Reconstructing sexual divisions of labor from fingerprints on Ancestral Puebloan pottery

John Kantner[a,1], David McKinney[b], Michele Pierson[a], and Shaza Wester[a]

[a]Office of Research, University of North Florida, Jacksonville, FL 32224; and [b]Department of Anthropology, Georgia State University, Atlanta, GA 30302-3998

Edited by Stephen Plog, University of Virginia, Charlottesville, VA, and approved May 2, 2019 (received for review February 3, 2019)

An understanding of the division of labor in different societies, and especially how it evolved in the human species, is fundamental to most analyses of social, political, and economic systems. The ability to reconstruct how labor was organized, however, especially in ancient societies that left behind few material remains, is challenged by the paucity of direct evidence demonstrating who was involved in production. This is particularly true for identifying divisions of labor along lines of age, sex, and gender, for which archaeological interpretations mostly rely upon inferences derived from modern examples with uncertain applicability to ancient societies. Drawing upon biometric studies of human fingerprints showing statistically distinct ridge breadth measurements for juveniles, males, and females, this study reports a method for collecting fingerprint impressions left on ancient material culture and using them to distinguish the sex of the artifacts' producers. The method is applied to a sample of 985 ceramic sherds from a 1,000-y-old Ancestral Puebloan community in the US Southwest, a period characterized by the rapid emergence of a highly influential religious and political center at Chaco Canyon. The fingerprint evidence demonstrates that both males and females were significantly involved in pottery production and further suggests that the contributions of each sex varied over time and even among different social groups in the same community. The results indicate that despite long-standing assumptions that pottery production in Ancient Puebloan societies was primarily a female activity, labor was not strictly divided and instead was likely quite dynamic.

archaeology | division of labor | human fingerprints | US Southwest | Chaco Canyon

The evolution of divisions of labor in the human species is debated in many disciplines, with much discussion regarding the biological, social, cultural, and economic influences on the organization of activities in different societies (see reviews in refs. 1 and 2). Most interpretations of how humans organize are based on proposed socioeconomic efficiencies gained by coordinated effort. For example, conventional wisdom suggests that the division of labor started along the axes of age and gender, presumably based on actual or perceived biological differences and their impact on productivity, and became increasingly specialized around those axes as human societies evolved. The problem with these or any other proposals, however, is that identifying incipient divisions of labor is very difficult, especially because their earliest manifestations occur in the context of small-scale societies with comparatively small quantities of typically poorly preserved material culture.

With its access to material evidence of past human activity over thousands of years, archaeology is uniquely poised to explore this topic from a deep evolutionary perspective. The discipline does face significant challenges, however, in reconstructing past forms of labor specialization, particularly along lines of age or sex. Traditionally, archaeologists have relied upon historical and ethnographic evidence and used observed material manifestations as analogs for looking into the past (see reviews in refs. 2 and 3). However, this evidence is often criticized as too heavily biased by histories of colonialism and European notions of gender and age to provide adequate analogs for past behavior.

This is particularly true in the US Southwest, where assumptions regarding ancient gender roles typically rely on the documented behavior of descendent Native American communities to build analogies back to precontact groups. For example, pottery production among one such group known as "Ancestral Puebloans" is usually reconstructed through reference to the practices of their descendants as recorded first by European invaders and later by anthropologists (e.g., refs. 4 and 5). These observations of a division of labor in which women were reportedly responsible for pottery production have been projected onto the archaeological record and used to interpret patterns ranging from gendered activity areas to differential mortuary treatment. Other past behaviors have been interpreted as if gender did not play a role at all in the organization of labor. This has been at least partly due to the absence of independent, confirmatory evidence demonstrating that the historical and ethnographic records are adequate for inferring past behavior from material remains.

What is needed for archaeology to contribute to the history of the human division of labor are methods for identifying gendered activities that do not rely upon analogy (e.g., refs. 6 and 7). This study provides an example of one such approach: the use of fingerprint impressions in archaeological ceramics to identify the sex of the potter. To the degree that the maker of each fingerprint is involved in ceramic production, and assuming that biological sex and cultural gender roles are correlated, the patterns of fingerprints recovered from ancient vessels can be used to infer gendered divisions of labor in pottery production.

Significance

The evolution of the sexual division of labor within human societies is difficult to reconstruct because of the scarcity of direct evidence recovered from archaeological contexts, and yet many disciplines make assumptions regarding how labor first became specialized in our species. We propose an innovative method for identifying the sex of potters through the analysis of fingerprint impressions recovered from material culture. An application of the method to ancient pottery demonstrates that males and females were both significantly involved in producing vessels. The study further suggests that the exact proportion of each sex involved in pottery making was quite fluid, and may have varied among different groups in the same community, as well as changed from generation to generation.

Author contributions: J.K. and D.M. designed research; J.K., D.M., M.P., and S.W. performed research; J.K. analyzed data; and J.K. wrote the paper.

The authors declare no conflict of interest.

This article is a PNAS Direct Submission.

[1]To whom correspondence may be addressed. Email: j.kantner@unf.edu.

