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Evolution & Behaviour

Apes and monkeys understand syntax-like structures

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ABSTRACT

We, humans, can combine a limited number of words into an unlimited number of possible sentences using syntax. We tested whether our closest living relatives, monkeys and apes, are able to understand sound sequences that follow some of the rules of language, shedding light on the mysterious evolutionary origins of this ability.

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Across the globe, humanity flourishes by sharing thoughts, culture, information, and technology through language – an incredibly complex method of communication used by no other species. Therefore, finding out why and when language evolved is crucial to understanding what it means to be human. However, since words do not become fossils, shedding light on this evolutionary history is extremely challenging! One of the most powerful tools at our disposal is comparing the communicative abilities of humans with animals, particularly primates, to find out which ones are truly uniquely human and which might have evolved a long time ago.

One of the most crucial abilities underpinning language is our capacity to process relationships (known as 'dependencies') between words and phrases – understanding that when they go together in particular ways, this changes their meaning. These dependencies can be between units that are next to one another, known as an 'adjacent dependency' (e.g. "*The dog – ran away*"), or those that are far apart, known as 'non-adjacent dependences'. For example, in the sentence "*the dog - who bit the cat -*

ran away," we understand that it is the dog who ran away, rather than the cat, because we can process the distant relationship between the first and last phrases. This example was simple, but it quickly becomes difficult in longer, more complex sentences! As far as we know, these kinds of relationships do not exist in the combinations of sounds produced by primates. However, even though animals don't *produce* these types of sequences, we wanted to explore whether they might nevertheless be able to *understand* them.

To do this, we tested the abilities of chimpanzees, with whom we share a relatively recent common ancestor (5-6 million years ago), and common marmoset monkeys, for whom our common ancestor is much more ancient (~40 million years), to process non-adjacent dependencies. We did this by exposing our subjects to complex acoustic sequences known as "artificial grammars": sequences made up of combinations of meaningless, computer-generated sounds following predictable patterns. For example, sound 'A' was always paired with sound 'B', and sound 'C' was always paired with sound 'D', mimicking the relationships found between elements of language. We separated these sounds with other, unrelated sounds to create our artificial 'non-adjacent dependencies' comparable to "*the dog - that bit the cat - ran away*". After playing these sequences for a long time (one hour per day for five days), we tested whether our subjects had learned the rules underlying how we put them together. We did so by playing them a) familiar sequences and b) sequences made of the same familiar sounds but combined in *unfamiliar ways* (e.g. 'A' with 'D'). If the primates were capable of processing non-adjacent dependencies, we expected them to express surprise when their expectations were violated like this. Specifically, because animals tend to look towards sounds that are surprising to them, we predicted that if our subjects really learned the dependencies, they should spend more time looking towards the speaker playing the sounds after these unfamiliar combinations.

What we found was that both chimpanzees and marmosets spent, on average, twice as long looking towards the speaker after unfamiliar combinations than familiar ones. From this we could confidently interpret that both species could easily process adjacent and non-adjacent dependencies in our artificial grammars. This is really interesting because it tells us that this ability is not unique to language-using humans but is widespread in the primate family. Since it is much more likely that our common ancestor with each of these species possessed this ability than it having evolved three separate times, this finding also gives us a unique insight into what our ancestors were capable of over 40 million years ago.

Now that we know primates can process these kinds of sound sequences, a big question arises: Why don't they produce complex sound combinations themselves? For humans, doing so greatly increases the expressive possibilities of language. Perhaps the brains of non-human primates differ from ours in some crucial way that means they understand complex sentences but can't say them. Or perhaps they only need to express simple signals, and it just isn't necessary for them to do so. This much we can be confident of: the ability to process non-adjacent dependencies, without which you could not understand the sentence you are reading right now, evolved at least 50 million years ago, the date our last common ancestor with chimpanzees and marmosets was alive. Having gained some idea of the 'when' for this ability, we hope that future research can begin to answer the 'why'.