



## Science Magazine Podcast Transcript, 18 September 2009

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### *Music*

#### **Host – Robert Frederick**

Hello and welcome to the *Science* Magazine Podcast for September 18th, 2009. I'm Robert Frederick. This week: the link between public opinion and international terrorism; locust-wing aerodynamics; and developing new ways to sterilize cats and dogs. All this, plus a wrap-up of some of the latest science news—including a story about remembering without knowing it—from our online daily news site, *ScienceNOW*.

### *Promo*

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#### **Host – Robert Frederick**

Terrorism is typically correlated with extremists' views. But in a paper in this week's *Science*, Alan Krueger of Princeton University and Jitka Malečková of the Czech Academy of Sciences have correlated occurrences of international terrorism with public opinion. That is, when people of one country disapprove of the leadership of another country, there is a greater incidence of international terrorism by people or groups from the first country towards targets from the second country. I spoke with Krueger from his office at the U.S. Department of Treasury. Please note that neither the contents of the paper nor the statements in this podcast necessarily represent the position of the U.S. government: Krueger was appointed to his government position after submitting the paper to *Science*.

#### **Interviewee – Alan Krueger**

This is the first study to look at whether the public opinion held by people in one country towards the leadership or policies of another country is related to the likelihood that terrorism occurs between the former country against people or targets in the latter country. And what we find is that public attitudes do seem to predict the incidence of terrorist attacks.

#### **Interviewer – Robert Frederick**

What prompted you and your coauthor, Jitka Malečková, to look for a link between public opinion and the occurrences of terrorism?

#### **Interviewee – Alan Krueger**

Well, this was kind of a natural extension of past research that the two of us had done. I approached terrorism more from a standpoint of quantitative social science, and Professor Malečková is a historian, who thinks in more qualitative terms. And for a long time, we were interested in whether we could link some qualitative measures, like public opinion, to number of terrorist attacks that were occurring. And when we looked around, we thought that these were the best data sources to merge together to do this type of an analysis.

**Interviewer – Robert Frederick**

How much a greater incidence of terrorist attacks did you and your coauthor find?

**Interviewee – Alan Krueger**

We found a very strong relationship. There's a chart in the paper. So, for example, to give some sense of the magnitudes of our results, what we find is that if in a particular origin country the percent of people who disapprove of the leadership of another country is say below 40%, which is fairly high approval, we see, on average, about 0.4 terrorist attacks directed against those foreign countries that the public opinion is reflecting.

**Interviewer – Robert Frederick**

Over each year?

**Interviewee – Alan Krueger**

No, this is over a four-year period...

**Interviewer – Robert Frederick**

Okay.

**Interviewee – Alan Krueger**

...from 2004 to 2008. If the disapproval rate is in the high end—over 70% of the public disapproves of the leadership of a particular country—we find that the number of terrorist attacks over that same period, over a four-year period, is about four times higher – we find 1.57 attacks over that four-year period. Now, one thing this indicates is that terrorism is rare – that's a very fortunate thing, that terrorist attacks have a low frequency. On the other hand, this also suggests that public opinion can provide some useful information about where terrorism might be more likely to occur. And that could be helpful, of course, for formulating counter-terrorism policy, as well as for understanding the sources of terrorism.

**Interviewer – Robert Frederick**

And how did you measure public opinion, and what question or questions put to the public were relevant for your and your coauthor's study?

**Interviewee – Alan Krueger**

Sure. Well, we used data that were collected by the Gallop organization. They conducted public opinion polls in a number of countries. We used data from 19 Middle Eastern and North African countries, and specifically people in those countries were

asked whether they approved or disapproved of the leadership in nine major countries – such as the United States, United Kingdom, Russia, Germany, and so on. This is looking at public opinion in 2006 and 2007 and terrorist attacks that occurred between 2004 and 2008. What makes these data unique is we could look at how public opinion from one country aligns with the views about another specific country, so it's not kind of public opinion in general. And we could do it for a fairly large sample of pairs of countries – so we could look at, you know, each of the 19 countries, their views towards these other nine countries. So that's 9 by 19 or, in all, when we eliminate missing data, we have 143 different pairs of countries that we examined.

**Interviewer – Robert Frederick**

Now, to the occurrences of terrorism, what was the definition there for your study?

