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## The Power of the Bilingual Brain

By Jeffrey Kluger / Salt Lake City

Classrooms are places where little eureka's happen--and teachers live for them. The sixth-grader struggling with the first week of algebra has no idea what a nonsensical instruction like "solve for x" means--and then all at once, blink, the light goes on. The second-grader grasps for the first time why a poem doesn't have to rhyme and then coins a perfect little word picture to prove it. For H el ene Cha-Philippe, a teacher at Morningside Elementary School in Salt Lake City, the moment happened when one of her first-grade girls said, "I eat the teacher."

Technically, that's not what the little girl said. What she said was "Je mange le professeur." Then she laughed in delight and pride, and Cha-Philippe did too. Just months before, the child had not spoken a word of French. Now she spoke many words. That day, she was working with the verb manger and was supposed to say, "I eat the banana." Instead she made a tiny, silly, first-grader's joke. She had stopped wrestling with the language and had begun playing with it--and with that, she had crossed a threshold.

"It was such a wonderful experience," says Cha-Philippe. "She realized that it was possible to combine words and make a joke in a language that wasn't her own."

All over Utah, elementary-school students are joking and studying and singing and reading and fluently speaking in languages not their own: French, Spanish, Mandarin Chinese and, soon, Portuguese. They are part of one of the most ambitious total-immersion language-education programs ever attempted in the U.S. It kicked off in the 2009 school year with 1,400 students in 25 schools and by this fall will include 20,000 kids in 100 schools--or 20% of all the elementary schools in the state, with nearly 95% of school districts participating up through grade 12. Competition for spots in the program is keen: families apply online before kids enter kindergarten or first grade--depending on the school district--and the ones who will participate are picked by lottery. Those who are chosen take half their subjects each day in the new language and the other half in English.

The idea behind the program has less to do with the usual talk about a globalizing world and America's need to become a polyglot nation if it's going to compete effectively with China and other rising economies--though that's part of it--and more to do with the nimble minds of the boys and girls doing the learning.

Research is increasingly showing that the brains of people who know two or more languages are different from those who know just one--and those differences are all for the better. Multilingual people, studies show, are better at reasoning, at multitasking, at grasping and reconciling conflicting ideas. They work faster and expend less energy doing so, and as they age, they retain their cognitive faculties longer, delaying the onset of dementia and even full-blown Alzheimer's disease.

A bilingual brain is not necessarily a smarter brain, but it is proving to be a more flexible, more resourceful one. In a polyglot world, that's a lesson that a largely monoglot country like the U.S. ignores at its peril. "Monolingualism," says Gregg Roberts, a language-immersion specialist with the Utah state office of education, "is the illiteracy of the 21st century."

### Wired for Words

When it comes to language, there's no such thing as starting too early--and it turns out the brain can be bilingual even before birth. The human auditory system is functional from the third trimester on, and the loudest thing an in utero baby hears is its mother's voice, speaking whatever language or languages she knows. Those sounds, with their characteristic rhythms and phonemes, are poured straight into the baby's brain and become comfortingly familiar.

Of course, it isn't easy to get inside a newborn's mind and determine what it does and doesn't like, but with language at least, investigators have figured out a method. The more vigorously a comfortable, well-fed baby sucks on a pacifier, the more stimulated it is by its environment. Developmental psychologist Krista Byers-Heinlein of Concordia University in Montreal has used this technique to study babies 3 days old and younger. The mothers of some of the children were monolingual English speakers; the mothers of the others spoke both English and Tagalog, a language common in parts of Canada where there are high concentrations of Filipino immigrants.

When the babies with pacifiers were played recordings from multiple languages, those with monolingual moms sucked harder only when they heard English; the others perked up both at English and at Tagalog. "You think, These babies are newborns--how can they be bilingual?" says Byers-Heinlein. "But their mothers' voices affected their preferences."

That exceedingly early start on language only accelerates as it goes along. Research by cognitive neuroscientist Janet Werker of the University of British Columbia and others extended Byers-Heinlein's work to babies who were a few months old, trying to determine if they could distinguish between languages by sight alone, watching silent videos of adults reciting lines from *The Little Prince* in English and French.

In this case it was eye contact--the amount of time they spent looking before they got bored and looked away--that indicated their interest and recognition. From 4 to 6 months of age, babies from both monolingual English homes and bilingual French-English homes could tell the difference. But by 8 months, the monolinguals dropped out of the race, and only the bilinguals could manage the task.

