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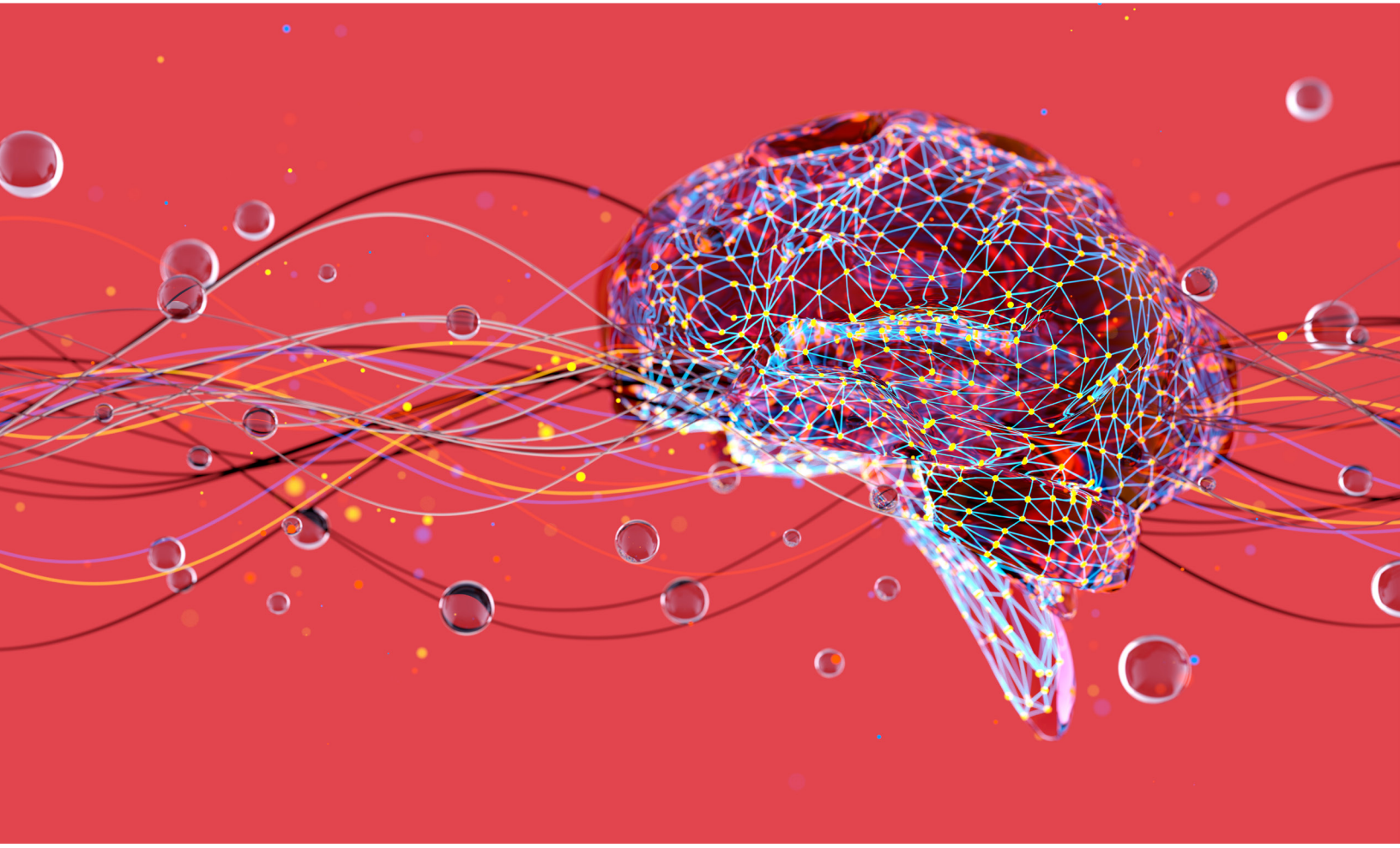
Defense Applications for Behavioral Neuroscience



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Defense Applications for Behavioral Neuroscience

IDA Ideas Host Rhett Moeller spoke with guest Sujeeta B. Bhatt about behavioral neuroscience, the biological basis for why people act as they do, and how this field applies to interviewing and interrogation, human-machine teaming, non-lethal weapons, and traumatic brain injury. Sujeeta is a Research Staff Member within the Strategy, Forces and Resources Division (SFRD) of IDA's Systems and Analyses Center, an IDA-operated federally funded research and development center. She has a background in cognitive science, psychology, deception detection and military criminal investigative organizations. The study of behavioral neuroscience offers a biological foundation for human actions and what parts of the brain are used for certain behaviors. Interpreting these changes has real-world applications within the FBI, DOD and other federal entities.

