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Cultural Evolution of Neolithic Europe

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The paper describes the background and some preliminary results of the author's project of the same name, funded by the European Research Council. It outlines the different elements of the cultural evolution research programme, from theory-building to understanding the past, and explains why demography is central to both the programme and the project. The specific objectives of the project are then described, revolving around the reconstruction of regional demographic patterns in the European Neolithic and assessing the extent to which cultural, social and economic changes are related to them as causes or consequences. Demographic patterns in the British and southern Scandinavian Neolithic show evidence of major fluctuations that seem to be related to changes in other domains, such as monument building.

Background

The last 25 years have seen the emergence of a new interdisciplinary field, the evolutionary analysis of culture, which integrates areas of biological and social anthropology, archaeology, biology, economics, linguistics and psychology, as well as mathematical modelling. It is based on the idea that culture, defined as 'information capable of affecting individuals' behaviour which they acquire from other members of their species through teaching, imitation and other forms of social transmission' (Richerson and Boyd, 2005: 5), can be seen as a Darwinian system. In the most general terms, biological and cultural evolution involves parallel mechanisms for inheritance, mutation, selection and drift. In the case of culture the inheritance mechanism is social learning: people learn ways to think and act from others, though the routes through which culture is inherited are of course much more diverse than those for genes (Cavalli-Sforza and Feldman, 1981), and different routes have different consequences for the patterning of cultural change through time. Variation in what is inherited is generated by innovations. Whether they will be widely adopted depends on a range of clearly specified selection and so-called 'bias' mechanisms, many of which have no equivalent in genetic evolution but whose existence and importance have formed the subject of major developments in the theory of cultural evolution from Cavalli-Sforza and Feldman (1981) and Boyd and Richerson (1985) up to the present.

Out of these ideas a broad interdisciplinary research programme has gradually emerged made up of three inter-related strands (cf. Mesoudi *et al.*, 2006). The first of these involves characterising the evolutionary processes that produce variation in human cultures, societies and economies in space and time. This characterisation is understandably far less developed than in evolutionary biology. Making progress here involves, for example, carrying out psychological experiments to identify the specific factors affecting social learning and the cultural transmission process (e.g. McElreath *et al.*, 2005);

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ethnoarchaeological studies of patterns of social learning and their consequences with respect to different aspects of material culture (e.g. Roux, 2007); and experimental and ethnographic studies of how people evaluate costs and benefits (e.g. Henrich *et al.*, 2005); not to mention the many high-profile studies of the extent to which people are altruistic or self-interested (e.g. Fehr and Gächter, 2002).

The second strand involves identifying the consequences of the operation of those processes in different conditions by means of modelling. This is of central importance because the consequences of the operation of specific processes cannot simply be intuited or derived from thinking through the consequences of verbal descriptions. Such modelling has been the core of the cultural evolution research programme since its beginning (Cavalli-Sforza and Feldman, 1981; Boyd and Richerson, 1985) because of the power of the mathematical population genetics tools on which it is based. On the other hand, it has also been an obstacle to entry into the field for many with humanities or social science backgrounds.

The final strand is specifically archaeological and historical. It involves using an understanding of the processes and their consequences to explain patterns of stability and change at particular times and places in a number of interrelated domains. One such domain concerns the histories of culturally transmitted practices and norms. The identification of such culture historical patterns in different parts of the world has been one of archaeology's greatest achievements (e.g. Buchvaldek *et al.*, 2007), but traditional culture history had very weak descriptive methods and explanatory mechanisms at its disposal. The developments in cultural evolutionary theory which have taken place in recent years provide the basis for recognising that different factors affect the differential inheritance and thus prevalence of different cultural practices.

