10

Evolutionary Implications of Metrical Variation in Great Basin Projectile Points

Robert L. Bettinger
University of California, Davis

Jelmer Eerkens
University of California, Santa Barbara

ABSTRACT

We used a sample of 5285 Great Basin projectile points to test several implications of the general prediction from Neo-Darwinist culture transmission theory that variation in a socially-transmitted behavior will vary inversely with: 1) its complexity; 2) the complexity of the social and technical context in which it occurs; and 3) the number of individuals that contribute to its transmission. Statistical analysis of these points demonstrates that 80% of the variation in metrical attributes (e.g., length, width) is accounted for by the mean of the attribute, suggesting that this variation is independent of the transmission process and primarily due to production in which error tolerances are relative, not absolute. The remaining variation, specifically, metrical variability that is substantially greater or less than normally occurs as a consequence of these relative production tolerances, is only partly consistent with transmission theory expectations. More complex point shapes show less metrical variation than simple forms, and arrow points show less metrical variation than dart points, as predicted. There is substantial variation by section, point type, and measurement, however, that remains unexplained by the transmission hypothesis.

INTRODUCTION

We note an unfortunate parallel between evolutionary archaeology and the weather: everyone *talks* about it but no one *does* anything about it. We think this is the fruit of research strategies charted some time ago in response to a debate among processualists about what was wrong with the New Archaeology and what should be done about it. In that case, the middle-range theorists (e.g., Binford 1977a,b, 1978a,b, 1979; Thomas 1986, Grayson 1986) held that the New Archaeology suffered from faulty arguments about the archaeological record itself, and what was needed was a set of tools that would permit direct engagement between theory and the archaeological record. A second group, mostly composed of individuals enamored with neo-Darwinian evolutionary theory (e.g., Dunnell 1980), held that the problem with the New Archaeology was more fundamental and had to do with flaws in its governing general theory – Whitean

culture evolutionary theory (White 1959), for which some version of neo-Darwinian evolutionary theory should be substituted.

It seems quite clear to us, nearly two decades down the road, that these two programs cannot possibly succeed independently: middle range research requires uniformitarian assumptions and principles directly guaranteed by general theory (Bettinger 1987). And general theory, especially neo-Darwinian general theory, is far too complex and theoretically ambiguous to be articulated in the absence of specific case studies that show how particular components of the theory are to be interpreted. To us, this means it is pointless to debate the philosophical complexities of evolutionary theory in the abstract. The winning version will not necessarily be the most conceptually elegant. Nor will it necessarily be the one that seems most compatible with what we now think we know about the course of human culture history. It will be the one that can be applied to real cases so that we

know more following the application than we did before. We intend here to provide such an example of an evolutionary analysis using a common subject matter (projectile points), common metrical data (length, width, etc.), common statistics (mean and standard deviation), and a middle range measure that relates patterning in the subject matter to theory.

BACKGROUND

It is hardly a secret that archaeologists are fascinated by projectile points. Much of this has to do with the fact that we think we know how and why projectile points were made and find enough of them so that we can regularly use what we know to make inferences about the past. Archaeologists, however, are probably more captivated by projectile point morphology. Projectile points seem to come in distinct shapes and sizes, varying outwardly in ways that are easy to measure. This diversity has been attributed to a wide range of factors of fundamental interest to the archaeologist, including time (Lanning 1963), function (Fenenga 1953), technology (Ericson 1982:144), and ethnicity/culture (True 1970:54). That it is difficult to decide which of these dimensions is mostly responsible for the variation observed in a given collection of points does not preclude the use of point morphology to index these dimensions. It is quite possible to devise a perfectly workable projectile point chronology without knowing why it works (e.g., Hester 1973). Nor is one required to argue that chronology is all that is being reflected in a projectile point typology that happens to tell time (e.g., Clewlow 1967). Regardless of root process, the same point classification can provide useful information about several archaeological dimensions. This makes it possible for one archaeologist to see in it function and another ethnicity, neither being sure why – but sure just the same that it is there because it seems to work. This is not something one wants to advertise. Closely inspected it amounts to an admission that we cannot distinguish the archaeological consequences of processes that theory tells us are separate and important. We think that some of the reasons for this have to do with the way archaeologists have developed, used, and thought about their classifications.

Traditional archaeological classification has understandably emphasized the definition of categories and means for identifying them. Here, what one wants to know most about the classification is whether it reliably indexes important dimensions: "good" ones do, bad ones don't. Most of the effort expended in describing different categories attends to attribute central location (mean, mode, median), which, in well-behaved attributes, is often linked to a material or symbolic function. For example, differences in the sizes of types of projectile points are often attributed to intended use (big vs. small game) or weapon type (atlatl vs. bow; e.g., Lanning 1963).

Much can be learned from this approach, but we think the emerging interest in evolutionary models and explanations justifies reversing the traditional logic of classification to ask what makes items in the same taxonomic category unlike. To do this we employ a measure of attribute dispersion akin to the coefficient of variation (i.e., standard deviation divided by the mean; Simpson, Lewontin & Roe 1960), to gauge the differences that exist between items within a category rather than those that exist between categories. We then use this to make inferences about cultural transmission in the populations these categories represent.

The contrasts between this approach and the traditional one, which emphasizes attribute central location, are not earth-shaking but they are important. Each measure of central location can be thought of as telling us about a commonality shared by items in a category, to which they are being driven by all the forces that make the category a category. Characterizing a category on this basis is problematic in two respects. Firstly, it is unclear whether all attributes are equally affected by the forces that "make" the category, for example length vs. thickness. Measures of central location provide no clues in this regard. They describe the commonalties uniting items in the category without telling us whether all those commonalties are equally important. It is implicitly assumed, of course, that most categories comprise a few salient, or key, attributes whose behavior is stable relative to that of the many more non-salient attributes, for example fluting in Folsom points. Secondly, it is much easier to statistically generalize or describe attribute central location, than it is to explain it. As just noted, most explanations of attribute central location are functional and heir to all the problems that beset such arguments (Orans 1975; Bettinger 1980, 1991).

Looking at archaeological categories from the perspective of attribute dispersion brings us a little closer to solving these problems. Dispersion can be thought of as measuring the extent to which an attribute is subject to stabilizing or centripetal forces, which account for its mean, and random or centrifugal forces, which account for its variance. This obviously has important implications for how we interpret and characterize our categories. Perhaps more importantly with regard to explanation, dispersion makes us think about populations rather than archetypal forms and lends itself to interpretation in a way that central location does not. The evidence from biology suggests that, when scaled relative to the mean, attribute dispersion takes on a narrow, and fairly

stable, range of values across disparate populations and variables (Simpson, Roe & Lewontin 1960). Because of this it is possible to compare attribute dispersion in individual populations to an expected value derived from what is essentially a biological constant. Significant departures from expected values can frequently be explained in terms of simple evolutionary or ecological principles. If this applies in the case of human material culture, and our data suggest that in the case of Great Basin projectile points it does, we should be able to develop a statistic that permits characterization of attribute dispersion to a standardized scale. The Neo-Darwinian culture transmission theory (Boyd & Richerson 1985, 1987) provides a coherent framework for interpreting significant departures from this standard.

VARIABILITY AND CULTURE TRANSMISSION THEORY

At the core of culture transmission theory are four basic models of the way humans acquire cultural behaviors, each having different population-level effects on behavioral variation. In two of these, one termed *guided variation* (Boyd & Richerson 1985: 83-98), the other *direct bias* (Boyd & Richerson 1985: 137-146), traits are socially acquired, then tested by experiment. Specifically, in *guided variation* individuals acquire behaviors socially by "averaging" the behavior of one or more models (cultural parents) and then attempt to improve this acquired average behavior by independent trial and error (Bettinger 1991: 186-188). The social phase of this process levels differences between models and reduces variation at the population level. Subsequent experimentation, on the other hand, generates new behaviors, increasing population-level variability. *Directly biased* social transmission (Bettinger 1991: 188-190) is similar except that *two* alternative behaviors are socially acquired and tested, and the variant judged superior is retained unmodified. It is easy to see that, because only extant variants are tested and the winning variant is unchanged, directly biased transmission reduces population variation.[1] In short, the experimental component of guided variation increases variation, direct bias and the social component of guided variation reduce it.

