Science Magazine Podcast
Transcript, 6 September 2013
http://podcasts.aaas.org/science_podcast/SciencePodcast_130906.mp3

Music

Host – Sarah Crespi
Welcome to the *Science* Podcast for September 6th, 2013. I'm Sarah Crespi.

Host – Linda Poon
And I'm Linda Poon. This week: Monitoring a North Korean volcano [00:57], numerosity in the brain [21:32], and failed stars [11:14]…

Interviewee –Trent Dupuy
So then the key question is whether the brown dwarfs we're interested in are cooler, fainter, and nearby, or if they're warmer, brighter, and more distant. And so the only way to know that for sure is to measure their distances directly.

Host – Sarah Crespi
Plus, a few stories from our online daily news site [29:19].

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Music ends

[00:57]
Host – Sarah Crespi
Science diplomacy is the use of scientific investigations as a bridge over troubled political waters. Richard Stone covered a recent example in a News Focus this week on collaboration between US and UK scientists with North Korean colleagues at the base of a volatile volcano. He starts our conversation with a description of the eruption of Mt. Paektu, one thousand years ago.

Interviewee – Richard Stone
Well, one thousand years ago Mt. Paektu erupted, and it was a gargantuan eruption. You had pyroclastic flows coming down valleys on both sides of the volcano – the volcano sits on the border of China and North Korea – so you had this massive searing hot gas and ash and rocks just flowing down the volcano through valleys. And then you had immense ash fall covered 33,000 square kilometers mostly on the Korean side of the border. Then ash fell as far away as Japan. Five centimeters of ash was recorded having fallen on Japan several hundred kilometers to the east. So, really, it was one of the

biggest eruptions in the last 10,000 years. It rivaled the 1815 eruption of Tambora, which created the so-called year without a summer.

Interviewer – Sarah Crespi
Wow! So what do we know about this volcano and what is powering it?

Interviewee – Richard Stone
This volcano is really an enigma. It's not on the Ring of Fire. So the Ring of Fire is where the tectonic plates come together in the Pacific – both sides of the Pacific. These seams in the tectonic plates give rise to volcanoes, and some of the most powerful volcanoes are located on this Ring of Fire. Mt. Paektu is several hundred kilometers to the west of the Ring of Fire, so it's not driven by that process. One possibility is you have the Pacific plates subducting under the Asian mainland, basically stabbing like a knife blade deep under Mt. Paektu, 600 kilometers below Mt. Paektu. What could be happening here is water being squeezed from minerals in this subducting plate. And you add water to hot mantle rock and that can make the mantle rock melt, creating the magma supply for Mt. Paektu. That's one hypothesis. There's a second idea, and that is that there is a mantle plume that's firing Mt. Paektu. And this mantle plume process is what is responsible for the Hawaiian volcanoes, for instance. So there could well be a mantle plume there. Some of the seismic imagery has pointed to the existence of a hole in the subducting Pacific plate, and that hole might indicate a mantle plume. Or there might be as yet undescribed mantle processes happening. Bottom line, though, Mt. Paektu is a mystery: why it's so potent, why it created such a powerful eruption a thousand years ago. And that's what the scientists are most curious about, you know, why they really want to go to this rather forbidding place and try to learn more about this volcano.

Interviewer – Sarah Crespi
Well let's talk about those teams. This isn't just North Koreans and Chinese researchers doing this, looking into this mystery. Can you talk about all the different groups that are involved in this?

Interviewee – Richard Stone
Up until now, you basically have had the Chinese and the North Koreans doing their own thing, so there wasn't really any joint studies. So the Chinese had been monitoring the volcano from their side of the border and the North Koreans from their side. Both countries are concerned about the volcano as a potential threat. There was shaking at the volcano about a decade ago. The shaking lasted a few years. So it indicated the likelihood of magma rising higher and possibly up into the volcanic cone as a precursor to an eruption. It didn't amount to anything, it petered out. But, yet, there's still potential for a powerful eruption there, so both sides have been monitoring it. The North Koreans, of course, have been pretty isolated and they reached out to seek western input into their studies. They made a connection with a volcanologist, Clive Oppenheimer, at University of Cambridge. Clive recruited a seismologist, James Hammond, who is now at Imperial College. So together they made a preliminary foray to Paektu in 2011 to size up the potential for collaboration. After two years of preparatory work they finally got out into the field for this summer's research expedition.

