A large-scale view on ‘small-scale societies’

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Introduction – Quantitative and qualitative aspects of ‘small-scale societies’

In ethnographic and archaeological research, the term ‘small-scale society’ has gained some popularity, in particular with regard to Palaeolithic communities. The usage of this label ranges from a synonym for Palaeolithic foraging societies across cases designating smallness in numbers (e.g., Jordan et al. 2013) or being restricted to a small area, to living in a local, kinship-based interaction network (e.g., Firth 1951) or having a non-centralized political system (e.g., Spielmann 2002; see Reyes-García et al. 2017 for a short overview). There are also combinations of several of these meanings. But recently, the notion of hunter-gatherer societies as being small-scale in the qualitative sense of living in kinship-based interaction networks of nested communities has been challenged, considering that while being perhaps small in population size, people are nonetheless living in fluid and large-scale social networks (Bird et al. 2019).

Generally speaking, scale levels (e.g., small – medium – large/local – regional – global) are used to refer to both quantitative and qualitative properties of objects, processes, or systems. In their quantitative sense, they convey relative notions about the size, extent, magnitude, or frequency of the investigated phenomena. In their qualitative sense, however, they also convey statements about properties of systems that are bound to and therefore characteristic for specific scale levels. This scale dependency of properties governs specific feedback processes, timing of system responses to external factors, and the occurrence of so-called emergent properties, i.e., characteristics of a system only observable at certain scale levels, but not at others (Zhang et al. 2004). It follows that not all questions can be addressed meaningfully at all scales and that it is necessary to match the process scale(s) of interest with the scale(s) of observation. In this contribution, we explicitly report observations from a large-scale perspective with time frames covering several millennia each, and a spatial extent of roughly two million square kilometres. We present estimates on the number, density, and connectedness of Upper Palaeolithic hunter-gatherers in Europe between 43,000 and 15,000 years (ka), thus addressing three fundamental aspects of 'small-scale' societies. We also explore how diachronic changes in these three factors – number, density, and connectedness – affect the evolution of material culture.

Instead of focussing on processes that operate over the lifespan of people, we target a much higher temporal scale level, where individuals turn into sometimes criticized 'faceless' collectives (French 2021; Damm, this volume). As a result, our findings can and probably will differ from observations at smaller scales. However, in light of what is stated above, we think that faceless collectives can contribute meaningfully to the question to what extent and in what respect hunter-gatherers are living in small-scale societies. We therefore see possible differences between our conclusions and those drawn from analyses at different scales as complementary rather than as conflicting, because: scale matters.

A short history of Upper Palaeolithic population and network development in Western and Central Europe

The quantitative aspects presented below are the results of palaeodemographic estimates carried out following the Cologne Protocol, an algorithm which provides regionally differentiated numbers and densities for mobile and sedentary societies (Schmidt et al. 2021). Inferences concerning qualitative aspects, namely the connectivity of the interaction networks, are based on similarities and differences in material culture traits. Fundamental here is the assumption that interaction between individuals and groups fosters significant similarities in the archaeological record (Boyd and Richerson 1985), while in the case of isolation already the phenomenon of drift will likely cause the accumulation of regional idiosyncrasies (Neiman 1995). Since 'drift is a consequence of sampling, it is amplified in smaller populations in which the number of people to copy from, and the number of objects or traits to copy are limited' (Buchanan and Hamilton 2009, 280). It follows that with a low network connectivity, difference in the material record will likely increase and overall similarity will decrease (Shennan 2000, 2001; Henrich 2004). We fully agree with Damm (2012a; this volume) that attention should be given to the fact that some similarities arrive easier than others and that different manufacturing processes can result into morphologically similar results. This is particularly true for studies concerned with processes that operate on small and intermediate spatial and temporal scales and are interested in individual decision making. On a large scale, however, the multitude of signals from the noisy choir of individual decision making are no longer observable. Averaged over millennia, individual actions cancel each other out or amplify one another, but eventually tune into a large-scale trajectory. This sum of individual decision making is not only a result of conscious actions, but also of accidental events, transmission errors and stochastic effects (Rindos 1989). Therefore, from the temporally large-scale perspective taken in this contribution, individual decision making is but one of many factors contributing to the observable processes and is thus not of major relevance.

