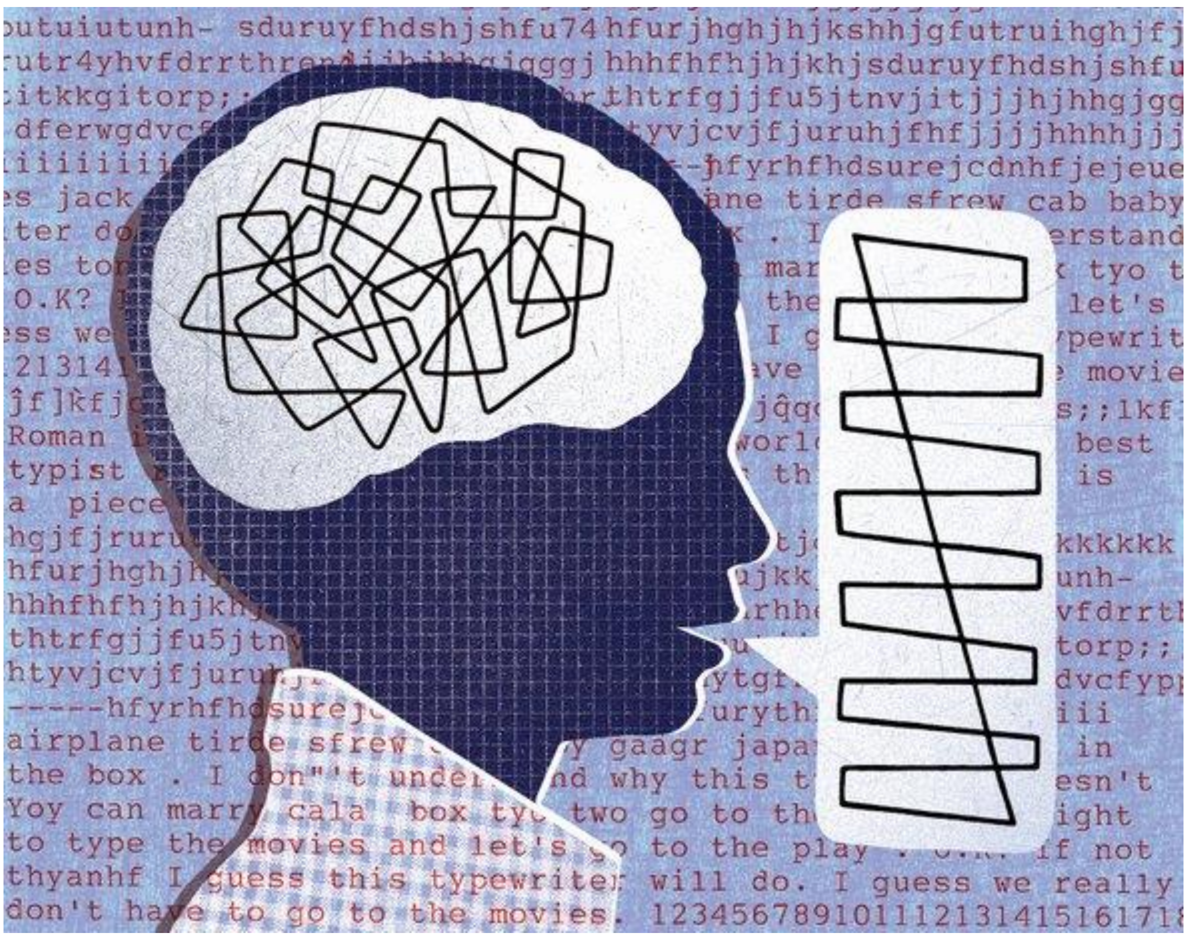
Observations

How Language Shapes the Brain

The ascent of Japan's Emperor Naruhito offers a lesson in the neuroscientific power of words

- By Sayuri Hayakawa, Viorica Marian on April 30, 2019



Getty Images

When Emperor Akihito stepped down from the Chrysanthemum Throne on May 1, 2019, in Japan's first abdication in 200 years, Naruhito officially became the new emperor ushering in a new era called *Reiwa* (令和;

“harmony”). Japan’s tradition of naming eras reflects the ancient belief in the divine spirit of language. *Kotodama* (言霊; “word spirit”) is the idea that words have an almost magical power to alter physical reality. Through its pervasive impact on society, including its influence on superstitions and social etiquette, traditional poetry and modern pop songs, the word *kotodama* has, in a way, provided proof of its own concept.

For centuries, many cultures have believed in the spiritual force of language. Over time, these ideas have extended from the realm of magic and mythology to become a topic of scientific investigation—ultimately leading to the discovery that language can indeed affect the physical world, for example, by altering our physiology.