Interviewer – Sarah Crespi
So for this trip, what kind of measurements were these researchers looking to make?

Interviewee – Richard Stone
So the North Koreans, they are isolated not just from their peers in the scientific community but they've been isolated in the kind of technology which they can acquire for studying this volcano, so they've been getting by with pretty basic equipment. One thing that the British researchers could add as an added value to what the North Koreans were already doing was they could install broadband seismometers. So they installed a linear array of seismometers, six of them. This will have two purposes. One is it will help the North Koreans monitor local shaking. So if the volcano becomes active again, they have these in place and they can have a very good record of exactly the types of seismic waves, and they could keep a pretty close eye on it. The other use of the seismometers is to image the magma chamber. And the way they do that is you have earthquakes all around the globe, and the waves from the earthquakes travel through the ground underneath Mt. Paektu. And when they reach the seismometers on the other side, on the North Korean side, the way that the seismic signals change as they go through different types of rock, you can get kind of a rough image of where the rock is molten. So it's pretty interesting. It's not a fine-grain picture, it's not like taking a snapshot, but they can get a rough sense of the size of the magma chamber. Now there was a second scientific objective to the expedition, and that was to collect geological samples. So Clive Oppenheimer and an American graduate student were out there collecting pumice from the massive eruption a thousand years ago and also possibly from more recent eruptions. There's historic record of at least two or three eruptions in the past thousand years – one as recently as 1903 – so try to get a better sense of the eruptive history of Mt. Paektu as well.

Interviewer – Sarah Crespi
Okay. As you kind of alluded to before, this is a remote and politically sensitive area. What were some of the hurdles that the scientists faced in trying to study this?

Interviewee – Richard Stone
The biggest impediments actually were sanctions. So you have sanctions imposed by the United Nations and additional sanctions imposed by the United States. And basically the sanctions prohibit the importation of scientific equipment. Even in this case for the expedition, the seismometers are going to be in place just for one year, so it's a temporary import. But to get permission to bring the seismometers into North Korea required getting what's called an export license from the US and the UK government. The US process, it's pretty lengthy but it came through. And the British review took longer; in fact the scientists were kind of sweating it. It came right down to the wire before the British government did sign off on its export license. Everything came together in the nick of time basically, because the field season at Mt. Paektu is a fairly narrow window. It's brutally cold there, very snowy in the wintertime. From about mid-October until mid-May, you can't access the area closest to the caldera. The caldera is basically not accessible for seven or eight months. So the field season is rather short. They needed to

get out there this August or, at the latest, September. It all came together and they were out in the field for about a week, and from what I understand things went very smoothly.

Interviewer – Sarah Crespi
Great. So these seismometers will be in place for a year and they have the samples that they collected. What are the next steps for this research? Where does it go from here?

Interviewee – Richard Stone
This is a fairly modest scientific objective at this point. They wanted to be able to achieve real research but not overreach. They do have aspirations for a much, much more extensive research program. One possibility would be a much larger array of broadband seismometers. That's very high on their wish list. Another possibility would be to conduct magnetotelluric studies, which is to look at the electric conductivity. And that can help in conjunction with the seismic studies. You can get a much sharper image of the magma chambers. There are various additional studies, which can conceivably be done. This would require much more extensive review from the US and UK governments, of course. And another long-term goal which would be helpful for really getting the best picture of how this volcano works is if you have collaboration on both sides of the volcano, so the Chinese and the North Koreans working together possibly with western colleagues. So if you get this whole volcano view, if the studies are done in concert on both sides of the volcano, then of course that'll give you the best dataset. That hasn't happened yet and that, of course, is something that, based on this initial success, they can start working toward that.

Interviewer – Sarah Crespi
Great. Well, Richard Stone, thanks so much for talking with me.

