Nature Podcast

Introduction

This is a transcript of the 10th May 2018 edition of the weekly *Nature Podcast*. Audio files for the current show and archive episodes can be accessed from the *Nature Podcast* index page (http://www.nature.com/nature/podcast), which also contains details on how to subscribe to the *Nature Podcast* for FREE, and has troubleshooting top-tips. Send us your feedback to podcast@nature.com.

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Interviewer: Shamini Bundell
Welcome back to the *Nature Podcast*. This week on the show, we're looking at the artificial intelligence recreating our sense of place, and liquid crystals that can deliver cargo.

Interviewer: Adam Levy
Plus, a first-hand account of dealing with depression as an academic. This the *Nature Podcast* for the 10th May 2018. I'm Adam Levy.

Interviewer: Shamini Bundell
And I'm Shamini Bundell.

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Interviewer: Shamini Bundell
Back in 2014, the Nobel Prize in Physiology and Medicine was granted for the discovery of cells which constitute a positioning system in the brain. Some of the key cells in question are called grid cells, special neurons which activate depending on where an animal is. It's sort of like an internal mental map, created by multiple grid cells firing in geometric grid-like patterns. Despite winning a Nobel Prize, there's still a lot we don't know about this neural GPS, and grid cells can be tricky to study experimentally. Now, neuroscientists from University College London, or UCL, have teamed up with machine learning experts at Google-owned company DeepMind. They wanted to see if artificial neural networks could help reveal more about how mammals navigate. I decided to set out for UCL to find out more.

[Street noise]

Interviewer: Shamini Bundell
Today I'm off to see Caswell Barry at UCL. Now, UCL happens to be just down the road from the *Nature* offices, so here I am walking down Euston Road, hoping I can find my way to his department. Aha, this looks like it. So, I've just made my way here in sort of mostly a straight line, with a few detours from the *Nature* offices. So, what kind of things are going in my brain while I'm trying to find this place?

Interviewee: Caswell Barry

So, we know quite a lot of about how the brain navigates. It has sort of multiple strategies and multiple different types of brain cell. So very broadly you can divide the strategies into route-based, where you know a sequence of actions that will get you somewhere and you can follow them, or sort of map-based, where maybe you want to take a route that you haven't followed exactly before, but you know where these places you're going from and to are, relative to each other. And so, if you followed a straight-line route to UCL, then you're almost certainly using a map-based strategy, and that's exactly what we think grid cells and their cousins place cells are important for. They're essentially the brain's way of representing space, and once you've got a representation of space, you can use it a bit like a map to plan routes between places where you've not gone that route before, or maybe take a shortcut, or work round something if there's a barrier to the way you want to get through. So, it's a sort of flexible navigational strategy, and that's presumably what you were doing.

Interviewer: Shamini Bundell
And so, we've known about grid cells and that particular element of navigation for a while, and the research got a Nobel Prize in 2014, but that doesn't mean that we necessarily know everything about it, so you still want to sort of dig in to how it works a bit more.

Interviewee: Caswell Barry
What most people agree on, is that grid cells look like they're important for path integration, so that is updating where you think you are based on how you're moving. So, if you know you're somewhere and you move to ten feet to the north, then you know you're somewhere else. But equally, there's sort of an emerging idea that you can do more with grid cells. If they really do function like the sort of backbone of a map, then actually you can use them to do things like plan direct routes, and so that's called vector-based navigation, but that was still to be proven. It's hard to prove experimentally, precisely because in an animal brain you can't just go in and sort of shut down the grid cells or change what they're doing. That's one of the things we wanted to use - artificial agents to test here.

Interviewer: Shamini Bundell
And that's where you've been working with the people at DeepMind who work on neural networks and machine learning?

Interviewee: Caswell Barry
Yes, exactly. So, this was sort of very much a collaboration several ways. It was a collaboration between UCL and DeepMind, but equally it was effectively a collaboration between neuroscientists and machine learning people.

