The Benefits of Multilingualism

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Multilingualism—the ability to understand and speak several languages—is exceptional in the United States but common elsewhere, especially in small-scale traditional societies. For instance, once while I was camped with some New Guinea Highlanders conversing simultaneously in several local languages, I asked each man to name each language in which he could converse. It turned out that everyone present spoke at least 5 languages, and the champion was a man who spoke 15. What are the cognitive effects of such multilingualism? Recent studies (1–5) show that children raised bilingually develop a specific type of cognitive benefit during infancy, and that bilingualism offers some protection against symptoms of Alzheimer’s dementia in old people.

Bilingual education is politically controversial in the United States. Even immigrants whose native language is not English often believe that their children should learn only English and will be confused by learning two languages simultaneously. Until the 1960s, research appeared to show that bilingual children acquired language more slowly than monolingual children and achieved smaller vocabularies. But other variables correlated with bilingualism in those early studies, such as schooling and parental socioeconomic status, confounded their interpretation. More recent studies, comparing subjects matched for those other variables, have found bilinguals and monolinguals to be largely similar in cognition and language processing (6–8).

The clearest difference identified by these studies involves an advantage that bilinguals have over monolinguals, rather than a disadvantage. Our minds are assaulted by varied sights, sounds, and other external sensory inputs, plus thoughts and proprioceptive sensations (which make us aware of the relative positions of our own body parts) (see the figure). To succeed in doing anything at all, we must temporarily inhibit 99% of those inputs and attend to just 1% of them, and the appropriate choice varies with the circumstances. That selective attention involves a set of processes, termed executive function, that reside in the prefrontal cortex and develop especially over the first 5 years of life (9).

Multilingual people have a special challenge involving executive function. Monolinguals hearing a word need only compare it with their single stock of arbitrary phoneme (sound) and meaning rules, and when uttering a word they draw it from that single stock. But multilinguals must keep several stocks separate. For instance, on hearing the phonemes b-u-r-r-o, a Spanish/Italian bilingual instantly interprets them to mean either “donkey,” if the context is Spanish, or “butter,” if the context is Italian. Multilinguals participating in a multilingual conversation, like my New Guinea Highland friends or shop assistants in Scandinavian department stores, switch frequently and unpredictably between their stocks of phoneme/meaning rules. As a result, multilinguals have constant unconscious practice in using the executive function system.

Recent studies assess this ability by assigning to subjects game-like tasks designed to be confusing, either because the task rules change unpredictably, or because the task presents misleading cues that must be ignored (1, 3, 7, 8). For instance, children are shown cards depicting either a rabbit or a boat, colored either red or blue, with or without a star. If the card has a star, the children must sort cards by color; if a star is absent, they must instead sort cards by the object depicted. It turns out that monolingual and bilingual subjects are equally successful if the rule remains the same from trial to trial (e.g., “sort by color”), but multilinguals have more difficulty than bilinguals at accommodating to a switch in rules. Although success at these games won’t by itself make one rich or happy, our lives are full of other misleading information and rule changes. If bilinguals’ advantage over monolinguals in these games also applies to real-life situations, that could be useful for bilinguals.

While this superior executive function has been reported for bilinguals of all ages, results for the youngest and the oldest subjects are of particular interest. Kovács and Mehler (4, 5) tested confusing game tasks on “monolingual” infants and “crib bilingual” infants—i.e., infants reared from birth to hear and eventually to speak two languages, because mother and father speak to the infant in different languages. It might seem meaningless to describe infants who cannot speak as monolingual or bilingual. Actually, infants learn to discriminate the sounds of the language or languages heard around them, and to ignore sound distinctions not heard around them. For instance, Japanese infants lose, and English infants retain, the ability to discriminate the liquid consonants l and r, which the Japanese language does not distinguish.

How can one test responses to speech by those preverbal infants? Kovács and Mehler (4, 5) devised a clever protocol in which infants looked for pictures of a puppet appearing on
Highly complex metal alloy phases have been replicated at a larger scale with spherical aggregates formed from polymers.

Recasting Metal Alloy Phases with Block Copolymers

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Crystalline order develops through a balance between short-range attractive and repulsive interactions (1) that not only operate on atoms but work at the nanoscale on supramolecular structures (2). Spherical particles often pack together into simple, high-symmetry arrangements, but more complex topologically close-packed structures, such as the Frank-Kasper σ phase (3, 4) first seen in metal alloys, have also been observed (see the figure, panel A). Spherical supramolecular aggregates formed from polymers and monodisperse branched macromolecules (5–7) can be used to mimic atoms and explore how these phases arise. On page 349 of this issue, Lee et al. (8) show that linear block copolymers that form spherical aggregates through microphase separation can crystallize into a Frank-Kasper σ phase. Relative to metal alloys, the volume of its crystalline repeating unit, the unit cell, is six orders of magnitude greater (see the figure, panel C). The scaling up of atomic lattices by using spherical supramolecular aggregates is also of practical interest because such structures could be used as photonic materials (9), nanoreactors (5), or drug delivery vehicles (10).

Understanding how spherical supramolecular aggregates organize into crystals remains a challenging task. In the ideal case of incompressible “hard” spheres—which are a good model for metal atoms—the most stable structures correspond to the hexagonal close-packed (hcp) and face-centered cubic (fcc) periodic close-packing configurations shown in panel A of the figure. These structures maximize the packing of atoms and fill 74% of their unit cell volume (versus 68% for the body-centered cubic, or bcc, packing). The stability of the packing derives from large numbers of nearest neighbors interactions that decrease free energy.

Spherical aggregates formed by soft macromolecules, including block copolymers, should follow the same principle and pre-