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# Stylistic variability of stemmed obsidian tools (*mata'a*), frequency seriation, and the scale of social interaction on Rapa Nui (Easter Island)

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ABSTRACT

Easter Island, or Rapa Nui, has been the focus of much research and speculation, particularly with reference to the island's hundreds of giant, enigmatic statues and the set of conditions that supported their construction and transportation. In this paper, we analyze an abundant class of lithic artifacts, *mata'a*, to study of patterns of cultural transmission with implications for the evolution of groups, competition, and scale of socio-political organization among this island population. While these kinds of studies often draw upon assemblages of decorated ceramics, here we show how analysis of variability unconstrained by performance allows us to measure aspects of inheritance related to the manufacture of these artifacts. In the case of *mata'a* from Rapa Nui, we demonstrate that it is possible to reach falsifiable conclusions about the evolutionary dynamics that shaped the remarkable archaeological record on Rapa Nui.



## 1. Introduction

Easter Island, or Rapa Nui as it is known in modern traditional terms, is a diminutive (164 $km^2$), isolated island situated in the southeastern Pacific (Fig. 1). The island sits at the easternmost edge of Polynesia, reflecting the origin, culture, and language of the island's native population. Rapa Nui is best known for its hundreds of megalithic statues (*moai*) carved and transported, some over several kilometers of rough terrain, and reaching nearly every part of the island. The great investment made in these colossal statues has intrigued visitors and researchers for centuries. Seeming to defy explanation, the so-called mystery of Easter Island emerged: how and why did ancient Polynesians on such a remote and impoverished island carve and transport these giant statues? Moreover, did the extraordinary investment in statues contribute to the island's prehistoric ecological devastation? The notion of an "irrational" statue cult and a history of deforestation led early visitors and modern writers alike to speculate that human-induced ecological change led to population and cultural collapse. Jared Diamond (2005:6) dubbed it "ecocide" — as ecological suicide committed by the prehistoric islanders. However, "ecocide" erroneously conflates the historically separated consequences of largely *prehistoric* deforestation with *post-European* disease-induced population collapse (see Hunt, 2007; Hunt and Lipo, 2007, 2009a,b). An integral part of the collapse narrative, beginning with early visitors, was that the island endured constant conflict and inter-group warfare supposedly contributing to a pre-European (self-induced) decimation of the population (e.g., Flenley and Bahn, 2003).

In efforts to better document the conditions and processes that explain the archaeological record of Rapa Nui, we examine *mata'a*, a class of lithic artifacts found in abundance on the island. We build artifact descriptions (i.e., classifications) to study patterns of cultural transmission among the island's prehistoric populations. The patterns of inheritance measured allow us to track social relations with implications for the evolution of groups, competition, and scale of socio-political organization. While these kinds of studies are often conducted using assemblages of decorated ceramics (e.g., Lipo et al., 1997), here we show how analysis of variability unconstrained by performance (*style*) allows us to measure aspects of inheritance related to the manufacture of these artifacts. In the case of *mata'a* from Rapa Nui, we demonstrate that it is possible to reach falsifiable conclusions about the evolutionary dynamics that shaped the archaeological record on this island.

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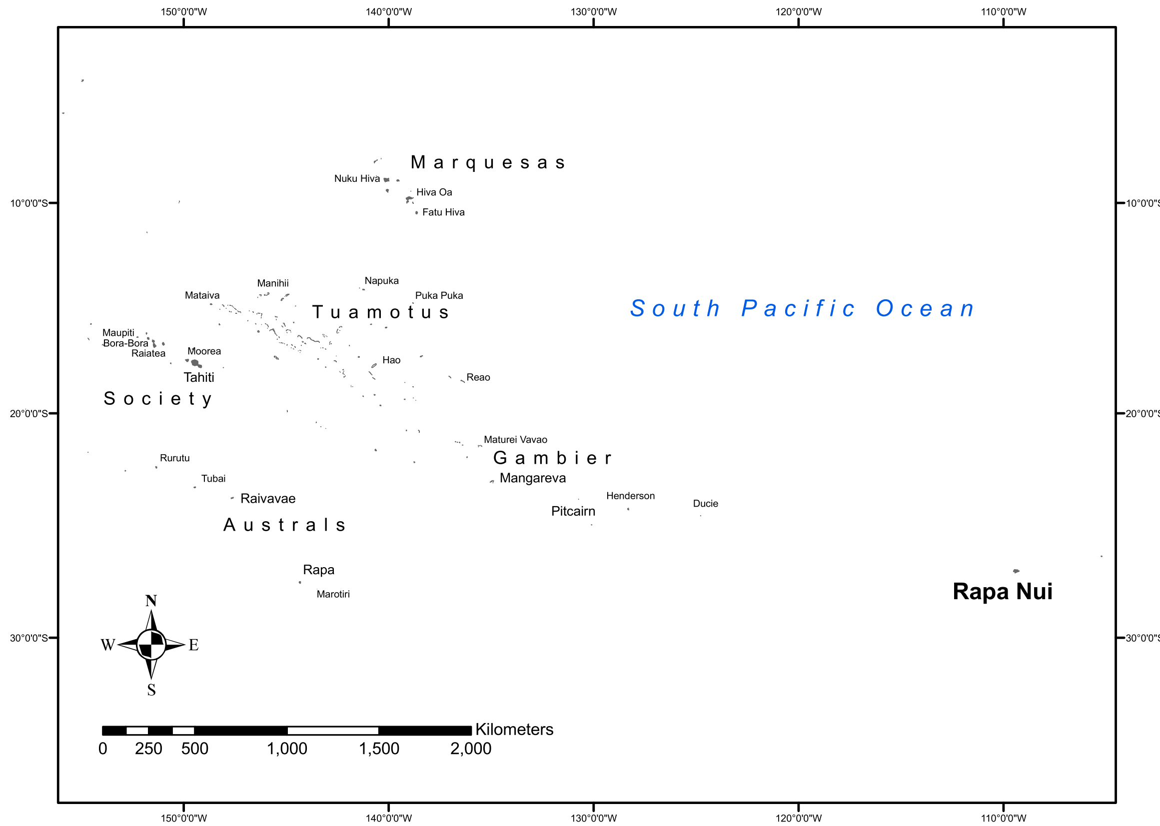