The two remaining models of cultural transmission, one termed *frequency-dependent bias* (Boyd & Richerson 1985: 206-213), the other *indirect bias* (Boyd & Richerson 1985: 247-259), are both variation reducing. In each case, behaviors are acquired socially but not tested by field trial as in guided variation and direct bias. In the conformist version of *frequency-dependent transmission* (Bettinger 1991: 194-196), for example, individuals sur-

vey the local model pool, then adopt the most common behavioral variants in preference to less common alternatives. It is again easy to see that local populations will become homogeneous for attributes acquired this way, and variation will be reduced. *Indirectly biased transmission* is likewise exclusively social. In it, individuals evaluate a social model pool using preferences for a certain model profile previously acquired by social transmission (Bettinger 1991: 196-198). Models matching the profile are then copied for profile behaviors and additional useful behavioral traits functionally unrelated to the profile. For instance, individuals with socially-acquired preferences for models with high status may copy, in addition to high-status profile behaviors (e.g., clothing, mannerisms, etc.), any number of purely functional traits – house-building, for example. The social transmission of house-building behavior is then said to be *indirectly biased* by the preferred model profile, which uses status-related behavior as an indirect measure of house-building competence. This entrains a correlation between model profiles (i.e., preferences), profile behaviors, and indirectly biased traits for which the profile behavior serves as a proxy measure of competence. Intra-population homogeneity increases as a result.[2] Because indirect bias requires variation, its force will be strongest where exotic social models are routinely encountered, e.g., at boundaries between strongly contrasting adaptive strategies (Boyd & Richerson 1987). This gives indirect bias the power not only to decrease within population variation (as with frequency dependent bias), but to create, maintain, and exaggerate the behavioral differences between adjacent, but differently structured, adaptive poses.

Because guided variation and direct bias use field trial as a basis for decision-making, they are most effective in relatively simple technological settings, where alternative behaviors are susceptible to direct experiment. Using these modes of transmission each individual personally assesses the causal linkage between behavior and outcome by actual exposure and decides what works and what doesn't. However, as experimentation becomes more costly, individuals will be forced to commit to behaviors without understanding all or even most the causal connections between components or having any reasonable chance to figure them out independently. In general, one expects cultural transmission systems to respond to these circumstances by adjusting the weight of the social transmission and experimentation. A workable rule of thumb is that emphasis on social transmission will be directly proportional to the cost of trial and error, and inversely proportional to the fitness differences between alternative behaviors and social transmission costs (Pruett-Jones 1992, Boyd & Richerson 1985: 94-98).[3]

Many relevant costs of both kinds are likely correlated with cultural/technical complexity and population density. Experimental costs obviously increase as organization and technology become more complex and socially coordinated (Sugden 1986), especially where population density decreases latitude for individual behavioral flexibility. Conversely, since costly sampling errors associated with model pool averaging decrease with increasing model pool size, the costs of social transmission should decrease with population increase, provided that increase is reflected in model pool size.

One then expects cultural transmission systems to emphasize guided variation and direct bias, in that order, and the experimental component of guided variation, when population densities and techno-organizational complexity are low. As population grows and/or technology grows more complex, transmission systems should increasingly emphasize direct bias, which experiments only with extant, i.e., socially pre-tested, behaviors, at the expense of guided variation, the social component of which should increase. The importance of direct bias relative to guided variation, and the social component within guided variation, should both increase with subsequent increases in population density and social complexity, but the collective weight of both modes will gradually decrease in relation to the much cheaper, purely social modes of frequency-dependent and indirectly biased transmission. The implications of this for behavioral variation at the population level are clear. Variation should decrease as cultural/technical complexity and population density cause transmission systems to shift emphasis from experiment to model averaging social acquisition within guided variation, and from guided variation to direct bias, and subsequently from guided variation and direct bias to frequency dependent and indirectly biased transmission.

Social transmission and trial and error learning were surely both significant in prehistoric projectile point manufacture, depending on local circumstances, including complexity of intended form, tolerance of intended use and susceptibility to retouch, and population density. Point-makers and users likely experimented with morphology during production and resharpening in direct relation to expected cost and benefit. Social transmission may have been limited to simple model averaging, as in ordinary guided variation. However, as the weight of social transmission increases, alert individuals can usually do better than simple model-averagers by using relevant collateral information to rank potential models. Thus, Great Basin point-makers and users may have made choices about behavioral alternatives that involved observations about model prestige and hunting success (indirect bias) and variant frequency (frequency-dependent bias).[4]

In arguing that these predictions can be applied to understand variability in Great Basin projectile points, one need not contend that other ecological and functional processes are unimportant. Raw material type and availability, for instance, certainly constrain knapper ability to produce and resharpen idealized forms, amplifying or dampening metrical variability in projectile points. However, we are prepared to argue that, at the trans-sectional scale of this study, these effects are sufficiently "averaged out" to detect the effects of cultural transmission. The data presented below at least partly justify this assumption.

GREAT BASIN PROJECTILE POINT TYPOLOGY

The projectile point typology in most general use in the Great Basin today was developed as a chronological device in the 1960s by Robert Heizer, Martin Baumhoff, and their students at the University of California, Berkeley, on the basis of collections obtained in the course of excavations at several western and central Great Basin sites during the 1950s and 1960s (Baumhoff & Byrne 1959, Clewlow 1967, Heizer & Baumhoff 1961, Heizer, Baumhoff & Clewlow 1968, Heizer and Clewlow 1968, Heizer and Hester 1978, Lanning 1963, O'Connell 1967). They held that Great Basin points naturally segregated into distinct combinations of size and shape, that could be assigned to distinct periods of time, one after the other, that began and ended synchronously across the whole of the Great Basin. Although the nomenclature has changed, nearly all of the original series and their constituent types are still recognized (Holmer 1978, 1986; Thomas 1981): Humboldt, Large Side-notched (e.g., Northern Side-notched and Bitterroot Side-notched types), Gatecliff (Gatecliff Contracting Stem and Gatecliff Split Stem types), Elko (Elko Corner-notched and Elko Eared types), Rosegate, and Desert (Cottonwood Triangular and Desert Side-notched types).

The original scheme proved unacceptably simplistic (e.g., Aikens 1970) and has been frequently revised as new stratigraphic and radiometric data have become available from a much larger sample of sites (see Thomas 1981, Beck 1984, Wilde 1985, Holmer 1986, O'Connell & Inoway 1994 for reviews and syntheses). Of the original types, only the two major arrow point series, Rosegate and Desert, are still widely accepted as defining consecutively discrete (i.e., non-overlapping) periods that began and ended more or less simultaneously wherever found across the whole of the Great Basin (Rosegate series: A.D. 600 - A.D. 1300, Desert series: A.D. 1300 - Euroamerican contact).

