CHAPTER 8

INVESTIGATING PROCESSES OF CULTURAL EVOLUTION ON THE NORTH COAST OF NEW GUINEA WITH MULTIVARIATE AND CLADISTIC ANALYSES

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INTRODUCTION

The evolutionary approach to human behaviour that has become known as 'dual inheritance theory' (eg, Smith, EA 2000) holds that an individual's actions are jointly shaped by genes, individual learning, and social learning (Pulliam and Dunford 1980; Cavalli-Sforza and Feldman 1981; Boyd and Richerson 1985; Durham 1990, 1991, 1992; Richerson and Boyd 1992). In this paper we will address two key questions that arise from this approach: (1) To what extent do traditions relating to different cultural practices co-evolve with one another, perhaps as parts of larger co-evolving packages that may include language and gene lineages? (2) Can we distinguish whether particular cultural traditions originate or change as a result of hybridising and mixing processes or branching and splitting processes? As we will see, the two questions are not unconnected.

Evolutionary packages

As noted in the introduction to this part of the book, Boyd *et al* (1997) have identified the existence of a continuum of possibilities regarding cultural coherence. At one extreme, whole cultures may be transmitted from one generation to the next. As Boyd *et al* point out, this characterisation of the nature of cultural traditions seems implausible, given extensive evidence for the diffusion of information between cultural traditions. At the other end of the spectrum of possibilities we have a situation where there is no spatial or temporal coherence because people always make their own decisions about how to carry out any specific activity on the basis of their own trial-and-error experience and the alternatives to which they are exposed. The temporal coherence we see in the archaeological record, together with the well-documented importance of social learning in generating human behaviour (eg, Boyd and Richerson 1985, Shennan and Steele 1999), indicates that this extreme is also implausible.

More likely are the two intermediate possibilities that Boyd *et al* (1997) describe. One is the existence of core traditions whose components cohere over time and provide a basic cultural framework that has a major influence on people's cultural practices but by no means organises everything they do. The other is the idea that there may be no single cultural core but rather 'multiple packages', that is, a number of separate groups of cultural elements, each with its own distinctive pattern of descent and quite possibly very different rates of change. In our view there is no reason to think that either the 'cultural core' or the 'multiple packages' view is right or wrong. Rather than deciding the issue *a priori* (eg, Terrell 1988, 2001; Moore 1994a, 1994b; Terrell *et al* 1997, 2001), we need to find out which model is relevant in a particular case and why.

Boyd *et al* (1997) cite a number of ethnographic examples where core traditions have been claimed to exist and have been postulated to extend deep into the past (eg, Rushforth and Chisholm 1991), and Ortman's (2000) study of metaphor and material culture in the Mesa Verde area of the North American Southwest during the Great Pueblo period (AD 1060–1280) provides an archaeological example in which a core tradition can be traced through time. Based on a comparative analysis of the designs on pottery and preserved basketry and other woven materials, Ortman contends that pottery designs were conceptualised as basketry/textile fabrics. This, he suggests, is linked to a larger world view based on container imagery. The underground kiva ritual structures of Mesa Verde were sometimes decorated in ways similar to the pottery decoration, while their roofs were constructed in ways that appeared similar to a coiled basket. These patterns in turn might relate to the fact that in some modern Pueblo cultures kivas are regarded as representing a cosmos made of an earth bowl and sky basket. The result of this core world view, which extended far more widely than a limited area of material culture, was that the cultural attributes were transmitted through time as a linked set, not easily infiltrated by innovations or influences from outside that were not in keeping with it.

The existence of multiple packages can also be demonstrated archaeologically, as Bettinger and Eerkens (1999) show in their study of the transmission of arrowhead form in the Great Basin of western North America. Indeed, identifying precisely which features are transmitted together as a package is an extremely informative exercise that can tell us about the nature of cultural tranmission processes and the factors affecting them. If integrated inherited packages can come in different sizes and contain a greater or lesser variety of different items, then it is possible to imagine the largest package as one that includes not only many non-linguistic cultural practices but also language and genes. Such a package implies that core non-linguistic cultural practices, language and genes are all being passed on through time together.

Branching versus blending

In biology the course of evolution is generally represented by bifurcating phylogenetic trees showing the splitting of existing species and the consequent creation of new ones, where specific evolutionary lineages are characterised by evolutionarily novel or 'derived' character states (eg, the species that comprise the hominid lineage all exhibit the derived locomotor character state of bipedality). As far as cultural traditions are concerned, tree representations based on the central importance of splitting, with lineages characterised by innovations (equivalent to derived characters in biology), have been well-established in historical linguistics for 150 years. The more recent suggestion that the model can be applied to non-linguistic culture too (eg, Durham 1990, 1992) has met with a

much more mixed response, since the prevailing assumption within anthropology since at least the early 20th century has been that blending is far more important (eg, Terrell 1988, 2001; Moore 1994a, 1994b, 2001; Dewar 1995; Terrell *et al* 1997, 2001). The appropriate way to represent descent relationships, according to this view, is not as a branching tree but as a braided stream, with different channels flowing into one another then splitting again. The basis of this argument is that humans have always interacted and thus ideas, innovations, goods and cultural practices, not to mention genes, have constantly flowed from one community to another. To the extent that language is an exception to this, it is because of the mutual accommodation of individuals' idiolects to one another that is required if speakers are to understand each other.

The great extent of human interaction clearly cannot be denied, but whether blending is the dominant cultural process that some have claimed it to be (eg, Terrell 1988, 2001; Moore 1994a, 1994b, 2001; Terrell *et al* 1997, 2001) is open to question. The archaeological record demonstrates the existence of long-lasting cultural traditions with recognisable coherence, despite evidence for the extensive movement of materials and artefacts across boundaries (eg, Pétrequin 1993). The fact that much cultural learning takes place in childhood means that 'mental filters' (Dennett 1995: 350–51) are installed in people at an early age and can render them less susceptible to innovation later in life, despite exposure to new possibilities (Aunger nd). Conformist transmission (Boyd and Richerson 1985) produces the same effect. In fact, as counterintuitive as it may seem, there is reason to believe that increasing interaction between people can actually lead to the emergence of cultural barriers and distinctions where none previously existed (eg, Barth 1969; Hodder 1982; McElreath *et al* 2003).

As with the extent of cultural coherence, there is a continuum of possibilities with regard to the relative importance of branching and blending processes. One intermediate possibility is the clear maintenance of phylogenetic continuity despite the existence of a certain amount of blending. This is what Ross (1997) suggests is the most characteristic pattern of linguistic change. Another possibility is more or less complete hybridisation, when elements of two or more lineages become so completely intermixed, possibly after some sort of break in continuity, that an ancestral lineage is no longer recognisable. This is the sort of process that is usually held to be at the origin of creole languages, although Mufwene's (2001) analysis casts doubt on this view, suggesting phylogenetic continuity with the language that provided the majority of the vocabulary (the lexifier) in circumstances of rapid change.

Branching, blending and the coherence of cultural packages

As suggested above, the issue of branching versus blending is closely related to the coherence of cultural packages. Strongly coherent core traditions will, by definition, be fairly immune to blending. The existence of multiple traditions, on the other hand, does not in itself represent blending, although it is a prerequisite. The point is best made with the aid of a semi-hypothetical example. If we take the early farming cultures of southern Scandinavia, their subsistence tradition of cereal agriculture had a lineage several thousand years deep going back spatially to the Near East. Their lithic tradition might have an origin in preceding generations of local mesolithic foragers. Both the farming practices and the lithic traditions might have undergone a process of branching differentiation previously and might continue to do so in the future. In other words, their co-existence in certain populations in southern Scandinavia at a particular point in time represents the contingent coming together of branching traditions, relevant to different aspects of life, that previously had entirely separate histories and could continue to do so in the future. On the other hand, they might become indissolubly associated, for whatever reason, so that cereal agriculture and specific forms of lithics would in future always be passed on together. The same process can also go on at a smaller scale, within a single cultural domain. Suppose that their burial tradition includes some elements that have an origin in earlier farming communities of Central Europe, but others that have an origin among local Mesolithic foragers. This might again simply represent the contingent intersection of different elements, but variation related to different burial practices rather than entirely different sets of activities. Again, though, the possibility exists that what will be passed on in future in terms of burial practice is an indissoluble combination of some local forager elements and some with an origin among farmers in Central Europe, so that we have true blending – recombination producing a novel unit of descent that is then passed on through time.

It follows from what has just been said that new strongly coherent core traditions are more likely to originate through branching rather than blending, but even if we imagine the point of origin of a new core tradition as arising from a blending process – for example, members of two or three different groups decimated by warfare coming together and combining their cultural practices – it will only be propagated through time by being resistant to outside influences and thus not amenable to blending. Where the culture of a given region at a given time is the result of the contingent conjunction of small cultural packages with different histories, change is likely to be faster and true blending is much more likely to occur. In general, the extent of blending will depend on the strength of the transmission and selection forces leading to the maintenance of cultural traditions.

In the light of the preceding discussion, it seems likely that when we find evidence for the correlated transmission of similar genetic, linguistic and many other cultural traits in several different populations the pattern will usually be explicable in terms of branching from a common origin. The mechanism normally assumed to link past and present in these circumstances is demographic expansion. In effect, some cultural feature, such as a subsistence innovation, provides members of the population with a selective advantage. An essentially accidental association of other cultural practices, language and specific genes then becomes propagated with the expanding population through processes of vertical and oblique transmission. Over time the result is diversification as populations become separated from one another and independent changes occur within them. It is the transmission processes, and the selective forces acting on what is transmitted, that determine whether the various different elements of the package

stay 'in step' with one another and whether any elements tend to spread outside the community of language speakers.