**Fig. 1.** The Pacific Islands, showing Rapa Nui on the remote southeastern edge of the region.

**Fig. 2.** Examples of mata'a (stemmed obsidian artifacts) from Rapa Nui assemblages.

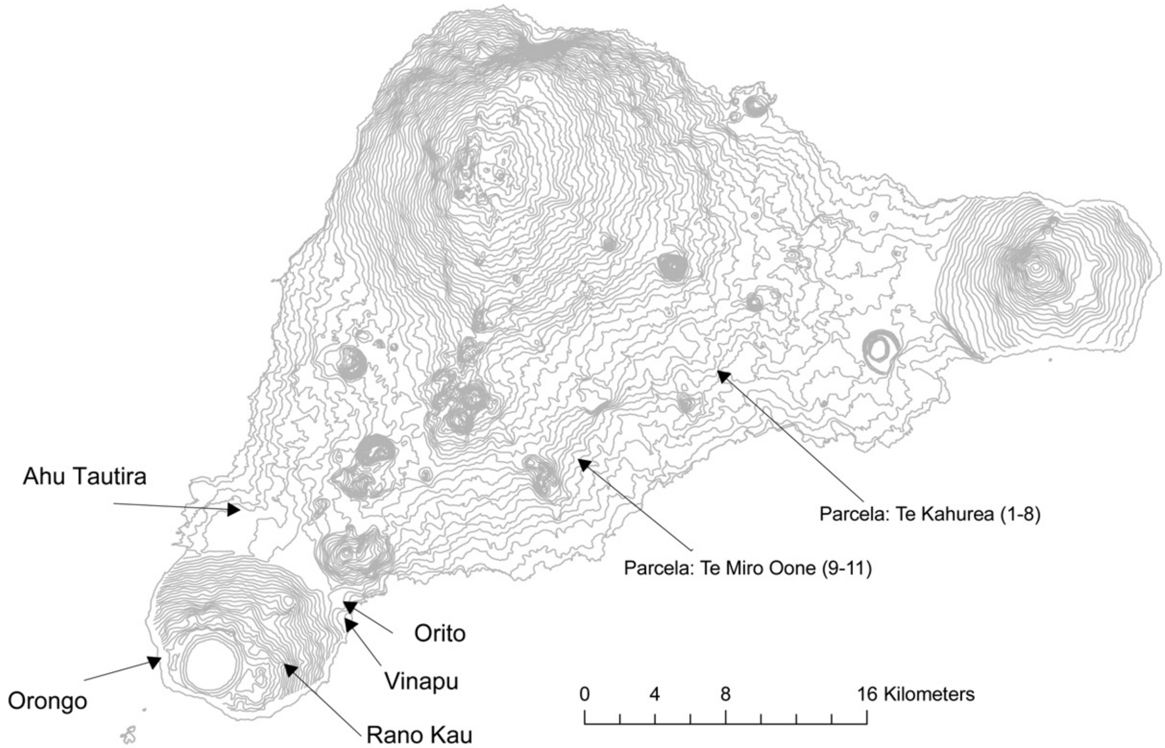


**Fig. 3.** Location of mata'a assemblages on Rapa Nui used in this analysis.

*Mata'a*, stemmed obsidian artifacts, comprise one class of material culture from Rapa Nui often cited as evidence for warfare. *Mata'a* are large flakes with a narrow stem shaped on one side relative to the bulb of percussion (Fig. 2). Found in abundance across the surface of Rapa Nui, these artifacts have been noted since the early European visitors described the island. European expeditions in the 17th and 18th centuries, for example, noted the presence of spears and knives that are comprised of "black glass material" (Thomson, 1891:532). In 1774, Forster (von Saher, 1992:35), who accompanied Captain Cook on his visit to the island, reported that some individuals "had lances or spears made of thin ill-shaped sticks, and pointed with a sharp triangular piece of black glassy lava."

*Mata'a* have been widely interpreted as "spearpoints" or other implements used in combat (Diamond, 2005:109; Flenley and Bahn, 2003:152–53; Metraux, 1940:166–167, 376). This interpretation has its roots in early European accounts. In 1770, for example, the Spanish explorer Don Francisco Antonio de Agura y Infanzon (Corney et al., 1908:63) noted that the native populations had no arms "although in some we observed sundry wounds on the body, which we thought to have been inflicted by cutting instruments of iron or steel, we found that they proceeded from stones which are their only [weapons of] defense and offence and as most of these are sharp edged they produce the injury referred to." That *mata'a* served primarily as weapons, however, is unlikely. As Van Tilburg (1994:109) has noted, most claims are in need of further evaluation. Indeed, ascribing an object to a single function remains logically problematic (Dunnell, 1978a).

The reoccurring theme that serves to reinforce the notion of *mata'a* as weapons has been a pervasive, now widely popular narrative of a pre-European "collapse." In these popular accounts, *mata'a* are assumed to have served a critical role in pre-European inter-tribal warfare that, in concert with other factors, resulted in the "collapse" of the prehistoric population; often described in terms of "ecocide" (Diamond, 2005; see also Flenley and Bahn, 2003; Stevenson and Haoa Cardinali, 2008:176; Vargas Casanova et al., 2006:233). Despite widespread acceptance, the notion of a *prehistoric* collapse, however, appears to have little empirical basis (Hunt, 2007; Hunt and Lipo, 2007, 2009a, b; Rainbird, 2002). Instead, demographic collapse is well documented to have been the result of European contact and the introduction of diseases after AD 1722. Thus, the role of *mata'a* may be different than most have assumed.

Empirical studies of *mata'a* point to a different conclusion for the ways in which these artifacts were utilized in prehistory. Microscopic use-wear analyses, for example, have shown that these tools have edge damage and wear consistent with cutting and scraping of fibrous plant materials (Church and Ellis, 1996; Church and Rigney, 1994), and not weapons. This view is consistent with observations by Bouman (von Saher, 1990:52) who states that the islanders "cut their bananas with a sharp little black stone."

Indeed the form of these artifacts is consistent with a more generalized array of uses. *Mata'a* consist of a large obsidian flake with minor bifacial or unifacial flake removed along an edge to produce a narrow, semi-rounded stem usually several centimeters in length. This stem serves as the means to haft the tool to a wooden shaft. The distal end and the lateral edges of the tool consist of the remaining unmodified portions of the flake. Usually the sharp cutting parts of the artifact consist of a single unretouched edge that may or may not be perpendicular or parallel to the long axis of the artifact. Rather than being ubiquitously pointed, as one would expect for "spearpoints," the shapes of the distal ends of *mata'a* are highly inconsistent and vary from rounded to subangular to angular to complex (Fig. 2).

