the results of the present study raise the possibility that fingers were missing because they were amputated either during life or post-mortem. A survey of UP skeletons specifically looking for missing finger bones in the absence of obvious taphonomic factors and/or the presence of cut marks could be enlightening. Lastly, it would be worth systematically examining the context of the known incomplete hand images, including associated paintings, artefacts, and landscape. This might reveal specific patterns that are associated with the incomplete hand images. Images or artefacts that occur with greater frequency or only occur in conjunction with the incomplete hand images could help discriminate between the different possibilities vis-à-vis the finger amputation practices captured by the UP rock art.

Conclusions

In the study reported here, we used ethnographic data to shed light on a phenomenon that has intrigued archaeologists since the 1950s—the existence of a large number of hand images with missing phalanges at some UP cave sites in Europe. There are reasons to think that the missing finger segments were amputated rather than simply being folded into the palm of the hand. Thus, we focused on phalangeal amputation practices. We first reviewed the ethnographic literature to identify societies that engage in or used to engage in phalangeal amputation. We then used the data collected in the literature review to develop a taxonomy of amputation practices. We identified 121 groups that engaged in finger amputation at the time they were studied by ethnographers. Among these groups, there were ten different reasons for engaging in finger amputation. Of these ten, the one that best fits the available data for the UP incomplete hand images is voluntary sacrifice to a deity or supernatural power. This interpretation of the UP incomplete hand images echoes the hypotheses put forward by Casteret (1951), Breuil (1952), and Lundborg (2014). All of these authors suggested that the images in question reflect the removal of phalanges for ritual purposes. Our interpretation of the UP incomplete hand images also echoes Valde-Nowak's (2009) conclusion regarding human finger bones unearthed at an Upper Palaeolithic cave site in southern Poland. The idea that UP groups engaged in dysphoric religious rituals has interesting implications. Research in the cognitive science of religion indicates that such rituals not only promote in-group cooperation but also foster hostility towards members of other groups. Thus, the incomplete hand images may be telling us something important about the dynamics of social life in Europe during the UP. We should consider the possibility that it was common for the members of UP to engage in dysphoric rituals and therefore to be both intensely bonded to one another and hostile towards members of other groups.

Acknowledgements We thank Alec Allan, Chris Carleton, Iain Davidson, Candice Koopowitz, Jim O’Connell, Kim Plomp, and Dennis Sandgathe for their comments on an earlier version of this paper. We also thank the editor of the *Journal of Paleolithic Archaeology* and three anonymous reviewers for their assistance with improving our paper. Lastly, we thank Jean Clottes for providing us with the photographs included in Fig. 1. We feel very fortunate to have such generous colleagues.

Funding Information Our research was supported by the Social Sciences and Humanities Research Council of Canada (766-2017-1115 and 895-2011-1009), the Canada Research Chairs Program (228117 and 231256), the Canada Foundation for Innovation (203808), the British Columbia Knowledge Development Fund (862-804231), and Simon Fraser University (14518).