Evolutionary packages and the origin of the populations of Polynesia

One of the cases where the coherence and comprehensiveness of an evolutionary package has been most extensively discussed is the colonisation of the eastern Pacific by speakers of a sub-group of the Austronesian languages. The so-called 'express train' model sees this as the result of a rapid demographic dispersal of populations originating in Taiwan 5,000 years ago (eg, Bellwood 1987; Kirch and Green 2001, Bellwood pers comm). The alternative 'entangled bank' model (eg, Terrell *et al* 1997, 2001) postulates that the Polynesian colonisers derived from a population in eastern Indonesia/Western Melanesia that had been there for tens of thousands of years, and that the cultural and linguistic patterns visible in the eastern Pacific are due to post-colonisation contact among the populations of the various islands rather than to the colonisation process itself.

Analyses of the linguistic evidence point to processes towards the 'express train' model end of the range of possible conditions (eg, Gray and Jordan 2000a but see also Greenhill and Gray, Chapter 3 this book). In contrast, some authors have argued that both mtDNA and Y-chromosome variants most characteristic of the populations of Polynesia can be traced back to mutations in eastern Indonesia or coastal New Guinea at a time long before the arrival of possible expanding populations from Taiwan (Oppenheimer and Richards 2002; Hurles 2003). This either undermines the idea of a branching demographic expansion leading to the spread of both language and genes or suggests that it was restricted to the later stages of the process, the colonisation of the eastern Pacific itself. However, the arguments currently remain unresolved. The early dates claimed for the origin of the characteristic Polynesian mtDNA motif have been challenged (Bellwood pers comm), while recently Hage and Marck (2003) have suggested that the genetic patterns can be explained in the light of the fact that proto-Oceanic societies were matrilocal and matrilineal and would have recruited local males.

As for the Lapita culture, which is generally regarded as the archaeological trace of the first colonisation of Polynesia, while Kirch and Green (2001) and others associate this with the spread of communities speaking Austronesian languages belonging to the Oceanic subgroup, Welsch *et al* (1992) suggest that there is no particular reason to associate the Lapita culture with a single linguistic community. Part of the basis for Welsch and colleagues' claim was a study they carried out on material culture variation on the north coast of New Guinea which, they argued, showed that, 'the North Coast comprised a remarkably widespread community of culture, within which people shared a more or less homogeneous material culture complex but not a common language. Lack of a common language did not prevent them from interacting with one another and sharing in a common pool of material products and cultural practices' (Welsch *et al* 1992: 591). To the extent that there was variation between communities, Welsch and colleagues argued, it depended only on the amount of interaction between the communities, which was influenced primarily by how far apart they were. Accordingly, they averred, if this could be the case in the ethnographic present of north New Guinea, there is no reason for it not to apply to the Lapita complex as well.

MATERIAL CULTURE VARIATION ON THE NORTH COAST OF NEW GUINEA

The goal of the remainder of this chapter is to revisit the Welsch *et al* study in light of the issues raised earlier concerning the inclusiveness and coherence of cultural lineages, and whether there is evidence that any patterns are related to linguistic or genetic ones. We are not the first to carry out such a re-analysis. The conclusions to be drawn from Welsch *et al*'s (1992) material culture dataset have been debated in print on a number of occasions (Moore and Romney 1994, 1996; Roberts *et al* 1995; Welsch 1996). Part of the reason the original study has received so much attention is that it presented one of the very few published datasets that enable questions to do with the extent and nature of cultural packages, and the processes that produce them, to be addressed. In what follows we will begin by summarising the results of the original publication. We will then outline the results of the various re-analyses, before going on to those from our own study. Lastly, we will discuss the relation between our results and those of the earlier studies, before looking at how other evidence not originally considered relates to the conclusions drawn.

Welsch *et al*'s (1992) original study

The questions that Welsch *et al* (1992) wished to address concerned whether variation in the non-linguistic cultural practices on the North Coast of New Guinea correlated with the variation in language group affiliation and, if not, what did account for the variation. The North Coast of New Guinea is particularly suitable for such an analysis because it is linguistically extremely diverse. The material culture data on which the study was based are artefacts from the collections of the Field Museum in Chicago, which were acquired by a number of individuals early in the 20th century. In all, 31 villages are represented in the dataset (see map, Figure 8.1), with counts provided for 47 different types of object. The types of object are defined in very general terms; for example, masks, carvings, string bags, hair ornaments, etc (see Table 8.1). Welsch and colleagues make the point that the types are not intended to be descriptive of material culture items in themselves but to be indicative of the presence of cultural practices involving the use of those items. Although they provide count information in the data table, they restrict their analyses to the presence/absence of particular types at particular villages. Welsch and colleagues followed this course of action because they felt that the uncontrolled nature of the collecting practices by which the objects reached the museum rendered the counts unreliable. It might also be argued that since the objects are not intended to be important in themselves, for example as indicating the extent of exchange, then statements about the presence/absence of a particular cultural practice are perfectly satisfactory.

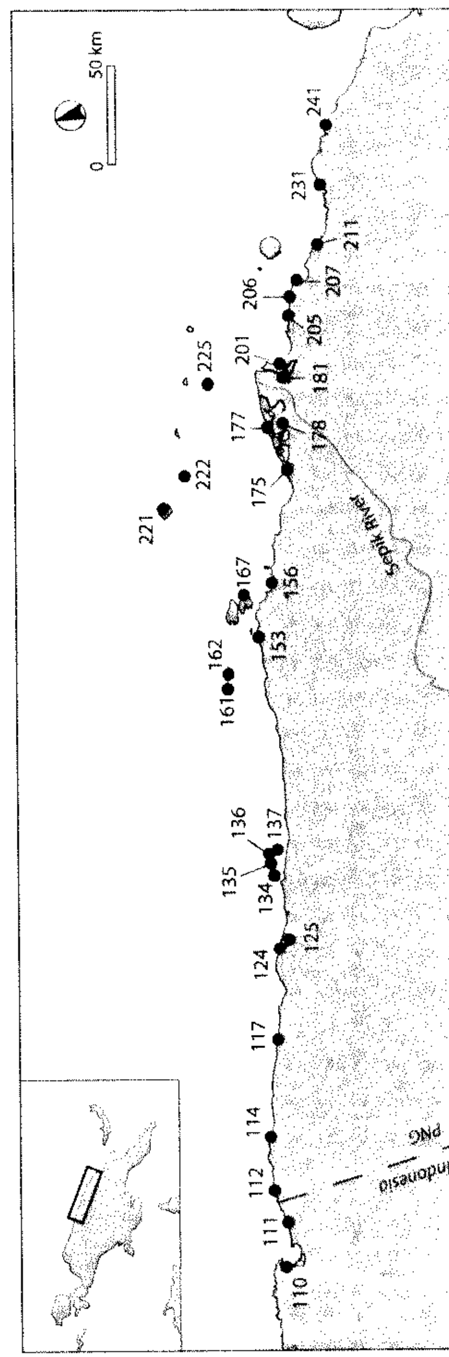

Figure 8.1 Map showing location of villages in sample along the North Coast of New Guinea. Base map taken from the Digital Chart of the World; site locations from Welsch *et al* 1992, Figure 1.

Table 8.1 Frequencies of artifact types collected from a number of villages on the north coast of New Guinea. Data from Welsch et al 1992.