Interviewer: Shamini Bundell
And, in this case you were interested in a specific problem, tasks that you think grid cells are responsible for, so you wondered how AI will cope with those?

Interviewee: Caswell Barry
Yes, exactly. So, in the first instance we set the network the task of performing path integrations. So, we essentially told it where it was to start with, we told it how it was moving, and we asked it to predict where it was, which is something we think grid cells are very important for in the brain. And so, remarkably we found that the network could learn

to do this, and actually the strategy it employed ultimately developed representations that were startlingly like grid cells. They shared the same hexagonal firing patterns, they shared similar ranges of scale, so grid cells in animals come in multiple scales. So, it really was a sort of very striking and remarkable convergence of form and function.

Interviewer: Shamini Bundell
And the reason you're interested in this is because of the brain, you're a neuroscientist, so what did this machine then tell you about the way that the brain is working?

Interviewee: Caswell Barry
Unlike an animal brain, it's very easy to sort of go in and access, you know, what is any given neuron in this artificial agent doing at a given time, and also, we potentially have direct control over them. So, one of the things we did to understand what advantage the grid cells had inferred on it was, we asked it to navigate, but then we could silence some of the grid cells, and we can then easily test, you know, what can't it do. And so, it's a very sort of powerful testbed for doing something that you would traditionally have done in neuroscientific experiments, but now we're doing them in this sort of artificial model.

Interviewer: Shamini Bundell
And how good is this programme at navigating a maze, say?

Interviewee: Caswell Barry
It's better than humans. So, one of the things we did, was test in the same set of environments how well a professional games player could perform the same task. So, ultimately the task is that you start off at some location, you find your way around, you find a goal, then you get teleported somewhere new, and you have to find your way back to the goal. So, the artificial agent is better than the professional games player, who is considerably better than me, I'd imagine.

Interviewer: Shamini Bundell
And aside from helping you sort of understand the neuroscience of it, is this machine that's better at navigating mazes than humans, is that going to be useful at all?

Interviewee: Caswell Barry
This agent is very good at navigating, certainly in sort of changeable, complex worlds, and so clearly there are uses for things like that. You know, if at any point, you have sort of autonomous vehicles, or things that need to find their way around complex environments then an approach like this, essentially borrowed from the mammalian brain, might prove to be quite effective. Of course, there are scenarios where it wouldn't be. So, if you just have to follow the same route day in, day out, then actually grid cells are much less useful, you might want a path-based strategy.

Interviewer: Shamini Bundell
And so, do you think this is a sort of field, neuroscience-machine learning combo field, that's going to be sort of growing from now on?

Interviewee: Caswell Barry

Yes, I do. I'm very hopeful that, maybe we should call it neuro-AI, but there's definitely mutual benefits to be had. On the machine learning side of things, then demonstrably taking things that we know about how the brain solves problems is really useful and can be incorporated into machine learning approaches, and makes those approaches more robust and more flexible. But equally, we're starting to see sort of information flow back the other way now, so that understanding how machine learning approaches solve a particular problem, is starting to tell us a lot about how the brain might have solved the same sorts of problems, and that's potentially very powerful and a new way of doing neuroscience.

Interviewer: Shamini Bundell
That was Caswell Barry of University College London. You can find his paper and a News and Views article, at nature.com/nature. And if you want to know about some previous work DeepMind has done with neural networks, you can head on over to YouTube, and search for our film: 'The computer that mastered Go'. Plus, there'll be more on artificial intelligence at the end of the show. Physicists are hoping AI can help piece together particle collisions at the Large Hadron Collider. That's in the News Chat, along with concerns about a bear hunt in America.

Interviewer: Adam Levy
It's Mental Health Awareness Month in the US, and Mental Health Awareness Week here in the UK. Mental health problems affect many around the world. In England for example, it's estimated that one in six people experienced a common mental health problem in the past week. And the stresses of research can have particular impacts on mental wellbeing. So, up next, we have a very personal story about the challenges of mental health in academia. Some listeners may find this account difficult, so please use your own discretion.

