Recent studies are showing that the environment, especially early in life, can influence a person's IQ—for better or for worse

# Nurture Helps Mold Able Minds

Each morning 20 years ago, a young mother waited with her child Susie* for the bus that would take Susie to school. Nothing unusual in that, except that Susie started when she was just 2 months old, and "school" was an experimental program at the University of North Carolina (UNC), Chapel Hill. There Susie received a wealth of interventions designed to foster her mental development—everything from bright objects dangled in front of her eyes while she was still a baby to lessons in the ABCs, color names, and counting as she became a toddler.

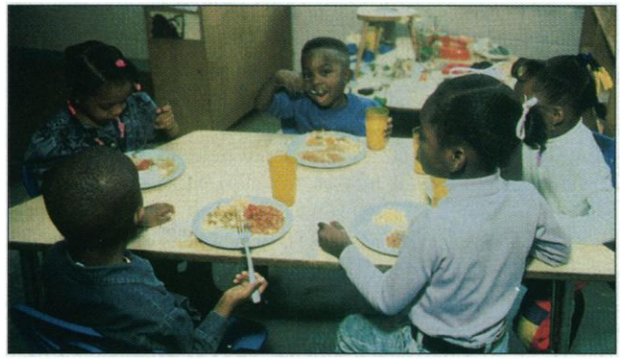
Without this early start, healthy development would have been a miracle for Susie, whose mother had an IQ, or intelligence quotient, in the 40s and could not read signs or determine how much change she should get from a cashier. Her grandmother had been similarly ill-equipped for modern life. Today, however, Susie's IQ measures some 80 points higher than her mother's did. She holds two bachelor's degrees and is on her way to a master's degree in speech pathology.

In the 1970s, when psychologist Craig Ramey, now at the University of Alabama, Birmingham, started the early-intervention project Susie attended, the tests used to assess a person's IQ were largely assumed to measure innate abilities—the product of genes, not the environment. Some researchers still think they do. For example, the authors of the 1994 book, *The Bell Curve*—political scientist Charles Murray of the American Enterprise Institute in Washington, D.C., and the late Harvard psychologist Richard Herrnstein—argued that genetic differences are a major reason why lower IQs are statistically more prevalent among certain races, such as African Americans. Others, however, attribute such variations to poverty and other environmental and cultural influences, such as poor schools, that might lead to intellectual impoverishment.

But even though the issue is important—a person's IQ consistently predicts both school and job performance—the disputes have been heavy on ideology and light on evidence. With a few exceptions, such as Ramey's program for the children of poor, low-IQ mothers, direct tests of the effects of the environment on the particular aptitudes measured by intelligence tests are a recent development.

And as in Susie's case—an admittedly dramatic one—they are showing that the environment, especially early in life, can exert a profound influence on IQ. Researchers have found that IQs can be modified, for better or worse, depending on such factors as how parents talk to their infants, the availability and quality of infant and toddler day-care programs, and the amount of schooling a person gets. "We have demonstrated that intellectual skills often believed to be innate are extremely sensitive to the environment," says Janellen Huttenlocher, a cognitive developmental psychologist at the University of Chicago.

Not everyone agrees that IQ is so easily tweaked. But even some who are focused on genes are enthusiastic about the attempts to tease out environmental influences on IQ. The studies "show you can make a difference" in IQ, says behavioral geneticist Robert Plomin of The Institute of Psychiatry in London. "Even something that's highly heritable may be malleable through interventions."



**IQ booster.** Engaging children in mind-expanding opportunities early and for a prolonged period may raise their IQs.

Much still remains to be learned about the nature and extent of the environmental influences on IQ. But what researchers have found so far already has important implications. Among other things, the new results provide support for the idea that racial differences in IQ are not genetically determined. The work implies that well-designed day-care programs might lower the risk of cognitive impairment and school failure in the 23% of American children who spend at least part of their childhood in poverty.

### Talking IQ

Studies of how the environment influences one ability often measured by IQ tests, namely language, have provided some of the new evidence. Vocabulary, in particular, is a common component of IQ tests. Until the early 1990s, the wide variation in people's vocabularies was largely attributed to differences in people's inborn abilities to learn language. But then Huttenlocher and her colleagues decided to systematically study what role an environmental input—speech by a young child's mother—might play in building the child's vocabulary. To test this, Huttenlocher's team taped many hours of chatter between 22 toddlers and their mothers during the children's typical daily activities.

