Nature Podcast

Introduction

This is a transcript of the 25th January 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: Adam Levy
Welcome to this week's *Nature Podcast*. In the show, we're learning about Three Dimensional Light Painting, and a hexagonal puzzle for rats.

Interviewer: Shamini Bundell
Plus, acrobatic, all-terrain mini-robots. This is the *Nature Podcast* for 25th January 2018. I'm Shamini Bundell.

Interviewer: Adam Levy
And I'm Adam Levy.

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Interviewer: Shamini Bundell
First up today, reporter Benjamin Thompson is here to tell us about an update to a classic neuroscience test.

Interviewer: Benjamin Thompson
Now, I know a lot of you listen to this podcast on your daily commute. You're probably fairly familiar with your route. You know the direction you need to go, the path you need to take and where you are at a given moment. A lot of this information, known as spatial memory, is stored in an area of the brain called the hippocampus. Much of what we know about the specialized cells that build up these mental maps comes from studying rats. But rather than looking at their daily commute, researchers run them through mazes. So, people have been using mazes for well over a hundred years now to try to study cognitive processes in rats.

Interviewer: Benjamin Thompson
This is John O'Keefe from the Sainsbury Wellcome Centre at University College London. John was awarded a Nobel Prize in 2014 for his work on the hippocampus and spatial memory.

Interviewee: John O'Keefe
Over the years now we and others developed many types of mazes and sometimes simpler tests for tapping into an animal's spatial memory and its navigational abilities.

Interviewer: Benjamin Thompson

One of the gold standards for testing rats' navigational abilities is the Morris Water Maze, and it has been used for decades. Now, this isn't a maze in the Greek Labyrinth sense. Instead, it consists of a circular pool about two metres in diameter with a little platform standing somewhere in it. To create the maze, this pool is filled with water, so it just covers the platform. And then something is added to make the water opaque – milk powder perhaps. A rat placed in the pool will swim and swim and swim until it finds the platform and gets out of the water. The first time this happens is entirely by chance. However, the more times the rat runs the maze, the better it knows its environment and the quicker it gets to the platform, regardless of where it starts. The inventor of the Morris Water Maze is Richard Morris. He explains one of the reasons his test has remained so popular.

Interviewee: Richard Morris
Well, it has been used in this standard way, and one advantage of that standardisation is that it's been possible to test, first, ordinary rats and mice and then transgenic animals which have had various mutations to particular genes and compare the results from one test to an earlier test, and in one laboratory they have tested several hundred strains of animal and as a consequence of this standardisation, been able to compare the results and build up great databases.

Interviewer: Benjamin Thompson
But the Morris Water Maze isn't without its limitations. You can measure how long a rat takes to find the platform or the distance it travelled while doing so. But what you can't easily study is the decisions it took along the way. This week, John, who we heard from earlier, has published a paper detailing a new testing method called the Honeycomb Maze.

Interviewee: John O'Keefe
So one of the things we've been interested in doing was to translate the Water Maze into a land-based, dry – if you will – version, where we could measure essentially what was the animal's strategy at any given point in the maze.

Interviewer: Benjamin Thompson
The Honeycomb Maze is a couple of metres across and is made of 37 identical hexagonal platforms, each of which is about the size of an outspread hand. These platforms can be raised or lowered independently of each other. To successfully navigate the maze, a rat has to reach a designated platform where it gets given a little bit of food. Now, this rat can't simply scamper across from start to finish, because it begins the test on a solitary raised platform that's apart from the rest of the maze. Two platforms, adjacent to the one the rat is sitting on then rise giving the rodent a choice as to which direction to follow to best reach the goal. Once it makes a choice and moves to another platform, the other two descend and another two pop up. The rat then chooses one of these and the process repeats until the rat reaches the goal and receives its tasty treat. Because the platforms are hexagonal, the researchers can play with the angle, giving the rats less obvious choices as to which platform will take them to the goal.

