Research Reports

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Climate, Econiche, and Sexuality: Influences on Sonority in Language

ABSTRACT Previous cross-cultural research by Robert Munroe and colleagues has linked two features of language to warm climates—a higher proportion of consonant-vowel syllables and a higher proportion of sonorous (more audible) sounds. The underlying theory is that people in warmer climates communicate at a distance more often than people in colder climates, and it is adaptive to use syllables and sounds that are more easily heard and recognized at a distance. However, there is considerable variability in warm as opposed to cold climates, which needs to be explained. In the present research report, we show that additional factors increase the predictability of sonority. We find that more specific features of the environment—such as type of plant cover and degree of mountainous terrain—help to predict sonority. And, consistent with previous research on folk-song style, measures of sexual restrictiveness also predict low sonority.
[Keywords: cross-linguistic research, phonetic variation, sonority, consonant-vowel syllables, climate]

IN A SERIES OF PIONEERING RESEARCH PAPERS, Robert L. Munroe and his colleagues (Fought et al. 2004; Munroe and Silander 1999; Munroe et al. 1996; Munroe et al. 2000) presented findings linking certain aspects of language to climate. The first aspect was the proportion of consonant-vowel (CV) syllables in a language; the second was the degree of sonority or audibility of individual sounds. The theory is that people in warmer climates generally spend more time outdoors and communicate at a distance more often than people in colder climates. It is presumably adaptive in such climates to use syllables and sounds that are more easily heard and recognized. So, for example, the CV syllable provides maximal contrast and is more audible at a distance than other syllables (for supporting evidence, see Jakobson and Halle 1968:441, as referred to by Munroe et al. 1996:61). And, assuming equivalence of pitch, length, and stress, sounds with higher sonority (vowels more than consonants, the [a] sound more than the [i] sound) are more easily heard (see Fletcher 1953:82–88, as referred to in Fought et al. 2004:31). Using cross-cultural data from 60 or more societies, Robert Munroe and colleagues (1996) presented evidence that societies in warm to moderate climates have a significantly higher percentage of consonant-vowel syllables in their languages, as compared with societies in colder climates. Munroe and Megan Silander (1999) show that this trend holds even within language families that straddle warm and cold climates. More recent cross-cultural research by Munroe and colleagues (Fought et al. 2004; Munroe et al. 2000) finds greater sonority in warmer climates both in the worldwide sample and within broad geographic regions.

In the present article, we focus on sonority, using the data from John Fought and colleagues (2004). We present evidence that adds an entirely new predictor of the proportion of sonorous sounds in a language: degree of sexuality. In addition, we explore the effects of specific aspects of the econiche on sonority.

SONORITY AND CLIMATE

In the recent article by Fought et al. (2004), the relationship between sonority and climate was tested on the sample of 60 societies in the HRAF Probability Sample Files (PSF, now included in the eHRAF Collection of Ethnography). A new point score was developed to measure the sonority of the sounds in up to 200 words in each sample language. Using this new improved measure of sonority, Fought et al. (2004) find that climate is strongly related to sonority. Using two different climate measures, Pearson's r is $-.63$ and $-.66$ (the colder the climate, the less the sonority).

As we noted previously (Ember and Ember 1999:731; Ember and Ember 2000:849), climate appears to have the greatest effect on language in cold climates, not warm climates, contrary to the theory of Munroe and his colleagues. We see the same puzzling pattern using the new measure of sonority presented by Fought et al. (2004); warm climates show less of a clear effect than cold climates. Figure 1 shows the scatter plot for the relationship between the average sonority score and the number of cold months. Note the

