Environment and climate helped shape varied evolution of human languages

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It's well known that gradual adaptation to the environment shaped the development of human bodies and brains, but recent work by an international group of researchers suggests that the variations in human linguistic evolution also reflect adaptations to the local ecological conditions.

The researchers, who hail from the University of New Mexico and Laboratoire Dynamique du Langage-CNRS, France, have conducted an extensive study to examine the relationship between the sound structures of a worldwide sample of human languages and climatic and ecological factors including temperature, precipitation, vegetation and geomorphology.

The study will be presented at the 170th Meeting of the Acoustical Society of America (ASA), being held Nov. 2-6, 2015, in Jacksonville, Fla. Their results show a correlation between ecological factors and the ratio of sonorant segments, which are produced by uninterrupted airflow, to obstruent segments, which are formed by obstructing airflow, in the examined languages. This supports the hypothesis that acoustic adaptation to the environment plays a role in the evolution of human languages.

"We believe this work is by far the most extensive and careful work on a possible link between specific aspects of human languages' sound patterns and environmental factors," said Ian Maddieson, the primary researcher and an adjunct professor in the Department of Linguistics at

the University of New Mexico.

"We find that the number of distinct consonants and the degree to which consonants cluster together in syllables correlate with mean annual precipitation, mean annual temperature, the degree of tree cover and the geographic elevation and 'mountain-ness' ('rugosity') of the area in which they are traditionally spoken," he said. "Both the number of distinct consonants and their distribution in syllabic structures are lower where tree cover and temperature are higher."

Both of these factors tend to make the transmission of higher frequencies less reliable. According to Maddieson, this could explain why languages spoken by people in tropical areas tend to make more vowels in their languages, as these are distinguished by differences in the lower frequencies. Additionally, by using simpler syllable structures, the vowels occur more often in the stream of spoken language.

Maddieson said that their findings offer support for an application of the Acoustic Adaptation Hypothesis—which argues that species adapt their acoustic signals to optimize sound transmission in the environment they live in—to human languages. The hypothesis was first proposed by E.S. Morton in 1975 in relation to the calls of 177 bird species. Morton suggested that birds in forested areas tend to sing at lower frequencies than birds living in open areas in order to enhance the effectiveness of transmission of the signal in the specific environment they live in. More recent work has shown that birds of the same species adapt their calls to make them more effective against the background of modern urban noise pollution.

To explore the relevance of the Acoustic Adaptation Hypothesis to the evolution of human languages, Maddieson's team correlated phonological data on languages from the Lyon-Albuquerque Phonological Systems Database (LAPSyD) with climatic and ecological

data from the International Steering Committee for Global Mapping.

Major world languages spoken such as English, Mandarin Chinese and Spanish were excluded, as they may not show any detectable relationship between environmental factors and linguistic traits. After other exclusions, such as cases where data was missing or where language names were ambiguous, 628 languages indigenous to all parts of the world were included in the final analysis.

"The transmission of sound waves consists of the propagation of small pressure differences through space in a medium such as air. For the most faithful propagation of sound waves, the medium needs to be uniform, otherwise some distortions will occur," Maddieson explained.

In an area with dense vegetation, the paths of transmission are not uniform. Some sound waves are reflected backwards by the vegetation, while others are diverted sideways, leading to signal degradation and ineffective transmission. Additionally, sound signals containing very rapid changes, or high frequencies—such as the consonants /p, t, k/—are more affected by dense vegetation than sound signals with steady-state or low-frequency characters, such as vowels.

"That could explain why languages in areas with greater tree cover tend to be less 'consonant-heavy,'" Maddieson said. "Environments in which higher frequencies are less faithfully transmitted may favor greater use of sounds characterized by low frequencies, that is, more sonorous sounds."

Maddieson noted that vegetation is not the only ecological factor affecting human sound transmission, as warm dry air can generate ripples in the air that break up the coherence of high-frequency sound transmission, and rough terrain can degrade high-frequency signals. Other factors such as temperature, wind and rain play roles in shaping

human languages in different areas as well.

Their analysis suggests that total annual precipitation, mean annual temperature and rugosity all contribute to explaining how consonant-heavy a language is. According to Maddieson, these factors account for almost a quarter of the variation in how 'consonant-heavy' a language is (see figure).

The researchers' next step is to study a large sample of spoken language recordings rather than summary data on inventories and syllable structures to see if ecological factors could predict the proportion of sonorant segments per unit time in spoken languages.

More information: Presentation #3aSC1, "Human spoken language diversity and the acoustic adaptation hypothesis" by Ian Maddieson, will be take place on Wednesday, Nov. 5, 2015, at 9:00 AM in Grand Ballroom 6. The abstract can be found by searching for the presentation number here: https://asa2015fall.abstractcentral.com/planner.jsp

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