get money is not something that strikes me as the way I'd do it," says Adrian Liston, an immunologist at the University of Leuven in Belgium. "I'd just take the grant to another agency."

Some researchers see Coveney's victory as an exception that proves the rule — science's version of 'You can't fight city hall'. Liston's own attempt to appeal a funding decision last year was foiled by a Kafkaesque process. When a funder that he declines to name denied a fellowship renewal for a postdoc in his lab, Liston was told that he first needed to request the reviews. They arrived two months later, and were positive. But the funder then told him that appeals had to be filed within a month of a rejection. "It's an appeals process on paper, but they make it so it can't ever be used," he says.

DIFFERING OPINIONS

A lack of expertise on the review panel is one of the few grounds on which the NIH says that it will grant an appeal, in addition to factual errors, bias or conflicts of interest on the part of reviewers. But Lauer says that such complaints often boil down to differences of opinion, which can't be appealed against.

Researchers are personally invested in their grant proposals, making rejection that much harder to handle, says Sally Rockey, Lauer's predecessor at the NIH, who is now executive director of the Foundation for Food and Agriculture Research in Washington DC. "People have a tough time separating their emotions from the actual review itself."

There may now be more motivation than ever to appeal against grant rejections, because the success rates of grant applications are in decline at many funding agencies, notes Björn Brembs, a neurobiologist at the University of Regensburg in Germany who still bemoans the denial in 2003 of a grant extension that he requested in from Germany's major funding agency, the DFG. "At a certain threshold of desperation and lack of alternatives, then an appeal doesn't seem as much of a cost any more," he says.

Appeals could waste the time of overworked agencies already faced with far too many strong applications to fund, warns Douglas Kell, a biologist at the University of Manchester, UK, and former head of the country's Biotechnology and Biological Sciences Research Council. Like the DFG, as well as Britain's other government funders, the biotechnology council does not have a formal appeals process.

"There are lots of things I would say we could do to improve funding procedures," says Kell. "But letting people bitch about the ones that go down isn't one of them." ■ SEE EDITORIAL P.147

SCIENCEATHOME.ORG

Games enable researchers to appeal to the public for help in solving scientific problems.

PHYSICS

Quantum world may be intuitive

A computer game suggests that the human mind is adept at grasping the bizarre laws of quantum mechanics.

BY ELIZABETH GIBNEY

With particles that can exist in two places at once, the quantum world is often considered to be inherently counterintuitive. Now, a group of scientists has created a video game that follows the laws of quantum mechanics, but at which non-physicist human players excel (J. J. W. H. Sørensen *et al. Nature* **532,** 210–213; 2016).

One implication of the team's results is that efforts to use computer games to crowdsource solutions to science problems can now be extended to quantum physics (see page 184). In the past, such gamification projects have been limited to challenging but less mind-bending problems, such as protein folding.

But the work also suggests that the human mind might be more capable of grasping the rules of the bizarre quantum world than previously thought — a revelation that could have implications for how scientists approach quantum physics, says Jacob Sherson, a quantum physicist at Aarhus University, Denmark, who led the study. "Maybe we should allow some of that normal intuition to enter our problem solving," he says. Scientists studying quantum foundations have also long said that finding a more intuitive approach to quantum physics could help to crack outstanding puzzles, although many doubted that this would ever be possible without new theories.

The game, called *Quantum Moves*, is based on a real problem in quantum computing: how fast a laser can move an atom between wells in an egg-box-like structure without changing the energy of the atom, which is in a delicate quantum state. In the quantum world, speed and energy are a trade-off limited by Heisenberg's uncertainty principle, so the trick is to find the sweet spot where the transition from one place to another is as fast as possible without disturbing the quantum state. Endless possible combinations of movement and timing exist, and scientists have designed computer algorithms to try to solve the problem.

In the game, an atom is represented by what looks like a liquid sloshing around in a well, which reflects the wave-like nature of a quantum particle. In one level, players move

a cursor to control a second well, which they use to collect the sloshing liquid and take it back to a base. The liquid behaves according to the laws of quantum mechanics rather than like an actual bucket of water — for example, to pick up the liquid, players can get it to 'quantum tunnel' from one well to another, something that players must learn to adapt to. Once they find ways to transfer the liquid, a computer can then convert their mouse movements to solutions to the real-world quantum egg box.

Sherson's team got around 300 people to play this level a total of 12,000 times on a volunteer-research platform called ScienceAtHome. The researchers then fed the human solutions into a computer for further refinement. Not only were more than half of the human-inspired solutions more efficient than those produced by just computer algorithms, but the two best hybrid strategies were faster than what the quickest computers had been able to achieve working alone. "I was completely amazed when we saw the results," says Sherson.

HUMAN ADVANTAGE

What abilities humans bring to the mix is unclear. Although an interest in physics seems to correlate with ability in the game, success did not correlate with years spent studying quantum physics. Sherson suggests that the superior human strategies stem from the mind's ability to capture the essence of a problem. Quantum concepts may seem less bizarre to people in a game than they do in other contexts, because it is an environment in which they expect rules to be broken, adds Sabrina Maniscalco of the Turku Centre for Quantum Physics in Finland, who runs an event aimed at making games that might benefit quantum physics.

"We should try to be more spontaneous and intuitive about problem solving."

To Sherson, the results also suggest that physicists could use their own intuition more. "We should try to be more spontaneous and intuitive about problem solving," he says. To that end, his team is building a version of the game in which physicists can tweak the scenario to represent different set-ups, potentially offering them new insights into their work.

Other quantum physicists agree that the finding that people can develop an intuition for quantum processes is surprising, but think that scientists already use intuition to solve quantum problems, at least at the mathematical level. By playing the game, people perhaps gain a form of that intuition, says Seth Lloyd, a physicist at the Massachusetts Institute of Technology in Cambridge. He notes that before babies learn to expect an object to stay where it is, they have a form of quantum intuition, which they lose. "Before three months, if it disappears, they guess that's just how things are in the world. After three months, they think, 'Where'd the toy go'?"

Lloyd also says that much of the success of *Quantum Moves* is due to its clever design, which successfully translates a quantum problem to a visual one, but which could fail with more-complex quantum problems.

Physicists who are trying to develop quantum-computing algorithms already play around with graphical interfaces to help them to improve on existing solutions, says Charles Tahan, a theoretical physicist at the University of Maryland in College Park.

But Tahan does think that teaching quantum intuition through games has benefits. He has developed another game, *Meqanic*, that gets players to perform basic quantum computations and intuit the rules as they play. He hopes that it could boost student's abilities and help to find individuals who have an untapped natural flair for the field. ■

CORRECTION

In the News story 'Controversial dark-matter claim faces ultimate test' (*Nature* **532,** 14–15; 2016), the last paragraph was amended to better reflect Katherine Freese's views on the DAMA collaboration's results.