[Begin transcript]

Rhett Moeller: Hello listeners. I'm Rhett Moeller and I'm the host of IDA Ideas, a podcast hosted by the Institute for Defense Analyses. You can find out more about us at www.ida.org. Welcome to another episode of IDA Ideas.

Today we're going to look at the subject of behavioral neuroscience, and coming to talk with me today is Sujeeta Bhatt, a Research Staff Member from our Strategy, Forces and Resources Division, or SFRD. Sujeeta, could you take a moment to introduce yourself?

Sujeeta Bhatt: Sure. Hi, my name is Sujeeta Bhatt. I am a behavioral neuroscientist here at IDA. I received a … [doctorate] in behavioral neuroscience, … a master's [degree] in psychology [and] psychopharmacology and a bachelor's degree in behavioral psychology.

Rhett: Well, thank you so much for making the time to chat with us today, Sujeeta. I think this is a fascinating subject, and I am excited to talk about this with you. Behavioral neuroscience sounds like a big idea. Can you break it down for us? Tell us what this field is?

Sujeeta: Sure, so starting with just neuroscience. Neuroscience is a scientific study of the nervous system: its function, its structure, as well as its dysfunctional diseases. And it's a very multidisciplinary field. Neuroscience itself can include things like molecular biology, anatomy, psychology and even math and chemistry. But behavioral neuroscience is a sort of a more specific area or field in neuroscience that looks at the biological basis of behavior. And so, it's also multidisciplinary in that it brings in psychology as well as neuroscience

and the structure. So, it's kind of identifying what parts of the brain are being used when we engage in certain behaviors.

It's also multidisciplinary across the neuroscience field in that, just as I've mentioned, neuroscience is kind of the broader term, and behavioral neuroscience is one of the sorts of subspecialties under that. There are other subspecialties such as cognitive neuroscience, affective neuroscience, which also play a part in behavioral neuroscience in that … we also understand how emotions can affect behavior and where in the brain that takes place, as well as how cognition (or your ability to problem solve and think) also again impacts behavior and how that is driven by brain processes.

Rhett: I'm an aspiring linguist, so psycholinguistics and how we formulate thoughts and turn it into words that then you can understand…it's such a neat field. Well, you've given us a lot to think about with behavioral neuroscience and certainly exposed just how large a field it is. Obviously, you've put in a lot of work to get to this point. Can you tell us a bit about your background?

Sujeeta: Yes, so my graduate work was on head injury and recovery of function after brain damage, and that was my eventual goal: … to work in a lab, come up with ways in which we can help individuals with traumatic brain injuries [and] recover that function that they've lost from the injury. But after completing my …. [doctorate], I received two awards that really kind of opened the door for me to get outside of the laboratory and into more of an applied setting for behavioral neuroscience.

The first was an American Psychological Association award. It was a summer fellowship that placed me in an office that no longer exists, but it was called the Counterintelligence Field Activity, and I was only there for the summer, but it opened the doors for me in terms of helping me meet all of the individuals that I actually even today keep in touch with. CIFA, which is the Counterintelligence Field Activity, had a very large number of behavior scientists on staff. I built my relationships with a whole host of colleagues, and they really showed me how I could apply behavioral neuroscience to national security problems.

Rhett: Sujeeta, sorry to interrupt. You mentioned CIFA?

Sujeeta: Yes, so the Counterintelligence Field Activity, it was CIFA, was part of the Department of Defense. It actually, I believe, rolled into the Defense Intelligence Agency in around 2008. So, it no longer exists but was around back then.

Rhett: Is that part of DOD?

Sujeeta: Yes, yes, it was … in 2005. Around 2008, it rolled into the Defense Intelligence Agency. And the second award I received was the Intelligence Community Postdoctoral Fellowship, and that at the time was actually headed by the CIA. And in that postdoctoral fellowship, I studied lie detection and neuroimaging. So, my goal here was to identify what parts of the brain are active when people lie. The design of the study was based on an issue

that we were running into. It was the global war on terror. We had high-value targets that we had rewards for, in terms of … if somebody knew who these people were or where they were, they could potentially receive award for turning them in.

