Behavior

Tracking bird-brained insight

Like a hungry child, the pigeon paces nervously in its cage, gazing longingly at the banana suspended overhead. Then it sights a box placed in the corner. Looking back and forth several times, from banana to box, it seems to say to itself, "Aha!" The bird pushes the box to a spot underneath the banana, climbs on top and pecks at its food.

What leads to this insightful problem solving? Pigeons that acquire relevant skills associated with both the box and the banana are likely to put two and two together when faced with the feeding problem described above, say psychologist Robert Epstein and colleagues at Harvard University. They offer the first "tentative" moment-to-moment account of how new behaviors emerge from previous responses.

The researchers, whose report is published in the March 1 NATURE, first trained four pigeons to push a box toward a green spot at the base of a cage wall. The birds did not push when the spot was removed. Next the animals were trained to climb onto a box and peck a banana placed overhead. Each bird was occasionally placed alone with the banana until the bird neither flew nor jumped toward it. The pigeons were able to use these experiences to solve the feeding problem; they pushed a box placed at the edge of the cage until they could climb onto it and peck at the banana.

Several other pigeons were trained to peck the banana but not to climb on the box; to climb and peck but not to push the box; and to climb, peck and push the box, but not toward a target. These birds also learned not to jump or fly toward the banana. But none of them could solve the feeding problem.

The pigeons who succeeded did so "because they learned directional pushing and because some history of reinforcement had made the banana 'important,'" says Epstein. For an as yet unclear reason, they were able to generalize the correct behavior from these experiences. Their performances, he adds, are similar to those observed in chimpanzees and children.

Epstein is now using his data to develop a mathematical model to predict human problem-solving behavior in experimental settings.

Alcohol test may be inaccurate

Efforts to identify drunk drivers by measuring their blood alcohol levels are often in vain. The percent of alcohol in the bloodstream does not accurately indicate whether one's judgment or physical responses are impaired, according to investigators at the University of Colorado in Boulder.

Some people are impaired below the legal limit for blood alcohol, while others act sober despite being legally drunk, say pharmacologist Gene Erwin and psychologists Robert Plomin and James Wilson. An acquired tolerance for alcohol and individual genetic differences account for the variations in response, they explain.

In the past three years, over 100 volunteers have been studied in a situation roughly analogous to social drinking. They imbibe until their blood alcohol levels reach Colorado's legal limit of 0.1 percent. Most subjects perform poorly on judgment, balance and muscle control tests at that point. When maintained at the level for three hours, however, about 30 percent of the drinkers perform as well on the tests as they do when sober.

Legal blood alcohol levels, whether determined by "Breathalyzer" measurements, urine or blood samples, are not reasonable indicators of drunkenness, says Plomin. "The old 'pull over, buddy, and let's see you walk this straight line' approach to determining drunkenness is a much more accurate way to see how impaired an individual may be," he notes.

Individual differences have largely been ignored, adds Plomin, because research has focused on alcoholics with an acquired tolerance for liquor, not social drinkers.

Mathematics

Computing a conjecture's disproof

One of the most famous unsolved problems in mathematics is called the "Riemann hypothesis." Attempts to solve this problem have occupied the time of many of the best mathematicians for more than a century. It continues to attract attention because it appears "tantalizingly vulnerable," as mathematician Harold M. Edwards of New York University puts it, "and because its solution would probably bring to light new [mathematical] techniques of far-reaching importance." A solution would have a bearing, for example, on the distribution of prime numbers (numbers evenly divisible only by themselves and one). Recently, Andrew Odlyzko of AT&T Bell Laboratories in Murray Hill, N.J., and Herman te Riele of the Center for Mathematics and Computer Science in Amsterdam disproved a mathematical conjecture that was once thought to be a possible path toward proving the Riemann hypothesis. Although the disproof is not a great surprise, comments one mathematician, "It's a major accomplishment."

Odlyzko and te Riele looked at something called Mertens' conjecture. If this conjecture were true, then it would imply the truth of the Riemann hypothesis. The conjecture involves a curious function called the Möbius function, $\mu(n)$, where n is a positive integer. For $n = 1, \mu(1) = 1$; if the factors of n contain two or more of the same prime numbers, then $\mu(n) = 0$; if n is divisible by distinct primes, then $\mu(n) = 1$ or -1 (depending on whether the number of primes is even or odd). Thus $\mu(12) = 0$ because $12 = 3 \times 2 \times 2$ (the same prime number appears more than once), while $\mu(15) = 1$ because $15 = 5 \times 3$ (two distinct primes). About 100 years ago, mathematician F. Mertens guessed that the sum of all the terms from $n = 1$ up to some value n would always be less than the square root of the number n. In the following years, mathematicians were able to show that the conjecture certainly was true for values up to 10 billion.

Odlyzko and te Riele took an indirect route toward finding out whether for some sufficiently large number the conjecture was no longer true. They used a newly invented, particularly fast, efficient mathematical algorithm that ran on high-speed computers to find a "funny" kind of average for the sum required by Mertens' conjecture. Because an average is always less than the largest number in the set of values being averaged, then it was enough to prove that the average itself was a sufficiently large number. The researchers found such an average, although they did not come up with a specific number or counterexample at which the conjecture is violated.

Odlyzko says, "We suspect that these counterexamples are quite high. My personal guess is that they are bigger than 10^{30}, but we really don't know." He adds, "We think we have a good guess for one possible neighborhood or place where it ought to be violated, but that number would be outrageously large: 10 to the 10^{70}th power. That is just way, way beyond any range that anybody can compute."

Mathematician George E. Andrews of the Pennsylvania State University in University Park says, "The fact that [Mertens' conjecture] has collapsed isn't really a great surprise to anybody. It's a surprise that anyone was actually able to find the appropriate numbers, large as they are, to get this thing to collapse." Ronald L. Graham of AT&T Bell Laboratories says, "If anything, it illustrates how much more effective algorithms are these days for doing the kinds of things that people have been working on for a hundred years."

Another factoring record

Mathematicians at the Sandia National Laboratories in Albuquerque, N.M., last week factored an extraordinarily difficult, 71-digit number to break the group's own recently set world record for factoring numbers (SN: 1/14/84, p. 20). Using a larger, faster computer and a refined algorithm, the researchers needed only about 9 hours to factor the number, a string of 71 ones.