	Village code																													
Type	106	111	112	114	117	124	125	128	134	135	136	137	153	156	161	162	167	175	177	178	181	201	205	206	207	211	221	222	225	231	241
Earthenware	14	2	0	2	0	10	0	0	93	0	1	2	2	1	0	1	0	6	13	19	3	0	?	0	7	7	1	0	0	0	0
Wooden dishes	2	0	0	2	0	17	37	0	11	14	5	17	6	8	51	17	0	2	5	4	0	13	7	5	1	16	9	3	0	0	7
String bags	3	0	0	11	0	2	?	8	7	25	11	7	?	52	20	5	2	1	14	3	6	1	9	1	6	17	0	?	1	1	1
Soft baskets	1	0	0	1	0	16	0	0	7	10	6	6	0	1	4	0	0	?	8	0	2	5	8	0	0	7	1	0	0	0	0
Masks	0	0	0	0	0	0	3	0	0	3	3	0	1	17	13	2	13	51	16	34	22	10	20	28	8	15	2	2	0	0	0
Carvings	4	10	0	12	0	0	2	0	0	5	4	3	4	27	12	17	21	32	22	8	35	27	15	4	1	7	1	0	0	0	0
Bows/arrows	121	55	47	270	171	43	127	16	258	2	132	89	5	23	29	0	6	0	0	0	0	0	6	9	7	39	0	0	0	1	15
Spears	2	0	0	7	0	0	0	0	2	2	1	5	2	34	0	0	0	1	0	7	24	2	20	21	46	95	4	6	0	6	24
Spear-throwers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	2	1	2	22	20	7	0	0	0
Shields	0	0	3	5	1	25	25	4	2	0	1	0	0	5	0	0	1	0	4	0	1	2	5	2	4	3	0	0	0	1	10
Clubs	0	0	0	0	0	13	1	1	9	11	8	10	0	10	0	0	0	0	3	0	0	0	0	0	2	0	26	12	2	0	0
Lime containers	47	11	0	11	0	13	0	7	6	14	23	2	1	1	0	0	2	0	6	3	0	0	2	2	0	5	0	0	0	0	0
Mortars	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2	4	2	1	1	6	5	0	1	0	0	0	0	0	0
Pestles	0	0	0	0	0	18	5	2	1	4	7	2	0	3	2	1	0	15	2	0	0	0	5	0	0	1	0	0	0	0	0
Headrests	15	0	2	1	0	2	1	7	9	11	10	3	1	7	2	3	1	2	2	0	1	2	9	5	5	17	0	?	0	0	6
Paddles/canoes	8	8	4	27	0	31	23	17	24	23	39	12	0	1	8	1	4	1	0	2	6	5	6	2	7	5	0	0	1	0	10
Hand drums	1	0	0	11	2	3	5	0	0	2	6	0	0	4	1	3	3	1	1	0	5	2	6	0	1	8	3	0	0	0	3
Axe/adzes	4	2	3	8	0	12	0	1	0	8	5	4	1	28	0	2	0	0	4	2	12	2	5	1	1	2	5	0	0	0	0
Hammers	1	0	2	0	0	7	0	0	1	0	3	0	3	?	2	1	0	0	3	1	4	0	3	0	0	0	1	2	0	0	1
Scrapers	1	1	0	23	0	6	0	9	1	5	12	12	0	2	5	6	0	0	2	0	0	0	1	0	0	3	0	3	0	0	0
Daggers	3	2	1	50	2	6	1	0	3	9	6	9	1	42	5	3	5	0	1	0	0	0	1	0	0	0	0	2	0	0	0
Drills	0	0	0	9	0	1	0	0	0	2	13	8	0	0	6	0	?	1	11	0	0	0	1	0	0	2	0	0	0	0	0
Forks etc	16	1	0	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spoons	0	0	0	0	0	1	0	0	0	22	14	20	1	3	2	0	0	0	0	0	0	2	0	0	0	8	6	5	0	0	0
Nose ornaments	0	0	0	11	2	28	1	1	2	8	?	0	0	1	1	0	0	0	6	0	0	0	1	0	0	25	10	16	0	0	0
Hair baskets	0	0	0	0	0	1	0	0	0	0	0	0	0	1	4	0	0	0	0	0	2	0	4	3	1	10	10	4	2	0	0
Hair ornaments	2	1	0	12	0	1	0	1	1	33	1	2	0	4	0	0	0	0	1	0	0	3	5	0	0	11	15	13	6	0	1
Combs	2	2	4	28	0	5	0	0	1	3	2	10	0	4	0	0	0	0	0	0	1	0	1	0	0	5	4	11	0	1	0
Earrings	5	0	0	10	2	10	4	1	8	5	5	4	0	15	4	1	0	0	0	0	0	0	0	0	0	4	0	0	2	2	0
Necklaces	1	3	1	7	4	1	0	0	3	3	1	6	0	48	3	0	2	0	0	0	2	0	0	2	0	6	0	1	1	0	0
Breast ornaments	1	0	1	15	4	0	1	6	18	4	0	6	?	28	3	0	0	?	0	0	2	0	2	0	2	5	0	0	0	0	0
Arm bands	4	1	0	35	6	7	3	2	7	7	4	9	0	17	20	4	2	0	12	0	1	0	2	0	2	12	3	0	3	7	0
Leg bands	3	0	0	5	6	0	0	3	1	4	0	1	0	11	0	0	0	0	0	0	0	0	0	1	0	3	0	0	0	0	0
Forehead bands	1	2	2	28	10	7	2	1	1	12	2	6	0	15	2	1	1	0	2	0	1	0	2	0	3	0	1	0	1	3	0
Skirt etc	0	0	0	0	0	0	0	0	0	1	0	0	0	7	0	1	0	0	0	0	0	1	2	5	2	17	0	3	1	2	2
Belts	1	4	0	21	0	9	4	20	8	2	10	3	0	3	0	2	0	0	5	0	0	0	2	0	2	9	0	3	4	2	0
Loincloths	0	0	0	3	0	2	0	0	0	1	5	0	0	1	0	2	0	0	1	0	0	4	0	0	2	9	0	0	0	4	0
Penis gourds	0	7	14	38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sleeping bags	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	1	1	2	1	0	0	0	0	0	0	0	0
Bamboo tubes	5	0	0	15	0	3	0	0	1	14	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	1
Cups	0	0	0	1	0	0	0	0	0	2	1	0	0	0	0	0	0	5	2	3	0	1	1	0	0	0	0	0	0	0	0
Dippers	1	0	0	0	0	3	0	0	3	0	0	2	0	3	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0
Slit gongs	2	0	0	0	0	0	0	0	0	0	2	3	0	0	0	0	0	1	0	0	8	0	0	0	0	4	2	0	0	0	4
Breast shields	0	0	2	11	0	14	6	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Nets	0	0	0	0	0	3	0	1	0	6	8	2	0	0	0	0	1	0	0	0	0	0	0	0	5	0	1	0	0	0	0
Baskets	0	0	0	0	0	7	0	6	0	3	2	0	0	0	0	0	0	0	2	0	0	0	0	0	7	1	0	0	0	0	1
Rattles	0	0	0	0	0	?	0	0	1	2	3	0	0	6	0	0	0	0	0	0	0	0	0	0	4	5	1	0	0	0	0

Welsch *et al* calculated a matrix of similarities between each pair of villages on the basis of artefact type presence/absence. The similarity measure they used (Driver's G) was designed to exclude similarity based solely on the fact that a particular type is absent from both villages in a pair. A measure of language similarity between each pair of villages was also constructed, on the basis of current knowledge of the relevant language relations, and the geographical distances between each pair of villages were also calculated. Bivariate and multivariate analyses were then carried out on the corresponding values of the matrices.

Cultural similarity showed low correlations with both distance (for the 31 site dataset r^2 = 7.5%) and with language (r^2 = 10.5%) (Welsch *et al* 1992: 584). Corresponding values for a 22 site subset of the data gave r^2 = 11.7% for distance; r^2 = 6.6% for language. For the 22 site dataset multiple and partial correlations were also carried out. Adding distance to the equation after sample size (the most important explanatory variable) produced an r^2 increase of c 12%; adding language after sample size produced an increase of c 2%. Adding language after sample size and distance produced no improvement at all (1992: 588).

Based on these results, Welsch *et al* concluded that cultural similarity on the North Coast of New Guinea in the early 20th century was not systematically related to language, except in so far as language similarity was correlated with geographic distance. The corollary of this, they suggested, is that anthropologists and archaeologists cannot assume that differences in language automatically translate into differences in cultural practices.

Moore and Romney's (1994) correspondence analysis

Moore and Romney (1994) adopted a different approach from Welsch *et al* (1992). First, they used the type frequencies as data rather than the presence/absence values. Secondly, rather than regressing the original data values against one another, they carried out correspondence analyses (see, eg, Shennan 1997) on all three datasets, the material culture type frequencies, the site spatial co-ordinates and the language similarities. They then took the co-ordinates of each site on the first two correspondence analysis (CA) dimensions of each analysis and carried out a correlation analysis on these.

Moore and Romney found that when CA-scaled distance and language were considered separately each accounted for around 70% of the variance in the scores of the villages on CA dimension 1 for the site artefact type frequencies (1994: 378). When distance and language were considered together, the variance accounted for was increased by about 11%. The relative increment of variance accounted for by adding distance after language was the same as for adding language after distance, approximately 35%. These figures appear to be substantially greater than those obtained by Welsch *et al* (1992), but it is important to put them in perspective. The first CA axis of the village and type frequency data only accounts for 21.3% of the total inertia in the data (Moore and Romney 1994: 382, Table 5). This means that it is 70% of 21% (14.7%) of the *total* variation that language and distance each account for, while the 11% improvement obtained by using both variables is 11% of 21% (2.3%). The 35% figure referred to above is more complex. It is 35% of the 30% of the variation in the first CA axis remaining after 70% has already been accounted for by distance or language. As we have seen, that axis accounts for 21.3%, so as a proportion of the total variation in the data, we have 35% of 30% of 21%, or 2.1%. In absolute terms then these figures are not so different from those of Welsch *et al* (1992) as they first appear, although it remains the case that, in contrast to the latter, Moore and Romney find that both language and distance are equally important. (Arguably the most important thing about both Welsch *et al*'s (1992) analyses and those of Moore and Romney (1994) is that they leave more than 80% of the material culture variation unaccounted for.)

However, apart from showing that language and distance were equally important in accounting for the variation in artefact type frequencies, Moore and Romney also took the analysis significantly further than Welsch *et al*. The latter's similarity matrix did not differentiate between the different types in terms of their role in relation to the overall patterning. Correspondence analysis makes it possible to examine the patterning in the distribution of the individual artefact types in relation to the villages where they are most prevalent (Moore and Romney 1994: 385, Figure 5). On the basis of this, Moore and Romney distinguished four different artefact clusters: one primarily associated with the western villages; another uniformly distributed across the whole area; a third associated with eastern villages speaking Austronesian languages; and a fourth group of eastern villages speaking Papuan languages. These results raise the possibility of distinguishing cultural packages in the sense described earlier and we will return to this question below. However, we can note here that Moore and Romney's uniformly distributed group is unlikely to form part of any such package since it has neither linguistic nor geographic coherence.

Roberts *et al*'s (1995) log-linear analysis

The subsequent study that Moore and Romney carried out with Roberts (Roberts *et al* 1995) used hierarchical log-linear analysis to model the values in the table of site and type frequencies. Roberts *et al* demonstrated that the artefact types are not distributed across the sites in proportion to their overall frequencies. They showed, in other words, that the type frequencies are not independent of the sites. CA-scaled distance (see above) accounted for around 29% of the departure from independence (using the G^2 statistic), and CA-scaled language for about 25%. Together, distance and language accounted for approximately 40% (1995: 72, Table 3) of the departure from independence. Thus, adding language to distance led to an 11% improvement in accounting for the departure from independence, while adding distance to language produced a 15% improvement. Once again, it appears that distance and language both play a role in accounting for variation.

