Cultural transmission theory and hunter-gatherer archaeology

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Abstract

Cultural transmission (CT) describes the myriad processes whereby information is transmitted from a transmitter to a recipient. Much empirical and modelling research suggests that there are many different pathways and biases through which such information is transmitted. In particular, the content, context, and mode of the transmission can structure variation over time and space in resulting information at a population level. These ideas can be applied to the archaeological record of all societies, but we explore how these ideas might inform specifically on hunting and gathering groups. CT theory suggests that hunter-gatherers, due to their smaller population sizes and simpler social structure, should be characterised by a more limited range and generally more simple material technologies, but display broader variation about a particular mean type, than other more densely populated societies. We exemplify some of these processes with two case studies from the North American Great Basin.

Author biographies

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Peter J. Richerson is a Distinguished Professor Emeritus at the University of California Davis. He is one of the major figures in the development of the theory of cultural evolution and has written widely on the subject. His first book with Robert Boyd in 1985, *Culture and the Evolutionary Process*, is a classic in the field. His work emphasizes the development of quantitative models that illuminate the evolutionary properties of human culture and animal social learning, and the processes of gene-culture coevolution.

Introduction

In this chapter, we highlight cultural transmission (CT) theory as a framework for understanding change over time and space in human material culture, with particular emphasis on how this approach can help archaeologists interpret the record. CT theory seeks to place the evolution of culture within a rigorous and scientifically-defined context, and describes the broad range of mechanisms that humans (or non-humans, in some cases) use to acquire, modify and retransmit cultural information. Such information can represent rules about eligible marriage partners, instructions for how to produce fishing nets, lyrics associated with a particular song, oral histories, gossip, or even misinformation or maladaptive information (e.g., the consumption of brains of dead relatives or the use of lead glazes on drinking cups). Many applications of CT attempt to define these mechanisms mathematically and to model their effects over time (e.g., Bentley 2005; Bentley and Shennan 2003; Boyd and Richerson 1985; Cavalli-Svorza and Feldman 1981; Henrich and Boyd 1998; Mesoudi and Lycett 2009).

By definition, CT applies to all humans over all time, hunter-gatherers, agriculturalists, and members of industrial societies alike. However, we attempt to highlight below more particular intersections between CT and hunter-gatherer lifeways. Although the processes of CT are similar, there are reasons to believe that certain modes of transmission will be dominant in hunter-gatherer settings. In this respect, we argue that CT has a predictable effect on structuring material culture and has a recognisable signature in the record of hunter-gatherers.

A common misconception about CT is that it only involves biological selection (e.g., individuals that do not survive are not able to pass on cultural information, resulting in selective or differential removal from the existing 'database' of cultural information; see also Dunnell 1981; Shennan 2006). While such processes are often included in CT modelling, we will argue that most of what is interesting about the predictions of CT stems from other processes, particularly human inventiveness and the biased, comparatively rapid, spread of useful (and sometimes distinctively non-useful) innovations, within and between populations. The accrual of such information and subsequent winnowing and modification is in many cases largely independent of the survival rates and fecundity of individuals. This is not to say that genes and biology are unimportant in CT processes. The human phenotype, including, for example, the structure of the brain, clearly affects how people acquire, sort and store cultural information (e.g., accuracy and ability to recall information; e.g., Gabora 2004; Sperber 1996). Likewise, genetically-controlled differences in manual dexterity affect the ability of individuals to materialise cultural information, and likewise, their ability to retransmit it (Eerkens 2000; Kerst and Howard 1984; Lachnit and Wolfgang 1990; Moyer *et al*. 1978). At the same time, culture, via gene-culture coevolution, could well have influenced the genetic evolution of such things as manual and linguistic skills (Laland *et al*. 2010; Richerson and Boyd 2010), and there is much to learn regarding the interplay between Genetic Transmission GT and CT for specific human traits.

Although CT has been used to explain learned behaviour among some non-human species, such as birds (Bonner 1980; Slater and Ince 1979), fish (Brown and Laland 2003), dolphins (Krützen *et al*. 2005), and elephants (Poole *et al*. 2005), the human propensity for social learning has put anthropological and archaeological studies at the forefront of CT theory-building and testing. For example, chimpanzees are able social learners compared to most non-humans, but have a much lower natural (i.e., instinctive) propensity for imitation and social learning, as elegant comparative experiments have shown (e.g., Tomasello 1996; Whiten and Custance 1996). Because of the diachronic nature of most archaeological studies, the focus on material culture within archaeology, and the fact that material culture is an aspect of human behaviour that is transmitted entirely through cultural means, archaeology is uniquely situated and has an important role to play in understanding long-term (i.e., macro) CT processes.