The situation is much different for dart points. Humboldt, generally conceded to be the least time-sensitive of all Great Basin point types, was evidently made throughout the Great Basin during the entire period in which the atlatl was in use, ending around A.D. 600 (Thomas 1981). Large Side-notched dart points are not well defined or dated but nevertheless widely regarded as reliable time-markers in the northern, eastern, and some parts of the western Great Basin (Thomas 1981, O'Connell 1975). Most of the difficulty with Great Basin dart points centers on variants of the most important common series, Gatecliff and Elko, which seem to be time-sensitive in degrees that vary with location. In the western and central Great Basin, it appears that Gatecliff series and Elko series points do in fact characterize mutually exclusive and consecutive periods of time (Gatecliff series: 2500 B.C. - 1200 B.C.; Elko series: 1200 B.C. - A.D. 600) in much the same way that Rosegate and Desert series arrow points do throughout the whole of the Great Basin later in time (Thomas 1981, Bettinger 1989). In the eastern and northern Great Basin, however, Gatecliff and Elko display very different historical trajectories. In these areas the Elko Corner-notched type in particular displays unusual longevity and is broadly overlapping in time with Gatecliff, limiting its utility as a time marker (Holmer 1986).

The question one wants to ask is why these outwardly similar dart points display such disparate historical trajectories and why dart points in general seem more susceptible to this than arrow points. We think culture transmission theory offers the potential for explaining these differences and devote the rest of this discussion to a test of this by measuring differences in metrical variation in large collections of projectile points from different parts of the Great Basin. In general we are prepared to argue that points are time-sensitive as a consequence of the relative weighting of the social and experimental components of cultural transmission. Time sensitivity results when, for any number of reasons, the social component of cultural transmission contributing to point shape is especially large. This, of course, requires that we explain why the weight of the social component of cultural transmission should differ between different kinds of projectile points in different parts of the Great Basin.

Expectations

In general, culture transmission theory leads us to expect that the weighting of social transmission in projectile point form should vary directly with population size and technical complexity. It follows that the metric attributes of complex, high-risk, or error-sensitive point shapes should vary less than those of simpler, more robust, and easily generated shapes. It is relatively simple to assess relative complexity of form within a point series in these terms: as illustrated in Fig. 1, Elko Eared points are more complex than Elko Corner-notched points because they are essentially Elko Corner-notched points modified by basal notching or indentation, i.e., they involve one additional step. Similarly, Gatecliff Split Stem is the Gatecliff Contracting Stem form with basal notching added, and Desert Side-notched is the Cottonwood Triangular form with side, and generally basal, notching added. Large Side Notch and Humboldt points cannot be related in this way but Humboldt is a simple, shoulderless form obviously comparable to Cottonwood Triangular. Similarly, the Large Side-notched form is obviously a complex form comparable to Desert Side-notched. Culture transmission theory makes the counter-intuitive prediction that within these series pairs, the more complex form will be metrically less variable than its simpler counterpart. This explanation is consistent with the observation that Elko Corner-notched – a simple form predicted here to be more prone to experiment, hence less time-sensitive, that contributes most of the length to the so-called "long chronology," i.e., is the least time-sensitive (Holmer 1986: Fig. 6, 12, 23).

It is also reasonable to think that technical differences relating to the use of the atlatl and bow were potentially large enough to affect mode and weighting of cultural transmission and hence metric variability in dart points relative to arrow points. That arrow points are as broadly distributed in space, yet more discretely distributed in time, than dart points, suggests greater importance of social transmission in the former and lends some credence to this (Holmer 1986: Fig. 16). The obvious possibility is that bow and arrow technology is more technically complex than atlatl technology, the bow involving more and moving parts. This might discourage tinkering with arrow point shape and favor greater emphasis on the social component in cultural transmission, causing arrow points to be less variable than atlatl points. That late-prehistoric, bow-using, populations seem to have been more numerous than their atlatl-using predecessors, similarly predicts greater late prehistoric emphasis on social transmission, hence less variability within arrow points.

Differences in the temporal persistence of certain dart point forms (e.g., the Elko series), on the other hand, suggest that the details of their transmission differed by section (Holmer 1986: Fig. 23). We hazard the hypothesis that the neat, replacive succession of dart points in the central and western Great Basin is the result of cultural transmission in which the social component was heavily weighted, perhaps because population densities were relatively high. These factors combined to produce homogenous populations favoring first one form, then another. The accompanying prediction is that where these

neat patterns of dart point replacement are lacking, as in the eastern and northern Great Basin, cultural transmission was more heavily weighted to individual learning, which, perhaps because densities were lower and behaviors less socially-coordinated, maintained a large range of general forms over long intervals.

In summary, we expect: (1) complex point shapes (Desert Side-notched, Elko Eared, Gatecliff Split-stem, and Large Side-notched) to be less variable than simple ones in the same series (Cottonwood Triangular, Elko Corner-notched, Gatecliff Contracting Stem); (2) arrow points (Cottonwood Triangular, Desert Side-notched, and Rosegate) to be less variable than dart points (Elko series, Gatecliff series, Humboldt and Large Side-notched); (3) temporally persistent dart shapes (Elko Corner-notched in the eastern and northern Great Basin) to be more variable than more temporally sensitive dart shapes (Gatecliff Split-Stem, Gatecliff Contracting Stem) in the same sections, and substantially more variable than their temporally-sensitive formal equivalents in the central and western Great Basin.

The Humboldt Concave-base form furnishes a baseline measure against which these expectations can be compared. This simplest of dart point forms is nowhere regarded as time-sensitive and by the line of reasoning developed above would represent an extreme instance of the more general case of a point form maintained by cultural transmission dominated by individual learning. In this view, Humboldt was a generally-useful, easily-imitated, robust shape that could be cobbled up on the spot to suit the special needs of individual hunters. This would minimize the contribution of social transmission and cause the Humboldt form to vary widely and independently of model group size.

APPLICATION AND RESULTS

To apply this transmission-based model, we turned to data compiled in an exhaustive survey of Great Basin projectile points by David Hurst Thomas in the early 1970's (Thomas 1981). The study examined and classified roughly 5900 pieces drawn from 38 well-documented collections representing all corners of the Great Basin (Fig. 10.2, Table 10.1). The sample used here comprises 5285 specimens from 37 collections in eight areas, termed here sections: North Lake in the northern Great Basin; South Lake, Lahontan and Reno in the western Great Basin; West Central and East Central in the central Great Basin; and Tonopah and Bonneville in the eastern Great Basin.[5] Thomas measured 9 attributes on each projectile point and assigned each one to a traditionally recognized Great Basin type using criteria initially established to clas-

sify projectile points from the Monitor Valley in central Nevada. Our observations here are confined to analyses of summary metrical data from six variables measured in units of length (i.e., mm): maximum length, axial length (i.e., centerline length), maximum width, basal width, neck width, and thickness.

Talking about variability in projectile points with respect to these different measures is easier than quantifying it. One cannot simply compare variances between different point types or measures without understanding how that variance is scaled. It would be unfair, for example, to compare variances in height of corn stalks against variance in the height of redwood trees. Redwood trees, being taller, simply provide more room for variability. Likewise, projectile points come in different sizes, and larger ones will naturally vary more than smaller ones. Does this mean they are "more variable" in the terms we have discussed above? The answer, of course is, "No." In order to talk about metrical variability in projectile points, one must scale that variation to a common denominator. In the case of Great Basin projectile points, the scale that relates mean and standard deviation is linear and surprisingly strong (Fig. 10.3).

This line is noteworthy in several respects. It shows, firstly, that, in Great Basin projectile points, as the mean of any basic metrical attribute (e.g., maximum length, maximum width, etc.) increases, so does its standard deviation by a factor of 0.24, which is the slope of the line relating mean and standard deviation (i.e., $y = .24x + 0.30$, where y is standard deviation, x is mean of any given metric attribute). Least-Squares regression shows that for all the major measured dimensions of all major Great Basin projectile points from all sections of the Great Basin, variation in measurement mean accounts for 81 percent of the variation in measurement variability ($r = .899$). This suggests that the production/rejuvenation/discard tolerances are scaled by size.

