

Whalesong patterns follow a universal law of human language, new research finds

February 8 2025, by Jenny Allen, Ellen Garland, Inbal Arnon and Simon Kirby



Credit: Pixabay/CC0 Public Domain

All known human languages display a surprising pattern: the most frequent word in a language is twice as frequent as the second most frequent, three times as frequent as the third, and so on. This is known as Zipf's law.

Researchers have hunted for evidence of this pattern in communication among other species, but until now no other examples have been found.

In [new research](#) published in *Science*, our team of experts in whale song, linguistics and [developmental psychology](#) analyzed eight years' of song recordings from [humpback whales](#) in New Caledonia. Led by Inbal Arnon from the Hebrew University, Ellen Garland from the University of St Andrews, and Simon Kirby from the University of Edinburgh, we used techniques inspired by the way human infants learn language to analyze humpback whale song.

We discovered that the same Zipfian pattern universally found across human languages also occurs in whale song. This complex signaling system, like human language, is culturally learned by each individual from others.

Learning like an infant

When infant humans are learning, they have to somehow discover where words start and end. Speech is continuous and does not come with gaps between words that they can use. So how do they break into language?

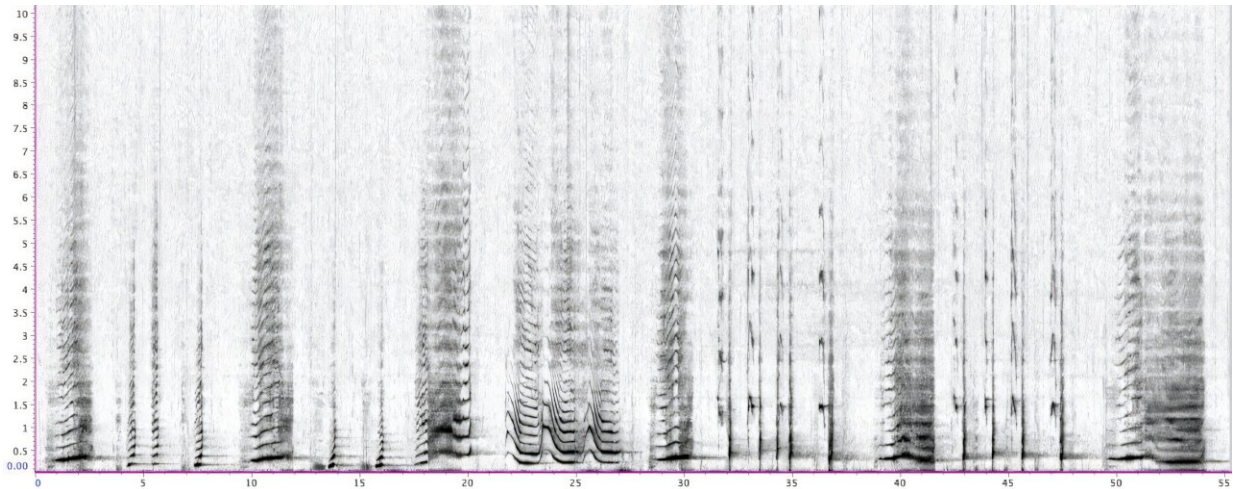
[Thirty years of research](#) has revealed that they do this by listening for sounds that are surprising in context: sounds within words are relatively predictable, but between words are relatively unpredictable. We analyzed the whale song data using the same procedure.

Unexpectedly, using this technique revealed in whale song the same

[statistical properties](#) that are found in all languages. It turns out both human language and whale song have statistically coherent parts.

In other words, they both contain recurring parts where the transitions between elements are more predictable within the part. Moreover, these recurring sub-sequences we detected follow the Zipfian frequency distribution found across all human languages, and not found before in other species.

Whale song recording (2017) Operation Cetaces, 916 KB ([download](#))



Close analysis of whale song revealed statistical structures similar to those found in human language. Credit: Operation Cetaces

How do the same statistical properties arise in two evolutionarily distant species that differ from one another in so many ways? We suggest we found these similarities because humans and whales share a learning mechanism: culture.

A cultural origin

Our findings raise an exciting question: why would such different systems in such incredibly distant species have common structures? We suggest the reason behind this is that both are culturally learned.

Cultural evolution inevitably leads to the emergence of [properties that make learning easier](#). If a system is hard to learn, it will not survive to the next generation of learners.

There is [growing evidence](#) from [experiments with humans](#) that having statistically coherent parts, and having them follow a Zipfian distribution, makes learning easier. This suggests that learning and transmission play an important role in how these properties emerged in both human language and whale song.

So can we talk to whales now?

Finding parallel structures between whale song and human language may also lead to another question: can we talk to whales now? The short answer is no, not at all.

Our study does not examine the meaning behind [whale song](#) sequences. We have no idea what these segments might mean to the whales, if they mean anything at all.

It might help to think about it like instrumental music, as music also contains similar structures. A melody can be learned, repeated, and spread—but that doesn't give meaning to the musical notes in the same way that individual words have meaning.

Next up: Birdsong

Our work also makes a bold prediction: we should find this Zipfian distribution wherever complex communication is transmitted culturally. Humans and whales are not the only species that do this.

We find what is known as "vocal production learning" in an unusual range of species across the animal kingdom. Song birds in particular may provide the best place to look as many [bird species](#) culturally learn their songs, and unlike in whales, we know a lot about precisely [how birds learn song](#).

Equally, we expect not to find these statistical properties in the communication of species that don't transmit complex communication by learning. This will help to reveal whether [cultural evolution](#) is the common driver of these properties between humans and whales.

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