

SCIENCE & TECHNOLOGY



SCIENCE FOCUS
WILLIAM WANG

Language sets the tone for brain's circuitry

Infants are born with the general potential to learn any tongue, but the one they end up using will play a major part in shaping their neural pathways

A team of scientists from Milan and Leipzig succeeded in imaging the brains of two-day-old infants. They report that although the brain structures for language are already in place in these newborns, there are significant differences between these structures and those found in adults.

Their paper just published in the American journal *Proceedings of the National Academy of Sciences* caught my attention.

We know that the infant's brain, weighing only about 300 grams, is tiny compared with an adult's. But it grows at an astounding rate, tripling its size in the first two years of life, eventually reaching some 1,400 grams when mature. Thanks to the European research, we now know that the brain not only grows in size, but also reorganises itself in important ways to learn about the world.

Research on the brain over the past century and a half has shown that for most of us, the left hemisphere plays a more dominant role in language than the right hemisphere. Pioneering scientists in France and Germany in the 19th century identified regions for language production and comprehension, and for reading. All these regions are in the left hemisphere.

With today's powerful methods of brain imaging, we now know that language goes much deeper than

the regions on the brain's surface observed by the early pioneers. Language is much more a whole-brain activity, involving many neural circuits operating deep below the cortex. The European research makes full use of the latest imaging technology in this infant study.

How neural language circuits eventually form depends critically on the nature of the language they support. For instance, the brain of someone who grows up speaking Chinese is surely different from the one of an English-only speaker since the auditory circuits must distinguish word tones and the visual circuits must read Chinese writing. Shaping the brain for a particular language comes later than the general ability for language. Initially the infant must come prepared to learn any language – Cantonese if born in Hong Kong, and English if born in London.

In comparing infant brains with those of adults, the European scientists found that basic structures



We now know that language goes much deeper than the regions on the brain's surface

are all already in place at the age of two days.

There are two observations about reorganisation that are especially interesting. One is that while the infant's brain has excellent connections across the hemispheres, the connections within each hemisphere are relatively immature. Much of the growth in coming years will be to form circuits within hemispheres.

The other observation reported in the European study is that the hearing area in the right hemisphere is more active than in the left hemisphere.

This suggests that infants process pitches in absolute physical values, in terms of hertz, rather than in relative terms, as rising or falling melodic contours. However, pitch is also a linguistic signal, used to carry intonation in all languages; as such it is primarily processed in the left hemisphere in adults.

