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Investigating the scale of prehistoric social networks using culture, language, and point types in western North America

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Abstract We examine the spatial scale of prehistoric social networks represented by point types documented in western North America through comparison with ethnohistorically documented Native American interactive networks at different levels of inclusion. The ethnohistorical data come from Joseph Jorgensen's (1980) *Western Indians*, which maps tribal boundaries at European contact and the associated language lineage for each tribe. We assume that frequency of interaction follows language relationships. Proximity aside, people will share ideas more often if they possess a language, or part of a language, in common. We use tribal regions and different levels of language affiliation (families, large language groupings, and phyla) that represent increasingly broad spatial scales of social interaction. We compare these measures with the areas calculated for point types in the same general region to determine which level of social interaction recorded ethnohistorically best fits with the point type data. Our analyses show that point type areas most closely resemble the spatial extents of large language groupings and language phyla. The areas of point types are greater than individual tribal regions recorded in western North America at the time of European contact and language families. Based on these results, we suggest that the conflation of point types with prehistoric cultures commonly implied in archeology is not justified. Building on the fundamental ideas of the culture historians, we suggest that point type distributions are a consequence of extensive social interaction networks where combinations of functional and neutral point traits are shared and inherited over a large area.

Keywords Point types · Networks · Ethnohistory · Languages · Western North America

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Introduction

A striking phenomenon of the North American archeological record is the diversity of bifacial stone weapon tips (hereafter called "points") that were made, used, and discarded over the last 14,000 years or more of human occupation on the continent. These once-hafted bifacial points were used in conjunction with a variety of delivery systems including spear, atlatl, and bow and arrow, and are found in every region of the continent.[1] Archeologists have classified these points into hundreds of different types (e.g., Justice 1987, 2002a, 2002b; Justice and Kudlaty 1999). These types are defined using combinations of unique characteristics and many typed

[1] We refer to once-hafted bifacial weapon tips as "points" rather than the more common "projectile points" because not all points were used as projectiles; some were used with thrusting spears and not thrown. Furthermore, some artifacts, assumed to have been projectile points that once tipped the ends of darts, presumably also did not always serve as projectiles. Ahler (1971) has suggested that hafted bifaces sometimes were used as knives, some of which may have never served as weapon tips. In this study, we use the short description "points" to refer to all once-hafted bifaces.

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specimens have limited distributions in space and time, which make them useful as spatial and temporal markers. As markers, point types help archeologists assign an approximate age to an assemblage or site when the means or materials necessary to carry out other forms of dating are unavailable (i.e., a lack of suitable material for radiometric dating). Because points are ubiquitous in North America, and can be used as markers, typed points are an important source of basic information about when and where people lived on past landscapes.

It is implicitly assumed by most archeologists that the spatiotemporal distribution of point types defines the boundaries of past cultural networks over which ideas were transmitted. The ideas being transmitted between individuals and ultimately between populations include the desirable morphological characteristics of points, but also processes related to the procurement of the material to make them, techniques and procedures for their manufacturing, and the acceptable ways to maintain them. The consistent formal attributes of points within types emerge from the interaction of these various processes. Consequently, the characteristics that identify types should demarcate the bounds of networks across which a range of information on how to make, use, and maintain points was regularly shared. Thus, the spatial and temporal scales over which particular types occur should provide clues as to the structure of information-sharing networks they demarcate.

The study presented here investigates the spatial scale of the social networks represented by point types documented in western North America through comparison with ethnohistorically documented Native American interactive networks at different levels of inclusion. The ethnohistorical data come from Joseph Jorgensen's (1980) *Western Indians*, which maps tribal boundaries at European contact and the associated language lineage for each tribe. We assume that frequency of interaction will follow language relationships. Proximity aside, people will share ideas more often if they possess a language in common. We use tribal regions and different levels of language affiliation (families, large language groupings [described below], and phyla) that represent increasingly broad spatial scales of social interaction. We compare these measures with the spatial areas calculated for point types in the same general region to determine which level of social interaction recorded ethnohistorically best fits with the point type data. By using ethnohistoric and point type data from western North America, our intention is not to make a direct analogy between specific point types and specific language groups, but rather to control for the effect of the environment on the spatial distribution of the underlying networks that we are investigating. We do not assume that the environment was static over the last 14,000 years; however, we assume that changes in the environment were more consistent within a particular region than it was among regions. By restricting our comparison to the west, we also keep the physical landscape constant; this is important because geographic barriers, such as large mountain ranges, can act as barriers to social interaction. Thus, by making our comparison within the same general region, we are keeping the physical landscape and, in very broad terms, the environment constant.

