EPISODE FIFTY THREE OF "ARMED WITH SCIENCE: RESEARCH APPLICATIONS FOR THE MODERN MILITARY," A DEPARTMENT OF DEFENSE WEBCAST HOST: DR. JOHN OHAB GUEST: DR. THOMAS MEITZLER, U.S. ARMY TANK AUTOMOTIVE RESEARCH, DEVELOPMENT AND ENGINEERING CENTER (TARDEC); DR. JOY HIRSCH, COLUMBIA UNIVERSITY PROGRAM FOR IMAGING AND COGNITIVE SCIENCES TIME: 2:00 P.M. EST DATE: WEDNESDAY, FEBRUARY 3, 2010

(Intro music begins.)

ANNOUNCER: "Armed with Science: Research and Applications for the Modern Military" is a weekly Webcast that discusses cutting-edge science and technology and how they apply to military operations.

Each week we will interview scientists, administrators, and operators to educate and inform our listeners about the importance of science and technology to the modern military.

(Intro music ends.) DR. OHAB: Good afternoon, and welcome to episode number 53 of "Armed with Science: Research and Applications for the Modern Military," on Wednesday, February 3rd, 2010.

I am Dr. John Ohab, at the Office of the Assistant Secretary of Defense for Public Affairs. I hope you're having a wonderful day.

Today we'll be exploring an issue of great concern to the U.S. military -- that is, traumatic brain injury, which has increased tremendously in both Iraq and Afghanistan, particularly for route-clearance soldiers who come in contact with improvised explosive devices.

Well, what is the Army doing about this problem?

We're joined by Dr. Thomas Meitzler. He's a scientist at the U.S. Army Tank Automotive Research, Development and Engineering Center, or TARDEC, and Dr. Joy Hirsch, professor at Columbia University and director of the Program for Imaging and Cognitive Sciences.

They're going to discuss a collaborative study to determine what areas of the brain are most susceptible to damage and, ultimately, to help further treatment and improve vehicle design.

Dr. Meitzler, it's a pleasure to have you back on the program once again. And Dr. Hirsch, we also really appreciate your time this afternoon. Thank you both for being here.

DR. HIRSCH: Thank you.

DR. MEITZLER: You're welcome, John.

DR. OHAB: I'll encourage any of our listening audience to tweet questions into @armedwscience. You can also post comments on our blog, Science.dodlive.mil. We'll make sure you get those answers.

Dr. Meitzler, as I mentioned, traumatic brain injuries have become increasingly common in Iraq and Afghanistan, but not simply severe injuries, but also those that can't necessarily be seen from the naked eye.

Can you tell us about some of the challenges in addressing traumatic brain injury and why it's such a concern to the Army?

DR. MEITZLER: Yes. Well, as you've mentioned, John, it's a large problem to the Army and, of course, to the soldiers.

And I guess how I'd like to start out is by telling you a little bit of how we got started with our collaboration with Dr. Hirsch and how we see that there's a link to this problem of diagnosing and treating traumatic brain injury. Several years ago, Dr. Hirsch and I got started on visual perception experiments and the treatment of vehicles. And we basically applied the science and technology of functional MRI to the visual perception problem, to determine what parts of the brain are being used for certain tasks.

And then later on, it -- the idea came to us that we could probably use the same technology and science to learn more about what's happening in traumatic brain injury.

DR. OHAB: And so tell us about the current collaboration between TARDEC and Columbia University.

DR. MEITZLER: Well, Professor Hirsch and I, and TARDEC and Columbia, have a CRADA -- that's a cooperative research and development agreement-- to basically apply and see what we can learn using functional MRI to do visual perception experiments and other kinds of experiments that could be of use to the Army.

DR. OHAB: And Dr. Hirsch, you're the director of the Program for Imaging and Cognitive Sciences, so I imagine you have a pretty good grasp for the neuroimaging tool that Dr. Meitzler referred to -- functional magnetic resonance imaging, or fMRI.

Can you tell us how fMRI works?

DR. HIRSCH: Sure. fMRI, or functional MRI, is the same as conventional MRI where we can look at the structure of the brain with beautiful, exquisite detail.

But in addition to being able to look at the structure of the brain, functional MRI allows us to look at the parts of the brain that are engaged during a specific function, so we can segment the brain by the working parts.

And what that means is that when we ask somebody to go in the scanner for a brain scan, we ask them to do very specific things, like a cognitive task or a language task or a memory task or a problem- solving task of some kind or another.

And we can watch the parts of the brain that are engaged in the systems that are called upon to do those tasks. And so one --

Getting back to your original question to Tom, why would functional imaging be relevant to traumatic brain injury, well, one of the reasons is that oftentimes in traumatic brain injury, as we're seeing from our soldiers returning from the field, is that they have symptoms of injury and yet the physical evidence for those symptoms is not obvious with conventional imaging.

