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Time for the Middle to Upper Paleolithic transition in Europe

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ABSTRACT

The Middle to Upper Paleolithic transition is a key period of change in the prehistory of the Old World and one of the most studied issues in paleoanthropology, as the nature of the transition(s) is still, after at least a century of archaeological research, largely unknown. Many of the issues at stake in the transition relate to the problem of building a reliable chronology for this period, which is at the limits of the radiocarbon method. The papers in this volume show that much progress has been made in our chronological knowledge of significant aspects of the transition, such as the age of the most recent Neandertal fossils and the earliest modern human remains in Europe, and the inferred overlap between the Châtelperronian and the Aurignacian. At the same time, the volume also shows where the chronological database for the period 40 to 30 ka ^{14}C BP is flawed and that significant contextual and methodological problems have been underestimated in a number of studies of the biological and cultural changes during this crucial period. Chronology is employed by paleoanthropologists to relate the record of the Middle to Upper Paleolithic transition to major biological and cultural developments. This paper takes a broader paleoanthropological perspective and attempts to evaluate and, to some degree, synthesize the main results of these proceedings, while also presenting a brief discussion of the Middle and Upper Paleolithic archaeological and fossil records, and possible explanations for the differences between the two, focusing on the role of differences in the ecology of Neandertals and early European modern humans.

Introduction

When the world was thought to have been created at around 4004 BC, insertion of the Ussherian chronology in margins of English editions of the Old Testament provided readers with a useful scaffold to locate its historical narrative in time at one glance. In our post-Darwin world alike, scientists studying past processes depend on chronological scaffolds. This volume deals with the construction of a chronological framework for one of the most widely debated issues in paleoanthropology, the Middle to Upper Paleolithic transition, a process of change that occurred in Western Eurasia between approximately 40,000 and 30,000 ^{14}C BP and led to the replacement of an "archaic" population (Neandertals) with a basically Middle Paleolithic technology by a population of modern humans (*Homo sapiens*) with an Upper Paleolithic technology (I am using the word "transition" here in a neutral sense, without implying a specific mode of change for the anatomical and behavioral changes in this time period). The study of this transition integrates data and scientists from a wide range of disciplines, including archaeologists, physical anthropologists, dating specialists, and geneticists. Transition studies attract the attention of specialists as well as the general public, with the latter being mainly interested in the "soap opera" parts of the transition, which are understandably of more interest to the highly social primate we call "modern human" than are the intricacies of the NotCAL curves (see below).

In recent years we have seen scientific papers in high ranking journals with detailed figures showing the inferred progress of modern humans and their new technology across an "archaic" Europe, almost like reports from a battlefield, of the "AMH at Bacho Kiro, Neandertals still hold on in Gibraltar"-type. Such maps (e.g., Mellars, 2006, his Fig. 4) form a good illustration of the two main problems with some of the recent studies of the transition: a somewhat cavalier attitude to dating issues, and a tendency to equate archaeological assemblages with populations or species. Firstly, the "Aurignacian" is routinely equated with "modern humans," despite the lack of skeletal remains associated with the early Aurignacian and the fact that the early Aurignacian remains poorly defined. And secondly, as will be discussed below, attempts at using the radiocarbon record for a calibration-like fine tuning of the chronology of the transition have been severely criticized by members of the radiocarbon dating community (e.g., Turney et al., 2006). As stressed in more general terms by Pettitt (2008), in the transition debate, artifact taxonomic units established in the first half of the twentieth century that generally form the basic units of analysis in this discussion are too often taken as proxies for human populations and float very broadly in Pleistocene time by the imprecise dating methods currently available. Such studies also

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often overlook the simple fact that Neandertals and modern humans were very similar in many important aspects of their biology as well as of their behavior; this should not surprise us given the fact that according to paleogenetic as well as fossil evidence they shared a common ancestor in the first half of the Middle Pleistocene, roughly between 700,000 to 400,000 years ago (Krings et al., 1997; Mellars, 2004; Bischoff et al., 2007).

In fact, the Middle to Upper Paleolithic transition is comprised of several different transitions, including an archaeological and a biological one, and in principle these should be studied as separate subjects. To a significant extent, the transition also represents a transition of research communities and traditions. Archaeologists working on the Lower and Middle Paleolithic generally work with coarse-grained time units, necessary because of the limits of the dating methods at their disposal and because of the clear palimpsest character of the archaeological record. Archaeologists studying the Upper Paleolithic tend to think in finer time units, which is to some degree possible through the successful application of radiocarbon dating for the major part of the Upper Paleolithic. For Lower and Middle Paleolithic archaeologists, stratigraphy, geological context, taphonomic bias, and subsistence are the stocks of trade, whereas for later periods, art, symbolism, identity-conscious social units, and even cosmology also feature prominently in scientific research agendas. In studies of the transition, these different research traditions meet, adding to the complexity of this multifaceted field.

Chronology is a key variable in this debate, and its relevance cannot be overestimated. This volume's explicit and detailed focus on the establishment of a solid chronology for this time period, where the commonly-used dating method, radiocarbon, has serious limitations, is a very welcome one. A second important aspect of the volume lies in the fact that many of its authors are archaeologists. And thirdly, in line with the long tradition of studies dealing with the "Human Revolution" of the Middle to Upper Paleolithic transition, this volume deals also almost exclusively with European data with two notable exceptions (Adler et al., 2008; Pinhasi et al., 2008). Beyond doubt, such a Eurocentric view of the transition tends to ignore data from other regions and time periods relevant for the wider context of transition issues (see below). In this case, the emphasis on Europe and dating issues makes for a generally tight and focused volume that will considerably improve our "understanding" of the chronological dimensions of the prominent boundary at stake here in this part of the Old World.