The great range of shapes displayed by *mata'a* remains largely unexplained. Early researchers assigned *mata'a* shape variation to what they conceived as ethnographic categories based on Rapa Nui words (e.g., Balfour, 1917; Routledge, 1919; Thomson, 1891:536). Later attempts to construct systematic classifications have also

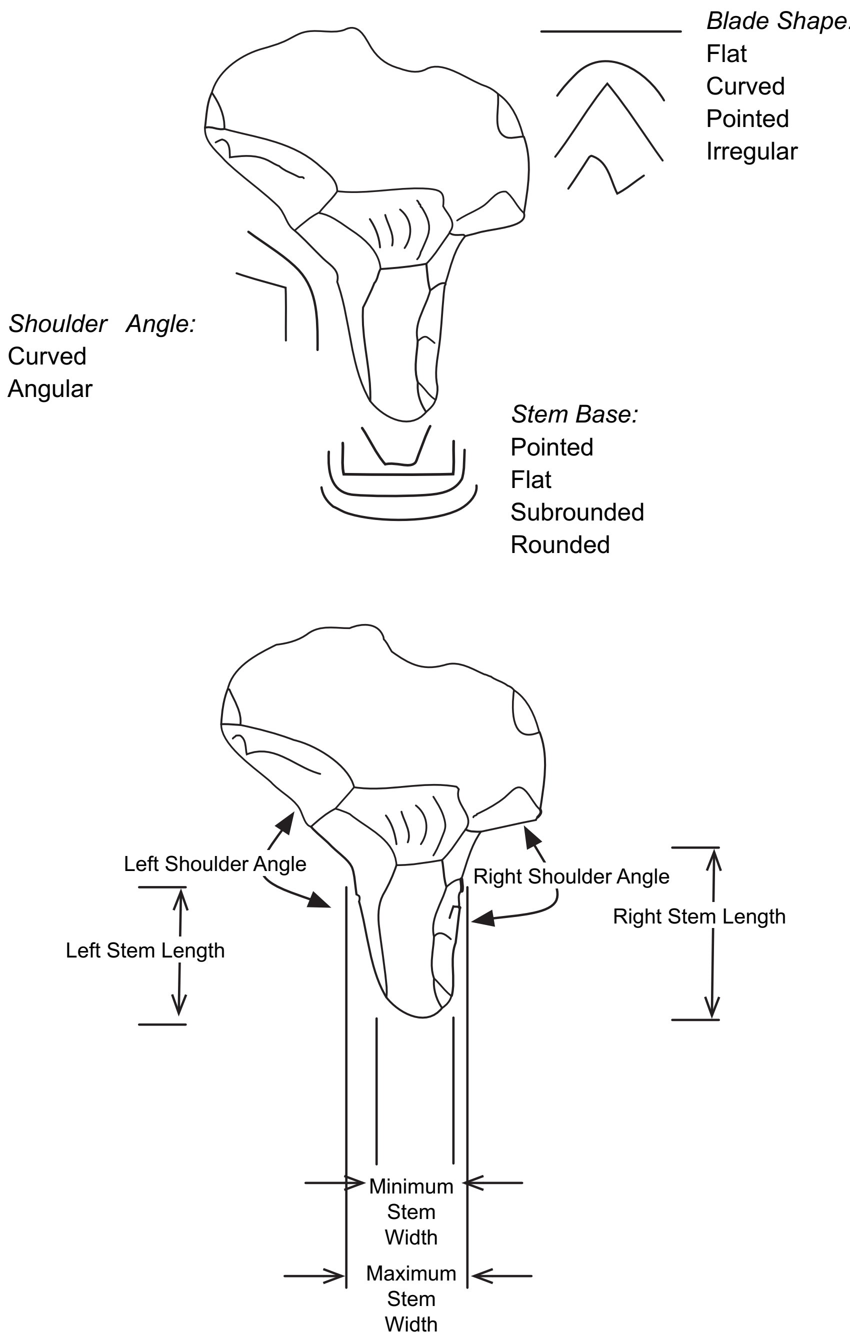


**Fig. 4.** *Mata'a* measurements and class divisions.

focused on identifying types based on characterizations of overall shape (e.g., Bormida, 1951; Skinner, 1940). William Mulloy (1961) used the classifications provided by Skinner (1940) and Bormida (1951) for 355 *mata'a* he collected from Vinapu on the south-western shore of the island. Mulloy (1961:151) ultimately concluded that "no significant clustering or correlations could be extracted… the material represents a continuous range of variation without objective natural order, and that the only classification possible must involve the subjective selection of ideal types from infinite series of possibilities, and the arbitrary reference of intermediate for to one or another of these." Mulloy astutely concluded, therefore, that manufacturing procedures dictated shapes and differences in overall shape of *mata'a* were best explained by chance.

Our goal in this study is to construct classes for *mata'a* to measure stylistic variability (*sensu* Dunnell, 1978b). Using an explanatory model in which variability in the hafting portions of *mata'a* varies according to the culturally transmitted instructions among manufacturers, we seek to determine if these classes can inform on the scale and spatial distribution of social interaction patterns among prehistoric populations on Rapa Nui. In this analysis, we use descriptions of assemblages of *mata'a* generated from 11 locations across Rapa Nui (Fig. 3). Our research examines the degree to which morphometric measures of stem variability are explained as a function of interaction distance through time and across space. This analysis employs frequency seriation, a method ideally suited for studying similarity explained by cultural

**Table 1**
Classification dimensions and class divisions used in seriations.

| Class | Value | Class | Value |
|---|---|---|---|
| Stem length | | Shoulder angle | |
| A | ≤2 cm | 1 | ≤122.0° |
| B | 2.1–3 cm | 2 | 122.0–125.0° |
| C | 3.1–4 cm | 3 | ≥125.0° |
| D | ≥4.1 cm | | |
| Stem width | | Stem length/width ratio | |
| a | ≤1.5 cm | 1 | Length > width |
| b | 1.6–2.0 cm | 2 | Length ≈ width |
| c | 2.1–2.5 cm | 3 | Length < width |
| d | 3.1–3.5 cm | | |
| e | | | |
| Stem shape | | Shoulder shape | |
| P | Pointed | C | Curved |
| R | Round | A | Angular |
| S | Square | | |
| SR | Sub-rounded | | |