Interviewee: John O'Keefe
Under some circumstances, one of those platforms is actually a good direction heading fairly directly towards the location of the goal. But it needn't be. We can give it a choice between

two platforms, one which is 90 degrees to the goal and the other which is 135 degrees to the goal. That enables us to actually force the animal to make choices which it wouldn't have to in, say, the water maze or in any other maze where it could take the best direction to the goal. By doing that we can ask, can the animal calculate which of two directions, neither of which is heading towards the goal, but which of two are better in terms of taking the animal closer to the goal.

Interviewer: Benjamin Thompson
As well as showing that the maze works, John and his team have published some early results. Like the Water Maze, rats don't know where the goal is the first time they run the Honeycomb Maze and it's only when they get there that they're fed. However, once they know where to go, they soon get quicker at solving the task regardless of where they start. But the honeycomb shape also let the team change some of the variables affecting success, like the distance to the goal and the angle between the platforms.

Interviewee: John O'Keefe
In a sense what we've done is taken the Water Maze and the principles behind it which are very important. We've taken that and made it into a maze which gives us a lot of power in asking questions as to what the animals are doing in different places in the maze.

Interviewer: Benjamin Thompson
The Honeycomb Maze does appear to offer the ability to test new variables and has already provided some insights into the complex processes involved in navigating to a goal. So does Richard Morris think the Honeycomb is an improvement on his Morris Water Maze?

Interviewee: Richard Morris
Well I think that the Honeycomb Maze is a very interesting new development. I also like the fact that they can measure performance in lots of ingenious new ways which has not been possible at all previously.

Interviewer: Benjamin Thompson
Richard did note that this new maze and the way it constrains choices may mean that other aspects of brain function will need to be considered when testing. But, as he explains, there are always pros and cons to new techniques.

Interviewee: Richard Morris
That's true of pretty much every test that's ever developed in biology, you know, there are pros and cons and part of the fun of doing it is realising what test you need to use to ask a particular question, but it's not going to answer all the questions. You then have to combine different approaches to really make progress. Without a question in my mind, the Honeycomb Maze is a great step forward.

Interviewer: Shamini Bundell
That was Richard Morris from the University of Edinburgh. You also heard from John O'Keefe. You can find his paper on the Honeycomb Maze over at nature.com/nature.

Interviewer: Adam Levy

Still to come, a new hologram-like display that might remind you of a certain princess from a certain science fiction classic. But before that, what do you picture if you imagine a robot? If you're anything like me, you imagine a metallic humanoid skeleton whose bone structure is eerily reminiscent of Arnold Schwarzenegger. Or perhaps you think of something more practical like a large articulated arm in a car assembly line. You're probably not thinking of a tiny swimming robot a few millimetres long. But mini robots like these could open up whole new avenues in medicine. They could access hard to reach parts of the body to diagnose disease. Or they could deliver a drug, right where it's needed. But the body is a tricky landscape to negotiate. I called up Metin Sitti whose wriggly, all-terrain robot is described in a paper in this week's *Nature*. We started off by talking about the mini medical robots that already exist.

Interviewee: Metin Sitti
They are all different robots with different designs – very specialized robots. However, the body is more complex and such specialized robots only work in specialized regions but when you want to reach the very complex general regions then you want to have many of these capabilities at the same time.

Interviewer: Adam Levy
So you guys decided to set out to build, I guess you could describe it as an all-terrain robot?

Interviewee: Metin Sitti
You could call it an all-terrain robot that can go on soil surfaces, on water surfaces, inside water, and climb on water. Different capabilities are possible.

Interviewer: Adam Levy
Now, how’s it doing this? Does it have like arms and flippers and all sorts of different appendages on it?

Interviewee: Metin Sitti
Indeed, it’s a very minimalist, very simple robot. It looks like an elastic sheet which is around four millimetres long and one millimetre wide and point one millimetre thick – very thin – with magnetic materials inside where we can remotely change the shape of the robot. In that sense it doesn’t use any appendages but the body of the robot is fully soft and changes shape of the body which can induce all these different locomotion modalities.