**Interviewee – Alan Krueger**

The terrorism data were derived from a database maintained by the National Counter Terrorism Center. They have a fairly rigorous and comprehensive set of procedures for identifying terrorist incidence around the world. And we very carefully went through their database to look at incidents that were carried out by groups or individuals from any of the 19 Middle Eastern and North African countries that targeted people or resources in any of those nine other countries.

**Interviewer – Robert Frederick**

With that definition of terrorism, how many terrorist attacks were there over the time period you studied?

**Interviewee – Alan Krueger**

In total, there were 952 terrorist attacks that were carried out by people or cells from those origination countries, we call "origin countries," where the public opinion polls were asked and directed towards the nine major world powers. However, 841 of these incidents involved Pakistan and India. In our analysis, we did the statistical estimates two ways—once including the India/Pakistan pair and for most the paper without it—because we didn't want the large number of incidents that occurred in that case to overly affect our results. Fortunately, the results were fairly robust to eliminating the Pakistan/India pairing. And the results I cited earlier did not include that pair. One justification for excluding Pakistan and India from our analysis is those were the only two countries that shared a border in our data set.

**Interviewer – Robert Frederick**

So, if I've done my calculation correctly that's 111 terrorist incidences or terrorist attacks spread across 143 pairings of countries, is that right?

**Interviewee – Alan Krueger**

That's correct. Many of the cells are empty, you know, fortunately there was no terrorism perpetrated by some of the countries against the U.S. in this period. So, we needed to use statistical techniques that were appropriate for having zeros in many of the cells.

**Interviewer – Robert Frederick**

So, the distribution of these attacks didn't directly correlate with public attitudes? There were other variables included in this analysis?

**Interviewee – Alan Krueger**

Well, if you look just at the direct relationship between public attitudes and the number of terrorist attacks, actually you do see a direct correlation. So, we show that very simply in the study. And we also do a more sophisticated econometric analysis where we control for a number of other variables, like the distance between the countries, the population of the origin and target country, GDP per capita in the origin and target countries, so we try to hold constant as many relevant variables as we can.

**Interviewer – Robert Frederick**

These are variables you and your coauthor have come across in previous studies, is that right?

**Interviewee – Alan Krueger**

That's right. In some of our own research and in research of others we thought that these were the most important variables to try to hold constant in the analysis.

**Interviewer – Robert Frederick**

I noticed in your paper the variable "percent Muslim of the population in the origin countries."

**Interviewee – Alan Krueger**

In previous work I didn't find that religion mattered very much. Put it this way, in previous work what I had found was that all major religious groups have had experiences with terrorism with people from those religious groups carrying out terrorism, and with people from those groups being targets of terrorism. And much of that work, I have a book, for example, called What Makes a Terrorist, which I think delves into that analysis in more detail and uses a larger sample of countries. So, I put more weight on that earlier work than on the findings in this study vis-à-vis religion.

**Interviewer – Robert Frederick**

Okay. Any hypotheses, then, as to why this correlation between public opinion and terrorism exists?

**Interviewee – Alan Krueger**

Excellent question. So, I think we're very careful to lay out a number of possible explanations for this relationship that we found. One is that if people in one country are unhappy with the policies being pursued by another country it may lead to more support, material support or encouragement, for terrorist groups – might even lead some individuals, some extremists, to join terrorist cells. It's also possible that public opinion is reflecting the same kinds of things that are affecting terrorist organizations. So, it's difficult to know whether public opinion per se is causing terrorism to rise, when I say

"public opinion per se" I mean an increase in negative attitudes towards the leadership of another country per se, or something which is driving those attitudes is what is causing terrorism to rise. So, we are very careful to point out that we've just documented a correlation here. However, this correlation, I think, is quite informative because it suggests that while terrorism itself is quite rare, fortunately, public opinion can be a strong predictor of the likelihood of terrorism. So monitoring public opinion can give us some purchase on areas where terrorism may arise, as well as may help us to understand a little bit better the sources of terrorism.

**Interviewer – Robert Frederick**

Will you be analyzing if this analysis is possibly predictive the other way – that is, if changes in leadership cause some kind of reduction in disapproval and so a decrease in terrorism acts against the country with the new leadership?

**Interviewee – Alan Krueger**

We conclude in the paper actually by suggesting that, and this study itself used I think the best data that were available. However, going forward, as more data accumulate on public opinion and terrorist incidence, it will be possible to look at changes and views towards other country's leaders, changes in one country's policies and how that affects views towards another country, and the likelihood of terrorism. And I think that's very valuable work that should be done to follow up on this study. Whether I do that work myself or not I'm not so sure, but I think that part of the... that should be part of the research agenda for this field.

