CHAPTER 7

The Use of Linguistic Data in Bioarchaeological Research: An Example From the American Southwest

M.A. Schillaci[1] and S. Wichmann[2,3]

[1]Department of Anthropology, University of Toronto Scarborough, Toronto, ON, Canada
[2]Leiden University Centre for Linguistics, Leiden University, Leiden, The Netherlands
[3]Laboratory of Quantitative Linguistics, Kazan Federal University, Kazan, Russia

7.1 INTRODUCTION

It has been suggested that the genes, language, and culture of ethnic groups in the prehistoric American Southwest need not have evolved together as a package in bounded social groups (Ortman, 2012). Consequently, genetic, linguistic, and cultural heritage may not have followed parallel patterns of descent (Ortman, 2012). To address this question of coevolution, a greater understanding of the relationship among datasets describing genetic, linguistic, and cultural variation for the archaeological groups of interest is needed. In this chapter we explore this notion of coevolution by examining the correlation of linguistic and genetic relationships among ancestral and present-day Tanoan-speaking Pueblo Indians of northern New Mexico. In addition, we examine the effects of geographic distance on linguistic and biological relationships by formally testing an isolation-by-distance model.

7.1.1 Previous Research

The Tanoan languages, Tiwa, Tewa, and Towa, along with Kiowa, belong to the Kiowa-Tanoan language family. Tiwa and Tewa are spoken at various pueblos within the Rio Grande Valley of north-central New Mexico, while Towa is spoken at Jemez Pueblo located on the banks of the Jemez River west of the Rio Grande Valley (Fig. 7.1). Although the languages, culture, archaeology, and biological variation of the Tanoan-speaking Pueblo Indians have received considerable