For paleoanthropologists chronology is "but" a means to an end, an important tool employed in our attempts to relate the record of the Middle to Upper Paleolithic transition to major biological and cultural developments, and it is to these that I will turn first in order to 'contextualize' the need for solid chronological scaffolds. I will start with a brief survey of the record on both sides of the boundary followed by a brief discussion of how these differences can be explained. In chronological terms, this is a very coarse-grained survey, taking stock of the record at two loosely defined points in time, for which basically no high resolution age estimates are necessary. Constructing a fine-grained chronology for the odd 10,000 ^{14}C years in between is not unproblematic, as the papers in this volume clearly show. I will highlight the key problematic areas distilled from the contributions to this volume in order to show where most progress can be made in future research. While pointing out the key problems, this volume also shows how much progress has been made in obtaining clear-cut chronological patterns in very important domains of transition studies. I will provide a short overview of what I consider to be the most important chronological accomplishments of these proceedings, and will conclude with a short discussion of the late Neandertal world and the archaeological time units within which we address the Middle to Upper Paleolithic transition.

A coarse-grained perspective

Neandertals and modern humans were very similar in many aspects of their biology and behavior, but we also know that differences exist between the records of the late Middle Paleolithic time range, for which we only have Neandertal remains in Europe, and the record of around 30,000 ^{14}C BP, the later part of the Aurignacian and the beginning of the Gravettian, which is associated with modern human skeletal remains (see below). Some of these differences are summarized in Table 1.

The space limitations do not allow a more nuanced consideration of the subject at hand, but the general trend is clear: compared to Middle Paleolithic Neandertals, *some* European Upper Paleolithic modern humans (Churchill et al., 2000) had a broader diet, invested more in various technological domains, including projectile technology and on-site structures, expanded their geographic range, and produced various forms of art. On the latter score, the Chauvet Cave data suggest that figurative parietal art also appeared within the later Aurignacian, in line with the presence of colored limestone fragments uncovered from Aurignacian horizons in various sites (Jöris and Street, 2008, contra Pettitt, 2008).

The differences between these two records are usually interpreted in cognitive terms, with Neandertals being on the cognitively challenged, "non-linguistic," "non-symbolic" side of the equation. Seen as technologically and culturally inferior to modern humans, their disappearance has often been interpreted as "… a straightforward case of direct competition for space and resources between the two populations, in which the demonstrably more complex technology and apparently more complex organization of the anatomically modern populations would have given them a strong competitive advantage over the Neanderthals" (Mellars, 2004: 464). However, alternative interpretations have been put forward in recent years. For instance, Relethford (2001, 2008) suggests that genetic data used to address the evolutionary relationship between archaic (including Neandertals) and modern humans may be telling us more about the demographic, rather than phylogenetic, history of our species: given the larger human population size in Africa, over time Neandertals may have become extinct through "swamping" genetically of larger populations of modern humans moving into Europe (Relethford, 2001, 2008).

Table 1
Biological, behavioral, and cultural comparisons between the late Middle and Upper Paleolithic in Europe[a]

Late Middle Paleolithic (ca. 50 ka ^{14}C BP)	Upper Paleolithic (30 ka ^{14}C BP)
Neandertals	Modern humans
Robust, energetically costly bodies [1,2]	Gracile, energetically less costly bodies [1,3]
Efficient hunters, relatively narrow focus on large mammals [3,4,5]	Efficient hunters, with somewhat broader prey choice, including smaller game and fish[3,4,5]
Stable isotopes: top carnivores with heavy emphasis on larger mammals[6]	Stable isotopes: comparable to Neandertal signal, with some individuals consuming significant amounts of fish[6]
Distribution south of 55 degrees North[7]	Northward range expansion[7]
Lithic technology, including laminar reduction, discoidal and Levallois[7,8]	Variety of lithic reduction strategies, including bladelet production[7,9]
Thrusting spears, little investment in projectile technology[9]	Well-developed projectile technology in bone, antler, ivory, and stone[9,10]
Very limited investment in on-site structures[9]	Structured hearths common[9]
Burials, without grave goods[8]	Elaborate burials[8]
Use of pigments[11]	Figurative portable and parietal art, personal ornaments[10]

[a] References. 1 - Churchill, 2006; 2 - Sorensen and Leonard, 2001; 3 - MacDonald et al., in press; 4 - Hockett and Haws, 2005; 5 - Kuhn and Stiner, 2006; 6 - Richards, 2007; 7 - Roebroeks and Verpoorte, in press; 8 - Gamble and Roebroeks, 1999; 9 - Verpoorte, 2006; 10 - Mellars, 2004; 11 - Soressi and d'Errico, 2007.

Under his model, the Neandertal gene pool could have been assimilated rather than replaced, even in the *absence* of the usually envisaged major behavioral, cultural, and/or biological differences between the two hominin taxa. Other explanations have stressed the importance of ecological differences between the two lineages for explaining the differences in their archaeological records and/or the demise of the Neandertals. Hockett and Haws (2005), for instance, have explored the extinction of European Neandertals from a demographic perspective with a focus on how dietary choices affect human fertility and mortality (see below).