**Interviewer – Robert Frederick**

Alan Krueger, thank you very much.

**Interviewee – Alan Krueger**

Sure, thank you.

**Host – Robert Frederick**

Alan Krueger from Princeton University is lead author of a paper on the link between public opinion and the occurrence of international terrorism.

*Music*

**Host – Robert Frederick**

Flapping micro air vehicles are tiny robots that often resemble insects. Engineers are designing them because they can be used to provide pictures or video of hard-to-reach or dangerous areas. But before flapping micro air vehicles become a useful reality—that is, flying for more than just a few minutes—researchers will need either an exceptional improvement in the power density of batteries on board the tiny machines, or an enormous improvement in the efficiency of the flapping wings. In a paper in this week's *Science*, Adrian Thomas and colleagues report their insights from examining the efficient flapping flight of desert locusts as well as their computational fluid dynamics model that simulates the insect's wing. The team found that the wing dramatically deforms during

flight and twists, too, increasing efficiency by 50% over non-deforming, non-twisting wings. I spoke with Thomas from his home in the United Kingdom. Thomas is a flight dynamicist at the University of Oxford.

**Interviewee – Adrian Thomas**

We have combined experimental analyses of real insects flying with computational fluid dynamic models. And so we've used the experimental work to check the output of the computational models. And that means we know that the results of the computational models are accurate. We've found that there's good match between what the models give and what experiments with real insects give. And then, the advantage of the computational models is we can do experiments on the design of the wings in the computer that you couldn't do with a real insect. And the results of changing the shape of the wings to simplify them by removing the detailed structure in the wing shape step-by-step is that if you switch from the insects wings with the full structural complexity that they actually have to a set of flat plate wings, so just rigid flat plates like an engineer might design, you get a 30% reduction in power required for flight for a given lift generation. Or, to put it another way, if engineers were to take their current flapping winged micro air vehicles and switch the flat plate wings they use for the carefully designed wings of an insect, they would get a 50% increase in efficiency.

**Interviewer – Robert Frederick**

And you and your team were modeling flight, not taking off and landing, is that right?

**Interviewee – Adrian Thomas**

Yes. The aspect of flight we modeled was steady flight at the speed that a migratory locust would choose to fly in the wild. So, we think that's an important speed because their migration flights, they cover very long distances. So, that's probably important flight speed from the point of view of adaptation.

**Interviewer – Robert Frederick**

What additional details or features of how the insect wing moved did you and your team's model have compared with previous models?

**Interviewee – Adrian Thomas**

Well, some of the work we've been doing over the last five years or so has allowed us to measure the shape of the surface topography—so the twists and the bumps and the curves on the wing structure—of an insect's wing while it's flapping with really very high precision, much higher than has been available before. Most previous work doing computational studies has either been based on flat plate models of wings or simple curves, simple aerofoil sections that are a sort of estimate of what goes through a real insect wing. We first measured the detailed structure in really very great detail, and having that information is what allows us to make accurate models.

**Interviewer – Robert Frederick**

Were there any wing or movement details that you and your team purposefully overlooked or left out?

**Interviewee – Adrian Thomas**

The only thing that we couldn't really deal with is the way that the.... So the locust's wing, the hind wing, has a fan that's a bit like the spokes of an umbrella, and when the wing sweeps backwards that folds up against the side of the body of the insect. And we were unable to model the complex folding there. So instead we replaced it with effectively what in our model amount to an elastic sheet that just stretches and shrinks and fills the gap between the body and the rest of the wing in the same way that the real insect's complicated structure does. So, that's a slight, and I guess that's less than 5% of the total wing area, but it adds a slight fudge to make sure everything moves smoothly and there aren't any – originally we had a gap between the body and the wing, and that gap accelerated a fast flow through it, and that introduced artifacts into the model. So, by sealing it with this elastic membrane we got a flow field that was much closer to what the real insect generates.

**Interviewer – Robert Frederick**

And with your model you were using a programmed computational fluid dynamics method or something off the shelf?