Publisher’s Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

References

- Anati, E. (1993). *World rock art: The primordial language*. Valcamonica: Edizioni del Centro.
- Andrews, E. (1959). Dzibilchaltun: lost city of the Maya. *National Geographic Magazine*, 115(1), 90–109.
- Aubert, M., Brumm, A., Ramli, M., Sutikna, T., Sapitomo, E. W., Hakim, B., Morwood, M. V., van den Bergh, G. D., Kinsley, L., & Dosseto, A. (2014). Pleistocene cave art from Sulawesi, Indonesia. *Nature*, 514(7521), 223.
- Baffier, D., & Girard, M. (1998). *Les cavernes d’Arcy-sur-Cure*. Paris: La maison des Roches.
- Baffier, D., Girard, M., Guillamet, E., Bertin, E., Delon, D., & Hardy, M. (2005). Les poissons de la Grande Grotte d’Arcy-sur-Cure (Yonne). *Munibe*, 57(5), 53–64.
- Bahn, P. (1998). *The Cambridge illustrated history of prehistoric art*. Cambridge: Cambridge University Press.
- Barrière, C. (1976). *L’art pariétal de la Grotte de Gargas, parts I and II*. Oxford: British Archaeological Reports.
- Barrière, C., & Suères, M. (1993). Les mains de Gargas. *Dossiers d’Archéologie*, 178(La Main dans la Préhistoire), 46–54.
- Barrow, I. (1801). *Reisen in das Innere von Süd-Afrika in den Jahren 1797 und 1789 II*. Leipzig: FA Brockhaus.
- Bijlmer, H.J.T. (1923). Anthropological results of the Dutch scientific central New-Guinea expedition A° 1920. Leiden: Brill.
- Boas, F. (1889). *First report on the northwestern tribes*. London: Burlington House.
- Breuil, H. (1952). *Quatre cent siècles d’art pariétal*. Montignac: Centre d’études et de documentation préhistoriques.
- Bullock, C. (1927). *The Mashona*. Cape Town: Negro Universities Press.
- Burchell, W. (1825). *Reisen in das innere von Sudafrika II*. Weimar: Marxverlag.
- Campbell, J. (1882). *Travels in South Africa (second journey) I*. London: Black and Parry.
- Casteret, N. (1951). *Dix ans sous terre*. Paris: Librairie Académique Perrin.
- Clottes, J. (1998). The ‘three Cs’: fresh avenues towards European Palaeolithic art. In C. Chippindale & P. S. C. Taçon (Eds.), *The archaeology of rock-art* (pp. 112–129). Cambridge: Cambridge University Press.
- Clottes, J. (2008). *Cave art*. London: Phaidon.
- Clottes, J., & Arnold, M. (2001). *La grotte Chauvet: l’art des origines*. Paris: Seuil.
- Clottes, J., & Courtin, J. (1994). *La grotte Cosquer: peintures et gravures de la caverne engloutie*. Paris: Seuil.
- Clottes, J., & Courtin, J. (1996). *The cave beneath the sea: Paleolithic images at Cosquer*. New York: Abrams.
- Clottes, J., & Lewis-Williams, J. D. (1998). *The shamans of prehistory. Trance and magic in the painted caves*. New York: Abrams.
- Clottes, J., Courtin, J., & Vanrell, L. (2005). *Cosquer redécouverte*. Paris: Seuil.
- Davenport, D., & Jochim, M. A. (1988). The scene in the shaft at Lascaux. *Antiquity*, 62, 558–562.
- Davidson, I. (2012). Symbolism and becoming a hunter-gatherer. *Bulletin de la Société Préhistorique Ariège-Pyrénées*, LXV-LXVI, 1689–1705.
- Delluc, B., & Delluc, G. (1993). Images de la main dans notre préhistoire. *Dossiers d’Archéologie (Les)*, 178, 32–45.
- Densmore, F. (1928). *Uses of plants by the Chippewa Indians. Forty-fourth Annual Report of the Bureau of American Ethnology 1926–1927*. Washington, DC: Government Printing Office.