Network formation: 43,000 to 33,000 years ago

At around 43,000 years ago, Anatomically Modern Humans had spread over large parts of Europe (Cortés-Sánchez et al. 2019). However, the population was not evenly distributed across the continent. On the contrary, in this period people were living in several regional clusters, in the following referred to as 'Core Areas', spatially separated from one another by areas which were only ephemerally used or totally uninhabited (Schmidt and Zimmermann 2019). Taken together, the Core Areas covered about 104,000 km^2 with a population estimate of presumably around 1,500 people living at the same time (Table 1). The average population density within these Core Areas has been estimated to about 1.5 people per 100 km^2 (Schmidt and Zimmermann 2019). The lithic and osseous tools during this period are remarkably similar throughout the area of investigation, while personal ornaments from shells (Vanhaeren and d'Errico 2006) and procurement areas of lithic raw materials (Schmidt and Zimmermann 2019) show regional differences. These findings indicate that regional communities in Franco-Cantabria, the Rhine-Meuse Area, the Upper Danube, and around the Western Carpathians (archaeologically visible via Core Areas, personal ornaments, and raw material procurement) maintained a highly efficient communication network among one another, spanning at least 2000 km from east to west and 1000 km from north to south (archaeologically visible via the strong similarities in lithic and osseous technology and tool design). However, a surprisingly clear boundary with regard to personal ornaments can be found that roughly coincided with the eastern border of present-day Germany, where – despite large overlaps with other groups – sites in Germany and Austria have a mutually exclusive spectrum of adornments (Vanhaeren and d'Errico 2006).

Network densification: 33,000 to 29,000 years

Within the next 5,000 years, roughly until 29,000 years ago, we can observe the growth and the emergence of new Core Areas alongside population growth and a densification of the network. The total extent of the Core Areas more than doubled to roughly 243,000 km² and the average amount of people living at the same time almost doubled to 2,800 people (Maier and Zimmermann 2017). At the same time, the density of people within the Core Areas dropped slightly to about 1.2 people per 100 km², an observation in accordance with the expansion of the population into previously uninhabited areas. However, this expansion process did not coincide with growing distances between the Core Areas or a thinning of the large-scale spatial structure of the network. To the contrary, during this period, a new Core Area forms in a geographic key region, namely around the Burgundy Gate (Maier et al. accepted, Fig. 9b). This is the only region in Europe, where three large rivers spring from relatively nearby sources, but flow in three different directions: The Rhone to the south, the Rhine to the north, and the Danube to the east (Maier 2019). Assuming that larger rivers served as important landmarks for long-distance travel (Hussain and Floss 2016), this area has high potential to form an important hub in the large-scale communication network at that time. An effective flow of information throughout the network from the Atlantic coast to the East European Plain – and thus a high connectivity – becomes evident in striking morphological similarities in female figures (Gaudzinski-Windheuser and Jöris 2015). Two specimens from Willendorf, Austria, and Kostenki, Russia, for instance, show almost identical traits despite a distance of about 1,700 km. Besides these overarching similarities, medium-scale differences are also observable. Regarding the lithic and osseous projectiles, for instance, a division in a western and eastern part of the network becomes apparent. The boundary between both parts still roughly coincides with the eastern border of present-day Germany, already observable during the previous period. The western part includes the area up to the Atlantic coast, while the eastern part extends eastward. These differences are reflected in the names of the archaeological units in both areas. The western assemblages are subsumed under the term Gravettian, while those in the eastern part are referred to as Pavlovian.

