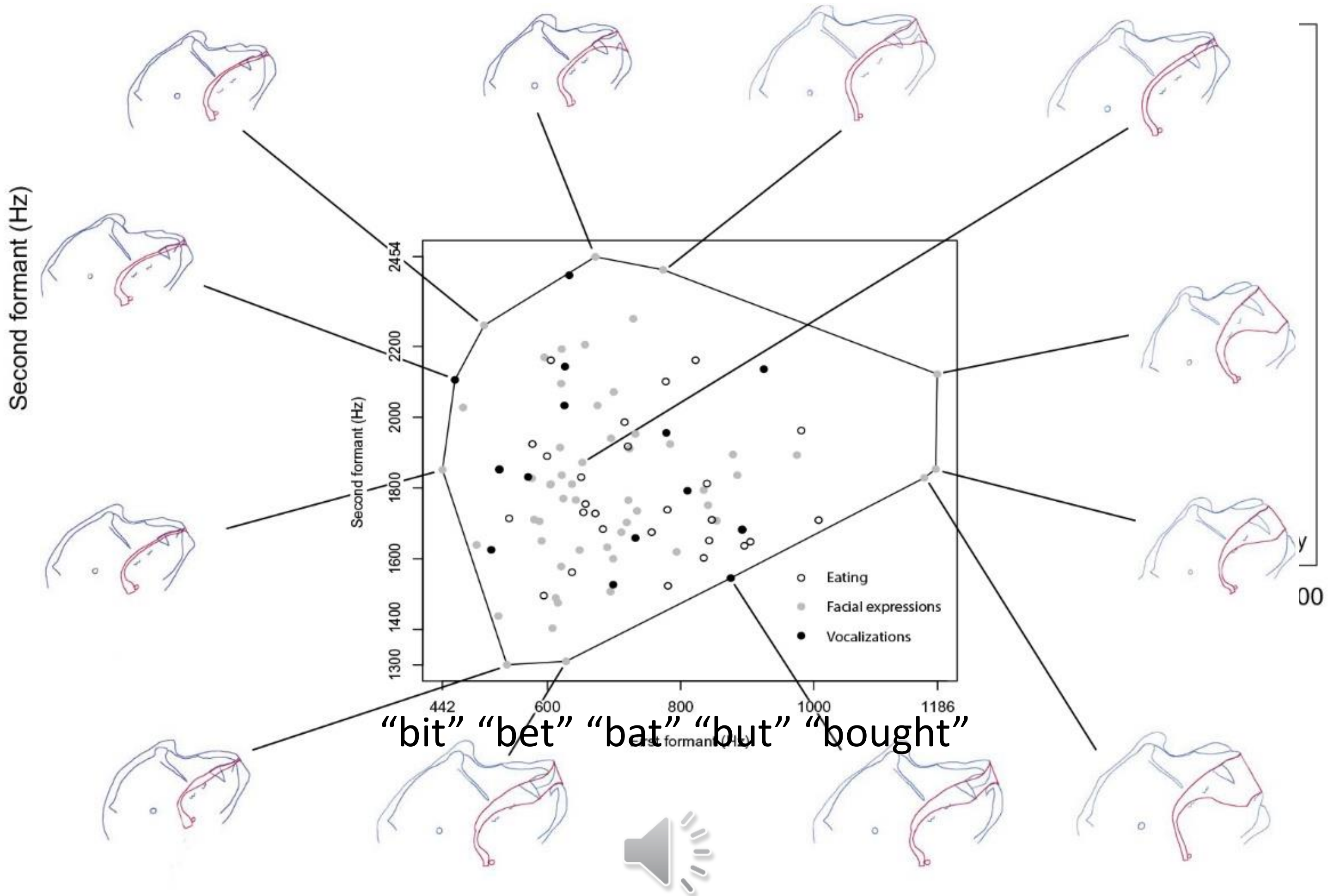
Dilin Evrimi

DBB 318

Özgür Aydın

Dilin evriminden ne anlamalıyız?

Onlar hayvan!



“bit” “bet” “bat” “but” “bought”

Will you marry me?