- Dinitz, F. (1925). Une étude de l'ethnographie d'Angola. *Anthropos*, 20(1/2), 321–331.
- Dohne, J. L. (1844). *Das kaffernland und seine bewohner*. Berlin: Miffionshaufe.
- Eastman, M. (1849). *Dahcotah: or, life and legends of the Sioux around Fort Snelling*. New York: John Wiley.
- Een, G. (1872). *Minnen från en flerarig vistelse i Sydvestra Afrika*. Stockholm: Haeggströms boktryckeri.
- Eliade, M. (1978). *The forge and the crucible: the origins and structure of alchemy*. Chicago: University of Chicago Press.
- Etheridge, R. (1904). Ethnological notes made at Copmanhurst, Clarence River. II: disarticulation of one of the little finger joints. *Records of the Australian Museum*, 5(5), 271–276.
- Fischer, R., Xygalatas, D., Mitkidis, P., Reddish, P., Konvalinka, I., & Bulbulia, J. (2014). The fire-walker's high: affect and physiological responses in an extreme collective ritual. *PLoS One*, 9(2), e88355.
- Forster, G. (1787). *Geschichte der See-Reisen und Entdeckungen im Süd-Meer*. Vol. 4. Berlin: Haude und Spener.
- Fritsch, G. (1894). Bericht über einen Berg-Damara. *Zeitschrift für Ethnologie*, 26, 79–108.
- Gilligan, I. (2010). The prehistoric development of clothing: archaeological implications of a thermal model. *Journal of Archaeological Method and Theory*, 17(1), 15–80.
- Glory, A. (1964). L'éénigme de l'art quaternaire peut-elle être résolue par la théorie du culte des Ongones? *Revue des Sciences Religieuses*, 38(4), 337–388.
- González, G. G. (1985). Aproximació al desenvolupament i situació de les manifestacions artístiques quaternàries: a les cavitats del Monte del Castillo (Doctoral dissertation, Universitat de Barcelona, Departament d'Història de l'Art).
- Grinnell, G. (1923). *Blackfoot lodge tales*. New York: Scribners.
- Groenen, M. (1988). Les représentations de mains négatives dans les grottes de Gargas et de Tibiran (Hautes-Pyrénées). Approche méthodologique. *Bulletin de la Société Royale Belge d'Anthropologie et de Préhistoire*, 99, 81–113.
- Haidt, J. (2012). *The righteous mind: why good people are divided by politics and religion*. New York: Vintage.
- Hooper, A. (1980). Further information on the prehistoric representations of human hands in the cave of Gargas. *Medical History*, 24(2), 214–216.
- Howitt, A. W. (1904). *The native tribes of south-east Australia*. London: Macmillan.
- Janssens, P. A. (1957). Medical views on prehistoric representations of human hands. *Medical History*, 1(4), 318.
- Jaubert, J. (2008). L'«art» pariétal gravettien en France: éléments pour un bilan chronologique. *PALEO. Revue d'archéologie préhistorique*, 20, 439–474.
- Jung, K. E. (1883). *Der Weltteil Australien*. Leipzig: Forgotten Books.
- Kinzer Stewart, N. (1991). Mates & muchachos: unit cohesion in the Falklands/Malvinas War. New York: Brassey's.
- Kolbe, P. (1745). *Beschreibung des Vorgeburges der Guten Hoffnung und derer darauf wohnenden Hottentotten*. Frankfurt und Leipzig: Monath.
- Lagercrantz, S. (1935). Fingerverstümmelungen und ihre Ausbreitung in Afrika. *Zeitschrift für Ethnologie*, 67(4), 129–157.
- Larken, P. (1923). *Zande notes*. Khartoum: Khartoum. University Press.
- Le Marinel, G. (1893). La region du haut Ubangi. *Bulletin of the Society Royal Belgium. Geography*, 17, 5–41.
- Leroi-Gourhan, A. (1967). Les mains de Gargas: essai pour une étude d'ensemble. *Bulletin de la Société préhistorique française. Études et travaux*, 64(Fasc. 1), 107–122.
- Leroi-Gourhan, A. (1968). The evolution of Paleolithic art. *Scientific American*, 218(2), 58–73.
- Leroi-Gourhan, A., & Michelson, A. (1986). The hands of Gargas: toward a general study. *October*, 37, 19–34.
- Lewis-Williams, J. D., & Dowson, T. A. (1982). The signs of all times: entopic phenomena in Upper Palaeolithic art. *Current Anthropology*, 29, 201–245.
- Lewis-Williams, J. D. (1997). Agency, art, and altered consciousness: a motif in French (Quercy) Upper Palaeolithic parietal art. *Antiquity*, 71, 810–830.
- Lewis-Williams, J. D. (2002). *The mind in the cave*. London: Thames and Hudson.
- Lindeman, M. (1997). Ingroup bias, self-enhancement and group identification. *European Journal of Social Psychology*, 27(3), 337–355.
- Lommel, A. (1967). *Shamanism: the beginnings of art*. New York: McGraw Hill.
- López, S. R., Perelló, E. R., Giraldo, H. C., Cornélla, M. M., & Jordá Pardo, J. F. (1999). Maltravieso. El santuario extremeño de las manos. / Maltravieso. A hands sanctuary in Extremadura. *Trabajos de Prehistoria*, 56(2), 59–84.