Table 1: Palaeodemographic estimates for the Upper Palaeolithic of Europe

Period in ka	**Core Areas (CA) in km2**	**Population size**			**Averaged density in CAs**
		min	*median*	*max*	*per 100 km²*
42-33	103,686	880	1,550	3,800	1.5
33-29	243,039	1,660	2,760	3,610	1.2
29-25	123,810	660	1,000	1,530	0.8
25-20	275,413	1,330	3,240	6,260	1.2
20-15	332,949	4,820	7,600	10,520	2.6

Network disintegration and fragmentation: 29,000 to 25,000 years ago

In sharp contrast to the previous period, the time between 29,000 and 25,000 years ago is characterised by a population decline both in numbers and distribution. The extent of the Core Areas shrank to 124.000 km² – but only half the area of the previous period – and the average population density within the Core Areas decreased to 0.8 people per 100 km². The estimated average number of people living at the same time dropped to 1000, only about one third of the previous period and probably close to the threshold of a minimal viable population (Maier and Zimmermann 2017). This decline affected the northern mid-latitudes particularly strong, leading to the disappearance of Core Areas north of the Alps. The Core Area in the Burgundy region, which had emerged in the previous phase, shrank strongly and the Core Area in the Upper Danube Area disappeared entirely. However, a decline in the number of people is observable for virtually all regions in Europe, indicating regional population breakdowns rather than movements of people from the north to the south (Ibid.). The decline in population and abandonment of large parts of Central Europe coincided with the disintegration of the large-scale network and fragmentation into two smaller structures. In consequence, regional idiosyncrasies accumulated within both networks. North of the Alps, the rupture in the large-scale, long-distance network followed again roughly the border observed for previous period. The western network contracted markedly to areas west of the Rhine, while the eastern network, referred to as Willendorf-Kostenkian, roughly kept the overall spatial extent.

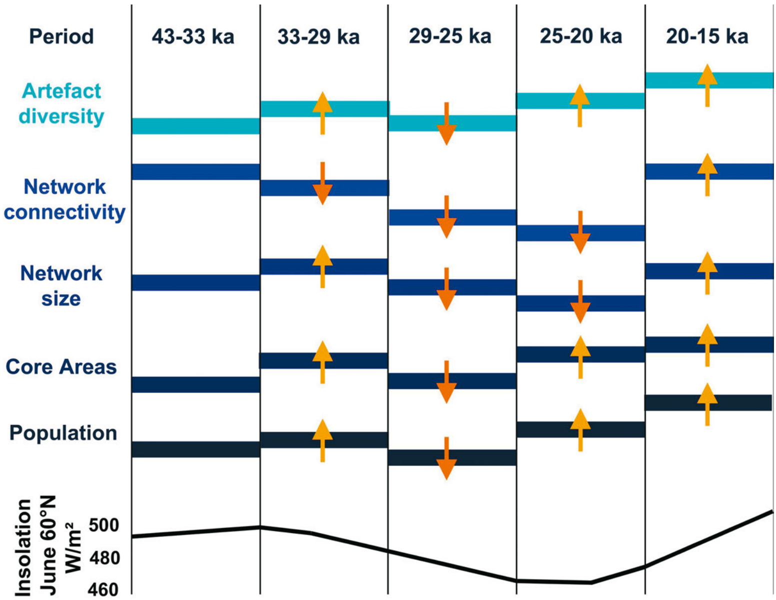
Network reorganisation: 25,000 to 20,000 years ago