Beyond the Bones. DOI: http://dx.doi.org/10.1016/B978-0-12-804601-2.00007-7

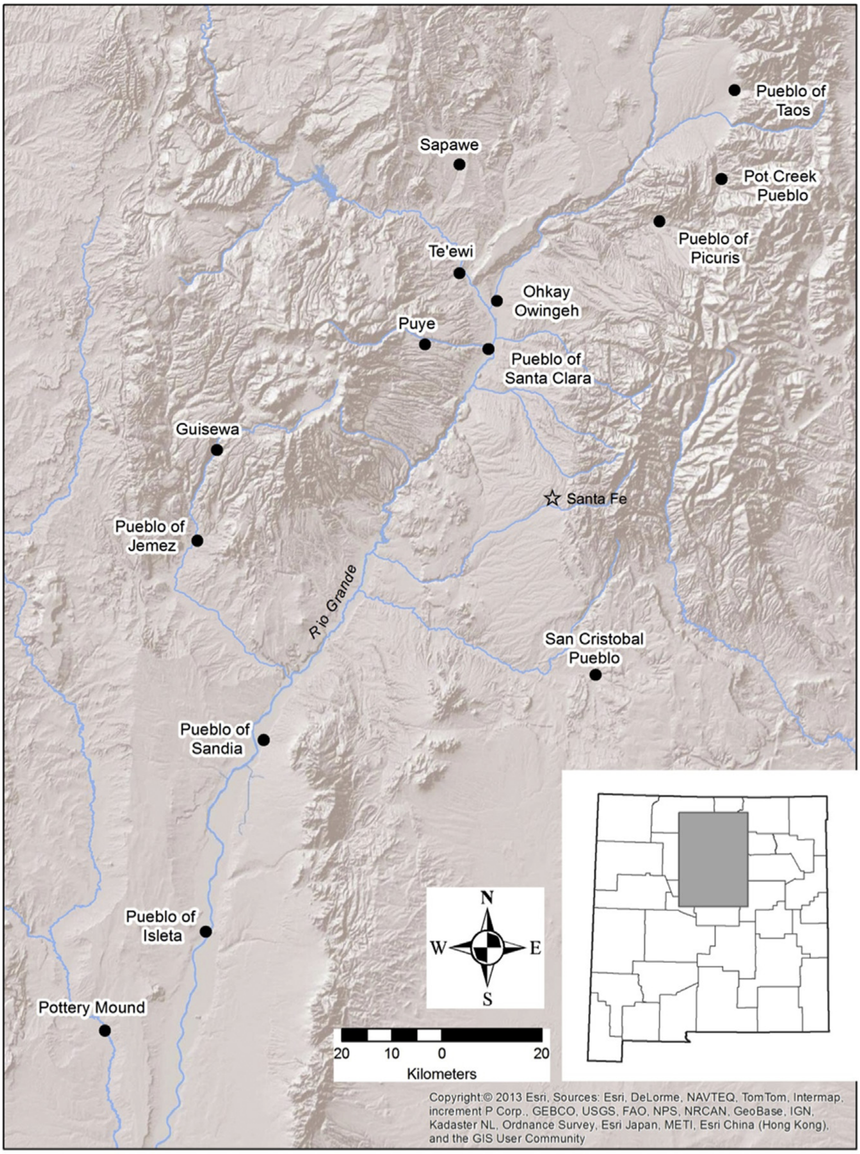

Figure 7.1 Map showing pueblo locations within the Rio Grande Valley of New Mexico. Map generated using ArcGIS.

attention in the anthropological literature (see Ortman, 2012, for a review), very little research has examined the relationships among these disparate datasets in a formal way. In their study of the population history and social organization of prehistoric Tewa, Schillaci and Stojanowski (2005) examined the effect of geographic distance on the genetic relationships among ancestral Tewa pueblos (c. AD 1350–1680), estimated using craniometric data. The results of the Mantel tests employed in that study indicated only a weak and statistically nonsignificant correlation ($r = 0.443$, $p = 0.261$) between geographic and genetic distances, suggesting that geography was not the primary basis of gene flow. Although not focused on Tanoan-speaking populations, research by Kemp et al. (2010) utilizing Mantel tests, found significant partial correlations (controlling for correlation with geographic distance) between genetic distances based on Y-chromosome variation and linguistic distances ($r = 0.33–0.384$; $p < 0.02$) among populations from the American Southwest and Mesoamerica, including the Tanoan-speaking population from Jemez Pueblo. The partial correlations between genetic distances based on mitochondrial DNA (mtDNA) and linguistic distances were not significant ($r = 0.124–0.153$; $p > 0.05$). Partial correlations (controlling for either Y-chromosome variation or mtDNA variation) between geographic distances and linguistic distances were low, ranging from between $r = 0.321$ and $r = 0.153$, and mostly nonsignificant ($p = 0.033–0.196$).

More recently, Ortman (2012) examined linguistic and craniometric datasets, as well as oral tradition and estimates of population size based on room counts at habitation sites in his analysis of Tewa ancestry. After careful evaluation of the results from the various analyses of these data, Ortman proposed that the ancestral Tewa people and language were brought to the northern Rio Grande Valley from the Mesa Verde region of southwestern Colorado by way of a large population movement. Although Ortman's study—by far, the most comprehensive to date—utilized disparate datasets, he did not incorporate multiple datasets into a formal analytical model. Here, we examine the correlation between language and genetic relationships among extant and ancestral Tanoan pueblos, and the effect of geographic distance on those relationships, using a formal analytical model.

7.2 METHODS

In order to estimate the relationships among Tanoan languages we generated pair-wise measures of lexical dissimilarity based on a 40-word subset (Table 7.1) of the Swadesh 100-word list using the Automated Similarity Judgment Program (Holman et al., 2011).

Table 7.1 40-Word Subset of the Swadesh 100-Word List (Swadesh, 1955) Used by the ASJP to Generate the LDND Measures of Lexical Dissimilarity Among Languages

Swadesh No.	Word	Swadesh No.	Word
1	I	47	Knee
2	You	48	Hand
3	We	51	Breast
11	One	53	Liver
12	Two	54	Drink
18	Person	57	See
19	Fish	58	Hear
21	Dog	61	Die
22	Louse	66	Come
23	Tree	72	Sun
25	Leaf	74	Star
28	Skin	75	Water
30	Blood	77	Stone
31	Bone	82	Fire
34	Horn	85	Path
39	Ear	86	Mountain
40	Eye	92	Night
41	Nose	95	Full
43	Tooth	96	New
44	Tongue	100	Name