Interviewer: Adam Levy
Was it inspired at all by any particular life form or anything like that or were you really just starting from scratch?

Interviewee: Metin Sitti
So, this type of soft, tiny robot is inspired by many soft bodied organisms, for example, caterpillars, beetle larvae and also jellyfish.

Interviewer: Adam Levy
So were you kind of thinking, oh well it can walk like a caterpillar but swim like a jellyfish?

Interviewee: Metin Sitti
Exactly, so all these kinds of properties are very close to natural soft bodied organisms. If you look at animals they do all of these modalities at the same time because they need to live in very complex environments.

Interviewer: Adam Levy
How do you actually achieve these different shapes in what essentially is just this little piece of paper almost?

Interviewee: Metin Sitti
So this paper has many magnetic particles inside that we program. So for example, when we give it a specific remote magnetic field, the sheet becomes a sine wave or a cosine wave. And then also it can look like a U shape or a V shape that has a specific shape that we control from outside.

Interviewer: Adam Levy
So it's not just this little robot on its own; it's also that in combination with this magnetic field?

Interviewee: Metin Sitti
Exactly. Our soft tiny medical robot is inside your body with a limited space where we can remotely input or apply a magnetic field to control its body shape and its navigation.

Interviewer: Adam Levy
It sounds like a relatively simple idea but was it difficult to actually achieve the physical reality of it?

Interviewee: Metin Sitti
The complexity is in the design and knowing which type of input can create all of these shape changes. The end result looks simple; that's the nice thing about it but the process is not so simple. But the end result hopefully looks simple enough.

Interviewer: Adam Levy
And it is really versatile: it can swim, it can walk about, and it can do things like jumping. So did you know, once you'd designed it it'll be able to do all these things or did you kind of discover new things it could do as you went along?

Interviewee: Metin Sitti
We didn't know how many of these we could achieve from the beginning. We started with swimming and we discovered at each step that we could achieve more and more. We could achieve seven different locomotion modalities for the first time.

Interviewer: Adam Levy
And one of the tests you've actually put it through was sort of obstacle courses where it has to do different things one after the other.

Interviewee: Metin Sitti

Since we wanted to show that we could achieve all of them at the same time, it's like a triathlon or a competition where you want to show a robot can roll, can jump, and then can go to the water surface and swim and dive, come out of the water surface and climb again. All of these modalities we can show in the same robot.

Interviewer: Adam Levy
This little robot, it's very cute, but when could we actually see something like this being used?

Interviewee: Metin Sitti
Very soon. Already we have started on our demonstration activities for medical use. For example, in the GI tracts or in the intestines or inner tract these kind of tiny, soft robots can reach the area that we want and then look like a patch that can go and deliver a drug for a long time in the given area. These are activities we are currently pursuing that we plan to demonstrate their medical demonstrations in one or two years.

Interviewer: Adam Levy
That was Metin Sitti, who's at the Max Planck Institute for Intelligence Systems in Stuttgart, Germany. His paper's available in the usual place. And if you want to learn about some much bigger designs for soft robots, we made a video a little while back all about the engineers developing octopus-inspired machines. Find it at YouTube.com/NatureVideoChannel.

Interviewer: Shamini Bundell
Now it's time for the Research Highlights. Benjamin's back, and he's brought some science with him.

[Jingle]

Interviewer: Benjamin Thompson
What are your eyes up to when you're sound asleep? To find out, researchers used infrared light to peer into mice's peepers while they snoozed. This allowed the researchers to measure the pupil size over the course of a nap. The deeper the sleep, the more the pupil constricted. The researchers suggest that this narrowing may be serving as a kind of back up for the eyelid, protecting the mouse from being woken by light, to help avoid interrupting the important brain activities that happen during deep sleep. Have a look at the paper over at *Current Biology*.