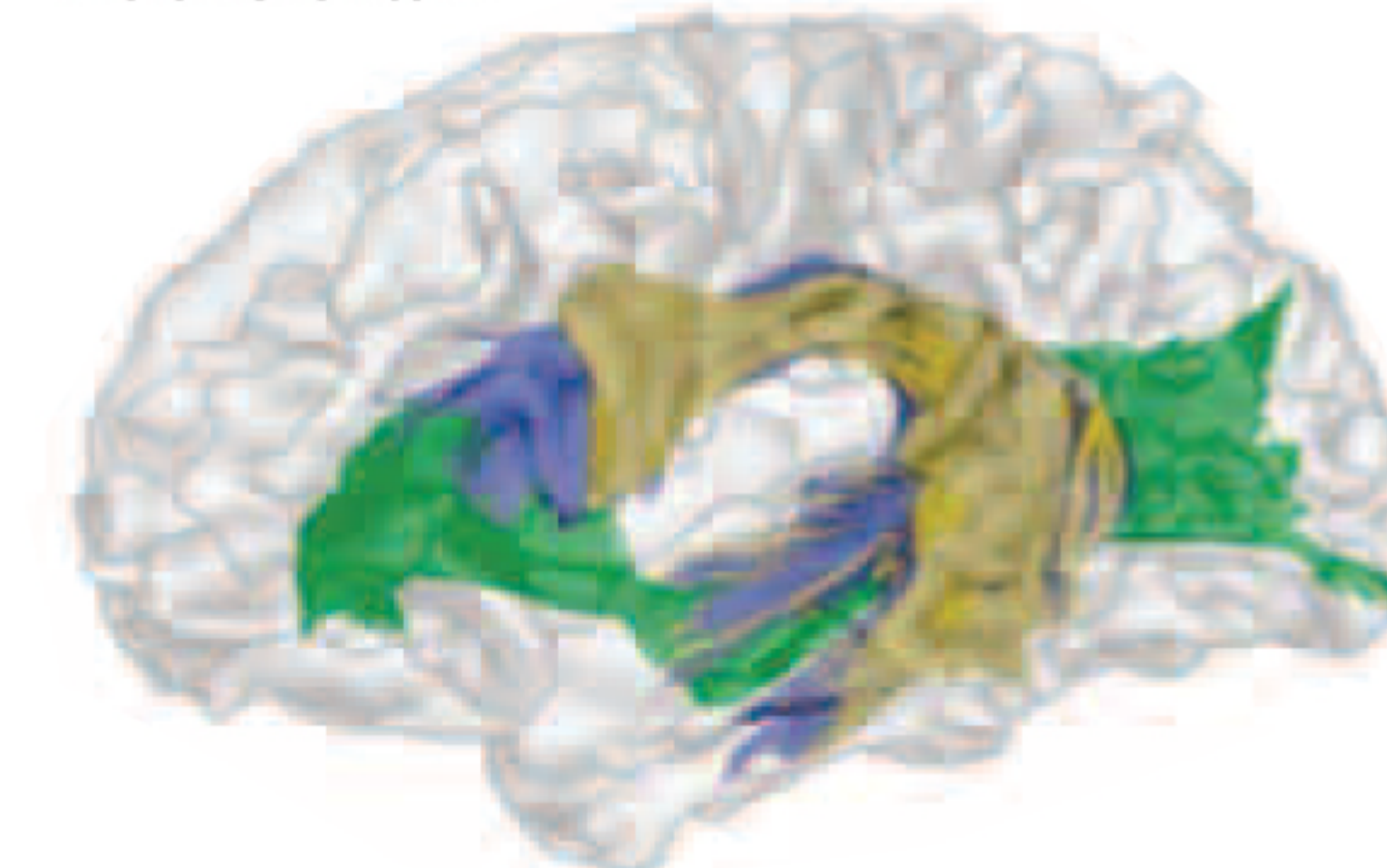
A man asking a question and a woman asking the same question use the same intonation, even though her voice is typically much higher in pitch than his. It is the same intonation only because linguistic pitch is perceived relatively, in the same sense that the same musical melody can be sung in many different keys.

In this connection, there was an interesting paper related to this in 2001 in the journal *Developmental Psychology*. The authors showed that eight-month-old infants perceive pitch absolutely, though adults perceived the same experimental stimuli relatively. These authors interpret the difference as evidence of the brain undergoing