Verpoorte (2006) focused on one of the most fundamental characteristics of any animal: its energetic requirements. Neandertal energetic requirements were considerably higher than those of Upper Paleolithic modern humans. These differences were the result of a range of factors, including Neandertals' larger body mass, high locomotion costs, and high activity levels (see for example Sorensen and Leonard, 2001; Steegmann et al., 2002; Aiello and Wheeler, 2003; Churchill, 2006; MacDonald et al., in press). As a result, their strategies regarding mobility, inhabiting northern environments, and innovation of technologies were selected under energetic constraints that were different from those of modern humans (Verpoorte, 2006; Roebroeks and Verpoorte, in press). Verpoorte (2006) demonstrated the importance of a higher energy budget for hominin spatial behavior by a simple central place foraging model, derived from Kelly (1995). The effects of Neandertal energetics involve two aspects of the central place foraging model: higher daily energetic requirements, and higher travel costs (due to body mass and lower limb length [Weaver and Steudel-Numbers, 2005]). The need to provide higher amounts of energy means that the effective foraging radius—the distance at which a forager can forage from camp at an energetic gain—becomes smaller. The increased travel costs lead to a steeper decline of net return rates with foraging distance, and hence to a shorter effective foraging radius. The effect of a smaller foraging radius is that campsites will be moved more frequently and over shorter distances. Moving more frequently implies that the use-life of a campsite is shorter and camps more ephemeral. With shorter anticipated use-life, one should expect less investment in site features, such as dwellings and other structures. Given the short periods of time Neandertals were present at "camp sites," their lack of investment in "site furniture" we so clearly see in the archaeological record becomes understandable. The absence of dwellings and other structures in the Middle Paleolithic record does not so much reflect a lack of organizational skills, planning depth, or "fully modern language," but rather an optimal solution to mobility under the high energetic constraints that Neandertals had to cope with. This is but one example of the implications of higher energetic needs, which would also have influenced investments in technological innovations (i.e., the lack thereof compared to the increase in rate of technological change in the European Upper Paleolithic) as well as the limits of the Neandertal range (see Verpoorte, 2006; Roebroeks and Verpoorte, in press).

A focus on the ecology of Middle and Upper Paleolithic hunter-gatherers not only yields alternatives to the standard cognitive explanations for the transition (see also: Kuhn and Stiner, 2006; O'Connell, 2006), it can also help us to explain differences *within* the records of modern humans. After all, the archaeological record contains sufficient data to infer that fully modern humans created very diverse archaeological signatures, and that these signatures sometimes resemble what Neandertals left behind in Western Eurasian landscapes, as, for example, presented in detail by Holdaway and Cosgrove (1997) for the Tasmanian archaeological record. Speth's (2004) comparison of the North American Paleo-Indian and early Archaic record to the Eurasian Middle Paleolithic concludes that the changes in the Late Archaic can be seen as a North American counterpart to the Eurasian Upper Paleolithic "revolution." In a similar way, Brumm and Moore (2005) have discussed the Australian archaeological record, where the mid- to late-Holocene exhibits a pattern of changes including increased diet breadth and intensification of marine and plant food resource extraction, the emergence of very extensive trading networks, and changes in artistic representation, religious systems, and burial practices. In both cases, demographic changes and greater population densities are considered to be behind this "symbolic revolution" (Brumm and Moore, 2005:167–168), as has been suggested for phenomena within the European Upper Paleolithic (e.g., Barton and Clark, 1994). Higher population densities generally imply more competition for resources, leading to a greater reliance on foods that are costlier to exploit, and so favor the development of "complex" technologies designed to handle these costly resources more efficiently (Hawkes and O'Connell, 1992; O'Connell, 2006). Complex technologies provide just one example of how an ecological approach can explain such changes, and there might be other applications, as suggested by Verpoorte (2006).

As most hunter-gatherers heavily focused on terrestrial mammals, Neandertals were probably present in low population densities (Wobst, 1976; Pettitt, 1999). After a long existence in Pleistocene Eurasia, they disappear from the record roughly around the time when modern humans start to expand into parts of the Neandertal range. But what do we mean by "roughly around the time?" While the demise of the Neandertals appears to coincide chronologically with the arrival of modern humans in Europe, this does not necessarily imply that these two phenomena are causally related. It is in the domain of these questions that the chronology of the transition takes prime importance. After all, in the cases from Australia and America, the transitions described occurred within the same species. But in the case of the transition under consideration here, biological and cultural processes of change (partially) coincided, creating questions concerning the sequence in which various cultural and biological phenomena occurred, as in the famous case of the Châtelperronian. The "Upper Paleolithic" elements in this complex have been interpreted in various ways, for instance as a result of Neandertal 'autonomous' indigenous developments towards "modernity" (e.g., Zilhão and d'Errico, 1999), or as the consequence of the transfer of ideas between Neandertals and intrusive modern humans (Mellars, 2005).

In the scheme discussed above, the focus was on major differences evident at different time periods. A number of key questions about the transition, including hypotheses about the role of humans in Neandertal extinction and the links between biological and cultural processes require a more precise handle on chronology.

Chronology: a perennial problem

Many of the issues in the transition debate somehow relate to the key problem of building a reliable chronology for the time range at stake, and radiocarbon is the key method here. As discussed by Blockley et al. (2008), the chronological problems with radiocarbon dating in this period can be broken down into the following areas of uncertainty: 1) the ability to successfully remove contamination from individual radiocarbon samples, 2) the problems of taphonomic processes within sites, distorting the stratigraphic relationship between dates, 3) the discrepancies between radiocarbon years and calendar time, and 4) the rarity, in many contexts, of other reliable dating information with which to evaluate radiocarbon chronologies.