The trend in population decline and range contraction stopped between 25,000 and 20,000 years ago. This period is connected to a drastic expansion of the total extent of the Core Areas to 275,000 km – surpassing even the extent of the previous expansion between 33,000 and 29,000 years – and a strong increase of the population density within the Core Areas to 1.2 people per 100 km². The average amount of people living at the same time more than tripled in comparison to the previous period to 3,200 people per 100 km². This population increase, however, is only observable for Western Europe, while the population in Central Europe remains at very low levels (Maier et al. 2016). This strong imbalance already speaks in favour of two separated networks with no or very low contact between one another. This impression is corroborated by the accumulation of regional idiosyncrasies that started in the previous period and now become particularly pronounced. Between 25,000 and 20,000 years, differences in material culture between areas east and west of the Alps are probably the strongest throughout the entire Upper Palaeolithic in Europe. Roughly between 25,000 and 23,000 years, sites in southern France and on the Iberian Peninsula show a very characteristic and regionally differentiated artefact spectrum referred to as Solutrean (Schmidt 2015), not shared by other sites outside this area. East of the Alps, assemblages contemporaneous to the Solutrean also seem to reflect a shared technological and typological background with regional differences. It is interesting in this regard that the Core Area in Burgundy still does not appear again. However, this state of two largely separated networks was overcome again already between roughly 23,000 to 20,000 years ago. At around that time, assemblages occur in Western Europe which are referred to as Badegoulian and which bear close resemblance to contemporaneous assemblages in Central Europe (Ducasse et al. 2021; Händel et al. 2021).

Network reinvigoration: 20,000 to 15,000 years ago

Between 20,000 and 15,000 years ago, the population grew again in both areas, Western and Central Europe. Previously abandoned areas became repopulated, and people expanded further north. During this period, the estimated amount of people living at the same time reaches maximum values for the Upper Palaeolithic with a median estimate of 7,600 people (Kretschmer 2015). The total extent of all Core Areas rose to 333,000 km² and population density within the Core Areas more than doubled to 2.6 people per 100 km². It is dur-

Figure 1: A temporally large-scale view on diachronic change in population size and extent of Core Areas (Schmidt et al. 2021), network size and connectivity (estimated according to the spatial distribution of Core Areas and similarities/dissimilarities in the archaeological record) and artefact diversity (estimated from a coarse diachronic survey and the data from Maier et al. 2021b) plotted against solar summer insolation at 60°N (as implemented in CalPal-Beyond the Ghost, Version 2016.2, Weninger et al., 2014) as a proxy for the timing and productivity of the vegetation period (cf. Maier et al. accepted).



ing this time that the areas of the Burgundy Gate and the Upper Danube Valley become re-integrated in the settlement pattern, probably an important cornerstone in the re-establishment of long-distance communication patterns (Maier et al. 2020). With regard to the material culture record, overarching similarities found from the Atlantic coast up to the Dnieper River indicate that ideas were circulating again on a pan-European scale (Gaudzinski-Windheuser and Jöris 2015). The re-established communication network must have been very efficient. Its presumably high connectivity can be observed at the advent of a special kind of hunting equipment, so-called barbed points, which occur virtually simultaneously in the Pyrenees and the Carpathians at around 16,000 years ago (Maier et al. 2020). However, within the large-scale network, the previous interaction structures are still visible. On a medium scale, two sub-ordinate networks are observable. The western network is visible through a far-flung pattern of mollusc transport, spanning from the Atlantic and Mediterranean over the Paris Basin to the Rhine valley. The eastern network, in contrast, does not participate in this pattern (Maier 2015). The border between these two medium-scale networks roughly runs from the Herzynian Mountains over the Bavarian Forest to the Alps, thereby following a course surprisingly similar to the border observable in previous periods.

Discussion

The brief survey of population dynamics and network development during the Upper Palaeolithic highlights that small in numbers, restricted to a small area, and living in local networks are three aspects of being 'small-scale' that are largely independent from one another and do not necessarily co-vary. Indeed, relatively many people can live in networks with comparatively small spatial extent and comparatively pronounced regional idiosyncrasies, as seems to be the case between 25,000 and 20,000 years ago in Western Europe. By contrast, relatively few people can maintain comparatively large networks with a high connectivity (Bird et al. 2019), as seems to be the case between 43,000 and 33,000 years ago (Fig. 1). With regard to networks, it is between 29,000 and 25,000 years ago that Palaeolithic communities were probably at their 'smallest scale' since the arrival of Anatomically Modern Humans in Europe. Being small in numbers, densities and distribution and living in a social environment of network disintegration, all of the discussed parameters were in a 'small-scale' state (Fig. 1). However, even then people were not living in truly 'small-scale' networks, since contact can still be traced over larger distances, connecting several Core Areas.