**Table 2**
Class totals for stem shape and shoulder angles.

| Assemblage | Classes | | | | | | |
|---|---|---|---|---|---|---|---|
| | PC | RA | RC | SA | SC | SRC | Total |
| 6 | | 2 | 3 | 1 | 9 | 11 | 26 |
| 7 | | | | | 2 | 5 | 7 |
| 8 | | | 5 | | 5 | 8 | 18 |
| 9 | | | 2 | 1 | 8 | 12 | 23 |
| 10 | | 2 | 3 | 2 | 5 | 7 | 19 |
| 11 | | 1 | 5 | 3 | 12 | 18 | 39 |
| Ahu Tautira | 4 | | 10 | | 1 | 13 | 28 |
| Orito | 1 | | 18 | | 9 | 18 | 46 |
| Orongo | 2 | | 17 | | 4 | 13 | 36 |
| Rano Kau | 2 | | 32 | | 14 | 37 | 85 |
| Vinapu | | | 13 | | 2 | 6 | 21 |
| Total | 9 | 5 | 108 | 7 | 71 | 148 | 348 |

transmission that simultaneously addresses temporal variability while controlling for space and vice versa (Dunnell, 1970; Lipo, 2001; Lipo and Eerkens, 2008; Lipo et al., 1997).

## 2. Methods and procedures

Descriptions of artifacts that detail variability in equivalent performance alternatives (i.e., "stylistic classes" *sensu* Dunnell, 1978b or "isochrestic variation" *sensu* Sackett, 1977) have the potential to track cultural transmission patterns among populations. This is axiomatic when heritable information is described in terms that do not differ in performance. Variability thus reflects differences in instruction sets that dictate the details of how artifacts are created (Lipo and Eerkens, 2008; Lyman and O'Brien, 2003). These instruction sets are subject to small errors in copying during transmission and innovation following transmission (Eerkens, 2000; Eerkens and Lipo, 2005). Because people tend to interact and learn from those around them more often than from people at greater distances, archaeological assemblages in close proximity (i.e., of comparable age) should be more similar than assemblages removed in space. Space constrains transmission events and the resulting dissemination of information. Similarly, because there is a temporal component to transmission, assemblages in a single location should be more similar if they are closer in time and increasingly dissimilar over time (Cochrane, 2001; Deetz and Dethlefsen, 1965; Dunnell, 1978b; Lipo et al., 1997).

Seriation provides a means to measure inheritance that varies through time and space. In seriation, spatial variability is minimized by the "local-area criterion," a long-known analytic tool to maximize dimensions of similarity in the temporal domain (see Dunnell, 1970, 1981; O'Brien and Lyman, 2000). If one uses a temporal model to order assemblages, for example, then residuals may be explicable as spatial factors. By measuring each of the factors involved in spatial distance, including the distribution of the population across a particular geographical configuration, it is possible to detect differences caused by population density and functional inter-dependency. These differences measured through time are the components of interaction that define lineages archaeologically (O'Brien and Lyman, 2000, 2002, 2003). Seriation, when framed as a tool for explaining the frequencies of classes through the concept of transmission, can be used to trace lineages comparable to lineages in biology (Beals et al., 1945).

Neutral traits – when measured in terms of relative frequencies of classes constructed of stylistic dimensions – often form "unimodal" distributions through time and space (Dunnell, 1970, 1981; Lipo et al., 1997; Neiman, 1995). Unimodality, however, is not a necessary condition of neutrality; it is merely sufficient. The parameter evaluated in cultural transmission is the degree of contingent heritable continuity: unimodality is one condition sufficient to meet this requirement. While often stated that neutral traits have unimodal distributions (e.g., Leonard and Jones, 1987; Teltser, 1995), this may not necessarily be true. Neutral distributions can result in multi-modal distributions as seen in the simulations of Neiman (1995). The presence of unimodality is sufficient for one to pose a robust hypothesis that the distribution of traits is driven primarily by cultural transmission.

In this way culture historians used seriation to chronologically order style-based descriptions of assemblages through time. Their work involved sorting the frequency values for individuals classes compared between assemblages until they all exhibited a single increase and decrease. The explanatory basis of this algorithm is an empirical generalization: when assemblages were described using stylistic classes and could be arranged to form patterns of unimodal frequencies, the order created of the assemblages tends to be chronological (Dunnell, 1970). By providing a theoretical basis using a relative simple theory of cultural transmission, deterministic frequency seriation is a tool for examining interaction history in the archaeological record (Lipo et al., 1997). As we consider other explanatory dimensions that can account for the products of cultural transmission beyond aspects of time, for example space and social structure, we can use the unimodality criterion in generating a non-chronological hypothesis. This procedure leads us to expect that cultural lineages will not be discrete bounded entities, but anomalously dense clouds of interaction within a background of continuous transmission through time and across space.

Analysis of human interaction using seriation consists of building models that comprise the largest number of assemblages possible, while simultaneously placing them in an order that conforms to a unimodal pattern (Dunnell, 1970). Assemblages are added in an iterative fashion with the orderings treated as hypotheses about their fit to a unimodal distribution. Testing the fit involves pair-wise comparison of assemblages using confidence intervals for class frequencies calculated on the basis of sample size. Assemblages that fit the expectations of the unimodal curve are accepted into a given seriation group; assemblages that do not fit within confidence limits are rejected and placed into different groups. In this way, the total group of available assemblages can be broken down into sets that produce consistent seriations within which frequencies scale by distance. These sets of assemblages can be treated as measures of the interacting populations. Assemblages

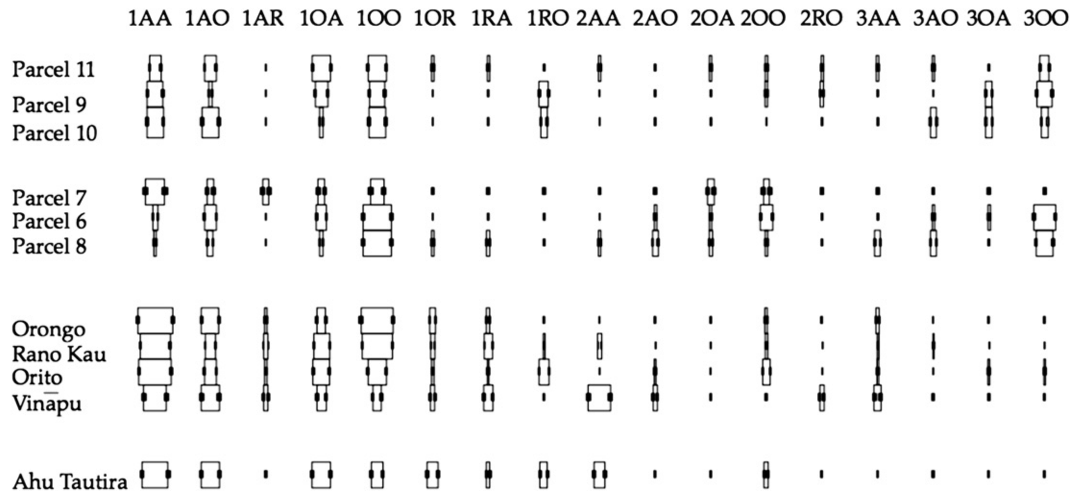


**Fig. 5.** Seriation solution for classes comprised of stem length/width ratios and shoulder angle measures. This seriation solution consists of the largest groups of assemblages that can be statistically ordered following the unimodality criterion using classes consisting of stem length to width ratios (1: length > width; 2: length ≈ width (with 1 cm); 3: width > length) and shoulder angles (right and left shoulder angle, respectively. O: >125°; R: 122–125°; A. <122°).

