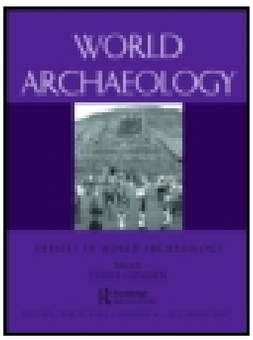

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Calculated or caring? Neanderthal healthcare in social context

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ABSTRACT

Explanations for patterns of healed trauma in Neanderthals have been a matter of debate for several decades. Despite widespread evidence for recovery from injuries or survival despite impairments, apparent evidence for *healthcare* is given limited attention. Moreover, interpretations of Neanderthals' approach to injury and suffering sometimes assume a calculated or indifferent attitude to others. Here the authors review evidence for Neanderthal healthcare, drawing on a bioarchaeology of care approach and relating healthcare to other realms of Neanderthal social life. The authors argue that Neanderthal medical treatment and healthcare was widespread and part of a social context of strong pro-social bonds which was not distinctively different from healthcare seen in later contexts. They suggest that the time has come to accept Neanderthal healthcare as a compassionate and knowledgeable response to injury and illness, and to turn to other questions, such as cultural variation or the wider significance of healthcare in an evolutionary context.

KEYWORDS

Neanderthal; archaic human; Middle Palaeolithic; healthcare; injury; impairment

Introduction – the Neanderthal healthcare debate

Discussions about Neanderthal healthcare provision have been part of a long-standing argument into how similar or how different Neanderthals were to ourselves. Interpretations of extensive evidence of survival with or following severe/disabling pathology amongst Neanderthals have been particularly influenced by shifting academic attitudes towards these archaic humans, and whether they are considered part of our evolutionary story or a 'dead end'. Scepticism surrounding healthcare provision and its motivations is common, and typically to a greater degree than that observed with similar evidence in later contexts (Spikins in press). Moreover, discussion has tended to focus on the details of pathology in isolation of its social or cultural context (Tilley 2015).

Neanderthal healthcare is a topic which, due to its apparently contentious nature, is only treated in summary and without discussion of the social behaviours surrounding the practice. Recovery from injury is often given scarce attention – the published discussion of a head injury in the St Césaire Neanderthal (Zollikofer et al. 2002), for example, focuses almost entirely on implications of violence with only passing mention of recovery from this trauma, which would have taken weeks or months of care (Tilley 2015). Discussions of Neanderthal economic practices tend not to include healthcare, or as something difficult to explain. Furthermore, the potential for

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an understanding of healthcare practices in Neanderthals to contribute to our understanding of their wider social behaviour, and of healthcare in an evolutionary context, remains to be realized.

There have been several different strands to a negative or sceptical perspective on Neanderthal healthcare. Although there are multiple cases of recovery from severe injury and survival despite notable impairment, some authors have critiqued interpretations that this evidence implies *active care* for Neanderthals. Dettwyler (1991) and Degusta (2002, 2003), for example, argue that recovery from debilitating injury may not be evidence for active healthcare as Neanderthals may have been far better at self-provisioning than we assume. Others are sceptical about whether healthcare was provided as a caring response to need or suffering, with care only provided to those who might contribute in the future (Berger and Trinkaus 1995; Wynn and Coolidge 2011). While Wynn and Coolidge (2011) note that care existed in Neanderthals, they describe their attitudes as 'callous'. Decisions about care have also been seen as difficult to explain given the costs of energy and resources. In a similar vein, Davies and Underdown (2006, 148–149) comment for example that 'the extensive intragroup care needed to sustain such infirm members is surprising unless they provided some valuable service'.

A recent contrasting perspective argues that the evidence for recovery and survival in Neanderthals is a reflection of managed health-related care in a social context of caring relationships. A number of authors take this approach to the palaeopathological evidence. Hublin, for example, refers to a 'prehistory of compassion', citing in support cases of survival despite traumatic injury (Hublin 2009). Thorpe (2016) and Doat (2016) likewise agree that evidence for recovery from injury and survival despite impairment should be accepted as evidence of care for the injured. Trinkaus and Villotte (2017) conclude that the survival of a number of Pleistocene archaic humans with pathologies indicates some level of social care. Spikins (2015, 2017), Spikins, Rutherford, and Needham (2010) and Tilley (2015) argue that widespread evidence of recovery reflects evolved caring motivations to ease suffering.

Here we discuss interpretations of evidence for recovery from injury and survival despite impairment in Neanderthals, situating this evidence within the wider social and cultural context of health-related care. We consider whether such care was typically motivated by calculated or caring relationships, and its relationship to the wider cultural context of other elements of Neanderthal lifestyles.