What reduces the network scale of Upper Palaeolithic societies?

Looking at the archaeological record, it seems that Upper Palaeolithic hunter-gatherers sought to build and maintain large-scale networks, if possible. It is important to stress that the archaeological evidence for these far-flung networks is not the result of the construction of palimpsest by averaging the behavioural patterns of many small-scale communities from different periods over large time frames. Evidence that these networks were active during the lifetimes of individuals are shown by objects transported over 800 km from the Atlantic coast to the Rhine (Maier 2015) or the quasi-simultaneous adaption of technological novelties in Western and Central Europe that happened below the resolution of modern AMS radiocarbon dating, i.e., some decades (Maier 2020). The question thus arises: What internal and external factors can trigger downsizing processes in the different aspects of hunter-gatherer societies and how do they influence one another?

Here it is important to point out that this question can be asked on different temporal scales. Depending on the scale of observations, different factors must be considered. For instance, decision making of individuals and groups (i.e., choosing one option over others by reflecting available arguments) and traditions (i.e., choosing one option over others by usually unquestioned routines) surely have the power to influence the scale of networks (Codding et al., this volume). Decisions or traditions against interaction with others will have downsizing effects on the network scale. They can thus leave traces at higher scale levels, but have their main effects in shorter periods of several decades or centuries. The temporal scale on which these factors have their main impact is thus usually much smaller than our five time frames of several thousand years each. At such a large temporal scale, decision making becomes but one factor. Other factors, in turn, become more important. In the following, we therefore focus on factors which are better observable at large temporal scales, namely environmental change, size and distribution of populations, size and connectivity of networks, and artefact diversity.

Given that Upper Palaeolithic hunter-gatherers had little influence on climate and seasonality, we start our reflections with these parameters external to the human system. It has been found that there is an interesting correlation between changes in solar insolation and long-term trends in population dynamics (Maier et al. accepted; Fig. 1). The reason for this might be that solar insolation has an influence on the timing and productivity of the vegetation period, which in turn influences migrating animals and thus resource availability for Upper Palaeolithic hunter-gatherers. Long-term trends in resource availability eventually seem to have visible impact on the size, density and distribution of hunter-gatherer populations. The observable long-term demographic trends, in turn, seem to have a strong influence on the long-term development of the extent and connectivity of networks. Looking at the Upper Palaeolithic record, it seems that population decline coincides with network disintegration and fragmentation. It is, however, noteworthy that during the period between 33,000 and 29,000 years ago network connectivity apparently declined, while the size and distribution of the population as well as the extent of the network grew.

In this regard it is interesting to consider that the connectivity of a network can be negatively influenced not only by too few participating individuals, but also by too many. Although it has been demonstrated that there is no fixed upper limit for human contacts defined by the size of their neo-cortex (Lindenfors et al. 2021), as has been suggested by Dunbar (1992), keeping contact requires the investment of time and energy. The same goes for learning and teaching skills. As a consequence, above a certain number of groups in the network, no group can maintain constant exchange with all other groups, and indirect contacts of 2nd, 3rd, etc. order will increase. Moreover, with more people inside each group, the necessity for maintaining long-distance networks for mating or subsistence security decreases. The maximum number of direct contacts between groups might be very specific for certain periods and areas, since it depends on the number of people per group, the geographic distribution of populations and topographic barriers, social mobility rules, the number of cultural traits available for learning, as well as transport and communication technology. In this regard, larger populations might even show a tendency to form spatially less extensive networks than smaller ones.

