

Science AMA Series: We're Karim Oweiss & Kevin Otto, engineering professors at the University of Florida and PIs in DARPA's Targeted Neuroplasticity Training program. We both enjoy helping people with neurological injuries and disorders. AUA!

Targeted<sub>Neuro</sub><sup>1</sup>and<sub>r</sub>/ScienceAMAs<sup>1</sup>

<sup>1</sup>Affiliation not available

April 17, 2023

### Abstract

A third of all human disease is related to the nervous system. That's why President Obama launched the BRAIN Initiative. That's why the two of us have devoted our lives to studying the brain. We are Karim Oweiss, professor of electrical and computer engineering, biomedical engineering, and neuroscience, and Kevin J. Otto, associate professor of biomedical engineering. We're both faculty in the Herbert Wertheim College of Engineering and members of a campus-wide community at the University of Florida that is working together to understand the structure and function of the brain, and to unlock breakthrough therapies. Last month we were each awarded \$4.2 million from the Department of Defense to investigate how applying electrical stimulation to peripheral nerves can strengthen neuronal connections in the brain and accelerate learning. Our research projects – which are actually totally separate – are two of eight projects nationwide selected for the Targeted Neuroplasticity Training program of the Defense Advanced Research Projects Agency, or DARPA. To the best of our ability we will answer questions about these projects, as well as anything you might want to about emerging neurotechnologies and tools, neurological disorders and diseases, and the effects of aging on the brain. Here's a little more information about us: Karim Oweiss (@koweiss): My lab is focused on studying the basic mechanisms of sensorimotor integration and learning, and engineering clinically viable brain machine interface (BMI) systems to restore, augment or repair damaged neurological functions like hearing, sight and movement. We focus on mechanisms of neural integration and coordination in executive control areas of the brain such as the prefrontal and sensorimotor cortices. We're working to understand how ensembles of neurons represent and integrate multiple sensory cues to guide motor action; how neural computations take place at the cellular and population levels with cell-type specificity; how neural ensemble activity can be decoded to actuate artificial devices; and how precise control of cell-type-specific events can perturb and control neural responses to evoke desired behavioral outcomes, as well as long-lasting plastic changes in neural circuits that mediate this behavior. An ultimate goal is to make a quantum leap in machine intelligence by developing bio-inspired smart algorithms for a variety of applications such as autonomous vehicles and Lifelong Learning Machines. I moved my lab to the University of Florida in 2014 after 11 years as faculty at Michigan State University. I am a professor in UF's Department of Electrical Engineering, with affiliate faculty appointments in the J. Crayton Pruitt Family Department of Biomedical Engineering and the McKnight Brain Institute. I received my Ph.D. degree in electrical engineering and computer science from the University of Michigan, Ann Arbor. I'm a senior member of the IEEE, received the excellence in Neural Engineering award from NSF, and am editor of the book: Statistical Signal Processing for Neuroscience and Neurotechnology (2010). Kevin Otto (@OttoKev): My research is focused on engineering neural interfaces for both research purposes as well as treatment options in neurological injuries or disease. In particular, multi-channel implantable microdevices in both the central and peripheral nervous systems. These interfaces are being investigated for many applications including sensory replacement, cognitive functional therapy, and neuromodulation for autonomic therapies. In 2014, I joined the J. Crayton Pruitt Family Department of Biomedical Engineering at UF as an associate professor after eight years as faculty at Purdue University. My post-doc fellowship at the University of Michigan, Ann Arbor, was in biomedical engineering and in the department of otolaryngology with a focus on cochlear implants.

I earned my Ph.D. in biomedical engineering at Arizona State University. I am the co-chair for this year's National Biomedical Engineering Society Annual Conference. We will be back at 1 pm ET to answer your questions, ask us anything! Hey everyone, we're jumping on now to answer your questions until 3pm ET

[REDDIT](#)

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TARGETED\_NEURO [R/SCIENCE](#)

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**Kevin Otto (@OttoKev):** My research is focused on engineering neural interfaces for both research purposes as well as treatment options in neurological injuries or disease. In particular, multi-channel implantable microdevices in both the central and peripheral nervous systems. These interfaces are being investigated for many applications including sensory replacement, cognitive functional therapy, and neuromodulation for autonomic therapies.