Crucial difference

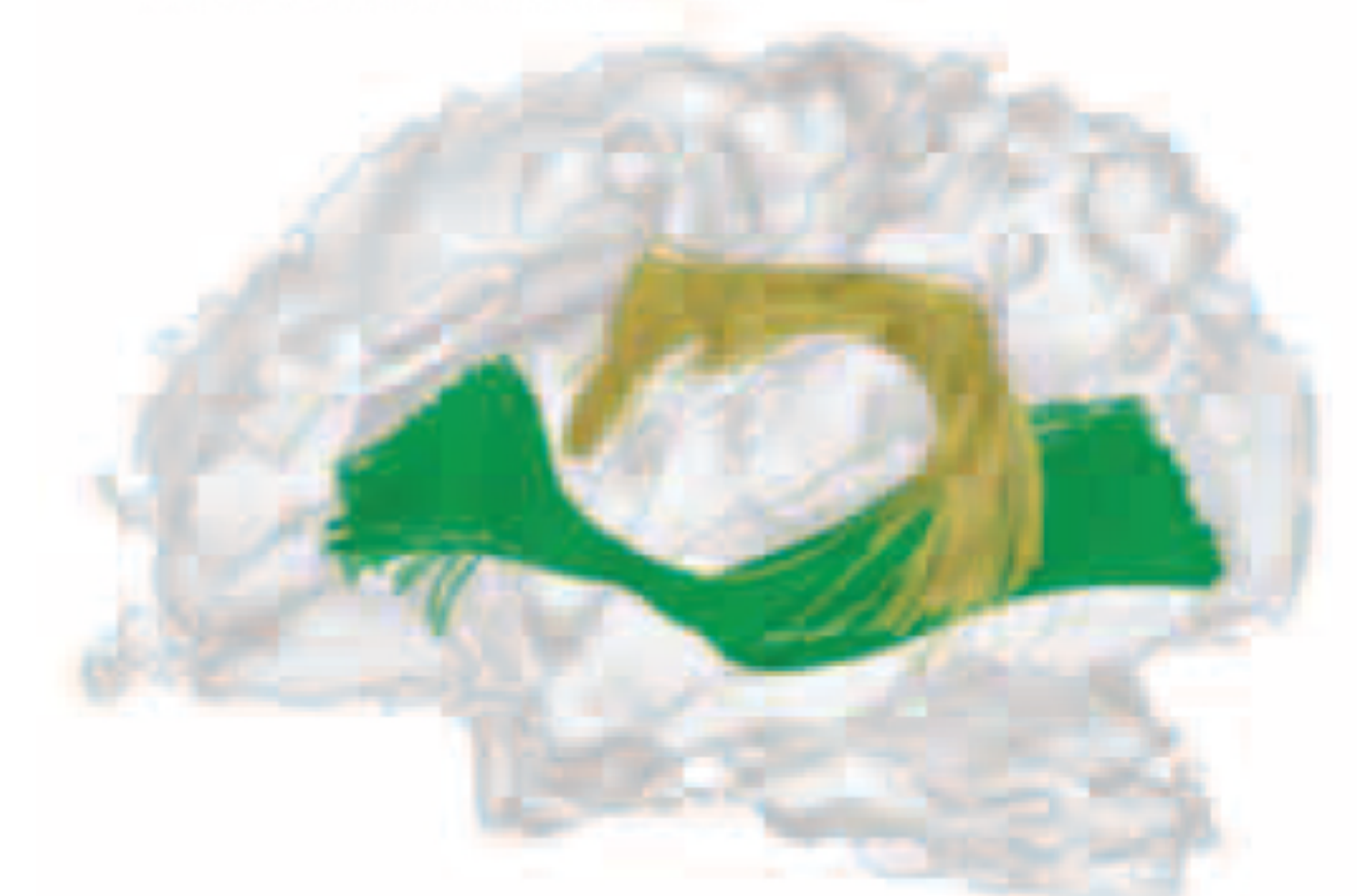
In an adult brain, the arcuate fasciculus (in yellow) connects solidly with Broca's area (in blue), which is critical for language. In a newborn brain, this connection is yet to be made. How the neural language circuits are eventually formed depends on the nature of the language they support.

Adult brain



Source: Daniela Perani, PNAS

Newborn brain



SMP

developmental reorganisation as a result of learning.

Since then, there have been many studies on pitch perception showing that this ability differs according to the language a person speaks. While speakers of tonal languages like Chinese make extensive use of relative pitch perception, they also retain the ability for absolute pitch significantly better when they study music, compared with students who do not speak a tonal language. Furthermore, it does not seem to matter what musical instrument they are studying, even though different instruments produce very different physical sounds.

While the European report is titled "Neural language networks at birth", the neural networks are surely serving a much broader function than just language. Language is just the interface for many independent skills – articulating diverse sounds,

categorising sensations, naming experiences, and combining these names into syntactic patterns. Other animals also have these kinds of skills but they haven't linked them together as effectively as we have.

Ever since life began, the forces of evolution have been "tinkering" with our bodies, to use a metaphor made famous by Nobel laureate for medicine Francois Jacob. Nature has endowed us with a brain that can learn complex symbolic systems like language, music and mathematics – systems that have been created and enriched by millennia of human culture. Although we are born to learn, we can only do so with the stimulation and nurturing that culture provides. Nature and nurture are therefore constantly interacting, and inextricably intertwined. William Wang, a linguist, is the Wei Lun Research Professor at the electronic engineering department of the Chinese University of Hong Kong