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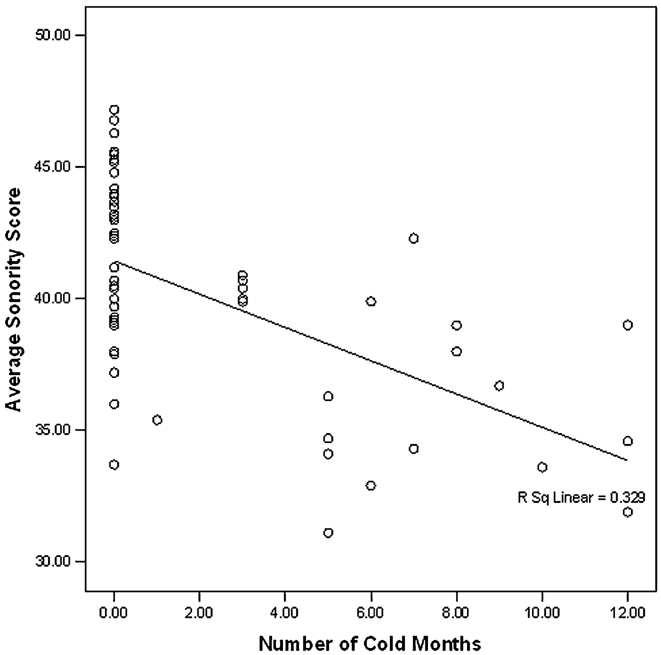

FIGURE 1. Scatterplot of average sonority score by number of cold months (Data derived from Fought et al. 2004; courtesy of Robert L. Munroe).

variability at 0 cold months. If there is so much variability in warm climates, there must be factors other than climate that explain the variation in sonority.

OTHER PREDICTORS OF SONORITY: ECONICHE AND SEXUALITY

A previous reviewer of one of our earlier articles suggested that communication in a warm, tropical forest would be quite different from communication in a warm and more open environment. In the former, the dense foliage would make distant communication quite difficult, despite the warm weather. If language responds to climate, more specific features of the econiche might explain some of the variability in sonority in warm climates. Thus, we decided to explore the effect of plant cover and the degree to which the terrain is hilly or mountainous. Although Munroe and his colleagues stress the adaptation of language to warm climates to increase communicative efficiency, we stress the disadvantage of speaking with a wide, open mouth in cold, windy climates. In cold climates, mountainous terrain would increase wind chill, especially at higher altitudes. Tall, dense plant cover might mitigate the effects of cold, and so languages in such climates might have somewhat greater sonority; but in mountainous regions, wind chill might necessitate keeping the mouth more closed, and, hence, the language might have less sonority.

We previously got the idea to look at baby holding as a predictor of CV proportion scores (Ember and Ember 1999; Ember and Ember 2000) from Barbara C. Ayres's (1973) research on variation in music. (She participated in Alan Lomax's cross-cultural study of folk song style.) Lomax (1968) found that premarital sexual restrictiveness predicted two aspects of song style—less vocal width and greater nasality. Lomax describes vocal width as follows: It ranges from singing "with a very pinched, narrow, squeezed voice to the very wide and open-throated singing tone of Swiss yodelers" (1968:71). A narrow voice is produced by "raising the glottis, raising the tongue and pulling it back, and tensing the muscles in the throat" (Lomax 1968:71). Nasality occurs when the sound is forced through the nose (1968:72–73). The highest ratings on nasality occur when nasality is heard throughout a song, regardless of the actual sounds sung. In Lomax's view, the singing voice reflects tension about sexuality (Lomax 1968:194). Could opening the mouth wide to make sonorous sounds be partially explainable as an effect of sexual permissiveness? We explore the effects of econiche and sexual permissiveness in the section on results below.

METHODS

The data on sonority come from Fought et al. (2004); they were kindly supplied to us by Robert L. Munroe. Although Fought et al. added some additional cases to the 60-culture PSF for their analyses, we use only those societies in the 60-culture sample that had overall sonority scores. The PSF sample was designed to maximize geographical coverage and independence of cases; one society that met certain data-quality controls was randomly selected from each of 60 culture areas (Naroll 1967).