At Spring Lane Elementary School outside Salt Lake City, the kids are a good deal more than 8 months old, but their brains are clearly still very language friendly. On a recent morning late in the school year, a class of first-graders learning Mandarin had broken down into smaller groups, working together on various assignments. One cluster of five kids sat on the floor, listening to a Mandarin-language story through headphones while reading along in books. The other children were busy with writing lessons. Their teacher, April Ridge, 30, who learned to speak Mandarin when she was 21 in preparation for two years as a Mormon missionary in Taiwan, was quietly coaching one little girl when the bell sounded. She looked up and made a series of rapid-fire announcements in fluent Mandarin that appeared to have something to do with getting coats on for recess or hands washed for lunch or who knew what, but if the instructions were a mystery to the monolinguals present, they made perfect sense to the kids, who scrambled and obeyed.

"They made steady progress through the year," Ridge says. "We started school in August when they could speak only English. They were able to follow directions in Mandarin by January. After that came speaking, then reading, then writing. Now I hear them at recess, mixing Mandarin and English. They help each other out and remind each other of words they forget."

Such cooperation is a formal part of the curriculum in the schools--what the teachers call "pair-share," with kids teaming up and turning to a designated buddy for a lost word or concept. That's a good thing, particularly when it comes to Mandarin, since the Utah school system doesn't fool around. The students are taught to read and write in traditional Mandarin characters, with pinyin--the phonetic, Roman-alphabet form of writing Mandarin--not introduced until the third grade and then only for the more difficult words.

Utah's program got its start in 2009 under then governor and later ambassador to China Jon Huntsman, the rare American political figure who is fluent in Mandarin. Huntsman argued that multilingualism in education would be increasingly essential in the 21st century for students, businesspeople and government officials, and while many people outside the state speculated that the missionary work of the Utah-based Mormon church was the real driver behind the plan, state education officials deny that. "This really was mostly about the state and millennial parents seeing the need for language training," says Roberts.

The program is a surprising bargain by government standards. It's funded by the state legislature at an average of \$2 million per year, plus a supplemental appropriation of \$10,000 per school per year to buy books. With the program entering its fifth year, that means grades 1 through 4 have already been supplied, with the remaining grades set to be added each year as the oldest kids move along. Both students and teachers are reminded to keep the books in good enough shape that they can be reused each year. "We

always tell them, "Take care of them, because when they're gone, they're gone," says Carolyn Schubach, associate director for advanced learning in the Granite school district.

Kids who make it through eighth grade in the language program take advanced-placement courses in ninth. For 10th- through 12th-graders, the state education office is collaborating with the University of Utah and Brigham Young University to offer college-level courses. Whatever Utah is doing, it must be doing it right: so far, officials from 22 other states have dropped by to study the program with an eye toward launching their own.

### The Polyglot Brain

It's too early to measure exactly what the lifelong benefits of early language training will be, but all of the science suggests that they will be considerable--and that some of the differences will be physically detectable in the brains of the polyglot kids. Research psychologist Ellen Bialystok of Toronto's York University cites brain scans of London cabdrivers, who are celebrated for their down-to-the-last-alley knowledge of their city's streetscape. Those scans show greater development in the regions of the brain responsible for spatial reasoning. Similar findings have turned up in the motor-control regions that govern the fingers of violinists and other musicians. Still, the cause and effect are murky here. "Does the training cause the brain changes," Bialystok asks, "or do you select into being a cabdriver or a musician because you already have a brain that's inclined toward those skills?"

Last year in Sweden, psychologists at Lund University decided to test that idea when it comes to multilingualism, scanning the brains of the incoming class at the Armed Forces Interpreter Academy in Uppsala, where students undergo a grueling program that takes them from no knowledge of an unfamiliar language like Arabic or Dari to total fluency in 13 months. As a control, the investigators scanned other students entering a similarly rigorous program in medicine or cognitive science for the same length of time. At the end of the period, all the students were rescanned. Among the language students, there was detectable growth in the hippocampus, which helps govern memory and mastery of new material, and in three areas of the cerebral cortex, where higher-order reasoning is processed. Among the other students there were no such changes.

Biologist Nina Kraus of Northwestern University has used scalp electrodes to record the activity of the auditory region in the brain stem, looking for how it behaves in bilinguals. What she found is that people who know more than one language are better than monolinguals at picking up speech-relevant sounds, such as key pitches or rhythms, out of a confusing soundscape, producing a telltale blip in the scalp readings. "As people use sound in a meaningful way," Kraus says, "the nervous system changes."

