By Dan Falk
Photographs by Chris van Houts

WHAT ARE ALL OUR MOTHER TONGUES TRYING TO TELL US?

The capacity for language is one of our most impressive cognitive abilities. How did it develop?

The world boasts some 7,000 languages. They vary greatly in which meanings they lexicalize or incorporate into a vocabulary: English has different words for red and white, for example, while Dani (spoken in New Guinea) has only two basic colours (one for cool/dark shades and another for warm/light shades). Some meanings are almost always lexicalized across languages, and some almost never. Nearly all known languages have a word whose meaning is "every," and no known language has a word whose meaning is "not every." Is there some rhyme or reason driving such diversity?

For linguist Milica Denić, it's not merely a question of how languages evolved, but why they evolved the way they did. "How come we have the kinds of languages that we have, out of the infinitely many kinds of languages that we *could* have?" asks Denić, an Azrieli International Postdoctoral Fellow at Tel Aviv University's Department of Linguistics.

Denić uses computer simulations to better understand the properties associated with today's languages. She's also tackling related "big picture" questions that are tied to language: How do children acquire language skills so effortlessly? Are humans born with an innate linguistic capacity? If so, how does this capacity interact with environmental pressures to shape language structure? What, exactly, is the relationship between language and thought?

"I'm interested in really fundamental questions about what makes us human, and about how our minds work," says Denić.

Denić pursued a PhD in cognitive science and linguistics at École normale supérieure in Paris, followed by a postdoc at the Institute for Logic, Language and Computation at the University of Amsterdam. Much of her research since then has focused on the various pressures that shape languages as they evolve.

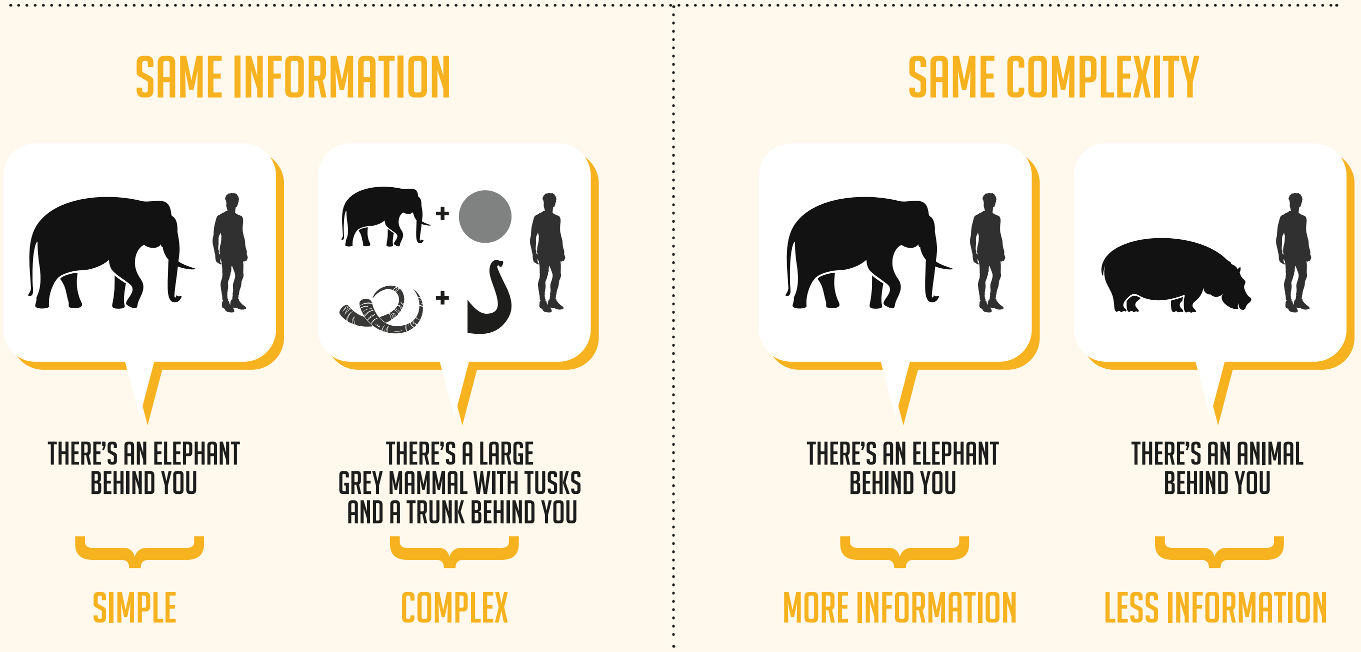
One is the pressure to keep things simple. A simpler language is easier to learn than a more complex one, but with a small vocabulary (a small lexicon, as linguists put it) you can lack a word for whatever you're trying to describe. A second pressure is to maximize how informative our expressions can be.