Data on plant cover were previously coded by us on a five-point scale based on information in the eHRAF Collection of Ethnography (Ember and Ember 2000:850). The highest-scale score had an environment with dense, tall vegetation; the lowest had an environment with low or sparse vegetation (see Appendix). For the present study, we also coded the cultures from the 60-culture sample (that had sonority scores) on a four-point scale reflecting degree of mountainous or hilly terrain. The highest score is mostly mountainous terrain; the lowest score is mostly flat terrain (see Appendix).

To measure sexual restrictiveness versus permissiveness, we used ratings from Brad Huber and colleagues (2004) for the 60-culture PSF. Huber et al. distinguish the frequency of premarital and extramarital sex from the degree of deterrence of sex exhibited by the society. We would have liked to have a measure of marital sex frequency to arrive at a more accurate measure of overall attitude about heterosexuality, but we decided against trying to measure it because Gwen Broude and Sarah Greene (1976) could not code marital sex for even half of their sample cases.

RESULTS

Plant Cover, Terrain, and Sonority

Just as we did previously (Ember and Ember 2000), we looked for an effect of plant cover interacting with climate. Our previous analysis suggested that the effect of plant cover would be opposite in warm versus cold climates.

Indeed, using Fought et al.'s (2004) latest measure of sonority, and controlling for warmer versus colder climate, that is what we find again. In warmer climates (cold months <4), the denser the plant cover, the lower the sonority ($\rho = -.29$, $p < .03$, one tail, $n = 44$). But in colder climates, the denser the plant cover, the higher the sonority ($\rho = .53$, $p < .025$, one tail, $n = 14$).

We expected mountainous terrain would decrease sonority in cold climates, but we did not expect mountainous terrain to relate to sonority in warmer climates. Indeed, there is no significant relationship between mountains and sonority in warmer climates, but there is a marginally significant effect of mountains in the expected direction (less sonority) in colder climates ($\rho = -.41$, $p < .08$, one tail, $n = 13$).

Sexuality and Sonority

Because we are primarily looking to improve the prediction of sonority in warm climates, we first look at the relationships with premarital and extramarital frequency and with deterrence in warmer climates (with fewer than four cold months). The strongest relationship is between the frequency of extramarital sex and sonority. The rho is .51 ($p < .005$, one tail, $n = 24$). The box plot is shown in Figure 2. Premarital sex frequency (shortened—low to moderate vs. high to very high) is in the same direction but is not significant ($\rho = .22$, $p < .145$, one tail, $n = 24$). Contrary to our expectation, deterrence is not related significantly to the frequency of either premarital or extramarital sex.

Given that premarital and extramarital sex frequency are correlated with each other ($\rho = .35$ in warmer climate, $p < .04$, one tail, $n = 24$; $\rho = .40$, $p < .01$, one tail, $n = 36$ in all climates), we decided to create a factor score for the two variables. This factor score is significantly related to sonority in warmer climates ($\rho = .42$, $p < .02$, one tail, $n = 24$) and is significantly related to sonority ($\rho = .32$, $p < .03$, one tail, $n = 36$) regardless of climate. Thus, it appears that where there are higher frequencies of premarital and extramarital sex, and, perhaps, freer attitudes toward sex in general, people tend to speak more often with wide open mouths.