Interviewee – Richard Stone
It's my pleasure.

Host – Sarah Crespi
Richard Stone is the International News Editor for *Science*. He writes about North Korea's 'slumbering giant' in this week's issue.

Music

[11:14]
Host – Linda Poon
Too small to be stars and too massive to be planets, brown dwarfs—sometimes known as failed stars—are often referred to as the missing link that bridges the gap between the two. Understanding the coolest known brown dwarfs, which share characteristics with gas-giant planets like Jupiter, may help us draw a clearer picture of what makes a star a star and a planet a planet. Trent Dupuy now presents a major piece of the puzzle in understanding these free-floating objects—the precise measurements of their distances, which can be extrapolated to more accurate measurements of temperature, luminosity, and mass.

Interviewee – Trent Dupuy
So astronomers are always looking for colder and colder free-floating, star-like objects. One key reason for this is that their atmospheres have similar temperatures to many of the gas-giant planets that have been discovered orbiting stars other than the sun, so they're like little laboratories where you can study atmospheric physics relevant to extrasolar planets but without the glare of their host star. And two years ago, several members of a new class of these star-like objects were identified by astronomers using data from NASA's Wild-field Infrared Survey Explorer mission. The best evidence available at that time suggested that these objects were colder than anything known previously, and it was even suggested that the surface temperature of the coldest of these was room temperature. So we set out to test these ideas by using Spitzer Space Telescope data to measure their distances through the annual parallax effect. And despite being somewhat warmer than expected, they're still by far the coldest brown dwarfs known, and to explain these low temperatures we find that their masses can only be 5-20 times that of Jupiter.

Interviewer – Linda Poon
So let's start with kind of understanding what a brown dwarf is. So they're kind of in an odd place, they're between stars and planets. So what makes a brown dwarf not quite a star but also not exactly a gas-giant planet either?

Interviewee – Trent Dupuy
Right. So the term brown dwarf applies to these objects that may have formed like our sun or other stars, but that didn't gather enough mass to raise their core temperature and pressure to levels needed for the nuclear fusion of hydrogen. So without hydrogen fusion, their only sustained energy source comes from the gravitational potential energy that gets released as they contract. So this causes them to warm up and then they radiate away this thermal energy over their lifetime, gradually getting colder and fainter. And so this is very different from the lifecycle of a main sequence star like our sun that shines stably for billions of years. On the other hand, the difference between brown dwarfs and planets is a little less clear cut. Most of the brown dwarfs that astronomers have studied over the last two decades are actually much more massive than the planets in our solar system. The most massive brown dwarfs can be up to 80 times the mass of Jupiter, and they also probably formed from a cloud of gas collapsing on itself under its own self-gravity. But both these traits make brown dwarfs seem a little more similar to stars than planets. However although the objects in our study probably did form from self-collapse too, they're actually much less massive. So the only thing that really distinguishes them from what most astronomers would term a planet is that they don't orbit a star.

Interviewer – Linda Poon
OK, so the missing piece of the puzzle to really understanding these objects is the precise distance, which in the past has been, you know, difficult to measure. So can you just explain why is it so important to know the distance?

Interviewee – Trent Dupuy

Sure. So for anything that glows thermally, like these brown dwarfs or even stars like the sun, they follow a simple rule. If you sum up the light that's emitted over all wavelengths, then the hotter the object is the more light it'll put out. And so this is a really great tool because it gives us a very direct way to measure the temperatures of stars, you just have to know how much light they're putting out. So we already have the means to capture most of the light that these brown dwarfs are putting out and measure how much of it we're receiving here at Earth. So then the key question is whether the brown dwarfs we're interested in are cooler, fainter, and nearby, or if they're warmer, brighter, and more distant. And so the only way to know that for sure is to measure their distances directly.

Interviewer – Linda Poon
So you were able to directly measure their distance using the Spitzer Space Telescope. So can you tell us a little bit about how it works?