And so, people were walking into embassies claiming to know one of these high-value targets, and there was no way for us to know whether they really knew them or not. So, I designed this study where I had study participants memorize faces, and they were similar looking, so you couldn't say, oh well, this person had a beard and the other two didn't. It was that everybody looked very similar. And they were either to lie or tell the truth.

And by lying, they could lie and claim that they didn't know somebody in the lineup when in fact they did, or they could lie and claim that they knew somebody in the lineup that they actually didn't know. And we looked at what parts of the brain are active when people lie in these types of situations. And we found that actually the parts of the brain that are active were not unique in that lying relies on certain cognitive processes like suppression of the truth, working memory. And so, the parts of the brain we saw that were active were those. The other big issue, of course, is that we're asking subjects to lie in the study, which really isn't deception, it's just instructed lie. And so, to date, the neuroimaging studies that have been done on lie detection in that type of context … [haven't] really studied deception. … [They've] really studied instructed lie. But once I finished my postdoctoral fellowship, I actually joined the Intelligence Community [IC] and was an employee for several years before I was detailed to the FBI's High Value Detainee Interrogation Group. And so in that position, we were really interested in identifying gaps in both knowledge and practice when it comes to interviewing and interrogation.

And we discovered, actually, that a lot of the approaches that were being used in interviewing and interrogation were not really science-based, and we had well over a century of behavioral science research that we could apply in a very non-coercive way, right? Like if you think about it, advertising companies get us to comply with what they would like us to do, right?

Like I said, we've known this, this type of research, we've known how to get people to do what we want them to do very easily, but none of that science had really been applied to interviewing and interrogation. At the High Value Detainee Interrogation Group, part of the research unit, we identified these gaps, we funded projects to fill those gaps and then developed training modules for state and local law enforcement, federal law enforcement as well as DOD interrogation units.

So, I was at the … FBI's High Value Detainee Interrogation Group for about four years before I left and went to the National Academy of Sciences, where I was very lucky to lead two really big studies, one on how people learn [and another on] the science and practice of learning. And the second one was for the Office of the Director of National Intelligence [ODNI]. I mean in that project, we were looking at what areas in the social behavioral

sciences could we identify that with enough support looking forward 10 years could really make an impact on intelligence analysis.

One of the areas that we talked about in this report was human-machine teaming. Human-machine teaming has been a really big topic for a number of years now. But there are a lot of things that we don't know. So, for example, how do you build trust with the machine? If you are a person working and the machine starts interrupting you … think about every time you get a text message or a Jabber message or something along those lines. How does that interrupt your train of thought and your flow? … There are a whole lot of questions that still need to be answered in this area, but these are the types of things that we were really interested in.

But I really missed my support to the DOD and the IC. And so, when I was looking, actually, oddly enough, [this position at IDA] was the only position that I applied to after the academies. And it was because the position actually asked for a research psychologist. In my experience with the government was that the job code for behavioral scientists like myself, there was only one, and that is psychologist, and that tends to be a clinical psychologist, which is not my background. And so, the fact that here's this office, this organization that understands research psychology, research as a behavioral scientist made me very, very excited. And so, I applied and I have been here now over five years working on a whole host of projects, some related to neuroscience, some not, but it's been just fantastic.

Rhett: Well, we're really glad you're here with us at IDA. Now, as we were preparing for this discussion, Sujeeta, you mentioned some things that you have been doing. You have been working in non-lethal weapons, specifically in area denial applications. Can you tell us a bit more about that, what that means, and then where your research has taken you in that area?

Sujeeta: Sure, I have been working with colleagues at IDA on one particular specific non-lethal weapon, which is flash bang grenades, which are also known as stun grenades. And so active denial technologies are those technologies that are trying to, as the name says, actively keep individuals from certain areas. It may be actively trying to keep someone from, or groups of individuals from, approaching an embassy or a U.S. government building. It may be also actively trying to prevent them from engaging in a violent act, whether that be throwing an object like a rock or using weapons against U.S. persons or bases or buildings. The work that we've been doing with the flash bang grenades has really been looking at human effects and human effectiveness, and there is a distinction, right? Human effects are how those components of the weapon affect the human. And then human effectiveness is how effective it is in these types of active denial situations.