This article contains supporting information online at www.pnas.org/lookup/suppl/doi:10.1073/pnas.1901367116/-/DCSupplemental.

Published online June 3, 2019.

To demonstrate the utility of this approach, partial fingerprints were extracted from a sample of archaeological ceramics from what is now northern New Mexico. The fragmented vessels were recovered during investigations of an Ancestral Puebloan community that was primarily occupied in the 10th and 11th centuries AD, a period associated with the growth of an influential socioideological system centered on the monumental center of Chaco Canyon, the history of which impacted a large part of the US Southwest (8). One of the many debated questions about the Chaco era is the degree to which labor became specialized and the role of gender in religious, sociopolitical, and economic organization (9–12). Because certain kinds of pottery known as "corrugated wares" were created by pinching coils of clay paste together, the resulting fingerprint impressions can be used to determine the sex of the potter and thereby make inferences about the organization of Chacoan labor through time.

Fingerprints and Biological Sex

The utility of fingerprints for identifying individuals is well known, particularly in the forensic sciences, in which dermal patterning has been used as proof of identity for more than a century (13). The notion that every person's fingerprint is unique permeates popular media—so much so that "fingerprinting" is a common metaphor applied to all kinds of situations, such as the use of DNA to identify individuals. Even in archaeology, distinct geochemical patterns that allow the investigator to trace stone artifacts to their geological origins are often referred to as "fingerprints" of that source.

Assumptions of human fingerprint uniqueness, however, have come under scrutiny (13, 14), with some evidence that close genetic relatedness can lead to shared elements of print pattern. Numerous recent studies in the forensic fields, for example, demonstrate strong relationships between specific fingerprint measurements and sex, with especially robust statistical patterns distinguishing adult males from adult females identified using friction ridge breadth. One such study (15) found that ridge breadth measurements of males and females differed significantly ($P < 0.001$), identifying the sex of the fingerprint maker with 80–90% accuracy. This relationship appears to be universal, having been confirmed within a number of biological populations (e.g., refs. 16 and 17). One recent study (16), for example, compared a sample of indigenous Argentinians with a sample from Spain and concluded that while differences exist between the samples, statistically significant sexual dimorphism in fingerprint ridge breadth can still be found within each sample. Other investigations suggest that while aging does impact print integrity, distinctions by sex are consistent regardless of adult age (e.g., ref. 18).

Forensic research has also explored intra- and interdigit comparability to determine whether different sectors of a fingerprint and prints from different fingers can consistently identify sex. Studies across different biological populations (16, 17) indicate that within a particular fingerprint, distal ridges tend to be consistently sized and clearly distinct by sex, although proximal ridges close to the knuckle are more variable. Not surprisingly, little fingers and thumbs are the most dissimilar digits when the same sector of the fingerprint is compared. In contrast, fingerprint ridge densities on thumbs and index fingers are comparable, especially on the ulnar side (toward the thumb) of these digits (15–17). In general, distal ridge breadths are statistically different for males and females, especially when comparing the same fingerprint sector of the same or adjoining digits.

Archaeologists often identify fingerprints in the material record, and yet only a very few have ever explored ways to use "paleodermatoglyphs" to reconstruct the past. The reasons for this apparent disinterest are varied—fingerprints identified in archaeological contexts are thought to be too distorted or partial to be useful, and the conventional view that fingerprints identify individuals has not fit with the discipline's focus on reconstructing normative sociocultural patterning. Accordingly, only a handful of research projects on ancient fingerprints have been published. Most have focused on methodological approaches to paleodermatoglyphics (19–21), while a handful have attempted to use ancient fingerprints to address questions about past human behavior (22, 23). These results mirror the recent forensic studies: sex and perhaps age can be discerned from ancient fingerprints.

In the US Southwest, archaeologists have been aware of the fingerprints that appear in some material culture, but they too have rarely used paleodermatoglyphs to interpret the past. Exceptions include the innovative research of Kamp et al. (24), who, after collecting information from living humans to develop correlations between friction ridge breadth and age, used fingerprints extracted from Ancient Puebloan ceramic vessels and figurines to identify the role of children in the manufacture of these artifacts. In another study (25), Susan Stinson used Southwestern Native American and Filipino fingerprint datasets for reconstructing the sex and general age of the producers of ancient Hohokam figurines. Despite the utility of paleodermatoglyphics demonstrated by these studies, however, few if any other archaeologists working in the US Southwest have used ancient fingerprints to understand the past.

Chaco Canyon and the Chaco World

Located in northern New Mexico (Fig. 1), the monumental architecture of Chaco Canyon has earned it a designation as a UNESCO World Heritage Site (26). The buildings found there, many of which are up to five stories high and contain hundreds of rooms, were primarily constructed in the 10th and 11th centuries AD (27–30). Surrounding Chaco Canyon itself were hundreds of contemporaneous farming communities spread across the northern US Southwest, most of which were tied socioculturally to the central canyon to such an extent that the region is often referred to as the "Chaco World" (31, 32). The excellent preservation, precise dendrochronological control, and lengthy history of archaeological investigation in this area contribute to a rich and detailed material record that continues to be the subject of scientific examination and anthropological interpretation.