SCIENCE ADVANCES | RESEARCH ARTICLE

HUMAN EVOLUTION

Monkey vocal tracts are speech-ready

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For four decades, the inability of nonhuman primates to produce human speech sounds has been claimed to stem from limitations in their vocal tract anatomy, a conclusion based on plaster casts made from the vocal tract of a monkey cadaver. We used x-ray videos to quantify vocal tract dynamics in living macaques during vocalization, facial displays, and feeding. We demonstrate that the macaque vocal tract could easily produce an adequate range of speech sounds to support spoken language, showing that previous techniques based on postmortem samples drastically underestimated primate vocal capabilities. Our findings imply that the evolution of human speech capabilities required neural changes rather than modifications of vocal anatomy. Macaques have a speech-ready vocal tract but lack a speech-ready brain to control it.

INTRODUCTION

Despite repeated attempts, no nonhuman primates have ever been trained to produce speech sounds, not even chimpanzees raised from birth in human homes (*1*). Humans appear to be the only primates with a capacity to flexibly control their vocalizations and to integrate respiration, phonation, and vocal tract movements in an intricate manner as required for speech (*2–4*). Since Darwin's time, two hypotheses have been considered to be the likely explanations for this fact. The first "neural" hypothesis is that other primates lack the brain mechanisms required to control and coordinate their otherwise adequate vocal production system; Darwin favored this hypothesis, and it was widely accepted until the 1960s (*5*). The second "peripheral" hypothesis, in contrast, identifies the basis of primate vocal limitations as the anatomy and configuration of the nonhuman primate vocal tract. This hypothesis is widely accepted today, largely due to a seminal 1969 *Science* paper by Lieberman *et al.* (*6*), which used a computer program to explore the phonetic capability of a rhesus macaque and, by extension, other nonhuman primates. They concluded that "the vocal apparatus of the rhesus monkey is inherently incapable of producing the range of human speech" [(*6*), p. 1187]. Later work used the same methods and reached the same conclusions for chimpanzees (*7*), and thus inaugurated the reign of the "peripheral" hypothesis, which today remains a widely accepted "textbook fact" concerning human speech (*8–13*). For example, "early experiments to teach chimpanzees to communicate with their voices failed because of the insufficiencies of the animals' vocal organs" (*9*). This now-traditional hypothesis has an important implication for the evolution of human language: that the broad phonetic range used in modern human speech required key changes in peripheral vocal anatomy during recent human evolution. Here, we present new data, based on x-ray images from living monkeys, that sharply challenge this hypothesis and thus its implication concerning language evolution.

Lieberman and colleagues (*6*) first made a plaster cast of the oral cavity of a rhesus macaque cadaver and sectioned it to derive an estimate of its resting shape. They then created a computer model of the monkey vocal tract, roughly estimating its boundary conditions by manipulating the tongue of an anesthetized animal, and finally explored the possible acoustic range of this computer model to outline the possible vowel range of a monkey. The use of a computer model is appropriate because animals do not necessarily exploit the full phonetic range of their vocal apparatus when vocalizing, and recordings of their vocalizations thus indicate only what the animal does, rather than what it could do. However, a computer model based on a plaster cast of the vocal tract of a monkey cadaver does not necessarily provide an adequate indication of the range of vocal tract shapes produced in living animals. More recent research suggests that investigations of postmortem anatomy drastically underestimate the flexibility of the mammalian vocal tract (*14, 15*).

To remedy this inadequacy, we first examined the vocal anatomy of behaving macaques using x-ray videos. To gain a full estimate of the dynamic flexibility in the vocal tract, we examined the configuration of the upper respiratory tract not only during vocalization but also during facial displays (such as lip smacking and teeth chattering) and during feeding and swallowing. On the basis of the tracings of 99 observed vocal tract configurations, we next constructed a computer model of the macaque vocal tract. Crucially, we never extrapolated beyond the observed anatomical range: Every data point is based on an actual observed configuration. We then used a maximization approach to choose—from the observed vocal tract configurations—five maximally distinct "monkey vowels" that make the best use of the observed space and synthesized these vowels using a monkey grunt vocalization as a source signal. These monkey vowels were finally played in a discrimination test to human listeners to evaluate the listeners' ability to discriminate among the five monkey vowels. We also used a nearest-neighbor approach to find the closest approximation to various human vowels producible by the monkey phonetic model (scaled for differences in overall vocal tract length). This approach provides a highly conservative estimate of potential acoustic output: Only macaque vocal tract configurations we actually observed are used in our model.