Scepticism of Neanderthal care

The pathologies present in one particular individual, Shanidar 1 (dated to 45,000–70,000 BP, from Shanidar Cave in Iraq) were particularly significant within initial interpretations of pathology as indicative of a wider social context of caring support for injury and impairment in Neanderthals. Shanidar 1 was aged between 35 and 50 when he died, but had suffered from a range of debilitating impairments (Crubézy and Trinkaus 1992, 411–412; Trinkaus and Zimmerman 1982, 61–62; Trinkaus 1983; Trinkaus and Villotte 2017). This included a violent blow to the face, possibly as a young adult, leaving him with blindness or only partial sight in the left eye, a withered right arm which had been fractured and healed resulting in the loss of his lower arm and hand and possible paralysis, deformities in his leg and foot leading to a painful limp and a hearing impairment. The injuries occurred long before his death and showed signs of healing, with curvature of his right leg compensating for injuries to the left (Trinkaus and Zimmerman 1982, 67–68). He also suffered advanced degenerative joint disease. Shanidar 1 would have been limited in mobility, in manual tasks and in perceptual abilities, yet survived to

an advanced age. Solecki (1971) and later Trinkaus and Shipman (1993) concluded that someone so badly injured could not have survived without daily provision of food and assistance. Moreover, Shanidar 1 was not alone in surviving trauma: Shanidar 3 similarly sustained injury likely requiring care (Trinkaus and Zimmerman 1982, 75; Trinkaus 1983) and many other Neanderthals show evidence of recovery from serious injury (Thorpe 2016; Doat 2016; Trinkaus and Villotte 2017). Given the prevalence of injury and survival across the skeletal sample of Neanderthals Trinkaus and Zimmerman commented (1982, 75) that Neanderthals 'had achieved a level of societal development in which disabled individuals were well cared for by other members of the social group'.

Scepticism about the social implications of recovery emerged as Neanderthals fell to the wayside of human ancestry following the acceptance of mitochondrial DNA evidence in the late 1980s (Cann, Stoneking, and Wilson 1987). Shanidar I's pathologies remained uncontested, but debates tended to focus in detail on questions in the interpretation of a small number of specific cases, and arguments that some Neanderthals may have been independent *despite* trauma (Dettwyler 1991; Degusta 2002). The implication was that Shanidar 1 might be an atypical case and Neanderthals were unusually tough. For example, Degusta (2002) cast doubt on interpretations of care for the Bau de l'Aubesier 11 Neanderthal who had lost nearly all her lower teeth before death, as well as suffering painful abscesses (Lebel et al. 2001). He argued against inferring care-giving from others such as in foraging and processing of specific foods on the basis that primates forage for themselves and survive despite tooth loss. Lebel's counterargument (Lebel and Trinkaus 2002) that primates with similar degrees of tooth loss do not survive remains contested (DeGusta 2003; Thorpe 2016).

Interpretations of caring motivations for support and recovery were also reconsidered in other cases. Berger and Trinkaus (1995) and Trinkaus (2012) for example highlighted an apparent lack of individuals with debilitating lower leg injuries at death as evidence for abandonment. Trinkaus (1995, 138) comments that 'abandonment of older individuals who could no longer move with the social group is likely to have been common. This would have occurred especially in cases of severe lower limb injury.'

Further findings as well as analyses of existing specimens have added to the picture of recovery/survival despite pathology or impairments in Neanderthals. However, an apparent ubiquity of trauma in this skeletal sample has also been a subject of debate. Neanderthals are often described as a population disadvantaged by unusually high levels of traumatic injury (Berger and Trinkaus 1995; Pettitt 2000; Nakahashi 2017), a feature commonly assumed to have contributed to their demise. Nakahashi even argues that exceptionally high trauma rates and thus impairments may have affected Neanderthals culturally, limiting their mobility to the extent of constraining transmission of their culture (Nakahashi 2017). Rather than cultural choice or response to social bonds, any healthcare practices can seem a desperate necessity in the face of extreme adversity.

An unbiased approach to the social interpretation of recovery from trauma in Neanderthals has tended to be elusive, particularly with ideas of modern human superiority often colouring interpretations (Villa and Roebroeks 2014). Evidence for interbreeding between archaic humans and our own species and a level of contribution of Neanderthal DNA to modern populations if anything further complicates interpretations (Green et al. 2010) bringing complex uncertainties and preconceptions about whether Neanderthals *ought* to behave in similar ways to modern humans or *ought* to behave differently. The social implications of care-giving in Neanderthals remains a contentious area.

Re-assessing interpretations of healthcare practices

Neanderthals occupied Europe and Asia from around 300,000 to 30,000 BP, and naturally their cultures (Ruebens and Wragg Sykes 2016) and subsistence practices (Weyrich et al. 2017) showed regional and chronological variation. Nonetheless, pathology seems to be common across time and space and throughout the known sample of Neanderthal fossils (Trinkaus and Zimmerman 1982; Pettitt 2000). Conditions range from the relatively minor (such as dental caries [Arnaud et al. 2017; Lebel and Trinkaus 2002, 665]) to the severe (such as breakage of major weight-bearing bones).