The researchers did the tapings every 2 to 4 months when the children's language skills were developing most rapidly, between 16 and 26 months of age. From the tapes, the researchers detected a remarkable parallel between the size of a child's vocabulary at 26 months and the talkativeness of his or her mother. At the extremes, the mothers varied 10-fold in how much they talked, and the toddler of the most talkative mother had a vocabulary more than four times the size of the vocabulary of the child of the quietest mother.

Of course, the correlation might result at least partly from genes for verbal ability shared by mother and child. But that's unlikely to be the primary cause, says Huttenlocher, because the moms in the study did not differ much in verbal IQ. What's more, the children were clearly picking up their vocabularies from their mothers, because the words each child used the most frequently mirrored those favored by the mother, and the mothers differed very little in the relative frequency with which they used various words.

And now, in as-yet-unpublished work, Huttenlocher and graduate student Elina Cymerman have found something similar for speech syntax, or grammar, an aspect of language long thought to develop similarly in all people due to shared mental machinery for language. Cymerman and Huttenlocher examined speech taped from 34 parents and their 4-year-old children for the proportion of complex, multiclause sentences, such as, "I

CREDIT: CRAIG RAMEY/UNIVERSITY OF ALABAMA, BIRMINGHAM

* This name has been changed.

am eating because I am hungry," versus that of simple, single-clause ones like "Pick up the truck." They found a striking relationship between the proportion of complex sentences spoken by the parents and the proportion of such sentences uttered by their children both at home and at school.

Although mothers and children also undoubtedly share some language genes, Huttenlocher says a syntax gene alone is unlikely to result in the close similarity her team found in the language used by a child and his or her mother. Developmental psychologist Peter Jusczyk of Johns Hopkins University in Baltimore agrees. Calling Huttenlocher's work "very interesting," Jusczyk says it lends considerable support to the idea that early speech input can have a dramatic effect on the development of a child's language skills.

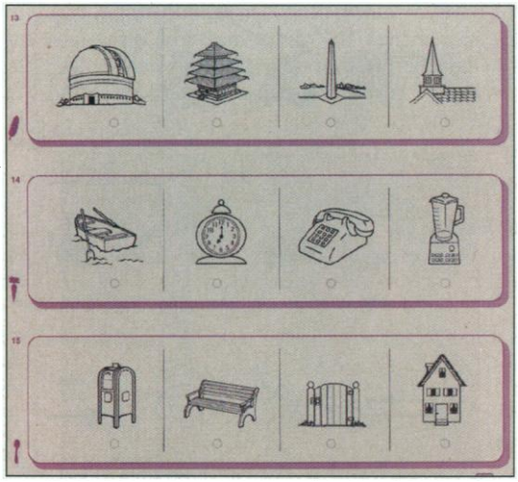
### Bringing up baby

These results suggest that mothers or other caregivers can help infants improve their language skills, but researchers have also long wanted to know if outside intervention could help as well. In 1964, researchers began the first national preschool program for poverty-level families, Project Head Start, then just a summer program for 5-year-olds. But a 1969 Westinghouse report on the project concluded that by the time the children had completed first grade, there were no detectable differences, in IQ or school performance, between children who had participated in Head Start and children of similar background who had not.

A budding cadre of developmental psychologists advanced an explanation that boiled down to too little, too late. Studies were hinting that the human brain develops at breakneck speed during the first years of life. To make a difference, they reasoned, one would have to intervene early, and with a vengeance. So in 1972, Ramey, his wife Sharon, and their colleagues started the Abecedarian preschool intervention program at UNC, which began at infancy and lasted 5 years. For the project, the researchers randomly assigned 111 children from poor and uneducated families in the surrounding community to either an intervention group, which received full-time, year-round day care along with medical and social-work services, or a control group getting medical and social benefits but no day care.

The day-care program included gamelike learning episodes integrated into the day and aimed at improving language, motor, social, and cognitive skills and concepts. For example, preschoolers participated in baking projects that required them to measure amounts, group chats about objects collected from a distant place, or games that involved jumping into containers filled with materials of different textures.