that fit in multiple seriation solutions document artifact classes that are shared by multiple lineages.

### 2.1. Classifications

Previous classifications constructed for *mata'a* have focused on measures of overall shape. Shape characterization, however, often includes a mix of dimensions that are both functional (i.e., performance driven) and stylistic (i.e., equivalent alternatives) (see Dunnell, 1986:159; Lyman et al., 1997:16). These mixed aspects of classification serve to explain Mulloy's (1961:151) conclusions: that the overall shapes of *mata'a* are explicable as the result of variation in use and the idiosyncratic and contingent nature of percussion technology on large obsidian flakes. Replication studies by Bollt et al. (2006) also supports this conclusion. Through a series of experiments, Bollt et al. reconstructed a sequence of steps that they argued were necessarily involved in the process of *mata'a* manufacture. This sequence demonstrates the parts of *mata'a* production constrained by physical properties (i.e., which step must come after another) as well as the aspects of manufacture contingent upon individual choices. In this way, their work provides an insight into prehistoric manufacturing grammar for *mata'a* in a similar fashion to the "chaîne opératoire" studies (e.g., Shott, 2003) and pottery grammar as described by Krause (1972). Bollt et al. (2006) demonstrate that much of the variability in the overall blade shape can be explained as details of the idiosyncratic stages of manufacture or the "life history" *plus* differences structured by functional variation related to the range and kinds of activities for which the tool was primarily used: cutting, scraping, or in combinations.

Focusing our measurements on variability in the stem portion of the *mata'a* potentially avoids this problem. Since the hafting portion simply must provide a means for attaching the object to a shaft, stems likely exhibit variability that reflects cultural transmission. Most bifacial artifact classifications focus on the hafting-end of pointed tools where variability comprises the greatest degrees of freedom, thus providing variability that reflects transmission in time and space.

## 3. Analyses

To evaluate hypotheses for cultural transmission through time and across space, we photographed *mata'a* collections from several parts of Rapa Nui, including Vinapu, Rano Kau, Ahu Tautira, Orito, and Orongo (Fig. 3). These *mata'a* were collected by multiple researchers over the past 50 years or more and are held in the P. Sebastian Englert Museum on Rapa Nui (e.g., Heyerdahl and Ferdon, 1961). In addition, we photographed *mata'a* identified during our pedestrian surveys of eleven parcels (*parcelas*) of land undertaken with field school students in collaboration with

**Table 3**
Class totals for *mata'a* stem length and width.

| Assemblage | Classes | | | | | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Aa | Ab | Ac | Ba | Bb | Bc | Bd | Cb | Cc | Cd | Db | Dc | Dd | De | |
| Parcel 6 | 11 | 12 | 2 | 3 | 8 | 3 | 2 | | | | | | | | 41 |
| Parcel 7 | | 3 | | 3 | 4 | | | | 2 | | | | | | 12 |
| Parcel 8 | 6 | 10 | 2 | 3 | 7 | 2 | | 3 | 2 | | | 2 | | | 37 |
| Parcel 9 | 4 | 10 | 1 | 4 | 9 | | | 1 | 2 | 1 | | | | 2 | 34 |
| Parcel 10 | 7 | 5 | 2 | 2 | 6 | 4 | | | 1 | | | | | | 27 |
| Parcel 11 | 13 | 11 | 3 | 3 | 9 | 2 | 1 | 6 | 2 | | | | 1 | 1 | 52 |
| Ahu Tautira | | 2 | | 2 | 5 | 11 | | 2 | 4 | | 1 | 1 | 1 | 1 | 30 |
| Orito | 1 | 5 | 2 | 2 | 21 | 13 | | 7 | 3 | 1 | | | | | 55 |
| Orongo | 3 | 3 | | 4 | 13 | 1 | 1 | 6 | 6 | | | | | | 37 |
| Rano Kau | 14 | 7 | 1 | 9 | 39 | 9 | | 7 | 8 | 2 | 1 | 1 | 1 | | 99 |
| Vinapu | 1 | 2 | | | 3 | 5 | 1 | 1 | 4 | 2 | | 1 | 1 | 2 | 23 |
| Total | 60 | 70 | 13 | 35 | 124 | 50 | 5 | 33 | 34 | 6 | 2 | 5 | 4 | 6 | 447 |

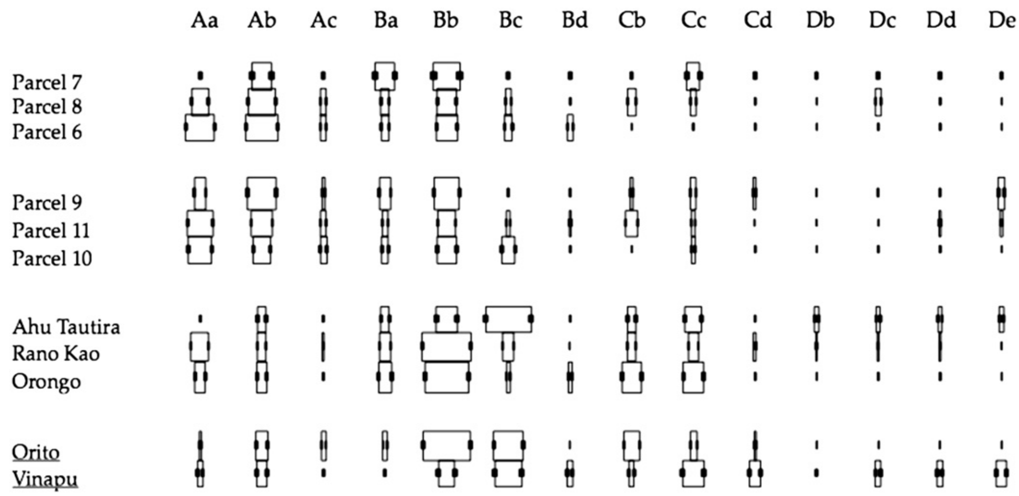


**Fig. 6.** Seriation solution for classes of *mata'a* constructed with measures of stem length and width. Classes represent increments of centimeters, the first letter represents length; A: ≤2, B: 2.1–3, C: 3.1–4, D: ≥4.1. The lower case letter stands for stem width; a: ≤1.5, b: 1.6–2, c: 2.1–2.5, d: 2.6–3, e: ≥3.5.