Interviewee: Dave Reay
Yeah, so I'm Dave Reay, I'm a professor of Carbon Management at the University of Edinburgh.

[Music]

Interviewee: Dave Reay
For this week in *Nature*, I've written about, I've written about depression, but my own depression, and it's one of the hardest things I've ever had to write, because we write obviously, research papers and things like that a lot, but writing something so personal has been difficult. And it's really been something that I've been looking to articulate, certainly, for myself, if no one else, in terms of what happened, you know, how I felt, but also how other people, people around me helped me deal with depression and actually helped me overcome it.

[Music]

Interviewee: Dave Reay
My PhD was really when I encountered really deep depression, and I really, honestly didn't have much of a clue of what I was doing at the start of my PhD. I went into it with eyes wide shut, and quite quickly started panicking that, you know, I didn't know what I was doing,

and everyone else did. I was just scared to admit that I was failing, that I didn't understand what to do, you know, that things were going wrong. It felt like everything was closing in, so it was one of those things where, when I was thinking through how the next day was going to go, how the next week or the month was going, it all just felt undoable, you know, so I just felt like every option open to me was closed off, that everything was going wrong, that was out of control. So, I put on, increasingly, this façade of it was all alright, and this kind of mask to cover that up because it was just turmoil inside. The depth of my depression I think, got so bad because, you know, I didn't talk to anyone. And the saving grace, was really, was my colleagues around me. And they didn't even know it, but just their kind of support, you know, just their warmth. There was one particular guy called Paul, and I really remember it even though it was 20 years ago. And I was like an eggshell, I was so fragile, I think if someone would have said boo, I would have just collapsed in tears. And this guy Paul had clearly just, you know, he was chatting with everyone, but he'd clearly seen in me that, you know, there was something not right. He just came up, and he kind of, he just had a chat, you know, are you alright, he checked I was alright. His warmth that day, just made the difference between my eggshell cracking, and actually it starting to get stronger.

[Music]

Interviewee: Dave Reay
You know, if I was giving advice back to my 20-odd-year-old self, it would be just to talk to someone about it, not to hide it, you know, to remember this is an illness.

[Music]

Interviewee: Dave Reay
What I've realised from talking to people and actually breaking through that, is that it's been a huge help actually speaking out. It's something which has a stigma associated with it still, I think, and the more we talk about it, the more we're aware of it, that, you know, it could be any of our colleagues and our friends, and you know, one the most important things is that they need to know they can speak about it without fear of ridicule, without fear of, you know, kind of being ostracised. Mental illness is with us, it's very common. Depression is part of that, it's also common. It affects academics more than most, actually, based on studies that are being done. People need to know they can speak about their mental illness, just like they would their physical illness, without fear of that kind of stigma.

[Music]

Interviewee: Dave Reay
I do reflect on how I was as a PhD student and as a postdoc, in terms of what would have worked well for me, and try and implement that for my PhDs, postdocs, and staff. For me, it has been learning to listen, and actually one of the things we always do as standard with all of my team and all of my students, is we talk about them. And often it is just, you know, how are you feeling, how are things, you know, and that's really valuable I think, just in terms of that feeling of community, feeling like we all care about each other.

[Music]

Interviewee: Dave Reay
I feel, not a hundred percent secure, in being public about my own depression. I still have anxiety that people will think less of me. But, you know, I feel like it's worth doing just to, if it helps other folk around the world with their PhD students, or other academics think yeah, I'm pleased Dave did that, that kind of chimes with how I feel sometimes, and that, you know, that gives some impetus for them to maybe speak to someone, to speak to a colleague, to speak to a therapist, whoever. If it helps in that little way, then that would be wonderful.

[Music]

Interviewer: Adam Levy
That was Dave Reay who's based at the University of Edinburgh, here in the UK. For more about Dave's experiences, have a look at his Comment piece out this week, aptly titled: 'You are not alone'. What's more, *Nature* is running a three-part series on mental health in academia, the second part of which is out this week. Find this, and Dave's Comment at go.nature.com/wellbeing. And if you are having difficulties, *Nature* has a page detailing a number of ways you can seek support. Just to head to the mental health collection: go.nature.com/wellbeing and click on the support tab. We'll also tweet a link to It from @NaturePodcast.