Brief methods

Our study used standard methods in speech science, similar to those used in earlier studies, but replaced the original cadaver estimates with more realistic and accurate input x-ray data from living animals. The methodology used is illustrated in Fig. 1. We first made x-ray videos of monkeys in various vocal tract configurations (Fig. 1A; shown is a macaque producing a threat call), extracted digitized still images of the most extreme vocal tract configurations observed, and digitally traced the vocal tract outlines for 99 configurations (Fig. 1B shows one example). With custom Matlab (version 2011b) scripts and C++ code,

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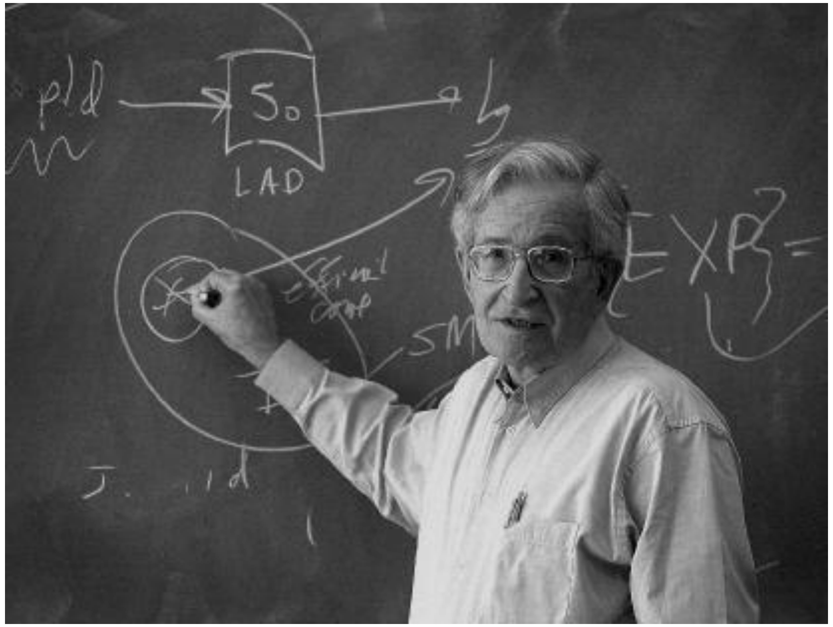
Diğer türler *insan dilini* ya da öğrenebilir mi?



Noam Chomsky (7.12.1928 -)

Nim Chimpsky (19 .11.1973 – 10.03.2000)

Nim Projesi

Nim iki haftalıkken bir ev ortamında bir aileye teslim edilmiş ve Amerikan İşaret Dili öğretilmiştir. Nim 125 işaret öğrenmesine karşın, Herbert Terrace, Nim'in Noam Chomsky'nin "dil" olarak tanımladığı anlamda bir şey edinmediğini belirtmiştir. Buna karşın Nim, eğiticilerinin uygun bağlamlarda kullandığı işaretlerini yineleyerek öğrenebilmiştir.

Table 1. Number of tokens and types of combinations containing two, three, four, and five or more signs.

Length of combination	Tokens	Types
Two signs	11,845	1,138
Three signs	4,294	1,660
Four signs	1,587	1,159
Five or more signs	1,487	1,278

Terrace ve diğ. (1979)

Table 5. Most frequent four-sign combinations.

Four-sign combinations	Frequency
eat drink eat drink	15
eat Nim eat Nim	7
banana Nim banana Nim	5
drink Nim drink Nim	5
banana eat me Nim	4
banana me eat banana	4
banana me Nim me	4
grape eat Nim eat	4
Nim eat Nim eat	4
play me Nim play	4
drink eat drink eat	3
drink eat me Nim	3
eat grape eat Nim	3
eat me Nim drink	3
grape eat me Nim	3
me eat drink more	3
me eat me eat	3
me gum me gum	3
me Nim eat me	3
Nim me Nim me	3
tickle me Nim play	3

Terrace ve diğ. (1979)

Dilbilim oldukça basit görünen ama yanıtlarında karmaşık kuramları barındıran şu sorulara yanıt aramaktadır:

→ Dile ilişkin bilgimiz nedir?

→ Bu bilgi nasıl edinilir?

→ Bu bilgi nasıl kullanılır?

→ **Bu bilgi nasıl evrimleşmiştir?**