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Born to dance: Ginger Rogers and Fred Astaire

for individuals. For a start, it can improve thinking skills. In one study, college students either danced, cycled, listened quietly to music or sat still, and did tests of mood and creativity before and after. Those who got up and danced showed increases in creative thinking after just 5 minutes of moving to music, and their mood improved too.

The two things are probably connected. Dancing releases feel-good neurochemicals into the bloodstream called endorphins, which relieve anxiety and depression. "You get an increase in mood when you dance and you also get an increase in creative problem-solving," says Lovatt.

"Mood has an important role in cognition," agrees Joe Verghese at the Albert Einstein College of Medicine in New York. But there's far more to dancing than that. The reason it has an edge over other types of exercise may stem from it encompassing so many elements: emotional, cognitive, physical and social. "Dance is a complex activity," says Verghese.

Less surprisingly, it can also boost coordination, spatial navigation and memory – particularly if you are trying to master a new step or routine. "There are multiple effects on the brain," says Verghese. Among other things, dancing engages cognitive and sensorimotor regions involved in planning and performing movement. It literally alters the connections between neurons and how they communicate.

"Dance affects some parts of the brain more than others," says Verghese. One key region is the hippocampus, a pair of structures deep inside that are involved in learning, spatial awareness and long-term memory. As we age, the hippocampus normally loses about 2 or 3 per cent of its volume every decade. After age 70, that increases to as much as 1 per cent each year. And the loss is particularly rapid in people who have dementias such as Alzheimer's disease. Intriguingly, however, the hippocampus can grow in response to various mental and physical challenges, including dancing.

A study published last year compared healthy adults aged 63 and older who either danced or took part in aerobics classes twice a week for six months and then weekly for a year. MRI scans showed an increase in the volume of the hippocampus in both groups. In the dancers, this appeared to be linked with improved balance. Another recent study found that dancing can reduce the loss of white matter in the brain, which also tends to accelerate with age. White matter tracts are like highways between brain areas and are involved in emotional processing, focus and problem-solving. When the researchers compared people who either walked, stretched or danced three days a week for six months, they found that only the dancers showed a slowdown in white matter loss.

These findings fit with research by Verghese into which leisure activities might reduce dementia risk. His team followed 469 people older than 75 for an average of five years and found that those who enjoyed cerebral hobbies such as reading and doing crossword puzzles were less likely to develop dementia. Dancing was the only physical activity with a similar effect – in fact, people who danced had the smallest cognitive decline of all.

Verghese hopes that more research will help quantify the effectiveness of dance and identify how it can best be used to improve brain health. He is now conducting a pilot study with 32 adults aged 65 and older, who for six months will participate in either social dancing (for example, foxtrot, waltz and Latin) or treadmill-walking. At the end, brain scans will reveal where any changes have occurred.

All this is very good news. If you have ever wanted to learn to tango or were simply too embarrassed to share your dad-dancing moves, here is your excuse to get on the dance floor and strut your stuff. It doesn't matter when in life you take it up, any time is the right time to dance. ■

"Your mood improves when you dance – and so does your problem solving"

Stephanie Kramer's motto is "Why walk when you can dance?"

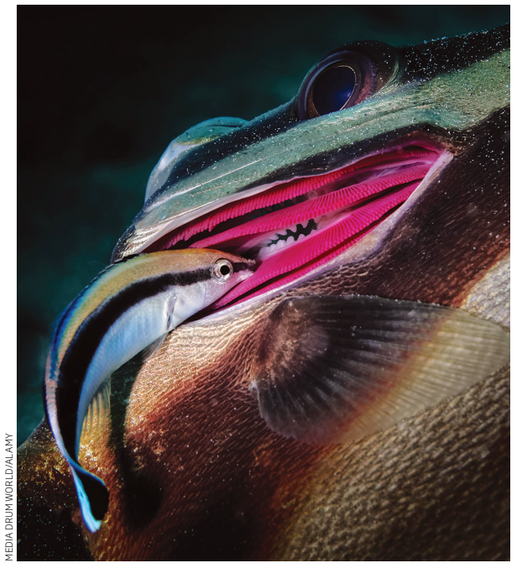
Rogue traders

We thought economics was a uniquely human pursuit. But even simple organisms are at it, says **Daniel Cossins**

"THE propensity to truck, barter and exchange one thing for another… is common to all men, and to be found in no other race of animals," wrote Adam Smith in *The Wealth of Nations*. That was back in 1776, but the idea that humans are the only species capable of economic behaviour persisted for a long time. Intuitively, it makes sense. Responding to shifts in supply and demand, for instance, must be the preserve of species with brains hefty enough to think through decisions rationally.