That is, we don't see any defects when we look at their brain with the conventional, anatomical methods. But when we apply functional MRI and ask them to do things in the scanner, then we can begin to understand what the neurophysiology that underlies some of the behavioral difficulties actually is.

DR. OHAB: So in this collaboration, who are the actual participants and how are they selected?

DR. HIRSCH: Well, the collaboration that Tom and I have right now really rests with the visual perception studies that have really laid the groundwork for this.

In my lab, not in collaboration yet with Army, we've done many studies on developing these methodologies to look at the neurocircuitry associated with cognitive, emotional control or problem solving, doing complex decisionmaking problems, and so on.

And in Tom's and my collaboration through this CRADA, we have begun to realize that the techniques that functional imaging offers, and that we have developed, apply not only to our collaboration in visual perception, but also perhaps could be applied to serve the needs of our soldiers as they return.

Tom, would you like to offer some additional comments on that question?

DR. MEITZLER: Sure. In addition to what Dr. Hirsch mentioned there, we are proposing a program where we scan soldiers before they're deployed, and then make a comparison after they come back to the scan

they receive post-deployment -- and then also store that before and after information on some kind of a digital dog tag, so that the information is always carried with them and it can referred to at a later time.

We're also thinking about perhaps integrating some sensors inside the armor or the vehicle which records the amount and the location of the blast, and then do the science necessary to correlate the amount of neurocircuitry damage to the blast exposure.

DR. OHAB: And what would the typical experience be like for a participant?

DR. HIRSCH: Well, this is a very non-invasive, quite benign experience. To receive a functional MRI scan is just like a normal MRI scan. You go in the scanner and the scanner makes a lot of noise and you hold your head still and we get beautiful pictures of your brain.

It's actually less invasive than most conventional scans, because we don't have to use any contrast-enhancing agents; that is, that there's no IV, there's nothing that's injected.

Because the contrast -- that is, the source of the signal -- is endogenous. That means that it's just part of the ordinary process of the brain doing what the brain does, and we can actually image that.

So there is nothing invasive, nothing that puts anybody at risk. The FDA considers these procedures what they call minimal risk, which means essentially no risk that exceeds that of our normal, everyday life.

So the experience that one has is that you spend about an hour, maybe less, in an MRI scanner doing things. DR. OHAB: Such as?

DR. HIRSCH: Such as problem solving.

We can do very, kind of, basic mapping. So we can map the areas of the brain, of course, associated with sensory, motor, language, visual, and auditory processes. So just that general map of the brain landscape for individual people takes about 15 minutes.

And then, if we are interested in questions of impaired emotional or cognitive control, we can ask our subjects to do other types of tasks that are well developed paradigms such as, trial-by-trial, indicating the emotional expression on a face when there's some kind of interference, like a word that is not the same as the emotional expression on the face, or so on.

So we have a battery of tasks that are aimed to probe people's ability to control emotions, to control memories, to solve problems. Syllogisms are a good example, where we ask people to do syllogisms in the scanner.

They're all cued. Nothing's hard. And we can watch the brain during those activities, and begin to understand when neurocircuits are impaired or have lost some integrity.

DR. OHAB: And what does one do with that information? How can that research be used to impact therapy or soldier care?

DR. HIRSCH: Well, that's a really, really good question. And I think it's important to understand that we're thinking a little bit beyond our data, beyond the programs that are actually implemented, at least as I understand them.

But what we would like to do is what Dr. Meitzler said, is to image people on some of these -- image high-risk people before they go into the field on some of these tasks, and then have that stored as baseline information so that should they come back with some question of whether they have some kind of TBI, we could compare them on the same tasks again.

And as soon as there was a neural indication that there was some loss of function or some impaired disability, then we could start treatment earlier, based on evidence that is physiological, rather than just behavioral.

And Dr. Meitzler, you are a scientist at the Army Tank Automotive Research, Development and Engineering Center, so let's talk about vehicles.

Where do the vehicles themselves come into the equation?

DR. MEITZLER: Well, as Dr. Hirsch mentioned, what we would be doing would be scanning soldiers that go on route clearance. Now, route clearance, as typically performed, is basically a visual perception task. Soldiers are going down in a vehicle, down a road, and they're scanning the side of the road, scanning garbage piles, all kinds of different things, looking for potential targets -- or looking for potential threats, something that might be a bomb or an explosive.

So the work that we've done previously in visual perception and developing that methodology ties directly into the testing paradigm, I think, that Dr. Hirsch has been speaking of.

And of course, since we're in the business of vehicles, we are thinking about ways to, of course, increase the safety of the soldier. And one way in which we could do that would be to instrument the vehicle with sensors which could in some way measure the magnitude of the blast, to be used later on for further studies.