This list of 40 words has been found to yield lexicostatistical results at least as accurate as the full 100-word list as determined by their correlation with language classifications by specialists (Holman et al., 2008). Using the shorter list allowed us to obtain complete datasets for all Kiowa-Tanoan languages. Tanoan words were gathered from the literature, experts, and native speakers by L. Sutton. Sources for the word lists are as follows. Southern Tewa (Arizona Tewa): Kroskrity (1993), Kroskrity and Healing (1978, 1980), Yegerlehner (1957); Rio Grande Tewa, including the San Juan and Santa Clara dialects: Kroskrity (1993), Harrington (1916), Hale (1967), Dozier (1953), Hoijer and Dozier (1949), Martinez (1982), Speirs (1966), Speirs and Speirs (1979), Wycliffe Bible Translators (1969); Towa (or Jemez): Hale (1967), Gatschet (1876), Yumitani (1998); Hale (1956–1957); Northern Tiwa (Taos Pueblo): Hale (1967), Trager and Trager (1959), Yu (2006), Harrington (1910), Trager (1935–1972), Trager (1946); Southern Tiwa (Sandia and Isleta Pueblos): Frantz (n.d.), Gatschet (1879), Leap (1970), and the Wycliffe Bible Translators (1978). For this analysis, Arizona Tewa is assumed to represent Southern Tewa (Tano). This assumption is commonly, though not universally (see Ortman, 2012), accepted. The dialect spoken at Taos was used to represent Northern Tiwa.

We used a measure of lexical dissimilarity based on a Levenshtein distance (LD), which is defined as the minimum number of successive changes needed to change one word to another, where each change is either a deletion, insertion, or substitution of a symbol representing a class of speech sounds (Holman et al., 2011, p. 843). The resulting value is then normalized by dividing the LD by the number of symbols of the longer of the two words. This results in a normalized Levenshtein distance (LDN) that corrects for differences in word length. A LDN divided (LDND) is then calculated by dividing the average LDN for all the word pairs involving the same meaning by the average LDN for all pairs of words referring to different concepts (Holman et al., 2011, p. 843). The LDN in the denominator, then, is the mean of $(40 \times 39)/2$ off-diagonal comparisons in a 40-by-40 item matrix of concepts. This normalization penalizes the overall similarity when words not referring to the same concepts are accidentally similar, thus correcting for chance similarity due to similar sound inventories. In the special case where words with different meanings are on average more similar than words with the same meanings, a LDND of greater than 100% will be the outcome. Using LDND rather than LDN has been shown to lead to more accurate classification results (Wichmann et al., 2010).

To estimate genetic relationships we calculated biological distances derived from the genetic relationship, or R-matrix (Relethford and Blangero, 1990; Relethford et al., 1997), based on craniometric data using Dr J. Relethford's RMET 5.0 software program (see http://employees.oneonta.edu/relethjh/programs/). The craniometric data for 12 variables (Table 7.2) were obtained from skeletal populations known to be directly ancestral to the same pueblos from which the linguistic data were derived (Table 7.3), with the possible exception of Pottery Mound, which may have included non-Tiwa immigrants from the west (Eckert, 2008). These data were generously provided

Table 7.2 Craniometric Variables Used in the Analysis

Variable	Abbreviation	Measurements[a]
Upper facial height	NPH	Nasion-prosthion
Upper facial breadth	UFB	Frontomalare—frontomalare
Minimum frontal breadth	WFB	Frontotemporale—frontotemporale
Bizygomatic breadth	ZYB	Zygion—zygion
Orbital breadth	OBB	Dacryon—ectoconchion
Orbital height	OBH	Perpendicular to OBB at midpoint
Interorbital breadth	DKB	Dacryon—dacryon
Biorbital breadth	EKB	Ectoconchion—ectoconchion
Nasal height	NLH	Nasion—nasospinale
Nasal breadth	NLB	Alare—alare
Palate length	MAL	Prosthion—alveolon
Palate breadth	MAB	Ectomalare—ectomalare

[a]See Howells (1973) and Steele and Bramblett (1988) for definition of cranial landmarks and measurements.

Table 7.3 Information on the Tanoan Populations Included in the Analysis

Pueblo	n	Language	Time Period
San Juan (OhkayOwingeh)		Tewa	Historic–Present
Santa Clara		Tewa	Historic–Present
Jemez		Towa	Historic–Present
Sandia		Southern Tiwa	Historic–Present
Isleta		Southern Tiwa	Historic–Present
Taos		Northern Tiwa	AD 1450–Present
Picuris	7	Northern Tiwa	AD 1200?–Present
Pot Creek	10	Northern Tiwa	AD 1250–1320
Sapawe	17	San Juan Tewa	AD 1350–1525
Te’ewi	9	San Juan Tewa	AD 1250–1500
Puye	58	Santa Clara Tewa	AD 1325–1540
San Cristobal	41	Southern Tewa	AD 1325–1675
Guisewa	7	Towa	AD 1400–1540
Amoxiumqua	7	Towa	AD 1325–1540
Kwasteyukwa	28	Towa	AD 1400–1540
Pottery Mound	27	Southern Tiwa	AD 1300–1500

n denotes sample sizes for the ancestral skeletal populations from which craniometric data were collected. See Fig. 7.1 for locations.