staff from the P. Sebastian Englert Museum. Our survey of these parcels was undertaken as a voluntary part of historic preservation and planning efforts made in conjunction with land repatriation from the Chilean Government to native recipients of the Rapa Nui community. We photographed a total of 447 *mata'a*. All photographs of *mata'a* can be found at http://www.rapanuidatabase.org.

Using ACD System's Canvas©[1], a computer-based drafting program, metric measurements were made from the scaled photographs. We followed procedures outlined by O'Brien and Lyman (2003). Our measurements consisted of left and right stem length, minimum and maximum stem width, and right and left shoulder angles (Fig. 4). We also made qualitative assessments of the shape of the stem (square, sub-rounded, rounded, pointed, broken/missing), shape of the shoulder angle (curved, angular), and the shape of the blade (pointed, flat, curved, irregular, broken/missing).

These measurements, both qualitative and quantitative, were used to create classifications based on attributes of the *mata'a*. Each classification consisted of the full set of *mata'a*, minus any incomplete (broken) *mata'a* eliminated from analyses in order to create a comparable set of descriptions. Table 1 shows the letters and numbers applied to each interval in centimeters or degrees in the classes built from quantitative measurements. The classes in the quantitative classification were composed of ranges of centimeters or degrees, which were in turn represented by arbitrary combination of letters and numbers (e.g., *Ab2II*). The qualitative measurements are denoted by three letters, one for each dimension. For example *RCI* denotes Round stem, Curved shoulder, and Irregular blade. The dimensions and class divisions used in our analyses are presented in Table 1.

### 3.1. Seriations

Once we tabulated class instances using the measurements and observations generated from the photographs of the *mata'a*, we constructed deterministic frequency seriations for each classification using a Microsoft Excel macro (Lipo, 2001). Following the algorithm described above, we created seriations using the tabulations of artifacts described by each classification. Differences in the frequencies of classes between assemblages that are caused by differences in sample size are evaluated using confidence values of $a = 0.01$ calculated using the beta distribution.

We constructed the first seriation based on classification that consisted of classes of quantitative dimensions (Table 2; Fig. 5) for the ratio of the maximum length and width of the stem and the maximum size of the shoulder angle measured relative to the stem. Stem measurements were divided into three classes: length > width, length ≈ width (values within 1 cm.), length < width. To determine class divisions for shoulder angles, we first measured shoulder angles for all *mata'a* and determined the average value, 123.5°. We then arbitrarily divided angles into classes comprising values greater than average value plus and minus one and a half degree (Table 1). Removing broken *mata'a* for which all measurements could not be made, our sample size comprised 348 artifacts (Table 2). In addition, Parcels 1, 4, and 5 had so few class members that, given proximity, these artifacts were grouped with Parcel 6.

The seriation analysis resulted in the generation of groups of assemblages that are spatially coherent (Figs. 5 and 8). These groups represent the largest sets of assemblages that can be ordered without violating the rules of deterministic frequency seriation following the algorithm presented by Lipo et al. (1997) and Lipo (2001). The spatial coherence of these groups appears to represent interaction among a population that decays with distance; that is, the more distant the location, the more distinct the combination of class frequencies. If spatial variation did not structure the frequencies of classes, one would expect a solution in which assemblages formed a single order, with no necessary spatial patterning.

Consistent with the transmission model that underlies the classes and the seriation method, the seriation groups can be potentially viewed as lineages where the order between assemblages is primarily temporal. It should be noted, however, that the temporal order of the assemblages is relative to the level of the classification used to generate the frequencies. At this level of measurement (*sensu* Dunnell, 1971), the difference in spatial variability is sorted into spatially segregated groups while within group variability is largely temporal. Within each seriation solution, however, the relations of the assemblages are primarily chronological, though the durations for each deposit (surface assemblage) may be overlapping and thus potentially "contemporary" to some degree (Dunnell, 1970; Lipo et al., 1997). Age determination for

[1] http://www.acdsystems.com.

**Table 4**
Class totals for *mata'a* stem shape and shoulder angle shape.

| Location | Classes | | | | | | Total |
|---|---|---|---|---|---|---|---|
| | PC | RA | RC | SA | SC | SRC | |
| 6 | | 2 | 3 | 1 | 9 | 11 | 26 |
| 7 | | | | | 2 | 5 | 7 |
| 8 | | | 5 | | 5 | 8 | 18 |
| 9 | | | 2 | 1 | 8 | 12 | 23 |
| 10 | | 2 | 3 | 2 | 5 | 7 | 19 |
| 11 | | 1 | 5 | 3 | 12 | 18 | 39 |
| Ahu Tautira | 4 | | 10 | | 1 | 13 | 28 |
| Orito | 1 | | 18 | | 9 | 18 | 46 |
| Orongo | 2 | | 17 | | 4 | 13 | 36 |
| Rano Kau | 2 | | 32 | | 14 | 37 | 85 |
| Vinapu | | | 13 | | 2 | 6 | 21 |
| Total | 9 | 5 | 108 | 7 | 71 | 148 | 348 |

artifacts at a scale and level below seriation would be required to distinguish the degree of contemporaneity and relative rates of changes between individual assemblages.

A means of evaluating the degree of robustness of the seriation solutions can be accomplished by generating multiple seriations using alternative descriptions of the assemblages (Dunnell, 1970:316). This procedure involves creating alternative style-based classification and generating new seriation solutions. Classifications can be varied to examine the effect of level on the results (see Dunnell, 1971). As classifications are constructed to use greater or fewer numbers of measurement dimensions, one can use the alternative results to evaluate the degree to which the seriations vary as a response to classification level (Lipo, 2001; Lipo et al., 1997). In addition, classifications can be built to include alternative dimensions. This procedure allows one to evaluate scale of cultural transmission patterns and the degree to which the original solution is tied to specific classes of attributes.