The impact of injuries and illnesses and the implications for care from others depends on the nature of the pathology. Many illnesses and injuries can be accommodated with self-care and self-provisioning, such as minor dental problems, minor wounds or infections such as intestinal infections. Evidence of probable self-treatment, for example, comes from a Neanderthal tooth from Cova Foradà (Spain) showing attempts to treat periodontal disease with the use of a tooth-pick (Lozano et al. 2013). Moreover, some care from others such as wound cleaning or minor short-term food provisioning through begging is in any case common in apes in general (Hart 2011).

Where pathology affects the essential activities of daily living (discussed in detail by Tilley 2015) such as when individuals are incapacitated for several days or more (as in the case of major breaks to lower limbs, severe systemic infections, inflammation with fever and so on) survival more clearly implicates extended healthcare from others, however. This help may have taken various forms, such as extended food and water provisioning, or in more severe cases the facilitation of an extended period of rest and immobilization, or perhaps even active nursing.

Pathologies sometimes lead to long-term impairments affecting typical activities and requiring long-term accommodation from the rest of the group. Even where 'disabled' individuals were not capable of the types of activity of healthy and unimpaired individuals they may nonetheless have been capable of less physically demanding tasks or those suited to their abilities, such as elements of child care, tending fires, certain tool manufacture or clothing preparation (such as preparing hides). Appropriate alternative roles may of course be culturally determined. Some evidence exists for different gender roles in Neanderthals on the basis of tooth-wear patterns for example (Estalrrich and Rosas 2015), and females may have used their teeth to chew certain materials, possibly leather, more often than did males. However, whether gender roles were clearly defined remains unclear. Some argue that a clear gender-based division of labour was not present in Neanderthals, instead being new to modern humans (Kuhn et al. 2006; Balme and Bowdler 2006), and even in modern ethnographic contexts it is clear that gender roles change according to situation, ecology and life history. In modern hunter-gatherers both males and females typically hunt (see Bird and Bird 2008) and are involved in childcare to varying extents (e.g. Hrdy 2011). Accommodations of even very severe impairments to mobility through alternative roles in modern hunter-gatherer contexts are also evident (Toda 2011).

Precise estimates as to the frequency of injuries or illnesses in Neanderthals are more elusive than they might appear. The skeletal sample is unlikely to be representative of an actual Neanderthal population due to taphonomic and cultural processes affecting deposition, such as choices affecting mortuary practices and who is given mortuary treatment. Mortality profiles from skeletal evidence are markedly different to those of either primates or hunter-gatherers, suggesting that these do not represent 'natural populations' (see Spikins et al. [2014]), a common challenge in almost all archaeological periods. However in this case the large chronological and spatial spread adds a further complication. Moreover, the fragmentary nature of

the sample, and so uncertainty about traumatic injuries in elements which are missing, is an additional factor which also makes estimation of injury rates uncertain. Nonetheless the pervasiveness of traumatic injuries across almost all skeletal material studies has contributed to a widespread acceptance that injury rates were significant (Berger and Trinkaus 1995), and to the idea it may have been rare to reach adulthood without a significant injury (Trinkaus and Zimmerman 1982; Pettitt 2000). Some even estimate that rates of individuals suffering serious traumatic injury before death might reach around 80–95% of the population (Nakahashi 2017). Though injuries must have been common such estimates are nonetheless largely speculative and perhaps influenced by preconceptions.

Certainly injury, disease and lasting impairments were a *familiar* element of Neanderthal lives, with certain Neanderthal specimens with severe yet healed injuries and illnesses being highly suggestive of care or long term accommodation (see Trinkaus and Villotte [2017]; Trinkaus and Zimmerman [1982]; Zollikofer et al. [2002]; Trinkaus, Maley, and Buzhilova [2008]; Estabrook [2009]; Hublin [2009]; Thorpe [2016]; Tilley [2015]; Cunha [2016]). Of these, Shanidar 1 is the best known, as discussed earlier; however there are several other cases which would also warrant further detailed study. La Ferrassie 1, La Ferrassie 2 and Tabun 1 have recovered from fractures to the main weight-bearing bones of their legs, and Shanidar 3 a break or sprain of the right foot leading to osteoarthritis, for example. Others have serious arm injuries such as Neanderthal 1 (Feldhofer), Krapina 180 and La Quina 5 which are likely to have affected foraging abilities. Stiffening of the vertebral column is likely to have affected mobility of Kiik-Koba and severe osteoarthritis the mobility of La Chapelle aux Saints 1. Conversely fractured crania are likely to have had an impact on St Cesaire 1, and Krapina 37, whilst Shanidar 3 had a projectile point injury to the ninth rib (speculated to be a result of interaction with modern humans [Churchill et al. 2009]). Whilst toothlessness does not necessarily imply care, Trinkaus argues that it is likely to have had more significant impact with severe inflammation as seen in Aubesier 11 and Guattari 1 (Trinkaus and Villotte 2017).