CT defined

CT should be thought of as a specific model within the more general class of inheritance systems, where information, be it genetic, language, or material culture, is passed between sources and destinations. The specific inheritance systems differ in their details, for example, the form and context in which information is transmitted (e.g., as DNA or as verbal instructions), how information is received and stored (e.g., encoded within chromosomes, or remembered within the brain), the fidelity of such information transfer (e.g., copying error), and how individuals subsequently act upon information received (e.g., modification, transformation). These dynamics greatly influence the overall evolutionary trajectories of genes, material culture, language, and the like, but at their most fundamental level, all inheritance systems share some similarities in how they operate over time.

A nice feature of such inheritance systems is that they can be modelled using recursive equations or as Markov Chains, facilitating the analysis of change (or stasis) over time. Such equations have been well-studied by mathematicians (e.g., Ewens 1979; Meyn and Tweedie 1993) and as a result, many Markov equations can be solved analytically (e.g., with mathematical equations with known solutions). Furthermore, with modern computers, extremely complex Markov processes can be analysed empirically, and equations that do not have defined analytical solutions can be examined and solved through computer simulation. From these efforts, anthropologists and others have been able to describe some of the regularities and patterns that should describe the transmission of cultural information, in other words, allowing researchers to *predict* the short- and long-term effects of CT. Thus, these two approaches, mathematical modelling and computer simulation, facilitate a scientific approach to CT studies, where hypotheses drawn from theory can be modelled and tested against actual data from the archaeological or anthropological record.

Commonly, mathematical modellers use the tools of population biology to study cultural evolution. The general form of such models is:

$$P_{t+1} = P_t + \sum_{i}^{n} forces$$

Where P_t is some property of the population (say the frequency of a particular stone tool type) at time t, P_{t+1} is the property of the population at time $t + 1$, and $\sum_i^n forces$ represents the combined effects of the processes acting to change the population over time. For example, suppose we are interested in the change over time in a stylistic feature of stone points, for example ribbon pressure flaking (i.e., where flake scars are long, parallel, and run across the entire surface of a flaked tool). An aesthetic force might favour new variants as knappers become bored with the common design, while utilitarian forces might favour a variant with the least drag and best penetration. A theoretical investigation might focus generically on the way aesthetic and function biases interact to generate evolution by picking forms for the two processes and iterating the model algebraically or by computer simulation (Boyd and Richerson, 1985; Cavalli-Sforza and Feldman 1981). An experimental study might ask participants to iteratively design projectile points on a computer, simulate their performance, and allow performance information to be exchanged between participants, in a time-transgressive manner (e.g., Mesoudi and O'Brien 2008), or have participants listen to, and subsequently retransmit, a narrative, observing where information is modified, innovated, or deleted (e.g., Mesoudi and Whiten 2004). A field study would attempt to use the archaeological record to infer the forces in operation in a sequence of change within a particular social and physical setting (Eerkens and Bettinger 2008; Eerkens and Lipo 2005).

Genetic transmission has been well-studied and many, though certainly not all, of the details have been worked out. By comparison, there has been much less research on CT, though the literature is rapidly expanding (for recent works see McElreath *et al*. 2008; Mesoudi and Lycett 2009). As a result, much of the scientific study of inheritance systems has focused on GT instead of CT. One of the main reasons for this, we believe, relates to the fact that many social animals use simple forms of transmission. Humans are unique in the sheer quantity of information transmitted culturally. For example, it has been argued that humans have highly evolved cognitive and communication skills to quickly and efficiently acquiring generic cultural knowledge, such as recognising eye contact and the use of social referencing to interpret emotional displays (e.g., Csibra and Gergely 2009; Gergely *et al*. 2007). These mechanisms allow humans, but apparently no other animal, to evolve extremely complex cultural adaptations by successive innovations and transmission (Boyd and Richerson 1996; Tomasello 1999).

A second difficulty in studying CT is that the majority of species that do use CT to transmit information (e.g., humans, chimpanzees) are long lived, making empirical study, especially long-term evolutionary outcomes, difficult. Progress has been made in this regard using laboratory experiments of CT (e.g., Mesoudi 2007), but there is much still to be understood. By contrast, scholars studying GT can turn to short lived species (e.g., peas, bacteria, fruit flies) to study such long-term effects and such empirical studies have led to many refinements of GT theory.

Theory and empirical evidence suggest a number of means by which cultural information can be transmitted between individuals. CT processes vary in terms of the information content, the context of transmission, the mode of transmission. Table 7.9.1 presents some of the possible variations (see Eerkens and Lipo 2007 for a more complete review and discussion of these ideas). These interacting factors affect the rate and accuracy of information transmission, which has important implications for evolutionary processes. As well, these processes act on both the originating (i.e., source) and recipient (i.e., destination) sides, Tehrani and Riede (2008) have recently referred to the process of teaching and learning together as 'pedagogy' and discuss the significance of such an approach to archaeologists (see also Caro and Hauser 1991; Thornton and Raihani 2008 for a discussion of these ideas among animals).