A second domain concerns the history of human populations. Paradoxically perhaps, cultural evolutionary theory and its foregrounding of the process of social learning as the foundation of cultural transmission also gives new life to that explanatory mainstay of traditional culture history, the idea that cultural change can be a result of population change. The best known recent example of this argument is the Renfrew-Bellwood farming and language dispersal hypothesis (see e.g. Diamond and Bellwood, 2003). Whether this particular hypothesis is valid or not, behind it lies the recognition that human populations, like those of any other living creature, are subject to natural selection; they expand when new reproductive opportunities arise, are subject to density-dependent checks but can overshoot local carrying capacities and then decline, or be negatively affected by adverse environmental conditions or competition from other populations. It has also become apparent that some cultural attributes are strongly subject to vertical parent-child inheritance, or within community inheritance, as a result of such processes as conformist bias, a tendency not simply to copy actions in proportion to their frequency in the local population but to favour only the most common ones, so that there really may be an association between specific cultural attributes and specific populations, as traditional archaeologists claimed, even if such attributes do not have a specific ethnic signalling function. In this case, such attributes may simply 'hitchhike' as the 'cultural baggage' that happens to be associated with a particular expanding, stable or declining population and will share its fate. Analyses of aDNA are beginning to provide independent evidence of such culture-population links (e.g. Bramanti, 2009). However, even if cultural attributes are neutral and change simply as a result of drift, effectively random variation in what is copied, the fact that innovation and drift are dependent on the size of populations and the extent of their interaction means that demographic history remains central to any evolutionary perspective (Shennan, 2000).

The third set of histories is concerned with social institutions and is, in a sense, the familiar agenda of social evolution, but viewed from the perspective of evolutionary game theory (Skyrms, 1996), which examines the payoffs of different competing interaction strategies. At its core are social agents, individuals with norms, dispositions, knowledge and resources, who make decisions in their own interests in the light of constraints and opportunities, who sometimes innovate and at other times follow existing practices. Those social and economic strategies that produce beneficial outcomes for the agents will spread through the members of the groups concerned, potentially changing the distribution of social norms, and may themselves be replaced if circumstances change. Moreover, when outcomes are aggregated they can have consequences unintended by any individual social actor, including the emergence of qualitatively new forms of social and economic patterns.

Last, there are histories of 'constructed niches' that change selection pressures and produce gene-culture interactions. Thus, for example, in both Europe and Africa the adoption of agriculture with domestic animals created new environments favouring the spread of genetic mutations that permitted the consumption of liquid milk into adulthood in populations of early farmers and herders, because this ability resulted in higher survival and reproductive success rates in those who could do so (Tishkoff *et al.*, 2007).

Archaeologists have often tried to write the sort of histories just described but without the appropriate theoretical perspective and methodological tools; without these, the 'histories' are descriptive, not explanatory. The integrated cultural evolution framework briefly outlined above provides us with a well-founded set of principles and micro-processes for understanding the histories and it offers new analytical methodologies for studying patterns and processes. Moreover, the approach plays to archaeology's strengths in that it is the only discipline to provide long-term records of cultural transmission. In turn, the results of such long-term studies feed back into the development of the generalising aspects of the cultural evolutionary programme, since they provide the ideal testing ground for exploring such processes on an evolutionarily-relevant time-scale.

Demographic foundations and their consequences

The project 'Cultural Evolution of Neolithic Europe', funded by the European Research Council, takes these ideas and the processes they postulate as a framework for studying change in the European Neolithic. It focuses in particular on demography as a basis for understanding the changes because population is the key basic dimension of cultural systems, with an impact on everything else.

The foundations for understanding demographic processes, whether in prehistory or the present, lie in natural selection. Decisions to have children or not, and how much to invest in them, are made at the individual or household level in the light of individual interests and the circumstances that affect them. Those circumstances also affect the outcomes of unconscious 'decisions', such as changing lactation spans arising from changing activity patterns (e.g. Bocquet-Appel, 2008). The macro-scale population level results of these decisions are unintended outcomes, not goals of regulation (Voland, 1998). There are trade-offs between the maximum number of children that can be produced and the maximum that can be brought to the stage of being successful parents themselves, because of the costs of parental investment. If changed conditions of some kind reduce the severity of those trade-offs then people will take advantage of them and population will expand to new limits (cf. Wood, 1998). Those limits will not be set by the starvation carrying capacity but by the point at which external conditions have a density-dependent effect on individual choices relating to fertility, survival and parental investment. Those changed conditions may be entirely exogenous, for example climatic variations, or stem from new culturally-transmitted adaptations like farming. Thus, a regional population increase is likely to be an indicator of new conditions promoting increased reproductive success for those who adopt strategies that make use of them. Population stability is an indication that a local ceiling has been reached, a process that will not take very long given the rapid increases in numbers that even relatively low growth rates produce (cf. Richerson *et al.*, 2001). In fact, population fluctuations can enable us to monitor patterns of economic growth and decline (Morris and Manning, 2005).