Or so we thought. As we get to know Earth's myriad other species better, it is becoming apparent that many animals and organisms make trades, and that some are surprisingly savvy wheeler-dealers capable of manipulating the market in their own selfish interests. From frisky baboons to fish offering spa treatments on the reef, pretty much everywhere we look in nature we find evidence of surprisingly sophisticated economic decision-making. Even fungi are at it, and according to the latest studies, these brainless soil dwellers give the impression of being more rational than us.

Such revelations are handing us a fresh understanding of the origins of cooperation. They also chip away at the idea that sophisticated behaviour requires a big brain. They might even teach us a thing or two about ourselves, says Toby Kiers, an evolutionary biologist at the Free University Amsterdam. "What are the basic strategies organisms have evolved to cope with relentless variation in resource availability? It is naive to think an MBA will teach us everything we need to know."



MEDIA DRUM WORLD/ALAMY

Clean your scales, guv'nor? Cleaner wrasse operate according to savvy economic principles

Anyone who has watched a wildlife documentary knows that cooperation is common in nature. Monkeys groom one another, hyenas hunt in packs. And it is not just animals of the same species that work together. Until recently, all this collaboration didn't make much sense in the context of Darwin's theory of evolution by natural selection. If ruthless self-interest is the rule, why cooperate?

When Ronald Noë began watching baboons in Kenya in the early 1980s, there were two answers to that question, both with flaws. The first was "kin selection", the idea that an animal sometimes stands a better chance of passing on its DNA not by finding a mate itself but by helping a close relative to reproduce. But kin selection can't easily account for cases in which unrelated species help each other.

The other argument was "reciprocal altruism", which says that animals that help others do so because they know they will get something in return. Game theory was invoked to explain how an altruistic animal could guarantee reciprocity, with evolutionary theorists using a two-player game called the prisoner's dilemma to figure out how it worked in nature. But there was a problem. "They were building card-houses of one model on top of another and never bothering about empirical evidence," says Noë, who recently retired from the University of Strasbourg, France.

Out in the field, he quickly noticed their error. When two low-ranking baboons teamed up to challenge the dominant male so that one of them could mate with a female, they didn't always stick with the same collaborator after the dethroning, as the theorists had assumed in their models. Quite the opposite. "These males switched partners and played their friends off against each other" to make sure they got more mating time than their collaborators, says Noë. Big baboons like Stu, the first challenger that Noe studied, knew that a collaborator ›

would accept less rather than risk losing his support.

"In a nutshell, this showed that the essence of cooperative relationships was partner choice," says Noë. In baboon society at least, when it comes to the exchange of services in pursuit of mating, the fact that individuals like Stu could shop around for the best deal from prospective collaborators makes all the difference. "Partner choice is what drives the market," says Noë.

In 1994, together with Peter Hammerstein, now at Humboldt University in Berlin, Noë set out his theory of biological markets, inspired by his observations of baboons. Then he tried applying it to all manner of other species to see if it would explain their cooperative behaviour. It worked. And although it didn't catch on immediately, the new theory captured the imagination of several young biologists, including Redouan Bshary, then one of Noë's PhD students.

Fishy business

At that point it had only been applied to animal behaviour already recorded in the literature. "I thought it would be nice to go out and explicitly test it in the wild in a new system," says Bshary, who is now at the University of Neuchatel in Switzerland.