Content	**Context**	**Mode**
Complexity of information (e.g., length, familiarity)	Environment of transmission (e.g., ritual, school, family)	Number of people (e.g., one-to-one, many-to-one, etc.)
Form (e.g., verbal, written, visual)	Cultural (e.g., foreign vs. domestic)	Direction (e.g., horizontal, vertical, oblique)
Degree of repetition		

Table 7.9.1. Content, context, and mode of information transmission

As well, transmission is affected by the operation of various cognitive or psychological biases that affect from and to whom information is differentially transmitted, and how this information is packaged, stored, and subsequently modified (see Boyd and Richerson 1985; Henrich and McElreath 2003 for more extensive discussions). Table 7.9.2 presents some of the commonlydiscussed biases, though others are certainly possible. Much research in CT examines the evolution of the biasing mechanisms themselves (e.g., is copying a prestigious person hard-wired or learned behaviour; e.g., Efferson *et al*. 2008), their universality among different cultures (e.g., Henrich *et al*. 2006), and their cumulative effects on culture over time. Cognitive biases, too, affect the rate and accuracy of information transmission. The biases listed in Table 7.9.2 affect primarily the recipients of cultural information. Less theorising has been focused on cognitive biases that might affect the transmitters, though some archaeologists (e.g., Spencer 1993), have considered how aspiring leaders might use biased transmission systems to increase their power base and/or authority.

Information acquisition	**Information packaging**	**Information modification**
Frequency-dependent (e.g., conformity, pro-novelty)	Independent-biases (e.g., hitchhiking / info. bundling)	Copying error
Model-based (e.g., prestige, success, similarity)	Acquisition of traits one at a time from a range of models	Filtration through individual worldview
		Purposeful innovation (e.g., directed vs. undirected)

Table 7.9.2. Cognitive biases in CT

The exact nature and universality of such biasing mechanisms has been debated. In any case, the interaction of the different biasing mechanisms with different content (e.g., auditory vs. visual; complex vs. simple), learning contexts (e.g., ritual vs. apprenticeship vs. domestic), and modes create a myriad of different transmission pathways. This complexity makes application to the archaeological record, where we may not be able to reconstruct all the different factors, challenging. However, as others have shown (and we hope to highlight below), there is interpretive ground to be gained by such applications.

CT and archaeology

Many of the basic ideas about the transmission of cultural information have been with anthropologists since the late 1800s. For example, Franz Boas (1896, 3-4, quoted in O'Brien and Lyman 2002, 229) suggested a general algorithm for understanding similarity in human cultures: the closer people lived to one another the more similar cultures should appear because similarity in culture was most likely due to dissemination of cultural information (as opposed to independent origin). Boas later suggested that most of the cultural inventory of a society was the cumulative result of 'diffusion' from neighbouring cultures (Hatch 1973).

Anthropologists such as Holmes (1886), Petrie (1899), and Kroeber (1916) were quick to pick up on these ideas, and to develop them further, to help explain similarity and/or difference in the archaeological record. For example, Kroeber (1940) considered how small errors during diffusion affected the distribution of culture-historical types over space and time. This view of culture included most of the important elements of a Darwinian evolutionary system, including the transmission of information (cultural in this case), mutation of that information (through copying errors), and retransmission of this information in the modified state. The only major Darwinian element lacking from this view is the notion of various global selective forces that winnow out some of these mutations. Today, such refinement of CT continues, and has focused on more rigorous and mathematical definitions of the specific processes involved. CT is being used by an increasing number of researchers in a diverse array of academic fields including anthropology, archaeology, biology, economics, and psychology, among others.

What is particularly relevant to archaeologists is not the ability to see and reconstruct every transmission event, but to deduce how transmission content, context, mode, and cognitive biases affect patterns in information and hence material culture, especially at a societal level (Eerkens and Lipo 2007; see also chapters in O'Brien 2008). Theory suggests that such patterning is likely to be evident especially in measures of information diversity or variance (e.g., Bettinger and Eerkens 1999; Eerkens and Bettinger 2001; Eerkens and Lipo 2005; 2007). In short, CT theory makes few predictions about modal or average tendency in assemblages of artefacts, but is more specifically concerned with measures of dispersion or variation. Testing CT theory then, requires population-level measures of dispersion or variation and archaeology is one the few, perhaps the only, discipline that can generate the necessary data to do so, especially for long-term outcomes. For example, direct extrapolation of evolutionary processes measured in the short run by direct observation are often very different from long run averages (Gingerich 1982). This is probably because evolution frequently meanders and reverses direction. Evolution observed over longer spans of time depicts long-term trends that average out much of the small-scale fractal variation that a direct observer of human transmission might see. Furthermore, many of the cultural traits transmitted by animals, such as birdsong, leave little material evidence behind, again, leaving archaeology as the main discipline that can contribute to the testing of predictions from CT over the long-term. Humans, of course, have especially excelled at the use of material culture, which archaeologists readily recover and study, and nearly all of material culture among humans is transmitted via cultural information (e.g., is not instinctive). For these reasons, archaeologists should take an active interest in developing and testing CT theory.