Two further sets of analyses

Welsch (1996) responded to the original Moore and Romney (1994) correspondence analysis by suggesting that the results were misleading for two reasons. On the basis of information about the collectors who obtained the items for the museum, and about their collecting practices, Welsch argued that collector bias was more evident in the frequency data used by Moore and Romney (1994) than in the presence/absence data analysed by Welsch *et al* (1992), and that any analysis based on the frequencies must therefore be disregarded as misleading. Welsch further argued that a CA of the presence/absence data showed that the patterning in the data resulted from the unusual distribution patterns of a very small number of types and was consequently relatively meaningless.

In response Moore and Romney (1996) carried out further analyses which demonstrated that the collector variable was unimportant in accounting for variation in the artefact data, and that different types of analysis of both the frequency and presence/absence data produced essentially the same result.

NEW ANALYSES

Aims

In the light of the foregoing, our own project had four related aims: (1) to come to our own conclusions about the results and interpretations presented by Welsch *et al* (1992), Moore and Romney (1994, 1996), Roberts *et al* (1995), and Welsch (1996); (2) to look for evidence of groups of co-associated variables that might be explicable as evolutionary packages; (3) to establish whether there is any connection between specific groups of material culture variables and the linguistic affiliation of the villages concerned, in particular between groups of variables and the speakers of Austronesian languages; and (4) to assess the role of drift processes in accounting for the patterns observed, which is, in effect, the converse of the previous aim.

The last three aims deserve some further comment. Since we have very little in the way of an archaeological record for this area, we have no way of knowing directly whether the reason for the existence of a given set of associated material culture types is that they have been transmitted through time as a package. However, since we know that linguistic affiliation does have a clear descent history, if we find an association between language and sets of material culture types, this will indirectly confirm the hypothesis that the items represent a package with a history of common descent, although that does not necessarily mean that the elements of the package are linked by any functional or cognitively meaningful relationship; they could simply have been carried along together within a single population. The lack of diachronic data also prevents us from directly testing for the operation of drift processes in producing the data patterns (cf Neiman 1995; Shennan and Wilkinson 2001; Bentley and Shennan 2003). However, if drift is the sole process operating then the only factors affecting the course of change are innovation and interaction rates. Since we are dealing with synchronic data, the first of these is irrelevant. However, as interaction decreases with distance, pure distance dependence is indicative of the operation of drift processes alone. Nevertheless, the converse – that evidence for an effect of

language implies some biased decision-making process – does not automatically follow. A language effect could arise either because members of a linguistic community are largely immune to the adoption of cultural attributes associated with other linguistic communities with whom they interact, or because they preferentially interact with members of their own linguistic community. In other words, it may be the transmission or the interaction, or possibly both, that are involved. However, in this particular case, the evidence that Welsch and Terrell (1998) provide concerning the extent of coastal interaction between different communities in northern New Guinea suggests that the existence of a language effect should be seen as arising from biased transmission rather than differential interaction.

There are two reasons to concentrate on the Austronesian question in particular. In principle, even allowing for the Holocene population movements implied by the existence of the Trans New Guinea language phylum, the populations speaking languages ancestral to many of the present-day Papuan languages have most probably been present in north coastal New Guinea for far longer than their Austronesian counterparts. Thus, it is more likely that items and practices will have spread beyond language boundaries, even if they were originally associated with particular language speakers, than in the case of Austronesian speakers, who have most probably only been present on the North New Guinea coast for about 3,000 years. As such, any evolutionary connection between language and cultural practices is much more likely to be still visible in the Austronesian case. The second reason concerns the putative link between Austronesian speakers and the Lapita culture. While some authors believe that cultural practices have become more homogenised over time from an original state that was differentiated by language (eg, Tiesler 1969–70, cited in Welsch *et al* 1992), Welsch *et al* (1992) believe that the lack of correlation between language and culture they have identified in the present has always existed and therefore undermines the assumption that the populations associated with the Lapita culture spoke Austronesian languages.

Methods

We employed several multivariate techniques in our analyses. The first step was to carry out a Principal Components Analysis (PCA) of the logged frequency data for the 31-site dataset, using all variables except those with missing data. A multiple regression analysis was then carried out with the scores of the individual villages on PC 1 of the logged artefact frequency data as the dependent and language and geographical variables as the independents. The two language variables were the scores of the languages on dimensions 1 and 2 of the CA carried out by Moore and Romney (1994). Since the vast majority of the villages lie in a straight line along the New Guinea coast, the geographical variable used was simply the x co-ordinate value of the village locations. Subsequently, the component loadings of the variables from the original PCA of the logged artefact frequencies were examined and the variables divided into groups on the basis of their scores. A standard PCA and a categorical PCA were also carried out on the presence/absence data to see if they produced similar results. The groups of variables identified were then analysed separately. First, a PCA was carried out on the logged frequency data for that group of variables, then the scores of the villages on PC 1 were taken as the dependent variable in a multiple regression analysis, with the language and location variables described above used as the independents. A further PCA and a multiple regression analysis were carried out using a subset of variables that the previous analyses and a separate set of crosstabulations of individual variables had established as showing an association with Austronesian speakers. Further analyses carried out included a t-test to determine whether or not geographical nearest neighbour sites were more similar in their material culture types when the nearest neighbours were Austronesian than in other circumstances. The measure of similarity used was the Jaccard coefficient on the presence/absence data. Like Driver's G this also excludes similarity based on joint absence of a type from consideration. Mantel matrix tests were also carried out, using the matrix of material culture similarities between the villages as the dependent and the language similarity and geographical distance matrices as independents, to investigate the multiple and partial correlations between them. This is the preferred version of the matrix comparisons carried out by Welsch *et al* (1992), since it takes into account the non-independence of the values, and is widely used in genetic studies (eg, Bertorelle and Barbujani 1995).

In addition to the multivariate analyses, we also carried out an analysis of the presence/absence data using the cladistic methods that are the main focus of this volume. The goal of the analysis was to determine whether the features of the Austronesian material culture assemblages are best explained in terms of descent from an ancestral assemblage (the branching hypothesis) or by interaction with their non-Austronesian neighbours (the blending hypothesis). Descent and interaction are difficult to tease apart analytically because they both have a geographic component (Tehrani and Collard 2002; Collard and Tehrani, Chapter 7 this book). In an effort to overcome this problem, we conducted a series of analyses in which the relationships among three villages were examined. Each three-village sample contained two Austronesian villages and a non-Austronesian village that is geographically closer to one of the Austronesian villages than the Austronesian villages are to each other. Like Welsch *et al* (1992), we assumed that geographic distance is a useful proxy for interaction, such that villages that are close to one another are more likely to interact frequently than villages that are further apart. We reasoned that, if the branching hypothesis is correct, and descent is more important than interaction, then the two Austronesian villages should form a well-supported phylogenetic unit or 'clade' to the exclusion of the non-Austronesian village. Conversely, if the blending hypothesis is correct, and interaction is more influential than descent, then the non-Austronesian village should form a well-supported clade with the nearest Austronesian village to the exclusion of the other Austronesian village. The relationships among the villages were evaluated using bootstrapping (see Collard and Tehrani, Chapter 7 this book). We conducted 63 bootstrap analyses in total. In all the analyses, 1,000 replicates were created, and absence was deemed to be the primitive state for the characters. The analyses were carried out in PAUP* 4 (Swofford 1998).

Results and discussion

Principal components and multiple regression analyses

The results of the PCA of the logged artefact frequencies for the analysis of all artefact types are shown in Table 8.2, where it is apparent that the first two axes account for 40% of the variation in the data. Figure 8.2 shows the scattergram of the collection sites against the first two axes of the PCA, with the village numbers

***Table 8.2** Results of PCA of all non-missing variables based on logged quantitative data (ie, material culture item frequencies).*

Component	Eigenvalues	% variance	% cumulative
1	10.150	26.710	26.710
2	4.979	13.104	39.813
3	3.545	9.329	49.142

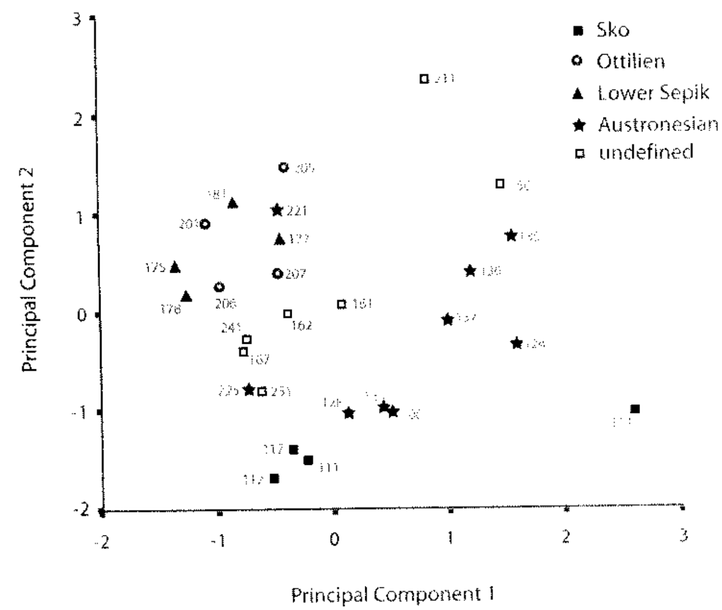

Figure 8.2 Scattergram of the collection villages against the first two PC axes from the PCA of logged artefact frequency data for 31 villages using all variables except those with missing values. Numbers correspond to those on Figure 8.1. Symbols coded by language family. For villages with speakers from more than one family or from rare families, family is marked as undefined.

marked and the symbols coded in terms of the language family of the speakers. It is apparent that there is a considerable, but by no means complete, degree of segregation between the different language families, particularly between villages speaking languages of the Austronesian family and the others. Interestingly, sites 211 and 156, in the Austronesian part of the scattergram but without an assigned language family, are villages of mixed Austronesian and Papuan language speakers. However, comparison of the village numbers with the map (Figure 8.1) makes it clear that there is also some geographical structure in the pattern, as previous results would lead us to expect.