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Interviewer: Benjamin Thompson
A couple of years ago, over 200, 000 antelope dropped dead in Kazakhstan in just three weeks. A post mortem of these *Saiga* antelope revealed the culprit was a bacterium called *Pasteurella multocida*, a microbe that doesn't usually harm healthy *Saiga*. The reason that these normally benign bacteria became so deadly is unclear, but researchers analysed the weather during several recent die-offs and found that the outbreaks were linked to high temperatures and humidity. Considering the world's changing climate, the team

recommend a number of management practices to protect the remaining *Saiga.* Find that study in *Science Advances*.

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Interviewer: Shamini Bundell
I'm a big fan of science fiction as some of you may remember from previous sci-fi themed podcast sections. I love the creative ideas about advanced technology but for some researchers, seeing the area of science they work in represented on screen can be rather frustrating.

Interviewee: Daniel Smalley
I went to see the movie *Iron Man* and there was a scene in that movie where Tony Stark sticks his hand into what is ostensibly a holographic gauntlet.

Interviewer: Shamini Bundell
This is Daniel Smalley, a holographer who designs three dimensional displays that are almost, but not quite, like the holographic gauntlet seen in the film.

Interviewee: Daniel Smalley
I couldn't enjoy the movie and I walked home sullen afterwards because this was a display that holography could not create.

Interviewer: Shamini Bundell
Despite making for a rather unhappy cinema experience, this frustration led Daniel to think about what he might do differently. He wondered how he could create a floating image that exists in real space that could wrap around objects like a gauntlet, one that you could interact with and view from every angle. Traditional holograms only work from a limited range of viewing positions so Daniel turned to a different field: volumetrics. Volumetric displays form an image in real three dimensional space, just like the displays of science fiction. Think of the *Star Wars* robot R2D2 projecting a miniature Princess Leia, or the large interactive screens of the film, *Minority Report*. In the real world, however, the technology is still in its infancy.

Interviewee: Daniel Smalley
There were a number of pieces of work, in particular, the hollow dust concept. The idea was you walk into a dusty room and you take an infrared laser and you scan the room to find those dust motes and then you shoot a visible laser at them and get them to shine. And if it's sufficiently dusty, you might be able to create an image in the room.

Interviewer: Shamini Bundell
The idea of a very dusty room should theoretically work but it doesn't sound very practical. Daniel wondered if he could adapt the basics of this idea – lasers shining at pieces of dust – but without needing a whole room full of particles. He found the answer in the field of optical trapping: the ability of light to capture small particles and in particular a technique called photophoretic trapping.

Interviewee: Daniel Smalley
You create something like a tractor beam for a small piece of dust. You create a little pocket inside a high intensity laser point and that particle, that little opaque particle, can just sit inside that pocket. And if it tries to get out, it will experience a force pushing it back to the centre.

Interviewer: Shamini Bundell
Photophoretic trapping meant that instead of relying on dust in the air, the team could suspend a particle exactly where they wanted using a low visibility laser and reflect visible light off it, using coloured lasers to make it glow. But how does a single coloured particle turn into the kind of detailed image needed for a 3D display?

Interviewee: Daniel Smalley
I think the best way to think about how this display is operating is just to imagine what it was like as a child on a summer evening to write your name with a sparkler in the dark. So you won't see a point, instead you'll see a line that you can write in the air.

Interviewer: Shamini Bundell
In this set up, the glowing particle is not just held by the laser beam, but also moved around by it. And it can move fast enough to create a solid looking floating shape. The images can be very high resolution but they are also tiny, less than a finger's width across, due to the distance the single particle has to cover. To scale it up, you'd need lots of particles moving at the same time, which would be a lot more complicated to control, but it could achieve what Daniel wanted when he walked out of the *Iron Man* screening: a display that could wrap around your body and react to your movements. But even then, Daniel isn't quite satisfied that he'll have properly recreated the 3D displays of science fiction.