While low population numbers can thus be insufficient to maintain large-scale networks, high numbers can decrease the necessity to do so or exceed the available energy for networking activities with all members. In both cases, network connectivity will decrease, and regional idiosyncrasies (the inverse function of network connectivity) will increase. However, the increase in regional idiosyncrasies (decrease in connectivity in Fig. 1) during the Upper Palaeolithic is of two different kinds, one is related to the increase of artefact diversity, the other one to its decrease. Artefact diversity during the Upper Palaeolithic, in turn, seems to be strongly positively correlated with population size (Fig. 1). Looking at the archaeological record, it thus seems that the decrease in network connectivity between 33,000 to 29,000 years and 25,000 to 20,000 years ago is related to an increase in artefact diversity linked to increasing population size and distribution, maybe exceeding the networks specific capacities. Between 29,000 and 25,000 years ago, by contrast, decreasing connectivity is related to a loss in artefact diversity, linked to strong population decline and network disintegration. While the rising regional idiosyncrasies between 33,000 and 29,000 years ago are thus 'differences of affluence', those between 29,000 and 25,000 years ago are 'differences of loss'.

Small-scale vs. small-world

Reflections on connectivity also raise questions about the structure of Upper Palaeolithic hunter-gatherer networks and how a high connectivity can be maintained at a pan-European scale, when the total number of individuals is small, and most individuals spend most of their lives interacting with others from the same region. The number of personal contacts and the area covered during a lifetime can differ markedly (Damm, this volume; Codding et al., this volume). However, it can be stated that the interactions of an individual throughout a lifetime is finite and unlikely to cover all other individuals living in the same network at a supra-regional or continental scale.

On an intermediate, regional spatial scale, networks can consist of several task-specific sub-network, or 'circuits', within which similar but not identical groups of people interact. These circuits are not nested, but broadly overlap with one another (Damm 2012b). Such a network structure would be rather robust against external distortion, since its connectivity does not rely on individuals, but is ensured by many members in broadly redundant circuits.

However, while such a network structure works on a regional scale, where distances between most members can be travelled within a few days, it is rather unlikely for large-scale and far-distance contacts, since the energy investment beyond certain distances would drastically exceed the benefits. Here, so-called small-word networks (Milgram 1967) offer an interesting model. Networks can be described in terms of the nature of contact between individuals from local (direct contact only with neighbouring individuals) to random (direct contact with potentially everybody in the network) and the corresponding path-length, i.e., the number of individuals that is needed to pass an information from one side of the network to the other (Watts and Strogatz 1998; Bentley and Maschner 2008). In contrast to local networks, which are characterized by exclusively local connections and therefore a high path-length, random networks are characterized by many cross-cutting connections between individuals and thus a shorter path length. In small-world networks, however, most individuals have only local contacts, but few individuals have long-distance contacts. These few long-distance contacts reduce the characteristic path-length of the network tremendously, almost to the extent of random networks. For Palaeolithic societies, this means that few far-travelling individuals can provide long-distance contacts between otherwise mainly regionally cantered groups, thereby lowering the characteristic pathlength of the network significantly, enhancing its connectivity and ensuring an effective flow of information throughout the entire network (Bentley and Maschner 2008.). Relying on few individuals to connect many, such networks can show a low resilience to distortion. A decline in population with decreasing numbers of far-travelling individuals may severely impact the connectivity of such networks. Erasing important hubs from the network, as can be those in Burgundy or the Upper Danube area, easily leads to a fragmentation of the network into several units of smaller scale.

Concluding remarks

There are three main conclusions following from our reflections. First, Upper Palaeolithic hunter-gatherers in Western and Central Europe were living in closely integrated communities of small size. This does not imply that they were or were not *per se* small-scale communities. Rather, it seems that some aspects of small-scale societies can be observed, for instance that they were very low in numbers. Other observable aspects, however, are at odds with the notion of small-scale societies. Evidence for long-distance interactions during the lifetime of individuals show that Upper Palaeolithic foragers actively maintained large-scale networks. Maintaining networks with a high long-distance connectivity is a good strategy to mitigate negative effects intrinsic to small groups, such as random variation in demographic parameters, inbreeding, as well as the loss of cultural knowledge because of drift, for instance.

Second, there seem to be differences between network structures, depending on the process scale. On a regional scale, overlapping circuits of changing composition seem to be a plausible assumption. Because of many redundant connections, regional networks are comparatively stable and resilient to distortions. On a large scale, in contrast, the network structure might have been rather like small-world networks, where few individuals travelling between close-knit regional groups ensured long-distance communication. Such a network structure would have much less redundant connections and thus would be more likely to disintegrate in case of distortions.