Interviewee – Trent Dupuy
Sure. So to measure these accurate distances, we had to look for very small changes in the position on the sky over time caused by the parallax effect. So the parallax effect is just a simple geometrical effect that is the same as when you hold a finger up at a distance from your face and then close one eye and then close the other, when you see your finger appear to move with respect to distant objects in the background. So classically, astronomers have used the Earth's orbit around the sun to provide the leverage needed to observe this small effect on nearby stars with respect to the distant background stars. The Spitzer Space Telescope also orbits the sun so it sees parallax motions in the stars too. But this motion is very small; it lies entirely within a fraction of one pixel in the camera aboard Spitzer Space Telescope. And so my collaborator, Adam Kraus, has been working on improving the precision to which positions can be measured with this camera, and this is what has enabled us to actually measure this tiny motion. In fact, Spitzer's camera is the ideal tool for this work because it can measure very sensitive images of these faint brown dwarfs very efficiently.

Interviewer – Linda Poon
Okay, so now that you have the better measurements, what can you tell us about the properties of these cool brown dwarfs?

Interviewee – Trent Dupuy
So first I can report that they are indeed the coolest brown dwarfs known. We now know that they have temperatures of about 400-450 Kelvin, which is about 250-350 degrees Fahrenheit. And to reach these cool temperatures after cooling for billions of years, it seems that they would have to have started out with no more mass than about 5-20 times that of Jupiter, and so they sort of fall around this blurred line between planets and brown dwarfs. Interestingly, they also turn out to be a bit warmer than what's expected. By comparing theoretical models of different temperatures to the actual measurements of the molecular absorption features in these brown dwarfs, some had previously estimated that they would have temperatures that were basically 15-25% cooler than what we found. And this may not sound like a whole lot, but that would be sort of equivalent to getting

the temperature of the sun wrong by over a thousand degrees Kelvin or 2,000 degrees Fahrenheit, and so it illustrates the sort of limitations we currently have in the complex atmospheres of these objects.

Interviewer – Linda Poon
So the coldest of the coldest brown dwarfs belong to what's called the Y-spectra class. And you found that temperature isn't the only determinant in shaping the spectra. So how does this change the way we classify extreme sub-stellar objects?

Interviewee – Trent Dupuy
Right. So these new cold discoveries were tentatively given the spectral type Y when they were discovered two years ago. This is meant to be an extension to the same special classification scheme that was established over a century ago and that, for example, calls the sun a G-type star because the existence of certain atomic absorption lines in the spectrum. In the late '90s and early 2000s, two new spectral types – L and T – were added to account for new cool stars and brown dwarfs being discovered in the infrared surveys at that time. So the new spectral type Y is only the third time that we've had to add a new classification to account for objects that are cooler than any of the ones that were known at the beginning of the 20th Century because new features keep showing up as you go to lower and lower temperatures. And so for stars and the warmer L- and T-type brown dwarfs, spectral type is generally very strongly correlated with temperature. This is partly by design but, really, it just comes down to the fact that the appearance and disappearance of different atomic and molecular features in the spectra correspond to the changing chemistry in the atmosphere. And this chemistry is typically driven by temperature. So our study provides the best temperature estimates yet for these new Y-type brown dwarfs, and what we see is the spectral classifications don't seem to track that well with temperature anymore. So, for example, the objects that's been thought of as the archetypal Y-dwarf, which has the most extreme spectral features of any of these new Y-type brown dwarfs, turns out to be warmer than the objects that are thought to be right at the transition from T- to Y-spectral types. So this and some other evidence points to physical properties driving the atmosphere chemistry that are not just temperature. So some possibilities are variations in the strength of gravity at the surface – which is basically determined by how massive the objects are – or maybe there are significant differences in how much convective mixing is going on in these different objects. More vigorous mixing would allow a greater proportion of warm material to well up from the deeper layers of the atmosphere and make it to the surface.

Interviewer – Linda Poon
So these brown dwarfs are often referred to as the missing link to gas-giant planets, and even you said it—they sit on a very blurred line. So do these measurements indicate that stars and planets actually lie on the same continuum and that there's more similarities between the two than we think?