It is thus necessary to analyse the factors that affect these economic patterns. These may include subsistence innovations and intensification versus over-exploitation; climatic factors affecting plant and animal yields positively and negatively (Schibler, 2004); and the nature of social institutions (North, 1981), in particular those affecting the degree and scale of social cooperation, for example peaceful social interaction versus endemic warfare and raiding, and hierarchy versus equality. All these factors impact cultural patterns and processes.

Of particular importance from a cultural evolution perspective is identifying the scale, nature and direction of exchange of materials and objects with known sources. First, the amount of inter-group exchange can be taken as a proxy measure of the extent of trust between communities, especially in contexts where centralised authority is lacking and there is little easy redress against defectors from agreements (cf. Seabright, 2004; North, 1981). In many societies a major source of economic growth has been the 'gains from trade' and the opportunities offered by comparative advantage (Shennan, 1999). Establishing whether this was the case for the early farming societies of Europe is of major importance. Conversely, the occurrence of warfare can mark the emergence of a defector equilibrium in which greater returns are gained from strategies involving hostility than openness.

The second set of reasons for looking at exchange patterns in objects and materials for which we know the source concerns the potential link between the extent and direction of exchange interactions and patterns of cultural similarity and difference. Extensive exchange connections may provide a basis for cultural hybridisation and the creation of cultural assemblages that are made up of multiple 'packages' from different sources, with different histories, as opposed to strongly bound cultural cores. Indeed, the explicit differentiation in the cultural evolution literature between situations where strong cultural 'cores' exist and those where different aspects of a specific cultural repertoire can be seen as distinct 'packages' that have had different histories (Boyd *et al.*, 1997) is of major importance in understanding the links between cultural and socio-economic processes. To the extent that population fluctuations have been the main motor behind the appearance and disappearance of cultural patterns, one would expect such patterns not only to be correlated with independent evidence of such fluctuations but also to be characterised by strong cultural cores, as whole cultural repertoires will tend to rise and decline with the population.

These questions and assumptions lead to the following objectives:

1. To reconstruct the population patterns of a number of key well-documented European regions from 6000–2000 BC.
2. To evaluate the links between subsistence, climate change and social institutions, especially inequality, exchange and warfare, on the one hand, and population patterns on the other; including the possibility of periods of economic growth and decline.
3. To assess the extent to which cultural and demographic patterns are associated with one another, and specifically the extent to which new cultural patterns result from population replacement rather than internal evolution.
4. To explore the relationship between cultural patterns and the nature and extent of social interaction.

The region selected for study by the project is temperate Europe, from Ireland to Poland, for the period c.6000–2000 BC, the time of the appearance and development of Europe's first farming societies, when major social, cultural and economic changes took place. There are several reasons for focussing on this broad region: the quality and quantity of modern studies of the Neolithic archaeology of the region are outstanding, probably the best anywhere in the world; a relatively broad scale is required in order to take a comparative approach to developments in different regions and to examine patterns of inter-regional interaction and the consequences of diffusion processes over time; finally, by no means all the different data series required are available for all regions. It is necessary to focus on different regions for different purposes while still working within an overall synthetic and comparative framework.

Reconstructing population patterns

The main focus of the project in its first two years has been the reconstruction of the population patterns. Addressing demographic questions at the regional scale has always been problematical. Possibilities of obtaining dendrochronological dates are strictly limited to very specific environments, and detailed seriation and site analysis studies are very hard to extend beyond limited micro-regions. On the larger scale the only option has tended to be counting the number of sites in a given cultural phase and then standardising this by the estimated phase length; however, this generally produces a very low degree of chronological resolution and it assumes that the archaeological evidence available for a particular cultural phase is distributed evenly within it. Over the last 20 years this assumption has been consistently shown to be invalid, initially through the use of dendrochronology on lake-village sites. More recently, the increasing application of Bayesian methods to the analysis of high-precision radiocarbon dates from good archaeological contexts has begun to provide an equivalent precision for dry-land sites, by making it possible to integrate stratigraphic and other information to narrow down calibrated date distributions, and has shown the same sort of pattern as the lake sites; that is to say, site phases are not scattered through the whole length of traditional cultural periods but concentrated in short intervals within them (e.g. Bayliss and Whittle, 2007; Whittle *et al.*, 2011). However, important though they are, such analyses are complex and time-consuming and, at least for some considerable time to come, will not be available in sufficiently large numbers to provide a basis for characterising broad regional and inter-regional patterns that could throw light on why particular phenomena are concentrated in those specific intervals.