Details of such pathologies are often isolated accounts and remain to be discussed in terms of their wider social implications. Whatever the precise rate of injury however it is clear that severe injury and illness will have presented both a practical and social problem for Neanderthals. In this context healthcare is perhaps not surprising. Such care is a key element to modern hunter-gatherer social relationships. For example, Gurven et al. (2000) note that adult males amongst the Ache of Paraguay are too ill or injured to hunt and are provisioned by others around a third of the time (Gurven et al. 2000). Similarly, Sugiyama (2004) notes that amongst the Shiwiar of Ecuador, around 50% of adults have spent at least a month incapacitated though illness or injury and would not have survived without care from others. Neanderthals were faced with additional direct encounters with dangerous game due to reduced dependence on projectile weapons as well as threats from a guild of predators including large cats and hyenas which may have further added to pressures to care for the ill and injured.

We argue that the social significance of the broader pattern of healthcare has been overlooked and interpretations of a limited or calculated response to healthcare needs in Neanderthals have been influenced by preconceptions of Neanderthals as 'different' and even brutish. A detailed consideration of the evidence in its social and cultural context reveals a different picture. Bioarchaeology of care analyses (Tilley 2012; Tilley and Cameron 2014) of two Neanderthal individuals from south-west France, La Chapelle aux Saints 1 (LCS1, 50,000–60,000 BP) and La Ferrassie 1 (LF1, 43,000–45,000 BP) for example suggest both likely received extensive care in response to their experiences of pathology (Tilley 2015, 219–257).

Figure 1. The crania of the La Chapelle aux Saints Neanderthal. Credit: https://upload.wikimedia.org/wikipedia/commons/e/e0/Homo_sapiens_neanderthalensis.jpgBy Luna04 (Own work) [GFDL (http://www.gnu.org/copyleft/fdl.html), CC-BY-SA-3.0

Analysis of LCS1 (Figure 1), a male aged between 25 and 40 years old at death, revealed that he suffered from extensive tooth loss and severe, chronic periodontal disease; temporomandibular joint arthritis; severe osteoarthritis in lower cervical and upper thoracic vertebrae, and moderate to severe degeneration of lower thoracic vertebrae; osteoarthritis in both shoulder joints; a rib fracture in the mid-thoracic region; degeneration in the fifth proximal inter-phalangeal joint of the right foot; and severe degeneration and likely chronic osteomyelitis in the left hip (Tilley 2015, 228).

Care for LCS1 likely comprised 'direct support' (such as fever management, hygiene maintenance, repositioning and manipulation) during debilitating health crises associated with flare-up of infection and/or experience of severe pain, and 'accommodation' such as providing suitable food and, very probably, taking measures to ensure he was not left behind when the group moved camp. Degenerative disease in the spine and shoulders would have affected LCS1's upper body function, likely restricting performance in areas requiring upper body flexibility and strength (such as hunting and transport of items between camps). LCS1's diseased left hip, his most serious pathology, would have imposed significant pain-based and mechanical restrictions on the use of his left leg in actions requiring

weight-bearing, balance and mobility. While likely remaining ambulatory until the end, he could not have participated in hunting. Patterns of dental wear at l'Hortus (France), Spy (Belgium) and El Sidrón (Spain) support the concept of a distribution of tasks according to different abilities or roles in domestic contexts (Estalrrich and Rosas 2015). LCS1 was thus likely able to perform other tasks, such as food processing, manufacturing tools or clothing, or childcare. Underlying infection, both localized and systemic, would have taken a progressive toll on health and strength over the last 12 months of life, and his ability to contribute to the group would have decreased accordingly. He was nonetheless clearly part of the group until death, with his articulated remains subsequently carefully buried (see Rendu et al. [2014]; Dibble et al. [2015]; Rendu et al. [2016] for further debate).

Analysis of LF1, a male aged around 40–55 at death revealed evidence of minor periodontal pathology, consisting of circumscribed apical abscesses on the left mandible, with some alveolar resorption on the mandible more generally and possibly on the maxilla (taphonomic damage makes this difficult to assess); minor osteoarthritic changes to the lower spine and right elbow joint (most of the major joint surfaces are damaged and therefore not assessable); a healed fracture of the greater trochanter of the right femur; and the presence of active systemic disease at the time of death (Tilley 2015, 241).