Interviewee – Trent Dupuy
I think it's true that nature doesn't seem to care if a ball of gas that will one day become a "star" has the mass needed to fuse hydrogen or deuterium or what. Deuterium fusion that

occurs briefly while the supplies last, the beginning of a brown dwarf's life, and so it's sometimes used to define what objects should be called brown dwarfs versus planets. In the traditional sort of evolutionary science sense of the term missing link, it does sort of apply to brown dwarfs because they possess traits that belong to both stars and planets. They form like stars with their own circumstellar discs, but they reach the temperatures of planets and even have weather due to clouds on their surface. So these new coldest brown dwarfs just push the envelope even more because they actually have masses that overlap with objects that most astronomers would consider to be planets.

Interviewer – Linda Poon
Well, Trent Dupuy, thank you so much for talking with me.

Interviewee – Trent Dupuy
Thanks, Linda.

Host – Linda Poon
Trent Dupuy and colleagues write about improved measurements for the coldest known sub-stellar objects in this week's *Science.*

Music

[21:32]
Host – Sarah Crespi
If you glance into an elevator, you can probably make a pretty good guess as to how many people are inside without actually counting them. This ability is referred to as numerosity. Scientists have known for some time that humans are born equipped for detecting numerosity in small collections of objects. And because of this, they have theorized that numerosity is organized in the brain as a topographic map—similar to the way our primary senses like taste and touch are laid out with different areas of the brain corresponding to different parts of the sensory organ. Ben Harvey spoke with Kristy Hamilton on how he sussed out the signals to map the structure of numerosity in the brain.

Interviewee – Ben Harvey
We know that some neurons respond specifically when you show an image with a certain number of items in it, so that number of items in a visual image is described as numerosity. We found that these neurons are arranged as a topographic map on the cortical surface so that small numbers are at one end of the brain area with large numbers at the other end of the brain area and a gradual change between them. Now, topographic maps are common in sensory and motor areas of the brain where we have maps of the brain organized to represent the surface of the skin, positions of the muscles, and the visual field or auditory frequency. But all of these maps reflect the structure of an external organ like the retina, the cochlea, or the skin. So perhaps these neurons only came to be organized like this because that's how the information came into the brain. Well, our map doesn't reflect the structure of an external organ but instead has emerged within the brain. So this means that it's effectively reflecting a cognitive function. However, it shows many properties with the sensory and motor map that we know in the

rest of the brain, so it suggests there's a common organizing principle between sensory areas and high cognitive processing.

Interviewer – Kristy Hamilton
So the outside world is very much a reflection of our brain and how it processes stimuli. What does this tell us about how a brain processes numerosity?

Interviewee – Ben Harvey
So, how we perceive the outside world reflects the activity of our brain, though often we don't perceive the outside world as it really is. Our brain uses a lot of tricks to effectively drive information that's useful for behavior, and these tricks often lead us to slightly inaccurate perceptions. In the case of numerosity, we found that we often perceive numerosity slightly inaccurately. For example, the size of items can often influence perceived numerosity. We also find that the size of items affects numerosity to which a neural population responds. So that tells us something about how the brain is extracting numerosity from the visual image in that it gets confused by other stimulus features. In fact, similar effects are seen in children as they learn about number. Children will often think that two pennies must be more than a quarter because it's two items instead of one. So there seems to be some later processing which is needed to get around these errors introduced by low-level features of the stimulus.

Interviewer – Kristy Hamilton
And how did you go about studying numerosity in the brain?

Interviewee – Ben Harvey
Well, first we had a very strong high-field MRI scanner with an extremely strong magnetic field in it. These are quite new technology; they weren't even around since around 2006-2007. But the great thing about these scanners is they give an excellent signal strength, which allows very accurate characterization of individual subject's brain with a reasonable amount of scanning. We also know from work in monkeys that only about 20% of the neurons in the area that we're looking at are responsive to numerosity at all, which means we should be looking at a fairly weak signal here. So even the high-field MRI scanner allowed us to get a really clear picture of this really sparse information. Another thing about our methods is that our methods aim to measure the combined response properties of a group of neurons as directly as possible. And we do this by incorporating a model of neural response preferences in our analysis. So we have an idea of how the neurons should respond not just to their preferred numerosity, but to every other numerosity. So we have a very good, clear, quantitative prediction of the type of response we expect to see. Now most MRI analyses don't do this to tell you the truth, of having a neuron model of what we think neurons are doing in response to our stimulus. This is again quite a new technique, only been around since 2008.

