Abstractions

FIRST AUTHOR

A 300-year old experiment provided the inspiration for a method to study the dynamics of microscopic particles. The technique, developed by Henry Chapman of the Lawrence Livermore National Laboratory in California and his colleagues, relies on fast and intense X-ray pulses, and is known as holography. The researchers used the FLASH soft-X-ray laser at the DESY electron synchrotron in Hamburg, Germany. They blasted tiny polystyrene spheres with an X-ray pulse, which was then reflected back at the spheres by an X-ray mirror. The scattered light generated a holographic recording of the spheres both before and after they exploded (see page 676). Chapman tells *Nature* about the history behind the techniqe and the brand new technology that made it possible.

What was the inspiration behind this experiment?

I had the idea while visiting the Chabot Space & Science Center in Oakland, California, with my wife and daughter. One of the exhibits demonstrated interference through the pattern of concentric circles formed when light scatters from particles sitting on a mirror and from their images in that mirror. As I explained how it works to my daughter, I thought, 'What if you did the same thing with short pulses and X-ray mirrors?'. Later, I found out that the exhibit was modelled after Isaac Newton's 'dusty mirror' experiment.

How does blowing up tiny objects with a laser translate to useful information?

Our work is based on the idea of flash imaging macromolecules. My collaborator, Janos Hajdu, had proposed that if you had an intense and short enough X-ray pulse you could actually get images of molecules without crystallizing them. Our motivation was to develop a method to do this. Up until now there have only been models and calculations done to say how fast an object will explode. Ours is one of the first tests of such models. We want to develop the techniques and determine the feasibility for single-molecule imaging experiments.

What sort of planning went into this work?

We planned the experiment before the beam needed to deliver the X-ray pulses became available. The facility didn't yet exist, and it wasn't clear when it would go online. When we finally got funding for this project, we only had six months to put everything together before it did come online. It was a mad rush. We were worried that the intense X-rays would destroy our equipment, and we knew we wouldn't get another chance at funding or beam time. Fortunately, when we got there everything worked. Someone had even remembered to pack the champagne. ■

MAKING THE PAPER

Gilles Laurent

Locusts have an advanced system for learning and remembering odours.

Researchers studying locust olfaction have uncovered a system of learning and memory previously thought to exist only in vertebrates.

Although insect and vertebrate olfactory systems were known to have a number of anatomical and physiological parallels, the mechanisms underlying insect olfaction were not well understood. Neuroscientist Gilles Laurent, at the California Institute of Technology in Pasadena, chose the locust as a model to study the neural mechanisms insects use to learn odours.

Laurent first began studying insect olfaction because it is a good way of tracing circuit function and neural computation in the brain. In this work, he and his graduate student, Stijn Cassenaer, turned their attention to the electrophysiological mechanisms at work in locust olfaction.

Odour representations are initially processed in an insect's antennal lobe, a structure analogous to the mammalian olfactory bulb. From there, they are projected to very selective neurons called Kenyon cells (KCs), which are located in a brain structure known as the mushroom body. This is the presumed centre of learning and memory in insects. Laurent and Cassenaer focused on a third layer of odour-processing cells — a population known as β-lobe neurons (β-LNs), found at the output of the mushroom body. "We hypothesized that if learning occurs in this structure, it's most likely at the synapse between the KCs and β-LNs," says Laurent.

Although the locust is an unconventional model organism and little is known about its genetics, Laurent recognized it as having several advantages. First, it is a large, sturdy insect, making it ideal for electrophysiological experiments that require embedded brain probes and lengthy recording sessions. Second, many of its neuronal populations can be identified by their electrophysiological signatures, which makes interpretation much easier.

The two researchers presented locusts with odours typically encountered in the field, and recorded activity in pairs of β-LNs. They discovered that β-LNs are tightly synchronized, which indicated that timing is important in learning odours (see page 709).

Cassenaer then devised a way to make paired electrophysiological recordings of KCs and β-LNs *in vivo*. This was no small feat, but his ingenuity and patience paid off, and during one recording session he and Laurent observed a KC and a β-LN fire at the same time. In the next trial, only 10 seconds later, they noticed that the connection strength between the two neurons had been considerably enhanced. This form of synaptic learning and strengthening of nerve-cell connections, known as spike-timing-dependent plasticity (STDP), was thought to exist only in vertebrates.

The two then hypothesized that information travelling through several layers of neurons would inevitably result in a progressive decrease in timing precision. For synaptic learning to take place, timing is everything. The β-LN synchronization necessary to 'learn' an odour is dictated by the change in synapse strength that results from the temporal relationship of pre- and post-synaptic spikes. "In retrospect, it is obvious that mechanisms must exist to correct timing errors, given its importance here," says Laurent.

To test the idea, they came up with a way of artificially modifying the timing of β-LN spikes evoked by an odour in an intact animal in real time. They found STDP to be adaptive — delaying or advancing spike time for each neuron cycle, and thus fine-tuning the β-LN spikes to work as a timing-regulation system. "Theorists had come up with the idea of a timing-regulation system without proof from the biological side," says Laurent. "This is the proof." ■

FROM THE BLOGOSPHERE

"Stripping off the white coat" is recommended on the 'Mind the Gap' blog at Nature Network (http://tinyurl.com/3b95km). Jennifer Rohn reveals how she and her partner-in-design Wynn Abbott have devised a competition to challenge fashion designers "from students all the way up to celebs, to reinterpret lab coats for the twenty-first century". The coats, according to the criteria, must still have a protective function, but they must also have a design that's "fun, fresh, sexy and original".

Rohn and Abbott plan to make a formal call for designs within the next few months, and to have a panel of judges make a decision from the shortlist in autumn. In addition to the main prize, they plan to give out awards for the best accessories, including masks, gloves and safety goggles. "So come on, people, pimp my coat!" Rohn writes. "I'm tired of putting on the same old stained, shapeless one every morning."

If you would like to comment on the idea or see more details, including an elegant example design, see Jennifer's Nature Network blog post (URL above) or Nautilus at http://tinyurl.com/35oqko. ■

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