As an additional analysis, we built a classification that employed length and width of the stems as dimensions (Table 3). Using observations from 447 *mata'a* that were complete enough to measure, this seriation produced results remarkably similar to spatial patterns observed with the classification that consisted of stem length/width ratio and shoulder angles (Figs. 6 and 8). While some aspects of the congruence relate to physical constraints inherent in the *mata'a*, and thus some degree of autocorrelation in the classifications, the degree of similarity in the solutions supports the idea that variability in stems is structured by cultural transmission and individual manufacturing preferences. The pattern, however, is not identical, thus suggesting that the attributes are not necessarily shared as a single unit of transmission. Instead, information about stem shape for *mata'a* is shared in a more piecemeal fashion, and not a single "recipe" (*sensu* Lyman and O'Brien, 2003).

Finally, we constructed a seriation based on the classification of the qualitative measurements comprising stem shape and shoulder angle shape (Table 1). Removing broken (incomplete) *mata'a* from our analysis, the number of artifacts included totaled 348 (Table 4). Once again the pattern of the grouping of assemblages is consistent with the other seriations (Figs. 7 and 8). This result also points to the scale of transmission occurring as the set of instructions necessary to replicate at least the entire stem portion of the *mata'a*.

## 4. Discussion

Significantly, all analyses of classes with dimensions that included measures of blade shape did not produce a seriation of any size that met the requirements of the method. Our inability to use blade shape in these analyses supports Mulloy's (1961:152) observation of the idiosyncratic nature of the overall shape of *mata'a* as well as the observation that shape of the blades was not transmitted with the instructions used to create the other portions of the objects. The lack of cultural transmission for blade shape suggests that it was either strongly functional (and no significant environmental differences existed across the area of the island studied) or that blade shape was not a central aspect of *mata'a* construction. In the latter case, the essential part of these artifact classes is the presence of a stem since the proximal end did no particular work other than being hafted on the end of a shaft. Additional research on the amount and location of use-wear should help distinguish these two possibilities.

While the seriation results are consistent with expectations of cultural transmission between individuals interacting locally, there are alternatives to this hypothesis. For example, if environmental resources varied along the coast then one would expect to see patterns that potentially relate to changing functional constraints for these tools. Changes in resources and thus processing

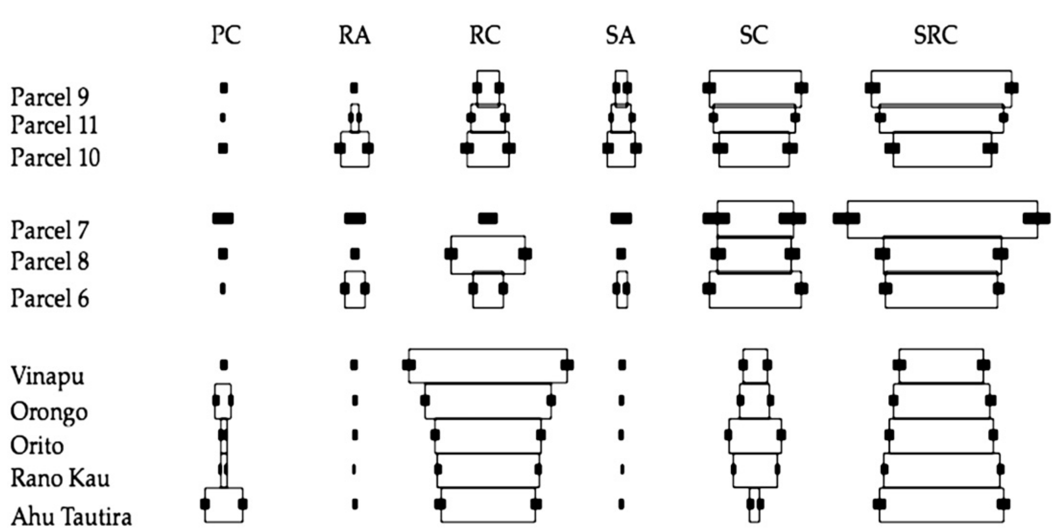


**Fig. 7.** Seriation solution for qualitative classes of *mata'a* in which the first letter of the class indicates the stem shape (Pointed, Round, Square, Sub-Rounded); the second letter indicates the shoulder shape (Curved, Angular).