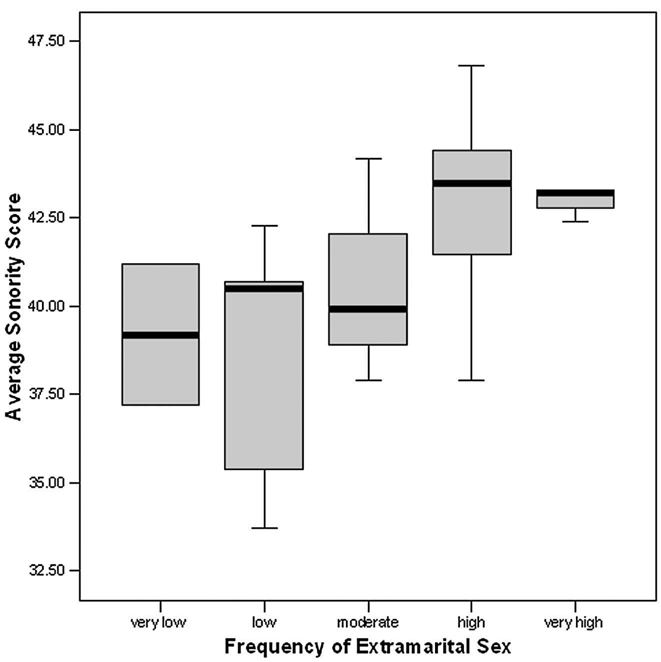

FIGURE 2. Boxplot of average sonority score (from Fought et al. 2004) by frequency of extramarital sex (from Huber et al. 2004) in warmer climates (number of cold months < 4).

Putting the Predictors Together

Do these factors add significantly to the effect of climate alone? Do we need all of these predictors? To answer these questions, we first did multiple regression analyses controlling on climate. Remember that some of the relationships change direction in different climates.

Looking first at warmer climates where the variability in sonority is greatest, we examine the possible influence of two factors that are bivariately significant—plant cover and the factor score for premarital and extramarital sex frequency. Table 1 shows the multiple regression analysis. The multiple R is .53 ($p < .03$). The sexuality factor score is significantly related to sonority. The standardized beta is .47 ($p < .01$, one tail). Plant cover is not significant, but the standardized beta is not that low (−.21).

Now turning to colder climates (four or more cold months), we put in two factors that are significantly related bivariately to sonority in colder climates—density of plant cover and mountainous terrain (see Table 2). Even though the number of cases is very small ($n = 13$), the multiple R is .67 and significant (.05). Both plant cover and mountainous terrain are significant independent factors—the respective standardized beta weights are .52 ($p < .025$, one tail) and −.44 ($p < .05$, one tail).

Can we put these factors into one multiple regression, adding in the climate effect found by Munroe and his colleagues? The problem is that plant cover has opposite effects in warm and cold climates. However, we can create new variables that combine the effects of climate and plant cover to approximate the results controlling on climate. The

TABLE 1. Predicting Average Sonority Score in Warmer Climates (No. of Cold Months < 4) Using Multiple Regression[a]

	Standardized Beta	Significance
Dense Plant Cover[b]	−.21	.13[c]
Factor Score of Premarital and Extramarital Frequency	.47	.01[c]
Overall R (n = 24)	.53	.03

Note. [a]Data on number of cold months and average sonority score from Fought et al. 2004, courtesy of Lee Munroe; data on plant cover available from authors; data on premarital and extramarital sex from Huber et al. 2004. [b]Dichotomized at 2.5–3 = 1 vs. 1–2 = 0 on plant cover (plantshort)—see Appendix. [c]one tail.

TABLE 2. Predicting Average Sonority Score in Colder Climates (No. of Cold Months Four or More)[a]

	Standardized Beta	Significance
Partly Hilly or Mountainous[b]	−.44	.05[c]
Degree of Plant Cover[d]	.52	.03[c]
Overall R (n = 13)	.67	.05

Note. [a]Data on number of cold months and average sonority score from Fought et al. 2004, courtesy of Lee Munroe; data on plant cover and mountainous terrain available from authors; data on premarital and extramarital sex frequency from Huber et al. 2004.[b]Dichotomized at hilly or mountainous (scores of 2–4 coded a 2) versus relatively flat (1–1.5 coded a 1) on mountainous terrain (mountaincoldshort)—see Appendix.[c] one tail.[d] Plant cover trichotomized as mostly sparse (1 = 1–1.5), mixed (2 = 2), and dense (3 = 2.5–3)—plantcoldshort—see Appendix.

first new variable is the combination of warmer climate with dense plant cover (1 vs. 0). The second is the combination of sparse plant cover with colder climates (1 vs. 0). Finally, we can create a variable of hilly terrain and cold climates (1 vs. 0).