**Interviewee – Adrian Thomas**

No, we used an absolutely standard off-the-shelf computational fluid dynamics model, called "Fluent," which you can go out and buy. It's a commercial model, and we programmed within that system, that scheme, because we wanted to use something completely generic that other people could then go and use to replicate our work. It probably isn't..., if you were really interested in the details of flow in this very unsteady regime with the particular viscosity and Reynolds numbers that we've got, it probably isn't what you'd actually choose if you were a dedicated computational fluid dynamics model maker. But, if you use a specific model you'd made yourself nobody else can really easily replicate it, whereas somebody else could repeat our results, well, not tomorrow, but in a couple of week's time, by using Fluent with the settings that we've used. It's completely reproducible. And that was the essence. And the key thing about this paper is the validation, really: we've got a computational fluid dynamics model that anybody can reproduce; we've got measurements of the insect that anybody can go out and could reproduce – somebody else could go and make the same measurements; and we've got the tie in between the two – we've got this very nice match between the output of the model and the measurements from real experiments. And so, the nice result there is that we now can really accurately model insect flight using standard off-the-shelf model, computational fluid dynamics method.

**Interviewer – Robert Frederick**

And then, you and your team re-ran your computational fluid dynamics model with simpler, less accurate models of the desert wing locusts?

**Interviewee – Adrian Thomas**

Yes, so what we did is rather than use the full geometric complexity of all the veins and folds and ridges on the locust wing, we first of all smoothed the wing out, so it was a

smooth but curved and twisted plate that has the same twist as the locust and the same aerofoil sections that curves from leading edge to training edge, but it doesn't have any of the wrinkles. And then we ran a further stage of simplification where we took out the twist and the curvature and just had flat plates. So we've got these three stages of simplification in the model.

**Interviewer – Robert Frederick**

If this kind of twisting and deformation is so much more efficient, what's it going to take before engineers can take this biologically inspired model your team has made virtually on the computer, and make it into a real flapping wing for a robot or vehicle? New materials or...?

**Interviewee – Adrian Thomas**

No, I think, well, there are some features of the materials in insect wings that are special. So, in general in engineering we try to avoid oscillating anything – flapping it up and down very repeatedly – and distorting it through the same set of distortions repeatedly because of stress fractures. And the insect wings are very good at coping with that: they flap their wings 15 times a second, and they'll do it for several days on end for the locusts. And you wouldn't want to do that with most engineered structures. But, there are several research groups around the world who are building little mechanical model insects using typically carbon fiber support spars and then maybe a Mylar or similar plastic flexible membrane to fill in the wing. But, what we've pointed out is that actually the details of the shape really matter: you can't just expect to get as good a result as the insect gets, unless you really look carefully at what the insect is actually trying to achieve with the wing design.

**Interviewer – Robert Frederick**

Adrian Thomas, thank you very much.

**Interviewee – Adrian Thomas**

Okay.

**Host – Robert Frederick**

Adrian Thomas of the University of Oxford is senior author of a paper modeling the aerodynamic function and efficiency of insect wings.

***Music***

**Host – Robert Frederick**

Every year, millions of cats in dogs are euthanized in animal shelters, and that's just in the United States. Worldwide, including the U.S., millions more cats and dogs run wild—literally, they're feral—with populations growing out of control and posing health risks such as the spread of rabies. Research to develop an inexpensive, permanent, and non-surgical way to sterilize cats and dogs has waned due to lack of funding. But as *Science's* David Grimm reports in this week's issue, a foundation's \$75 million in

research and prize money is revitalizing past efforts and promoting new sterilization research that may work for more animals than just cats and dogs.

**Interviewee – David Grimm**

This story is all about the massive problem of feral cats and dogs throughout the entire world. And the problem in the U.S. is that there are so many feral animals on the streets, and they reproduce so fast, that millions end up getting euthanized in shelters every year because we can't find homes for them, and they also pose a public health risk. And in developing countries, feral dogs pose a special public health risk, especially in places like India and China, they contribute to the vast majority of the rabies cases in these countries, which can be thousands of cases a year. And what humanitarian groups have tried to do up to now is try to surgically spay or neuter as many of these cats and dogs as possible. And that's had a lot of success in the U.S., and yet still there's millions of cats and dogs being euthanized in the U.S.. With developing countries, even if you were to do spay and neuter in these countries, it's a slow process, it's an expensive process, it requires skilled expertise – this is not an ideal solution for controlling these populations. So, for years, humanitarian groups have been hoping for what they call a "non-surgical sterilant." And this would be something like a vaccine or a pill that you could just give a feral cat or a dog that would make them permanently sterile, something that's cheap and it's very easy to use. So, what this story is really all about is efforts to develop this non-surgical sterilant for cats and dogs, which there hasn't been money for up until about a year ago, when all of a sudden \$75 million was put on the table to develop such a product.