Third, size and connectivity of the large-scale, long-distance networks seem to be strongly dependant on demographic thresholds. From a temporally large-scale perspective, demographic long-term developments, in turn, seem to be coupled to environmental change. Depending on social mobility rules and the available transport and communication technology, these networks seem to have had historically contingent conditions when the flow of information through the network connectivity was optimal, i.e., all members had access to all information virtually at the same time. Such optimal conditions would have a strongly homogenizing effect on the archaeological record and are potentially part of an explanation for the strong similarities between 43,000 and 33,000 years ago. There are two ways how large-scale network connectivity can deviate from such optimal conditions. The first is population decline alongside habitat fragmentation and eventually large-scale network disintegration. This process, observable between 29,000 and 25,000 years ago, seems also to be connected to decreasing artefact diversity. Given that this decrease is likely to exhibit stochastic properties because of drift phenomena differing within disconnected regions, the process thus fosters the formation of regional 'differences of loss'. At the same time, network fragmentation due to population decline is connected to the danger of becoming truly small-scale and thus perceptible to the perils connected with it. The second way of deviating from optimal connectivity starts from increasing population size and distribution. On the one hand, having more people in the regional neighbourhood reduces the necessity to maintain long-distance networks for mating, subsistence, etc. On the other hand, having many people in your local and regional network might exhaust the temporal capacity of individuals to maintain personal contacts beyond the regional scale. As a consequence, the network's large-scale connectivity and thus the homogenous flow of information throughout the entire network will decline, while regional sub-networks, or 'circuits' become stronger within which information on certain cultural traits circulates. This process thus fosters increasing artefact diversity, although the occurrence of certain traits is restricted to specific areas of the network, causing 'differences of affluence'. Such processes might be observable in the archaeological record for instance between 33,000 and 29,000 years ago. Accumulating regional idiosyncrasies which do not arise from stochastic loss, as in the former, but from innovations, as in the latter case, are beneficial for the innovative potential of a community. An optimal flow of information throughout the entire network that homogenises differences in artefact diversity might thus not be optimal for the technological development, since it can counteract the accumulation of cultural traits in different regions, thereby lowering the material for potential innovations. Such a reading of the archaeological record is also in line with the finding from a computer-based experiment on the accumulation of innovations (Derex and Boyd 2016). Disruptions in the connectivity of large-scale networks due to population decline thus seems to put societies in danger of becoming truly small-scale with negative effects for their viability and technological development, while a reduced connectivity due to population increase can be beneficial, since it fosters the accumulation of regional artefact diversity. However, a reduced maintenance of long-distance contacts again raises the danger of disruption in periods of crisis.

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Comment by Robert L. Kelly

I agree with this chapter's position, that archaeology, and especially paleolithic archaeology, is best at understanding the manifestation of human agents at a high level of abstraction, the collective results that produce patterns in archaeological data at a scale of thousands of years. Here we can see changing levels of population and network size/connectivity over a period of nearly 30,000 years in paleolithic Europe. The relationship between population and network size/connectivity, however, is not entirely consistent. On this matter I have two comments.

First, the work here focuses on the role of population, which is certainly important. Low population levels can make network connectivity difficult – it is hard to meet up with members of other residential groups if those groups are spread widely across the landscape. Higher population levels, on the other hand, can obviate the need for long-distance connections or "max-out" an individual's capacity for meeting/knowing others – because there is already too many people to know in the local neighborhood.

What could be added to this picture is some understanding of the variables that condition the extent to which foragers at different time periods needed the social connections with those living in other regions and the extent to which foragers could provide aid to neighbors. This is largely a product of the extent to which two regions (to take a simple case) are in sync climatically or not. Regions that are in sync cannot provide aid in times of need, and do not need aid in good times. Conversely, regions that are not in sync can provide aid, because a resource bloom in one area would be a resource decline in a neighboring one. Necessary to this proposal would be the climate data that permit reconstruction of at least relative differences in the degree of correlation between those regions demarcated here through artifact styles.