Interviewer – Kristy Hamilton
And what did you see? So what were your results? Did the numerosity map differ from primary sense maps or was it similar?

Interviewee – Ben Harvey
The organization of the map was strikingly similar to what we see in sensory maps, like cortical magnification factors and variations in tuning width with numerosity, which are both features that we see in all of the sensory maps.

Interviewer – Kristy Hamilton
That's interesting. And what do you mean by cortical magnification in the brain?

Interviewee – Ben Harvey
Cortical magnification factor describes the way that when you have more of the brain processes smaller numbers and less of the brain that processes larger numbers. This is very interesting for us because behaviorally when you show larger numbers of items, people are less good at knowing exactly how many items that is. So if I show you two dots very quickly, you'll always know that it's two, you'll very rarely think that it's one or three. If I show you like nine or ten dots, you're never too sure which it is until you can count them. So it seems that more of the brain is devoted to processing smaller numbers, and certainly in the real world we come across distinctions between one and two a lot more than we come across distinctions between nine and ten. So it seems that more of the brain processing smaller numbers is a very useful thing for us, behaviorally.

Interviewer – Kristy Hamilton
So even though there is no sensory organ like eyes or ears devoted to numerical structure, numerosity is still represented topographically in the brain. What are some of the implications of this?

Interviewee – Ben Harvey
We believe that topographic maps are common in sensory areas of the brain because they allow neurons with similar response properties to interact over the shortest possible distances, making the brain more efficient. Now more efficient wiring of the brain from an evolutionary standpoint leads to less energy being used by this very metabolically hungry, energy-intensive organ. Also, more efficient wiring means that the brain can be as small as possible. A human head is so large that giving birth is already a very difficult thing for humans, so we seem to be basically at the maximum limit in the size of the human head. And one way to increase the brain's surface area is by decreasing the length of connections. Another very closely related thing is that we can fit more cortical surface into the head by increasing brain folding. Now it seems that the pattern of brain folding is also optimized to minimize the distances over which neurons have to communicate with each other. So again, that just makes the brain more and more efficient. So it seems that many aspects of cortical organization are really optimized following this one same principle: maximum efficiency through minimum connection lengths.

Interviewer – Kristy Hamilton
And does this finding suggest a possibility for an evolutionary basis for numerosity?

Interviewee – Ben Harvey

Many animals have behaviors that rely on numerosity perception. For example, pigeons can tell the difference between more and less numerous piles of food. So this is really quite well evolutionarily preserved. But humans, on the other hand, can do much more complicated things with numerosity and number. So number processing ultimately underlies humans' very unique mathematical ability.

Interviewer – Kristy Hamilton
Very cool. Well, Ben Harvey, thanks for talking with me.

Interviewee – Ben Harvey
Thank you.

Host – Sarah Crespi
Benjamin Harvey and colleagues write about numerosity in the brain in this week's *Science*.

Music

[29:19]
Interviewer – Sarah Crespi
Finally today, Erik Stokstad, staff writer for *Science Magazine* and *Science*NOW, is here to give us a rundown of some recent stories from our daily news site. I'm Sarah Crespi. So first up we have a story on Richard III. The body of Richard III, who ruled England from 1483 to 1485, was recently uncovered under a parking lot and he wasn't alone.

Interviewee – Erik Stokstad
That's right, Sarah, and it was actually might not be what you would have expected. Researchers who've gone through the grave and the remains after it was discovered last year found traces of roundworms. So it looks like during his life before he got the back of his head lopped off with a halberd, he may have suffered from an infection of roundworms.

Interviewer – Sarah Crespi
So how do they know that these roundworms came from the body and were not just in the surrounding soil?