**Interviewer – Robert Frederick**

How much does it cost to surgically sterilize a cat or dog?

**Interviewee – David Grimm**

Well, it really varies. If you have a vet do it it can cost over a hundred dollars per procedure. Shelters have a lot of volunteer vets working for them, and they can do it for as low as 50 dollars, sometimes a little cheaper. But, even at 50 dollars this is still a very—I mean you're talking about the millions of cats and dogs that are out there—this is still a prohibitively expensive surgery, especially for poorer areas of the country of the U.S. and especially, as I said for developing countries.

**Interviewer – Robert Frederick**

So, this money, this 75 million dollars, is this revitalizing any past research that might lead to a non-surgical sterilization in cats and dogs? I mean has there been any success in non-surgically sterilizing other animals?

**Interviewee – David Grimm**

Yeah. One of the really interesting things that I learned in this story was that efforts to develop a non-surgical sterilant trace back to the early 1970s to dealing with wild horse populations in the American West. It turns out, for a long time these horses were being hunted down for pet food, which the silver lining, if you can call it that, from these massive hunting programs was it was keeping these feral horse populations low. But in the early 70s Congress passed this act, which protected all of these horses, and all of a

sudden they started, as you would expect, breeding out of control. And so, there was a researcher in Montana, named Jay Kirkpatrick, who found a way to contracept these horses without surgery. And it's a vaccine called a "zona pellucida vaccine," and zona pellucida is the membrane that surrounds the female egg. And basically what the vaccine does is it causes the body to make antibodies against this membrane, and when this membrane is coated with antibodies, the sperm can't get in and females don't become pregnant. And since then, since the early 1970s, researchers have had enormous success with this vaccine. They've contracepted everything from wild horses to elephants in Africa to even sea lions. It's worked on a ton of species. But this is only a temporary contraceptive, you know, it only lasts for maybe two or three years. So, it's not something that's going to permanently sterilize the animal. But, for whatever reason, it doesn't work in cats and dogs. And even if it did, it still wouldn't be a great solution to the problem because with a feral animal you want to permanently sterilize them; you don't want something that's only going to last a couple of years and then these animals can be able to get pregnant again.

**Interviewer – Robert Frederick**

So, what happened to the research on dog and cat non-surgical sterilization?

**Interviewee – David Grimm**

Well, you know, all of the research, all the early research on dog and cat non-surgical sterilization really derived from this wildlife research. So, first people tried this zona pellucida vaccine in dogs and cats and found that it didn't work. So, they turned to another approach they'd been trying in wildlife, which is called a GnRH vaccine. And GnRH is gonadotropin-releasing hormone, and this is a hormone in the brain that causes the release of various sex hormones in our body, and so the idea is if you can block that pathway you can block fertility. And researchers also had a lot of success with this vaccine in wildlife. They used it in horses and prairie dogs and a bunch of other animals. And unlike zona pellucida, when people started using it in cats and dogs, it worked. A researcher in Florida named Julie Levy ran a clinical trial with cats, and she found that it contracepted cats for up to five years. So that was a good amount of time. It wasn't perfect because it still wasn't permanent, and also the effect sort of diminished over time, but it showed some promise in cats. It worked in dogs too, but it caused a really painful reaction in dogs when they would inject it, so they stopped clinical trials on dogs. And again, this wasn't, you know, it was an okay product for cats and dogs, but it wasn't really what people were looking for because again it wasn't permanent, and also they had all of these problems with dogs. So, you know, researchers are really looking for this sort of single pill or vaccine that's going to work in both dogs and cats, males and females, and it's going to be permanent. And that's been the real problem up to this point is, you know, people really want to develop that, and they've got all this great preliminary research with these other, you know, potential methods, but there's just no money. You know, the NIH isn't funding this work, you know, big private foundations don't fund this work, because, you know, these foundations tend to be focused on human health.

**Interviewer – Robert Frederick**

Which brings us to the 75 million dollars for developing this non-surgical sterilization for cats and dogs. Who's donating the money, and how does the funding work? What's the goal?