Our study uses types defined by Justice in point type guides of western North America (Justice 2002a, 2002b). Although these types are traditional in the sense that they were formed using extensionally derived classes (see Dunnell 1986; O'Brien and Lyman 2000, 2002; Lyman et al. 1997) and have overlapping and sometimes vaguely defined criteria for diagnosis, most work as spatiotemporal markers at a large scale. They work as markers because the unique characteristics that help to define types change over space and time as a consequence of cultural evolutionary processes. The main processes are the cultural dynamics involved in the teaching and learning of point manufacture, use, and maintenance. These processes include selection, drift, and biased forms of cultural transmission (Bentley and Shennan 2003; Eerkens and Lipo 2005; Lycett 2015; Lycett and von Cramon-Taubadel 2015; O'Brien 2008; Shennan 2002). Where traditionally defined point types begin to break down is at the boundaries of their spatiotemporal ranges. This is where the ambiguity of type characteristics can lead to misidentification, but because they are constrained to assign artifacts to one category or another, analysts may draw sharp boundaries where none may exist. Our analysis does not attempt to resolve this issue, but it is our contention that the fuzzy boundaries produced by extensionally derived units do not adversely impact our results. Fuzzy boundaries and definitions are much more of a problem for researchers using points as temporal or cultural markers in local sequences. The point types in our sample are distributed over large areas and small-scale boundary shifts are unlikely to change the outcome of our comparative analysis.

In the next section, we describe the methods we used to calculate the spatial boundaries and areas for our sample of point types and for the ethnohistorically recorded tribal regions. In the ensuing "Results" section, we compare these areas using summary descriptive statistics and two-sample tests of mean and median areas. We show that point type areas are best fit to large language groupings and language phyla. Next, we carry out analyses that examine the distribution of point type areas by time and subsequently conduct a set of comparative analyses between the point type areas before and after 6000 radiocarbon years BP and the ethnohistoric data. In the last section, we discuss the implications of our findings.

Methods

Our sample of point types is taken from two volumes on the point typology of western North America by Noel Justice (2002a, 2002b). The first volume covers the Southwestern

United States and encompasses the Colorado Plateau and portions of the Chihuahuan and Sonoran deserts. The second volume includes California and the Great Basin. Both volumes include point types with ranges that extend beyond the Southwest, California, and the Great Basin, but overlap at least partially in these focal regions.

Justice (2002a, 2002b) defines point types on the basis of what he terms special attributes. These can include aspects of point shape, flaking pattern, edge treatment, hafting characteristics, resharpening features, and morphometric measurements. Both volumes provide estimates of the spatial distribution for 93 point types. Areal estimates are given as boundaries drawn around the maximum extent of documented locations where specimens for each type are known to occur; Justice does not provide quantitative estimates for the individual point type areas. To obtain quantitative estimates of these areas, we scanned each point type distribution figure and imported the scanned images into geographic information system software (ESRI ArcMAP 10.2.2). We overlaid the point type boundaries onto a map of North America (NAD 1983 UTM Zone 10N) and calculated the area of each polygon describing the spatial extent of each type. Point type names and associated areas are provided in the Supplementary Table 1.

Using the same method as described above, we generated data on the spatial ranges for 171 ethnohistorical tribal regions by scanning a map of each from Jorgensen's overall map (1980:5). Jorgensen's (1980) study includes 172 tribes; however, the spatial range for one tribe (Coast Yuki) is not provided. Jorgensen identified 21 language families, nine large language groupings, and three language phyla (or macro-unit, see Golla 2000) affiliated with each tribe. The large language grouping category includes the three language phyla identified by Jorgensen (Aztec-Tanoan [also see Campbell 1997], Penutian [also see DeLancey and Golla 1997], and Hokan [also see Langdon 1979]) and six other language groupings that represent both large language families comparable to phyla (including Eyak-Athapaskan, Wakashan, Salishan, Keresan, and Algonkian) and a disputed language phylum, Na-Dene, which includes Haida and Tlingit languages that some researchers consider to be mutually unintelligible (see Golla 2000). The non-phylum language groupings do not include language families affiliated with the three language phyla. We use Jorgensen's language classification to identify families, large groupings, and phyla to be consistent with his use of tribal regions. Jorgensen's classification for western North America is comparable to other classifications made by several linguists in terms of the numbers of language families and phyla (e.g., Campbell 1997; Goddard 1996; Golla 2000; Kaufman and Golla 2000). For estimates of the areas occupied by language families, large language groupings, and phyla, we used Jorgensen's language classification of each tribe and summed the areas of tribal regions affiliated with each.

Following the calculation of spatial areas, we derived bootstrapped estimates for several descriptive statistics. We then carried out Fligner and Killeen's (1976) distribution-free two-sample tests (hereafter called the "FK test") to assess differences in the coefficient of variation (CV) between the areas of the point types and the categories of Western Indian tribal region, language family, large language grouping, and language phylum. The CV normalizes the amount of variation in a set of measurements and is calculated by dividing the sample standard deviation by the sample mean and multiplying the quotient by 100. The FK test has been shown to be the best means of reducing type I and type II errors when comparing CVs (Donnelly and Kramer 1999). Lastly, we carried out a series of two-sample tests to determine if the means and medians of the point type areas were statistically different from the tribal region, language family, large language grouping, and language phylum areas. We used the Shapiro-Wilk normality test (Razali and Wah 2011) to determine if the samples conformed to an underlying normal distribution prior to conducting the two-sample tests (Table 1). Only one of the samples (tribal regions) departed significantly from a normal distribution after log transformation. Based on this result, we decided to use *t* tests to evaluate differences in the means of the log-transformed data. We also used the non-parametric Mann-Whitney procedure to test for differences in the median area between the samples. We did this because the mean and median areas were far apart for these distributions.