A relationship was to be expected, of course, but several alternatives are clearly possible. Variation or tolerance in the cultural world, for instance, is frequently independent of scale. Thus, a carpenter asked to cut a board to length will generally produce a board with fixed variation, independent of overall board length (say, plus or minus one-quarter inch). It doesn't matter how big or how long the board wants to be, the carpenter's ability to read a tape measure and cut the board is the same, resulting in a fixed error independent of size. Hupa craftsmen calculated finished canoe height in just this way, using an accepted standard the length of which was tattooed on the leg for easy reference (Goddard 1903-1904: 50). In Great Basin projectile points, by contrast, the variation in metrical attributes is relative to scale. The regression line demonstrates that variation in all measured at-

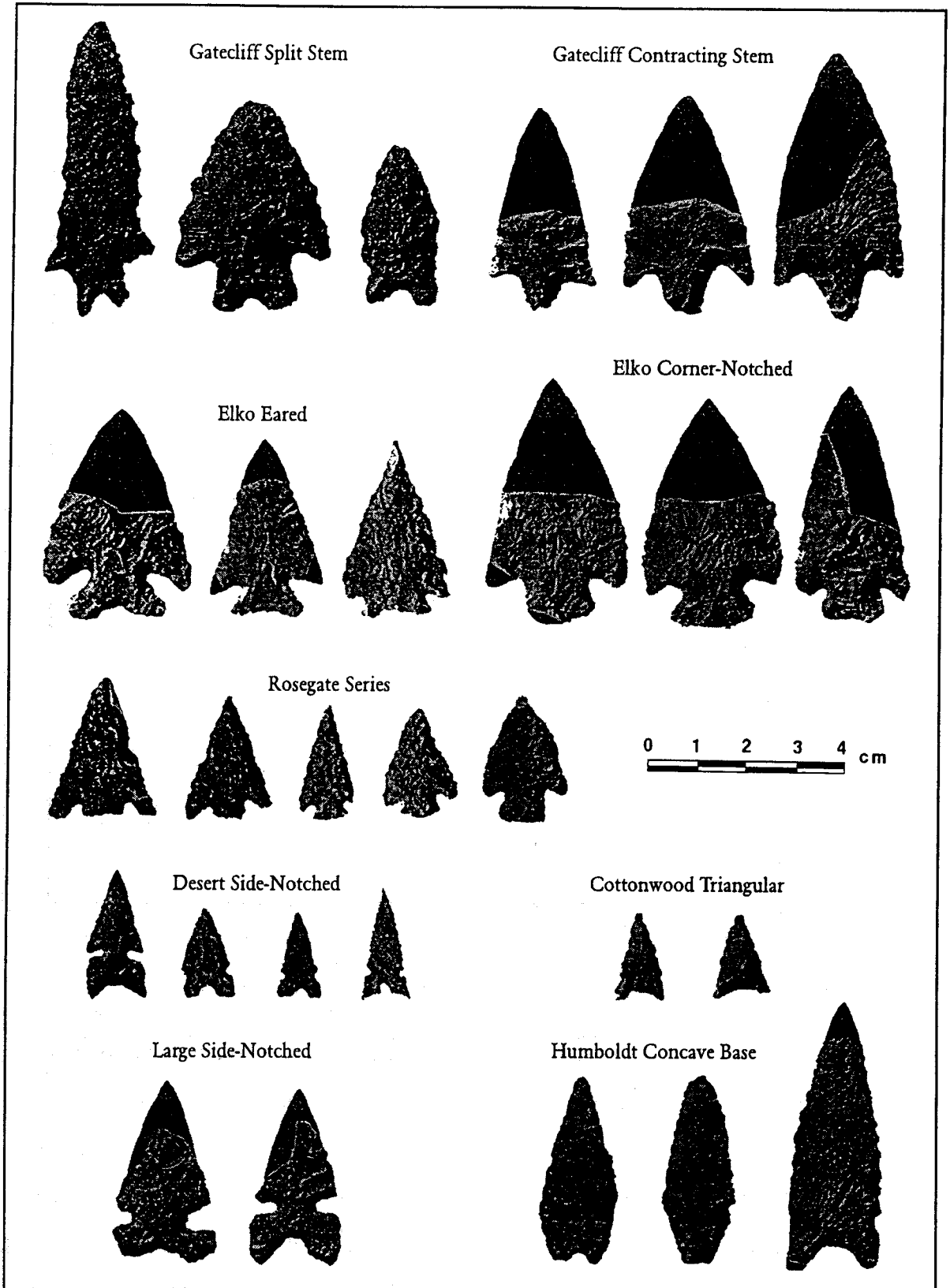Gatecliff Split Stem

Gatecliff Contracting Stem

Elko Corner-Notched

Elko Eared

Rosegate Series

Desert Side-Notched

Cottonwood Triangular

Large Side-Notched

Humboldt Concave Base

0 1 2 3 4 cm

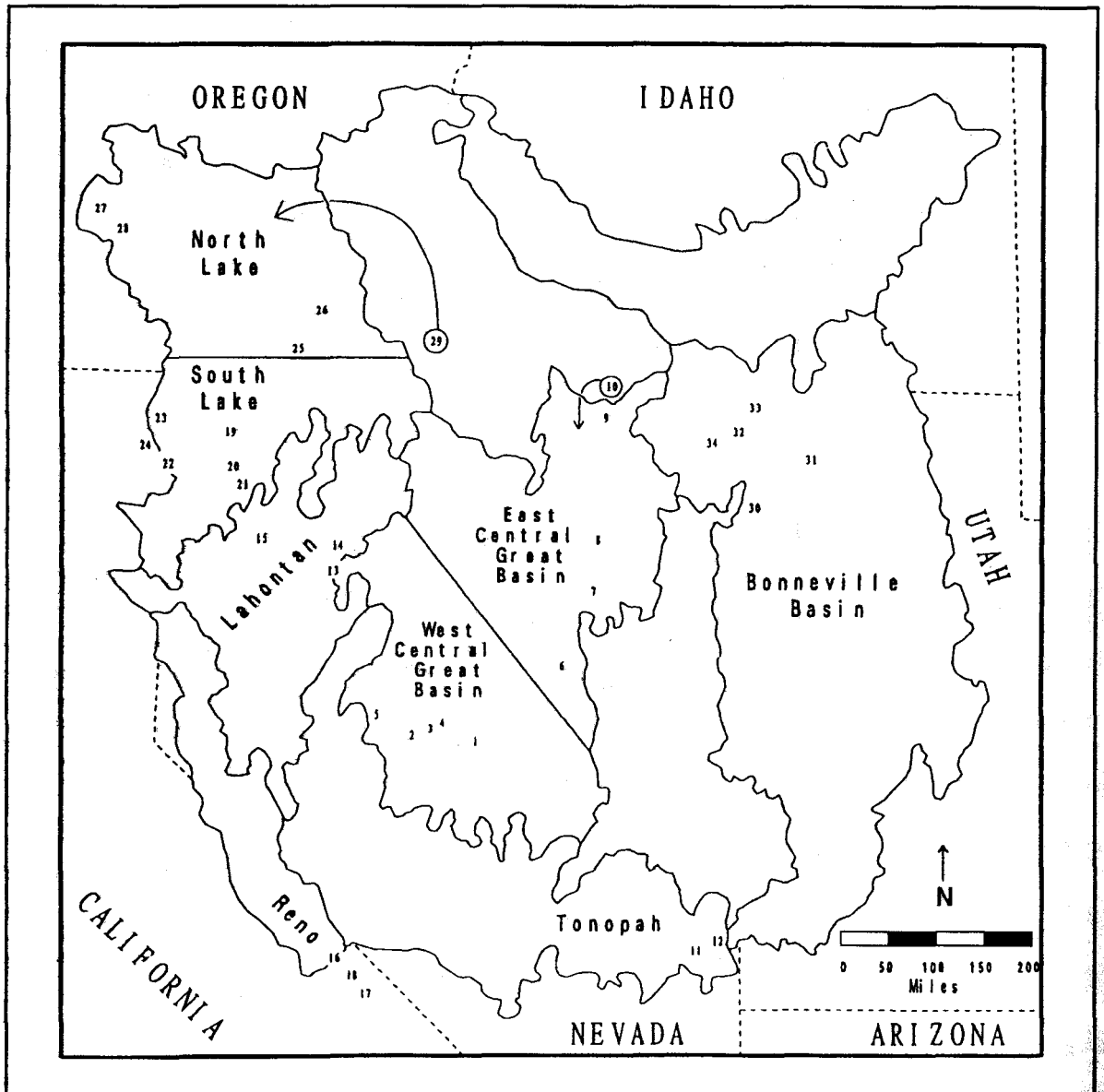**Figure 10.1** Great Basin Projectile Point Types.