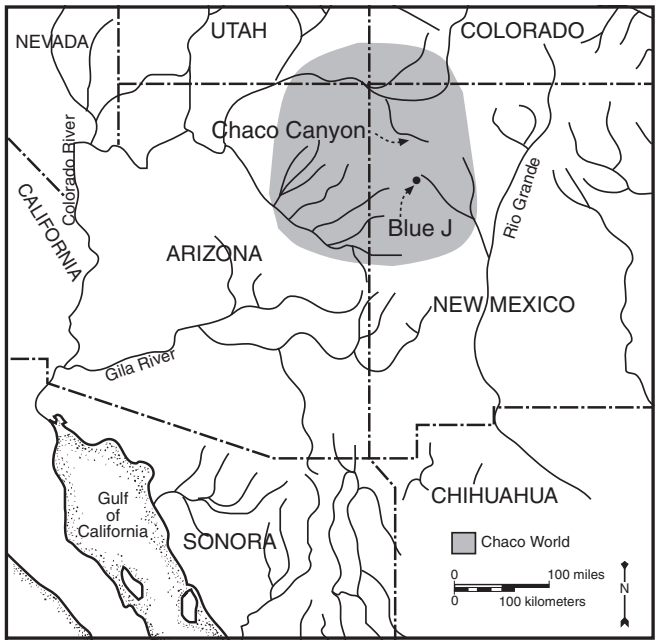

Fig. 1. Location of Chaco Canyon and surrounding Chaco World in northwestern New Mexico, USA.

Fig. 2. Reconstructed corrugated vessel recovered from the Blue J Ancestral Puebloan community, a Chaco-era village located in the Chaco World.

While scholars still debate exactly what Chaco Canyon was and its causes and consequences, there is nearly universal agreement that its development signaled important changes in Ancient Puebloan sociocultural organization (33–35). Less clear, however, is exactly what changed and why. The role of women in society, the intensity of craft production, and the scale and manner in which labor was specialized are among the topics that researchers are actively exploring. The evidence so far suggests that women were generally responsible for the production of domestic goods such as cooking and serving vessels, while men's roles were focused on other activities, such as ritual preparation and hunting (36–38). Most of these conclusions are drawn from ethnographic analogy and cross-cultural comparisons (39), with imagery on pottery or in rock art seemingly confirming this gendered division of labor (40, 41). A handful of scholars, in contrast, have pointed to ethnographic and historical accounts suggesting that women and men often shared responsibilities for some crafts (42). What is missing is any direct evidence of the gender(s) of the individuals involved in specific production tasks.

Of all of the archaeological materials recovered from Chaco World contexts, fragmentary ceramic vessels are the most numerous. Ancient Puebloan people in the Chaco Canyon region produced several different kinds of pottery, ranging from finely made and beautifully painted "black-on-white" serving vessels to undecorated utilitarian jars. Because of their ubiquity, chronological sensitivity, and variability in material, source, and style, these ceramics are an excellent source of information for reconstructing past human behavior in the US Southwest.

One notable pottery type relevant to this study is "corrugated" cooking ware, the name reflecting a surface texture created by the potters manually pinching the coils of clay paste together (Fig. 2). Studies suggest that this production method provided a number of advantages, including easier handling, better temperature control, and increased use-life (43–45). Thousands of these pots were imported into Chaco Canyon from communities dozens of miles away that produced them in large quantities (46, 47).

Because corrugated pottery was produced by pinching coils together, the resulting vessels are covered with the partial fingerprints of the potters involved in production (Fig. 3). Assuming that fingerprints encode an individual's sex, it should be possible to determine the sex, and thus make strong inferences about the gender, of the individuals involved in the production of each Chaco-era corrugated vessel. We propose that an examination of a large number of fingerprints across an entire collection of pottery can be used to draw conclusions about the role of men and women in the production of corrugated wares. Furthermore, sampling collections from different time periods can contribute to discussions regarding how craft production and gender roles in Chaco society changed over time.

Results and Discussion

Fingerprint impressions from 985 corrugated ceramic sherds were analyzed to determine the sex of individuals involved in the