Following these tests, we conducted a set of analyses that examined the relationship between the mean age of the types and area. To do this, we fit an exponential curve to the logged area data and visually assessed the location of the inflection point. We investigated the relationship between type age and area before and after 6000 radiocarbon years before present (hereafter called C14 BP). To assess the impact of type age on the results of our first set of analyses, we split our type area sample into pre- and post-6000 C14 BP samples and separately

Table 1 Results of Shapiro-Wilk tests of sample normality

	N	Shapiro-Wilk *W*	*p* value
Tribal regions	171	0.5264	< 0.0001*
Tribal regions-logged	171	0.9696	0.0008*
Language families	21	0.5532	< 0.0001*
Language families-logged	21	0.9400	0.2165
Large language groupings	9	0.9084	0.3045
Large language groupings-logged	9	0.9054	0.2851
Language phyla	3	0.9779	0.7148
Language phyla-logged	3	0.9991	0.9437
Point types	93	0.4133	< 0.0001*
Point types-logged	93	0.9774	0.0647

*Sample distribution is significantly different from normal

Table 2 Descriptive statistics for the areas of 171 tribal regions, 21 language families, nine large language groupings (including four language phyla and five large language families), three language phyla, and 93 point types in western North America. Confidence intervals based on a bootstrapping procedure using 9,999 permutations are given in parentheses after the values (*CV* = Coefficient of Variation)

	Tribal region	Language family	Large language groups	Language phyla	Point type
Min.	518.4	1417.7	7089	237,580.3	6997.6
Max.	177,137.9	840,922.5	853,394.8	853,394.8	12,335,954.6
Mean	14,695.7 (10,486.8–18,429.9)	106,721.5 (5346.4–182,550.2)	295,157.2 (113,875.5–454,549.5)	518,738.3 (184,081.9–799,896.3)	747,860.1 (347,650.3–1,061,197)
Std. error	2043.8 (1184.8–2547)	46,734.7 (0–65,374.6)	94,604.3 (53440–127,401)	179,771.5 (149,997.4–254,235.3)	186,580.6 (0–249,194.5)
Std. dev.	26,726.2 (18,977.1–35,584.9)	214,165.2 (114,983.5–383,799.2)	283,812.9 (199,662.4–445,068.1)	311,373.4 (267,206.2–622,746.9)	1,799,318 (984,003.7–2,761,986)
Median	4743.8 (3471.6–5640.1)	12,472.3 (−40,414–17,649.6)	237,580.3 (−86,654.9–457,903.2)	465,239.8 (77,084.9–692,899.3)	168,156.1 (38,079.2–236,168.7)
CV	181.9 (157–214.8)	200.7 (123.3–274.5)	96.2 (48.4–138.3)	60 (39.8–120.1)	240.6 (195.5–304.7)

reanalyzed the samples following the analytical steps described above.

All statistical tests were carried out using the free software PAST version 3.14 (Hammer et al. 2001).

Results

Descriptive statistics for the area of tribal regions, language families, large language groupings, language phyla, and point types are presented in Table 2. Bootstrapped confidence intervals for the mean and median of point type areas overlap with the mean and median areas of language phyla and large language groupings, but not with the areas of language families or tribal regions.

FK tests indicate that the variation in point type areas is similar to the variation observed in the spatial extent of large language groupings and language phyla, whereas variation in the areas of tribal regions and language families is significantly less than the variation in point type areas (Table 3). Histograms of the log-transformed data show some degree of overlap among all of the sample distributions (Fig. 1; a histogram of the three language phyla is not shown because there are too few data points). Two-sample *t* tests of the log-transformed data demonstrate that the mean areas of tribal regions and language families are significantly smaller than the mean area of point types (Table 4). These tests also show no significant difference in the mean area between large language groupings and point types and language phyla and point types. The results are similar for comparisons of the median area (Table 5). Tribal regions and language families have smaller medians than point types and large language groupings and language phyla have larger medians than point type areas.

Table 3 Results of two-sample Fligner-Killeen tests comparing coefficients of variation of the untransformed areas from 171 tribal regions, 21 language families, nine large language groupings (including four language phyla and five large language families), and three language phyla with 93 point type areas (*CV* = 240.6) in western North America

Comparison with point type areas	*CV*	*z*	*p* value
Tribal regions	181.9	2.39	0.0167*
Language families	200.7	1.03	0.3017
Large language groups	96.2	0.19	0.8465
Language phyla	60	0.98	0.3277

**p* value indicates a significant difference at the α-level of 0.024 adjusted for four tests using the Benjamini and Yekutieli method (2001); also see Narum 2006)

In the analysis of point type age in relation to area, we fit an exponential curve to the relationship of the mean age of the point types and the areas they occupy (Fig. 2; $y = 0.458*\exp(0.0002x) + 11.1$). What is visible from the curve is that area decays rapidly and after about 6000 C14 BP, the relationship between area and age becomes less steep and the amount of variation increases.[2] The types that predate 6000 C14 BP have much larger areas than point types that postdate 6000 C14 BP. In the next two sets of analyses, we analyze the pre- and post-6000 C14 BP samples separately.