Bshary settled on a diminutive reef fish called the cleaner wrasse, which scrapes a living nibbling tiny parasites from between the scales of other fish that pass its cleaning station. He picked this wrasse because even though its behaviour is a nice example of mutualism, in that the cleaners get food and the clients get cleaned, there is a conflict of interest. The cleaners like to take nips of their client's protective mucus layers more than they do the parasites, so they are liable to cheat. "That means [to get good service] clients have to get cleaners to go against their preference, and cleaners have to choose when to cheat," says Bshary.

Having learned to scuba-dive, Bshary spent countless hours observing cleaner wrasse in the Red Sea. He saw that they have two types of client. There are "visitors", such as parrotfish, which can grow 40 cm long and can travel easily between several cleaning stations. And there are "residents", like the smaller melanurus wrasse, that tends to stick to one. Bshary figured that visitors had a strategic advantage because they could shop around. Sure enough, in 2002, he showed that visitors almost always got better service. They were seen more quickly and treated more gently, with the cleaners less likely to sneak a bite of them than residents. "Clients can switch partners to enforce a good service," he says.

The canny adjustments to the coral reef free market don't end there. Bshary has found that cleaners are less likely to cheat when another fish is watching, and that they never do when the client is a predator. Most recently, observing around Lizard Island in Australia, Bshary and his colleagues noticed that cleaners had stopped giving visitors priority access. The reason, he suggests, is that several cyclones and an El Niño climate oscillation killed off 80 per cent of its cleaner wrasse. It has suddenly become a restricted market and the cleaners know it. There's nothing to stop them from making visitors wait.

> "In one recently unearthed biological market, the traders have no brains at all"

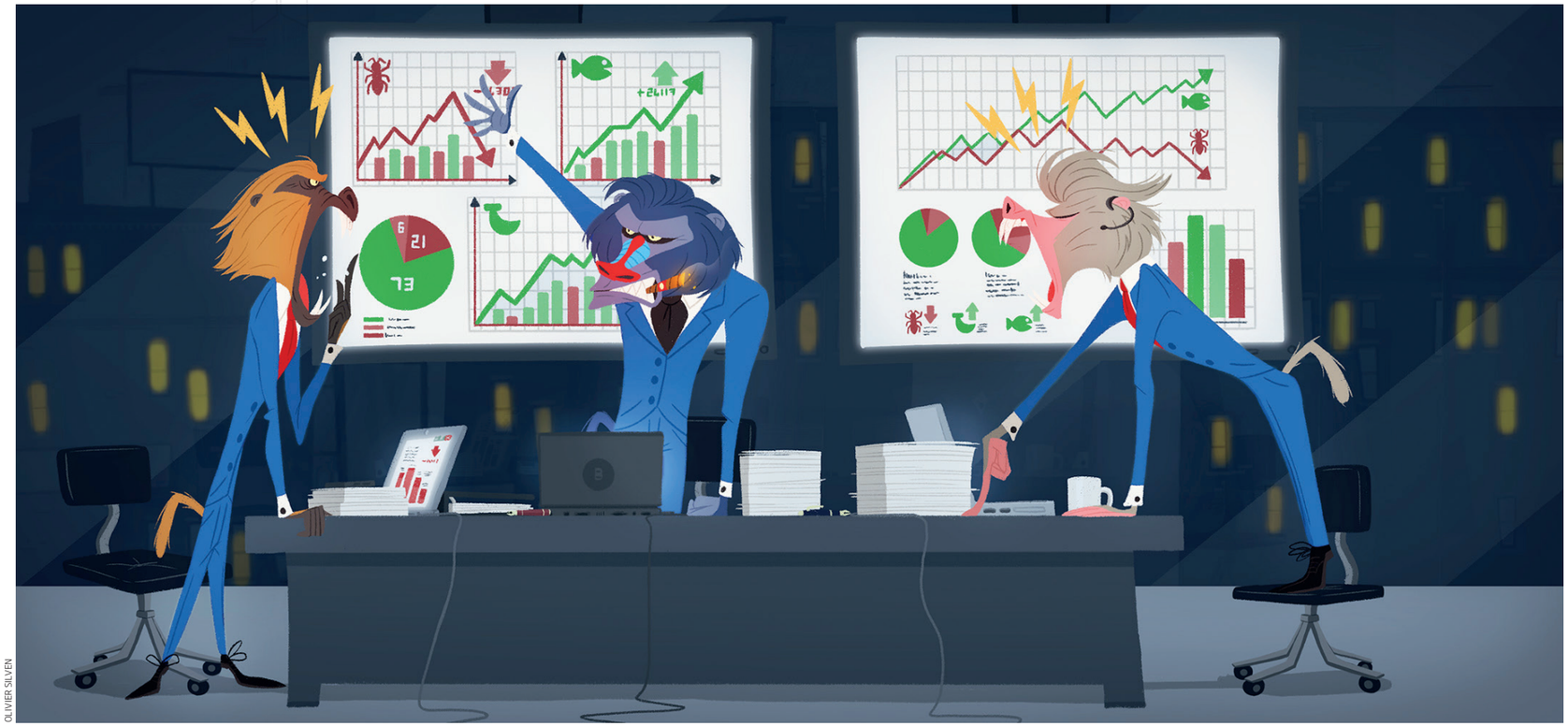
"I was optimistic that the market paradigm would work in this system," says Bshary. "But the sophistication continues to surprise me. These fish are constantly adjusting to market conditions and updating their strategies accordingly."