CT and hunter-gatherers

As mentioned in the opening paragraphs, CT has no *special* relevance to hunter-gatherers. There is nothing to suggest that economic mode of subsistence, in and of itself, has implications for how people transmit cultural information. However, because a number of other factors, such as lower population density, less complex material technologies, and simpler social organisation *tend to* characterise hunter-gatherers, CT has important implications for how material culture might evolve among hunter-gatherers versus other groups. In the sections below, we define some models derived from CT theory, focusing on those that we think have special relevance to hunter-gatherers. We believe that some of these ideas could be expanded to include other aspects of hunter-gatherer lifeways such as niche construction (e.g., Laland and O'Brien 2010; Rockman 2009), but do not pursue those issues here, focusing instead on material culture.

Effects of population size and density

Cross-cultural research shows that hunter-gatherer groups tend to live at lower population densities and sizes than agricultural or industrial ones (Kelly 1995; Winterhalder *et al*. 1988). As well, CT modelling suggests that population size, especially the number of transmitters and receivers, affects the range of information that can be retained within a cultural system. For example, Henrich (2004) attributes the loss of a number of complex material technologies in ancient Tasmania to rising Holocene sea levels that cut Tasmania off from mainland Australia. This isolation dramatically cut the effective population size and the ability to retain and transmit complex technologies. Kline and Boyd (2010) detected a similar pattern in the Pacific Islands. Similarly, Richerson *et al*. (2009) argue that the appearance and subsequent disappearance of more complex lithic technologies during the Middle Stone Age of Southern Africa (e.g., Howiesons Poort) may be due to an uptick in effective population sizes that could not be sustained in the long run. Such notions are in line with others such as Diamond (1998), who argued that such an effect operates at all sizes of populations, not just small-scale ones, and recent modelling research by

Shennan (2001) and Powell *et al*. (2009), which shows that population size and connectedness have a positive relationship with the maintenance of complex cultural information.

Thus, CT theory predicts that, due to their smaller population sizes, hunter-gatherers in general ought to be characterised by a more limited range of material technologies than agricultural and industrial ones (e.g., Powell *et al*. 2009; Richerson *et al*. 2009). This result is not especially surprising, but might explain the long periods of apparent stasis witnessed in Lower and Middle Palaeolithic sites in the Old World. In those sequences, a narrow range of tools and technologies characterise tens to hundreds of thousands of years. As well, this line of reasoning may explain the explosion in the diversity of material culture observed during the Mesolithic and Neolithic periods as global climates warmed in the Holocene and populations appear to have grown (Shennan 2001). Likewise, the rapid evolution of very complex artefacts beginning with the industrial revolution involved both large numbers of communicating innovators and the expansion of formal education that made the transmission and storage of complex information much more efficient. Donald (1991) ranks the development of literacy and numeracy one of the major human cognitive advances, although they are cultural not genetic innovations.

Effects of information content and complexity

CT theory also predicts that the form in which information is transmitted (e.g., written, verbal, visual instructions) and the complexity of this information (the length and regularity of instructions; see Gell-Mann and Lloyd 2003) should affect fidelity and the preferred mode of transmission. For example, written instructions are likely to be transmitted with greater fidelity than verbal or visual ones, and given a particular transmission mode, complex information is subject to greater copying error (lower fidelity). Likewise, while simple technologies are subject to more tinkering and experimentation, the attributes of complex technologies are often transmitted together as part of information packages. This leads to greater linkage or correlation between the attributes or components of a complex technology.

Lacking writing, hunter-gatherers transmit information via verbal and visual means. Hence, one prediction of CT theory is that within a particular technology, there should be greater variation in the size and shape of tools than among societies where technological information is transmitted primarily by writing. Similarly, because hunter-gatherers tend to have simpler tools (as per the reasoning above), all other things being equal, we expect more tinkering and experimentation with these technologies, per capita, than more complex ones that characterise agricultural and industrial ones. The net result of these effects is that hunter-gatherer material technologies should have fewer technologies and artefact 'types,' but a broader range of variation about a particular mean, and less covariation between attributes within a type. By contrast, material technologies among agricultural and industrial societies should be much more diverse overall (e.g., more types), but with less variation about means within a technology (or artefact type) and greater covariation between the attributes of those technologies.