In recent years, the main method for identifying regional population fluctuations has been the use of some version of summed radiocarbon probabilities as a demographic proxy (e.g. Gamble *et al.*, 2005; Tallavaara *et al.*, 2010; Shennan and Edinborough, 2007; Collard *et al.*, 2010). Given that radiocarbon dating is extremely widely used this provides a means of looking at many different regions rather than just a small number where very intensive work has been carried out. Clearly, there are potentially problems with this as a proxy, including biases in site survival, in the intensity of archaeological investigation of different regions and periods, and in differential investment in dating programmes, as well as issues relating to the calibration curve. However, to a first order of approximation, especially if large numbers of dates are available, there should be a relationship between the number of dates falling within a given time interval in a given region (or their summed probabilities) and the amount of human activity, which depends on the population size. The key point is that even though a single date may have a broad calibrated range, the accumulation of the probability distributions of a large number of dates produces a high degree of chronological resolution making it possible to trace population fluctuations in considerable detail. As part of the project we have recently

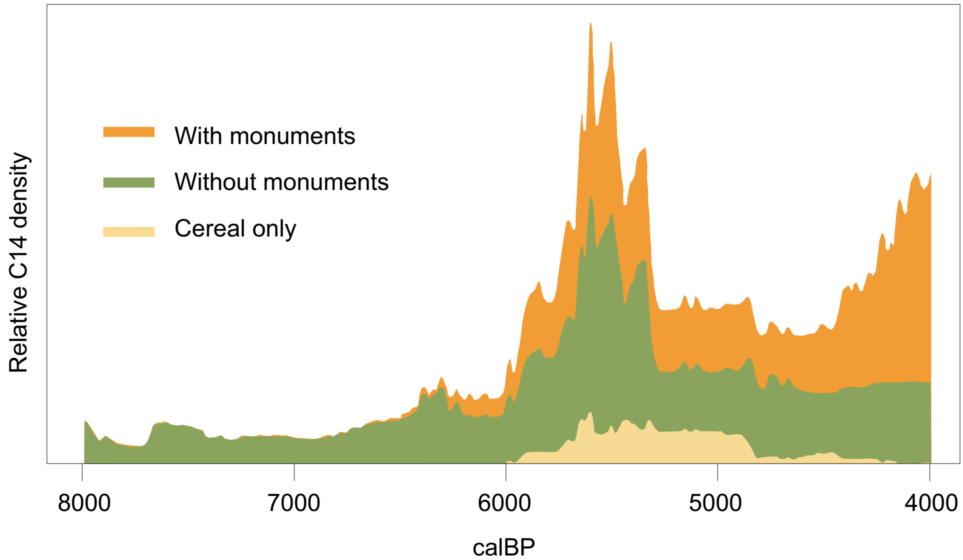

Fig. 1: Summed radiocarbon probability distribution for dates from Britain between 8000 and 4000 cal. BC. The procedure for producing the distribution is described in the text. Dates from all sites including monuments (burial mounds and earthwork enclosures) are distinguished from those from non-monumental sites; the dates from cereal grains indicate that the rise in population inferred from the distribution is associated with the beginning of farming (from Collard *et al.*, 2010).

developed a new statistical technique which takes into account many of the problems with the method and indicates whether particular fluctuations in the summed probability distribution are likely to be significant or not (Shennan *et al.*, submitted). Moreover, there are often independent sources of data that can be compared with the radiocarbon reconstructions, in particular anthropogenic impacts in pollen diagrams (e.g. Dörfler, 2008).