Figure 10.2   Great Basin sections and locations of projectile point collections used in the analysis. 1. Monitor Valley: Gatecliff Shelter, Triple T Shelter, Monitor Valley survey, Other Monitor sites; 2. Reese River I survey; 3. Reese River II survey; 4. Mateo's Ridge; 5. Wagon Jack Shelter; 6. Newark Cave; 7. Ruby Cave; 8. South Fork Shelter; 9. Deer Creek Cave; 10. Freighter's Defeat; 11. Conaway Shelter; 12. O'Malley Shelter; 13. Humboldt Lakebed site; 14. Hesterlee site; 15. Black Rock Desert survey; 16. Owens Valley survey; 17. Rose Spring site; 18. Stahl Site; 19. Hanging Rock Shelter; 20. Smokey Creek Cave; 21. Silent Snake Springs; 22. Rodriquez site; 23. Menlo Baths; 24. Bare Creek Cave; 25. Catlow Cave No. 1; 26. Roaring Springs Cave; 27. Fort Rock Cave; 28. Connely Caves; 29. Dirty Shame Rockshelter; 30. Danger Cave; 31. Hogup Cave; 32. Swallow Shelter; 33. Beatty Springs; 34. No Name Valley.

tributes conforms to the same basic scalar relationship. Variation in axial length, for example, is basically the same scale as variation in thickness, maximum width, and so on. This runs counter to much received wisdom, intuiting that certain of these metrical attributes are qualitatively more stable than others (e.g., basal width, Thomas 1981:15). Our data show that there are differences in the variability of different metrical attributes but that they are quantitative and generally situational, varying from place to place and form to form (see below). Thirdly, the line says that the slope of the regression is much steeper than the 0.04 - 0.10 slopes normally associated with biological traits under simple genetic control (Simpson, Lewontin & Roe 1960). This suggests projec-

Table 10.1 Distribution of Projectile Points Used in the Analysis.

Region		Desert Side-notched	Cotton-wood Tri-	Rose-gate	Elko Corner-notched	Elko Eared	Gate-cliff Contract-ing Stem	Gate-cliff Split Stem	Hum-boldt	Large Side-notched	TO-TAL
West Central	collections[1]	8	8	8	8	8	8	7	8	5	8
Great Basin	specimens[2]	128	72	281	535	244	143	105	190	45	1743
East Central	collections	5	3	5	5	4	5	5	5	5	5
Great Basin	specimens	44	7	91	135	14	30	29	66	66	482
Tonopah	collections	2	2	2	2	1	2	1	1	1	2
	specimens	17	27	89	89	10	104	9	48	15	408
Lahontan	collections	3	2	2	2	2	1	2	2	2	3
Basin	specimens	22	13	28	38	22	33	30	22	14	222
Reno	collections	3	3	3	3	3	2	3	3	0	3
	specimens	39	37	61	78	53	15	50	63	0	396
Southern	collections	3	2	6	6	5	3	6	6	5	6
Lake	specimens	23	2	61	95	91	10	60	79	47	468
Northern	collections	5	2	4	4	4	4	2	4	4	5
Lake	specimens	56	25	173	140	76	12	11	46	46	585
Bonneville	collections	4	3	4	5	5	5	5	5	5	5
	specimens	20	29	120	362	73	62	98	90	127	981
TOTAL	regions	8	8	8	8	8	8	8	8	7	8
	collections	33	25	34	35	32	30	31	34	27	37
	specimens	349	212	904	1472	583	409	392	604	360	5285

1. Number of collections in which a form is represented.
2. Thomas does not report actual numbers by collection or region. This is the sum of minimum values for each type and collection given by the number of measured specimens for the variable represented by the greatest number of measurements (observations) of that form in that collection.

tile points were not scaled with reference to anatomical features (e.g., digit length) or to other projectile components (e.g., shaftments or foreshaftments) produced with reference to such scales (e.g. Kroeber 1976: 197). This is not the place to explore the implications of this potentially important observation except to note that supports the notion of Boyd & Richerson (1985: 150) that cultural traits provide sufficient variation to make relatively weak bias forces effective in producing evolutionary change. The fourth point of interest is that the Y-intercept of the regression at -0.3 is non-zero, and is statistically less than zero at the 95% confidence interval. Since there are neither data points with negative standard deviation nor ones with means of zero, this likely implies

that the relationship between mean and standard deviation is at least slightly curvilinear, being initially relatively flat, then increasing in slope to a value close to the one observed in the overall data set.

The linear relationship that predicts the relationship of standard deviation to mean in Great Basin projectile points is a particularly powerful middle range metric that allows us to examine variability independent of absolute size and measurement type across many different categories and collections. This is important because the statistical tests for equivalence of variance between two samples (e.g., Bartlett's or O'Brien's homogeneity of variance tests) are strongly conditioned by sample size. Since our data were summary statistics from collec-
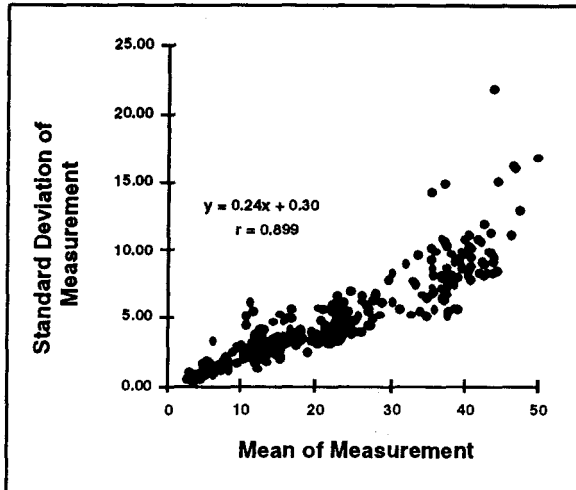
Figure 10.3   Mean and standard deviation for metrical variables of Great Basin projectile points calculated by section.

tions of unequal size, these tests yielded results that largely mirrored sample sizes. Differences in the variance between any two collections were almost always significant when sample sizes were large, and insignificant when they were small. In short, with these variance tests, "Large samples make everything significant!"

The 19% of overall variability that is not explained by variation in the mean can be parsed out by point type, section, and measurement type using the standardized residuals that remain when the scalar effect of the mean is subtracted from the original values of standard deviation. Large positive standardized residuals tell us that a particular measurement is more variable than the Great Basin average (Tables 10.2 – 10.5). Likewise, large negative measurements indicate less than average variability. These residuals directly bear on predictions for Great Basin projectile points derived above from culture transmission theory.