The pre-6000 C14 BP sample consists of 14 point types with the broadest distributions. Ordinary least squares regression shows a significant positive relationship between point type mean age and area ($r^2 = 0.53$; $t = 3.68$; $p = 0.0032$). The mean and median areas are significantly greater in this subsample compared to the full sample (Table 6). The Shapiro-Wilk test for normality indicates that this subsample of point

[2] Our assessment of where this split occurs was done visually. However, additional analyses using dividing lines of 8000 C14 BP and 5000 C14 BP indicate qualitatively similar results to the results we report using 6000 C14 BP as the dividing line. For the older dividing line, we used 8000 C14 BP rather than 7000 C14 BP because no point types date to the period between 6000 C14 and 7000 C14 BP. The results indicate that the areas of point types that date pre-5000 C14 BP, pre-6000 C14 BP, and pre-8000 C14 BP have significantly greater means and medians than tribal areas, language families, and large language groupings. Whereas, point type areas that date post-5000 C14 BP, post-6000 C14 BP, and post-8000 C14 BP have significantly smaller means and medians than tribal areas and language families. The additional analyses of pre- and post-8000 C14 BP and pre- and post-5000 C14 BP are reported in the Supplementary Materials.

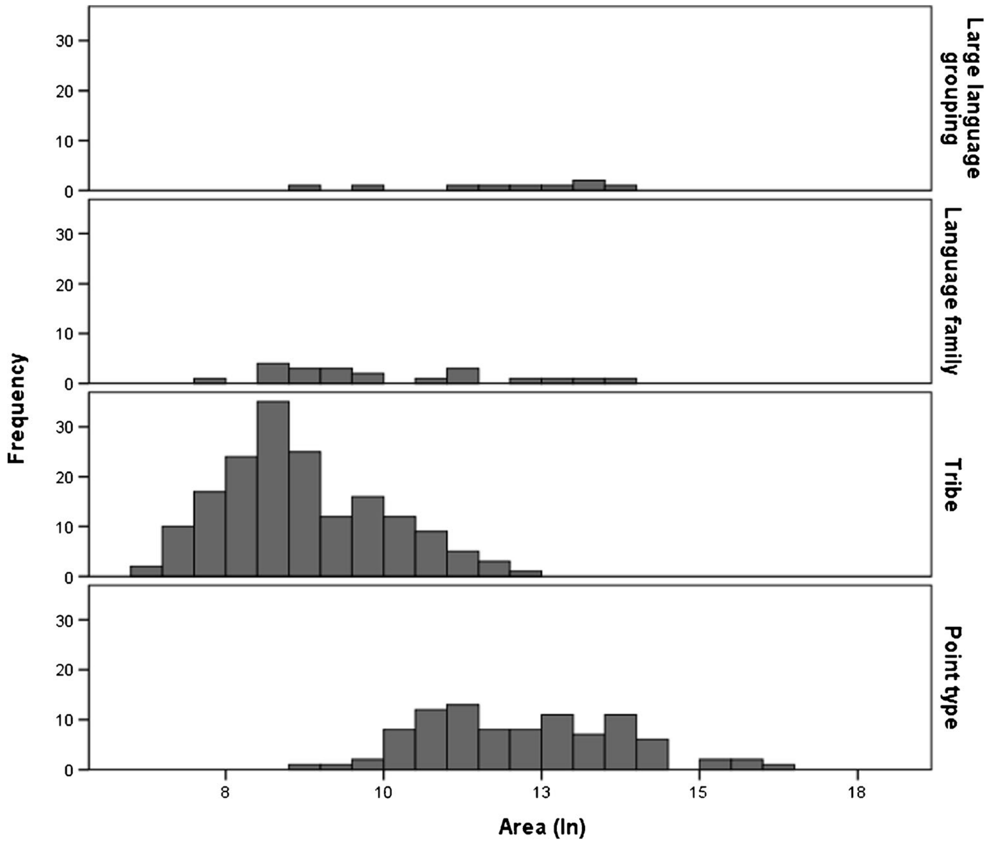

Fig. 1 Histograms of areas (natural logarithm of area (km^2)) for nine large language groupings (including four language phyla and five large language families), 21 language families, 171 tribal regions, nine large language groupings (including four language phyla and five large language families), and 93 point types in western North America

type areas is non-normal ($W = 0.80$; $p = 0.0051$); however, the log-transformed data do conform to an underlying normal distribution ($W = 0.96$; $p = 0.734$). FK tests reveal that the pre-6000 C14 BP sample has a similar level of variation to the four categories of ethnohistoric areas (Table 7). *T* tests of the log-transformed data show that tribal region, language family, and large language groupings have significantly smaller means compared to the pre-6000 C14 BP sample, but that the pre-6000 C14 BP sample is not different from the mean area of the language phyla (Table 8). The comparison of median areas of the pre-6000 C14 BP sample yields results similar to the comparison of the mean (Table 9).