**Interviewee – David Grimm**

Well, the guy who is actually making this money available is named Gary Michelson, and he's one of the richest people in America due to a lot of surgical devices he invented. He also happens to be an animal lover. And so he's been really frustrated, like a lot of humanitarian groups are, with this whole idea that there's too many homeless cats and dogs out there, and so he's made this 75 million dollars available. And what it is is it's 50 million dollars available in grant funding, and then 25 million dollars is a prize. So whoever develops, you know, this sort of Holy Grail product, this product that would work in both dogs and cats, males and females, be permanent and cheap—so it's a lot criteria there, it's a lot of scientific criteria to meet—but whoever develops that product is going to get 25 million dollars.

**Interviewer – Robert Frederick**

Are dogs and cats so similar that one product will work? You said this zona pellucida vaccine worked in horses and many other animals, but do researchers know that just one thing, the same thing, will work for males and females, cats and dogs?

**Interviewee – David Grimm**

Well, it's a really good question. And a lot of researcher actually think this is possible, and that's because a lot of the fertility pathways are conserved across mammalian species. In other words, you know, when I mentioned GnRH, we all have this GnRH pathway, and all mammals have sperm and eggs. So it's possible that a product will work across a couple of species.

**Interviewer – Robert Frederick**

So, what's then the expectation here from the funders? When are they expecting a solution, given that they only have this 50 million dollars in research money?

**Interviewee – David Grimm**

Well, when I heard from Gary Michelson, he said his hope is that a product could be available in about 10 years. And he set up this whole scientific board that's vetting.... You know, once they announced this money about a year ago they got flooded with all of these grant applications from researchers that had never even worked with dogs and cats before. But they were so sort of intrigued by this problem, and a lot of them were actually emotionally moved by this problem, and a lot them are bringing these new ideas, like RNA interference or targeted cytotoxins to the field that were never part of the field before just because there wasn't the money and there wasn't the interest. There wasn't as much brain power devoted to this problem as there is right now.

**Interviewer – Robert Frederick**

So, after 10 years the funding dries up?

**Interviewee – David Grimm**

Well, first of all 50 million dollars is actually a really big pot of money, especially for a small field like this, so that money will probably last a long time. But, what's also really important to note is, you know, a lot of these people that are applying for these grants are basic researchers. These are people that are just doing the preliminary experiments or maybe the preliminary clinical trials. And that's what's also really important about what Gary Michelson is doing: he's actually saying, 'Look, once you've got the product to the stage where it's ready to be commercialized, my foundation's going to step in and help with commercialization; it's going to help with the regulation.' And his goal for this is two fold. First of all, he wants to make sure the product is cheap because if this product ends up costing as much as spay/neuter surgery then it has no advantage. And also, he wants to make sure it gets onto the market as soon as possible. He doesn't want this languishing in regulatory limbo forever. He really wants to make sure that once somebody really finds something that's going to work, the foundation can make sure it gets out to all of these shelters and all of these developing countries that desperately need something like this.

**Interviewer – Robert Frederick**

David Grimm, thank you very much.

**Interviewee – David Grimm**

Thanks, Rob.

**Host – Robert Frederick**

*Science's* David Grimm writes on the growing research and development of a non-surgical method to sterilize cats and dogs.

***Music*****Host – Robert Frederick**

Finally today, Michael Torrice, sitting in for David Grimm, is here with a selection of stories from *ScienceNOW*, the online daily news site of *Science*, including a story about remembering without knowing it. Is this subconscious/conscious? Michael, how do you remember something but not know that you've remembered it?

**Interviewee – Michael Torrice**

Well, Rob, this is kind of like when your brain remembers something, but you're consciously not aware of that memory. And so, for example, say I went into your office, and I went to your desk, and I took your can of pens away, and you came in and I said, "Is there something missing from your desk?" You'd look at the desk, and even though you might not be able to say that can is missing, your eyes would sort of unconsciously focus on where it was on the desk. And that's kind of called a "relational memory" – relating where that can was on your desk, and your eyes are kind of unconsciously showing that you remember it.

**Interviewer – Robert Frederick**

This sounds like a different understanding of the definition of memory.

**Interviewee – Michael Torrice**

Right. This is kind of part of a controversy in neuroscience about memory. And for the most part people have talked about "declarative memory." So, if I asked you, "What's missing on your desk," you couldn't say what was – that's not a declarative memory. And the controversy comes down to a part of the brain called the "hippocampus," which is crucial for declarative memories. People with damage to the hippocampus aren't able to talk about memories from the past.