Bialystok believes the relevant difference in the brains of bilinguals involves less the density or shape of the gray matter--the neurons--than the white matter, the myelin sheathing that insulates neural connections.

She and her colleagues conducted scans showing healthier myelin in the frontal lobes and the corpus callosum--the neural cable that connects the two hemispheres of the brain--in bilinguals than in monolinguals. "Structural differences are where the new science is unfolding," she says.

## Brain Be Nimble

But it is the knock-on effects--not how the brain looks but how it functions--that argue most for learning additional languages, and it appears that the bilingual brain is simply more efficient. The constant toggling that comes from having to choose between two words for every object or concept in your world is a total-immersion exercise in what cognitive scientists call task switching and what the rest of us call trying to do 17 things at once. Every time you interrupt an e-mail to pick up the phone, then interrupt the phone call to respond to someone who pops into your office, and then go back to the phone and the e-mail, the tracks in your brain must clank one way or the other. It's more challenging still when you're handling multiple tasks not sequentially but simultaneously.

How deftly any one person responds to these messy real-world challenges is hard to measure, but there are some good experimental proxies. In one, known as the Stroop test, subjects are flashed the names of colors on a screen, with the word matching the actual color of the letters, and are told to say the color's name or hit a key indicating what it is--a task nearly anyone can do instantaneously. Next they are flashed mismatches--the word red printed in blue, say--and told to ignore what the word says and announce only the color. This is a lot harder than you think, especially when you don't know when you'll get a matched example and when you'll get an unmatched one. Almost universally, bilinguals are faster and make fewer mistakes than monolinguals. Related studies have shown that the multilinguals' advantage is especially pronounced not in young adulthood, when the brain's executive functions are operating at their peak, but among kids and seniors, whose cognitive capabilities have either not fully come online or are starting to slip.

"The loss of efficiency when we rotate among tasks is called the global switch cost," says Bialystok.

"Everyone slows down some or makes more errors, but multilinguals in all age groups have less of a drop-off." If that increased efficiency plays out in people's lives outside the lab--and there is no reason to think it doesn't--that would confer a real advantage over monolingual classmates, colleagues and others.

The advantages of multilingualism in the senior population are especially important--and comparatively easy to measure. Cognitive neuroscientist Brian Gold of the University of Kentucky tested seniors in the 60-to-68 age group on several of the familiar task-switching tests and found that bilinguals were more accurate and also faster than monolinguals. When he scanned the subjects with functional magnetic resonance imaging while they worked, he also found that the bilinguals' brains were less rather than more active in the relevant regions than the monolinguals'. That's actually a good thing: greater activity means the brain is working harder, breaking a sweat it wouldn't have had to in its younger days. "Older people

have to activate their brains more in general than younger people do," says Gold. "But bilingual seniors have to do it less." Bialystok has studied seniors suffering from serious age-related cognitive decline and those who are still high functioning and estimates that on average, bilinguals get an extra 4.1 years of clarity before symptoms of any form of dementia set in; those who develop Alzheimer's specifically get an extra 5.1 years.

None of that is to say that the monolingual middle-ager who is worried about dementia can simply take up a language and reap the same benefits a lifetime bilingual would. "The practical reality," says Gold, "is that adults are simply less likely than children to learn and continue to use a second language because they have to go far out of their way to do it, whereas it comes gift-wrapped for kids." At best, he says, language lessons in adulthood fall into the couldn't-hurt category--one more way to keep the aging brain active.

The children in the Utah grammar schools are, of course, thinking about none of this yet, with their brainpower and their language talents still on a steep upward arc. The incoming fifth-graders who have been with the program since its first year represent an educational vanguard, the leading edge of a living longitudinal study that renews itself each year as more and more families clamor for spots in the participating schools. The planned addition of 20 to 25 schools per year for the next five years should help satisfy that growing demand.

For the Utah teachers and kids, policy issues matter a lot less than the simple day-to-day richness of bilingual living. Third-grade French teacher Georgia Geerling had never taught below the level of community college and high school before she took a job at Morningside Elementary School, and she was not fully prepared for what the experience would be like. "When they hug me, I'm so touched," she says. "We had an assembly, and the kids were all onstage singing in French, and I just cried. They're so wiggly!" That's as fair a way of describing third-graders as any. But their restless bodies reflect equally active, playful, energetic brains. Learning the lyricism and the magic of another language can make them better brains too.

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