by S. Ortman, and are the same used in his recent study of Tewa ancestry (Ortman, 2012). To increase sample sizes the male and female data were pooled after conducting within-sex z-score transformations. These transformed data were then pooled by language grouping before calculating biological distances. We generated neighbor-joining trees (Saitou and Nei, 1987) based on the linguistic and biological distance matrices using MEGA 6.0 (Tamura et al., 2013). These trees describe the historical or evolutionary relationships among either the Tanoan languages or populations (pueblos) included in our study.

Geographic (straight-line) distances (km) among pueblos were measured using the ruler tool with mouse navigation in Google Earth. We use the measured geographic distance among pueblos to test a generalized isolation-by-distance model borrowed from the field of population genetics (Wright, 1943). This model predicts that divergence among populations will be proportional to geographic distances due to the isolating effects of spatial separation on the magnitude of genetic or linguistic exchange such as borrowing. For our analytical model we used distance matrix correlation analyses (Mantel tests) to examine the relationship between linguistic and biological distance matrices, and to test a generalized isolation-by-distance model. The Mantel tests were conducted using MANTEL 3.1 (see http://employees.oneonta.edu/relethjh/programs/).

7.3 RESULTS

The lexical and biological distances are presented in Table 7.4. The structure of relationships among Tanoan languages described

Table 7.4 Lexical (LDND) and Biological (R-Matrix)[a] Distances Among Language Groupings

	SJT	STE	TOW	STI	SCT	NTI
1. San Juan Tewa (SJT)	0.00	0.041	0.016	0.111	0.036	0.093
2. Southern Tewa (STE)	29.09	0.00	0.026	0.098	0.029	0.011
3. Towa (TOW)	86.46	90.22	0.00	0.201	0.036	0.102
4. Southern Tiwa (STI)	76.94	82.97	89.03	0.00	0.138	0.076
5. Santa Clara Tewa (SCT)	11.14	36.44	86.74	76.46	0.00	0.054
6. Northern Tiwa (NTI)	76.76	79.07	89.32	45.90	77.61	0.00

Lexical distances are listed below the shaded diagonal, with biological distances listed above the diagonal.
[a]*R-matrix distances were calculated using a narrow-sense heritability $h^2 = 0.55$ with relative population weights set to 1.*

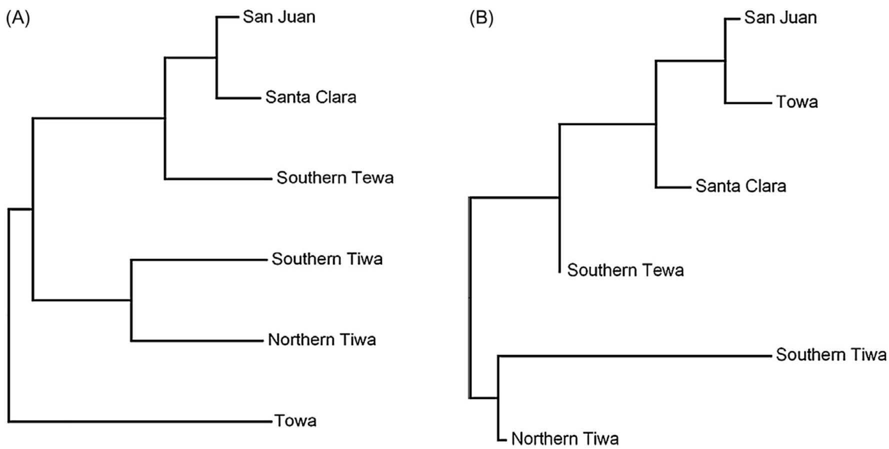

Figure 7.2 Neighbor-joining trees based on (A) linguistic distances, and (B) biological distances.