- Lorblanchet, M. (1980). Piendre sur les parois de grottes. *Les Dossiers d'Archéologie*, 46, 33–37.
- Lundborg, G. (2014). *The hand and the brain: from Lucy's thumb to the thought-controlled robotic hand*. London: Springer.
- Macdonald, D. (1882). *Africana I*. London: Simpkin, Marshall, and Co..
- Majno, G. (1975). *The healing hand*. Cambridge: Harvard University Press.
- Mathew, J. (1899). *Eaglehawk and crow*. London: D. Nutt.
- McDonald, M. M., Navarrete, C. D., & Van Vugt, M. (2012). Evolution and the psychology of intergroup conflict: the male warrior hypothesis. *Philosophical Transactions of the Royal Society B*, 367(1589), 670–679.
- Miller, V. (2007). Skeletons, skulls, and bones of the art of Chichén Itzá. In V. Tiesler & A. Cucina (Eds.), *New perspectives on human sacrifice and ritual body treatments in ancient Maya society* (pp. 165–189). Berlin: Springer.
- Moritz, E. (1915). *Die ältesten reiseberichte über Deutsch-Südwestafrika*. Windhoek: Namibia wissenschaftliche Gesellschaft.
- Moulton, G. E. (1989). *The journals of the Lewis & Clark expedition*. Lincoln: University of Nebraska Press.
- Owsley, D., Bruwelheide, K. S., Burgess, L. E., & Billeck, W. T. (2007). Human finger and hand bone necklaces from the Plains and Great Basin. In R. J. Chacon & D. H. Dye (Eds.), *The taking and displaying of human body parts as trophies by Amerindians* (pp. 124–166). New York: Springer.
- Pfeiffer, J. (1982). *The creative explosion: an inquiry into the origins of art and religion*. New York: Harper and Row.
- Pigeaud, R., Rodet, J., Devière, T., Dufayet, C., Trelohan-Chauve, E., Bettion, J. P., & Bonic, P. (2006). Palaeolithic cave art in West France: an exceptional discovery: the Margot cave (Mayenne). *Antiquity*, 80(309), 81–92.
- Pike, A. W. G., Hoffmann, D. L., García-Diez, M., Pettitt, P., Alcolea, J., de, B. R., González Sainz, C., de las Heras, C., Lasheras, J. A., Montes, R., & Zilhão, J. (2012). U-series dating of Paleolithic art in 11 caves in Spain. *Science*, 336, 1409–1413.
- Powell, F. P. J. (1969). *Sweet medicine: the continuing role of the sacred arrows, the sun dance, and the sacred buffalo hat in northern Cheyenne history. Volume 1*. Norman: University of Oklahoma.
- Raffield, B., Greenlow, C., Price, N., & Collard, M. (2016). Ingroup identification, identity fusion and the formation of Viking war bands. *World Archaeology*, 48(1), 35–50.
- Rattray, R. S. (1927). *Religion and art in Ashanti*. Oxford: Oxford University Press.
- Rouillon, A. (2006). During the Gravettian, in the Cosquer cave (Marseille, Bouches-du-Rhône), has the man counted on his fingers? *Anthropologie*, 110(4), 500–509.
- Sahagún, F.B. (1961). *Florentine Codex: general history of the things of New Spain*. Book 10: The People, translated and annotated by A.J.O. Anderson and C.E. Dibble. Sante Fe: School of American Research.
- Sahagún, F.B. (1969). *Florentine Codex: general history of the things of New Spain*. Book 6: Rhetoric and Moral Philosophy, translated and annotated by A.J.O. Anderson and C.E. Dibble. Sante Fe: School of American Research.
- Sahly, A. (1966). *Les mains mutilées dans l'art préhistorique*. Tunis: M.T.E.
- Sax, B. (1994). Animals in religion. *Society & Animals*, 2(2), 167–174.
- Schapera, I., & Farrington, B. (1933). *The early cape Hottentots*. Cape Town: Van Riebeek Society.
- Scherzer, K. V. (1864). *Reise der österreichischen fregatte novara um die erde in den jahren 1857, 1858, 1859 I*. Wien: C. Gerold's Sohn.
- Scott, H. L. (1911). Notes on the kado or sun dance of the Kiowa. *American Anthropologist*, 13(3), 345–379.
- Smith, W., & Dale, A. (1920). *The Ila-speaking peoples of northern Rhodesia I*. London: Macmillan.
- Snow, D. (2006). Sexual dimorphism in Upper Palaeolithic hand stencils. *Antiquity*, 80, 390–404.
- Sollas, W. J. (1911). *Ancient hunters and their modern representatives*. London: Macmillan.
- Swann Jr., W. B., Gómez, A., Seyle, D. C., Morales, J., & Huici, C. (2009). Identity fusion: the interplay of personal and social identities in extreme group behavior. *Journal of Personality and Social Psychology*, 96(5), 995.
- Swann Jr., W. B., Jetten, J., Gómez, Á., Whitehouse, H., & Bastian, B. (2012). When group membership gets personal: a theory of identity fusion. *Psychological Review*, 119(3), 441.
- Thunberg, P. (1789). *Resa uti Europa, Africa, Asia, förrättad åren 1770–1779 II*. Uppsala: Edman.
- Trilles, R. P. (1932). *Les Pygmées de la foret équatoriale*. Paris: Bould and Gay.
- Utrilla, P., Baldellou, V., Bea, M., & Viñas, R. (2013). La cueva de la Fuente del Trucho (Asque-Colungo, Huesca). Una cueva mayor del arte gravetiense. In C. de las Heras, J. A. Lasheras, A. Arrizabalaga, & M. De la Rasilla (Eds.), *Pensando el Gravetiense: nuevos datos para la región cantábrica en su contexto peninsular y pirenaico* (pp. 526–537). Madrid: Monografías del Museo Nacional y Centro de Investigación de Altamira.