The multiple regression is now very high (.82, $p < .00$; see Table 3). Three predictors are significant and independent: Number of cold months predicts less sonority (the standardized beta is −.49, $p < .00$, one tail), the combination of cold climate and sparse vegetation predicts less sonority (the standardized beta is −.38, $p < .01$, one tail), and a higher factor score of premarital and extramarital sex frequency predicts more sonority (the standardized beta is .33, $p < .00$, one tail). The combination of warm climate and dense vegetation is only marginally significant in predicting less sonority (the standardized beta is −.16, $p < .08$, one tail). Because the number of cases is relatively small, we did a backward regression to eliminate the number of variables in the equation. The number of cold months, the combination of cold and sparse plant cover, and the sexuality factor score all remain significant and the multiple R remains high ($R = .81$; see the last two columns of Table 3). Dense plant cover in warm climates and mountainous terrain in cold climates appear not to be important independent factors. However, we should not rule out the possible effects of these other factors because they are significant predictors in the separate multiple regression analyses when climate was controlled.

Finally, we ask the following question: Do these new predictors also help us explain the variation in percentage of consonant-vowel syllables? To answer this question, we change the dependent variable in the multiple regression analysis to the proportion of consonant-vowel syllables, and we add baby holding and literacy, previously found to be significant predictors. The resulting multiple R is .79, $p = .00$ (see Table 4). Just as we found little effect of plant cover on CV scores in a previous analysis (Ember and Ember 2000), here there are also no significant effects of the plant/mountain combinations on CV score. The factor score from Huber's data on premarital and extramarital sex is significantly and positively related (one tail) to the percentage of consonant-vowel syllables, and literacy is negatively related significantly. Baby holding is marginally significant and climate is not significant. If we do a backward regression eliminating the variables with little predictive power, baby holding and literacy both become significant along with the factor score on sexuality derived from Huber. Baby holding and more sexuality are positive predictors; literacy is a negative predictor. The multiple R is .75 ($p = .00$).

CONCLUSION

The fact that climate remains an independent predictor of sonority lends support to the Munroe et al. theory of communicative efficiency. But remember that variability is greater in warm climates than in cold. Additional factors in the environment, such as density of plant cover and mountainous terrain, appear to improve the predictability of sonority. Our results suggest that cold climates, particularly in conjunction with sparse vegetation, have a separate inhibiting effect on sonority. Recall our suggestion (Ember and Ember 1999; see also Ember and Ember 2000) that in cold, windy climates it may be disadvantageous to keep the mouth wide open for any length of time. (As yet, there is no hard evidence to support this idea.) We do not mean to suggest that higher sonority would normally occur if

TABLE 3. Multiple Regression Predicting Average Sonority Score—All Climates[a]

	Standardized Beta	Significance	Backwards Regression Std. Beta	Significance
Number of Cold Months	−.49	.00[b]	−.43	.00[b]
Cold (cold mos > 3) and Sparse [c]Plant Cover	−.38	.01[b]	−.36	.02[b]
Cold (cold mos > 3) and Partly Hilly or Mountainous[d]	.03	.42[b]		
Warmer (cold mos < 4) and Dense Plant Cover[e]	−.16	.08[b]		
Factor Score of Premarital and Extramarital Frequency	.33	.00[b]	.32	.01[b]
Overall R (n = 34)	.82	.00	.81	.00

Note. [a]Data on number of cold months and average sonority score from Fought et al. 2004, courtesy of Lee Munroe; data on plant cover and mountainous terrain available from authors; data on premarital and extramarital sex frequency from Huber et al. 2004. [b]one tail. [c]Sparse plant cover is 1–1.5 on plant cover or 1 on plantcoldshort—see Appendix.[d] Partly hilly or mountainous is a score of 2–4 on mountainous terrain or 2 on mountaincoldshort—see Appendix.[e] Dense plant cover is 2.5–3 or 1 on plantshort—see Appendix.