Metrical Variation by Type

The residuals in Tables 10.2 and 10.3 are consistent with many implications arising from the hypothesis that, in the case of Great Basin projectile points, the social component of cultural transmission will vary in force directly with technical complexity, its signature being reduced behavioral variation. As expected, Humboldt Concave Base, whose simple form and temporal persistence suggest cultural transmission with minimal social contribution, is more variable than any other Great Basin point type (mean residual = 0.74). Beyond this, complexity of shape correctly predicts overall metric variability for all other Great Basin dart points, the simple forms of which (Elko Corner-notched: 0.23; Gatecliff

Contracting Stem: 0.59) are metrically variable and exhibit mean residuals above zero, and the complex shapes (Elko Eared: -0.28; Gatecliff Split Stem: -0.24; Large Side-notched: -0.60) are not and exhibit mean residuals below zero. Complexity of shape, however, not does predict variability in arrow points within the Desert Series, where the simpler Cottonwood Triangular shape is less variable overall (-0.26) than its more complex Desert Side-notched counterpart (-0.16). Indeed, Cottonwood Triangular, which is among the simplest of all Great Basin point forms, is also among the least variable. Perhaps this is because, being neckless, Cottonwood Triangular cannot be measured for neck width, which, following thickness, is the most variable of all point dimensions considered (Table 10.3). The neckless Cottonwood Triangular shape, then, is predisposed to be "less variable" than the necked Desert Side-notched shape. The greater variability of Desert Side-notched points relative to Cottonwood Triangular points, however, is mostly due to axial length, reflecting differences in basal treatment (e.g., straight, concave, notched, etc.) traditionally used to define variants within the basic Desert Side-notched type (Baumhoff & Byrne 1959). This suggests the cultural transmission of Desert Side-notch basal morphology contained greater experimental or individual stylistic contribution than characterized the other dimensions of that form (e.g., maximum length, maximum width), which are markedly less variable, presumably reflecting relatively greater social contribution to their transmission. In this case at least, the social and experimental contributions to transmission seem to differ by dimension.

Independent of the above, the hypothesized relationship between technical complexity, emphasis on social transmission, and reduced behavioral variability further predicts observed differences in arrow point and dart point variability. As expected, arrow points – which represent the more complex weapons system, are less variable overall (-0.15) than dart points (0.07). It is quite thinkable here that the Cottonwood Triangular shape is neckless precisely because neck width is inherently variable (i.e., that this neckless form facilitated efficient cultural transmission relative to necked forms, which frequently proved too difficult to maintain within reasonable tolerances through social transmission). Shape complexity, however, is a clearly more powerful determinant of variability than weapon system, since complex dart shapes are less variable (-0.37) than arrow points taken as a whole (-0.15). This suggests that the dart shapes characterized here as "complex" are not the locus of individual cultural expression of the kind Weissner (1983; Chapter 9) has termed "assertive style," which should be highly variable. The Desert Side-notched arrow point, on the other hand, which is more variable in basal mor-

Table 10.2 Standardized Residuals by Projectile Point Type.

	Desert Side-Notched	Cotton-wood	Rose-gate	Elko Corner-Notched	Elko Eared	Gate-cliff Contracting Stem	Gate-cliff Split Stem	Hum-boldt	Large Side-Notched
Mean	-0.16	-0.25	-0.04	0.23	-0.28	0.59	-0.24	0.74	-0.60
S	0.51	0.46	0.31	0.92	0.57	1.76	0.92	1.18	0.66
Minimum	-1.31	-1.24	-0.57	-1.13	-1.80	-1.32	-2.31	-0.76	-2.48
Maximum	1.05	0.56	0.99	3.72	1.49	8.00	1.61	4.33	0.58
Cases	48	36	48	48	48	48	48	40	42

phology than its more simply-shaped counterpart (Cottonwood Triangular), may contain such assertive stylistic expression in this dimension (see also Barton, Chapter 8).[6]

Metrical Variation by Section

The results are more mixed when we parse out the standardized residuals by section (Table 10.3). Elko Corner-notched points, which are time-sensitive in the central and western, but not northern or eastern, Great Basin, display patterns of variance that only partly conform to the argument that time-sensitivity is a function of variability-reducing social transmission. In accord with the hypothesis, Elko Corner-notched is less variable in the central Great Basin (East Central: -0.39; West Central: -0.29), where the type is time-sensitive, than in the Bonneville section of eastern Great Basin (0.19), where it is not time-sensitive. At the same time, the type is everywhere *more* variable in the western Great Basin (South Lake: 0.25; Reno: 0.96; Lahontan: 1.54), where the type is time-sensitive, than in the Tonopah section of the eastern Great Basin (-0.12) and northern Great Basin (North Lake: -0.32), where it is not time-sensitive. In short, these data provide no clear evidence that time-sensitivity is connected with variability-reducing social transmission as we have hypothesized.

That time-sensitivity overall is so poorly correlated with metric variability in these sections might be due to the presence of multiple transmission systems. We noted earlier that heavily weighted social transmission—indirectly biased social transmission in particular, will depress variation within, and exaggerate variation between, adjacent populations. Hence, where the weight of social transmission is large, sectional variability should be extremely low if intra-sectional boundaries (i.e., between transmission systems) are absent and extremely high if

they are present. Culture transmission theory further predicts such boundaries should form where there is substantial opportunity for culture contact and movement between environmentally dissimilar sections (Boyd & Richerson 1987). This might explain the usually high metrical variation in the spatially contiguous Lahontan, Reno, and South Lake sections, which are situated along the Sierra Nevada-Cascade rim where Great Basin peoples routinely encountered representatives of the very differently organized adaptive systems of California. This is certainly an area of demographic impermanence and fluidity. Penutian-speaking groups are believed to have entered California through the South Lake district (Shipley 1978), the Lahontan section is the hypothesized location of major prehistoric population replacement (Aikens & Witherspoon 1986), and Washo groups ethnographically centered around Lake Tahoe are regarded by many as remnants of a formerly much larger Hokan population that once occupied the Reno section (Heizer & Baumhoff 1962). Given that South Lake and Lahontan section projectile points are highly variable in general, it is potentially significant that the Humboldt form, which is highly variable and nowhere regarded as time-sensitive in the Great Basin, is in fact relatively invariable (metrically at least) in the continuous Lahontan and South Lake sections, where the type was first identified and is particularly common (Heizer & Clewlow 1968). This suggests socially dominated cultural transmission of the Humboldt form in these sections and raises the possibility it might constitute a good chronological marker in these sections.

Metrical Variation by Measurement

As hinted very early above, when parsed by measurement, the residuals are at odds with many traditional

Table 10.3   Standardized Residuals for Projectile Point Types by Measurement.

Point Form	Maximum Length	Axial Length	Maximum Width	Basal Width	Neck Width	Thicknes	Mean	Standard Deviation
Desert Side-notched	-0.54	-0.02	-0.42	-0.21	0.05	0.18	-0.16	0.51
Cottonwood	-0.59	-0.33	-0.26	-0.23	–	0.09	-0.26	0.46
Rosegate	-0.12	-0.03	-0.17	0.04	-0.02	0.08	-0.04	0.31
Elko Corner-Notched	0.46	0.46	-0.32	0.22	0.23	0.31	0.23	0.92
Elko Eared	-0.60	-0.40	-0.58	-0.25	-0.11	0.23	-0.28	0.57
Gatecliff Contracting Stem	0.79	0.84	-0.16	1.11	0.72	0.25	0.59	1.76
Gatecliff Split Stem	-0.40	-0.13	-0.93	-0.06	0.03	0.06	-0.24	0.92
Humboldt	1.24	1.36	0.16	0.62	–	0.33	0.74	1.18
Large Side-Notched	-1.33	-1.08	-0.73	-0.61	0.13	0.00	-0.60	0.66
Mean	-0.10	0.10	-0.37	0.08	0.15	0.17		
Standard Deviation	1.56	1.50	0.55	0.68	0.42	0.24		

Table 10.4   Standardized Residuals for Projectile Point Types by Region.