The results of a multiple regression, with the scores of the villages on PC 1 from the analysis described above as the dependent and the x co-ordinate of the village location and the two language dimensions as independents are shown in Table 8.3. Between them, the three variables account for approximately 43% of the variation in the data (adjusted R2 c. 36%). The standardised regression coefficients for location and language dimension 1 are similar but only language dimension 1 is statistically significant and it has a higher partial correlation. In other words, the effect of language dimension 1 controlling for the other two variables is greater than the effect of distance controlling for the other two. These results confirm those obtained by Moore and Romney.

Our next aim was to look at the evidence for the existence of sets of co-associated types. Figure 8.3 shows the plot of the variable loadings against the first two principal components from the PCA of all the artefact type variables described above. On the basis of these loadings four groups of variables were identified: (1) masks, mortars, sleeping bags, cups, slit-gongs, carvings, spears, spear-throwers, hair baskets and skirts; (2) wooden dishes, hand drums, string bags, spoons, axe/adzes, loin cloths, pestles, clubs, nets, baskets, shields, hair ornaments; (3) necklaces, leg bands, arm bands, ear-rings, daggers, forehead bands, breast shields, scrapers, combs, belts, bamboo tubes, lime containers, paddles; and (4) penis gourds, bows and arrows, and forks. Clearly, these groups are not completely distinct from one another and the assignment of some items, for example shields and baskets, is ambiguous. However, they are not completely arbitrary. They correspond closely to the groups identified by Moore and Romney (1994, Table 6).

Table 8.3 ***Results of multiple regression analysis with the scores of the collection villages on PC1 of the analysis of logged material culture item frequencies as the dependent variable. The independent variables are east-west geographical position of the village (xcoord), score of the language spoken by the village on axis 1 of Moore and Romney's language CA (MRLNGDM1) and score of the language on axis 2 of the Moore and Romney language CA (MRLNGDM2).***

R	R^2	Adjusted R^2
0.653	0.427	0.355

Coefficients	Unstandardised coefficients B	Standardised coefficients Beta	t	Sig.	Correlations Zero-order	Correlations Partial
(Constant)	0.690		1.474	0.153		
xcoord	–0.003	–0.331	–1.492	0.149	–0.512	–0.291
>MRLNGDM1	–0.424	–0.364	–2.346	0.028	–0.397	–0.432
MRLNGDM2	–0.278	–0.227	–1.021	0.317	–0.493	–0.204

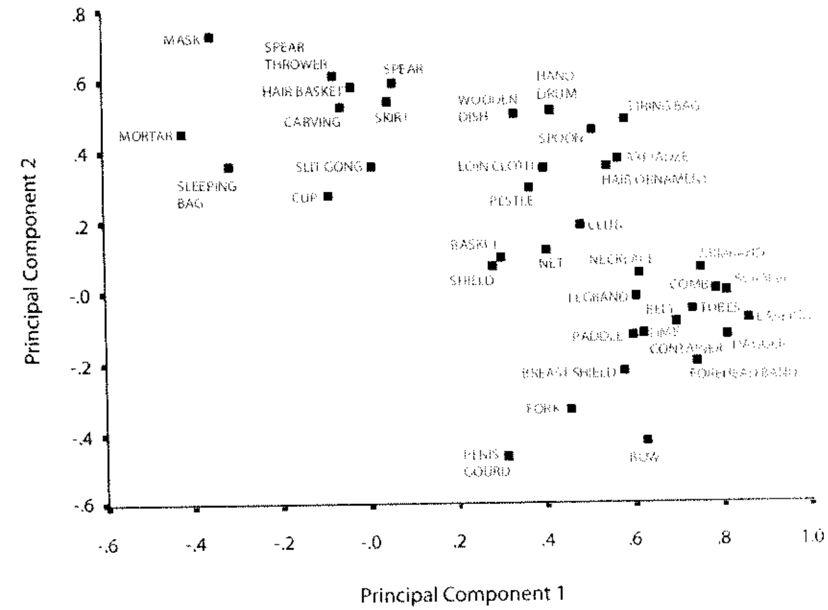

Figure 8.3 **Plot of the component loadings for the variables from the PCA of the logged frequencies of all variables without missing values.**

The results of a standard and a categorical PCA on the presence/absence data were very similar to those just described. In what follows separate PCA analyses of the logged frequency data and associated regression analysis results are presented for each group of variables.

Group 1 variables

The PCA results are shown in Table 8.4 and it is apparent that the first two axes account for a very high proportion of the variation. Figure 8.4 shows that this analysis basically differentiates the Ottilien (OTT) and Lower Sepik (LSEP) families from the others, but there is also some differentiation between the two families on axis 2.

Table 8.4 Results of PCA of group 1 variables.

Component	Eigenvalues	% variance	% cumulative
1	3.361	33.613	33.613
2	3.040	30.395	64.009
3	1.000	10.002	74.011

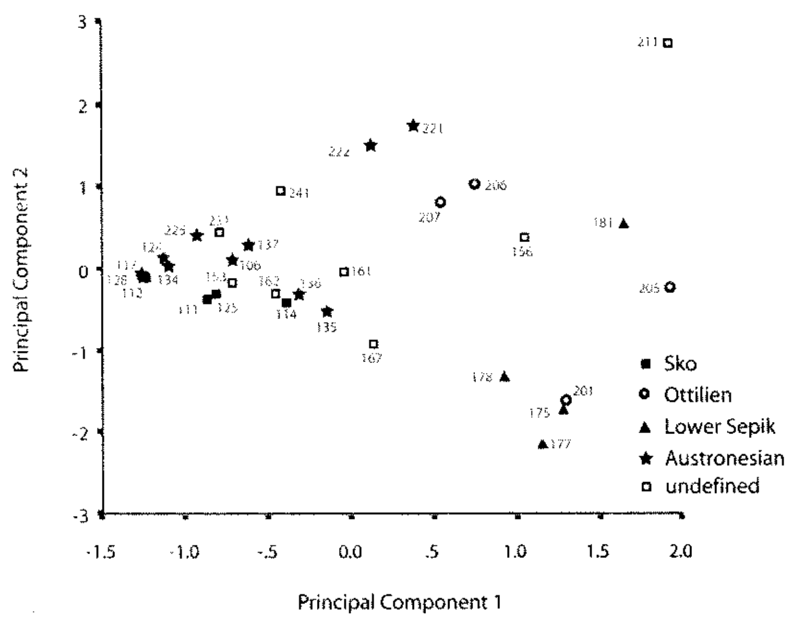

Figure 8.4 Scattergram of the villages against the first two PCs from the PCA of the logged frequencies of the group 1 variables. Numbers correspond to those on Figure 8.1. Symbols coded by language family. For villages with speakers from more than one family or from rare families, family is marked as undefined.

Table 8.5 shows the loadings of the individual group 1 variables on the components. It is apparent that they do not all behave in the same way. PC 2 contrasts mortars, sleeping bags, cups, carvings, and to a lesser extent masks, which all have negative values, with spears, spearthrowers, skirts and hair baskets, which have positive ones. The former are associated with Romney and Moore's eastern Papuan cluster IV. The other types are more generally eastern.

Table 8.6 shows the results of the multiple regression with the scores of the villages on PC 1 of the PCA of group 1 variables as the dependent and the same three independents as before. In this case the regression accounts for c 55% of the variation in the dependent. The most important variable is language dimension 2, which is significant at 0.016 and has the highest partial correlation and regression coefficients, but distance is also significant at 0.1.

Table 8.5 Loadings of the group 1 variables on the first two principal components.

	Component 1	Component 2	Component 3
LOGMASK	0.879	–0.198	–0.125
LOGMORT	0.698	–0.537	–0.09
LOGSLEEP	0.539	–0.520	0.108
LOGCUP	0.435	–0.659	0.064
LOGSLIT	0.280	0.408	0.815
LOGCARV	0.683	–0.448	0.111
LOGSPEAR	0.609	0.561	–0.048
LOGSPRTH	0.508	0.710	0.166
LOGSKIRT	0.467	0.586	–0.497
LOGHBASK	0.479	0.692	–0.083

Table 8.6 Results of multiple regression analysis with the scores of the collection villages on PC1 of the analysis of group 1 items as the dependent variable. The independent variables are east-west geographical position of the village (xcoord), score of the language spoken by the village on axis 1 of Moore and Romney's language CA (MRLNGDM1) and score of the language on axis 2 of the Moore and Romney language CA (MRLNGDM2).

R	R^2	Adjusted R^2
0.744	0.554	0.504

Coefficients

	Unstandardised coefficients B	Standardised coefficients Beta	t	Sig.	Correlations Zero-order	Partial
(Constant)	–0.660		–1.622	0.116		
xcoord	0.003	0.314	1.707	0.099	0.649	0.312
MRLNGDM1	0.173	0.149	1.158	0.257	0.142	0.218
MRLNGDM2	0.577	0.472	2.562	0.016	0.696	0.442

Because PC 2 accounts for almost as much of the variance in the group 1 variables as PC 1 it is also worth carrying out a regression with the PC 2 values as the dependent. The results are shown in Table 8.7. Once again the regression accounts for a significant proportion of the variance (46%) and in this case the partial regression coefficients for all three independents, the location and the two Moore and Romney language dimensions, are significant.