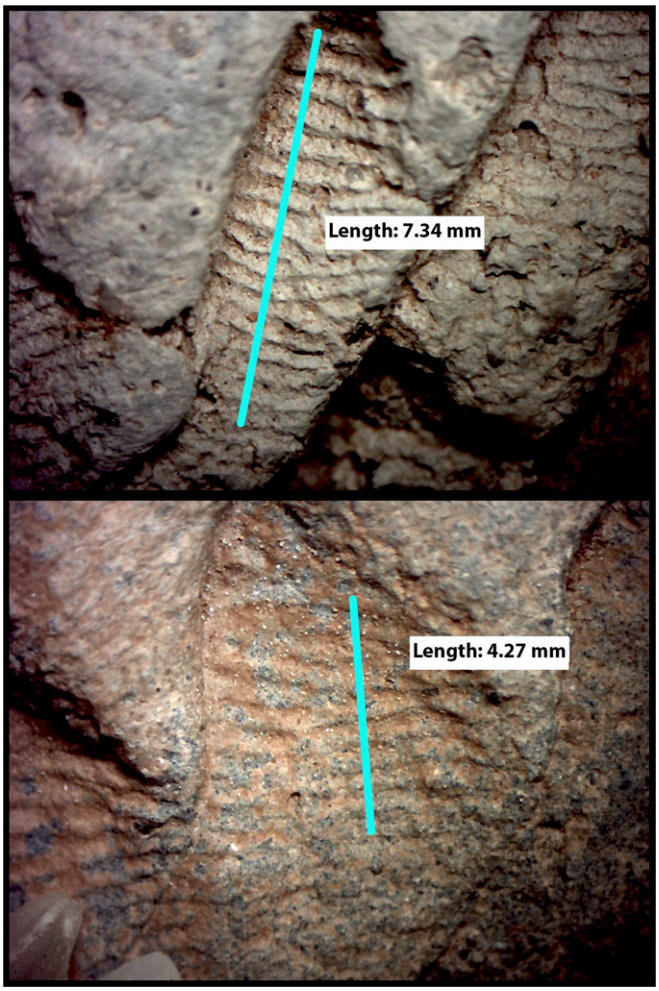

Fig. 3. Sample images of magnified ceramic sherds (25×) showing residual fingerprints in the corrugations, and the measurements made using Motic Images Plus 2.0 software.

production of pottery in the Blue J Ancestral Puebloan community (Fig. 4), a Chaco-era village located within the Chaco World (Fig. 1). As shown in Fig. 5, the histogram of fingerprint breadth measurements exhibits a bimodal distribution, strongly suggesting that adult males and females were equally involved in pottery production—or at least in the stage of production in which coils of clay paste were pinched together to form vessels. While a bimodality coefficient measure of 0.45 for the dataset is below the 0.55 threshold for statistically confirming a bimodal distribution (48), this is not unexpected since forensic studies show that fingerprint breadth distributions for males and females overlap (15, 20).

Confirmation that both sexes were involved in production of these ceramics is provided by comparing the fingerprint breadth measurements with the average breadth ranges identified in living humans by Králík and Novotny (20). Of the 985 sherds, 464 (47.1%) fall exclusively in the adult male range, 398 (40.4%) are in the adult female or juvenile range, and the remaining 123 (12.5%) sherds exhibit breadth measurements that fall into the range for both sexes—although the histogram suggests that more of these unknowns are in the presumably female mode of the bimodal distribution (Fig. 5). A Mann–Whitney U test on the adult male and female modes, with likely juveniles and unknown sex removed, rejects the null hypothesis that the distributions of fingerprint breadth are the same ($u = 147{,}088$, $P = 0.000$, $n = 904$); the effect size value ($d = 0.85$) suggests a high practical significance. While using breadth ranges identified by other researchers (e.g., refs. 15–17 and 25) would change the exact distributions of adult males and females, the results would still lead to the conclusion that the two sexes were both significantly involved in producing corrugated pottery in the Blue J Ancestral Puebloan community.

Beyond this important conclusion, the data suggest two additional patterns. First, when the sample is parsed chronologically, a trend emerges indicating that older corrugated vessels were produced primarily by males, while later production included equal numbers of both sexes. This pattern is identified when the smaller sample of sherds associated with a particular time period ($n = 430$) is divided into those dating before and after AD 1040. For the earlier period, 66.7% of datable sherds ($n = 40$) exhibit fingerprints in the male range, with a mean ridge breadth of 0.52 mm, while the later period is almost evenly split among the sexes, with 49.9% of the sample ($n = 390$) affiliated with males and a mean ridge breadth of 0.48 mm. A Mann–Whitney U test suggests that the pattern is significant ($u = 5{,}917$, $P = 0.021$), although the effect size ($d = 0.11$) is weak, likely due to the smaller size of the early sample. The pattern nonetheless indicates that gender roles in corrugated pottery production were likely not fixed and static.

This apparent shift to equal numbers of male and female potters as the Chaco phenomenon became more elaborate is suggestive. During this later period, Chaco Canyon had become a major consumer of pottery, with many surrounding areas likely overproducing vessels to be transported to the central canyon (46, 47). It may be that this growing demand necessitated, almost literally, "all hands on deck" to produce enough corrugated pots to meet both local community needs and the external demand.

A spatial pattern suggesting the presence of two social groups with distinctive divisions of labor in pottery production is also seen in the data (Fig. 4 and Table 1). The earliest Blue J habitations (cluster A) were established directly to the south of the community's only spring, with a separate cluster (cluster B) appearing soon thereafter just to the west, below a series of gulches draining the mesa. The ceramic samples from these two initial habitation clusters show distinct patterns, with cluster A exhibiting an average fingerprint breadth of 0.440 mm, while the cluster B breadth is 0.462 mm. As these residential centers expanded—cluster A likely growing eastward to establish a new habitation area (cluster D), and cluster B creating clusters C and E to the west and north—the residents of the newer habitations produced pottery with average fingerprint breadths nearly identical to those in the parent clusters.