Interviewer: Shamini Bundell
Still to come: liquid crystals that can deliver tiny cargo on demand. But first, it's time for the Research Highlights with Noah Baker.

[Jingle]

Interviewer: Noah Baker
First up, bats keep quiet to avoid rivals. Many bats find their way around with echolocation, making calls and listening to how the sound bounces back. But when researchers listen in to the echolocation of hoary bats in California, they found that in some situations, bats made much quieter calls, or no calls at all. What's more, they were very interested in a speaker playing echo location sounds. The researchers suggest that by keeping quiet, the bats are hoping to avoid being heard and attacked by rival bats. Locate that paper in the *Proceedings of the Royal Society B*.

[Jingle]

Interviewer: Noah Baker
Researchers have created a lightweight, flexible laser. It takes the form of a polymer membrane, less that a micrometre thick, which can be affixed to all kinds of things from bank notes to contact lenses. Engineers could already make stretchy, bendable LEDs, but typically, early polymer lasers were rigid and bulky. The new polymer laser is powered by an external source, and can be tuned to emit light in a unique set of wavelengths. The researchers say that this could allow the creation of barcode-like laser tags, which could be

used to make bank notes that are harder to counterfeit, or to label sensitive official documents. You can scan through that paper at *Nature Communications.*

[Jingle]

Interviewer: Shamini Bundell
If you've ever pressed down hard on the screen of your smartphone or laptop, you'll have noticed the funny rippling pattern it makes under your finger. What you're seeing is the flowing of liquid crystals, a material that, as the name suggests, combines the properties of liquids and solid crystals. Now, researchers have found another clever use for liquid crystals: tiny cargo delivery systems. Reporter Anand Jagatia spoke to professor Nicholas Abbott from the University of Wisconsin about the research.

Interviewer: Anand Jagatia
So, liquid crystals, probably most people are familiar with them, they're in our smartphone screens, calculators. But what actually are they and what properties do they have?

Interviewee: Nicholas Abbott
Liquid crystal, it's a phase of matter. And so, we're all familiar with things like gases, liquids, and crystalline solids. And so, liquid crystal is yet another state of matter. So, it flows like a liquid, and then like a crystal, the molecules, although their mobile, they are ordered relative to each other over very long distances.

Interviewer: Anand Jagatia
In this paper, you've managed to manipulate liquid crystals in a way that lets you introduce and trap really tiny amounts of cargo inside them.

Interviewee: Nicholas Abbott
Yeah, so, a general characteristic of a liquid crystal is that it's very sensitive and responsive to its environment. And so, we've been using them as a type of sensor. What we've shown more recently, is that you can also use the liquid crystal to provide a response, and so you can release chemical species in response to a whole range of stimuli, and they can be physical stimuli as well as chemical and biological stimuli.

Interviewer: Anand Jagatia
What actually happens to the liquid crystals in response to these stimuli, that makes them kind of release their cargo?

Interviewee: Nicholas Abbott
It's an elastic material, and so just like you can store energy in stretching a rubber band, we can store energy in a stretched or strained state of a liquid crystal. And so, what we're doing, is we're designing liquid crystalline systems that will eject these micro-cargo, sort of by pinging them out, a bit like launching something using a rubber band.

Interviewer: Anand Jagatia
One of the setups that you managed to create was cargo that was released in response to a touch from a human finger, and I think it was responding to the heat, is that right?

Interviewee: Nicholas Abbott
That's right. And so, sort of, the idea is that if somebody touches the material, it will release some chemical content from its interior, and that could be, for example, antiseptic agent, so if you want sort of a self-sterilising material.

Interviewer: Anand Jagatia
Oh, so maybe surfaces and worktops in healthcare environments and things like that?