Rhett: That makes sense.

Sujeeta: The goal, of course, because these are non-lethal weapons, is to prevent forward movement, or clear an area of individuals, or get people to move in a certain direction with the objective of doing this in the most non-lethal way. The goal here is to reduce the risk of significant injury while also protecting U.S. persons and buildings.

The work that we've been doing with the flash bang grenades has been really … interesting because we know, right, there's obviously a flash, there's a loud bang, and then there's this feeling of … pressure, it's called overpressure, from the explosion. And developers have now flash bang grenades that have multiple flashes and multiple bangs, but we really don't understand which of those components are most effective, right? Is it the flash? And anecdotally we've heard no, I mean, if you think about it, if you know [the] flash is about to come, you just close your eyes, right?

Rhett: Right.

Sujeeta: The countermeasures are really simple in that regard. But also, the effect of the flash is flash blindness. Which of course means that it's like those of us who remember, I guess even in cell phones, you still have these flashes, right? If you stare at a flash, you'll get what's called an after image, sort of this activation of the eye that makes it so that you can't see anything but that image of the flash, right?

Rhett: I've been there.

Sujeeta: Yes, right. … All of us have experienced this, and you know that it does temporarily blind you. But it's temporary and it's very short-lived. Flash bang grenades, obviously, the luminescence of that light is much greater than you would have on a flash of a camera. After effects are much longer, but nonetheless, it can still affect your ability to see.

Rhett: Obviously, you don't want the effects to overpower the ability to respond the way you want people to, right? So, if there's a flash of light and you can't see, it's not reasonable to expect them to be able to move where you want them to go.

Sujeeta: Right, yes. You know, I think for flash blindness, it is relatively short-lived, but you can see how that could cause people's stress response to increase significantly.

Rhett: Sure. Yes.

Sujeeta: I think that one of the interesting areas, also, [is] just the sound, right? If your hearing is muffled and you can't hear clearly, [if] someone is giving instructions … you can't either make out where the sound's coming from or … make out what's being said to you. And then if you think about a DOD context, oftentimes these are in areas where we don't speak the language. And so, you've got DOD personnel giving instructions in English to a group of people who may not understand English, or [who] may, but now that it's muffled and it's difficult to make out; you can see how that could cause all kinds of confusion and might actually be counterproductive.

Rhett: Absolutely.

Sujeeta: But then with the sound, it's a loud enough decibel where we're not looking to, again, cause permanent hearing loss, but you will end up with what's called temporary threshold shift, which is kind of that deafening that you might hear after we go to a concert. I think again, we've all experienced this or tinnitus—the ringing in the ears. And these are all temporary.

And then the overpressure is that feeling of pressure and it's really you feel it in your lungs — [or] any hollow organ — from the explosion. When you look at things like human effectiveness, if the objective is to clear an area and get people to move from this area to wherever, and you've now used a flash bang grenade to do so, but [if] now people can't hear or they can't see where they're going that's counterproductive to what you want to do. The research that we've been doing is looking at just that, like which of the components are the most important to reach the objectives that the DOD might be wanting to achieve with the use of flash bang grenades. But [we're] also … [trying to understand] is it the flash? Is it the bang? Is it the combination of the flash [and] bang? These types of first orders and second order effects haven't really been studied. We've just kind of been using them because they have been effective.

Rhett: You've described the mechanical workings of the flash grenades that you've been studying, and it sounds like you've obviously put a lot of work into that, but you're also trying to figure out how it influences people's ability to do what you want them to do. Can you tell us a bit more about that aspect of your work?

Sujeeta: Another area that we've really done a deep dive into (and this kind of goes into the more behavioral side of things) … is looking at what the mediator variables are to lead to the behavioral changes that we're seeking, right? One example is the stress response. Obviously, not being able to hear…being in a situation like that in a crowd of people, think of a protest for example … you're going to have really high levels of stress to begin with. People are amped up. But what we've discovered is that when you have a flash bang grenade that goes off, your stress level goes up, and that stress level can lead to, essentially, the stress cascade. You can have fight, fight and freeze. You want to use these weapons in the context where you're going to get the greatest compliance with what you want to have happen in terms of movement or stopping people.