Testing these hypotheses derived from CT theory will require collecting large sets of data across diverse ecological and temporal scales, and examining diversity and variation in artefact types, and covariation among attributes within types. Limited data sets examined by Eerkens and Bettinger (2008; Bettinger and Eerkens 1999) for just hunter-gatherer groups of different population densities generally support these notions. However, additional comparisons using other data sets are clearly necessary.

Effects of social organisation

Many, though certainly not all, hunting and gathering groups are characterised by simpler social organisations, generally lacking formalised and/or institutionalised positions of leadership (e.g., Fried 1967; Service 1962). In such settings, social and political organisation tends to be much smaller in scale and localised. As a result, individuals tend to have greater interaction with the members of their immediate group, and more limited contact with people living in more distant locations. In more complex societies, individuals from a wider range of social and political settings are often brought together (e.g., in markets or urban living), where they may acquire and transmit cultural information.

Individuals in smaller and simpler groups are apt to acquire information through social learning (e.g., copying) and individual learning (e.g., experimentation) in frequencies similar to their counterparts in more complex societies. However, the low degree of political organisation in hunting and gathering groups will tend to limit the spatial extent over which material culture will spread (e.g., Powell *et al*. 2009; Richerson *et al*. 2009). For material culture that contains a high degree of stylistic information (as conceived by Dunnell 1978; see also Rogers and Ehrlich 2008), that is, where environmental or other 'global' conditions do not greatly influence performance characteristics (see Eerkens and Bettinger 2008), this should result in smaller and more localised distributions of attributes or artefact styles. In the archaeological record, this should appear as culture-historical ‘units’ with more restricted spatial distributions.

By contrast, in societies with large-scale political or social organisation, and by extension, larger-scale economic organisation, cultural information has the potential to spread more quickly and over a larger area. Indeed, some political organisations may deliberately encourage or even force the adoption of a particular technology or production system across their sphere of influence or control. For artefacts imbued with stylistic information and/or produced under conditions of craft specialisation (e.g., economic organisation), this should be reflected in the archaeological record by culture-historical units with broader spatial distributions. Turning this back to predictions about variation and diversity of material culture, among hunter-gatherers we should expect to see lower diversity of artefact types as there is less transmission of ideas across larger social units, and greater variation per unit area for stylistic artefacts due to the more localised nature of transmission systems. Agricultural and industrial systems should be marked by the opposite patterns, greater diversity and less variation within a type. These predictions are the same as above.