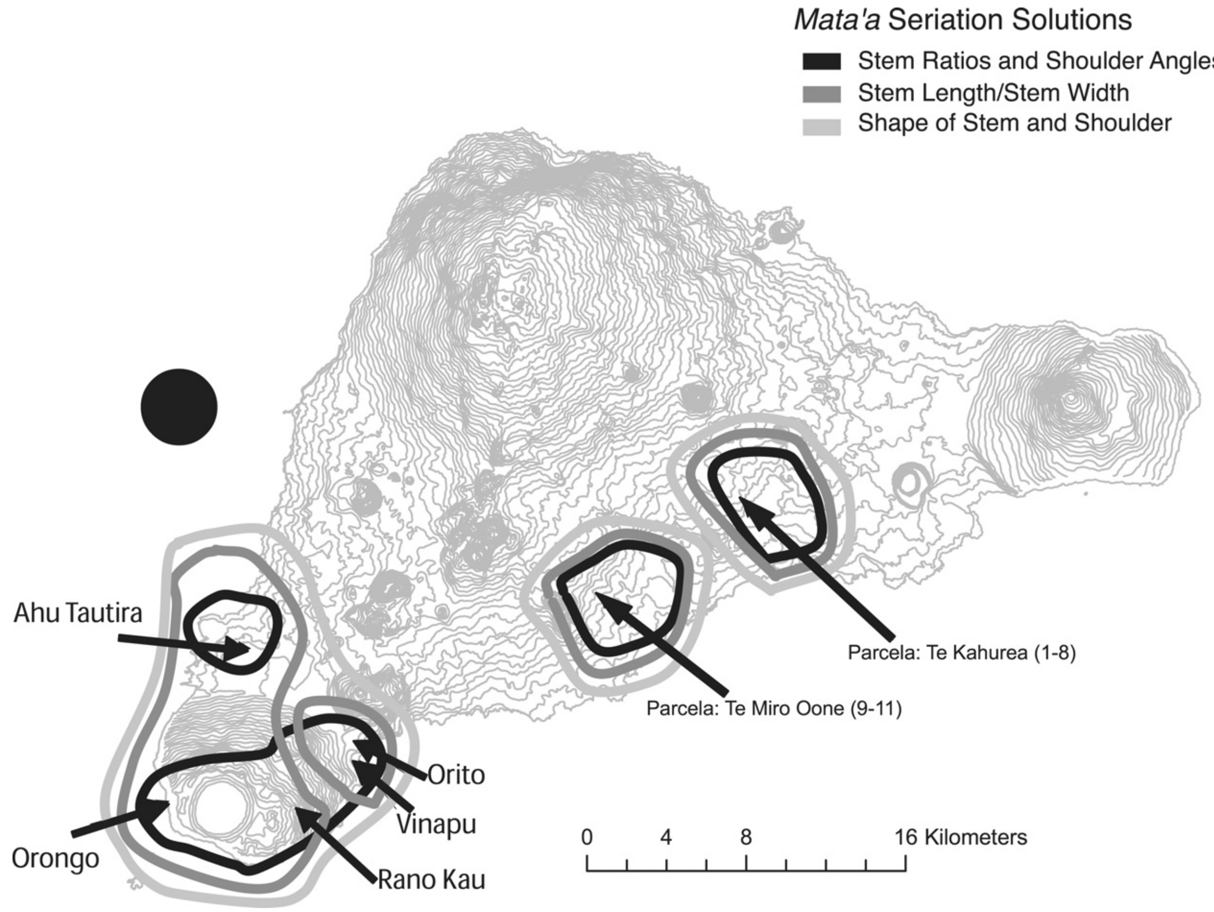


**Fig. 8.** Spatial distributions of the seriation groups on Rapa Nui.

requirements potentially explain the patterns observed. In the case of Rapa Nui, however, there is little evidence that resources potentially related to the use of *mata'a* varied to any significant extent across the island. The island is small, only about 23 km in its longest dimension. The volcanoes that form the three corners of this triangular-shaped island reach only a few hundred meters elevation and produce little if any orographic effect. The soils from these areas were all formed from eruptions from the same volcano, Terevaka (Vezzoli and Acocella, 2009), and thus have similar composition and levels of soil nutrients (Louwagie et al., 2006). Archaeologically, surveys have shown that the material record for areas from which these collections were made have similar redundant combinations of features including earth ovens (*umu*), small circular gardens (*manavai*), and rock mulched fields (McCoy, 1976; Wozniak, 2003). Thus, there is no clear evidence that sufficient environmental differences exist across the island that could explain the pattern of *mata'a* stem shape.

Similarly, variability in *mata'a* stem shapes may be primarily from change through time. Under this scenario, temporally distinct stem forms may have been created and then deposited in distinct areas over time. If the occupation of the island by *mata'a* users varied systematically through time, a spatial pattern could emerge similar to what we observed in our seriation solutions. This possibility, however, seems unlikely. The chronology for the island is relatively short (less than 800 years, see Hunt and Lipo, 2006), human occupation appears to be widespread across the diminutive island almost immediately after first colonization and there is no evidence for temporal shifts in areas of occupation of the portion of the island covered in this study.

## 5. Conclusions

Previous studies of overall shape have failed to produce discernable patterns among stemmed obsidian artifacts (*mata'a*) from Rapa Nui. We can now see that this failure is not from a lack of structure among the variability in the artifact classes, but in the absence of explicit theory-based classifications. Classifications are the key to the process of explanation since it is from these conceptual structures that meaning is determined. By using cultural transmission models to structure classes and to make measurements, one is able to produce results that can then be explained in terms of the model and allows us to address issues of social interaction and the scale of integration.

Here, we have shown that stylistic classes of *mata'a* stem variability reliably demonstrate a strong spatial and temporal pattern among assemblages. The consistent results we obtained allow us to posit two substantive conclusions about Rapa Nui prehistory. First, the results show that information about *mata'a* manufacture (i.e., cultural transmission) was differentially shared on a "local" scale distinguished in the portions of the island analyzed. In each of these classifications, spatial division of the assemblages was required to produce a successful seriation order (Fig. 7). Particularly noteworthy is the observation that groupings were consistent in each independent seriation. This result reveals a pattern in which prehistoric populations interacted on this small island, not as a large-scale social network, but in relatively smaller ones.

The second conclusion posits that the scale of cultural transmission among makers of *mata'a* comprised an instruction set for producing the stem portion of the artifact, but not the entire object.

Blade shape, it appears, freely varied and was probably conditioned by the happenstance of the flake selected for the artifact in the first place. This pattern suggests that *mata'a* were not used extensively as weapons given the lack of a specific pattern in shape driven by the function of stabbing or inflicting other serious injuries. This conclusion indicates that whatever roles *mata'a* played in prehistoric subsistence and settlement systems, shape was not heritable and these tools performed multiple, varied jobs. We posit that *mata'a* were used for generalized tasks and perhaps in symbolic displays related to non-lethal competition (i.e., they would not have been effective weapons).

Our conclusions should be examined more thoroughly with additional measures of *mata'a* including larger collections from a greater portion of the island. The relatively limited regional distribution of the assemblages (the south and southwestern portions of the island) and restricted sample size (a total of 447 *mata'a*) make it difficult to draw particular conclusions about the spatial extent of individual groups. Consequently our generalizations remain preliminary.

When we consider additional lines of evidence for artifact variability (including non-portable artifacts such as rock art and architecture), similar patterns of cultural transmission among multiple "localized" groups emerge. Patterns of statue transport roads (Lipo and Hunt, 2005), stylistic variation in statues (Lipo and Hunt, 2006), earth oven planimetric shapes (McCoy, 1976), and rock art motifs documented in detail by Lee (1992) reveal convergent patterns conforming to cultural transmission constrained by spatial distance. This is remarkable given the small size of Rapa Nui. While further studies are warranted, variability in human biology (genetic and chemical data) among the ancient Rapa Nui population appears to indicate a pattern of localized differentiation and limited mobility (Dudgeon, 2008). It follows that that social organization was relatively small in scale, likely configured along local kin-based corporate groups, rather than island wide cooperation or leadership (i.e., a centralized chiefdom), in contrast to what some have suggested (e.g., Van Tilburg, 1994). Our archaeological observations find parallels in the ethnographic record of descent groups (*mata*) organized in a territorial system (*kainga*) for Rapa Nui (Metraux, 1940; Routledge, 1919). The evidence for smaller scale, relatively autonomous social groups, in contrast to a paramount chiefdom, has implications for models to explain the evolution of competition and cultural elaboration (Hunt and Lipo, 2001) on this remote and relatively resource-poor island.

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