Computer reveals clues to spiderwebs

More than 180 million years ago, nature embarked on one of its most creative engineering projects.

At that time, the common garden spider, *Araneus diadematus,* devised the planar orb web, an extraordinarily efficient structure for capturing fast-flying and, on an insect's scale, massive objects. So strong and resilient has spider silk proved that, on the human scale, a web resembling a fishing net could catch a passenger plane.

Yet several mysteries surround the spiderweb. How does such a delicate net dissipate so much kinetic energy? How can a web capture such relatively massive projectiles and not be ripped to shreds? Does the secret lie more in the silky material or in the clever structure?

Investigating these questions, physicist Donald T. Edmonds and biologist Fritz Vollrath of the University of Oxford in England and structural engineer Lorraine H. Lin of Ove Arup and Partners in London used a computer model to analyze structurally a complete spiderweb.

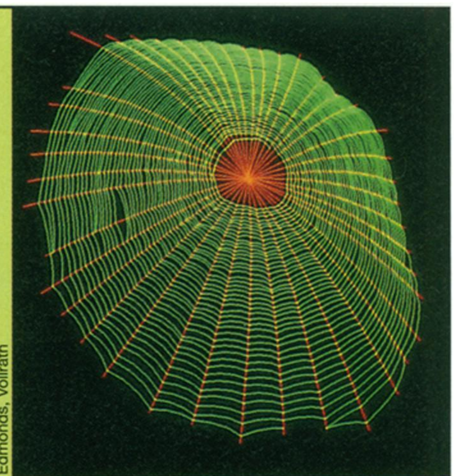
"In this study, we tried to learn about the way a web is engineered as a structure for capture," Edmonds says. "We took a computer program normally used for crash-testing automobiles and put into it a model of a whole spiderweb. The program lets you deform the structure in particular ways and then analyze the effects of those distortions."

The researchers fed into the computer data from laboratory experiments on individual silk threads, how those strands are connected, and how insects strike the net.

"If the web can't dissipate the kinetic energy of an insect flying into it, the bug will either break through the web or bounce out, as if from a trampoline," Edmonds says. "With the model, we found, unexpectedly, that aerodynamic damping has a tremendous effect on capturing prey. On the scale of insects, air resistance plays a large role. Energy is dissipated as the whole web bobs back and forth through the air."

The scientists found this surprising. Ordinarily, one would not expect a thread less than one-thousandth of a millimeter in diameter to create much resistance in air. In fact, as they report in the Jan. 12 NATURE, it does.

To confirm their computer findings, the trio recreated the simulation in their laboratory. "We shot Styrofoam bullets from a small cannon at real webs and measured the results," Vollrath says. "At that scale, we find that air is very viscous. It's like pulling ropes through water."



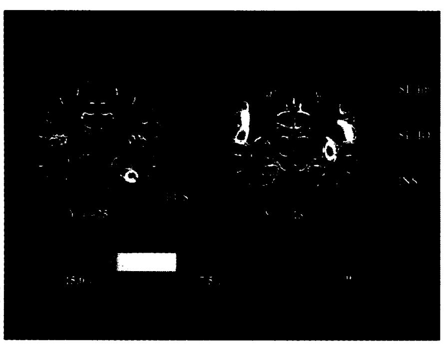
Edmonds, Vollrath

A computer model of a spiderweb.

The scientists also measured the way a web uses its unique geometry to balance stresses and tensions, distributing forces across its surface. Such information may have practical applications for architects building tentlike structures with many cables, Lin notes.

"Since natural structures evolve over millions of years, they're often more intelligently designed than man-made ones for similar purposes," Lin says. "Architects and engineers are always looking for fresh approaches to solving structural problems. Nature has much to teach, not just about aesthetic forms but about mechanics." — *R. Lipkin*

Brain activity calms down to expectations



Drevets

Orange and red areas of PET scan show marked blood flow drops in lip and mouth areas of somatosensory cortex during anticipation of a finger shock.

The mere anticipation of a particular feeling in one part of the body — from a gentle touch on the finger to a sharp shock on the toe — selectively numbs the brain's sensory processing areas. Activity dampens everywhere save for patches of tissue that correspond to the thought-about body part.

These new findings, published in the Jan. 19 NATURE, add to earlier evidence that many physical and mental functions slow down while one concentrates on an actual or expected stimulus.

"[The] new results imply that suppression of competing stimuli is a central element in many aspects of preparing to receive a stimulus," writes Michael Posner, a psychologist at the University of Oregon in Eugene, in a comment accompanying the report.

Psychiatrist Wayne C. Drevets and his colleagues at Washington University School of Medicine in St. Louis measured blood flow in the brains of 27 adults while they rested and again while they anticipated an upcoming touch or electric shock, which they expected on the left or right big toe or the right index and middle fingers.

Trials took place after volunteers had inhaled minute, harmless amounts of radioactively labeled oxygen. A positron emission tomography (PET) scanner then recorded the breakdown of this substance in the brain and transformed the data into color-coded images of blood flow; increased flow in an area indicates greater brain activity.

Subtracting volunteers' cerebral blood flow while at rest from that recorded during anticipation — both representing an average of 40 seconds of brain activity — revealed brain areas where activity changed markedly in response to mental preparation for a sensation.

Awaiting an impending touch or shock to the fingers produced substantial drops in blood flow in the parts of the somatosensory cortex that deal with facial sensation, while the region concerned with finger sensation held steady. Expectation of a touch or shock to a big toe sparked blood flow decreases in somatosensory zones devoted to the face and fingers but not to the toes.

Anticipation of shocks elicited the steepest of such blood flow declines, a process perhaps facilitated by anxiety and associated facial expressions of emotion, the scientists note. Suppressed activity in brain regions that handle sensations from places on the skin where no stimulus will occur may improve transmission of the anticipated stimulus via the appropriate somatosensory neurons, Drevets' group asserts.

Paying attention to what one sees relies on complex changes in cerebral electrical activity, some taking a fraction of a second. Thus PET data, which represent an average of 40 seconds of blood flow activity, reveal only "a crude net effect" of sensory anticipation, Posner argues. Further studies must combine both PET imaging and measurements of neural changes in electrical activity, in Posner's view. — *B. Bower*