Skeletal evidence suggests LF1 received care on at least two occasions during his life. The first involved a short-term disability – a comminuted fracture of the greater trochanter of the right femur (Tilley 2015; Trinkaus 1985) which caused compromised movement of the leg, hip and leg pain, and several weeks of limited mobility and was likely to require some support from other group members for up to two to three months. LF1's second diagnosis was more serious as periostitis on proximal and distal surfaces of upper and lower limb bones (see Figure 2) suggest LF1 was in the 'early stages of an acute form of HPO [hypertrophic pulmonary osteoarthropathy], with a duration of the disease at the time of death of 2–14 months' (Fennell and Trinkaus 1997, 994). Although HPO has clinical implications in its own right, it is a syndrome secondary to more serious underlying pathology, most commonly pulmonary or cardiac disease (Assis, Santos, and Roberts 2011). The following symptoms are almost always associated (if indirectly) with HPO: depressed immune function; loss of energy, with fatigue following minor activity; difficulties in sleeping; localized and/or generalised pain and discomfort; problems with maintaining homeostasis; loss of appetite and weight; and fevers and other physiological symptoms associated with acute (intermittent) disease crises (Amital et al. 2004). Conservatively, it can be assumed that over the last months of LF1's life his disease impinged on all facets of everyday experience. He would have become incapable of hunting or foraging, and therefore wholly dependent on others for food. Reduced energy levels would eventually make independent mobility over even short distances difficult or impossible. This same lack of energy, combined with acute and/or chronic pain and likely loss of psychological as well as physical resilience, would render more sedentary tasks increasingly difficult to accomplish. Dedicated care, including monitoring, massage, manipulation and repositioning, fever management, and hygiene maintenance, would be required during acute episodes. His complex mortuary treatment shows he was not abandoned: LF1's articulated remains indicate interment shortly after death (Figure 3).

Providing care for the most severe pathologies of both LCS1 and LF1 was undoubtedly 'costly' in economic terms and argue against any calculated 'payoff' for the energy invested in care. Tilley (2015) argues that both instances, group members – undoubtedly familiar with signs of pathology and capable of calculating odds of recovery – would at some stage have become aware their kinsmen were unlikely to be restored to health. Their care could have had no goal other than providing practical and emotional support to ease the passage of dying.

Figure 2. Examples of periosteal proliferation on LF1 (a) distal right tibia (posterior view); (b) distal left femur (posterior view) (Tilley 2015, 244).

Although not subject to detailed study of this kind, the pathologies in other Neanderthals also provide evidence for varied types of care and accommodation. Many of these individuals with severe pathology are likely to have required practices such as provisioning, maintaining body temperature, facilitation of sleep and rest, ensuring safety, maintaining or assisting mobility, maintenance of personal hygiene, maintaining posture and maintaining physiological functioning (such as by staunching wounds) (Tilley 2015, 81–82). For example, Shanidar 3 is likely to have required a period of healthcare provision and later accommodation around constraints of mobility due to their foot pathology. La Ferrassie 2, the young female adult buried in close proximity to LF1, displays evidence of a proximal fracture of the right fibula that is completely healed, although with significant distortion (Heim 1976b). In a conservative scenario, this injury would cause pain on weight-bearing and would restrict, although probably not prevent, locomotion – but it would have precluded direct participation in demanding activities, such as hunting, for around six to eight weeks (Tilley 2015, 257). These cases as well as those of notable longstanding impairments which are likely to have required accommodation also argue against a calculated approach to who might be economically 'valuable' in future.

Consideration of the wider archaeological evidence also casts doubt on interpretations of selective abandonment, such as of those with lower limb injures. Firstly, the sample size is small and it cannot be ruled out that an apparent lack of lower limb injury is the result of chance (Spikins

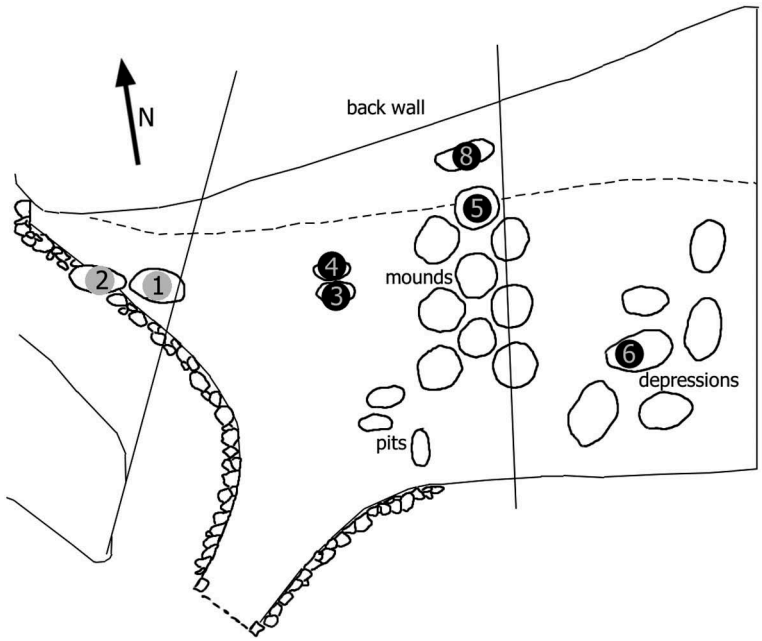

Figure 3. Plan of La Ferrassie 'cemetery' with the position of five child burials and two adult burials, LF1 is marked '1' (drawing by Gail Hitchens, redrawn from Heim 1982).