The success of the endeavor, and its ability to mold IQ, was evident by the time the children were 3 years old. The toddlers in the program showed normal IQs averaging 101, a whopping 17-point advantage over the average IQs of the controls. Follow-up results, to be reported in an upcoming issue of *Applied Developmental Science*, demonstrate that the effects are long-lasting. More than a decade later, at age 15, children from the intervention group still maintained an IQ advantage of five points over controls, with respective averages of 97.7 and 92.6. They also did better on standardized tests of reading and math and were less likely, by nearly a factor of 2, to have been held in the same grade in school for a second year.



**Word test.** In one assessment of their skills, children were asked to mark the picture corresponding to a word, such as "steeple" in the top problem.

And the greatest improvements were shown by children whose mothers had particularly low IQs, those below 70. (The average IQ of the mothers in the Abecedarian group was 85.) At age 15, these children showed a 10-point IQ advantage over a group of children whose mothers had IQs of less than 70 but who did not receive intervention. Comparable results came from a similar preschool intervention study begun several years earlier, called the Milwaukee project, in which all the mothers' IQs were below 75.

The psychologists suspect that the early stimulation leads to lasting physical changes in the brain, analogous to what William Greenough, a neuroscientist at the University of Illinois, Urbana-Champaign, has seen in studies of rats. In the late 1980s and early 1990s, Greenough's team found that the brains of rats reared in groups surrounded by interesting plastic forms and toys showed more extensive neuronal branching and more connections, or synapses, between neurons than the brains of rats reared alone in sparsely furnished cages. The rats in the enriched environments also had double the total volume of capillaries feeding individual brain neurons that the isolated rats had.

Still, recent work by Ramey suggests that the early-intervention approach may be less effective at compensating for physical disadvantages, such as low birth weight, which is associated with depressed intelligence. In the mid-1980s, he and colleagues at medical centers in eight U.S. cities recruited 985 babies who weighed 2.5 kilograms or less when born. Children in the intervention group received weekly home visits as infants and attended preschool from ages 1 to 3.

Early gains were impressive—at age 3, the toddlers in the intervention group had IQs up to 13.2 points higher than controls, with somewhat smaller gains for the lightest children. But over time, the benefits diminished, particularly for the lightest infants. In 1997, a team led by pediatrician Cecelia McCarten, then at Albert Einstein College of Medicine in the Bronx, New York, one of the eight sites, reported no lasting benefits at age 8 for the children who had been born extremely small, but an IQ advantage of 4.4 points for those born somewhat heavier, who also showed significantly higher scores on math and vocabulary achievement tests.

The gains may have been less dramatic than those of the Abecedarian Project because the low–birth weight babies may have needed more nonenvironmental interventions, such as medical attention, than the program provided. But another possible explanation, the study's investigators believe, is that the program was shorter, ending at age 3, due to limited funds. "[It] stopped before developmental change reached its apex," Ramey suggests.

### Teaching intelligence

Although very early intervention may be the most effective at bolstering IQ, a later source of environmental input—school—now seems to have a smaller and more gradual, but still significant, effect. Psychologists and social scientists have long known that people with higher IQs tend to have more education, but many assumed this resulted solely from the fact that smarter people tend to get farther in school. Over the years, a smattering of studies has hinted that schooling itself can also push up a person's IQ, or prevent it from falling. But nothing emerged to convince the doubters of schooling's impact until 1991, when Cornell developmental psychologist Stephen Ceci reviewed the results of dozens of studies and concluded that schooling is a strong force in

forming and maintaining IQ.

For example, he cited studies that found a high correlation between schooling and IQ after controlling for the fact that smart children tend to begin school earlier and remain there longer. Other reports showed that IQ can drop over summer vacations and that the IQs of children born to gypsies or transients declined as they missed more and more school. Still other data documented IQ drops resulting from the sudden unavailability of school, as in the Netherlands during World War II when the Nazi occupation forced the closure of many schools. Probably as a result, the children's IQs dropped by about seven points.

Since Ceci's paper appeared, even stronger evidence for schooling's impact on IQ has emerged. In 1996, economists Derek Neal, now at the University of Wisconsin, Madison, and William Johnson of the University of Virginia, Charlottesville, found that a year of schooling can raise IQs by about 3.5 points. They came to that conclusion by comparing the scores on an IQ-like test called the Armed Forces Qualifying Test of children whose birthdays were in the first 9 months of the year with the scores of children born in the last 3 months of the same year, who generally entered school a year later. Because the amount of schooling was determined by a chance event in the timing of birth and not on personal decisions that could reflect IQ differences, the lower IQs of students with late-year births are "entirely a function of [these students] being more likely to attend school one less year than their peers born during the first 9 months of the year," comment Ceci and colleague Wendy Williams in a 1997 paper in *American Psychologist*.