If your goal is to stop people and you cause them to freeze, great. Then it worked, right? But if your goal is to get people to move from one area to another, and now you've caused their stress response to be so extreme that you caused them to freeze, that's counterproductive. And so, some of these questions just hadn't been studied in the context of non-lethal weapons and flash bang grenades. That's what our team has been doing.

Rhett: You and your team have obviously put a lot of work into what you've talked about already. What implications and (or) conclusions have you come to?

Sujeeta: The stress response has been a very well-established response in both animal and human models. But what we did was … [bring] it to the sponsor's attention in terms of something that they need to think about and [we] also developed a list of research questions, actually, to continue finding more information on [it]. For example, if you think about how flashbang grenades are used, in law enforcement, they're oftentimes used in … a single situation, whether it's somebody's barricaded in the house and they want that person to leave. So, it's a single person or a very small number of people that are going to be affected by this. In a DOD context, it's oftentimes a crowd that has gathered. And so, one of the things that we are really interested in that hasn't really been studied in great detail is how behavior of a crowd can affect the context and the human effectiveness of a flashback grenade.

There are just a lot of open questions that we've identified for the sponsor that we really do need to continue doing some research on. The sponsor has taken the work that we've provided and has looked into developing animal models. Obviously, flashbang grenades are not something that you can actually use to study in humans because of human subject protections, thankfully. In those types of situations where it's very difficult to study these types of things in a human population we will turn to animal models. And so, the sponsor has been looking at animal models of how behavior changes because of the stress response. They've continued to do this work and continue to fund projects and we help to provide guidance in terms of what we know from the human literature and where they need to take the animal research in the animal models in to better understand the effects and effectiveness of non-lethal weapons.

Rhett: Well, that's really interesting, Sujeeta. You mentioned using animal behavior models. How well do those map to human behavior models?

Sujeeta: You know, it depends on the … context of what you want to study. Obviously, we can't understand animal cognition that well. … There are certain parts that we can. We could test an animal's memory, for example, but there are animal emotions [and there is] still debate on whether they have emotions. So, there's certain things that we can't study. When it comes to something like flash bang grenades, it depends really also on the animal that's being used.

Oftentimes lab research uses rodents, but they tend to be prey animals. And so, their stress responses are different than predator animals, or humans, for that matter. Their immediate response tends to be to freeze. Anyone who's seen a squirrel dash in front of your car knows they do freeze very instantly. Sometimes it's difficult to do, but when you're … studying something like movement from one area to another, you can actually use animal models to study that quite well. It's particularly effective when you're looking at gross motor behaviors and not trying to understand the basic neuroscience, the cognitive neuroscience and the effect of neuroscience of what's happening in the brain.

Rhett: As you're talking, Sujeeta, I'm struck by just the wide range of expertise we have here at IDA, and it's just neat to me to realize how many interworking parts there are [and] so many disciplines and backgrounds working together. We have social sciences, we have behavioral sciences, we have physics and other harder math-related subjects. It just makes me wonder what has your experience been working here at IDA with perhaps multiple different disciplines on the same team.

Sujeeta: It's been just a fantastic experience. The flashbang grenade studies, for example, I'm not the task lead on it, but I am fortunate enough to be asked to contribute my expertise to that project. On this particular project, oftentimes [we] have other behavioral scientists as well as physicists and engineers working on this. In my perspective, that diversity of thought makes our products so much stronger. If you think about it, how an engineer approaches a problem or describes a problem is very different than how a behavioral scientist might describe a problem.

Rhett: Right.

Sujeeta: And for us to be able to work together, we have to speak a common language. And so, we're able to do that quite effectively. As a behavioral scientist, one of the things that I find just really exciting about being at IDA is … just the sheer number of projects that I get asked to be part of. The recognition that there's a human at the center of everything. If you think about it, this is an area that was actually in the ODNI report I mentioned earlier, but it's an area that I think we're all starting to turn towards and understand better. … Up until not that long ago, when you talk about cybersecurity, you think of it as a technical problem with a technical solution. The problem with approaching it that way is that you ignore the person behind all of that. So, you've got a person who's engaging in the attack, but there's also individuals who are vulnerable to those attacks. And so, there's a human component to all of that.

