RETOUR AU QUOTIDIEN

RETOUR HOMEPAGE

Actualités

Chercher

[NOTE: This is a direct translation from French using atla-vista, please excuse the English.]

Comprendre -- AVRIL 2000 -- N° 638

Mathematical chance and biological chaos

Who win loses

Try your chance with a game of chance. Generally, you lose. Play two games of chance, alternatively and in a random way: surprised, you gain! This paradox lights the apparently chaotic mechanisms, and yet oiled well, of the cells or proteins.

Accoudé with the zinc of your preferred bar, you are in full discussion with another consumer. He subjects a problem to you: " Imagine two games of chance A and B the elements of these plays, the dice or the parts, as you want, are faked. If I play play A, I am likely much more to lose than to gain. With the play B, similar. And yet, if I start to play two plays by alternating them, and this in a completely random way, I will reverse the vapor and will suddenly put myself to gain in an incredible way. " This level of the discussion, if your companion of counter proposes to you to bet that it can carry out such a wonder, a consulting: abstain from. This informed player wants to make you fall into the paradox from Parrondo.

J. CH. GERARD/DIAF

This last, Juan Manual of its first name, is a Spanish physicist working at the Complutense university of Madrid. As opposed to what one could think, the author of this strange mathematical paradox (to read p. 83) does not study the game theory, not more than the probabilities. " My field of search is that of the stochastic processes, i.e. disordered, in the physical systems and biophysics, explains it. I study in particular the mechanisms which make it possible proteins to be transported in a cell. " And of proteins to the pipés dice, there is only one step, that where chaos joined the chance.

Indeed, in the world of infinitely small, below the thousandths of millimetre, all is only agitation and vibration. The objects are so small that they are subjected to ceaseless thermal fluctuations. With our scale, these variations do not produce any perceptible effect. But, in the cells, the situation is quite different: the result seems cataclysmic and disastrous. Proteins and organoids are shaken in all directions and are agitated permanently as under the effect of microrafales of wind of most capricious. This dance of molecular Saint-Guy, against which the researchers cannot anything, bears a name: the Brownian movement, discovered in 1828 by a botanist, Robert Brown.

And yet, surprisingly, in spite of this chaotic, apparently déliquescente and anti-productive environment, the activity of the cell is not less world disturbed. The Brownian stochastic movements do not prevent in any manner the molecular engines of being perfectly oiled mechanisms which manufacture, transport and assemble all the proteins which needs the cell - and more generally our organization. And pallets it engines of alive is very broad. Some are in rotation on themselves, like dervishes, salting out, at each end of turn, a lately synthesized molecule. Others, they are most

numerous besides, progress in a linear way. In this last group, one of the most studied nanomachines is the kinésine. This security guard transports the molecules of an end to the other of the cell while moving along the filaments of another protein, the tubuline, a such engine on its rails, at the speed of 1 micrometer a second is 3,6 millimetres per hour. And this, while vibrating like insane because of intrinsic thermal agitation!

Also, after having wondered, in vain, lasting more than one century, how the cellular life could put up themselves well with the Brownian movement, the physicists and biologists have, since a score of years taken the problem with grain-hair and turned over the question. Wouldn't Brownian agitation, instead of being unfavourable, be rather an advantage and a force for the cell, which could exploit it with its advantage? In other words, couldn't chaos be generating of command? And it is there that intervenes the paradox of our Iberian physicist. Its greater merit was to consider this concept in a macroscopic way by illustrating it by a mathematical play showing than it is possible to gain with plays which, with the first access, have very to make lose. "And, in my opinion, known as Juan Parrondo, the most significant consequence of the paradox is that it clarifies that the alternation of two phenomena can have completely unexpected consequences, that is especially not needed mésestimer."

So radical reversals of situation make in fact call to the same guiding principle: an astute use of asymmetry, that they are structures, in the case of the molecular engines, or the rules in that of the mathematical play of Parrondo (to read above). But the number of fields where the paradox could find an application is much broader. " We are, adds the Spanish physicist, trying to generalize the plays by hoping that they will be able to bring answers to problems of statistical mechanics, chemistry or even, of policy. " Derek Abbott, of the university of Adelaide, in Australia, studied the paradox. He adds: " It can be found in many situations of the life of tous.les.jours. The economists are very interested to apply the strategies " parrondiennes " to the market trends. It is also very possible that the genes, on their level, play such plays. The animals have all a certain stock of goods and bad genes. The paradox says that the interaction between two bad genes can prove to be positive and make evolve/move the species. "

Other fundamental point which comes to confirm the plays of Juan Parrondo: the role of the noise within the physical or biological phenomena. " Here are ten years, concludes this last, the Brownian movement was regarded as a harmful effect. It is not any more the case today. And it is perhaps there the greatest paradox. The background noises, the interferences of any kind are far from playing an only harmful role. The researchers realize some more and more: the noise has two faces. In many cases, it is constructive and makes it possible to create new things. "