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CORRESPONDENCE:

DATE RECEIVED:

May 12, 2017

DOI:

10.15200/winn.149450.03454

ARCHIVED:

May 11, 2017

CITATION:

Targeted\_Neuro , r/Science , Science AMA Series: We're Karim Oweiss & Kevin Otto, engineering professors at the University of Florida and PIs in DARPA's Targeted Neuroplasticity Training program. We both enjoy helping people with neurological injuries and disorders. AUA!, *The Winnower* 4:e149450.03454 , 2017 , DOI: [10.15200/winn.149450.03454](https://doi.org/10.15200/winn.149450.03454)

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1. What are your thoughts on Elon Musk's Neuralink initiative as it relates to your work?
2. With evidence of the effectiveness of certain psychotherapies and psychedelics such as ibogaine, LSD, and ayahuasca as it relates to overcoming disorders like PTSD and drug addiction, do you take that into account or foresee a synthesis between your work (in any capacity) and these psychedelic treatments?

[HawkofDarkness](#)

1. Neuralink is a very intriguing initiative! They have recruited some outstanding people to work on this very challenging problem. I would argue that direct brain interfacing and our approach (peripheral neural interfacing) are significantly different.
2. I think that pharmacological effects on the brain are definitely intriguing. Due to their accessibility many have been investigated for focus, learning, and directed brain effects. Unfortunately, they have systemic effects as well, and consequently a lot of side effects. It will be interesting to see how our approaches compare and contrast. --Kevin

1. What are your thoughts on Elon Musk's Neuralink initiative as it relates to your work?
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[HawkofDarkness](#)

1. A good step forward, but very ambitious endeavor that may stumble across too many hurdles given our current state of knowledge.
2. Cannot comment, but yes there is a synthesis. If we know which circuits these treatments mostly affect, we can devise better therapy that is more personalized with less side effects. --Karim

Hi, i'm a composer living with Tourette Syndrome, OCD, ADHD and Asperger's Syndrome. I've been interested in transhumanism and brain-computer-interfaces for a long time. My question is: how long will it be until i can get a brain-computer-interface to eliminate the symptoms of my neurological disorders? for instance, make me less sensitive to overstimulation and erase my constant urge to do my tics?

bonus question: How long will it be until i can compose music by just imagining it into a brain-computer interface instead of using programs like Ableton Live?

thank you for reading this :)

[petermobeter](#)

I would encourage you to check out recent UF work on Deep Brain Stimulation and Tourette's syndrome: <http://brainmappinglab.org/brain-mapping-lab-featured-on-cnn/>

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thank you for reading this :)

[petermobeter](#)

perhaps soon if we are able to identify the neural markers of tics. You can certainly imagine anything you want to compose; the question is how well we can develop a BMI that translates neural signatures of your imaginations into sequences of notes that you like. I would say this is not unfeasible, provided we have the right technology that measures these signatures.

-Karim

when will we use brain-computer interfaces ?

[eyupcanakman](#)

Brain-computer interfaces are used everyday already. The question is when will the information transfer accomplish tasks that we take for granted with our natural sensory, motor, and autonomic systems. --Kevin

Thank you very much for this AMA. Do you think we will ever get to a point where BMIs get so good that it becomes desirable for the average person to augment perceptual or action capabilities via artificial devices even without having a condition. On that note I would also be interested if this is one of your goals from an ethical point of you since there is plenty of literature deals with the problem of the human body becoming "obsolete" and the consequences this might have on society.

[HalloweenheadEUW](#)

In fact, the goals of this DARPA program are for "the average person" to use Targeted Neuroplasticity through peripheral neural stimulation. The DARPA program managers have had considerable foresight and the program has Ethicists on board that will continue to work with the scientists to address these kinds of issues. --Kevin

Dr. Otto,

I took your BIOL 599 class at Purdue my senior year as a prerequisite for dental school. I felt out of place with all the BMEs but I found your lectures to be extremely interesting!