Interviewee: Daniel Smalley
There is a missing piece here. So, free space volumetric displays historically have only been able to make ghosts and holes. That is to say that one part of the image can't include or eclipse the image. So for example, if you're projecting out an image of Princess Leia, you're going to be able to see both her hair buns at the same time from every different direction. Now, this could be overcome if there were a way to get those particles to only scatter in one direction and not another and since this is part of our current effort, I can't say too much about that. But I'm going to say that I think that is absolutely possible.

Interviewer: Shamini Bundell
So, can we all look forward to floating 3D displays in the middle of our living rooms? Barry Blundell, who also works on volumetric displays, doesn't think so.

Interviewee: Barry Blundell
Volumetric displays are never going to provide us with some form of 3D television. They are not for photo realism, they are for spatial information. If you're looking at things like fluid dynamics where you want to view three dimensional motion within 3D space, volumetric displays are perfect.

Interviewer: Shamini Bundell

Barry can see a range of uses for volumetric displays, including visualizing delicate surgery or 3D design work, but he suspects that different applications may require different technologies. Which technique you would use would vary with the size and detail of the image, or the need to move around and interact with it. Different groups are working on a variety of options and technologies but Barry considers Daniel's team's work particularly novel.

Interviewee: Barry Blundell
The 3D volumetric research world is full of that reinventing the wheel. What these researchers have done is come up with a refreshingly interesting technique that is nothing like anything that's been done before.

Interviewer: Shamini Bundell
That was Barry G Blundell of the University of Derby in the UK who has written a News & Views article about the new paper. You also heard from paper author Daniel Smalley of the Electro-Holography Group at Brigham Young University in the US. Find out more about this story on nature.com/nature.

Interviewer: Adam Levy
Time now, as ever, for our weekly News Chat, and I'm joined on the line by Lauren Morello, *Nature*'s Americas Bureau Chief. Hi Lauren.

Interviewee: Lauren Morello
Hey Adam.

Interviewer: Adam Levy
Now, the US Government shut down for a few days. It's now opened back up. How big a disruption did these few days of no US Government cause for everyone?

Interviewee: Lauren Morello
So just to recap for people who weren't following this obsessively, the US Congress didn't put in place a spending bill to pay for government operations after Friday the 19th which is when the previous short term spending bill expired, so the government shut down at 12.01am on Saturday the 20th. It reopened late yesterday which was Monday the 22nd. The effects of the shutdown were kind of blunted by the fact that it was three days and it started on the weekend. Even so, we've heard from a lot of scientists that their agencies were kind of scrambling, definitely for that last few days before the shutdown to figure out which employees were essential and what things they'd have to do to prepare labs and offices to shut down for some indefinite period of time, because when the shutdown began, nobody knew it was going to be three days long. The last shut down was 16 days long.

Interviewer: Adam Levy
Yeah, so I guess they had to prepare thinking it could be a few weeks.

Interviewee: Lauren Morello
Yeah, normally what happens is under US law, if there's not a budget in place, the only people who are allowed to stay on the job are so called essential employees and they are

the ones that are needed to protect life and property. Everybody else gets told, you know, come in for a couple of hours, anywhere from two to four hours, clean out your office. Make sure you throw out that sandwich left over from yesterday so it doesn't attract bugs while everything shuts down. Then go home. You're not allowed to use your government email or check your government voicemail until the government reopens. You can't come back to your office or your lab. It's really disruptive.

Interviewer: Adam Levy
And who's it actually disrupting? Who are the researchers who are affected by this kind of thing?

Interviewee: Lauren Morello
So it affects individual agencies to different degrees based on what kinds of science they do and whether they have any outside funding. At the Food and Drug Administration their shut down plan calls for 45% of their employees to be sent home which is a pretty low percentage and the reason they're able to keep more than half of their employees working is because they get significant user fees from industry. But at the US Geological Survey, their shut down plan calls for 99.1% of their employees to be sent home. Basically, the only people that would still be working during a shutdown there would be the seismologists in Colorado that do 24/7 real time analysis of earthquakes around the world.