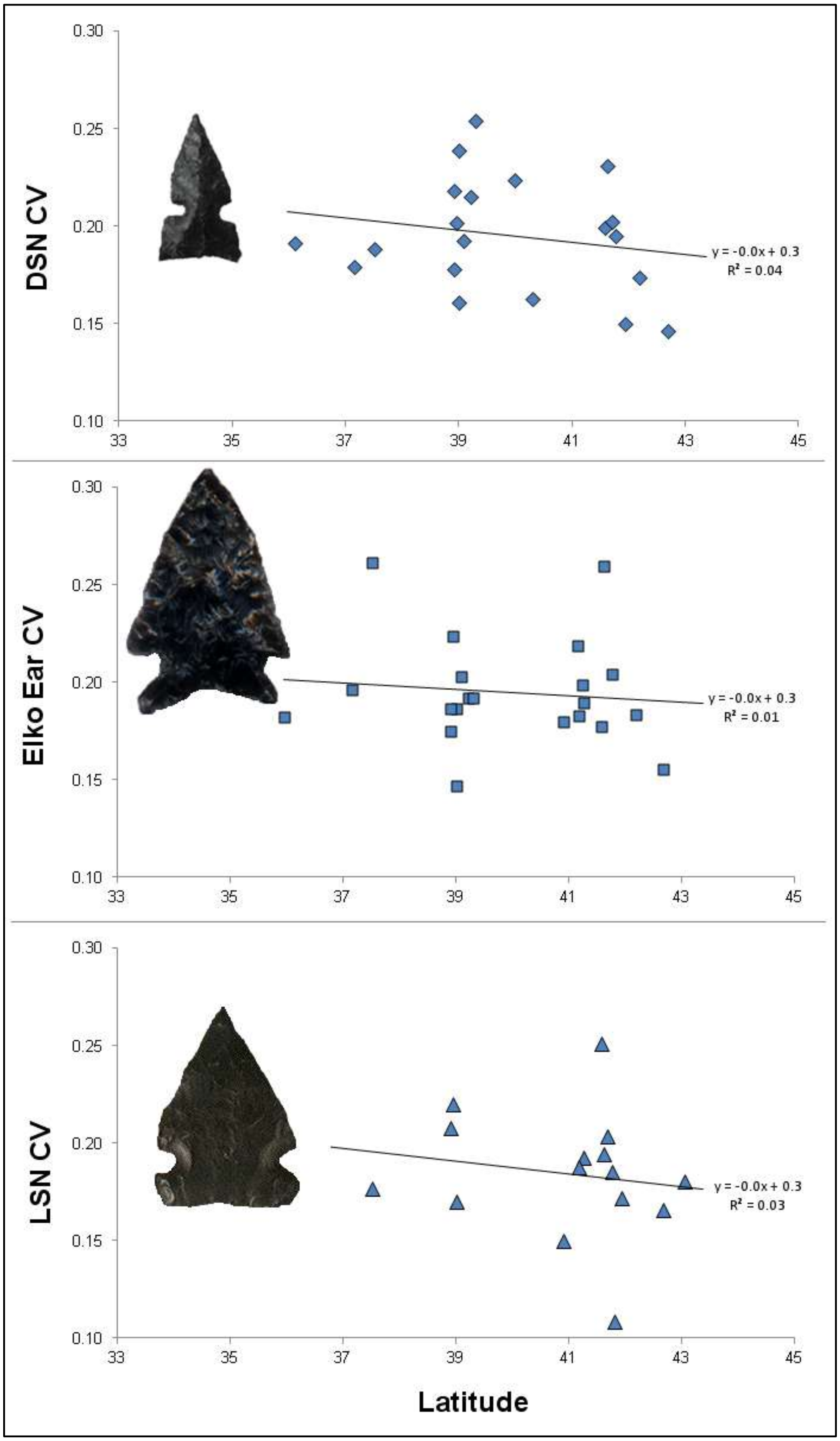
Potential for application

The application of culture transmission theory to the hunter-gatherer archaeological record does not require, but benefits immeasurably from large, geographically diverse suites of data. For example, Eerkens and Bettinger (Bettinger and Eerkens 1997; Eerkens and Bettinger 2008) have made extensive use of statistics that summarise variation in a sample of more than 5000 projectile points from nearly 40 individual site and survey collections representing all major sub-areas of the Great Basin, and more than seven thousand years of its prehistory, graciously made available by David Hurst Thomas. As detailed elsewhere (Bettinger and Eerkens 1997; Eerkens and Bettinger 2001), the coefficient of variation (CV, standard deviation divided by mean) is appropriate to the study of variation in such collections because it corrects for a near-universal scalar relationship between mean and standard deviation that prevents comparison between variables with different means using standard deviation alone. This mean-standard deviation relationship is particularly marked in Great Basin projectile points, the regression of the standard deviation on the mean being essentially identical for all major metrical variables (maximum length, axial length, maximum width, neck width, and thickness). Mean CV (CV averaged across all metrical variables) thus provides a fair representation of overall variation of a given point type in a given Great Basin collection. CV and related measures (see Eerkens and Bettinger 2001) are salient in archaeological studies of cultural transmission, which has fairly straightforward implications about artefact variation. As noted above, for example, cultural transmission will produce greater trait variation in smaller populations than larger one.

Myriad other forces, many directly connected with environment, also affect cultural transmission and trait variation (e.g. Eerkens and Bettinger 2008). For example, three particularly well-defined Great Basin point types – Desert Side-notched, Large Side-notched, and Elko Eared – show a small but nevertheless consistent decrease in mean CV at higher latitudes ($r_{\text{Desert Side-notched}} = -.20$; $r_{\text{Large Side-notched}} = -.16$; $r_{\text{Elko Eared}} = -.10$). There are many potential explanations for this, the most likely being the greater dependence on hunting among Great Basin groups at higher latitudes ($r_{\text{latitude-hunting}} = .34$, $n_{\text{groups}} = 39$; Binford 2001). That projectile point mean CV decreases along with this suggests the hypothesis that as hunting becomes more important, hunters are increasingly inclined to standardise the projectile points they use, perhaps by more carefully copying the points knapped by good hunters, Desert Side-notched, Large Side-notched, and Elko Eared all showing this basic environmental relationship. Figure 7.9.1 shows these relationships for these three point styles, graphing the mean CV by latitude.