Second, the nature of the social connections that create the networks is not discussed here because, in fact, that level of detail is difficult for paleolithic archaeology to achieve. Nonetheless, the nature of the connection among regions may matter. One likely vehicle is marriage (and so the model proposed by Widlok and Henn in this volume might be usefully combined with this chapter's project). Would particular marriage practices adaptively push people to search for mates far afield under different levels of population density? Or would low population density select for cultural practices similar to "walkabouts" so as to create connections (e.g., locate culturally-appropriate spouses)? One might say that the specific cultural practices do not matter – the connections were somehow made (as evidenced by regional similarities in artifact styles). But one wonders if this position is taken for theoretically sound reasons, or only because the specific cultural practices (e.g., second cousin marriage) are impossible to see archaeologically. Agent-based modelling is one way to test different scenarios.

Adding both of these elements into the current project might help understand why population measures alone produce some inconsistencies in the patterns.

Comment by Graeme Warren

In their contribution Andreas Maier and colleagues usefully highlight that what is meant by small-scale can vary considerably, and that the term is used in multiple, and not always consistent senses. Their focus is on population size, density and distribution: using demography as an index of one aspect of scale. This is supported by an analysis of interaction, which is indexed by patterns of regional material culture similarity and difference. Their demographic estimates are based on the Cologne Protocol – which is not presented in detail here but uses site density over time and space as the basis for its calculations. The demographic turn in archaeology of recent years has seen extensive use of either site density or, more commonly, radiocarbon dates as proxies for population. It is important to note that the use of all such proxies is challenging. For the purpose of this comment, however, the demographic reconstructions are accepted as given.

Maier et al. emphasise that their view is of the long term, and that this perspective will show different aspects of scale than those focused on the lifespan of individuals, including potentially highlighting emergent properties of behaviour at the long-term and large-scale. Their reconstructions of Upper Palaeolithic networks and demography in Europe show that aspects of scale relating to demography – the size, distribution and density of population – change significantly and that interaction between these groups also changes.

Significantly, there is no single relationship of demography and interaction: it is not possible to predict changes in scale of interaction simply from changes in population scale.

The period 33-29 ka, for example, sees a 'difference of affluence', with a break down of regional interaction argued have been created by population growth. Population density reduced the need for long distance contact and is argued to lead to the capacity of individuals to manage their networks being transcended. This leads to an increased regionalisation in material culture. This relationship is perhaps unsurprising – at the broadest of levels, for example, population growth in the Mesolithic of Europe has long been argued to see increased regionalisation.

From 29-25ka by contrast, the break-down of regional interaction networks is argued to derive from climate-change driven demographic decline leading to smaller population groups. In such groups it is proposed that long distance contacts were sustained by a comparatively small number of individuals, and that these networks were therefore fragile and susceptible to collapse: in this instance the break down of interaction is a 'difference of loss'.

There is much of interest in these discussions, highlighting the complex relationships that bind demography and interaction. At the same time however, it is worth noting that the movement to the largest of scales and the emphasis on 'faceless collectives' also creates its own explanatory relationships. Variation in insolation is argued to lead to changes in the availability of resources and therefore hunter-gatherer demographic change. This in turn has implications for network maintenance and the scales at which these communities lived. This may well be the case. But by moving to this time scale, climate and the environment has become the only explanatory framework for network change – there is no other data set operative at this scale against which the demographic data can be mapped. This is not to argue that the climate driven explanation is incorrect. But it is important to ask what might have been lost in moving to this scale, and what other perspectives on hunter-gatherer scale and networks – be it small or otherwise – are occluded behind the clouds of climate change. Finding ways of integrating other scales of analysis within the large scale would help provide these different perspectives. In this regard, more detail of the material culture similarities or differences might complement the large scale demography here, allowing some consideration of alternative scales.