The demography of the Neolithic in Britain

Given that most of our analyses are still in progress, it is useful to take Neolithic Britain as an example of what we are doing. Collard *et al.* (2010), in a precursor of our current work, used summed calibrated radiocarbon dates to infer the demographic pattern associated with the first appearance of farming in Britain (**Fig. 1**). This study was based on thousands of dates, as it has been standard practice for many years in Britain to obtain radiocarbon dates for Mesolithic and Neolithic sites, so the picture is unlikely to be the result of sampling variation, a point confirmed by our more recent work. One obvious potential source of bias when comparing Mesolithic and Neolithic patterns is that the kinds of monuments that are found in the Neolithic, such as burial mounds and enclosures do not occur in the Mesolithic. Accordingly, figure 1 shows dates from all sites, including monuments, and also dates from non-monument contexts only. It is clear that there is very little difference between the two patterns for the earlier Neolithic; the fact that they then diverge in the 3rd millennium BC is likely to be telling us something interesting. A further point to note is that where site phases have multiple dates, these have been calibrated and summed then normalised to have the weight of a single date, to remove another obvious source of potential bias. A final point to make is that the treatment of the dates is if anything biased against finding the dramatic fluctuations that are apparent, because we have included all dates that are not obviously wrong, charcoal as well as short-lived samples, thus inevitably tending to smear the pattern rather than accentuate it. More recently, in the context of the current project, the validity of the demographic picture has been confirmed through a collaboration between our group and a pollen analysis team from Plymouth University which has compared the summed radiocarbon probability results with those from a reconstruction of anthropogenic impacts on the environment based on pollen analysis; this matches the demographic picture (Woodbridge *et al.*, in review).

As Collard *et al.* (2010) argued, the rise in population is associated with the introduction of farming and wholesale cultural change, the increase in population being at a rate that could only be accounted for by significant immigration, in keeping with the scale of cultural change. Equally important though is the indication of a pattern of 'boom and bust' in the early farming population, which rises to a peak in 300–400 years and declines in the subsequent 300. Though there have been hints of such a pattern for more than 30 years, with references to a middle Neolithic 'recession' (e.g. Bradley, 1978), its reality and significance have not been appreciated until now.

Does the trough represent a significant discontinuity? There is considerable evidence that it does and that it sees the end of the cultural types and practices that appeared in Britain in the 200–300 years following the arrival of farming at 4000 BC. Whittle *et al.*'s Bayesian analysis (2011: fig. 14.145) of the radiocarbon dates for the earlier Neolithic of southern Britain shows that the classic British earlier Neolithic pottery types go out of use c.3300 BC, as do the characteristic earlier Neolithic monuments , the causewayed enclosures. The equally characteristic long barrow and cairn burial mounds end c.3000 BC, and linear monuments c.2800 BC; in other words, the currency of these cultural phenomena is essentially the product of a population 'boom and bust', which also has an impact on the exploitation of flint mines (**Fig. 2**).

Fig. 2: Kevan Edinborough, one of the project postdocs, at the bottom of one of the Grimes Graves flint mine pits (photo Tim Kerig).

What might be the explanation of the link between the cultural and demographic patterns? One possibility is that cultural change follows demographic 'busts' because the crisis destroys existing social and economic institutions. Linked to this, and to the sheer decrease in numbers of people, demographic decline is also likely to result in the collapsing together and mixing of previously separate communities. Both processes increase the potential for local innovations, cultural and institutional, that may then spread. The other possibility is that population decline means that regions become available for occupation by groups from adjacent areas that have not suffered the same effects. In Britain it seems that the changes are largely local, because the new cultural forms are specific to this region, though it may be that the renewed population upturn in the late 3rd millennium BC involves the incursion of new groups from elsewhere associated with the Bell Beaker culture.

Conclusion

It is increasingly apparent that the different regions of temperate Europe, and not just Britain, were characterised by regional demographic booms and busts over the course of the Neolithic, rather than long-term equilibria (Collard *et al.*, 2010; Hinz *et al.*, 2012; Shennan *et al.*, submitted). Thus, the identification and explanation of demographic fluctuations is crucial to any historical or sociological understanding of continuity and discontinuity and the factors affecting them. Indeed, it is useful to envisage the regions we study as population surfaces or landscapes that change over time, with social, economic and cultural processes playing out on those surfaces but also affecting their changing shape. As it continues the project will address the objectives listed above and attempt to identify the causes and consequences of the demographic patterns identified.

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