A third pressure is to minimize the complexity of utterances. When we say, for example, "there's an elephant behind you" or "there's a large grey mammal with tusks and a trunk behind you," both convey the same information, but the second is much more complex. On the other hand, "there's an elephant behind you" and "there's an animal behind you" are equally simple utterances, but the first one conveys more information (while also demanding a larger lexicon, since it requires the language to have a word for that specific animal).

A particular problem that Denić investigated is the way speakers of different languages refer to numbers. In English, for example, each number from one to 12 has its own name, as do 100, 1,000 and similar multiples. But numbers 13 to 99 are built out of building blocks: 13 is thir-teen, 30 is thir-ty. These building-block numbers use "morphemes" to construct more complex expressions for numbers.

CREATIVE COMPLEXITY

Languages seem to be shaped by how they handle competing pressures: the need to keep vocabularies simple while maximizing informativeness and minimizing the complexity of utterances (illustrated below). "There's an elephant behind you" is more complex than "There's an animal behind you" but requires a larger vocabulary. How various languages resolve such pressures may explain why they are so different yet so similar to one another.



Different languages have different sets of morphemes. Denić points out that in Fulfulde, a language spoken in western Africa, the numbers six through nine are not lexicalized; if you want to say "six," you must say the equivalent of "five plus one." And yet, many languages share common features. Nearly every language, for example, lexicalizes the numbers one, two, three, 10 and 100.

For Denić, the key question is whether similarities and differences among languages can be explained in terms of those competing pressures: to keep lexicons simple, to maximize informativeness and to allow for simple utterances. That's where the computer simulations come in. The idea is to simulate thousands of languages and observe how they respond to those pressures. By necessity, these simulations only try to mimic certain essential features of a language rather than complete languages; they focus on, say, pronouns or numbers. In response to competing pressures, these artificial languages "evolve," and their characteristics can be compared to real-world languages.

Denić's findings suggest that her hunch was on the right track. When she looked at more than 120 real-world languages, she found that the optimal "solutions" that her simulated languages settled on were strikingly similar to the real-world solutions that the world's various languages appear to have adopted as they evolved.

Denić's work is helping to make sense of the diversity — and commonalities — seen in today's languages, says Wataru Uegaki, an associate professor at the University of Edinburgh. "Milica's research is significant because it touches on one of the central mysteries about human language — why are languages so different from one another and yet so similar?"

Uegaki says Denić's work on numbers shows that the words we use for counting have their own "mini grammar," as he puts it, with very specific rules. How, then, can we explain those rules?

Linguist Milica Denić uses powerful computer simulations to tease out how and why the world's 7,000 languages evolved the way they did. She is an Azrieli International Postdoctoral Fellow at Tel Aviv University's Department of Linguistics.

Is there something deep about the human mind that underlies the common patterns? Alternatively, does the explanation lie in how languages dynamically evolve so people can efficiently use them for communication? "Denić tries to answer these core questions by bringing together theories in linguistics, cognitive science and theories of cultural evolution," Uegaki says.

Denić hopes her research will point the way to more fundamental discoveries about the nature of language. Is there a connection, for example, between how we use language and how we think? "One of the foundational hypotheses in cognitive science is that some of our thinking happens in a mental language, a language of thought," says Denić. "One can imagine that the expressions we have are mapped onto these 'building blocks' from this language of thought. What I'm hoping is that the language data may actually shed light on what the building blocks of this language of thought may be like."

It's possible that certain numbers function as such building blocks, Denić speculates. "Maybe some numbers are 'cognitive primitives,'" she says. "Given our biological and evolutionary baggage, we may have evolved to represent certain numbers as primitive — possibly just a few low numbers such as one, two and three — and we have to mentally build other numbers from these primitives."

Because the elements that make up this language of thought are unobservable, one of Denić's research goals is to try to "reverse engineer" them based on what we know about how real-world languages respond to competing evolutionary pressures.

Denić's work raises larger questions about how the mind works, says Roni Katzir, an associate professor of linguistics who works in the same lab as Denić at Tel Aviv University. While scholars have long debated whether human minds work in a similar way to computers, Katzir finds the analogy useful. "If we think of our cognitive apparatus as being like some kind of computer," he says, "we can ask, what kind of 'programming language' do we have inside our heads that we're born with? This goes to the heart of who we are, of what makes us special."

While some researchers may be reluctant to embrace such overarching questions, Denić enjoys thinking big. "Our capacity for language is one of the most fascinating cognitive abilities that we have," says Denić. "We want to understand how we humans came to have this really complex and intricate capacity." ▲●■