Converting the breadths into sex using Králík and Novotny's ranges (20) indicates that corrugated sherds from the "Spring Group" (clusters A and D) have slightly more adult female than male prints (52.4 vs. 47.6%), while habitations in the "Gulch Group" (clusters B, C, and E) have many more adult male than female prints (65.4 vs. 34.6%). A χ^2 test of association between habitation cluster and fingerprint sex is significant ($\chi^2 = 22.39$, $df = 1$, $P < 0.0001$, $n = 775$), although a low Cramér's V does not suggest a strong association ($\phi_c = 0.173$). These patterns are consistent with the hypothesis that the Blue J community was established by at least two social groups, perhaps organized around kinship (35), and that each maintained distinct divisions of labor by gender for the production of corrugated pottery.

Parsing the sample simultaneously by both spatial and chronological distributions to further explore these suggestive patterns and their proposed explanations is not possible due to the limited

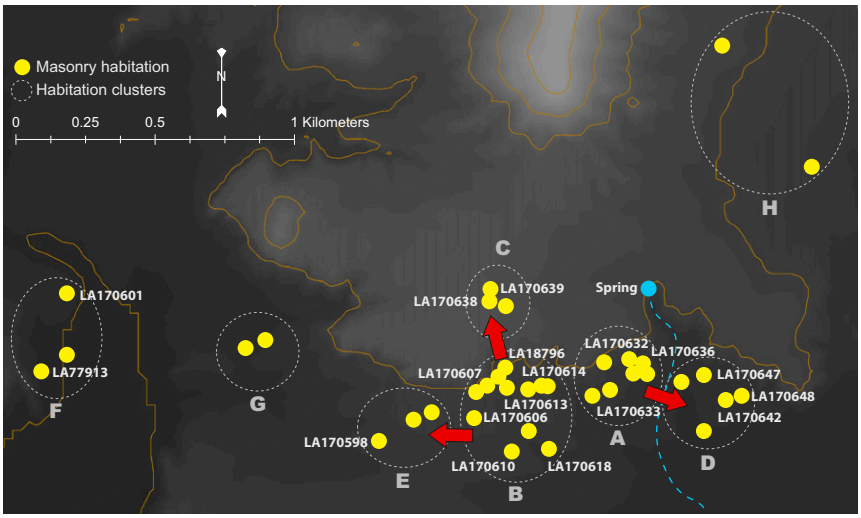

Fig. 4. Map of Blue J Ancestral Puebloan community showing locations of domestic structures and habitation clusters. Those structures with site numbers were sampled for this study. Arrows indicate directions in which the community expanded from the earliest clusters A and B.

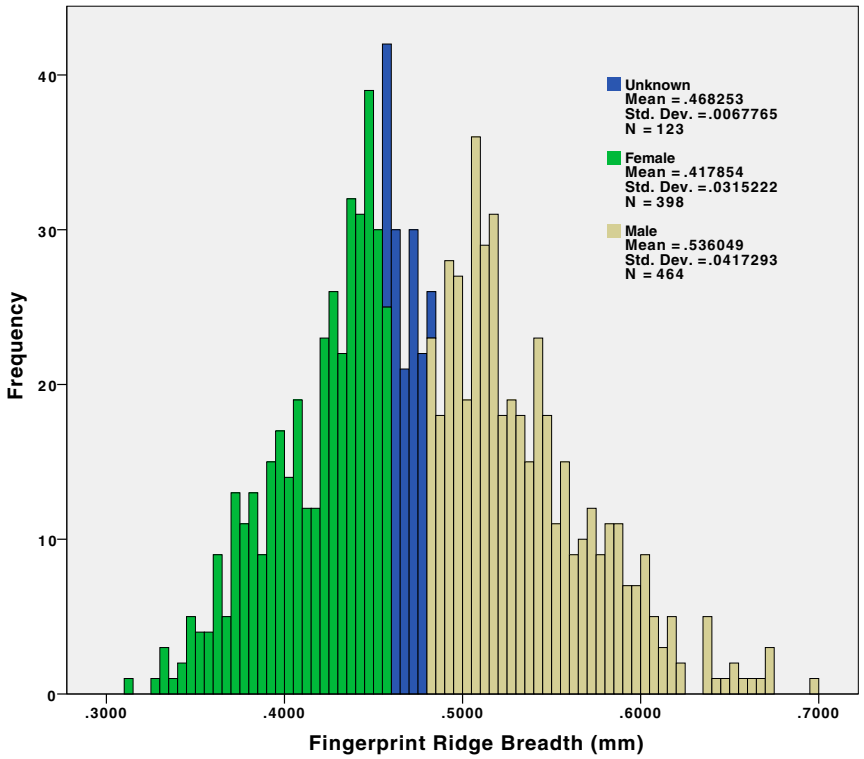

Fig. 5. Histogram of fingerprint breadth measurements from 985 corrugated pottery sherds. Colors indicate the distribution of sex identifications based on thresholds defined in Králík and Novotny (20).

sample sizes (*SI Appendix*, Table S1). We also cannot assume that patterns observed for the corrugated vessels extended to the production of other utility or decorated wares; it may be, for example, that the production of particular ceramic types were more restricted to men or to women. Similarly, we cannot readily extend any conclusions about the division of labor in pottery making to other activities in Ancestral Puebloan society.