The post-6000 C14 BP sample includes 79 point types and ordinary least squares regression shows that mean ages of point types do not predict area ($r^2 = 0.02$; $t = 1.33$; $p = 0.1864$). Descriptive statistics reveal that the mean and median area of post-6000 C14 BP point types overlaps with those of the large language groupings and phyla, but not with tribal regions and language families (Tables 2 and 10). The Shapiro-Wilk test for normality indicates that this subsample

Table 4 Results of *t* tests comparing logged mean areas from 171 tribal regions, 21 language families, nine large language groupings (including four language phyla and five large language families), and three language phyla with 93 logged point type areas in western North America

Comparison with point type areas	Test statistic	*p* value	Monte Carlo *p* value
Tribal regions	19.52	< 0.0001*	0.0001*
Language families	5.11[a]	< 0.0001*	0.0001*
Large language groups	0.60	0.5488	0.5495
Language phyla	0.91	0.3640	0.3716

**p* value indicates a significant difference at the α-level of 0.024 adjusted for four tests using the Benjamini and Yekutieli method (2001; also see Narum 2006)

[a] Unequal variances *t*

Table 5 Results of Mann-Whitney tests comparing median areas from 171 tribal regions, 21 language families, nine large language groupings (including four language phyla and five large language families), and three language phyla with 93 point type areas in western North America

Comparison with point type areas	Test statistic	*p* value	Monte Carlo *p* value
Tribal regions	669	< 0.0001*	0.0001*
Language families	364	< 0.0001*	0.0001*
Large language groups	395	0.7861	0.7956
Language phyla	87	0.2735	0.2851

**p* value indicates a significant difference at the α-level of 0.024 adjusted for four tests using the Benjamini and Yekutieli method (2001; also see Narum 2006)

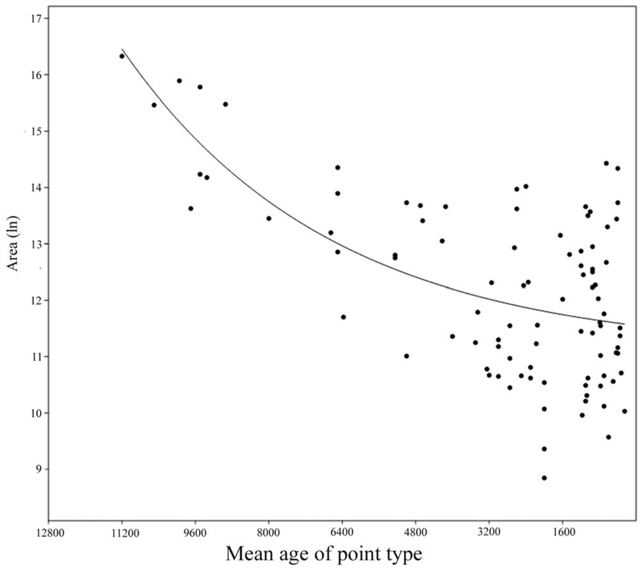

Fig. 2 Exponential fit for the mean C14 age of point types (x-axis) and the natural logarithm of the associated point type areas (y-axis) (the mean ages are shown as negatives to indicate years before present and therefore the exponent in the equation is shown as negative)

of point type areas is non-normal ($W = 0.72$; $p < 0.0001$); however, the log-transformed data do conform to an underlying normal distribution ($W = 0.97$; $p = 0.0731$). FK tests indicate that the post-6000 C14 BP sample has a similar level of variation to the four categories of ethnohistoric areas (Table 11). The results of the *t* tests of the log-transformed data are similar to the results from the full sample; tribal region and language family have significantly smaller means than the post-6000 C14 BP sample, but it is not different from the mean area of large language groupings and language phyla (Table 12). The comparison of median areas of the post-6000 C14 BP sample again yields results similar to the comparison of the mean (Table 13). In sum, the pre- and post-6000 C14 BP analyses showed that point types pre-6000 C14 BP have areas that are greater than the large language groupings and get smaller over time, whereas the post-6000 C14 BP point type areas are of similar size to both large language groupings and phyla and do not increase or decrease over time.

Table 6 Descriptive statistics for 14 pre-6000 C14 BP point type areas in western North America. Confidence intervals for statistics are based on a bootstrapping procedure using 9,999 permutations

	Point type area	Lower C.I.	Upper C.I.
Min.	120,919.1	–	–
Max.	12,335,950	–	–
Mean	3,302,002	1,292,553	5,029,055
Std. error	991,193.8	498,037.8	1,311,152
Std. dev.	3,708,708	2,514,718	5,562,326
Median	1,478,065	− 2,286,460	2,262,001
CV	112.3	71.5	150.6

Table 7 Results of two-sample Fligner-Killeen tests comparing coefficients of variation of areas from 171 tribal regions, 21 language families, nine large language groupings (including four language phyla and five large language families), and three language phyla with 14 pre-6000 C14 BP point type areas ($CV = 112.3$) in western North America

Comparison with point type areas	*CV*	*z*	*p* value
Tribal regions	181.9	0.17	0.8636
Language families	200.7	1.22	0.2238
Large language groups	96.2	0.72	0.4724
Language phyla	60	0.98	0.3289

