

thought about her own work with adults born with Williams syndrome, a condition that leads to severe mental retardation, and offered to join Zaitchik's project herself. Although adults with Williams syndrome have extensive factual knowledge and advanced language abilities, their understanding of biology remains stalled: one subject, for example, had an avid interest in the "funerary practices of other religions," but no biological understanding of death. As Carey asked herself how this gap could occur, it became clear that conceptual development involves more than "just acquiring new facts."

Zaitchik and Carey are now engaged in a multiyear, interdisciplinary research project that investigates the relationship between such conceptual change and "executive function" (EF), a suite of mental processes including inhibitory control (the ability to suppress distractions and inappropriate responses); set-shifting (the ability to switch between different modes of thinking depending on the nature of a problem or a goal); and working memory (the ability to actively hold information in mind while updating it). Adults with Alzheimer's or Williams syndrome, they explain, have less EF and thus have either lost, or never built, a more advanced theory of biology. As for the healthy elderly,

Zaitchik and Carey suspect they haven't truly "lost" their biology knowledge; instead, their deteriorating EF undermines their ability to express that understanding. Their inhibition has become too weak to suppress the instinct that moving objects are alive.

In the case of young children, the literature linking stronger inhibitory control and working memory to higher math and reading scores had already suggested that these functions affect skill development. With their new finding that EF scores predicted scores on biology tests, Carey and Zaitchik showed that executive function also shapes conceptual development. Recently, one of their postdoctoral research fellows, Igor Bascandzjev, ran trials in which he led young elementary school children in "training sessions" that modeled how body parts work together. Children with higher EF scores left with a stronger understanding of bodily systems and, more surprising, of vitalist concepts they hadn't been explicitly schooled in: the ideas of "alive" and "dead." As Zaitchik puts it, "They got the bigger bang for the buck." For those children, "Learning is more effective."

Understanding the cognitive functions that govern learning may, down the road, change pedagogy. "The business of educa-

tion is conceptual change," says Carey. Yet the implications of their research reach beyond curriculum design. Children in higher-income households tend to have stronger EF, she points out, emphasizing that "executive function is not a fixed trait." Indeed, new research suggests the opposite. Last November, psychologists at New York University published a study showing that kindergarteners in a program focused on strengthening their executive function demonstrated large gains in math, reading, and vocabulary—and the effect was particularly large for children in low-income schools.

Zaitchik and Carey remain hopeful about the potential "downstream" impact of their work generations hence, but for now, they will focus on the big, underlying theoretical questions that excite psychologists and philosophers. Three years into their National Science Foundation grant, says Carey, they feel confident they are "barking up the right tree." They've established that executive function has a powerful relationship to conceptual change. In the next two years, they'll seek to answer the questions of how and why.

~SOPHIA NGUYEN

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## OUTSIDE INGENUITY

# Company Size Matters

**B**ECAUSE she has spent decades writing about how businesses manage innovation, Rebecca Henderson calls it a fitting coincidence that, before moving to Harvard in 2009, she spent many years as the Eastman Kodak professor of management at MIT's Sloan School. It was, after all, the monumental shift from film to digital photography that sent Kodak into bankruptcy.

"I work with firms that are worried that they are going to be Kodak," the McArthur University Professor explains. She has found that companies that innovate successfully are skilled at anticipating consumer needs, managing the research and development of new products to meet those needs, and constructing business

models that include new offerings.

But recently she has focused on one of the most globally consequential shifts in history—from an economy based on fossil fuels to one based on alternative energy—and she is finding that some past lessons about innovation may need to be reconsidered.

Under most circumstances, Henderson has found, small start-up companies may be better equipped to launch and cope with "disruptive innovation"—changes that set off a sea change (see "Disruptive Genius," July-August 2014, page 38). A large company's assets can limit its ability to maneuver. "If you're Kodak, for example, some of the assets that kept you in business for so long include unbelievable

manufacturing ability in film, so one of the constraints as you attempt to innovate is keeping your existing assets, which are a huge source of advantage, but not letting them trap you into models that don't make sense."

Among those existing assets in large, successful firms are employees with "skills and capabilities that support the pursuit of operational excellence"—but this is "often a quite different set of skills and approaches than one that generates innovation and experimentation," she says. Start-ups, on the other hand, often work without restrictive mental models that can stifle creativity. And, she adds, smaller firms in many industries see a greater return, dollar for dollar, on their research investments. A start-up's lack of cash can be a problem, but it can also force a company to be nimble: "It's a great advantage because you have to really hustle. If a project doesn't work, you take it down and start again." Big firms need to act like small, cre-

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RIGHT NOW

ative ones to innovate significantly, she says, acknowledging that this is a difficult proposition for a large, tightly run company.

Yet Henderson—who also co-directs Harvard Business School’s Business and Environment Initiative—says small companies don’t necessarily have an advantage in alternative energy “because the capital requirements for energy are so great.” Large, established companies have guaranteed revenue streams, and cheaper access to capital. Yet, as in other sectors, those companies are often deeply invested in their traditional businesses, with little incentive to move into carbon-free technologies.

Still, “There are a number of very large firms making aggressive and exciting moves in this space,” Henderson reports, citing Walmart, which draws 25 percent of its energy from renewable sources, as well as Amazon and Google, which have made “massive investments in renewable power” to run their server farms. BP, she adds, has invested significantly in plant-based biofuels, and General Electric’s Ecomagination initiative includes a large investment in wind power.

But making real progress in clean energy, Henderson points out, requires establishing a fair price for carbon: increasing fossil-fuel prices to cover the costs of their use beyond harvesting, refining, and transporting them. Coal, for example, is cheap only if you don’t count its effects on human health and the climate. Higher, more realistic prices, she asserts, would motivate businesses to use alternatives such as nuclear, geothermal, solar, or wind power.

In her course “Reimagining Capitalism: Business and the Big Problems” (also the topic of a forthcoming book), she discusses the power of business to foster solutions to large-scale social problems such as climate change, access to clean water, and inequal-



ity in education. She sees both “enormous economic opportunity and significant risk” in tackling such problems. “One of the things I say to my students is that running a business in such a way that it both generates great returns and tackles the big problems is difficult, since it requires paying constant attention and balancing multiple goals. But I also suggest that, in many ways, it’s much more satisfying.”

Ultimately, though, she believes corporations will accept these challenges because it’s smart business practice—it involves employees in the enterprise of innovation. “Firms that have goals that are pragmatic, but focused on really making a difference,” Henderson says, “can generate a sense of purpose and commitment in the workforce, among their suppliers, and within the communities they work with, which can dramatically increase the creativity and productivity and engagement of the firm.”

~ERIN O’DONNELL

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