DR. OHAB: So --

DR. HIRSCH: Yeah. Dr. Meitzler, could I just interrupt, just to elaborate on that?

One of the things that you and I've spoken about which I think is just a terrific idea is that if we have information from the vehicle about the magnitude or type of blast that the vehicle has experienced

and, therefore, the passenger has also experienced, that we might be able to relate that to the individual neural damage for the passengers.

And that may be very, very useful, as we strategize efficient treatment routines for our soldiers as they return.

It may be very different type of injury that could result from a shearing or a type of direct, traumatic blast and so on -- or a very, very high-magnitude blast relative to one that wasn't so high- magnitude, of a low-speed blast relative to one that was high-speed, and so on.

There may be ways in which the vehicle can inform us about the injury that our soldier has experienced, and that will jump-start our abilities to help the remediation.

DR. OHAB: Dr. Meitzler, so the information gathered from the neuroimaging, combined with information gathered from the vehicle sensors, could that actually be used to design combat vehicles, then?

DR. MEITZLER: Yes. And it could also be used to guide the therapy of the particular soldiers involved.

There is a group here at TARDEC called the Blast Mitigation Team, and they're very involved with the safety of the soldier, making the vehicle safer in terms of seats and some other things. Perhaps in a later interview, you could speak with some of them about that. But all these systems tie together. Making a vehicle safer; adding some sensors so that we can make the vehicle intelligent; gathering that information, then using that to guide therapy, all ties together.

DR. OHAB: Now, I understand you're hoping to further apply some of the new noninvasive techniques for studying visual perception and how the brain processes camouflage.

Dr. Meitzler, could you talk a little bit about that?

DR. MEITZLER: I can talk about the test method that we're trying to use.

Dr. Hirsch's lab is basically offering us a window into the brain on how the brain perceives different kinds of camouflage and different kinds of paints and colors and things like that.

And it's an extraordinary opportunity for the Army to learn more about that whole process.

DR. OHAB: Dr. Hirsch, could you comment on that?

DR. HIRSCH: Yes. One of the important sort of realizations about neuroprocessing that really has developed since functional imaging has become a mainstream technique is that vision and visual perception isn't just the purview of the occipital lobe or the primary and secondary visual areas.

But indeed, the frontal lobe and higher-level centers of the brain have the ability -- that is, the built-in neurocircuitry -- to actually modulate information that comes into the brain.

Now, those models and those ideas really changed the way we think about tasks like visual search. And you can imagine soldiers in a vehicle, as Dr. Meitzler said, looking for items that would be threatening.

So these soldiers have these search mechanisms fully engaged. That's frontal lobe engagement.

The engagement of those systems actually up-regulates the parts of the brain associated with low-level detection so that there's a handshaking between the front of the brain and the back of the brain, or the bottom-up systems of the brain and the top-down systems of the brain, to enhance performance, to improve search and detectability.

Understanding these mechanisms is a very, very important part of understanding how to optimize those tasks.

And so we're hoping that the application of neuroimaging that extends our understanding of models of perception and tasks that are related to our soldiers could actually be very meaningful and productive.

DR. OHAB: And Dr. Hirsch, could you tell us a little bit about your organization, the Program for Imaging and Cognitive Sciences?

DR. HIRSCH: Sure. We're the core imaging facility for all imaging research at Columbia University, and we have a lot of collaborations outside the university as well. One, of course, is illustrated by the CRADA that we have with Dr. Meitzler's group in the Army.

It is a facility that is based on three MRI scanners and trans-cranial magnetic stimulation, electrophysiology, behavioral testing methods. And our aim is to apply these facilities in the service of understanding the underlying neurophysiological substrates that support cognition, perception, emotion, and their control in normal brain and in brain that is impaired.

So it's a very extensive mission. But we're sitting, of course, right in the middle of Columbia University Medical School, and so we have opportunities to work with populations of patients -- not just brain-injured, but also populations of patients with addiction disorders, alcohol abuse disorders, eating disabilities, obesity, for example; patients with neurological disorders, neurodegenerative diseases, seizure disorders, and so on.

And so we have a very, I think, privileged view of the brain where many of these neurological and psychiatric medical specialties and basic science disciplines kind of all come together.

And the boundaries that have separated them conventionally aren't so meaningful in this type of collaborative environment, where our aim is to understand brain mechanisms.

DR. OHAB: Now, does a function MRI offer specific advantages over other neuroimaging techniques, or are there other tools that you could be using to do this kind of study?

DR. HIRSCH: That's a really, really good question. There's advantages and disadvantages.

The main advantage to functional MRI is the extraordinarily high resolution. That is, I can image your entire brain in a few seconds at a resolution that's millimeter or sub-millimeter.