Discussion

Our study shows that the spatial extents of point types in western North America most closely resemble the spatial extents of large language groupings and language phyla. Our comparative analyses indicate that the spatial extent of point types encompasses significantly more area than individual tribal regions recorded in western North America at the time of European contact. Point types also have larger areas than those comprising the 21 language families affiliated with western tribes. However, overlap in the areas of large language groupings and phyla with point type areas suggests that the two phenomena are consequences of similar levels of social interaction. To reiterate, large language groupings and phyla areas are the summation of all tribal regions associated with language families that comprise each grouping or phylum. In linguistic taxonomy, a phylum consists of language families derived from a common ancestor; a similar approach was used to define the large language groupings. Thus, the

Table 8 Results of *t* tests comparing logged mean areas from 171 tribal regions, 21 language families, nine large language groupings (including four language phyla and five large language families), and three language phyla with 14 log-transformed pre-6000 C14 BP point type areas in western North America

Comparison with point type areas	Test statistic	*p* value	Monte Carlo *p* value
Tribal regions	15.85	< 0.0001*	0.0001*
Language families	7.65[a]	< 0.0001*	0.0001*
Large language groups	3.98	0.0007*	0.0004*
Language phyla	1.61	0.1288	0.1353

**p* value indicates a significant difference at the α-level of 0.024 adjusted for four tests using the Benjamini and Yekutieli method (2001; also see Narum 2006)

[a] Unequal variances *t*

Table 9 Results of Mann-Whitney tests comparing median areas from 171 tribal regions, 21 language families, nine large language groupings (including four language phyla and five large language families), and three language phyla with 14 pre-6000 C14 BP point type areas in western North America

Comparison with point type areas	Test statistic	*p* value	Monte Carlo *p* value
Tribal regions	3	< 0.0001*	0.0001*
Language families	10	< 0.0001*	0.0001*
Large language groups	13	0.0018*	0.0009*
Language phyla	8	0.1153	0.1206

*p value indicates a significant difference at the α-level of 0.024 adjusted for four tests using the Benjamini and Yekutieli method (2001; also see Narum 2006)

languages within a phylum or grouping have more in common with each other than they do with a language from another phylum or group. Because the spatial extent of point types closely matches the extent of large language groupings and phyla, we suggest that they too were shared across tribal and language boundaries.

Our subsequent analyses revealed that the relationship between the age of the point types and the area they encompass is non-linear and can be separated into two samples that pre- and postdate 6000 C14 BP. The pre-6000 C14 BP sample consists of the oldest and largest point type areas. Most of these point types date to the Paleo-Indian period and thus were made and used by the earliest hunter-gatherer groups in western North America. The large spatial extent of these groups likely is a consequence of their small population sizes, the need to interact over large areas to share information and find mates, and the limited intergroup competition. On the other hand, the post-6000 C14 BP sample of types is associated with groups having range sizes that are much reduced as a result of population growth, finer-scale regional adaptations, and more active competition. Our comparisons reflect this pattern as well. The comparison of the pre-6000 C14 BP sample with the areas from the four ethnohistoric categories showed that

Table 10 Descriptive statistics for 79 post-6000 C14 BP point type areas in western North America. Confidence intervals for statistics are based on a bootstrapping procedure using 9,999 permutations

	Point type area	Lower C.I.	Upper C.I.
Min.	6997.6	–	–
Max.	1,854,011	–	–
Mean	295,227.4	205,830.6	373,257.5
Std. error	43,255.3	27,779.1	52,947
Std. dev.	384,461	284,507	496,610.8
Median	104,166.2	− 5109.5	131,649
CV	130.2	108.4	152.8

Table 11 Results of two-sample Fligner-Killeen tests comparing coefficients of variation of areas from 171 tribal regions, 21 language families, nine large language groupings (including four language phyla and five large language families), and three language phyla with 79 post-6000 C14 BP point type areas (*CV* = 130.2) in western North America

Comparison with point type areas	*CV*	*z*	*p* value
Tribal regions	181.9	0.23	0.8188
Language families	200.7	2.22	0.0266
Large language groups	96.2	1.29	0.1980
Language phyla	60	− 0.93	0.3507

*p value indicates a significant difference at the α-level of 0.024 adjusted for four tests using the Benjamini and Yekutieli method (2001; also see Narum 2006)

they are much larger than the tribal regions, language families, and large language groupings and overlap only with that of the language phyla. The post-6000 C14 BP types, similar to the full sample, have areas that overlap with large language groupings and language phyla. Thus, even the types produced by forager and farmer populations with smaller ranges and reduced mobility, represented in the post-6000 C14 BP sample, still have areas that are significantly larger than tribal regions and language families recorded ethnohistorically.