2015). Secondly, whilst no individual within the known Neanderthal skeletal sample was demonstrably immobile from a lower limb injury *at death*, there are several individuals who suffered from severely restricted mobility and possibly complete immobilization for at least some period of time. A significant limitation in mobility is likely to have occurred over a long timeframe as a consequence of injury or disease in the case of La Ferrassie 1 (probably on two occasions), La Ferrassie 2, Tabun 1, La Chapelle-aux-Saints 1 and Shanidar 1. That these individuals were *later* mobile following a severe injury or disease does not imply a *lack* of care for severe lower leg injuries when they occurred. Indeed, later mobility following such an injury could alternatively imply particularly successful care and recovery. Lastly, preservation bias is likely to have affected interpretations of selective abandonment of individuals incapacitated by lower limb injuries. Most well preserved skeletal material comes from rock-shelter sites, which like Shanidar itself (Figure 4) are difficult to access even for those without lower limb impairments. In modern hunter-gatherers such as the Baka, individuals with severely impaired lower limb mobility undertake particular tasks or forage in accessible locations (Toda 2011; Toda 2013). Neanderthals already needed to accommodate slow mobility in young children (Shaw et al. 2016). It is far more probable that the relative absence of those with immobilizing lower leg injury in the archaeological record is a result of these individuals not joining those using difficult to access rockshelters and caves than their selective abandonment.

A closer consideration also casts doubt on the concept of unusually harsh lifestyles in Neanderthals. Whilst injuries *are* common, the occurrence of trauma is unusual within the wider context of similar hominins, both earlier archaics and early modern humans. Like other archaic and earlier humans Neanderthals lived physically demanding lives which involved high

Figure 4. Shanidar Cave, like most cave and rockshelter sites where near complete Neanderthal skeletons have been recovered, is a difficult to access location even for the healthy and fully able. Individuals with severe and entirely immobilizing leg injury are likely to have stayed in more accessible locations rather than their absence in the record implying abandonment.Credit: By JosephV at the English language Wikipedia, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=1445491

mobility (Shaw and Stock 2013). Indeed, Neanderthals adapted successfully to live in rugged mountainous environments, as evidenced by over 30,000 years of occupation at Esquilleu cave, for example (Yravedra and Gómez Castanedo 2014). They also dealt with encounters with often dangerous prey as well as predators (Camarós et al. 2015). There is no notable difference in adult mortality between Neanderthals and early modern humans (Trinkaus 2011), with serious pathological conditions common across archaic and early human populations (Wu et al. 2011). Estabrook comments: 'The idea that Neanderthals are more frequently traumatized than modern populations is based on little evidence, but it has been well received because it dovetails nicely with this paradigm [of Neanderthals as "dumb"]' (2009, 337). There is no reason to assume the healthcare practices in Neanderthals were driven by the necessity of a life that was *unusually harsh* rather than being a caring social and cultural response to illness, injury and vulnerability.

As well as supporting an argument for an 'uncalculating' approach to healthcare, the archaeological evidence also supports the notion that Neanderthals had a medical competence, a finding consistent with a pattern of high rates of healing and low levels of infection (Trinkaus and Zimmerman 1982, 75). The presence of interproximal grooves in teeth supports the use of toothpicks to reduce irritation in inflamed gums in cases of periodontal disease, for example (Lebel and Trinkaus 2002, 665; Lebel et al. 2001, 11,100; Lozano et al. 2013). The analysis of dental calculus has evidenced the presence of bitter tasting plants with minimal nutritional value, suggesting possible medicinal consumption (Hardy et al. 2012; Hardy, Buckley, and Huffman 2013). For example, poplar found in dental calculus of a Neanderthal from El Sidrón with a dental abscess also demonstrated the likely use of painkillers in the form of salicylic acid, the active ingredient in aspirin (Weyrich

et al. 2017). More speculatively, the mastery of tar production (Grünberg 2002; Boëda et al. 2008; Mazza et al. 2006) may suggest an awareness of the health benefits in chewing this substance, both as an antiseptic and in maintaining the teeth (Aveling and Heron 1999). Similarly, the use of ochre is now well demonstrated (Zilhão et al. 2010) and this substance can be used as an antiseptic when applied to wounds (Velo 1984).

In short, a closer consideration of trauma, recovery and impairment and their social implications shows no good evidence to support an interpretation of Neanderthal healthcare as unusually callous or calculating. Instead there is good evidence for individuals with injuries and impairments being supported and accommodated, often with considerable effort, skill and knowledge.

A broader social and cultural perspective on healthcare practices in Neanderthals

A broader social and cultural perspective can yield significant insights into the likely context of Neanderthal healthcare. From a large-scale evolutionary perspective substantial investments in healthcare are not surprising. Strong pro-social bonds and care for those who are vulnerable are recognized as key elements contributing to human success and pre-date Neanderthal populations. In effect, strong bonds provide a social buffer against individual shortfalls in resources, health or capacity to raise young and provide a distinct evolutionary advantage (Crittenden and Marlowe 2013; Hare 2017). Apparently 'costly' cases are a necessary element of how pro-social bonds 'work' through trust to reduce individual risk (Manapat, Nowak, and Rand 2013; Spikins 2015; Spikins in press; Jordan et al. 2016).