Table 8.7 ***Results of multiple regression analysis with the scores of the collection villages on PC2 of the analysis of group 1 items as the dependent variable. The independent variables are east-west geographical position of the village (xcoord), score of the language spoken by the village on axis 1 of Moore and Romney's language CA (MRLNGDM1) and score of the language on axis 2 of the Moore and Romney language CA (MRLNGDM2).***

>R	R^2	Adjusted R^2					
0.678	0.460	0.400					
Coefficients							
	Unstandardised coefficients B	Standardised coefficients Beta	t	Sig.	Correlations Zero-order	Partial	
(Constant)	−1.609		−3.594	0.001			
xcoord	0.006	0.766	3.781	0.001	0.221	0.588	
MRLNGDM1	−0.401	−0.345	−2.438	0.022	−0.354	−0.425	
MRLNGDM2	−0.941	−0.769	−3.801	0.001	−0.220	−0.590	

Group 2 variables

The results of the PCA of the group 2 variables are shown in Table 8.8 and it can be seen that the first two components account for a markedly smaller proportion of the variance, 48% as opposed to 64%.

Figure 8.5 shows the positions of the villages on the first two axes of the PCA of the group 2 variables. In this case it is apparent that there is a distinction between a significant number, but by no means all, of the Austronesian (AN) (and

Table 8.8 ***Results of PCA of the group 2 variables.***

Component	Eigenvalues	% variance	% cumulative
1	4.208	35.066	35.066
2	1.652	13.770	48.836
3	1.376	11.468	60.304

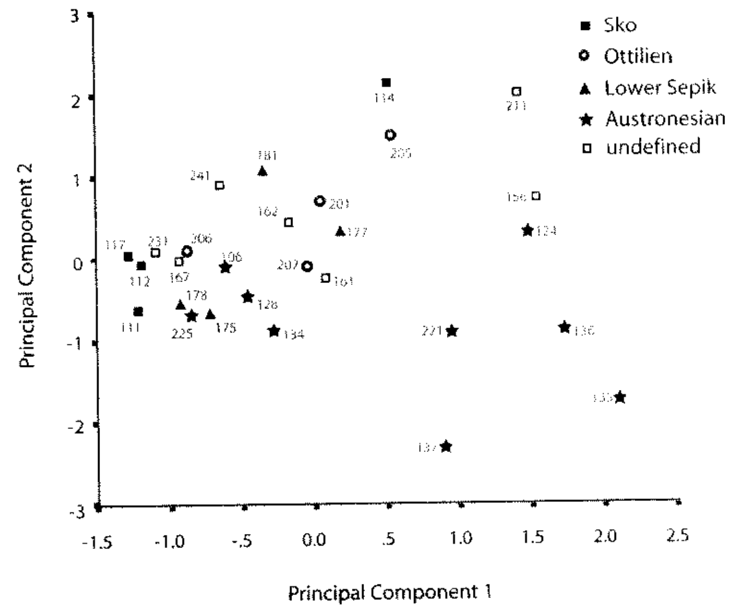

Figure 8.5 Scattergram of the villages against the first two PCs from the PCA of the logged frequencies of the group 2 variables. Numbers correspond to those on Figure 8.1. Symbols coded by language family. For villages with speakers from more than one family or from rare families, family is marked as undefined.

part Austronesian) sites and others. The loadings of the variables on PC 2 (see Table 8.9) indicate that this group of variables too is not completely coherent. There is a contrast between shields and drums on the one hand, which are in Moore and Romney's (1994) uniformly distributed category, and spoons, nets and clubs on the other, which chi-squared tests indicate are associated with Austronesian-speaking villages.

The results of the regression of the scores of the group 2 variables on PC 1 on the location and language dimensions are shown in Table 8.10. In contrast to the group 1 variables, the independents account for only half as much of the variation in group 2, in keeping with fact that these mostly belong in Moore and Romney's uniformly distributed group. In this case language dimension 1 is the only statistically significant predictor variable.

Table 8.9 Loadings of the group 2 variables on the first two principal components.

	Component 1	Component 2
LOGWOOD	0.648	−0.048
LOGDRUM	0.567	0.630
LOGSTRBA	0.668	0.149
LOGSPOON	0.796	−0.378
LOGAXE	0.665	0.183
LOGLOIN	0.498	0.390
LOGPEST	0.578	−0.160
LOGCLUB	0.680	−0.504
LOGNETS	0.579	−0.471
LOGHBASK	0.305	0.281
LOGSHLD	0.227	0.567
LOGHRORN	0.649	0.059

***Table 8.10** Results of multiple regression analysis with the scores of the collection villages on PC1 of the analysis of group 2 items as the dependent variable. The independent variables are east-west geographical position of the village (xcoord), score of the language spoken by the village on axis 1 of Moore and Romney's language CA (MRLNGDM1) and score of the language on axis 2 of the Moore and Romney language CA (MRLNGDM2).*

R	R^2	Adjusted R^2
0.530	0.281	0.191

Coefficients

	Unstandardised coefficients B	Standardised coefficients Beta	t	Sig.	Correlations Zero-order	Partial
(Constant)	0.07		0.134	0.895		
xcoord	−0.003	−0.038	−0.154	0.879	−0.006	−0.031
MRLNGDM2	0.099	0.081	0.324	0.749	0.012	0.066
MRLNGDM1	−0.619	−0.531	−3.059	0.005	−0.527	−0.530

Group 3 variables

The results of the PCA of the group 3 variables are shown in Table 8.11. As with the group 1 variables, the first two components account for a considerable proportion of the variation, although in this case PC 1 is by far the most important.

Table 8.11 Results of PCA of group 3 variables.

Component	Eigenvalues	% variance	% cumulative
1	6.675	51.348	51.348
2	1.615	12.422	63.770
3	1.095	8.425	72.195

As with the other groups of variables, there are contrasts in the loadings of some of the group 3 variables on PC 2 (see Table 8.12), suggesting that this is not a completely homogeneous group. The positive loadings of paddles, lime-containers, belts and bamboo tubes contrast with the negative loadings of necklace, legband and forehead band. The scattergram of the collection sites against the first two components of the PCA of the group 3 variables (Figure 8.6) indicates once again a separation of Austronesian villages but this is by no means complete.

Table 8.12 Loadings of group 3 variables on first two principal components.

	Component 1	Component 2
LOGNECK	0.678	−0.540
LOGLEGB	0.663	−0.373
LOGARMB	0.796	−0.213
LOGEARNG	0.874	−0.08
LOGDAG	0.846	−0.239
LOGFRBND	0.788	−0.326
LOGBRSHL	0.560	−0.034
LOGSCRAP	0.778	0.268
LOGCOMB	0.681	−0.041
LOGBELT	0.681	0.402
LOGTUBES	0.718	0.310
LOGPAD	0.554	0.591
LOGLIME	0.611	0.536

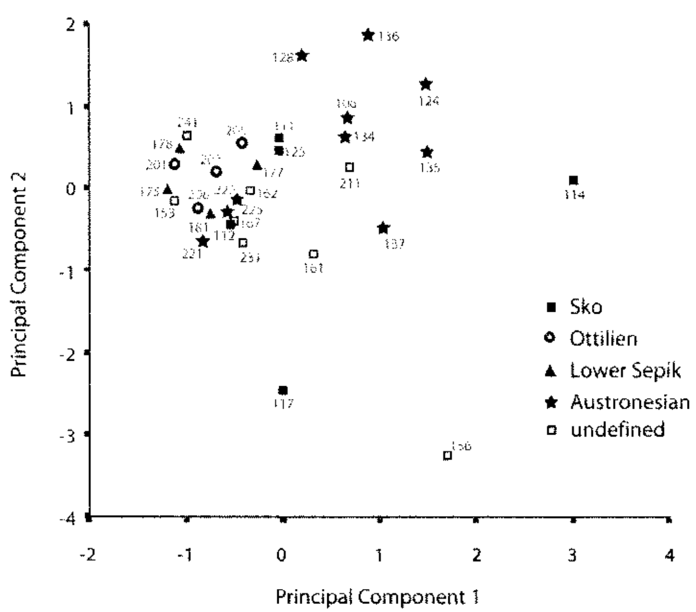

Figure 8.6 Scattergram of the villages against the first two PCs from the PCA of the logged frequencies of the group 3 variables. Numbers correspond to those on Figure 8.1. Symbols coded by language family. For villages with speakers from more than one family or from rare families, family is marked as undefined.

Table 8.13 ***Results of multiple regression analysis with the scores of the collection villages on PC1 of the analysis of group 3 items as the dependent variable. The independent variables are east-west geographical position of the village (xcoord), score of the language spoken by the village on axis 1 of Moore and Romney's language CA (MRLNGDM1) and score of the language on axis 2 of the Moore and Romney language CA (MRLNGDM2).***

R	R^2	Adjusted R^2
0.629	0.395	0.328

Coefficients

	Unstandardised coefficients B	Standardised coefficients Beta	t	Sig.	Correlations Zero-order	Correlations Partial
(Constant)	0.908		1.917	0.066		
xcoord	−0.003	−0.432	−2.017	0.054	−0.542	−0.362
MRLNGDM2	−0.196	−0.160	−0.749	0.461	−0.468	−0.143
MRLNGDM1	−0.346	−0.297	−1.986	0.057	−0.290	−0.357

Turning now to the regression analysis with the PC 1 scores from the analysis of the group 3 variables as the dependent (see Table 8.13), c 40% of the variation is accounted for, half way between the values for the first two groups. Language dimension 1 and geographical location are equally significant and have almost identical partial values.

Group 4 variables

There are only 3 variables in group 4 and PC 1 represents a contrast between the four extreme westernmost villages, three of which are Sko-speaking, and all the other villages, which have essentially the same score on this component.