While our study demonstrates a correspondence between the areal extent of large language groupings, language phyla, and point types, we want to be clear that we are not implying a direct equivalence between archeological point types and prehistoric language groupings or phyla. Although they are similar in size, point type distributions do not necessarily map into distributions of language phyla. The distributions of languages during the periods when the points were created were certainly not the same as the boundaries mapped by Jorgensen using the nineteenth and twentieth century data. Moreover, while a shared mother tongue certainly facilitates exchange of knowledge and skills, the transmission of ideas about how to make, use, and maintain a particular type of point

Table 12 Results of *t* tests comparing logged mean areas from 171 tribal regions, 21 language families, nine large language groupings (including four language phyla and five large language families), and three language phyla with 79 log-transformed post-6000 C14 BP point type areas in western North America

Comparison with point type areas	Test statistic	*p* value	Monte Carlo *p* value
Tribal regions	17.68[a]	< 0.0001*	0.0001*
Language families	4.29[a]	0.0002*	0.0001*
Large language groups	0.09	0.9267	0.9312
Language phyla	1.60	0.1142	0.1184

*p value indicates a significant difference at the α-level of 0.024 adjusted for four tests using the Benjamini and Yekutieli method (2001; also see Narum 2006)

[a] Unequal variances t

Table 13 Results of Mann-Whitney tests comparing median areas from 171 tribal regions, 21 language families, nine large language groupings (including four language phyla and five large language families), and three language phyla with 79 post-6000 C14 BP point type areas in western North America

Comparison with point type areas	Test statistic	*p* value	Monte Carlo *p* value
Tribal regions	666	< 0.0001*	0.0001*
Language families	354	< 0.0001*	0.0001*
Large language groups	329	0.7203	0.7192
Language phyla	53	0.1084	0.1088

**p* value indicates a significant difference at the α-level of 0.024 adjusted for four tests using the Benjamini and Yekutieli method (2001; also see Narum 2006)

was not necessarily limited by mutually intelligible languages; techniques could have been observed and traits borrowed from neighboring peoples. The similarities in the spatial extent suggest that point types spread across landscapes through interaction networks beyond the scale of language families. The large scale of most point type distributions suggests that some combination of adaptation to particular regions and phylogenetic inertia play a role in the distribution of point characteristics or traits that we see in the archeological record.

The findings of our study are in general agreement with Wotzka's (1997) study that investigated the size of European Neolithic "cultural" areas compared to a worldwide sample of ethnographically derived cultural areas and found that ethnographic cultures occupied much smaller ranges than the archeological entities. Our study also is in agreement with the work of Croes (1989) that compared the areal distribution of lithic types with basketry and cordage types from archeological sites across a portion of the Northwest Coast region. Croes (1989) argues that the basketry and cordage from Northwest Coast sites are more stylistically sensitive and indicative of ethnic boundaries, whereas stone tool types are more widespread and have encompassed several ethnic boundaries defined by basketry and cordage. His contention is that stone assemblages were probably linked to changes in adaptation rather than to cultural styles. In other words, stone tools types more closely correspond to areas of similar adaptation than to areas of shared culture or ethnicity. While our result is consistent with Croes' results in terms of the scale of stone tool type distributions, we think that adaptation alone cannot explain the large spatial area of point types. Instead, we suggest that it is a combination of adaptive traits and traits from a shared common ancestry that can explain the expansive areas covered by most point types in western North America. In their study of European Mesolithic burial goods, Newell et al. (1991) identify distributional units similar in size to forager tribes or even bands in North America. As in the case of Croes' study, this does not necessarily conflict with our results. Instead, as might be expected, it suggests that burial practice and ornamentation operated under different constraints and followed different pathways of diffusion from point forms.

Based on our finding that the point types in western North America correspond most closely in areal size to ethnohistorically documented large language groupings and phyla, we can reject the common usage of equating point types with prehistoric cultures (for a related argument see LeTourneau 1998). One cannot assume, for example, that point types that are so widely distributed signaled boundaries between self-identifying groups; it is very unlikely that the many tribes making up a language phylum would have all considered themselves as part of the larger group. However, point types do embody similarities in behavior, as it has been generally assumed since culture historians began using them as temporal and spatial markers more than 100 years ago. Building on the fundamental ideas of the culture historians, we suggest that point type distributions are a consequence of extensive social interaction networks where combinations of functional and neutral point traits are shared and inherited over a large area.

Future research could build on the findings presented here by working toward improving the data associated with the spatial and temporal distributions of point types and using these data to test hypotheses concerning the factors that drive changes in the spatial and temporal distributions of the networks that produce point types. Future research could also focus on those types with distributions similar in size to tribal regions and language families to determine if these point types covering smaller areas are different in some way to the other types in the sample with larger areas. The fact that the distributions of many commonly used point types reflect very diffuse levels of interaction does not imply that certain characteristics, or even particular types, could be the products of smaller, tighter interaction networks. A similar observation was made by Golla (2000) for North American language families. Golla (2000) suggested that language families can be divided into two subgroups, spread and compact. The spread families are described as having language dialects that arise primarily as the result of drift. The boundaries between languages in spread families are informal and innovations are rapidly diffused across the languages. In contrast, compact families develop in areas where rigid boundaries are maintained and co-occur with distinct adaptive systems within circumscribed territories. Further research aimed at exploring if point type distributions adhere to a similar spread and compact subgrouping would be potentially informative. Lastly, we suggested that the large areas covered by point types are a consequence of both adaptation to the physical environment and cultural inheritance. Future research could evaluate the relative contributions of both these factors in specific cases with detailed analyses designed to elucidate the cultural phylogeny of the point lineages and experiments to assess the performance of hypothesized functional traits. The role of the environment can also be assessed in future studies by examining how environmental changes within particular areas of the west influence the spatial distribution and diversity of point types (e.g., Buchanan et al. 2016).