by the neighbor-joining tree derived from the lexical data (Fig. 7.2A) is consistent with what has been presented by Davis (1959) based on shared cognates, and with that presented by Ortman (2012) based on shared phonetic innovations. As expected, Towa appears as the sister to two separate clades comprising the Tewa and Tiwa language dialects respectively. The tree describing the biological relationships among populations (Fig. 7.2B) is visibly similar to the lexical tree, with the exception of the Towa population, which is placed within the Tewa grouping, or clade. As was seen in the tree based on lexical data, the two Tiwa populations again form a single clade. The appearance of a Tiwa clade and a largely Tewa clade suggests that there may be some degree of linguistic structuring to biological relationships. Interestingly, the population from Pottery Mound appears to be closely related biologically to the Northern Tiwa population from Pot Creek and Picuris, suggesting this pueblo is likely made up primarily of Southern Tiwa residents rather than non-Tiwa immigrants.

Although the trees describing linguistic and biological relationships exhibited moderately similar structure visually, the results of the Mantel test indicate that there is not a significant relationship between linguistic and biological distances ($r = 0.309$, $p = 0.171$). It is important to note, however, that the linguistic distances were generated from data collected during the 19th and 20th centuries, and therefore partly reflect linguistic change that has occurred after the occupation of the pueblos from which the craniometric data were derived. In other words, the linguistic variation analyzed in our study has been subject to the historical and evolutionary processes that influence the relationships among populations for a longer period of time. Although this time difference between datasets may have reduced to some degree the correlation between linguistic and biological relationships, its effect was likely not great. The isolation-by-distance model was rejected for both language ($r = 0.520$, $p = 0.068$) and biological relationships ($r = 0.305$, $p = 0.094$), suggesting that linguistic and biological differences are not mediated by geographic proximity, at least not in this case and at this level of resolution.

7.4 DISCUSSION AND CONCLUSIONS

The present study illustrates the potential utility of linguistic data in bioarchaeological analyses of population history. Our results support the suggestion that genes and languages have not evolved together as a package among Tanoan pueblos (cf. Ortman, 2012). In other words, the genetic and linguistic heritage of Tanoans may not have followed parallel patterns of descent. Furthermore, linguistic and biological relationships among pueblos do not seem to have been mediated primarily by geographic proximity. Our results suggest that gene flow across linguistic boundaries was likely common. In particular, gene flow with the Towa speaking pueblo of Jemez seems to have been pronounced among Tewa pueblos, despite greater linguistic and geographic distances. This would be consistent with the suggestion by Schillaci and Stojanowski (2005) that gene flow among ancestral pueblos may have been mediated through a complex social network built on reciprocal exchange of esoteric knowledge and ritual paraphernalia (see Ware and Blinman, 1998), given that exchange within such a network need not be proportional to geographic proximity. While intriguing, there is no way to test whether or not a ritual exchange network existed, and if it did, whether or not it mediated linguistic and genetic exchange. There are myriad factors other than isolation by geographic distance that could have shaped the linguistic, genetic, and cultural variation among Tanoan pueblos, including ancestry, migration, and the historical and economic processes associated with subsistence, population aggregation and integration, and the control and exchange of raw materials (cf. Wendorf and Reed, 1955; McNutt, 1969; Ford et al., 1972; Fowles, 2004a,b; Fowles et al., 2007; Boyer et al., 2010; Ortman, 2012). Future holistic integrative research on Tanoan prehistory should incorporate the disparate datasets reflecting such processes. Importantly, future research should also utilize quantitative analyses that incorporate such disparate datasets in a formal analytical framework.

ACKNOWLEDGMENTS

We are grateful to the following individuals who contributed to this research. Logan Sutton compiled and edited the word lists used in this study, expanding on the existing Automated Similarity Judgment Program database (Wichmann et al., 2013). The added lexical data were transcribed by Julia Bischoffberger. This paper benefited greatly from discussions with S. Lakatos and S. Ortman. We would like to thank the editors Madeleine Mant and Alyson Holland for inviting us to contribute to this volume. MAS's research was funded in part by a grant from the Social Sciences and Research Council (SSHRC) of Canada. SW's research was funded by the ERC Advanced Grant MesAndLin(g)k, Proj. No. 295918, and by a subsidy from the Russian Government to support the Program of Competitive Development of Kazan Federal University.

REFERENCES

Boyer, J.L., Moore, J.L., Lakatos, S.A., Akins, N.J., Wilson, C.D., Blinman, E., 2010. Remodeling immigration: a northern Rio Grande perspective on depopulation, migration, and donation-side models. In: Kohler, T.A., Varien, M.D., Wright, A. (Eds.), Leaving Mesa Verde: Peril and Change in the Thirteenth-Century Southwest. University of Arizona Press, Tucson, AZ, pp. 285–323.