1. Significant progress has been made in the pretreatment of samples for radiocarbon dating. The importance of removing contamination from radiocarbon samples cannot be overestimated in this time range (i.e., >5 half-lives). This is well-illustrated by a recent attempt at dating the Okladnikov Neandertal: a subadult

humerus fragment was dated in three laboratories, yielding substantially different ^{14}C dates ranging from 29,990 ± 550 ^{14}C BP (KIA-27011) to 37,800 ± 450 ^{14}C BP (OxA-15481) for the same bone (Krause et al., 2007: supplementary material). Jacobi and Higham's (2008) redating of the (already redated) Red Lady of Paviland suggests that removal of contamination has led to the Lady aging gracefully, from a ^{14}C age of around 18 ka ^{14}C BP in the late 1960s to 25–26 ka ^{14}C BP in the late 1990s (Aldhouse-Green and Pettitt, 1998) and now redated to 28–29 ka ^{14}C BP (Jacobi and Higham, 2008). Higham was also involved in the re-dating of Vindija G1 Neandertal remains (see below), where application of the ultrafiltration method led to higher ages (Higham et al., 2006). The latest results from the application of ultrafiltration methods show "…that the ages originally reported from archaeological contexts should be considered as only minimum estimates" (Turney et al., 2006). On the other hand, it is interesting to note here that the Pestera cu Oase dates referred to below were obtained independently by two laboratories and these yielded comparable dates, one obtained with ultrafiltration (Oxford), the other without (Groningen; Trinkaus et al., 2003).

2. Post-depositional vertical migration of archaeological objects in stratified sites is a well-known phenomenon, which archaeologists must—and generally do—take into account when interpreting sites or when sampling for dating purposes. In more general terms, site formation processes need to be studied and understood in order to prevent erroneous interpretations like those forwarded in the interstratification debate (see below) or in the context of recent claims for late Neandertal survival in Gibraltar (Zilhão and Pettitt, 2006 contra Finlayson et al., 2006). The re-dating of the Stetten hominin remains, excavated from what where believed to be "Aurignacian" levels, to the Neolithic (see below; Conard et al., 2004) provides one of the most dramatic illustrations of the relevance of the study of site formation processes and the careful selection of dating samples in the field.

3. It is well-known that as a result of variation in past atmospheric $^{14}C/^{12}C$ ratios, ages obtained by radiocarbon dating cannot be directly compared with age estimates obtained by other dating methods. Hence, radiocarbon ages need independent and absolute age calibration, which is now possible up to 26 ka cal BP, by means of the internationally-recommended radiocarbon curve IntCal04 (Reimer et al., 2004). Beyond that date, data sets deviate by up to several millennia from each other. The implications of these differences are important: "For example, the famous Chauvet Cave in France dates to approximately 31,000 BP, which would "calibrate" to around 31,000 BC using a comparison curve formed from the data from Lake Suigetsu, around 38,000 BC using the Bahamian stalagmite data, and around 36,000 BC using the Cariaco Basin data" (van der Plicht et al., 2004:1236). Given these discrepancies, large data sets have been published for comparative purposes, not for the sake of calibration, as underlined by the name, NotCal04 (van der Plicht et al., 2004). The debate over the (im)possibilities of calibrating in the time range at stake here was recently highlighted by Mellars' prominent use of the NotCal04 data to calibrate radiocarbon dates beyond 26 ka cal BP (Mellars, 2006). In the ensuing debate, members of the radiocarbon community again stressed the discrepancies between the various pre-26,000 cal BP data sets and urged archaeologists to be extremely careful with "calibrating" their radiocarbon dates to pre-26,000 cal BP radiocarbon records until an accepted calibration curve has been developed (e.g., Turney et al., 2006).

But time is the stock and trade of archaeologists, and many cannot just sit on their flints and bones and let time go by without trying to get a better grip on it (Van Andel, 2005). In fact, many contributors to this volume write as if calibration can be applied to radiocarbon dates from this period. The CalPal program is widely used and a new version is published in this volume, referenced to the U/Th-based Greenland$_{Hulu}$ timescale (Weninger and Jöris, 2008). Blockley et al. (2008) explicitly make the point that although there are now calibration data available for this period (most already published in NotCal04), it is still not certain how reliable all the data are as a time series calibration curve. "Calibration in full is not yet possible" in this time range, they conclude. Weninger and Jöris (2008) would probably agree, but would argue that usage of the CalPal program creates "dates" that enable users to situate their dated objects more precisely in calendar years time than straightforward usage of the raw carbon dates would do, regardless of whether the age conversion can be called "calibration" or not. More than a systematic attempt at refining radiocarbon age estimates, an impetus behind the development of the CalPal program has been the possibility of relating archaeological phenomena to glacial climate archives, such as ice cores and deep-sea records, of crucial importance to our understanding of the geochronology and paleoenvironmental setting of archaeological sites and cultures.

4. Radiocarbon dating is clearly at its very limits in the time range at stake here, and thus, independent dating methods become very important, illustrated in this volume by Richter et al.'s (2008) study of the thermoluminescence (TL) age of the Bohunician type locality. The application of TL and optically simulated luminescence (OSL) is becoming an important tool in this time range, as was previously shown by a comparison of TL and ^{14}C dating results for the southern German cave sites (Richter et al., 2000; Conard and Bolus, 2003). Adler et al. (2008) present an extensive comparison of a large series of TL, electron spin resonance (ESR), and accelerated mass spectrometry (AMS) dating results for the Ortvale Klde sequence, and conclude that after "calibration" of the ^{14}C dates, the TL and ^{14}C dates are in agreement for layers 5–7, within the error limits of the TL results.

Within the time range considered here, a very important datum line to compare our mostly radiocarbon based chronologies against consists of volcanic deposits associated with the Campanian Ignimbrite (CI) eruption from the Phlegrean Fields, near Naples, southern Italy. This was one of the largest late Quaternary eruptions in the northern hemisphere, impacting an area of at least 5,000,000 km^2 in which its distal deposits have, until now, been traced. The eruption spewed a plume of ash over southcentral and Eastern Europe, occasionally covering early Upper Paleolithic (EUP) assemblages in both open-air sites and in caves across Eastern and southeastern Europe. As described in this volume by various authors (e.g., Blockley et al., 2008; Fedele et al., 2008; Hoffecker et al., 2008), the event can be dated to approximately 40,000 calendar years (i.e., within the interval of the Middle to Upper Paleolithic transition).