- Utrilla, P., Baldellou, V., Bea, M., Montes, L., & Domingo, R. (2014). La Fuente del Trucho. Occupation, style, and chronology. In S. Corchón & M. Menéndez (Eds.), *Cien años de arte rupestre paleolítico* (pp. 119–132). Salamanca: Ediciones Universidad De Salamanca.
- Valde-Nowak, P. (2003). Oblazowa Cave: New light on Gargas hands? *INORA (International Newsletter on Rock Art)*, 35, 4–6.
- Valde-Nowak, P. (2009). Oblazowa and Hlomcza: two Paleolithic sites in the north Carpathians province of southern Poland. In B. Adams & B. S. Blades (Eds.), *Lithic materials and Paleolithic societies* (pp. 196–207). Hoboken: Wiley-Blackwell.
- Valde-Nowak, P., Nadachowski, A., & Wolsan, M. (1987). Upper Palaeolithic boomerang made of a mammoth tusk in south Poland. *Nature*, 329, 436–438.
- Van den Broeck, A. (1950). *Dc dageraad mensheid*. Utrecht: Ossthoek's Uitg.
- Vanhaeren, M., & d'Errico, F. (2006). Aurignacian ethno-linguistic geography of Europe revealed by personal ornaments. *Journal of Archaeological Science*, 33(8), 1105–1128.
- Walsh, G. L. (1979). Mutilated hands or signal stencils? A consideration of irregular hand stencils from central Queensland. *Australian Archaeology*, 9, 33–41.
- Westermarck, E. (1906). The origin and development of the moral ideas. Volume 1. London: Macmillan.
- Weyer, E. M. (1932). *The Eskimos: their environment and folkways*. New Haven: Yale University Press.
- Whitehouse, H. (1995). *Inside the cult: religious innovation and transmission in Papua New Guinea*. Oxford: Oxford University Press.
- Whitehouse, H. (2002). Modes of religiosity: towards a cognitive explanation of the sociopolitical dynamics of religion. *Method & Theory in the Study of Religion*, 14(3), 293–315.
- Whitehouse, H. (2012). Ritual, cognition and evolution. In R. Sun (Ed.), *Grounding social sciences in the cognitive sciences*. Cambridge: MIT Press.
- Whitehouse, H. (2018). Dying for the group: towards a general theory of extreme self-sacrifice. *Brain and Behavioral Sciences*, <https://doi.org/10.1017/S0140525X18000249>.
- Whitehouse, H., & Lamman, J. A. (2014). The ties that bind us: ritual, fusion, and identification. *Current Anthropology*, 55(6), 674–695.
- Whitehouse, H., McQuinn, B., Buhrmester, M., & Swann, W. B. (2014). Brothers in arms: Libyan revolutionaries bond like family. *Proceedings of the National Academy of Sciences*, 111(50), 17783–17785.
- Whitley, D. S. (2009). *Cave paintings and the human spirit: the origin of creativity and belief*. New York: Prometheus.
- Wigley, F. M. (2002). Raynaud's phenomenon. *New England Journal of Medicine*, 347(13), 1001–1008.
- Wildgoose, M., Hadingham, E., & Hooper, A. (1982). The prehistoric hand pictures at Gargas: attempts at simulation. *Medical History*, 26(2), 205–207.
- World Cultures Ethnography Database (2008). Human Relations Area Files, Inc. <http://ehrafWorldCultures.yale.edu>. Accessed 20 November 2017.
- Xygalatas, D., Mitkidis, P., Fischer, R., Reddish, P., Skewes, J., Geertz, A. W., Roepstorff, A., & Bulbulia, J. (2013). Extreme rituals promote prosociality. *Psychological Science*, 24(8), 1602–1605.