Davis, I., 1959. Linguistic clues to northern Rio Grande prehistory. El Palacio 66, 73–84.

Dozier, E.P., 1953. Tewa II: verb structure. Int. J. Am. Linguist. 19, 118–127.

Eckert, S.L., 2008. Pottery and Practice: The Expression of Identity at Pottery Mound and Hummingbird Pueblo. University of New Mexico Press, Albuquerque, NM.

Ford, R.I., Schroeder, A.H., Peckham, S.L., 1972. Three perspectives on Puebloan prehistory. In: Ortiz, A. (Ed.), New Perspectives on the Pueblos. University of New Mexico Press, Albuquerque, NM, pp. 19–30.

Fowles, S.M., 2004a. The Making of Made People: The Prehistoric Evolution of Hierocracy Among the Northern Tiwa of New Mexico (unpublished PhD thesis). University of Michigan, Ann Arbor, MI.

Fowles, S.M., 2004b. Tewa versus Tiwa. In: Adams, E.C., Duff, A.I. (Eds.), The Protohistoric Pueblo World AD 1275-1600. University of Arizona Press, Tucson, pp. 17–25.

Fowles, S.M., Minc, L., Duwe, S., Hill, D.V., 2007. Clay, conflict, and village aggregation: compositional analyses of pre-Classic pottery from Taos, New Mexico. Am. Antiquity 72, 125–152.

Frantz, D., n.d. Lexicon of Isleta Tiwa (unpublished manuscript).

Gatschet, A.S., 1876. Zwölf Sprachen aus dem Südwesten Amerikas. Hermann Böhlau, Weimar.

Gatschet, A.S., 1879. Classification into seven linguistic stocks of Western Indian dialects contained in forty vocabularies. In: Wheeler, G.M. (Ed.), Report on United States Geographical Surveys West of the One Hundredth Meridian, vol. 7, Archaeology, Appendix, Linguistics. Government Printing Office, Washington, DC, pp. 403–485.

Hale, K.L., 1956–1957. Unpublished notes on Jemez grammar.

Hale, K.L., 1967. Toward a reconstruction of Kiowa-Tanoan phonology. Int. J. Am. Linguist. 33, 112–120.

Harrington, J.P., 1910. An introductory paper on the Tiwa language, dialect of Taos, New Mexico. Am. Anthropol. 12, 11–48.

Harrington, J.P., 1916. The ethnogeography of the Tewa Indians. 29th Annual Report of the Bureau of American Ethnology. Government Printing Office, Washington, DC.

Hoijer, H., Dozier, E.P., 1949. The phonemes of Tewa, Santa Clara dialect. Int. J. Am. Linguist. 15, 139–144.

Holman, E.W., Wichmann, S., Brown, C.H., Velupillai, V., Müller, A., Brown, P., et al., 2008. Explorations in automated language classification. Folia Linguist. 42, 331–354.

Holman, E.W., Brown, C.H., Wichmann, S., Müller, A., Velupillai, V., Hammarström, H., et al., 2011. Automated dating of the world's language families based on lexical similarity. Curr. Anthropol. 52, 841–875.

Howells, W.W., 1973. Cranial variation in man. A study by multivariate analysis of patterns of difference among recent human populations. Pap. Peabody. Mus. Am. A 67, 1–259.

Kemp, B.M., González-Oliver, A., Malhi, R.S., Monroe, C., Schroeder, K.B., McDonough, J., et al., 2010. Evaluating the farming/language dispersal hypothesis with genetic variation exhibited by populations in the Southwest and Mesoamerica. Proc. Natl. Acad. Sci. USA 107, 6759–6764.

Kroskrity, P.V., 1993. Language, History, and Identity: Ethnolinguistic Studies of the Arizona Tewa. University of Arizona Press, Tucson, AZ.

Kroskrity, P.V., Healing, D., 1978. Coyote and bullsnake. In: Bright, W. (Ed.), Coyote Stories I IJAL Native American Texts Series, Monograph 1. University of Chicago Press, Chicago, IL, pp. 162–170.

Kroskrity, P.V., Healing, D., 1980. Coyote woman and the deer children. In: Kendall, M.B. (Ed.), Coyote Stories II. IJAL Native American Texts Series, Monograph 6. University of Chicago Press, Chicago, pp. 119–128.