I feel very fortunate that the staff at IDA recognize the importance of the human in all of these problems that are central to the DOD. We may have teams working on developing planes or helicopters, but again, you've got a human … [who is] still flying that. And so, you've got people with an expertise in human factors, which actually does fall into some of the neuroscience background as well. We're quite lucky, I think, in that regard here at IDA that we are able to bring together such varied expertise that I think are one of the unique features about being here.

Rhett: Well, speaking of expertise, I know you haven't done any work in this, but you see a potential application and use for our sponsors about CTE, chronic traumatic encephalopathy, and other blast-induced injuries. What do you see being the utility of that? How do you see that helping with [the] Department of Defense and its interests?

Sujeeta: Yeah, so there's been some interest, actually, in the news as of late on effects of CTE on service members. I think we've naturally thought of traumatic brain injury being a potential effect of combat related injuries. And what we're actually discovering now is that there is the potential to have these types of repetitive injuries from blasts alone. So non-combat injuries that could happen during practice, whether that be using a tank, using certain weapons [or] repetitive grenade blast exposure. There was a report about sailors developing CTE (or at least repetitive concussions) from being on high-speed boats as they hit the water.

Rhett: Wow.

Sujeeta: There has been some movement in trying to do something about this. You know, Congress introduced the Blast Overpressure Safety Act in April of 2024, and that act orders the military to begin recording troops' individual blast exposures in training and regularly giving exposed troops a neurocognitive test to check for signs of possible concussions. … We've known for a long time about post-concussion syndrome or secondary concussion syndrome, right? If you have a concussion and you don't have sufficient time for your brain to recover, and then you would have a second concussion, the effects are significantly worse. The DOD has not been keeping track of — particularly in training exercises — how often an individual may be exposed to a blast. For the DOD broadly, I think [that] thinking about ideas on how we can develop something like a concussion protocol for service members as they're practicing with their weapons, … would be really, really helpful.

So, there was actually a paper from the New England Journal of Medicine that looked at CTE in service members. So, one of the issues with this type of research is compounding variables. And so, we know that contact sports are the primary reason why people are developing CTE. And when you look at service members, you know, these are people who are highly athletic and great shape, and most of those individuals have participated in some form of contact sport. And so how do you distinguish the injuries that they received from childhood on in terms of concussions versus later on. And so, there's actually a brain bank, the DOD has a brain bank that people can donate their brains to after they've passed away. So, in this New England Journal of Medicine article, they looked at the brains of individuals who had served and looked for CTE and they didn't find the rate that you would expect. But again, some of that is this confounding variable of people playing sports. They also didn't have a good history. As I mentioned before, the DOD isn't keeping track of how many times somebody is exposed to a blast. And so, when you're looking at someone's brain, you need to have some of that information in hand. And so, I think for us, better record keeping on these types of things will really help the research.

Rhett: Having served in the field artillery battalion I … know the pressure that comes from the repeated explosions.

Sujeeta: The New York Times has had a number of stories about this as of late. So, there was the person in Maine last year who engaged in a mass casualty event. They actually didn't find CTE in his brain, but they did find that he had significant brain damage, and he was a grenade instructor, and so he'd been exposed to over 10,000 blasts. And there's just been story after story like this. And to be honest, [the] DOD has been, and thankfully and rightfully so, focused on reducing the rates of suicide in service members and veterans. And it makes me wonder sometimes how much of those suicides could be attributed to these types of, maybe not quite CTE, but enough brain damage to cause significant personality and life changes — lifestyle changes. And we're just starting to better understand that now, but I don't know how much anyone's really looked into this.

Rhett: Well, Sujeeta, this is a very important topic. I think you have made it abundantly clear just how critical it is for us to look into these things to understand them, and I want to thank you for taking the time to discuss this timely topic with us and for sharing your expertise. It has been most illuminating.

Sujeeta: Thank you so much, Rhett.

Rhett: As always, if you want more information on IDA and its ongoing work, please check us out at IDA.org. We also have a presence on X at IDA_ORG, and we have a channel on YouTube. … IDA Ideas is hosted by the Institute for Defense Analyses, a nonprofit organization based in the Washington, D.C. area. Once more you can find out more about us and the work we do at IDA.org. Thank you for tuning in, and we hope you'll join us again next time as we discuss some other big idea here at IDA Ideas.

Show Notes

Learn more about the topics discussed in this episode via the links below.

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