Leaving aside its possible "volcanic winter" environmental impact—to which Fedele et al. (2008) pay much attention—it is a very important event marker that also shows the potential variability of radiocarbon ages in this time range. The CI signal has been identified in the Greenland ice core records, while Hoffecker et al. (2008) follow the tephra from the Bay of Naples to the river Don, 2,200 km east of the source. There, at Kostenki, various find layers are present beneath the CI ash, containing assemblages with blade technology, burins, end-scrapers, bone and ivory artifacts, ornaments, imported fossil shell, and possibly figurative art. They are interstratified with several "transitional" assemblages with a high percentage of typical Middle Paleolithic stone artifact forms, but without bone artifacts, imported materials, ornaments, and art. Hoffecker et al. (2008) "correct" the many ^{14}C data obtained on charcoal (only) samples from the various Kostenki sites, using "two recently developed calibration curves" (i.e., the Fairbanks et al. [2005] data set and the CalPal (2005) calibration curve). This is an interesting comparative exercise given the presence of the CI marker horizon in these ^{14}C dated sequences. Although application of the "calibration curves" (sic) improves the fit between the charcoal dates and other dating methods, Hoffecker and colleagues (2008) conclude that the corrected dates still appear to underestimate the age of the tephra by more than 1,000 calendar years. The "calibrated" date for the CI tephra at Kostenki 14, for example, is 37,835 ± 814 cal BP (from an "uncorrected" date of 32,420 ± 440/420 ^{14}C BP [GrA-18053]). The consensus date for the tephra has been obtained by variants of the Ar/Ar dating technique at different exposures, which has yielded an unusually high precision age of 39,280 ± 110 BP ^{40}Ar/^{39}Ar (see Blockley et al., 2008). Fedele et al. (2008) underline these problems with "calibration" in this time range by stressing that specific "CalPal calibrated" ^{14}C dates of samples underlying the CI tephra underestimate the calendar age by at least 2,500–3,500 years.

Blockley et al. (2008, see their Fig. 1) also compare the available radiocarbon dates either immediately below the CI ash or embedded within it with the latest ^{40}Ar/^{39}Ar age estimate for the CI ash and the revised Hughen et al. (2006) calibration data. All of the radiocarbon dates would be expected to slightly predate the age of the ash, although significant uncertainties make interpretation difficult. In actual fact, the radiocarbon dates fall into two groups: those fitting the expected relationship with the ash age, and those that appear far too young. The authors suggest that the best explanation for the patterning in these data is differential removal of contamination due to the very low levels of original ^{14}C in such old samples. As Blockley et al. (2008) point out, we are only aware of these problems because we have well-dated marker horizons in known stratigraphic relationships with the radiocarbon dates. Such markers are extremely rare in Paleolithic archaeology. The clear result of the CI-radiocarbon date comparisons in this volume is that we have to take large dating uncertainties into consideration in this time range.

Knowledge in transition: a very short review

While pointing out where the problematic areas are, this volume shows at the same time the enormous progress that has been made in dating important aspects of the transition. Let us now consider those domains.

On the age of the last Neandertals

There is considerable doubt about when the last Neandertals lived, and in recent years, late survival has been suggested for "refuge" areas in Europe up to 28 ka ^{14}C BP, as claimed for Gorham's Cave (Finlayson et al., 2006; but see Zilhão and Pettitt, 2006 for a critique). It is refreshing to see Jöris and Street's (2008) paper in this volume taking a critical stance at this late survival hype. Their evaluation of the direct dating evidence for Neandertal skeletal remains concludes that the latest Neandertals date to shortly before 38 ka ^{14}C BP: these include the two individuals from the Neandertal type site, El Sidron in Cantabrian Spain, Kůlna Cave in the Czech Republic, Les Rochers de Villeneuve in France, and Vindija G3 in Croatia. They dismiss the appreciably-younger radiocarbon dates for the two specimens from Vindija G1, earlier dated to between 28,000 and 29,000 ^{14}C BP (Smith et al., 1999), and now, after application of ultrafiltration methods, with dates of 32,400 ± 800 ^{14}C BP (OxA-X-2089-06) and 32,400 ± 1,800 ^{14}C BP (OxA-X-2089-07). These new dates have explicitly been presented as minimum ages (Higham et al., 2006). As for the Mesmaiskaya infant, Jöris and Street (2008) argue that context data show that the young ^{14}C age for this fossil is very problematic and should not be incorporated in the data set of well-dated Neandertals, a point made in more detail by Adler et al. (2008). Jöris and Street (2008) suggest clearly that as far as their reading of the directly dated fossils go, an overlap between Neandertals and the earliest modern humans in Europe (see below) is not indicated. It is, however, difficult to assess whether the small sample of Oxygen Isotope Stage (OIS) 3 Neandertals currently available also samples the very latest Neandertals in Europe. Furthermore, contra Jöris and Street (2008), there is some contextual evidence that Neandertals did survive in Europe beyond 38 ka ^{14}C BP. For example, the preliminary radiocarbon dates of around 36 ka ^{14}C BP reported for faunal remains associated with the late Neandertals at Jonzac, France (Richards et al., 2008) would situate this population close in time to the earliest modern humans in Europe at Pestera cu Oase (see below).