**Interviewer – Robert Frederick**

Declaring them, as it were, that's the declarative memory?

**Interviewee – Michael Torrice**

Correct. Declaring them, talking about them. But, the debate has been, "Can this part of the brain retrieve memories and you not know it," basically, and you're not aware of that retrieval of a memory.

**Interviewer – Robert Frederick**

My eyes looking to where the cup of pens were, but not being able to retrieve that memory of it being actually missing.

**Interviewee – Michael Torrice**

Not being able to say that can was missing – not being able to be conscious that, "Oh, that can is usually next to the phone on my desk." So, these scientists wanted to test these relational memories and see if this eye movement was linked to activity in the hippocampus. And the way they did this was they gave people this sort of memory pairing test: they'd show people a scene, like the Grand Canyon, and then they'd show them a face. And then later, they would show them the scene again and give them three faces, and say, "Which one of these faces went with the scene before?" And they did this inside a brain scanner while they were watching where their eyes moved to see which face they looked at. And the scanner is a functional magnetic resonance imager, which is able to show how blood circulation changes in the brain, which suggests where activity is changing in the brain. And they found that when subjects looked at the correct matching face, even when they got it wrong – even if they couldn't say that was the face that went with the scene – they saw greater activity in the hippocampus.

**Interviewer – Robert Frederick**

So, the declarative memory may not match the relational memory, but the amount of activity suggested by the fMRI scan suggests that the brain does know the right answer, even if the conscious self doesn't.

**Interviewee – Michael Torrice**

Right. It's sort of like the hippocampus is able to find that folder in your memory where that information is held, but you consciously can't see what's in that folder. And so, they looked at other areas of the brain, like the prefrontal cortex, which is at the very front of

your brain and is involved in decision-making, and they find that activity there is higher when subjects made the right decision – picked the right face. And the two areas—the prefrontal cortex and the hippocampus—their activities sort of mirror one another. And so, they think that in order for you to sort of consciously act on this memory that the hippocampus has found, it needs to talk to the prefrontal cortex.

**Interviewer – Robert Frederick**

So does that suggest that somebody actually does remember something if their eyes move around when you're asking them to recall something?

**Interviewee – Michael Torrice**

Well, some neuroscientists think that using eye movement data could help understand what a person does or doesn't really remember and maybe in infants, or someone who can't actually say what they remember, or even in cases where someone might not want to tell you what they remember.

**Interviewer – Robert Frederick**

So, a potential for a tool then to uncover someone's memory, whether they're subconsciously suppressing it or not?

**Interviewee – Michael Torrice**

Right.

**Interviewer – Robert Frederick**

Okay. So, what other stories have you brought with you?

**Interviewee – Michael Torrice**

Well, the next story is about an idea that could help slow climate change. And these three scientists in New York City want to basically forest the Sahara Desert.

**Interviewer – Robert Frederick**

Well, sounds like a good idea! But there's a lot of sand and a lot of heat there. How do they propose to do that?

**Interviewee – Michael Torrice**

Right. So, their idea is that they will desalinate water from the ocean around the desert and then use sort of these drip-irrigation lines that you could sort of deliver water slowly and allow the water to not evaporate in this really hot desert. And also, they'd grow trees, like Eucalyptus trees, that can withstand the heat and maybe need a little less water than other trees.

**Interviewer – Robert Frederick**

So, assuming that this could work, and that cost were not a consideration, have the scientists modeled what affect that would have on the climate?

**Interviewee – Michael Torrice**

Well, they've run some climate change simulations on what would happen if the Sahara was now a forest, and they find that the whole desert would probably cool by about eight degrees Celsius and that rainfall in the area would probably increase by about a thousand millimeters a year. And more importantly, though, the big effect would be it would pull down eight billion tons of carbon a year, which is about as much as we put into the air each year from fossil fuels or burning wood already.

**Interviewer – Robert Frederick**

And so now, what's the cost of this proposal?

**Interviewee – Michael Torrice**

Well, they estimate the price tag to be about two trillion dollars a year.

**Interviewer – Robert Frederick**

Every year?

**Interviewee – Michael Torrice**

Every year.

**Interviewer – Robert Frederick**

So, not just when the forest is growing but ongoing?

**Interviewee – Michael Torrice**

Right: to maintain the forest and to run the desalination plants that would be required for this project.