Healthcare, food sharing and care of vulnerable children are likely to be intimately related, and to have emerged early in human evolution. Food sharing and risky hunting emerged at least 1.3 million years ago (Domínguez-Rodrigo et al. 2014) and its emergence is associated with shared childcare and increasing group investments in vulnerable young (Hrdy 2011), as well as likely egalitarianism (Whiten and Erdal 2012). A *Homo ergaster* from Olduvai dating to around 1.6 million years ago for example was provisioned and protected from predators for several weeks despite severe pain and loss of consciousness arising from hypervitaminosis A (Walker, Zimmerman, and Leakey 1982; Spikins, Rutherford, and Needham 2010). Other cases of possible care at this time also exist, such as limited mobility due to juvenile disc herniation in WT1500 (Haeusler, Schiess, and Boeni 2013), though in cases of severe tooth loss, such as the Dmanisi hominin (Lordkipanidze et al. 2005) it has been more difficult to make an interpretation in terms of care (Gilmore and Weaver 2016). By around 400,000 years ago, there is good evidence for support for injury and impairment from the site of Sima de los Huesos in northern Spain. Here a child with craniosynostosis was supported for several years (Gracia et al. 2009), as well as an individual with deafness and an elderly man who would have found walking extremely difficult and painful due to a damaged hip (Bonmatí et al. 2010, 2011). This earlier context of care within highly collaborative early humans helps to illustrate that primate comparisons fail to be relevant to Neanderthals – unlike other primates hominins forage cooperatively, care for offspring who are vulnerable both at birth and for an extended period of infancy, and accommodate the risks imposed by both hunting large game as well as defence from predators. Bonmatí et al. (2011, 145) argue the treatment of those with impairments in all other species of human are likely to have been much closer to that seen in our own species than that seen in primates.

In modern hunting and gathering societies healthcare is effectively inseparable from sharing in its many different forms (Spikins in press) and healthcare cannot be fully understood outside of its social and cultural context. Though healthcare has received less attention, it is as essential to

group survival as other behaviours such as food sharing or childcare (Sugiyama 2004). In such contexts, everyone needs support at some time, which can take many different forms. Investments in others' wellbeing and motivations to help those we care about may not 'pay off' in an instance, but do so over evolutionary timescales. By demonstrating a willingness to take costs on others' behalves individuals become more trusted themselves, ensuring willing help when they need it. Given the significance of trust to social relationships in close groups any injured group member allows others to display their generosity and willingness to help rather than simply being an economic cost (Nesse 2009). As noted above, amongst the Ache of Paraguay, for example, even the young adult males, the healthiest sector of society, are unable to hunt on around one day in every three due to illness and injury (Gurven et al. 2000). Their food provisioning at these times is impossible to separate from care for injury or illness, and is simply part of how communities work together to accommodate vulnerabilities. Generosity to others, in terms of time and resources, is essential to survival and social life. It is the most trusted and generous hunters who are most willingly looked after when elderly, for example (Gurven et al. 2000). Likewise, even those who have impairments which severely affect mobility are accommodated and perform alternative roles and tasks amongst the Baka (Toda 2011; Toda 2013). Calculating someone's functional or economic value would be seen as untrustworthy, much as it is in modern close relationships (Nesse 2001; Manapat, Nowak, and Rand 2013; Spikins in press).

For Neanderthals food sharing, hunting, childcare and healthcare are likely to have been inseparable elements of social relationships based on strong social bonds and willingness to take risks and give up time or resources to improve others' survival. The relationships between these different realms of life in which shared investments in the wellbeing of others were essential are rarely explored, but it is not difficult to see that *comparable* social and emotional investments in others' wellbeing are made in each of these realms, with these investments equally essential to how collaboration works (Smith et al. 2017). Risking injury in hunting, spending time in caring for others' infants, giving away food resources, accommodating those with impairments or caring for the ill or injured are all 'costs' on behalf of others which are essential to the survival of mobile hunter-gatherer groups. The same motivations to 'look out for' and 'look after' each other structures these intimately related realms.

The ecology of Neanderthals may even have made such investments in others' wellbeing particularly critical to survival. A combination of typically arid mid-latitude ecosystems alongside Neanderthal robust physique and high energy requirements (Churchill 2014) led to a dependence on collaborative hunting (and sharing) of large game in most regions (Smith 2015). Hunting of such game without the benefit of long-range projectiles was notably dangerous, with some individuals inevitably risking serious injury on behalf of others. At sites such as La Cotte de St Brelade (Jersey), Neanderthal reliance on investments in others' wellbeing to survive are clearly apparent. In Layer 5, an MNI of 11 mammoths and two woolly rhinoceros were recovered, interpreted as a result of planned hunting and subsequent butchery (Scott 1980; Scott et al. 2015; Shaw et al. 2016). Planned hunting of dangerous animals such as mammoth and woolly rhino depended on hunters being willing to risk injury or death and it is difficult to imagine this being possible without both strong bonds and a confidence that care for injury would be forthcoming. Even hunting of other less dangerous game, such as ibex, carried risks of injury (Yravedra-Sainz de los Terreros and Cobo-Sánchez 2015). Foraging or even surviving alone were unlikely to be options even for the most healthy and able. Middle Palaeolithic environments in Europe may well have been one of the contexts in which buffering risks through healthcare may have been most essential to survival.