On the age of the earliest modern humans in Europe

In recent years, direct dating of skeletal remains of modern humans thought to be associated with the Aurignacian has shown that many of these remains are considerably more recent, with the Cro-Magnon material dated to the early Gravettian period and the Vogelherd Stetten 1 and 2 "Aurignacian hunter-gatherers" now downgraded to simple Neolithic farmers (Conard et al., 2004). The earliest unambiguous modern human material comes from Pestera cu Oase, with a ^{14}C age of approximately 35 ka ^{14}C BP (Trinkaus et al., 2003). There is no diagnostic archaeology associated with this find, the only fossil material contemporary with the early Aurignacian in Europe. The next oldest modern human sample from Mladec (Czech Republic) is associated with Aurignacian bone points. The human fossils date between 30 and 31.5 ka ^{14}C BP (Wild et al., 2005). Several other Romanian sites have yielded modern human remains in the 29–30 ka ^{14}C BP range, and they are about the same age as the redated Red Lady of Paviland burial (Jacobi and Higham, 2008). Given the fragmentary nature and the scarcity of human remains—not to mention the problems surrounding the definition of the Aurignacian—the taxonomic affinities of the makers of the early Aurignacian are virtually unknown (but see Bailey and Hublin, 2005). Although some authors are comfortable equating the Aurignacian with modern humans (e.g., Mellars, 2006), unambiguous skeletal evidence attesting to such an association is lacking.

From interstratification to stratigraphic succession

Long term regional contemporaneity of the Châtelperronian and the Aurignacian technocomplexes has been inferred based on claims for the interstratification of the two at various sites, for instance El Pendo in northern Spain, the French sites of Roc de Combe and Le Piage 15, and for the Grotte des Fées, the type site of the Châtelperronian (Gravina et al., 2005). Proponents of the interstratification camp, assuming that Neandertals were the makers of the Châtelperronian (for which there is some evidence at St. Césaire and at Arcy-sur-Cure) and modern humans the makers of the early Aurignacian (for which there is no skeletal support), interpret these data as supporting long term contemporaneity of the two species. Furthermore, some viewed the same data as an indication that the "Upper Paleolithic" elements of the Châtelperronian resulted from contacts between Neandertals and modern humans, and were not the result of an "autochthonous" development (Mellars, 2005). All of these claims for interstratification have been refuted though, often on the basis of site formation arguments (Zilhão and d'Errico, 1999; Djindjian et al., 2003). The Grotte des Fées was the last stronghold for the supporters of interstratification. In the recent (fierce) debate on the stratigraphy of the site, Zilhão et al. (2008) have claimed that the putative interstratified deposits are in fact 19th-century backfill. While Mellars and Gravina (2008) contest this interpretation, it is clear that the site is at least very problematic in this respect. As far as the stratigraphic evidence is considered, the Châtelperronian preceded the Aurignacian in Western Europe, and the inferred long term overlap of the two technocomplexes must be seen as an unsupported hypothesis (cf. Zilhão et al., 2008).

In this context, ^{14}C dates have also been used to support considerable overlap or absence thereof, and it is interesting to read comments by Jöris and Street (2008) on the different signals obtained by bone versus charcoal dates for this period. For example, Middle and Upper Paleolithic radiocarbon dates on bone and charcoal taken together show an extremely broad chronological distribution, which has been seen as indicating a very long (> 10,000 ^{14}C years) overlap between the Middle and the Upper Paleolithic in parts of Europe. In contrast, results of charcoal dates often tend to be significantly older and consistently date the latest Middle Paleolitic sites to before 38,000 ^{14}C BP, whereas EUP charcoal post-dates 38,000 ^{14}C BP, strongly suggesting a successive appearance in line with the secure stratigraphic evidence.

Finally, it is worth mentioning that one of the origins of this debate, the presence of personal ornaments in a few late Neandertal Châtelperronian contexts, such as at Arcy-sur-Cure and at Grotte des Fées, is a very exceptional phenomenon, with more than 120 Châtelperronian assemblages known from France and Cantabria (Demars, 1996) yielding no personal ornaments at all. White (2001) has suggested that the small number of personal ornaments currently known from the Châtelperronian is the result of admixture with overlying Aurignacian layers, including the famous assemblage from the Grotte du Renne at Arcy-sur-Cure. Zilhão et al.'s (2008) study of the Grotte des Fées sequence referred to above implies that the former attribution of two perforated teeth in level B4 to the Châtelperronian is flawed, as these objects probably come from backfill deposits. In a more general treatment of this topic, Alvarez Fernandez and Jöris (in press) see no unambiguous evidence for the production and usage of personal ornaments in the entire European pre-Upper Paleolithic record.

On late Middle Paleolithic variability

As addressed in this volume by Jöris and Street, the late Middle Paleolithic (OIS 5–3) displays a large amount of typo-technological variability, more so than in the earlier phases of the Middle Paleolithic, even if the causes of this variability are poorly understood. Consider the Eastern European Micoquian, the Central European Keilmesser-groups, the Mousterian of Acheulian Tradition or the typical blade technology *s.s.*, so well-documented in the north of France, Belgium, and Germany at many sites dating to OIS 5. Where associated with human fossils, these are exclusively those of Neandertals.