**Interviewer – Robert Frederick**

How does that cost and potential benefit compare to other projects to reduce the amount of carbon in the atmosphere?

**Interviewee – Michael Torrice**

Well, some plans would take CO<sub>2</sub> from the air and sort of inject it underground. And the costs are about comparable for this Sahara project and the underground projects, but also the Sahara project has the possible benefit of producing wood from these trees that you're now growing in the desert.

**Interviewer – Robert Frederick**

And the costs are about the same?

**Interviewee – Michael Torrice**

Yeah. For the underground project it's about 200 dollars per ton that they would inject, whereas the Sahara projects about 400 dollars per ton that you'd pull out of the air.

**Interviewer – Robert Frederick**

So, about twice as expensive then>

**Interviewee – Michael Torrice**

Exactly.

**Interviewer – Robert Frederick**

But, you know, since we're talking trillions of dollars, what's a trillion dollars between friends, right?

**Interviewee – Michael Torrice**

Right. There are also some other issues – turning the Sahara into a wetter forest might have consequences like unleashing swarms of locusts on the rest of Africa and also possibly disrupting neighboring ecological systems. So, a number of issues to think about, but it's another idea out there in possibly slowing climate change.

**Interviewer – Robert Frederick**

Okay. So, last story. What's this last one about?

**Interviewee – Michael Torrice**

Well, this story also involves a desert, but this deserts in Chile, and this is a sort of archeological mystery that's been going on for three decades in this desert. So, in the 1970s archeologists uncovered these four skulls of women who died maybe about a thousand years ago, and their skulls had sort of been eaten away and deformed, and they couldn't understand why. Some people thought it might have been cancer or leprosy, but there had been no good explanation for what happened to these skulls.

**Interviewer – Robert Frederick**

So, scientists applied some new analysis or tool/technique to understand what happened?

**Interviewee – Michael Torrice**

Well, scientists were able to retrieve samples of flesh, because these were actually mummified due to the dry climate in this part of Chile. And when they analyzed DNA that was in this flesh, they found the DNA of the parasite *Leishmania*, which causes the disease leishmaniasis. And that can cause skin lesions and ulcers, especially around the face.

**Interviewer – Robert Frederick**

Enough to deform the skulls, too, though?

**Interviewee – Michael Torrice**

Yeah, they believe that this is a reasonable explanation, and that the disease actually can go on for years if untreated.

**Interviewer – Robert Frederick**

So, mystery solved!

**Interviewee – Michael Torrice**

Well, not exactly. *Leishmania* doesn't thrive in dry, arid climates like this desert. And so, some anthropologists think that these women possibly came from a more tropical area to the East. And during this time in Chile these groups in the desert and the tropics traded a lot, and they possibly also intermarried, so these women probably came from the tropics where they developed the disease, and then died in the desert community.

**Interviewer – Robert Frederick**

Okay. Well, thank you, Michael.

**Interviewee – Michael Torrice**

Well, thanks, Rob.

**Interviewer – Robert Frederick**

So, what other stories are you looking into either on *ScienceNOW* or on the policy blog, *ScienceInsider*?

**Interviewee – Michael Torrice**

Well, we're working on a story about using gene therapy to reverse color blindness in a species of monkey. Also, we have a *Science* shot that's looking at how rowers, when they row in groups, have a greater endorphin rush than when they row alone. For the policy blog, there's a conversation with two scientists who are sort of at the beginning of their career discussing all of the demands of being a young scientist starting their career. So, be sure to check out all of these stories on our site.

**Interviewer – Robert Frederick**

That's Michael Torrice sitting in for David Grimm with a selection of stories from *ScienceNOW*, the online daily news site of *Science*. You can check out the latest science news, plus find a link to the science policy blog, [ScienceInsider](http://ScienceInsider), at [sciencenow.sciencemag.org](http://sciencenow.sciencemag.org).

**Music**

**Host – Robert Frederick**

And that wraps up the September 18th, 2009, *Science Magazine* Podcast. If you have any comments or suggestions for the show, please write us at [sciencepodcast@aaas.org](mailto:sciencepodcast@aaas.org). The show is a production of *Science Magazine* with the support of AAAS, the Science Society. Jeffrey Cook composed the music and I'm Robert Frederick. On behalf of *Science Magazine* and its publisher, the American Association for the Advancement of Science, thanks for joining us.

**Music ends**