Environment, however, is unlikely to account for differences across these same three point types in the relationship between mean CV and sample size. In theory, mean CV should vary independently of sample size; it will vary more across small samples than large ones drawn from the same population, but the mean of many small samples and many large samples, both measuring mean CV, should be the same. This expectation holds for Large Side-notched and Elko Eared points, where the effect of sample size on mean CV is weak and conflicting, slightly increasing in Large Side-notched points ($r_{\text{Large Side-notched}} = .06$), slightly decreasing in Elko Eared points ($r_{\text{Elko Eared}} = -.13$). In Desert Side-notched points, by contrast, mean CV is very strongly, and inversely, correlated with sample size ($r_{\text{Desert Side-notched}} = -.52$). While sample size is jointly determined by a host of factors, including sampling intensity, that Desert Side-notched mean CV varies so strongly with sample size suggests that in this case sample size is closely tied to assemblage size, and potentially, population size. While this is not a particularly strong test of the hypothesis that cultural transmission reduces trait variation in larger populations, it demonstrates the kind of data and statistics appropriate to testing the implications of cultural transmission theory in the archaeological record.

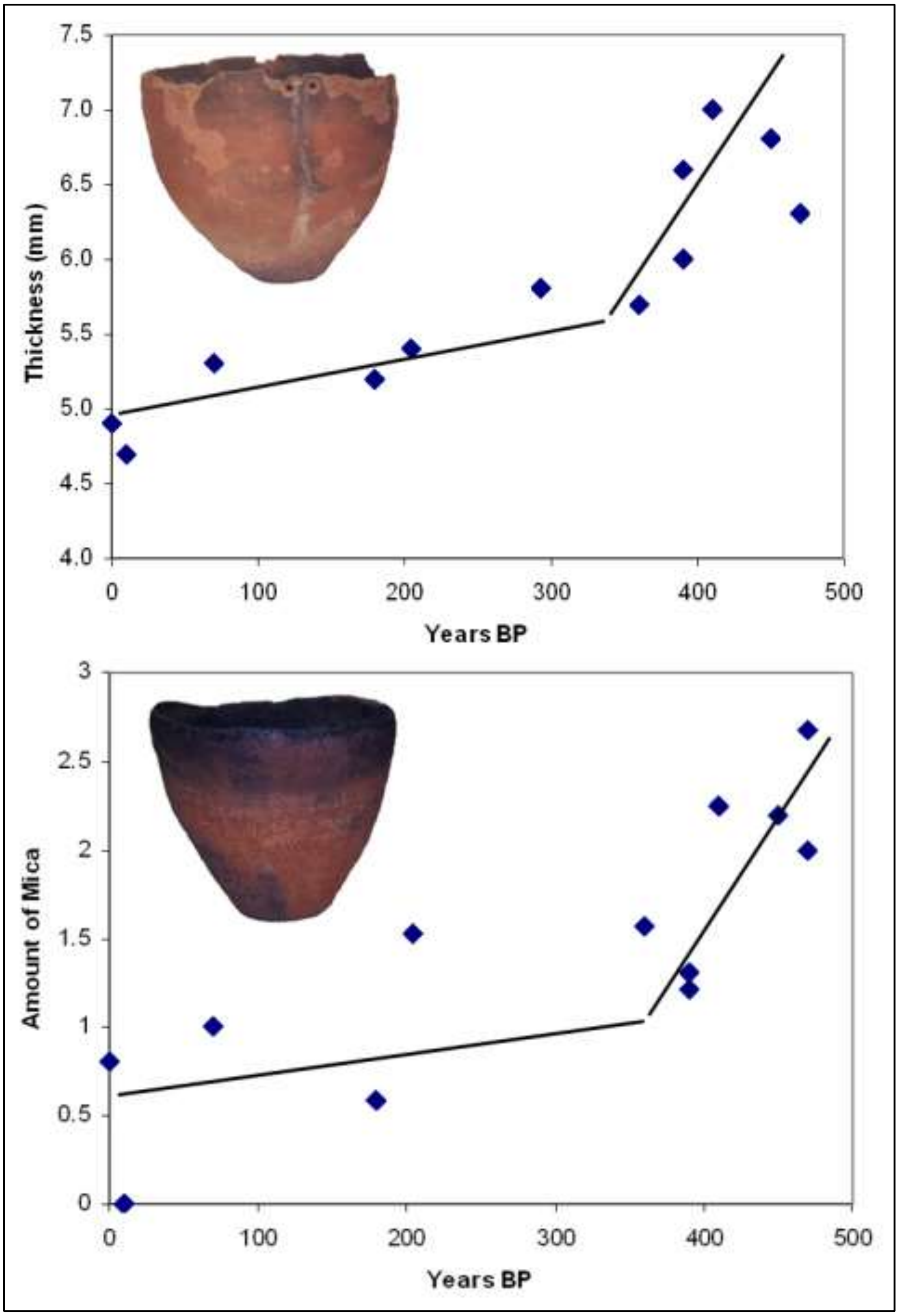
Figure 7.9.1. Variation in means, as measured by CV, with latitude in three projectile point types in the North American Great Basin. The graphs show a weak but consistent effect where points become less variable with increasing northerly latitude.