What is clear, however, is that the production of corrugated pottery during the 10th and 11th centuries AD in the northern US Southwest was not subject to a highly gendered division of labor. Instead, the direct evidence from fingerprints on pottery sherds demonstrates that both adult males and females were routinely involved in production. The evidence also suggests considerable spatiotemporal variability in the Blue J Ancestral Puebloan community, reflecting sociocultural differences among groups residing in the village, changes over time during the evolution of the Chaco phenomenon, or a combination of both. Insofar as past assumptions about craft labor have often singled out pottery production as among the activities most restricted to a particular gender, the fact that pottery making involved varying numbers of men and women challenges the notion that gendered divisions of labor observed in the ethnographic present or through historical accounts can be extended into the distant past. Instead, they illustrate complexity of human behavior among our ancestors that mirrors differences in gender roles observed among many human populations today.

Materials and Methods

The Blue J Ancestral Puebloan community, located in northwestern New Mexico (Fig. 1), includes 75 archaeological sites, the majority of which are domestic structures typically consisting of 3–15 rooms each. These habitations are arrayed in clusters along the front and top of a low mesa, at the base of which is one of the region's rare springs (Fig. 4). Additional details about the community and its history of investigation are provided in *SI Appendix*.

Materials recovered from Blue J suggest a close affinity with Chaco Canyon, and the community's location places it in the midst of the Chaco World—an area under the influence if not direct control of Chaco Canyon (31, 49).

Table 1. Average fingerprint breadth and sex identification for each habitation cluster

Habitation cluster*	Mean ceramic date range, AD	# of sites sampled	# of sherds analyzed	Average print breadth	Female, %	Male, %
Spring Group						
Cluster A	885–1124	3	240	0.440	51.1	48.9
Cluster D	969–1126	3	124	0.440	55.1	44.9
Gulch Group						
Cluster B	914–1115	7	306	0.462	31.5	68.5
Cluster C	946–1121	2	194	0.456	39.5	60.5
Cluster E	1005–1080	1	8	0.454	40.0	60.0
Others						
Cluster F	999–1111	3	113	0.463	34.8	65.2

*No sherd samples were analyzed from habitation clusters G and H.

Focusing on a community outside of the central canyon provides a number of advantages compared with analyses of materials from the monumental center itself. First, the occupational history of the canyon is complex, and associated deposits represent complex palimpsests of past behavior (30). Second, material culture from all over the Chaco World was brought to Chaco Canyon during its height, resulting in extensive mixed deposits reflecting a wide array of sources (47). In contrast, Chaco World communities like Blue J have much simpler occupational histories, allowing for more control of the many variables that contribute to patterns in the material record. For example, a geochemical analysis of ceramics from Blue J demonstrated that most ceramics there were produced locally from nearby clays (50). Insofar as a community like Blue J is representative of the Chaco World, analysis of its material culture provides significant advantages over a comparable sample from Chaco Canyon.

For this fingerprint study, 19 of the 47 total habitations from the Blue J Ancestral Puebloan community were selected to ensure a representative spatiotemporal sample (*SI Appendix*, Table S1). All 3,063 corrugated sherds collected from these habitations were examined for partial fingerprint impressions, resulting in a subset of 1,211 sherds for analysis. Details on the paleodermatoglyphic method used to extract partial fingerprints using a stereomicroscope and to measure friction ridge breadths are provided in *SI Appendix*. The resulting dataset includes average ridge breadth measurements for 985 sherds (Dataset S1). All statistical analyses on these data were conducted using SPSS Statistics 23.

ACKNOWLEDGMENTS. We thank the many archaeologists and students who participated in the Lobo Mesa Archaeological Project's investigation of the Blue J Ancestral Puebloan community. Funding and support for the archaeological investigations and laboratory studies were provided to J.K. by the National Science Foundation (Awards 0237579 and 0715996), Georgia State University, the School for Advanced Research, and the University of North Florida. A small area of the Blue J community that is not privately owned but managed by the US Bureau of Land Management (BLM) was investigated under BLM Permit 288-2920-12-A. We are grateful to the editor and two anonymous reviewers for their constructive suggestions for improving the manuscript.