Interviewee: Nicholas Abbott
Yeah, yeah that's right. Or, you know, things like touch screens.

Interviewer: Anand Jagatia
Yeah, I was going to say I've got so many smudges on my touchscreen right now, could you create something that every time I touch it, it'll just clean itself?

Interviewee: Nicholas Abbott
Yeah, and in fact, I know that there are companies who work on creating touchscreens that will release chemical species to clean the touchscreen.

Interviewer: Anand Jagatia
Well fingers crossed. The next application that you talk about in the paper, which is, I think, really fascinating, is creating a liquid crystal that can store antibiotics, so that's the micro-cargo, and it releases them in the presence of bacteria. Can you tell us more about that?

Interviewee: Nicholas Abbott
In all past examples, the materials have leached the antimicrobial agent continuously.

Interviewer: Anand Jagatia
So, they're just kind of constantly releasing a steady stream of antibacterial agent?

Interviewee: Nicholas Abbott
That's right, that's right. And so, that has many disadvantages, and one is that it can lead to the resistance of the organisms to those agents. But also, it leads to a relatively short lifetime, because you exhaust the supply. So, what we were able to show, is that we can design micro-cargo that incorporate the antibacterial agent. And so, when the microorganisms move past the surface of the liquid crystal, the mechanical forces associated with the motion of the microorganism trigger the release of the antibacterial agent.

Interviewer: Anand Jagatia
So, if you imagine like, I don't know, like a bacterium like *E. coli* swimming along with its little tail, it's these tiny forces that are influencing the liquid crystal?

Interviewee: Nicholas Abbott
That is right, that's correct. So, it's only in the presence of the living bacteria that the antibacterial agents will be released, so it's a self-regulating release.

Interviewer: Anand Jagatia
So, it seems like you've been able to create these materials that can respond potentially to quite a wide range of triggers: movement, heat, electric fields, and potentially can be used to release lots of different kinds of cargo. So, where do you see this kind of technology going in the future?

Interviewee: Nicholas Abbott
Actually, inside the body there are all sorts of mechanical forces which are operating and things like blood flow, can transmit mechanical forces and so, I think there are lots of exciting opportunities to create delivery systems that can be used to deliver drugs in vivo.

Interviewer: Shamini Bundell
That was Nicholas Abbott from the University of Wisconsin talking to Anand Jagatia. And you can see video of the liquid crystal cargo release in the papers supplementary material at nature.com/nature.

Interviewer: Adam Levy
Finally, this week it's the News Chat, and after a year away on maternity leave, Chief News and Features Editor Celeste Biever returns to the studio. Hi Celeste.

Interviewee: Celeste Biever
Hi Adam, really good to be back.

Interviewer: Adam Levy
Now first up, we have a story about bears under threat in America. Now, what are they actually under threat from in this story?

Interviewee: Celeste Biever
They're under threat from hunting. The story is about grizzly bears, and specifically about a proposal from the state of Wyoming, which is one of the states that hosts Yellowstone National Park. And, the state has proposed allowing a hunt of grizzlies to go ahead, which is something that hasn't been allowed for a long time, and follows in the wake of the federal government taking grizzly bears off the list of endangered species last year.

Interviewer: Adam Levy
So, if they're no longer endangered that seems like it would be more okay for them to be hunted, right?

Interviewee: Celeste Biever
Some of the critics of the proposed hunt say that the methods to take them off the list have some issues, and they would contest that this species really is established and safe enough to hunt now. So, for example, there's questions of how the data was collected, that the methods have changed and critics of the hunt say that means that the estimates aren't right. There's also assumptions about females, and how long they continue to reproduce for and that the method was based on the assumption that females will continue to reproduce, but critics say that their reproduction falls off quite dramatically as they get older.

Interviewer: Adam Levy
What are the details of the actual hunt that has been proposed?

Interviewee: Celeste Biever
So, the hunt would involve 24 bears in total, 12 in an area immediately surrounding the Yellowstone Park that's under monitoring, and a further 12 in a wider area that's still counted as the Yellowstone ecosystem.