Our bodies evolve to adapt to our environments, not only over millions of years but also over the days and years of an individual’s life. For instance, off the coast of Thailand, there are children who can “see like dolphins.” Cultural and environmental factors have shaped how these sea nomads of the Moken tribe conduct their daily lives, allowing them to adjust their pupils underwater in a way that most of us cannot.

Just as extensive diving can change our pupils, and exercise can change our bodies, so can mental activity, such as learning and using language, shape the physical structures of our brains. When two neurons respond to a stimulus (such as a word), they begin to form chemical and physical pathways to each other, which are strengthened or weakened depending on how often they are co-activated. This process of “neurons that fire together, wire together” is the basis for all learning, and is reflected in the formation of gray matter (where neurons communicate with each other) and white matter (fatty tracts connecting gray matter regions).

The brain’s ability to adapt to its environment explains how we become specialized to the sounds of our native tongue. All infants are born with the ability to discriminate between the speech sounds of different languages, but eventually become tuned to the inputs they hear the most; neural pathways corresponding to native phonemes are strengthened, while those corresponding to foreign sounds are pruned. For bilinguals, this window of “universal” sound processing stays open longer because of their exposure to richer language environments. In other words, the inputs that our brains receive shape how we experience the world around us.

Despite the fact that multilingualism is the norm rather than the exception, the monolingual model remains the standard for studying neurocognition. A review of over 180 studies recently published in the journal *Behavioral and Brain Functions* discusses how the challenges associated with juggling multiple languages can affect the way we perceive and respond to our surroundings, as well as the physical structure of the brain.

For example, neuroimaging has shown that bilingualism can enhance attention and sensitivity to sounds, even past infancy, and even if you begin to learn another language later in life. Bilingualism can also make your brain more efficient at managing the immense volume of information that comes streaming in on a second-to-second basis, helping you focus on what matters and ignore distracting inputs.

Both of these skills are critical for learning new languages, which may explain why learning a second language can make it easier for you to learn a third or a fourth. This is in stark contrast to older, now debunked, ideas that the brain only has room for one language (as if the brain divides up a fixed amount of space among languages, as opposed to being an active living organ with dense and interacting connections). Learning a new language changes, and even optimizes, how you use what you already have.

To illustrate, extensive exposure to multilingual speech can result in more robust encoding of sounds in the evolutionarily ancient brainstem, as well as increased gray and white matter in the primary auditory cortex. As a result, after training, even adults may find it easier to perceive foreign speech sounds, as well as mimic foreign accents, compared to monolinguals.

Decoding complex speech signals is just one challenge encountered by the bilingual brain. As a spoken word unfolds (e.g., “c-a-n-d-l-e”), both monolinguals and bilinguals need to suppress interference from similar words that come to mind (e.g., “cat,” “can,” “candy”). However, in addition to similar words from the same language, multilinguals also consider words from other languages they know.

In fact, the bilingual brain is always ready to process words from all known languages—multiplying the number of so-called “linguistic competitors.” Over time, bilinguals can become experts at controlling these competitors, to the point where the brain regions that monolinguals rely on to resolve withinlanguage competition (e.g., the anterior cingulate cortex) show less activation for bilinguals unless they need to manage competition across languages.

Just as having stronger muscles allows you to lift weights with less effort, increased gray matter in classic executive control regions may make it easier for bilinguals to manage irrelevant information. Bilinguals also have increased white matter in the tracts connecting frontal control areas to posterior and subcortical sensory and motor regions, which may allow them to off-load some of the work to areas that handle more procedural activities. Because the same neural machinery can be used for both linguistic and nonlinguistic tasks, multilingual experience can even affect performance in contexts that involve no language at all.

Increased gray and white matter, as well as the ability to flexibly recruit different brain regions, may help explain why bilingualism can delay the onset of dementia symptoms by four to six years. Fortunately, there doesn't appear to be a deadline for fortifying your brain, as learning a foreign language can still have an impact well into adulthood and after relatively brief amounts of training. Furthermore, changes to one area or function are likely to have cascading effects; better cognitive control can enhance auditory processing, which may facilitate further language learning and continued neural restructuring.

The human capacity for language has played a critical role in the development of civilizations, the transmission of knowledge and our ability to collectively shape our environments. Mythology and magic aside, endowing the new Japanese era with the word *Reiwa* could have tangible outcomes by influencing people's thoughts and choices.

While such external consequences of language have been observable throughout history, we have only recently acquired tools such as fMRI, EEG, PET, MEG, NIRS, CT and eye tracking that enable us to see how language reaches back to shape the brain itself. We now know that experience with multiple languages can produce extensive changes to our neural architecture that are observable across the lifespan and across domains: from infancy to old age, from sensory perception to higher cognitive processing. Using and learning language can change our very biology, thereby confirming the ancient intuition that words can, in fact, alter physical reality.