Herve Ratel

The double game raid the setting

Two different plays illustrate the paradox of Parrondo. Play A is a part with which you are likely less to draw one from the faces than the other. It makes lose. The play B, it, consist of two parts. Part 2 is also " losing ", with it, one can gain only one time out of ten. Part 3, on the other hand, is one " gaining ". It is faked in such way that one loses only one time out of four. When it plays B, the player uses part 2 if its capital is multiple of a certain figure M, fixed in advance (2, 3, 5..., that does not have any importance) and part 3 in the other cases. That means that it will play, on average, more once part 3 than the 2. Despite everything, the fact that it has very few chances to gain with part 2 compensates for that. With the result that the play B is losing, in the last analysis. The paradox comes owing to the fact that if the player alternates these two plays losers, it is then put to gain in a constant way (see the diagram).

Most astonishing is that this reverse of chance takes place even when the passage of A with B and B with A is made completely randomly, independently of the profits. The paradox is to be studied by the mathematicians and, by many aspects, still preserves its mystery. What one observes in any case is that the play A, compound with B, changes the frequency of use of the parts, more utilizing the good part of the play, the 3, that the bad one, the 2. The researchers compare this effect with that of a ratchet wheel, a toothed wheel provided with a pawl which only enables him to turn in one direction. Thus, whereas repetitions of the same play inevitably involve a fall of the capital, the intervention of

play A within the play B traps, to some extent, the profits obtained (in particular those of part 3). They as are then involved in a cog wheel where they accumulate more and more. It is the ascending spiral, the player cannot lose more. Do not hope however not to apply the paradox to gambling. Indeed, A and B require rather specific rules and they are not independent, the result of the hard copy of the one influencing the other. What makes impossible an application on the green carpets and ruins any hope of martingale.

Alternation is born the movement

How to advance a microscopic object in a direction given without pushing it or blowing to him above, in short without applying an unspecified force directly? A solution was proposed by two physicists of CNRS, Armand Ajdari, of the higher School of physics and chemistry industrial, and Jacques Prost, of the Institute Curie, in Paris. " With the origin, tells Armand Ajdari, the goal was to sort and separate from/to each other of the particles in solution, pieces of ADN, proteins. Seen under the microscope, their world appears very different from ours. They are not subjected to the inertia and gigotent constantly because of thermal agitation. " From where the astute idea to propose a method of separation which exploits the Brownian agitation of the objects of infinitely small. For that, they subjected particles to an asymmetrical electric potential in teeth of saw. While alternating the powerings and not under tension of the system, they managed to make progress the particles in a given direction. They proved thus that the alternation of two reliefs is enough to direct the displacement of Brownian " objects ".

" The effectiveness of the method, continues Armand Ajdari, rests on the good choice of the time of alternation of the two potentials. Too long Ni, nor too short, in order to exploit the Brownian spreading out " of " the particules.Cela well imposes limitations from the technological point of view. But, in any case, the scientific community accepts from now on the idea that similar principles of operation are with work in the cell and that certain molecular engines exploit thermal agitation to be driven. "

Indeed, when this " loco " molecular that is the kinésine advances on the filaments of the tubuline, it makes only " vibrate ". The direction of its movement is provided to him, actually, by the asymmetry of the assembly, in chains of pearls, of the rails of the tubuline. That does not want to say in so far as displacement is done without expenditure of energy. In the cell, it is the consumption of ATP, the fuel of the alive one, which ensures the equivalent of alternation undulating landscape plat/paysage of the diagram above, by causing changes in form of the kinésine. Thus, while passing from a configuration with another, the kinésine behaves as if it evolved/moved on two quite distinct roads. Result: just like the particles of the experiment of Armand Ajdari and Jacques Prost, the molecular engine " sees " a succession of different paths, which enables him to advance.

Now replace the two highway types opposite by the two plays suggested by Juan Parrondo. The path, soft inclined and in teeth of saw, is play b: if some particles can stop, for a time, their descent while being wedged in a valley, it does not remain about it less than because of the Brownian movement, all, in the last analysis, will dégringoleront, slowly but surely, the slope until in bottom. Translated concerned that gives: even if you can gain some parts with the play B - with its two different parts -, in the last analysis, you will lose. The soft inclined path, flat, is the equivalent of play A. It are not more of the particles which fall unrelentingly, but your capital which falls. And the final paradox is the same one in the two situations: if you alternate from now on the two roads (or the two plays), the particles are then put to go up the slope (or your profits, suddenly, fly away). CQFD.

Sciences & Future N°638

summary return