That they can do so with tiny brains challenges the idea that only creatures with weighty lumps of grey matter are capable of complex behaviour such as responding to shifts in supply and demand. "One of the lessons here is that we are probably going to have to rethink that," says Bshary. "We now see that, at least within ecologically relevant contexts, pretty much any animal can show high levels of sophistication in terms of their behaviour."

Indeed, over the past few years, biologists have shown that scores of animals are capable of responding to market forces, including chimpanzees, macaques, mongooses, ants, wasps and small fish called cichlids.

In one of the most recently unearthed examples of a biological market, the traders don't have brains at all. Kiers studies the underground marketplace in which mycorrhizal fungi trade phosphorus for carbon with the roots of plants. This is the perfect environment for market dynamics to emerge, she says, because a single fungal network can be connected to many plants and switch between trading partners rapidly. The plants in turn can choose from many competing fungal strains.

Sure enough, as Kiers tracked exchanges in these underground networks, she discovered all kinds of economic shenanigans. She and her colleagues employed a series of choice experiments, in which a fungus is connected to several hosts at once. These showed that the fungus will avoid trading with plants growing in the shade, for example. "The fungi are avoiding bad trading partners," she says. But that is far from the fungi's most cunning ploy. Kiers has also caught them hoarding resources, storing their phosphorus in a form that is inaccessible to the plants. "In doing so, they can artificially inflate the price, getting more carbon in return from the plants," she says. "It's a brilliant strategy."



OLIVIER SILVEN

But what is really going on here: is a fungus acting rationally in a way Adam Smith would never have thought possible?

That depends on how you define rational. We know that trading strategies can be determined by evolved mechanisms, not just cognitive means. These are "less flexible, but have been tested and fine-tuned by natural selection", says Noë. "This means that when they are used in situations in which the species at hand find themselves frequently, these strategies can yield better results." Even the simplest organisms operating in markets can give the impression of rational self-interest.

Still, animals, plants and fungi can't match the complexity of humans' economic behaviour. As far as we know, they don't employ a common currency, for instance.

But that can make them all the more revealing. "While primates are undoubtedly more interesting to watch, fungal-plant systems can be precisely manipulated and trades can be tracked," says Kiers. "We can watch trade strategies evolve, study tipping points for when and how trade relationships break down."

Kiers' work has recently attracted attention from Albert Menkveld, a finance researcher at the Free University of Amsterdam. Menkveld is interested in how best to police and regulate high-frequency trading, in which algorithms compete against each other to make profitable trades on split-second timescales. Since both fungi and algorithms are competing with trading partners in similarly uncomplicated ways, it might be possible to use the fungal system to better understand how so-called "flash-trading" markets will respond to certain strategies.

For Kiers, the most interesting thing about studying mycorrhizal fungi is that it reveals trading strategies uncontaminated by cognition. "These are pure economic decisions, nothing to do with resentment or hope or anything like that," she says. "Here we can witness economic behaviour in its most pure and ancestral form." ■

Daniel Cossins is bullish