References

Ahler SA (1971) Projectile point form and function at Rodgers Shelter, Missouri. Research series 1. Missouri Archaeological Society, Columbia, Missouri

Benjamini Y, Yekutieli D (2001) The control of the false discovery rate in multiple testing under dependency. Ann Stat 29:1165–1188

Bentley RA, Shennan SJ (2003) Cultural transmission and stochastic network growth. Am Antiq 68:459–485

Buchanan B, O'Brien MJ, Collard M (2016) Drivers of technological richness in prehistoric Texas: an archaeological test of the risk and population size hypotheses. Archaeol Anthropol Sci 8:625–634

Campbell L (1997) American Indian languages: the historical linguistics of Native America. Oxford studies in anthropological linguistics 4, Oxford University Press, Oxford

Croes DR (1989) Prehistoric ethnicity on the Northwest Coast of North America: an evaluation of style in basketry and lithics. J Anthropol Arch 8:101–130

DeLancey S, Golla V (1997) The Penutian hypothesis: retrospect and prospect. Int J Am Linguistics 63:171–202

Donnelly SM, Kramer A (1999) Testing for multiple species in fossil samples: an evaluation and comparison of tests for equal relative variation. Am J Phys Anthropol 108:507–529

Dunnell RC (1986) Methodological issues in Americanist artifact classification. Adv Archaeol Method Theory 9:149–207

Eerkens JW, Lipo CP (2005) Cultural transmission, copying errors, and the generation of variation in material culture and the archaeological record. J Anthropol Archaeol 24:316–334

Fligner MA, Killeen TJ (1976) Distribution-free two-sample tests for scale. J Am Stat Assoc 71:210–213

Goddard I (1996) The classification of the native languages of North America. In: Goddard I (ed) Handbook of North American Indians, Languages, vol 17. Smithsonian Institution, Washington DC, pp 290–323

Golla V (2000) Language families of North America. In: Renfrew C (ed) America past, America present: genes and languages in the Americas and beyond. The McDonald Institute for Archaeological Research, Cambridge, pp 59–72

Hammer Ø, Harper DAT, Ryan PD (2001) PAST—palaeontological statistics, ver. 1.35. Palaeontol Electron 4(9)

Jorgensen J (1980) Western Indians: comparative environments, languages, and cultures of 172 western American Indian tribes. WH Freeman, San Francisco

Justice ND (1987) Stone Age spear and arrow points of the Midcontinental and Eastern United States. Indiana University Press, Bloomington

Justice ND (2002a) Stone Age spear and arrow points of California and the Great Basin. Indiana University Press, Bloomington

Justice ND (2002b) Stone Age spear and arrow points of the Southwestern United States. Indiana University Press, Bloomington

Justice ND, Kudlaty SK (1999) Field guide to projectile points of the Midwest. Indiana University Press, Bloomington

Kaufman T, Golla V (2000) Language groupings in the New World: their reliability and usability in cross-disciplinary studies. In: Renfrew C (ed) America past, America present: genes and languages in the Americas and beyond. The McDonald Institute for Archaeological Research, Cambridge, pp 47–55

Langdon M (1979) Some thoughts on Hokan with particular reference to Pomoan and Yuman. In: Campbell L, Mithun M (eds) The languages of Native America: historical and comparative assessment. University of Texas Press, Austin, pp 592–649

LeTourneau PD (1998) The "Folsom problem." In: Ramenofsky AF, Steffen A (eds) Unit issues in archaeology: measuring time, space, and material. University of Utah Press, Salt Lake City, pp 52–73

Lycett SJ (2015) Cultural evolutionary approaches to artifact variation over time and space: basis, progress, and prospects. J Archaeol Sci 56:21–31

Lycett SJ, von Cramon-Taubadel N (2015) Toward a "quantitative genetic" approach to lithic variation. J Archaeol Method Theory 22:646–675

Lyman RL, O'Brien MJ, Dunnell RC (1997) The rise and fall of culture history. Plenum, New York

Narum SR (2006) Beyond Bonferroni: less conservative analyses for conservation genetics. Conserv Gen 7:783–787

Newell R, Kielman D, Constandse-Westermann T, Van Gijn A, Van Der Sanden WAB (1991) An inquiry into the ethnic resolution of Mesolithic regional groups: the study of their decorative ornaments in time and space. Brill Academic, Leiden

O'Brien MJ (2008) Cultural transmission and archaeology: issues and case studies. Society for American Archaeology Press, Washington, DC

O'Brien MJ, Lyman RL (2000) Applying evolutionary archaeology: a systematic approach. Kluwer Academic/Plenum, New York

O'Brien MJ, Lyman RL (2002) The epistemological nature of archaeological units. Anthropol Theory 2:37–56

Razali NM, Wah YB (2011) Power comparisons of Shapiro-Wilk, Komolgorov-Smirnov, Lilliefors, and Anderson-Darling tests. J Stat Model Analytics 2:21–33

Shennan S (2002) Genes, memes, and human history: Darwinian archaeology and human evolution. Thames and Hudson, London

Wotzka HP (1997) Maßstabprobleme bei der ethnischen Deutung neolithischer 'kulturen'. Das Altertum 43:163–176