Austronesian associated types

For the final PCA all those variables were selected that univariate chi-squared analyses had suggested were associated with Austronesian-speaking villages. The results of the analysis are shown in Table 8.14. It can be seen that the first two components account for nearly 60% of the variance. Examination of the component loadings (Table 8.15) shows that there are some contrasts on component 2, with spoons, clubs and hair ornaments having quite high positive loadings, nets and combs weaker ones, whereas paddles/canoes and lime containers have quite high negative loadings, with belts, bamboo tubes and earrings weaker. The basis of this distinction is a partial contrast between the eastern and the western Austronesian-speaking villages.

Unsurprisingly, this analysis achieves virtually perfect separation between the Austronesian-speaking villages and the others, as Figure 8.7 shows, with the east-west Austronesian axis represented, albeit not perfectly, in PC 2. As noted already, villages 156 and 211 are shown by Welsch *et al* (1992) as both Austronesian and another language. This analysis suggests that in material terms they are Austronesian. The fact that they group with the Austronesian villages also confirms the idea that there is a specific set of artefact types that tends to be associated with Austronesian language speakers, even if it is not restricted to them.

The results of the regression analysis of the scores of the villages on component 1 of the PCA of 'Austronesian' types are shown in Table 8.16. It accounts for 44% of the variation in the component scores. Language dimension 1 is the most

Table 8.14 ***Results of PCA of variables identified by chi-squared analysis as Austronesian associated.***

Component	Eigenvalues	% variance	% cumulative
1	5.341	44.506	44.506
2	1.677	13.974	58.479

Table 8.15 ***Loadings of Austronesian-associated variables on the first two principal components.***

	Component 1	Component 2
LOGDIP	0.503	–0.047
LOGSPOON	0.618	0.627
LOGNETS	0.551	0.200
LOGCLUB	0.615	0.581
LOGBELT	0.725	–0.294
LOGHRORN	0.615	0.449
LOGLIME	0.689	–0.422
LOGPAD	0.614	–0.489
LOGTUBES	0.724	–0.275
LOGCOMB	0.725	0.234
LOGSCRAP	0.799	–0.124
LOGEARNG	0.760	–0.230

Table 8.16 ***Results of multiple regression analysis with the scores of the collection villages on PC1 of the analysis of Austronesian-associated items as the dependent variable. The independent variables are east-west geographical position of the village (xcoord), score of the language spoken by the village on axis 1 of Moore and Romney's language CA (MRLNGDM1) and score of the language on axis 2 of the Moore and Romney language CA (MRLNGDM2).***

R	R^2	Adjusted R^2
0.665	0.442	0.380

Coefficients

	Unstandardised coefficients B	Standardised coefficients Beta	t	Sig.	Correlations Zero-order	Partial
(Constant)	0.850		1.867	0.073		
xcoord	–0.003	–0.405	–1.965	0.060	–0.415	–0.354
MRLNGDM2	–0.032	–0.026	–0.126	0.901	–0.313	–0.024
MRLNGDM1	–0.604	–0.519	–3.612	0.001	–0.513	–0.571

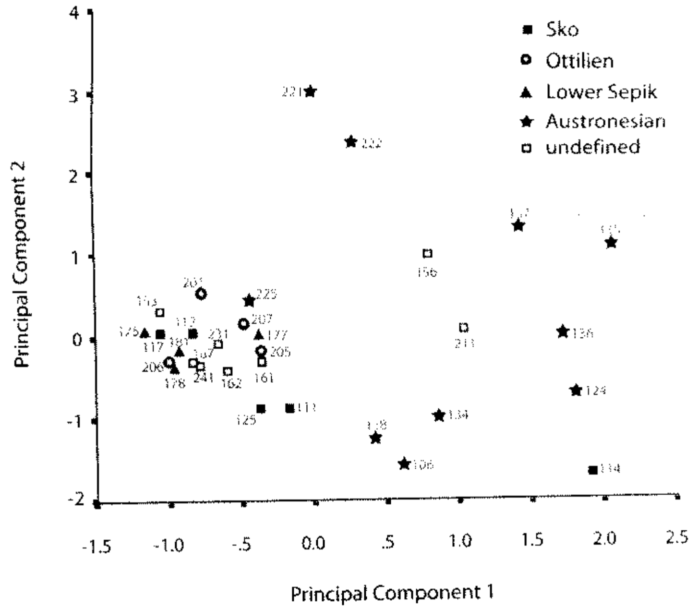

Figure 8.7 Scattergram of the villages against the first two PCs from the PCA of the logged frequencies of the variables associated with Austronesian speakers. Numbers correspond to those on Figure 8.1. Symbols coded by language family. For villages with speakers from more than one family or from rare families, family is marked as undefined.

important variable; it is significant at the 0.001 level, with a partial correlation of –0.571, while location is significant at 0.06, with a partial correlation of –0.354.

FURTHER ANALYSES

In addition to the analyses described above, two further sets of analyses were carried out, as indicated in the methods section. First, spatial nearest neighbour pairs were identified and the cultural similarity between the pairs was recorded, to contrast the degree of similarity between nearest neighbour pairs which were both Austronesian with that between all other nearest neighbour pairs. A t-test was carried out to test for the significance of the difference in mean cultural similarity. The result is significant at the 0.001 level, indicating that nearest neighbour villages that are both Austronesian are significantly more similar to one another in terms of material culture/practices than other types of nearest neighbour pairs. A t-test was also carried out contrasting the cultural similarity of spatial nearest neighbour pairs for which the language categorisation was the same (ie, Austronesian-Austronesian pairs or Non-Austronesian-Non-Austronesian pairs) with those for which it was different (ie, A-NA pairs). The result was not even nearly significant. This suggests that Austronesian pairs tend to be similar, whereas non-Austronesian-speaking pairs of villages are not particularly similar. This is presumably because of the cultural diversity represented by the non-Austronesian-speaking groups, which only serves to throw into relief the cultural similarity between the speakers of the different Austronesian languages.

In addition, we carried out a series of Mantel matrix tests. As mentioned earlier, Welsch *et al* (1992) reported regression analyses of material culture similarities against geographical distance and language similarity. Unfortunately, the standard regression techniques used by Welsch and colleagues do not take into account the lack of independence between the observations. This problem is solved by the Mantel matrix test. The results of the Mantel test using the matrix of cultural similarities for all variables are shown in Table 8.17. Both the language and the distance partial correlations are highly significant and not very different from one another, but together the two variables only account for c 12% of the variance in the similarities. A Mantel matrix test was also carried out for the case where the material culture similarity matrix was based only on the set of variables which chi-squared tests had suggested were significant in distinguishing different language families from one another. The results were more or less identical, except that the proportion of variance accounted for was slightly greater. In sum, the Mantel matrix tests support the previous results in emphasising the role of both language affiliation and distance in accounting for the patterns of material cultural variation between the villages.

Table 8.17 Mantel test results. Y is cultural distance, using the Jaccard coefficient, X1 is language distance as per Welsch et al X2 is the log of the distance between the villages. All variables used in the analysis.

Regression coefficient (bY1)	–0.002
Regression coefficient (bY2)	0.105
Partial regression (bY1_2)	–0.001
Partial regression (bY2_1)	0.07
Correlation coefficient (rY1)	–0.3
Correlation coefficient (rY2)	0.293
Correlation coefficient (r12)	–0.476
Partial correlation (rY1_2)	–0.191
Partial correlation (rY2_1)	0.179
Determination of Y by X1(%)	0.062
Determination of Y by X2(%)	0.057
Total determination of Y (%)	0.119
Unexplained variance of Y (%)	0.881

Three-village cladistic analyses

The cladistic analyses basically agreed with the multivariate analyses. To reiterate, our assumption in the cladistic analyses was that, if the branching hypothesis is correct, then in the three-village samples the two Austronesian villages should form a well-supported clade to the exclusion of the non-Austronesian village. We also assumed that, if the blending hypothesis is correct, the non-Austronesian village should form a well-supported clade with the nearest Austronesian village to the exclusion of the other Austronesian village. Sixty-one of the 63 analyses returned well-supported clades. The prediction from the branching hypothesis was fulfilled in 34 of the 63 analyses. Thus, in 54% of the samples the features of the Austronesian material culture assemblages are best explained by descent from an ancestral assemblage associated with Austronesian speakers. The prediction from the blending hypothesis was also supported by the analyses, but much less strongly. The prediction that the non-Austronesian village should form a well-supported clade with the nearest Austronesian village to the exclusion of the other Austronesian village was fulfilled in only 14 (22%) of the 63 analyses. It is noteworthy, however, that in another 13 (21%) of the 63 analyses the non-Austronesian village was linked with the Austronesian village furthest from it. This is not in line with the prediction from the blending hypothesis that we adopted, but it nonetheless clearly suggests that the material culture assemblages of some Austronesian villages are more strongly influenced by their interactions with non-Austronesian villages than they are by inheritance from an ancestral Austronesian settlement. Interestingly, these 13 cases suggest that raw distance is perhaps not as good a proxy for interaction as has been assumed hitherto. If we add the 13 analyses that support the blending hypothesis in an unexpected manner to the other 14 blending hypothesis-supporting analyses, it is reasonable to conclude that the cladistic analyses support a role for both branching and blending in the generation of the material culture similarities and differences on the North Coast of New Guinea, with branching playing a slightly more important role than blending (54% versus 43%).

CONCLUSIONS

Our aim in this chapter was to come to our own conclusions regarding the debates between Welsch *et al* and Moore and Romney on the role of linguistic affiliation versus geographical distance in accounting for variation in artefact type assemblages on the north coast of New Guinea and in doing so to assess the evidence for the existence of multiple cultural 'packages' among the artefact types and their possible association with language patterns. In turn this was intended to lead to a consideration of the role of branching and blending processes of cultural evolution in this particular case, which has implications for the importance of cultural drift.