Point Form	North Lake	South Lake	Lahon-tan	West Central	East Central	Reno	Tono-pah	Bonne-ville	Mean	Standard Deviation
Desert Side-notched	-0.47	0.05	0.23	-0.08	-0.36	-0.24	-0.10	-0.32	-0.16	0.51
Cottonwood	-0.61	–	0.21	-0.24	-0.47	-0.30	-0.61	0.17	-0.26	0.46
Rosegate	-0.02	0.07	0.03	-0.14	-0.06	0.17	-0.23	-0.13	-0.04	0.31
Elko Corner-Notched	-0.32	0.25	1.54	-0.29	-0.39	0.96	-0.12	0.19	0.23	0.92
Elko Eared	-0.79	-0.06	-0.40	-0.46	-0.11	-0.16	-0.01	-0.27	-0.28	0.57
Gatecliff Contracting Stem	-0.01	0.21	3.56	0.05	-0.26	0.11	0.50	0.58	0.59	1.76
Gatecliff Split Stem	-0.86	-0.01	0.43	-0.22	-0.07	0.02	-0.64	-0.53	-0.24	0.92
Humboldt	0.36	-0.11	-0.19	1.02	2.33	1.58	0.54	0.40	0.74	1.18
Large Side-Notched	-0.71	-0.26	-0.80	-0.44	-0.66	–	-0.75	-0.40	-0.60	0.66
Mean	-0.40	0.02	0.53	-0.11	-0.04	0.25	-0.16	-0.06		
Standard Deviation	0.79	0.45	1.82	0.59	1.06	0.96	0.80	0.55		

intuitions about metrical variability in different projectile point dimensions (Table 10.5). In particular, maximum length (-0.10) turns out to be less variable overall than basal width (0.08), which is at odds with the commonly held view that because length is more subject to post-manufacture alteration (i.e., resharpening and repair) than basal width, it should be more variable. Underlying the traditional view, of course, is the assumption that production standards (represented by basal width) are inherently more uniform than discard standards (represented by maximum length). Our data suggest just the opposite: that discard standards are more uniform than production standards, and that metrical variability diminishes with life span age of Great Basin projectile point populations.

The measurement residuals are instructive in two other respects. First, it is quite clear that thickness is consistently variable, across all types, weapon systems, and sections. Since thickness is presumably consequential to structural integrity, one is inclined to speculate that Great

Table 10.5 Standardized Residuals for Regions by Measurement.

Region	Maximum Length	Axial Length	Maximum Width	Basal Width	Neck Width	Thick- ness	Mean	Standard Deviation
North Lake	-1.04	-0.83	-0.60	0.01	0.00	0.13	-0.40	0.79
South Lake	-0.11	0.03	-0.38	0.26	0.20	0.12	0.02	0.45
Lahontan	1.02	1.32	-0.02	0.38	0.35	0.10	0.53	1.82
West Central	-0.44	-0.26	-0.39	0.14	0.16	0.21	-0.11	0.59
East Central	-0.02	0.17	-0.44	-0.12	0.08	0.12	-0.04	1.06
Reno	0.56	0.74	-0.20	0.05	0.05	0.26	0.25	0.96
Tonopah	-0.33	-0.19	-0.73	-0.11	0.25	0.21	-0.16	0.80
Bonneville	-0.34	-0.14	-0.22	0.07	0.08	0.25	-0.06	0.55
Mean	-0.10	0.10	-0.37	0.08	0.15	0.17		
Standard Deviation	1.56	1.50	0.55	0.68	0.42	0.24		

Basin point makers were simply less able to control it. Perhaps there are technical reasons for this, but it is tempting to argue it reflects point makers working with plan view, i.e., two-dimensional, templates. It is of significance in this regard that, by varying thickness as needed, San metal arrow point makers in the Kalahari attempt to maintain overall point length, width, and plan view outline, regardless of the wire gauge with which they happen to be working, even though this yields unduly thin and easily bent points when lighter wire gauges are used (Weissner 1983:261). In both the San and Great Basin cases, point makers seem to be acting as though point shape were a two-dimensional, not three-dimensional, problem. Second, our Great Basin data indicate that, of all the measures examined, maximum width is by far the most stable (-0.37), suggesting it was the most salient in the minds of point-makers and the one most strongly dominated by social transmission.

CONCLUSION

We have tried to demonstrate here a simple method for exploring the consequences of important evolutionary processes in the archaeological record. Perhaps the most innovative aspect of our proposal is its emphasis on variability rather than central tendency. This follows directly from basic evolutionary theory where variation plays a central role and is more tractable to theoretical analysis than central tendency. We have outlined a process by which one might set about measuring the relative weights of different components of cultural transmission that maintained distinctive projectile point shapes in the Great Basin. In the course of this, we demonstrated

quite convincingly that metrical variation in projectile points is strongly scaled by size and that this relationship is linear. The metric obtained here is eminently well suited to measuring relative variability in other collections of Great Basin projectile points. Further, it points the way to similarly structured studies of projectile points from other regions and of other artifact classes. Perhaps the most important aspect of this study is that we used culture transmission theory to learn something we did not already know about the archaeological record. We established the basic character of metrical variability in Great Basin projectile points and made some progress toward linking the remaining variability to fundamental evolutionary processes.

ACKNOWLEDGEMENTS

END NOTES

1 The mechanics of the directly biased transmission, however, preclude habitat specific biases (e.g., "Use Elko Eared points in tall timber, Elko Corner-notched points in scrublands.") and extend only to generalized biases of the sort commonly imagined to guide rational choice, i.e., that permit discrimination between better and worse outcomes (Boyd & Richerson 1985:155-157).

2 Preferences are acquired by the same process. Thus, preference for models with high social standing would result in the acquisition of house forms made by high-status individuals *and* the preferences high-status individuals themselves use to rank potential models, which are

likely to attach greater than average importance to social status. In this way, house-building and social standing could increase in importance together: the initial preference for social standing increases the importance of social standing by reinforcing positive feedback, increasing at the same time the variant of house-building initially displayed by individuals of high social standing. If the effect is strong enough, this results in populations in which the preferences, preferred traits, and the indirectly-acquired behavioral traits are very strong, highly-correlated, and frequently exaggerated.

3 Pruett-Jones (1992) suggests that copying will conform to frequencies given by, $p = 1 - (k/f)$, where p is the frequency of copying, k is the cost of trial and error, and f is the fitness benefit of making the "right" choice.

4 It is important to note here that while cultural transmission is traditionally discussed principally in terms of its effects on production behavior, especially in the case of projectile points, there is every reason to think it was equally important in determining discard behavior, including the standards that caused objects to be classified no longer useful. Accordingly, that most of the points we recover archaeologically are extensively reworked discards does not negate the importance of cultural transmission in understanding the variability they display. Data bearing on this point are presented below (see Metrical Variation by Measurement).

5 As shown in Figure 10.2, geographical realities required that we divide Thomas's floristically-defined Central Great Basin section into an East Central section and a West Central section, and his Lake section into a North Lake section and a South Lake section. Following Thomas, we assigned Dirty Shame Rockshelter to the North Lake section and Freightor's Defeat to the East Central section, although both sites fall slightly outside these sections as floristically defined. Further, following existing convention (e.g., O'Connell and Inoway 1994), we treat the South Lake section as part of the western Great Basin, which it most closely matches in terms of point chronology. Likewise, we treat the Tonopah section as part of the eastern Great Basin because the two sites representing that section are clearly in the eastern Great Basin, even though the section as whole is not.

6 Rosegate Series as identified by the Thomas key comprises two recognized types – Rose Springs and Eastgate, which, if separated, might clarify some of these ambiguities. Eastage is generally conceded to be more formally redundant and carefully made, suggesting greater emphasis social transmission. If that is so, and if point shape is a more important determinant of the weight of social transmission than weapons system, then the simple Rose Springs form should be more variable than the more elaborate Eastgate alternative and approach simple dart point forms in this respect. If, on the other hand, weapons technology is the more important determinant the weighting of social transmission, then, as in the Desert Series, the simpler Rose Springs form might be quite invariable, though that need not be so.