1. R. Bliege Bird, B. F. Codding, "The sexual division of labor" in *Emerging Trends in the Social and Behavioral Sciences*, R. Scott, S. Kosslyn, Eds. (John Wiley & Sons, Hoboken, NJ, 2015), pp. 1–16.
2. R. Jarvenpa, H. J. Brumbach, "Revisiting the sexual division of labor: Thoughts on ethnoarchaeology and gender" in *Integrating the Diversity of Twenty-First-Century Anthropology: The Life and Intellectual Legacies of Susan Kent*, W. Ashmore, M.-A. Dobres, S. M. Nelson, A. Rosen, Eds. (Archaeological Papers of the American Anthropological Association, American Anthropological Association, Washington, DC, 2006), **vol. 16**, pp. 97–107.
3. S. L. Kuhn, M. C. Stiner, What's a mother to do? The division of labor among Neandertals and modern humans in Eurasia. *Curr. Anthropol.* **47**, 953–980 (2006).
4. E. P. Dozier, *The Pueblo Indians of North America* (Holt, Rinehart and Winston, New York, 1970).
5. B. J. Mills, Intermarriage, technological diffusion, and boundary objects in the U.S. Southwest. *J. Archaeol. Method Theory* **25**, 1051–1086 (2018).
6. J. E. Clark, S. D. Houston, "Craft specialization, gender, and personhood among the Post-conquest Maya of Yucatan, Mexico" in *Craft and Social Identity*, C. L. Costin, R. P. Wright, Eds. (Archaeological Papers of the American Anthropological Association, American Anthropological Society, Washington, DC, 1998), **vol. 8**, pp. 31–46.
7. A. Estalrrich, A. Rosas, Division of labor by sex and age in Neandertals: An approach through the study of activity-related dental wear. *J. Hum. Evol.* **80**, 51–63 (2015).
8. J. Kantner, *Ancient Puebloan Southwest* (Cambridge University Press, Cambridge, 2004).
9. B. S. Shaffer, K. M. Gardner, J. F. Powell, "Sexual division of labor in the prehistoric Puebloan Southwest as portrayed by Mimbres potters" in Sixty Years of Mogollon Archaeology: *Papers from the Ninth Mogollon Conference, Silver City, New Mexico, 1996*, ed Whittlesey SM (SRI Press, Tucson, Arizona, 1999), pp 113–117.
10. P. L. Crown, Ed., *Women & Men in the Prehispanic Southwest: Labor, Power, & Prestige* (School of American Research Press, Santa Fe, New Mexico, 2000).
11. C. C. Heitman, "A mother for all the people": Feminist science and Chacoan archaeology. *Am. Antiq.* **81**, 471–489 (2016).
12. T. A. Kohler, K. Kramer Turner, Raiding for women in the pre-Hispanic northern Pueblo Southwest. *Curr. Anthropol.* **47**, 1035–1045 (2006).
13. S. A. Cole, *Suspect Identities: A History of Fingerprinting and Criminal Identification* (Harvard University Press, Boston, 2002).
14. N. R. Council, *Strengthening Forensic Science in the United States: A Path Forward* (National Academies Press, Washington, DC, 2009).
15. A. Z. Mundorff, E. J. Bartelink, T. A. Murad, Sexual dimorphism in finger ridge breadth measurements: A tool for sex estimation from fingerprints. *J. Forensic Sci.* **59**, 891–897 (2014).
16. E. Gutiérrez-Redomero *et al.*, A comparative study of topological and sex differences in fingerprint ridge density in Argentinian and Spanish population samples. *J. Forensic Leg. Med.* **20**, 419–429 (2013).
17. K. Krishan, T. Kanchan, C. Ngangom, A study of sex differences in fingerprint ridge density in a North Indian young adult population. *J. Forensic Leg. Med.* **20**, 217–222 (2013).
18. S. Yoon, A. K. Jain, Longitudinal study of fingerprint recognition. *Proc. Natl. Acad. Sci. U.S.A.* **112**, 8555–8560 (2015).
19. M. Králík, L. Nejman, Fingerprints on artifacts and historical items: Examples and comments. *J. Ancient Fingerprints* **1**, 4–15 (2007).
20. M. Králík, V. Novotny, Epidermal ridge breadth: An indicator of age and sex in paleodermatoglyphics. *Var. Evol.* **11**, 5–30 (2003).
21. G. Mull, K. Püschel, E. Jopp, Fingerprint identification on a bog body (650 BC). *Archaeol. Anthropol. Sci.* **3**, 201–207 (2011).
22. D. Chrisman, R. S. MacNeish, J. Mavalwala, H. Savage, Late Pleistocene human friction skin prints from Pendejo Cave, New Mexico. *Am. Antiq.* **61**, 357–376 (1996).
23. A. Sanders, Fingerprints, sex, state, and the organization of the Tell Leilan ceramic industry. *J. Archaeol. Sci.* **57**, 223–238 (2015).
24. K. A. Kamp, N. Timmerman, G. Lind, J. Graybill, I. Natowsky, Discovering childhood: Using fingerprints to find children in the archaeological record. *Am. Antiq.* **64**, 309–315 (1999).