The results of our multivariate and cladistic analyses indicate that language affiliation and geographical location both play a role in accounting for the variation in assemblages of artefact types and associated cultural practices on the north coast of New Guinea, confirming what Moore and Romney (1994, 1996;

Roberts *et al* 1995) had demonstrated. Consequently, they cannot be used to support Welsch *et al*'s proposal that the early cultural uniformity represented by the Lapita culture could perfectly well have emerged without any corresponding linguistic uniformity.

The results also confirm and amplify Moore and Romney's (1994) identification of specific groups of artefact types that behave in different ways, in other words of multiple cultural packages. The language dimensions, especially the first, play an important role in accounting for variation in all four of the groups of variables identified. Of the group 4 types, penis-gourds are restricted to the villages speaking Sko languages. Group 3 includes a number of types associated with Austronesian-speaking groups, especially the more westerly ones, while group 2 also includes types with Austronesian affinities, in this case more strongly to the eastern group. The group 1 variables distinguish groups speaking languages of the Ottilien and Lower Sepik families from the rest, with some tendency for the two to be separate from one another on the second PC axis, mortars, sleeping-bags, cups, carvings and masks being rather more prevalent in Lower Sepik-speaking groups than Ottilien ones. It is important to be aware, though, that these are statistical tendencies rather than absolute distinctions and by no means all the types have distributions across the villages that are related to the language family of the inhabitants.

Nevertheless, since all the analyses point to a significant association between the linguistic affiliation of the villages and their material culture types, especially in the case of Austronesian-speaking villages, it appears that we have strong evidence for the importance of branching processes of cultural evolution, as well as blending. In the light of the discussion in the first part of this chapter it would seem that the most likely explanation for the association between certain types and Austronesian-speaking villages is that it represents a historical signature derived from incoming groups of Austronesian speakers who have subsequently differentiated both culturally and linguistically, but that there has also been some spreading of types and practices from Austronesian communities to groups speaking Papuan languages, and vice versa. Despite the mutual borrowing, the continuing existence of a signal of inheritance from a common ancestor indicated by the association between cultural attributes and Austronesian language speaking shows that cultural filters have prevented it being blended away by repeated interaction between neighbouring groups with different linguistic and cultural histories.

This argument has been made here solely on the basis of a limited set of synchronic evidence from the early 20th century, but other evidence points in the same direction. As Foley (2000: 392–95) emphasises, in the estimated 3,000 years that Austronesian speakers have lived on the coast of New Guinea, while the Austronesian languages have remained recognisably Austronesian, in some cases there has been considerable language convergence and mutual borrowing between Austronesian and Papuan languages. Foley (2000: 392) cites examples of the borrowing even of basic vocabulary in both directions, while structural traits, bound morphology and phonological rules have also diffused from Austronesian to Papuan and vice versa. In other words, there is not a simple contrast between

the languages that have remained intact and only been subject to internal processes of evolution, and material culture and cultural practices that have been subject to borrowing and diffusion. The same processes have been going on in both, although the phylogenetic history of the languages remains more readily recognisable. Genetic studies of both nuclear (Main *et al* 2001) and mtDNA (Merriwether *et al* 1999) genes support a similar picture, with considerable evidence for the distinctiveness of Austronesian-speaking populations from other New Guinea groups, and specific indications of southeast Asian genetic connections not found among New Guinea highlanders. Equally, however, there is evidence for the spread of genes of 'Austronesian' ancestry into non-Austronesian-speaking populations.

The evidence provided by the analysis of Welsch *et al*'s data is not the only indication that traces of phylogenetic history are to be found in New Guinea material culture. Mortars, which are one of the most strongly Papuan-associated items in the analyses described above, have a long history in highland and northern Papua-New Guinea, especially the Sepik-Ramu area, with an example from Kuk swamp in the highlands dated to >7000 BP (Golson 2000). Even stronger evidence for the significance of descent in New Guinea material culture comes from Pétrequin and Pétrequin's (1999) study of the transmission of pottery-making techniques. Their ethnoarchaeological fieldwork has enabled them to estimate relative apprenticeship speeds for different techniques. Paddle-and-anvil construction techniques take a long time to master but then allow the production of the best quality pots in the least time. Furthermore, once you have acquired a set of motor techniques, it is difficult to change to a new set. In other words, while form and decoration can evolve quickly, techniques, at least the complex ones, do not. Except under sustained outside influence, the most likely direction of change is towards gradual simplification. Pétrequin and Pétrequin (1999: 80) point to distinct contrasts in pottery vessel-building techniques between current Austronesian-speaking and non-Austronesian villages on the coast, the former using paddle techniques and the latter using coil construction methods, only finishing with paddle and anvil. They outline a sequence for the north coast of West Papua, starting in the first millennium BC with the intrusion of complex paddle construction techniques from the Moluccas to the west. Subsequently, there is closure to the west but influences from the east, with the introduction of new paddle-based techniques whose distribution is specifically coastal and associated with Austronesian speakers. Finally, there is a re-opening to the west after the 15th century, with the rapid acceptance of flat-based jars made with large ring coils, originally from the Moluccas, again associated with Austronesian-speaking populations. Indeed, apart from the strong evidence for phylogenetic continuity in material culture production traditions associated with specific groups of people and therefore with their languages, perhaps the most important point to emerge from Pétrequin and Pétrequin's study is the dynamism of the historical patterns suggested. Data solely from the ethnographic present cannot inform us about this.

In sum, if we ask, with Merriwether *et al* (1999), whether there is any evidence of the presumed package of genes, language and culture that arrived on the north coast of New Guinea c 3,000 years ago with Austronesian-speaking communities, the answer would appear to be 'yes', despite the subsequent contact and diffusion processes that have taken place, evidenced in all three domains. That this should be so should come as no surprise in the light of what we now know about the processes of cultural transmission.

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CHAPTER 9

CULTURAL TRANSMISSION IN INDIGENOUS CALIFORNIA

Peter Jordan and Stephen Shennan

INTRODUCTION

This chapter investigates the basketry traditions of Northern California. Local patterns of linguistic and cultural diversity were extremely high despite a more general dependence on similar modes of hunting, fishing and gathering, in turn related to distributions of anadromous salmonids, acorns, and deer. As a result of this complex linguistic geography, local communities – often described as 'tribelets' in the ethnographic literature – were surrounded by groups speaking related and non-related languages. Some workers have argued that the origins of these complex small-scale language distributions lay first in a series of population movements into the region, the most recent wave being the arrival of Na-Dene speakers from the North, and secondly in the need for communities to maintain control over key resource points (eg, fishing sites and acorn groves), with language functioning as a form of boundary defence mechanism (cf Jorgensen 1980). Nevertheless, the bulk of the ethnographic literature indicates that interaction across these language frontiers remained high and generally friendly in nature, with common marriages and other material exchanges between different communities leading to a significant degree of bilingualism.

At one level there was a general unity in the broader Californian basketry tradition, which Elsasser (1978: 626) ascribes to the prominence of acorn processing as a key subsistence adaptation:

> Gathering, carrying, storing, milling and cooking of acorns, from north to south, were all performed in approximately the same way; and the similarity of procedures reflected in the forms of the baskets that otherwise remotely related groups employed.

Within the framework of this broader tradition – reflected in the common presence of seed beaters, sifting baskets, trays, boiling baskets, burden baskets, storage baskets and a range of other woven containers – there was much local diversity, the origins of which are poorly understood. A general distinction is made between coiled and twined basketry weaves (Figure 9.1), with both proceeding in either clockwise or anticlockwise directions (Elsasser 1978; see Voegelin 1942; Driver 1939; Gifford and Kroeber 1937). Twining techniques are divided further into a range of methods including plain, diagonal, openwork, closework and wrapped twining. Despite much of the basketry fulfilling similar functional roles in the different communities, local shapes varied, as did decoration, with varying use of banded woven ornamentation, feathers, porcupine-quills and shell-beads (Figure 9.2).

THE EVOLUTION OF CULTURAL DIVERSITY

A PHYLOGENETIC APPROACH

Edited by

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PREFACE

This book arose proximally out of a session at the Human Behaviour and Evolution Society annual meeting that was held at University College London in 2001. Present at that session were a number of us that were interested in applying phylogenetic methods to understanding cultural diversification, be it in languages, material artefacts or behavioural and bio-cultural traits. For all of us, our interest had arisen some time earlier. In my case, I trained as an evolutionary ecologist working in zoology, then moved into human behavioural ecology; I first wrote about applying phylogenetic comparative methods to cultural evolution soon after I had joined the Department of Anthropology at University College London, when I co-authored a paper with Mark Pagel in 1994 (who at that time was at the Department of Anthropology at Harvard). Clare Holden joined me as a PhD student not long after that and has worked on phylogenetic approaches to linguistic and cultural evolution at UCL ever since. Meanwhile, Stephen Shennan, at the Institute of Archaeology at UCL, had a longstanding interest in evolutionary archaeology, and in 1999 began working on formal phylogenetic approaches to material culture with Mark Collard (in Anthropology at UCL). Archaeology and Anthropology at UCL and Archaeology at Southampton jointly put forward a successful bid to set up the AHRB Centre for the Evolutionary Analysis of Cultural Behaviour, which was up and running by 2000. Most of the contributors to this book have been members of or visitors to the CEACB at some time. We thank all the members of the Centre for their discussions of many of these papers at seminars. And we are grateful to the UK Arts and Humanities Research Board, the Wellcome Trust and the Leverhulme Trust for the funding which has made much of this work possible. This book covers our range of interests in cultural phylogenies and comparative methods to date, and includes much of the pioneering work in this field. But the field is moving forward and growing all the time – hopefully an indication of the value of this approach to understanding the evolution of human cultural diversity.

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