On "transitional" industries

As with the debate on the autochthonous or intrusive character of the "Upper Paleolithic" elements in the Châtelperronian (but see above), there is uncertainty about the degree to which transitional industries, such as the Bachokirian, Bohunician, or Protoaurignacian, emerged from "indigenous" habits of tool making or from intrusive ideas or even people. Jöris and Street (2008), amongst others, interpret some of these transitional lithic assemblages as proxies for Neandertals, what they call their final Middle Paleolithic transitional industries, mostly dating between 41–38 ka ^{14}C BP up to 35 ka ^{14}C BP. Initial Upper Paleolithic and early Upper Paleolithic transitional industries date to 39–35 ka ^{14}C BP, and testify to the appearance of modern humans, in their view. The advantage of this hypothesis is that it is a falsifiable one, with clear predictions. We do indeed need diagnostic skeletal remains as exercises in lithic phylogeny are not going to solve the debate over the character of transitional industries or their authorship. We simply do not know whether the similarities between these technocomplexes "…represent technical convergences, diffusion of ideas, or human migrations" (Teyssandier, 2006: 14).

On the origins of the Aurignacian

The view that the Aurignacian is an intrusive phenomenon that arrived in Europe in a wave of advance of modern humans is a dominant paradigm, most prominently defended by Mellars (e.g., 2006). However, there also exists the suggestion that in southwest France the Aurignacian evolved "in situ," from the preceding Protoaurignacian and Châtelperronian, as far as the lithics are concerned (Bordes, 2006). Bon (2002), amongst others, has demonstrated the existence of different traditions within the Aurignacian in southwestern Europe, which underlines the variability within the Aurignacian and alters the vision of a homogeneous settlement wave. His technological study of the Aurignacian suggests that it had many things in common with other European industries between 40–30 ka ^{14}C BP, especially features related to the development of technical solutions for the manufacture of projectiles. For the Aurignacian, that entailed, amongst others, the production of microliths used as projectile components (Bon, 2006: 142). As far as its earliest appearance is concerned, previous arguments for a very early (prior to 35 ka ^{14}C BP) appearance of the Aurignacian in Central Europe (Conard and Bolus, 2003) have been criticized for their usage of ^{14}C data (e.g., Verpoorte, 2005). Jöris and Street (2008) conclude that the best estimate for the Geissenklösterle Aurignacian is between 34.8–33.2 ka ^{14}C BP for the older phase of the Aurignacian (AH III) and around 33.2–29.8 ka ^{14}C BP for the younger phase. In line with the evidence from this region (Conard and Bolus, 2003), Jöris and Street suggest that the Aurignacian seems to appear simultaneously over large parts of Europe beginning around 35 ka ^{14}C BP, the approximate radiocarbon age of the CI eruption in Italy (see above): "Wherever this secure stratigraphic marker is present, the Aurignacian consistently overlies the Campanian Ignimbrite" (Jöris and Street, 2008).

Climate and the demise of the Neandertals

Ice core studies have taught us that the time span of Middle and Upper Paleolithic was punctuated by rapid climatic transitions on timescales of centuries or even decades (Adams et al., 1999). Vegetation responses to such rapid fluctuations must have varied on small scales among sites and regions, according to the differences in initial environmental conditions, local and regional species pool, and the climate events concerned, and the same applies to faunal elements, including Neandertals and modern humans. Various authors have suggested that such climatic fluctuations were instrumental in the disappearance of the Neandertals, one of the latest climatic hypotheses having been presented by Mellars (2006) who suggests that their final demise may have coincided with the sudden onset of the much colder and drier conditions of the Heinrich Event 4. However, extremes of temperatures reached during this period were not exceptional, and had been experienced in earlier glacial-interglacial cycles survived by Neandertals, where the extremes of OIS 4 and 6 led to abandonment of the northern parts of Europe, as did the most extreme parts of OIS 2, for modern humans (e.g., Roebroeks et al., 1992). Recently Tzedakis et al. (2007) have also made the point that climate change was probably not the key factor here, as before 28 ka ^{14}C BP (i.e., according to most of the papers in this volume long after their demise) Neandertals would have faced a pattern of climatic fluctuations that they had been surviving for at least 100,000 years already.

Discussion

The papers in this volume very clearly show where the chronological database for the period 40 to 30 ka ^{14}C BP is flawed and that major contextual and methodological problems have been underestimated in a number of high profile papers on the biological and cultural changes during this crucial period. In the ^{14}C domain we now have "conventional" ^{14}C dates, AMS dates, and dates obtained with the ultrafiltration techniques, and these methods have been applied to different materials, to wit mainly charcoal and bone. A straightforward comparison of these categories has become difficult, so critical evaluation of the existing ^{14}C database is necessary, as shown by some of the papers in this volume. For specific research questions, systematic re-dating of find categories might even be in order.

The volume also shows the considerable progress made in dating key aspects of the transition, as a combined effect of the work of dating specialists and archaeologists. By the volume's focus on large data sets, on the critical analysis of dates and their contexts, on establishing solid patterns rather than focusing on small numbers of dates, it shows how to sort out the chronological "muddle in the middle." The juxtaposition of authors critical of calibration beyond 26,000 cal BP and those who work on the "translation" of ^{14}C dates beyond 26,000 into more precise estimates of calendar years makes for a refreshingly broad-spectrum perspective on this time range, so clearly at the limits of the radiocarbon method. Clear cut patterns in the archaeological and fossil record emerge from these papers, which set welcome constraints on the content of future models of the transitions concerned.

