

Strings and springs net mechanical surprise

Intuition can sometimes lead one astray. Consider a weight hanging from a spring, which in turn is suspended by a piece of string from an identical spring attached to the ceiling. Cutting the connecting string would send the weight and the lower spring plummeting to the floor.

Now add two "safety" strings to the original arrangement. One string joins the upper end of the lower spring to the ceiling. An identical string joins the lower end of the upper spring to the weight. Both safety strings initially hang limply.

When the taut string in the middle is cut, the safety strings prevent the weight from plunging all the way to the floor. Intuition suggests that, given the safety strings' slack, the weight will end up hanging somewhat lower than before. However, for certain combinations of springs, string lengths and weights, the opposite is true.

In the Aug. 22 NATURE, applied mathematician Joel E. Cohen of Rockefeller University in New York City and physicist Paul Horowitz of Harvard University argue that under a broad range of conditions, cutting the linking string and letting the safety strings carry the load actually pulls the weight above its initial position and closer to the ceiling.

The idea for this startling demonstration arose out of Cohen's long-standing

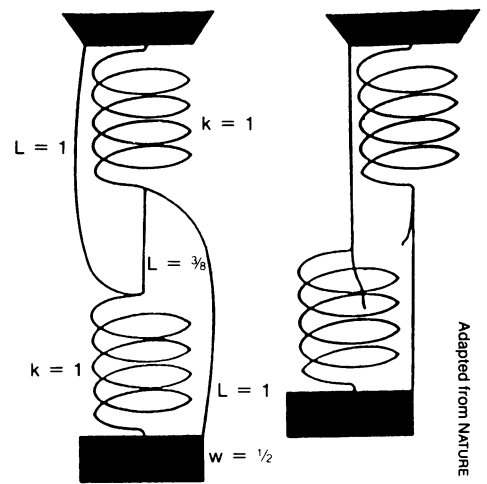
interest in mathematical models of biological competition, especially models that produce counterintuitive outcomes. One model involving traffic flow, discovered in 1968 and now known as Braess' paradox, demonstrates that adding extra roads to a congested transportation network may actually increase the amount of congestion rather than alleviate it.

As a step toward learning whether the same kind of surprising result could occur in a biological system, Cohen started by looking for a mechanical analog of the traffic paradox, and he came up with the string-spring arrangement described above. He then turned to Horowitz for an electrical version of the same situation.

"That turned out to be straightforward," Horowitz says. He designed an electrical circuit in which appropriate resistors replaced the springs, and devices known as Zener diodes replaced the strings.

"The result is quite surprising," Horowitz says. "When you add extra current-carrying paths, less current flows." The same paradoxical behavior occurs in a hydraulic system in which appropriate lengths of tubing and pressure-relief valves replace springs and strings.

These theoretical results were intrigu-



With string lengths (in meters), spring constants (k) and weight (in newtons) as shown, cutting the middle string will raise the weight.

ing enough to prompt Richard L. Garwin of the IBM Thomas J. Watson Research Center in Yorktown Heights, N.Y., to construct a working model made up of strings, rubber bands and a plastic jug partially filled with water as a weight. "It's real easy to do," Garwin says. "When people see [the effect], they just don't believe it."

The more general lesson, Cohen and Horowitz say, is that physical networks may not necessarily behave as expected when paths or components are added.

— I. Peterson

Infant daycare: Nothing beats quality

Children placed in high-quality daycare programs during infancy fare quite well in preschool and elementary school, three new studies suggest. However, investigators also note a stark reality facing many U.S. parents: Good daycare remains either unavailable or unaffordable.

The new reports, presented last week at the American Psychological Association annual meeting in San Francisco, enter a heated debate over the merits of daycare for infants (SN: 7/25/87, p.54). Some scientists argue that quality daycare—including well-trained staff serving small groups of infants—promotes social growth and emotional security. Others contend that thrusting babies into daycare of any type often disturbs the mother-child relationship.

Data collected by Tiffany Field of the University of Miami Medical School support the former position. In one study, Field examined 28 children aged 5 to 8 who had entered full-time daycare before age 2 at a University of Miami child center. The children came from two-parent, dual-career families. The center features carefully trained teachers and numerous play activities, with a maximum of 16 infants attending

at any one time.

Questionnaires administered to the children and their mothers showed that youngsters in early grade school who had spent the most time in daycare had more friends, displayed greater emotional well-being and assertiveness, and engaged in less aggressive behavior toward others. More than half the children—19 of 28—now participate in public school programs for the gifted.

In a second study, Field's team examined 56 sixth graders who began full-time daycare before age 2 in one of six high-quality centers. These 11- to 12-year-olds came from middle-class homes.

Sixth graders who had spent the most time in quality infant daycare received the highest ratings on emotional well-being, assertiveness and attractiveness by their teachers, Field says. The same children received substantially higher mathematics grades and more often entered programs for gifted students.

Similar conclusions come from a study by Alice S. Honig of Syracuse (N.Y.) University and Kyung Ja Park of Korea University in Seoul. Honig and Park questioned the teachers of 105 preschoolers aged 3½ to 5. During the

first three years of life, these children had received full-time daycare beginning before 9 months of age, full-time daycare beginning after 9 months of age, or no full-time daycare.

Teachers rated preschoolers with full-time infant daycare as more competent on tasks involving problem solving and abstract thinking; the longer in daycare, the higher the rating. However, experimenter observations revealed more hostility and aggressive behavior among these same children.

Honig attributes the greater aggression to poor-quality daycare, lower parental income and a preponderance of males in the group. The findings, she says, emphasize the need for extensive training and competitive salaries for teachers in infant daycare centers.

"There's a tremendous turnover of daycare teachers across the country, up to 85 percent annually at some centers," Honig notes. "But our study indicates that stable daycare teachers make a big difference later on."

"Some daycare services are improving, such as those sponsored by large businesses," says K. Alison Clarke-Stewart of the University of California, Irvine. "But in many areas, daycare is getting worse and moving toward larger, more impersonal centers." — B. Bower