In a similar vein, Huttenlocher, along with Chicago colleague Susan Levine and UNC's Jack Vevea, measured the rate of IQ growth in a national sample of 1500 children over 6-month periods that vary in the amount of schooling children receive. In work published this past August in *Child Development*, they found that the children's language, spatial, and conceptual skills improved much more sharply during the school-packed October-April period than in the April-October interval, which includes summer break and the less intense beginning and end of the school year. "It's a very clean way of showing that schooling has an effect on IQ or IQ-like tests," says Levine. Overall, conclude Harvard sociologist Christopher Winship and economist Sanders Korenman of Baruch College in New York City in the 1997 book, *Intelligence, Genes, and Success*, "a year of education most likely increases IQ by somewhere between 2 and 4 points."

If school does influence IQ, it might help explain something called the Flynn Effect after its discoverer, political scientist James Flynn of the University of Otago in Dunedin, New Zealand. In 20 countries to date, Flynn has documented a rise of about 20 IQ points every 30-year generation—a trend obscured by the fact that the major IQ test manufacturers renorm their tests every 15 to 20 years, resetting the mean to 100. However, if everyone who took an IQ test today was scored using the norms set 50 years ago, more than 90% of them would be classified as geniuses, with IQs of about 130 or higher, depending on the test. Similarly, if our parents' or grandparents' IQ scores circa 1949 were measured using today's norms, over 90% of them would be labeled "borderline mentally retarded," with IQs below 70 or so.

**IQ researchers.** Janellen Huttenlocher (right), shown here with Chicago colleague Erin Alexander, is studying how the environment influences language abilities.

Although biological factors, such as better nutrition, could underlie the Flynn Effect, gene-pool changes are much too slow to account for it. Schooling is a primary suspect, however, as the average length of schooling has increased enormously—from less than 8 years in the 1920s to more than 13 years today. Another possible contributor to the Flynn Effect, Ceci notes, is more cognitively advanced home environments created by better educated parents.

None of this means, the researchers say, that a person's genetic heritage plays no role. They concede that IQ is a product of genes, but of genes that environmental forces can, over time, deftly bend this way or that, to boost or depress IQ. "The old debate—nature versus nurture—is not a constructive way to frame this issue," says Ramey. "Instead, we must recognize that for any [genetic makeup] there are experiential contributing factors. We want to catalog which of these factors contribute to intelligence and discover" how much they contribute.

Some researchers, however, continue to downplay environmental factors in IQ. The intervention literature resonates with "a depressingly common theme," says *Bell Curve* co-author Murray. "The anecdotes are great, but every time you look at those data in detail—from the Abecedarian project, the Milwaukee project, and so on—again and again the claims of major gains become very hard to sustain." He argues that benefits are seen only in severely deprived children and that nobody knows how to raise the IQs of children from only moderately poor backgrounds.

But Ramey counters that although the most deprived children do benefit the most, his intervention studies show benefit to children from a broad range of backgrounds, from those whose mothers dropped out of high school to those whose mothers attended college. Ramey says that Murray dismisses the intervention data simply because "they present the most direct challenge to his central thesis" that genes largely determine a person's intelligence.

Ideology aside, major questions remain about what specific kinds of intervention produce the biggest effects on cognitive performance—from the relative benefits of full-time versus part-time programs to the value of providing home visits by social workers. For now, the evidence strongly suggests that quality preschooling by any standard would provide an important safety net for children who might otherwise not get the mental stimulation they need. The price tag is steep—more than $10,000 per child per year. But the payback in productivity, and in reduced social support programs later in life, may be even greater, if national preschool programs accrue a benefit similar to that seen in North Carolina—something now being tested by a 200-site, Early Head Start program in which infants are enrolled right after birth.

And although researchers are only now starting to define the particular kinds of external stimuli that promote optimal intellectual development, the work may reveal clear guidelines for parents about how to increase the odds of bringing up bright, well-adjusted children. Already, science is starting to underline some of the common-sense guidelines conscientious parents have followed for years—giving children activities that challenge their minds, praising them generously, and of course, talking to them a lot.

–INGRID WICKELGREN

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