One example, which will allow me to refer back to the short survey of the Middle to Upper Paleolithic differences listed above, concerns the length of the possible overlap between Neandertals and modern humans. If we follow the directly dated fossil evidence as read by Jöris and Street (2008), there is a 3,000 ^{14}C year chronological *hiatus* in the record, which turns into a 1,000 ^{14}C years long one if we include the context dates for Jonzac, as discussed above. So purely on the basis of the skeletal evidence, the biological "transition" takes the form of a hiatus. Assuming that our fossil sample includes the last Neandertals and the first modern humans (which is improbable), Neandertals and modern humans may never have even met. The archaeological record is clear in terms of the (lack of) overlap between key archaeological industries: Middle Paleolithic and Châtelperronian assemblages everywhere underlie the Aurignacian, interstratification is no longer a clear cut case (on the contrary), and in Swabia there is even a clear hiatus between the latest Middle Paleolithic assemblages and the earliest Aurignacian there, suggestive of a significant chronological break between. The Aurignacian appears more or less simultaneously over large parts of Europe around 35 ka ^{14}C BP, with only marginally younger dates in its southwestern-most distribution (Andalucia) than in the easternmost parts of Europe, as shown by Jöris and Street (2008). We know that the later Aurignacian is associated with modern human remains, but do not know the taxonomic status of the producers of the early Aurignacian. However, some of the authors in this volume assume that these were modern humans too, an interpretation that remains in need of skeletal support.

A hiatus of 1000 ^{14}C years or the presently inferred (Mellars, 2006) 6,000 calendar years overlap make for big differences regarding models of Neandertal-modern human interaction. If there was a hiatus, modern humans just expanded their range into an empty area, whereas in the case of overlap, other scenarios are called for, such as competitive exclusion between the two species. And these questions will obviously not be solved by better dating methods only, as in this case, the ambiguity may mainly be a result of the limitations of the skeletal sample at our disposal, as a lack of fossils may overemphasize a hiatus. After all, if we had not had the Pestera cu Oase fossils, the earliest modern humans would be those from Mladec, 3,500 ^{14}C years younger, yielding a fossil hiatus of at least 4,500 ^{14}C years. This is an artifact of the size of our sample, and we simply have to see whether the present skeletal hiatus will be transformed into an overlap and how large that overlap might be.

But what is a long overlap in this domain, and how 'short' is a short period of time? The level of precision we require from our chronological frameworks is related to our questions. As shown by Tzedakis et al.'s (2007) paper on the climatic context of late Neandertals, we can use "raw" radiocarbon dates within the record without having to refer to calendar years if the grain of the question is compatible with the grain of the data. In this case, all one can confidently say is that in some areas the Middle to Upper Paleolithic 'cultural' transition was indeed rapid, as in the Caucasus area reviewed by Adler et al. (2008) and that the chronological overlap between Neandertals and modern humans was probably very short, 1,000 to maximally 4,000 ^{14}C years, if we follow the line of reasoning of some authors in this volume, most notably Jöris and Street. In these cases, 'short' and 'rapid' are assessments made in comparison to earlier views of overlaps in cultural and biological domains in the range of 10,000 ^{14}C years. As Zubrow (1989) has shown, it is possible to envisage major biological processes relevant for the demise of the Neandertals that operated on timescales considerably shorter than 1,000 ^{14}C years, falling within one standard deviation of the average radiocarbon date for this time range (see below). The process of extinction could have occurred on such a rapid scale that there would not be any detectable evidence of the period of overlap between the species in which competition and extinction occurred.

What does this all possibly entail for the demise of the Neandertals? Given what we know about the Neandertal record, and given the new data presented in this volume on the chronology of the transition, the main factor instigating the disappearance of Neandertals seems indeed to have been the arrival of a modern human competitor in the Neandertal stronghold of Western Eurasia (and who knows how much further east; cf. Krause et al., 2007) around 38,000–35,000 ^{14}C BP. These competitors were equipped with gracile bodies that required less energy, and they exploited the same animal species as Neandertals while at the same time broadening their diet to include species not commonly exploited by Neandertals. European modern humans seem to have had a more diverse subsistence base as far as the archaeological record and some isotope studies suggest. This may have afforded them with selective advantages over the Neandertals with their dietary focus on large terrestrial mammals. Nutritional studies have shown that in humans, more diverse diets are linked to lower infant mortality rates and longer life expectancies (Hockett and Haws, 2003; Hockett and Haws, 2005), and from this nutritional ecology perspective, Neandertal subsistence strategies " … would have been inferior to competition from other human populations consuming a diverse range of food types because the latter decreases maternal and fetal-to-infant mortality, as well as increases average life expectancy. Both of these latter demographic parameters would result in upward population curves through time … In head-to-head competition, Neandertal populations consuming a lower diversity of essential nutrients would not have been able to maintain their genetic uniqueness in the face of healthier and longer-living AMHs populations—in short, the Neandertals would have been demographically swamped by the more reproductively-successful AMH populations" (Hockett and Haws, 2005: 30; but see also Relethford, 2001, 2008, discussed above). As modeled by Zubrow (1989), a small demographic advantage in the order of a two percent difference in mortality would have resulted in the rapid extinction of the Neandertals, in approximately 30 generations time. Zubrow's model is interesting in the context of this volume, not only because of its possible bearing on the rate of Neandertal extinction, but because it shows the short timescale over which small differences (in this case: biological parameters) can have major implications.

In this speculative scenario, as well is in alternative models, the key question lies in understanding the relationship between the measurement of time in archaeological contexts (with which this volume deals) and the constitution of archaeological and paleontological phenomena as sources of information about the human past, with which we have only rarely dealt thus far (Murray, 1999). The limitations of the chronological, archaeological, and fossil data make it, for the time being, difficult to test such scenarios; nevertheless, it might be fruitful to develop them within the constraints of the new data about the transition presented in this volume, in order to see how the various competing scenarios will do with future improvements in dating methodology. Speculative scenarios might even function as heuristic instruments to challenge current techniques for the measurement of time.

This volume certainly sets the standards for the future measurement of archaeological time in the critical period of the Middle to Upper Paleolithic transition. Its results have the added benefit of forcing us, once again, to question the nature of archaeological phenomena, as the measurement of time, no matter how precise, is meaningless if we do not know what it is that we are trying to study.

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