Moreover, the structure of Neanderthal social groups may even have led to more intense internal social bonds than might be typical of modern hunter-gatherers. Whilst it is challenging to reconstruct demography in the Palaeolithic (see French 2016), El Sidrón cave in northern Spain does provide a unique insight into the composition of Neanderthal groups. Dating to 49,000 BP, the site has produced the remains of 13 individuals, including seven adults, three adolescents, two juveniles and one infant (Rosas et al. 2013). Genetic analysis (Lalueza-Fox et al. 2011) and the occurrence of rare congenital conditions (Dean et al. 2013; Ríos et al. 2015) all support the case for a closely related, contemporaneous social group. The relatively small size of the El Sidrón 'family' is also consistent with broader archaeological evidence (Spikins, Hitchens, and Needham 2017). The potential intimacy of these groups is further emphasized when viewed at a regional scale, where patterns of Neanderthal mobility gleaned from the movement of raw materials consistently suggest a local focus (e.g. Burke 2006; Conard, Bolus, and Münzel 2012; Henry 2012). Social and emotional ties are likely to have been focused within the group throughout their lifetime (Spikins et al. 2014, 124), with most members of groups closely related (Spikins, Hitchens, and Needham 2017).

Other evidence supports the concept that care for the vulnerable was a key element of Neanderthal social life, as reflected in the treatment of the young. The portrayal of particularly short and stressful lives for children has become increasingly insupportable, with evidence arguing against interpretations of rapid development (Rosas et al. 2017), frequent trauma (Estabrook 2009) and excessive dietary stress (Dobrovolskaya 2014). Episodes of stress are not exceptional in human evolution for example, as reflected in other hominins which show evidence of mortality due to nutritional deficiency (Domínguez-Rodrigo et al. 2012). The treatment of Neanderthal children in death also offers a picture of considerable care, far from previous views of infants simply being 'dumped' (e.g. Pettitt 2000, 359). The 10-month-old infant recovered from Amud Cave in Israel for example, was found laid on its right side and buried within a small niche in the cave wall, with a red deer maxilla on its pelvis (Hovers et al. 1995). Several of the five children buried at La Ferrassie in France were also laid into depressions, including an infant less than one year old, possibly associated with three flint scrapers (Heim 1976a). Whilst it is difficult to be confident about any 'grave goods' which are not clearly symbolic in nature, this is in addition to the two infants at Dederiyeh cave, one of which had a small flint placed upon its chest and a stone slab possibly laid under its head (Akazawa and Muhesen 2002).

Neanderthal burial practices also clearly demonstrate a care for the body *after* death. Pettitt (2011) notes the presence of complex and diverse mortuary practice, including the caching of remains, secondary processing such as defleshing and cannibalism, and at least 30 intentional burials, some of which possibly included grave goods. Pettitt (2011, 136–137) suggests the body may have been important in Neanderthal society and a locus through which social relationships were negotiated. It is perhaps unsurprising then that patterns of care evident through cases of trauma are extended into further complex treatments of the body at death. Given this linkage between the living and dead, it is likely that mortuary practice extended elements of the same socio-emotional framework that engendered care for the living into death.

The wider cultural context of Neanderthal social lives casts healthcare not as an anomaly requiring explanation, but rather as a reasonable expectation given their interdependence, widespread investments in others' wellbeing and a caring, knowledgeable and organized approach to survival.

Conclusions

Neanderthal healthcare has been treated with either scepticism or with assumptions that despite evidence for widespread recovery from illness and injury such care was at best carried out with a callous and calculating attitude. Here we argue that Neanderthal care for illness and injury, and support of impairments, was widespread, and motivated by similar close social bonds to those in our own species. A social perspective on Neanderthal healthcare contributes to our understanding of Neanderthals as living in groups with deep investments in each other's wellbeing and with a competence to apply knowledgeable approaches to preserve health.

Neanderthal healthcare is significant not in its *distinctiveness* compared to that of biologically modern humans in later periods but in its *similarity*. Neanderthals appear to share a common human emotional and practical response to vulnerability and suffering of those that they were close to, attitudes also reflected in care of children, attitudes to the body at death through mortuary practice. The very similarity of Neanderthal healthcare to that of later periods has important implications however – that organized, knowledgeable and caring healthcare is not unique to our species but rather has a long evolutionary history. Healthcare provisioning is likely to have been significant in reducing mortality and ameliorating risks in resource acquisition far into the distant past.

We argue that it is time to bring Neanderthal healthcare 'in from the cold' and discuss its broader implications within our understanding of Neanderthal social relationships and with within wider discussions of healthcare in the human past.

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