Interviewee – Erik Stokstad
That's a great question. The reason is that they found the eggs of these roundworms, and roundworms can lay apparently 200,000 eggs a day during their life for an entire year. They found a concentration of eggs in the area where his intestines would have been in the grave and very few of them elsewhere. So that really suggests that this is something that came from his life and not from a subsequent contamination of the soil.

Interviewer – Sarah Crespi
So how did a King of England get roundworms?

Interviewee – Erik Stokstad

Probably the same way that people today get them in other parts of the world. It's most likely—because they would have been killed by cooking—that it would have been through raw vegetables, water, something that would have been contaminated by human feces out in the fields.

Interviewer – Sarah Crespi
And would this type of infestation have actually affected his health?

Interviewee – Erik Stokstad
There are symptoms from it – abdominal pain. Apparently the worms can burrow through the heart and lungs, so he might have coughed blood every once in a while – not pleasant.

Interviewer – Sarah Crespi
Yeah.

Interviewee – Erik Stokstad
An interesting thing about this research is that in addition to learning more about his bloody end, we're learning more about his life.

Interviewer – Sarah Crespi
Next up we have this story on the highly specific calls of titi monkeys. It's been known for a long time that animals like monkeys warn each other of danger, but is that all they are really saying, just watch out?

Interviewee – Erik Stokstad
These are monkeys that live in the trees of the Atlantic Rainforest in Brazil. They eat fruit and they swing around a lot. They're about a half a meter long. And researchers knew that they were saying at least two things with these soft, chirpy alarm calls. One was, "Hey, there's a bird that might be a predator." And another is "Look out, there's a cat." So by doing an experiment with stuffed animals, researchers have figured out more about exactly what they're saying.

Interviewer – Sarah Crespi
So what's the setup here? How did they use the stuffed animals to test what these guys are talking about?

Interviewee – Erik Stokstad
They did a little bit of swapping around. They put a stuffed cat on the ground and they heard the call you would expect – "Cat on the ground." And they put a raptor, a bird of prey, in the trees and they got the call, "Watch out, bird of prey in the trees." But then they swapped them around. They put the cat in the tree and they got a new call, which meant look out, there's a cat in the tree. I think it was actually backwards, it was tree and a cat, which was a reversal of the other pattern.

Interviewer – Sarah Crespi

So it was a combination of two calls that were swapped out.

Interviewee – Erik Stokstad
Right. So what these monkeys are doing that hadn't been observed in a primate before is saying what kind of predator to watch out for and exactly where it is.

Interviewer – Sarah Crespi
You said this is the first time it's been observed in primates. Has it been seen in any other animals?

Interviewee – Erik Stokstad
These kinds of calls have been seen in chickadees and also in meerkats, which are a relative of the mongoose that lives in Africa. And we should say, of course, humans are other primates that have alarm calls too.

Interviewer – Sarah Crespi
Finally we have a story on building up brains using video games. Learning games have been around for a long time and we've all heard about the brainy benefits of crossword puzzles. But now scientists are looking to see if the effects of video games on memory and attention can be quantified.

Interviewee – Erik Stokstad
So just to clarify, what we're talking about here in this new research is games that are designed for the aging brain. These are not Baby Mozart-type games. One thing that these games focus on is improving memory, recall, and also focusing attention.

Interviewer – Sarah Crespi
Right. So these are video games actually designed by neuroscientists. What would a video game designed by a neuroscientist look like?

Interviewee – Erik Stokstad
Well, you'd have electrodes stuck all over your scalp. Sorry, that's an extra key you have to buy. What's different about these games – and there have been other games designed by neuroscientists – they were really trying to focus on what we know about how the brain works with memory and recall. What this game does is it combines two types of tasks. One is observing symbols that get flashed onto the screen, and since that doesn't sound like a whole lot of fun there's also a driving portion of it where you're controlling a car and trying to keep it on the road while you see these symbols flashing up on the screen.

Interviewer – Sarah Crespi
And, of course you're, all these measurements we're taking from your brain as you're playing. So they first looked at how the video game affected young and old brains. What did they see in those comparisons?