Interviewer: Adam Levy
And how does that number compare to the number of grizzly bears at least believed to be in Yellowstone National Park?

Interviewee: Celeste Biever
The number believed there is around 700.

Interviewer: Adam Levy
So, what would be the effects on this bear population of removing this number of bears through hunting?

Interviewee: Celeste Biever
Critics of the planned hunt say that in addition to the bears killed in the hunt, any evaluation of the proposal should also take in to account bears that are going to die anyway from other causes. In 2017, 56 died of natural causes or conflicts with people, for example. And so, if that happened again this year, that could be 80 bears altogether and then that doesn't include knock-on effects of killing females who can carry up to 4 cubs.

Interviewer: Adam Levy
And, it hasn't been decided that this hunt will go ahead yet, but it seems some people are concerned that it probably will.

Interviewee: Celeste Biever
So, there's going to be a vote on 23rd May. The proposal has been up for public comments, so we'll see, but it does seem that the state of Wyoming is quite determined to go ahead with it.

Interviewer: Adam Levy
Now, our second story this week is looking at the Large Hadron Collider, and the LHC is looking to artificial intelligence to solve quite a tricky problem. What is this problem that they're hoping AI can solve?

Interviewee: Celeste Biever
So, can I just first of all say that I love this story because it brings together two scientifically rich and interesting topics which is AI and the LHC, and two of my personal favourite sort of things that we report on, so, just to throw that out there. Yeah, the issue at the LHC, which is the Large Hadron Collider, the world's biggest particle accelerator which is situated at CERN, is that they, in the coming decade, they're going to have 20 times more particle

collisions going on which will produce a huge amount more data, which they're going to have to sift through to find kind of the interesting collisions, and sift those out from the noise of the background data.

Interviewer: Adam Levy
And how are they actually sifting through that data at the moment, and why won't that work going forwards?

Interviewee: Celeste Biever
Right now, the way it works is, they get a sort of mess of everything that's being produced in the collider, and the goal is to use that to retrace the tracks that various particles took through the collider. And they're using pattern recognition algorithms to retrace those tracks right now, so it's already being automated. But given the massive increase in volume, those algorithms are basically too slow, and so the idea is, or lots of physicists suspect, that if they set a technique called machine learning, which is kind of the hottest thing in AI right now, and set that to work on this problem instead of the pattern recognition algorithms, that those AI algorithms would be much, much faster and more productive at sifting through these collisions and coming up with the good stuff.

Interviewer: Adam Levy
But they haven't just hired a really good developer or something like that, they've actually laid out a competition.

Interviewee: Celeste Biever
Yeah, that's right, and the organisers of the competition have made public a bunch of simulated data, and challenged software developers to write a programme that can then retrace the tracks from that simulated data, and because they've created that data, they sort of have the actual answers of those tracks. And they've added in some cash prizes, so a coder could win up to $12,000 if their algorithm is the best at reconstructing these tracks.

Interviewer: Adam Levy
And there have been previous artificial intelligence competitions, right? And including one that was sort of searching for the Higgs boson?

Interviewee: Celeste Biever
This was after the Higgs boson was actually found at the LHC, but it was a kind of way to re-find it just using these kind of algorithms, and that was a really sort of sexy competition because the Higgs boson created such a kind of news wave, you know, across the world, not just in science circles. But actually, that challenge was much easier. So, what the coders are being challenged to do with this is a much harder problem, which just makes it more exciting!

Interviewer: Adam Levy
Celeste, thank you for joining us once again, and for more on both those news stories head over to nature.com/news.

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Interviewer: Shamini Bundell
That's all for this week, but make sure to check out the *Nature* video channel, where we're using puppetry to tell the story of an evolutionary trap that caught out an unsuspecting butterfly. That's at youtube.com/naturevideochannel. I'm Shamini Bundell.

Interviewer: Adam Levy
And I'm Adam Levy.

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