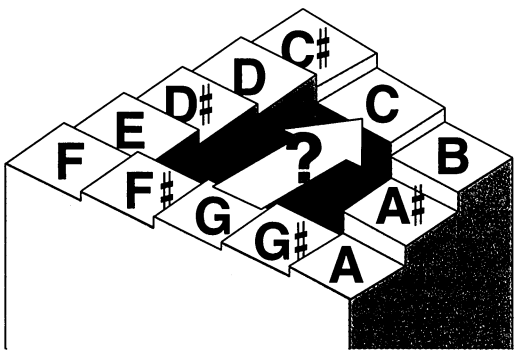

Step lively. In this visual equivalent of the tritone paradox, no step is highest.

biguous notes by superimposing tones from many octaves and carefully shaping the relative loudness of the higher and lower frequency components, masking how high or low the note is. Although listeners can perceive one of these notes as, say, a C, they can't tell its octave, whether high C, middle C, or low C. Indeed, the tone doesn't really belong to any octave at all.

Things get interesting when people compare tritone pairs of ambiguous notes, such as an ambiguous C with an ambiguous F sharp. Even though neither note is higher or lower than the other—because higher and lower don't have any meaning with ambiguous notes—people consistently perceive one tone as high and the other as low. But strangely, they don't agree which is which. "The musical illusion is perceived very differently by different people," says Deutsch. This is the tritone paradox.

Things got even weirder when Deutsch played ambiguous tritones to different groups of people. In 1992, she noticed that people from California and people from Southern England hear tritones in the opposite way; if a Californian thinks that a C is above an F sharp, the Britisher will swear that the F sharp is higher than the C. This led some psychologists to believe that a person's perception of ambiguous tritones depends strongly upon the intonations of the language he learns as a child. Since then, psychologists have been trying to prove it.

At the Acoustical Society of America's meeting last week, Deutsch described her latest experiment, in which she played ambiguous tritones to two groups of subjects who had emigrated to California from Vietnam. The first group came to the United States as children, and although Vietnamese was their first language, most no longer spoke it fluently. The second group, on the other hand, arrived in the United States as adults and spoke little English. The two groups perceived the tritones in the same way—but differently from their California neighbors. "This study presents strong evidence, we believe, that individual differences [in perceiving the tritones] are caused by individual speech patterns to which [the subjects] are exposed early in infancy," says Deutsch.

"It reinforces the idea that early linguistic background affects perception," says Magdalene Chalikia, a psychologist at Minnesota State University in Moorhead, who has shown that Greek speakers and English speakers perceive tritones differently. The tritone paradox gives neuropsychologists intriguing hints about the effects of training on the brain. The results suggest that as an infant learns its first language, the brain may adjust its neural connections in a way that affects the perception of sounds. But for the moment, scientists have little idea which languages cause which interpretation of the tritone paradox, much less how each language rewires the brain differently. "You can't make predictions," sighs Chalikia. "It's frustrating." The devil, it turns out, is in the details.

–CHARLES SEIFE

ACADEMIC RESEARCH

California Sets Up Three New Institutes

Three University of California (UC) campuses were chosen yesterday as sites for a new $900 million program designed to keep the state a world leader in research and to bolster its economy. Each of the three schools will receive $25 million a year for 4 years from the state, with companies and other sources putting up at least twice that amount.

The money will create California Institutes for Science and Innovation at the Los Angeles (UCLA), San Francisco (UCSF), and San Diego (UCSD) campuses. UCLA will team up with UC Santa Barbara on a nanosystems institute that will be led by Martha Krebs, former director of the U.S. Department of Energy's Office of Science. UC Berkeley and UC Santa Cruz will join with UCSF in an institute on bioengineering, biotechnology, and quantitative biomedical research headed by David Agard, a UCSF professor of biochemistry and biophysics. The third institute, on telecommunications and information technology, will be a collaboration between UCSD and UC Irvine led by UCSD computer science and engineering professor Larry Smarr.

"We'd like this to be a magnet for the best and brightest of the scientific community," says California Governor Gray Davis, who pushed the idea through the state legislature (*Science*, 26 May, p. 1311). "We can't make them come, but we'd like them to know they're welcome." Davis also promised to lobby next year for a fourth center, based at Berkeley, that would apply information technology to critical societal problems such as transportation, education, emergency preparedness, and health care. The Berkeley proposal fell just short in a competition among six finalists.

The contestants were encouraged to dream up novel collaborations and projects, and the winners were eager to describe how their research plans will push the boundaries of their field. "The growth of the wireless Internet will lead to radical change," says Smarr, describing sensors embedded in bridges, cars, and even people that may someday transmit information to a computer miles away that can assess problems such as stresses during an earthquake or wear-and-tear on a vehicle's brakes. "Wouldn't it be nice if you got a call on your cell phone that said, 'Hello, we thought you'd like to know that your right front brake will fail in about 100 miles.' "

Officials also emphasized that the institutes should tackle topics not historically addressed on their own campus. Developing innovations in engineering and technology, says Agard of UCSF, a campus devoted to the health sciences, is "a new game in biology and [requires] resources that go beyond what normal medical schools can come up with."

Although winning entrants were restricted to the 10 UC campuses, the new institutes are also hoping to work with some of the state's most prestigious private schools, including Stanford and the California Institute of Technology. "I envisioned a research process open to the best minds, wherever they were," says Davis. The same goes for collaboration with industry, which is expected to contribute heavily to the new institutes. "Places like Hewlett-Packard and Sun want our students," says Krebs, "and they also want access to the results of our research."

–EVELYN STRAUSS

NEW CALIFORNIA INSTITUTES

Institute	Director/Host	Partners
Bioengineering, Biotech, and Quantitative Biomedical Research	David Agard/UCSF	UC Berkeley, UC Santa Cruz
Nanosystems	Martha Krebs/UCLA	UC Santa Barbara
Telecommunications and Information Technology	Larry Smarr/UCSD	UC Irving