Abstractions

SECOND AUTHOR

Objects in nature move in random and deceptively complicated ways — each sequential step can go in any direction. Modelling the properties that underlie the first encounter between any 'random walker' — be it an animal, biomolecule or virus — and its target has become a hot topic among physicists. A key parameter is the 'first-passage time' (FPT), which describes the time taken by a walker to first reach its target. But this has proved difficult to apply to real-world conditions — the best estimates have been limited to simple, uniform conditions lacking real-world significance. Olivier Bénichou at the Laboratory of Theoretical Physics of Condensed Matter in Paris and his colleagues have developed a general theory to evaluate the mean FPT in more complex situations (see page 77). Bénichou tells *Nature* about the work.

Why are first-encounter properties crucial?

Because the random walker — for example, a diffusing biomolecule in a cell — must encounter the target before a reaction or process can occur. For biomolecules, reaction times are often controlled by the time taken for molecules to meet.

Were there real-world motivations for this theoretical work?

Three years ago, we modelled the dynamics between proteins and DNA, which rely on intermittent diffusion strategies. One day I was trying to find my daughter's glasses and it occurred to me that my search strategy — searching slowly in one place and then moving quickly to a new one when the target is not found — was also intermittent. I realized that animals adopt this approach when searching for food. The model we proposed to account for such animal behaviours involved the calculation of mean FPTs of random walks.

How does your theory overcome previous constraints?

Determining FPT in complex environments, which are often multidimensional, is a complicated mathematical task, partly because it depends on the necessary boundary conditions, or confinement, of the system being described. In this analytical theory, we use a mathematical trick to isolate and replace the confinement effect. Then, we relate the mean FPT in confined conditions to properties of random walks in infinite space, which are easier to estimate.

Might this theory prove useful elsewhere?

It could have many uses across disciplines. It should be useful for evaluating the kinetics of reactions between biomolecules in a cell, and for estimating the time a computer virus will take to reach a given node on the Internet. ■

MAKING THE PAPER

Tali Sharot

Imaging identifies the brain regions that make us optimistic.

Our outlook for the future tends to be unrealistically positive. Most of us expect to live a longer, healthier and more successful life than evidence suggests is likely. This optimistic bias seems to be important to good health, as a pessimistic outlook has previously been linked to depression. Several brain regions have been implicated in negative emotions — could the brain also be responsible for generating our rose-tinted view of the future?

Tali Sharot, now a postdoc at University College London, didn't set out to answer this question. Brain-imaging data indicate that emotion and memory are neurologically intertwined, and Sharot wondered whether the same was true of emotion and future predictions. The results of a pilot study changed the direction of her work.

In the pilot — which Sharot conducted while a postdoc with Elizabeth Phelps in New York University's psychology department — she asked volunteers to rate each of 80 events as positive, negative or neutral. The volunteers overwhelmingly cast the best light on these hypothetical future events, even when the scenarios they considered weren't intended to elicit optimism.

For example, one participant rated 'going to a museum' as positive, because she imagined meeting a romantic partner there who presented her with flowers. And several rated 'the end of a relationship' as positive, saying that they expected their next romantic partner to be more satisfactory. "We had trouble getting people to imagine negative events," says Sharot. "They made them neutral and even positive." She hadn't anticipated that it would be so difficult to get people to think of their future in a negative way, and, she says, "that made me think of the positivity bias".

The next step was to set up a study similar to the pilot but with an imaging component. Volunteers were asked to read descriptions of events on a computer screen while inside an MRI scanner. The events were labelled either 'past' or 'future' to indicate whether the volunteers should think of events in the past or imagine an event that might happen in the future. When they had formed a clear mental picture, the volunteers pressed a button — to capture their brain's activity — then labelled the event as positive, negative or neutral. After they emerged from the machine, volunteers were asked to describe the image and rate how vivid it was and how long ago or far into the future it took place.

The results were striking. "I could pretty much predict what their optimism scale was just from the MRI data, before they e-mailed me back the questionnaire," Sharot says. Matching the questionnaires to the MRI images only confirmed her hunches (see page 102).

The images showed that the same parts of the brain that are involved in processing memory and emotion have a role in anticipating and rating the future. They also showed a neurological basis for optimism. "When behavioural data are that robust, there's usually a link to some observable neural mechanism," Sharot says. "When we looked at the MRI data, it was clear that the activation was much stronger for the positive-rated events."

Sharot says she enjoyed the research, and not just because the experiments went relatively smoothly and produced robust results. She enjoyed seeing volunteers' glass-half-full outlooks manifest themselves by means of brain imaging — basically imaging the hardiness of the human spirit. "I'm very optimistic myself," Sharot says. "I can relate." ■

FROM THE BLOGOSPHERE

"Are you satisfied with the current scientific publishing process?" asks Anna Kushnir, a student at Harvard Medical School, in the "Publishing in the new Millennium" forum on Nature Network (see http://tinyurl.com/2eoz4b). Maxine Clarke of *Nature* responded that most published authors say that the peer-review and publication process has improved their work, and some authors even say decisions not to publish work, when they include constructive criticism, have helped them to improve their papers for publication elsewhere.

Craig Rowell, of Duke University in Durham, North Carolina, replied that although the peer-review process does a very good job of quality control, people sometimes forget about the "gate-keeper" role of the editor. Even when reviewers like a paper, if the editor disagrees, the journal might not accept it. The role of the editor is to decide, after review, whether a paper in which the science is technically correct meets the publication criteria of that particular journal. Unfortunately, writes Craig, some mentors do not explain this to their students, let alone keep it in mind for themselves. ■

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