So I could (TOL ?) your brain in little units about the size of a grain of rice. And each little grain of rice, or voxel, as we call it, actually emits a signal that can be read.

So it's noninvasive, it's without any toxicity, extraordinarily high-resolution, and very, very fast.

And that is in contradistinction to, say, positron emission tomography, or PET imaging, which is slow, not such high-resolution, and you have the disadvantage of the toxicity due to the radiation.

Other neuroimaging techniques are electrophysiological, like EEG or magnetoencephalography. And they have the advantages of recording or measuring the temporal conditions in the brain -- that is, how fast these neurons are actually firing. But the resolution is very, very, very poor.

So you know about where some things come from, but you can't distinguish between sub- or cortical structures. So we get good timing, but very poor spatial resolution.

So in terms of neuroimaging techniques, functional MRI is about as optimal as we can get.

The disadvantage, of course, is that these machines are expensive. You can't just bring them to field easily; you've got to site them properly. They're touchy, et cetera, et cetera. But other than that, when you get a good measurement, then you have information that's valuable.

DR. OHAB: And what other industries -- for instance, sports -- are taking advantage of the functional MRI, and are there lessons that you could learn from some of the studies in those fields?

DR. HIRSCH: Well, that's a really, really good question.

Functional MRI has really become the backbone of neuroscience. If you go to the Society of Neuroscience annual meeting, it used to be that only about 10 percent of the papers involved functional imaging. And

now it's, I would say, closer to 85 percent of all the papers involve some type of supporting evidence from functional imaging.

So the basic disciplines -- of course, behavioral sciences like psychology and psychiatry, but of particular interest now are the economics, neuroeconomics -- decisionmaking, neuromanagement, business school, law school, neurolaw.

All of these fields are emerging, turning to the neurocircuitry of the brain as a kind of way of understanding old models and old questions.

So now, that's a little bit tangential, but getting back to your question, what have we learned that can actually help us in the service of our soldiers, we have a great deal of experience now in using functional MRI to quantify deficits, for example, in neurological decline, Alzheimer's Disease, types of medical applications that lead us to new ways of thinking about treatments.

And so there's an arsenal of experience that can be called upon in this regard, I think.

The other advantage is that we have a whole lot of tasks that are well established, things that people can do in the scanner that are standard; people understand them.

You say that you've done a particular task, everybody knows what you have done. And so there's a lot of standardization with respect to that that's very helpful.

DR. OHAB: Dr. Meitzler, as we wrap up today's program, do you have any final thoughts?

DR. MEITZLER: Well, I hope Dr. Hirsch and I can continue with our collaboration in the veins that she's mentioned.

Some of the sports industries that came to my mind while she was speaking are, potentially, boxing, football (teams ?), even snowboarding and skiing. There are numerous head injuries in all of those. DR. OHAB: Dr. Hirsch --

DR. HIRSCH: So yeah, that's right. Whenever there are injuries related to the head in any kind of sport -- particularly boxing; there's been a lot of studies looking at boxing -- potential injuries, using functional imaging, very much of the kind that would be applied to TBI.

DR. OHAB: Well, wonderful. I really appreciate both of your time today. I'd like to give each of you the opportunity, if you'd like to offer any closing thoughts.

DR. HIRSCH: Well, thank you, John, for the opportunity to present this. I think that there are many, many important opportunities in moving forward that could apply functional imaging to serve our

soldiers, and that I certainly, for one, would be very, very happy to engage in any or all of those that are possible.

DR. OHAB: Dr. Meitzler?

DR. MEITZLER: I'd like to also thank you, John, for offering us this venue to talk about our research and suggest that perhaps you also talk with the Blast Mitigation Team here sometime in the future.

DR. OHAB: I think that would be a wonderful opportunity.

Our guests today are Dr. Thomas Meitzler, scientist at the U.S. Army Tank Automotive Research, Development and Engineering Center, or TARDEC, and Dr. Joy Hirsch, professor at Columbia University and director of the Program for Imaging and Cognitive Sciences.

I think both of the work you guys are doing is very important, and I really hope that we can touch base down the road and see how things are going.

DR. HIRSCH: Thank you, John.

DR. MEITZLER: Thank you, John.

DR. OHAB: Please tune in next Wednesday, February 10th, when we are joined by Colonel Paul Shepherd, deputy commander of Joint Task Force, the Port Forces Antarctica -- commonly known as Operation Deep Freeze.

Operation Deep Freeze is the name given to operational and logistics support conducted by the U.S. military in support of the National Science Foundation's efforts to explore Antarctica.

It should be a cool show, no pun intended.

Thank you again. I'm Dr. John Ohab, and you've been scienced.

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