Interviewee – Erik Stokstad

Well let me just add one thing, that the reason the electrodes were on the brain, that's not part of the game itself, that was really designed to evaluate how well it's working. So in order to do that, in order to figure out how much of a difference this might be making, the first thing that they did was they tried out the game on 20-year-olds, 30-year-olds, 40-year-olds, all the way up to 70-year-olds and see if they could see differences. Then they took a subset of the older group in the 60s and 70s and they trained them on it. They sent them home with the game and they spent one hour a day three days a week for a month, I think – it was a total of about 12 hours of elapsed time on the game. Then they brought them back into the lab, retested them, and looked to see if there were any differences.

Interviewer – Sarah Crespi
And so what did they see, how effective was this training on the older brains?

Interviewee – Erik Stokstad
What they saw was that the adults had improved in their ability to multitask. So when the symbol test was added on top of the driving test making things harder, their ability to deal with that was better than it had been when they started out before the training. One fun part of the results is that the 60- to 70-year-olds after they were trained, their performance was, in fact, better than 20-year-olds who were trying out the game for the first time. So take that, grandkids! And what's also pretty neat and remarkable is that they kept that improvement for six months after the training stopped when they came back into the lab. So it looks like it really did persist.

Interviewer – Sarah Crespi
Did they actually see any changes in the brains?

Interviewee – Erik Stokstad
Well that's where the electrodes come in. There's a part of the brain called the midline frontal theta, and this is a part of the brain that is associated with memory and attention. And they saw that the firing of neurons in that part of the brain was strengthened after the training. Now that's really consistent with the performance change that they saw as well.

Interviewer – Sarah Crespi
And so what about outside the context of the video game? They weren't just trained to be better at a video game, right? This is supposed to apply outside.

Interviewee – Erik Stokstad
That's the real hope of these games. And the thing that makes this study notable is that they saw that the training translated into an improvement in recall of working memory – that's where you have to keep something, say, like a phone number or where you just set your car keys down – that working memory, they found an improvement in recall from that of about 100 milliseconds, which is fairly significant.

Interviewer – Sarah Crespi
How strong is this effect? Would it have a big impact on someone who maybe was headed for a nursing home?

Interviewee – Erik Stokstad
We don't know that yet. So that's going to take a bigger study with more adults and a look at whether this training translates to more everyday tasks as opposed to specific cognitive tests.

Interviewer – Sarah Crespi
Okay. So what else is on the site this week, Erik?

Interviewee – Erik Stokstad
There's a really neat study about dolphins and bats, and it shows that these two very different types of animals evolved the ability to echolocate through the same steps of genetic changes. We've also got a story about the number of viruses that might be lurking out in nature as yet undiscovered. This was a study of flying foxes that came up with an estimate that there might be more than 300,000 unknown viruses out in mammals worldwide. And on *Science*Insider, two stories that we're following. One is a story about a labor strike that's paralyzed the world's largest radio telescope in Chile. And we're also following a battle between the US House of Representatives and the Environmental Protection Agency here in Washington over the release of some confidential health data if it underlies air pollution regulations.

Interviewer – Sarah Crespi
Great. Alright, Erik, thanks so much.

Interviewee – Erik Stokstad
Fun to talk with you, Sarah.

Interviewer – Sarah Crespi
Erik Stokstad is a staff writer for *Science Magazine* and for *Science's* daily news site, *Science*NOW. I'm Sarah Crespi. You can check out the latest news and the policy blog, *Science*Insider, as news.sciencemag.org.

Music

Host – Linda Poon
And that concludes the September 6th, 2013 edition of the *Science* Podcast.

Host – Sarah Crespi
If you have any comments or suggestions for the show, please write us at sciencepodcast@aaas.org.

Host – Linda Poon
The show is a production of *Science* Magazine. Jeffrey Cook composed the music. I'm Linda Poon.

Host – Sarah Crespi

And I’m Sarah Crespi. On behalf of *Science* Magazine and its publisher, AAAS, thanks for joining us.

Music ends