REFERENCES CITED

Aikens, C. M., & Y. Witherspoon
1986   Great Basin Numic Prehistory: Linguistics, Archaeology, and Environment. In *Anthropology of the Desert West: Essays in Honor of Jesse D. Jennings* (C.S. Condie & D.D. Fowler, eds.), pp. 7-20. Salt Lake City: Anthropological Papers No. 110. University of Utah.

Baumhoff, M. A., & J.S. Byrne
1959   Desert Side-notched Points as a Time Marker in California. *Archaeological Survey Reports* No. 48, pp. 32 - 65. Berkeley: University of California.

Beck, C.
1984   *Steens Mountain Surface Archaeology: The Sites.* Unpublished Ph.D. dissertation, Department of Anthropology, University of Washington.

Bettinger, R. L.
1987   Archaeological Approaches to Hunter-gatherers. *Annual Review of Anthropology* 16: 121-142.

1980   Explanatory/predictive Models of Hunter-gatherer Adaptation. *Advances in Archaeological Method and Theory* 3: 189-255. New York: Academic Press.

1991   *Hunter-Gatherers: Archaeological and Evolutionary Theory.* New York: Plenum.

Binford, L. R.
1977a   General Introduction. In *For Theory Building in Archaeology* (L. R. Binford, ed.), pp. 1-10. New York: Academic Press.

1977b   Forty-seven Trips: A Case Study in the Character of Archaeological Formation Processes. In *Stone Tools as Cultural Markers: Change, Evolution, and Complexity* (R. V. S. Wright, ed.), pp. 24-36. Canberra: Australian Institute of Aboriginal Studies.

1978a   *Nunamiut Ethnoarchaeology.* New York: Academic Press.

1978b   Dimensional Analysis of Behavior and Site Structure: Learning From an Eskimo Hunting Stand. *American Antiquity* 43: 330-361.

1979   Organization and Formation Processes: Looking at curated technologies. *Journal of Anthropological Research* 35: 255-273.

Boyd, R., & Richerson, P. J.
1985   *Culture and the Evolutionary Process.* Chicago: University of Chicago Press.

1987   The Evolution of Ethnic Markers. *Cultural Anthropology* 2: 65-79.

Clewlow, C. W.
1967   Time and Space Relations of Some Great Basin Projectile Point Types. *Archaeological Survey Reports* No. 70: 141-150. Berkeley: University of California.

Conover, W.J., Mark E. Johnson & Myrie M. Johnson
1981   A Comparative Study of Tests for Homogeneity of Variances, with Applications to the Outer Continental Shelf Bidding Data. *Technometrics:* 23: 351-361.

Ericson, J. E.
1982   Production for Obsidian Exchange in California. In *Contexts for Prehistoric Exchange* (J. E. Ericson & T. K. Earle, eds.), pp.129-148. New York: Academic Press.

Dunnell, R.
1980   Evolutionary Theory and Archaeology. *Advances in Archaeological Method and Theory* 3: 35-99.

Fenenga, Franklin
1953   Weights of Chipped Stone Points: a Clue to Their Functions. *Southwestern Journal of Anthropology* 9: 309-323.

Goddard, I.
1903-1904   Life and Culture of the Hupa. *Publications in American Archaeology and Ethnology* 1(1). Berkeley: University of California.

Grayson, D. K.
1986   Eoliths, Archaeological Ambiguity, and the Generation of "Middle-Range" Research. In *American Archaeology: Past and Future,* (D. J. Meltzer & D. D. Fowler, eds.), pp. 77-133. Washington: Smithsonian Institution Press.

Heizer, Robert F. & M. A. Baumhoff
1961 Archaeology of Two Sites at Eastgate, Churchill County, Nevada: I Wagon Jack Shelter. *Anthropological Records* 20: 119-138.

1962 *Prehistoric Rock Art of Nevada and Eastern California*. Berkeley: University California Press.

Heizer, Robert F., Martin A. Baumhoff, & C.W. Clewlow, Jr.
1968 Archaeology of South Fork Shelter (Nv-El-11), Elko County, Nevada. *Archaeological Survey Report* No. 71, pp. 1-58. Berkeley: University of California.

Heizer, Robert F., & C.W. Clewlow, Jr.
1968 Projectile Points From the Site NV-CH-15, Churchill County, Nevada. *Archaeological Survey Report* No. 71, pp. 59-88. Berkeley: University of California.

Heizer, R. F., & T. R. Hester
1978 Great Basin. In *Chronologies in New World Archaeology* (R. E. Taylor & C. W. Meighan, eds.), pp. 147-199. New York: Academic Press.

Hester, T. R.
1973 Chronological Ordering of Great Basin Prehistory. *University of California Archaeological Research Facility Contributions* No. 17. Berkeley: University of California.

Holmer, R. N.
1978 *A Mathematical Typology for Archaic Projectile Points of the Eastern Great Basin*. Unpublished Ph.D. dissertation, Department of Anthropology, University of Utah.

1986 Common Projectile Points of the Intermountain West. In Anthropology of the Desert West: Essays in honor of Jesse D. Jennings (C. Condie & D. Fowler, eds.). *Anthropological Papers* 110: 89-116.

Kroeber, T.
1976 *Ishi In Two Worlds*. Berkeley: University of California Press.

Lanning, Edward P.
1963 Archaeology of the Rose Spring Site Iny-372. *Publications in American Archaeology and Ethnology* 49: 237-336.

O'Connell, J. F.
1967 Elko Eared/Elko Corner-notched Projectile Points as Time Markers in the Great Basin. *Archaeological Survey Reports* 70: 129-140.

1975 *Prehistory of Surprise Valley*. Palo Alto: Ballena Press Anthropological Papers No. 4.

O'Connell, J. F., & C. M. Inoway
1994 Surprise Valley Projectile Points and Their Chronological Implications. *Journal of California and Great Basin Anthropology* 16: 162-198.

Orans, M.
1975 Domesticating the Functional Fragon: An Analysis of Piddocke's Potlatch. *American Anthropologist* 77: 312-328.

Pruett-Jones, S.
1992 Independent Versus Nonindependent Mate Choice: Do Females Copy Each Other. *American Naturalist* 140: 1000-1009.

Shipley, W. F.
1978 Native Languages of California. In *California, edited by R. F. Heizer*, pp. 80-90. *Handbook of North American Indians, vol 8* (W.C. Sturtevant, ed.). Washington: Smithsonian Institution Press.

Simpson, G.G., A. Roe, & R.C. Lewontin
1960 *Quantitative Zoology*. New York: Harcourt and Brace.

Sugden, R.
1986. *The Economics of Rights, Co-operation and Welfare*. Oxford: Blackwell.

True, D. L.
1970 Investigation of a Late Prehistoric Complex in Cuyamaca Rancho State Park, San Diego County, California. *Archaeological Survey Monograph*. Department of Anthropology, University of California, Los Angeles.

Thomas, D. H.
1981 How To Classify the Projectile Points from Monitor Valley, Nevada. *Journal of California and Great Basin Anthropology* 3: 7-43.

1986 Contemporary Hunter-gatherer Archaeology in America. *American Archaeology: Past and Present* (D. J. Meltzer & D. D. Fowler, eds.), pp. 237-276. Washington: Smithsonian Institution Press.

White, L.
1959 *The Evolution of Culture*. New York: McGraw-Hill.

Weissner, P.
1983 Style and Social Information in Kalahari San Projectile Points. *American Antiquity* 48: 235-276.

Wilde, J. D.
1985 *Prehistoric Settlements in the Northern Great Basin: Excavations and Collections Analysis in the Steens Mountain Area, Southeastern Oregon*. Unpublished Ph.D. dissertation, Department of Anthropology, University of Oregon.