A second case study examines variation over time, rather than space. Theory in both biology (e.g., Gould *et al*. 1977) and anthropology (e.g., Lyman *et al*. 2009) predicts that new forms typically exhibit a period of rapid innovation or diversification following their introduction, with gradual winnowing thereafter and a slowing of innovation. Following the adoption of a new technology people attempt to fit the craft within existing social systems and learn to use local resources to fashion those goods. The hunter-gatherers of southern Owens Valley in south-eastern California began experimenting with ceramic technologies around 1200 years ago and the technology became widespread after 700 years ago (Eerkens 2003; Eerkens *et al*. 1999). We expect high rates of experimentation following the introduction of this technology, with people gradually settling on the forms and production techniques that best fit local lifestyles thereafter.

Figure 7.9.2 shows changes in the thickness of pot sherds (top) and a qualitative measure of the amount of mica (bottom) over time, for assemblages of pot sherds from radiocarbon-dated houses in Southern Owens Valley, south-eastern California. Two pots are also shown, one in each panel, as examples of typical forms for this ceramic tradition. Thickness is believed to relate to the function of pots, especially a balance between heating efficiency (thinner is more efficient) and strength (thicker is stronger), while the amount of mica is believed to relate mainly to the source of the clay that potters used. As shown in the figure, both attributes vary over time, with pots decreasing in thickness and decreasing in the amount of mica that is present. However, the rate of change is faster earlier in time, before 350 BP, for both attributes, and slower thereafter, as indicated by the black trend-lines. Greater experimentation, or innovation, with potting technologies is evident early when the craft was relatively new. This experimentation seems to have included changing the form of pots as well as the sources of clay. After 350 BP, innovation and rates of change slowed for these attributes as potters became familiar with the technology and the local sources of raw material (e.g., clay and temper). Again, the predictions from CT are borne out by archaeological data collected at the right temporal scale.

Figure 7.9.2. Variation over time in the thickness and amount of mica in pottery assemblages from radiocarbon-dated houses in southern Owens Valley. The figures show higher rates of experimentation and change before 350 BP, and less afterwards as the technology becomes commonplace.



Discussion and conclusions

At its most basic, CT is simply a means to explain how cultural information is transmitted between individuals. This is how CT theory was applied in the early part of the twentieth century. However, in the last several decades CT theory-building and modelling exercises now provide archaeologists with rich explanatory framework to interpret and make predictions about the archaeological record, especially at different temporal and spatial scales.

In our view, the most powerful aspects of CT relate to predictions about variation and diversity in material culture, and changes over time and space therein. Although the majority of these predictions relate to other aspects of human societies, some of these predictions are of special relevance to hunter-gatherers. Thus, the population size and density of most hunter-gatherers, the types of tools they tend to produce, and the means by which they transmit culture (verbally and visually), is likely to structure the material culture left behind by such peoples. In particular, CT theory predicts a more limited range of tools (i.e., less diversity) for hunter-gatherers, but greater variation within a particular tool type, compared to subsistence strategies that support higher population densities.

One interesting aspect of these predictions regards the rate of evolutionary change within such material technologies. Rates of change in the diversity of technologies should be strongly and positively linked to population size. On the other hand, rates of change within a particular technology should not, but may be more strongly tied to the amount of time a technology has been used within a particular socio-economic setting. Thus, hunter-gatherer ceramic or bow-and-arrow technologies should change just as rapidly (and we specifically refer to change in within-type variation), if not more so owing to higher copying error, or drift-like effects, than agricultural or industrial ones. Of course, such changes may degrade the functionality of certain implements, which may cause them to be abandoned.

Owing to the nature of the data we collect, namely material culture as it appeared at different points in space and time, archaeology has much to contribute to CT studies. Testing hypotheses derived from theory with actual data is one aspect of this, but we hope that future research will also contribute to CT theory-building. As we have shown, certain aspects of hunter-gatherer culture, especially long-term evolutionary change, can be informed and understood by CT. We hope that others will agree and continue to apply these ideas to other parts of the archaeological and ethnographic record.

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List of figures

Figure 7.9.1. Variation in means, as measured by CV, with latitude in three projectile point types in the North American Great Basin. The graphs show a weak but consistent effect where points become less variable with increasing northerly latitude.

Figure 7.9.2. Variation over time in the thickness and amount of mica in pottery assemblages from radiocarbon-dated houses in southern Owens Valley. The figures show higher rates of experimentation and change before 350 BP, and less afterwards as the technology becomes commonplace.