Leap, W.L., 1970. The Language of Isleta, New Mexico (unpublished PhD thesis). Southern Methodist University, Dallas.

Martinez, E., 1982. San Juan Pueblo Téwa Dictionary. Bishop Publishing, Portales.

McNutt, C.H., 1969. Early Puebloan occupations at Tesuque by-pass and the upper Rio Grande Valley. Anthropological Papers No. 40. Museum of Anthropology. University of Michigan, Ann Arbor, MI.

Ortman, S.G., 2012. Winds from the North: Tewa Origins and Historical Anthropology. University of Utah Press, Salt Lake City, UT.

Relethford, J.H., Blangero, J., 1990. Detection of differential gene flow from patterns of quantitative variation. Hum. Biol. 63, 629–641.

Relethford, J.H., Crawford, M.H., Blangero, J., 1997. Genetic drift and gene flow in post-famine Ireland. Hum. Biol. 69, 443–465.

Saitou, N., Nei, M., 1987. The neighbor-joining method: a new method for reconstructing phylogenetic trees. Mol. Biol. Evol. 4, 406–425.

Schillaci, M.A., Stojanowski, C.M., 2005. Craniometric variation and the population history of the prehistoric Tewa. Am. J. Phys. Anthropol. 126, 404–412.

Speirs, R.H., 1966. Some aspects of the structure of Rio Grande Tewa (unpublished PhD thesis). State University of New York Buffalo, Buffalo.

Speirs, R.H., Speirs, A., 1979. Tewa Workbook. Summer Institute of Linguistics, Huntington Beach, CA.

Steele, D.G., Bramblett, C.A., 1988. The Anatomy and Biology of the Human Skeleton. Texas A&M Press, College Station, TX.

Swadesh, M., 1955. Towards greater accuracy in lexicostatistical dating. Int. J. Am. Linguist. 21, 121–137.

Tamura, K., Stecher, G., Peterson, D., Filipski, A., Kumar, S., 2013. MEGA6: molecular evolutionary genetics analysis version 6.0. Mol. Biol. Evol. 30, 2725–2729.

Trager, G.L., 1935–1972. The Papers of George L. Trager. University of California-Irvine, Langson Library Special Collections and Archives, unpublished notes.

Trager, G.L., 1946. An outline of Taos grammar. In: Osgood, C. (Ed.), Linguistic Structures of Native America. Viking Fund, New York, NY, pp. 184–221.

Trager, G.L., Trager, E.C., 1959. Kiowa and Tanoan. Am. Anthropol. 61, 1078–1083.

Ware, J.A., Blinman, E., 1998. Cultural collapse and reorganization: the origin and spread of Pueblo ritual sodalities. In: Hegmon, M. (Ed.), The Archaeology of Regional Interaction in the Prehistoric Southwest. University of Colorado Press, Boulder, CO, pp. 381–409.

Wendorf, F., Reed, E.K., 1955. An alternative reconstruction of northern Rio Grande prehistory. El Palacio 62, 131–173.

Wichmann, S., Holman, E.W., Bakker, D., Brown, C.H., 2010. Evaluating linguistic distance measures. Physica A 389, 3632–3639.

Wichmann, S., Müller, A., Wett, A., Velupillai, V., Bischoffberger, J., Brown, C.H., et al., 2013. The ASJP Database (version 16). <http://asjp.clld.org/> (accessed 20.01.16).

Wright, S., 1943. Isolation by distance. Genetics 28, 114–138.

Wycliffe Bible Translators, 1969. Mark itaˀnannin: Jesus Christ-vį́ˀgeḏi.

Wycliffe Bible Translators, 1978. Mark nashiamiwe Jesus Christ-‘ayti. Selected portions from Mark in the Tiwa language of Isleta Pueblo. (B. Allen, D. Gardiner, Trans.).

Yegerlehner, J.F., 1957. Phonology and Morphology of Hopi-Tewa (unpublished PhD thesis). Indiana University, Bloomington, IN.

Yu, D., 2006. Comparative phonology of Picurís and Taos. Available from: <http://linguistics.berkeley.edu/~dom/historical-picuris.pdf> (accessed 2.01.16).

Yumitani, Y., 1998. A Phonology and Morphology of Jemez Towa (unpublished PhD thesis). University of Kansas, Laurence, KS.