25. S. L. Stinson, "Household ritual, gender, and figurines in the Hohokam regional system," PhD dissertation, University of Arizona, Tucson (2004).
26. B. J. Mills, What's new in Chaco research? *Antiquity* **92**, 855–869 (2018).
27. S. H. Lekson, Ed., *The Architecture of Chaco Canyon, New Mexico* (University of Utah Press, Salt Lake City, 2007).
28. R. G. Vivian *et al.*, "Ecology and economy" in *The Archaeology of Chaco Canyon: An Eleventh-Century Pueblo Regional Center*, S. H. Lekson, Ed. (School of American Research Press, Santa Fe, NM, 2006), pp. 45–65.
29. T. C. Windes, "This old house: Construction and abandonment at Pueblo Bonito" in *Pueblo Bonito: Center of the Chacoan World*, J. E. Neitzel, Ed. (Smithsonian Books, Washington, DC, 2003), pp. 14–32.
30. P. L. Crown, W. H. Wills, The complex history of Pueblo Bonito and its interpretation. *Antiquity* **92**, 890–904 (2018).
31. J. Kantner, K. Kintigh, "The Chaco World" in *The Archaeology of Chaco Canyon: An Eleventh-Century Pueblo Regional Center*, S. H. Lekson, Ed. (School of American Research Press, Santa Fe, NM, 2006), pp. 153–188.
32. J. Kantner, N. M. Mahoney, Eds., *Great House Communities Across the Chacoan Landscape: Anthropological Papers of the University of Arizona* (University of Arizona Press, Tucson, 2000), vol. 64.
33. S. Plog, "Understanding Chaco: Past, present, and future" in *Chaco Revisited: New Research on the Prehistory of Chaco Canyon, New Mexico*, C. C. Heitman, S. Plog, Eds. (University of Arizona Press, Tucson, 2015), pp. 3–29.
34. R. M. Van Dyke, *The Chaco Experience: Landscape and Ideology at the Center Place* (SAR Press, Santa Fe, NM, 2008).
35. J. A. Ware, *A Pueblo Social History: Kinship, Sodality, and Community in the Northern Southwest* (School for Advanced Research Press, Santa Fe, NM, 2014).
36. P. L. Crown, "Gendered tasks, power, and prestige in the prehispanic American Southwest" in *Women & Men in the Prehispanic Southwest: Labor, Power, & Prestige*, P. L. Crown, Ed. (School of American Research Press, Santa Fe, New Mexico, 2000), pp. 3–42.
37. K. A. Hays-Gilpin, "Gender ideology and ritual activities" in *Women & Men in the Prehispanic Southwest: Labor, Power, & Prestige*, P. L. Crown, Ed. (School of American Research Press, Santa Fe, New Mexico, 2000), pp. 91–136.
38. M. Hagstrum, Household production in Chaco Canyon society. *Am. Antiq.* **66**, 47–55 (2001).
39. P. L. Crown, "Socialization in American Southwest pottery decoration" in *Pottery and People: A Dynamic Interaction*, J. M. Skibo, G. M. Feinman, Eds. (University of Utah Press, Salt Lake City, 1999), pp. 25–43.
40. M. K. Munson, *The Archaeology of Art in the American Southwest* (AltaMira Press, Lanham, Maryland, 2011).
41. J. J. Brody, *Mimbres Painted Pottery* (School of American Research Press, Santa Fe, NM, 2004), Revised Edition.
42. P. L. Crown, Life histories of pots and potters: Situating the individual in archaeology. *Am. Antiq.* **72**, 677–690 (2007).
43. L. C. Young, T. Stone, The thermal properties of textured ceramics: An experimental study. *J. Field Archaeol.* **17**, 195–203 (1990).
44. C. Pierce, Reverse engineering the ceramic cooking pot: Cost and performance properties of plain and textured vessels. *J. Archaeol. Method Theory* **12**, 117–157 (2005).
45. C. Pierce, The development of corrugated pottery in southwestern Colorado. *KIVA* **71**, 79–100 (2005).
46. F. Arakawa, D. Gonzales, N. McMillan, M. Murphy, Evaluation of trade and interaction between Chaco Canyon and Chaco outlier sites in the American Southwest by investigating trachybasalt temper in pottery sherds. *J. Archaeol. Sci. Rep.* **6**, 115–124 (2016).
47. H. W. Toll, "Organization of production" in *The Archaeology of Chaco Canyon: An Eleventh-Century Pueblo Regional Center*, S. H. Lekson, Ed. (School of American Research Press, Santa Fe, New Mexico, 2006), pp. 117–152.
48. J. B. Freeman, R. Dale, Assessing bimodality to detect the presence of a dual cognitive process. *Behav. Res. Methods* **45**, 83–97 (2013).
49. S. H. Lekson, *A History of the Ancient Southwest* (SAR Press, Santa Fe, NM, 2009).
50. J. Kantner *et al.*, "Interaction between great house communities: An elemental analysis of Cibolan ceramics" in *Great House Communities across the Chacoan Landscape*, J. Kantner, N. M. Mahoney, Eds. (Anthropological Papers, University of Arizona Press, Tucson, 2000), **vol. 64**, pp. 130–146.