TABLE 4. Multiple Regression Predicting Proportion of CV Syllables[a]

	All Variables		Backward Regression	
	Std. Beta	Sig.	Std. Beta	Sig.
Number of Cold Months	−.36	.13[b]		
Cold (cold mos > 3) and Sparse[c] Plant Cover	−.08	.33[b]		
Cold (cold mos > 3) and Partly Hilly or Mountainous[d]	.16	.22[b]		
Warmer (cold mos < 4) and Dense Plant Cover[e]	−.01	.48[b]		
Factor Score of Premarital and Extramarital Frequency	.30	.02[b]	.24	.04[b]
Degree of Baby Holding	.34	.06[b]	.58	.00[b]
Literacy	−.30	.04[b]	−.27	.02[b]
Overall R (n = 30)	.79	.00	.75	.00

Note. [a]Data on number of cold months, cv scores (revised), and literacy, courtesy of Lee Munroe; data on plant cover and mountainous terrain available from authors; data on premarital and extramarital sex frequency from Huber et al. 2004; data on degree of baby holding from Ember and Ember 1999. [b]one tail. [c]Sparse plant cover is 1–1.5 on plant cover or 1 on plantcoldshort—see Appendix. [d]Partly hilly or mountainous is a score of 2–4 on mountainous terrain or 2 on mountaincoldshort—see Appendix. [e]Dense plant cover is 2.5–3 or 1 on plantshort—see Appendix.

not for cold climate, sparse vegetation, or mountainous terrain. We only assume that sonority will decrease after people with high sonority move into an econiche that inhibits it. In other words, we suggest that high or low sonority in a language may be selectively advantageous in particular econiches—not just because the climate is warmer or colder. Finally, we suggest that greater sexual expressiveness also affects sonority. Paralleling findings regarding music, sexual inhibition (at least with regard to premarital and extramarital sex) seems to discourage speaking with a wide open mouth, and sexual expressiveness may encourage it.

We have not tested all possible hypotheses about sonority in language. We have only tested hypotheses we had theoretical reasons to expect might be true. Needless to say, there is more research to be done. For example, as one reviewer of an earlier draft of this article suggested, societies located in mountainous or cold environments may be smaller in scale and, thus, require less explicit speech performance across public space for coordinating social practices. Or, perhaps, singing with a wide open mouth, along with high sonority in the language and more sexuality, are all indicative of a generalized cultural pattern of higher emotional expressiveness. And climate may have a direct effect on emotional expressiveness (Robbins et al. 1972). In addition, more research needs to be done to verify whether the assumptions made are correct. Is there more distant communication in warmer climates? Is there any detrimental health effect of speaking with a wide open mouth in cold climates? We hope that other researchers may join in the search for worldwide patterns in languages that challenge the long-standing assumption of arbitrariness in phonetics.

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APPENDIX

Definitions of Plant Cover (Plant):

1 = low or sparse vegetation (e.g., tundra, grassland)
1.5 = preponderance of low or sparse vegetation, but some dense, tall cover
2 = mixed environment, some with low or sparse vegetation, some dense, tall plant cover
2.5 = preponderance of heavy, tall vegetation, but some low or sparse
3 = dense, tall vegetation (e.g., tropical forest, dense woods, swamp with tall plants)

Plantshort = Plant dichotomized at 2.5–3 = 1 vs. 1–2 = 0

Plantcoldshort = Plant trichotomized: 1–1.5 = 1; 2 = 2; 2.5–3 = 3

Hilly or Mountainous Terrain (Mountain):

1 = mostly flat
2 = mixed; flat in some places, hilly or mountainous in others
3 = mostly hilly
4 = mostly mountainous

Mountaincoldshort = Mountain dichotomized at 1–1.5 = 1; 2–4 = 2