Interviewer: Adam Levy
And all those people could be sent home again in a few weeks' time, right?

Interviewee: Lauren Morello
Yeah, so the spending bill that congress approved yesterday and the President signed last night only goes through February 8th which is less than three weeks from now. And if the folks in congress haven't resolved this disagreement that sparked to shut down last weekend which was over immigration policy, it's totally possible that the government could shut down again in early February.

Interviewer: Adam Levy
How are researchers reacting to all this uncertainty?

Interviewee: Lauren Morello
Well, it's part of a bigger problem for them. The shutdown is the most visible part but the 2018 fiscal year began on October 1st of last year. And since then the government has been run by either four or five short term spending bills and basically what those bills do is continue the spending level from the 2017 budget year. No new programs can start. No programs that people want to end can end. It just perpetuates the status quo and that creates a lot of uncertainty. It's really hard if you're an agency, to figure out how much money you have to give out for the grants for the rest of the fiscal year which goes through the end of September if you only know what your funding is through the middle of February. There's just a lot of uncertainty right now because Congress hasn't been able to agree on a spending plan for the rest of this budget cycle.

Interviewer: Adam Levy

Let's move across the Atlantic to France where a fossilized femur has been causing quite a bit of a stir.

Interviewee: Lauren Morello
Right, so, this is a femur from a primate that was unearthed in Africa and some researchers think that this is a femur from a hominin, so a relative of humans and two researchers wanted to present their analysis on this femur at a meeting organised by the anthropological society of Paris and the society turned them down.

Interviewer: Adam Levy
What was their explanation for turning them down?

Interviewee: Lauren Morello
So what they told us is that they'd rejected six out of 65 abstracts submitted as presentations for this meeting and they said, 'this work is conducted by an independent and impartial scientific committee which is sovereign in its decision, hence any accusation about this would not be founded.' So that's interesting. You normally don't hear organizers of scientific meetings talking about their sovereignty.

Interviewer: Adam Levy
But this femur goes alongside a skull which has been described previously in quite a lot of detail.

Interviewee: Lauren Morello
So, the femur bone is related to a skull, a seven million year old fossilized skull from a species that's been named *Sahelanthropus tchadensis*. It was discovered in 2001 at a site in Northern Chad in Africa and some people argue that the skull is the oldest fossil evidence of a hominin species, so of a human ancestor.

Interviewer: Adam Levy
And although there hasn't been a papal or a presentation on the findings related to this femur, do we know whether they support this hypothesis that these remains did belong to a hominin.

Interviewee: Lauren Morello
So the two researchers that analysed the femur argued that it looked pretty different from the bones of another ancient species – a hominin found in Kenya in 2000 that's about six million years old. So the researchers who analysed the *Sahelanthropus* femur don't think it's actually a hominin. They think it's some other kind of primate – maybe a great ape. They also say that it's going to be really hard to make a final conclusion without a little bit more study.

Interviewer: Adam Levy
How are others in the field reacting to, I suppose, all this secrecy around this femur?

Interviewee: Lauren Morello

I think folks are a little bit frustrated because what everybody seems to agree is that analyzing this femur is going to be crucial to determine whether this *Sahelanthropus* species actually was a human ancestor, a hominin, and whether it walked upright.

Interviewer: Adam Levy
Lauren, thank you very much for speaking with us. For more on that fossil femur or on the US shutdown, head on over to Nature.com/news.

Interviewer: Shamini Bundell
That's it for this week but if you'd like to see some of the floating 3D images we were discussing earlier, you can head on over to youtube.com/naturevideochannel. You'll also find there, a new video about the evolutionary arms race between predators and prey. I'm Shamini Bundell.

Interviewer: Adam Levy
And I'm Adam Levy. Thanks for listening.

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