In dentistry, iatrogenic nerve injuries, while not super common, can and do happen during oral surgery. Could there be any potential applications of your research to guiding these tissues to re-innervate and restore function for my patients?

Thanks!

[sopjohn](#)

Great to hear from you! I hope dental school is going well.

There is a lot of interest from dentists and oral surgeons in cranial nerve interfaces. I am very excited to begin collaborations with these experts here at UF. In fact, we have begun discussions along the line that you mention. --Kevin

As someone who has just recently moved to Florida and plans to attend UF with the dream of becoming a neurosurgeon, this ama is awesome! The brain is so exciting to me because it seems like we know so much about it and yet so little. So I was wondering, how many years, if ever, are we from "mastering" the brain. Also, are there any myths such as the "only use 10 percent of the brain" that are circulated in the general public?

[ArcadianGhost](#)

Welcome future Gator!

There is a philosophical theory that no entity can completely understand itself. So, human learning will change the brain, which then is a new entity! I guess neuroscience has plenty of work to do (and maybe job security?).

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[ArcadianGhost](#)

Probably many, depending on your definition of "mastering". Mastering can be "reading" an entire brain, but could also mean "controlling" it. Regardless, we are still far away from either, but we're making good steps towards the first.

There are myths, and the '10% of the brain being used' is probably one of them, otherwise why would the other 90% exist in the first place? --Karim

Im a cognitive scientist about to start work at the VA with mTBI vets. If you had to pick one question to pursue in my shoes (2 years, VA data and subjects), what would it be?

Fwiw I'm interested in hyperconnectivity after brain injury, and my specialty is human vision.

[Reggaeocalypse](#)

understand how cognitive visual decline occurs after TBI, and the extent to which changes in the brain's structural connectivity give rise to hyper functional connectivity after injury. --Karim

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Sorry to hear about your struggles, but glad to hear that you are continuing to regain function! It is not clear at this point how PNS stimulation might address pathological conditions. Hopefully we'll learn more! It's Great to Be a Florida Gator!

We know that the PNS has a better and more robust regenerative capacity than the CNS, so what research is being done for degenerative CNS diseases? Are there any new therapies or techniques on the horizon? Also, is there any work currently being done on remyelination therapies for disorders such as MS, and what is the outlook?

Thank you, and Go Blue!

[pkbonez](#)

Great question! We are very interested in some of the unique capabilities of the peripheral nervous system. There are some outstanding PNS technologies that are coming out, some directly from this program. We are excited to use them in our studies!

Given my 4 years in Ann Arbor, Go Blue! But also, it's Great to Be a Florida Gator! --Kevin

I think this one is directed towards Dr. Oweiss. Can you expand a bit on "bio-inspired smart algorithms?" Also talk some more on the neural engineering based algorithms you are hoping to improve? I'm an undergrad in computer science and neuroscience, so this kinda stuff is fascinating! Thanks again for the AMA!

[JamesHalloday](#)

1- Algorithms that are designed based on what natural neural circuits are set to learn and do. Examples include short and long term memory formation, preventing catastrophic forgetting of past experience, generalize learned rules from limited data to new situations, etc...

2- Improve current ones to have better cognitive abilities, i.e., to create, maintain and recall different types of memories and update learning rules based on limited training data.

undergrads in CS are great to work in this area! --Karim

I'm a graduating high school senior presenting a cognitive neuroscience study (regarding electroencephalography of participants with differential handedness) at the Intel ISEF next week, so I have *some* cogneuro intro-level course knowledge. I'm planning to go to an (undisclosable) Florida university and am wondering what the general requirements are for seeking a PhD in cognitive neuroscience, regarding stuff similar to what you guys do (I'm very interested in neuroplasticity and its purported limits, and how we can further make neuroplasticity more efficient and readily applicable). I only have decent knowledge in EEG measures and analysis, however. Thank you very much for this AMA!

[Thr0o0owawhere](#)

Fantastic! I guess that it's not UF?

Typically undergraduate majors would be in Neuroscience or Psychology to prepare you for a Cognitive Neuroscience PhD. You might consider applying for summer research programs in neuroscience at UF to augment your undergraduate studies. --Kevin

Since you mentioned neurological problems I was wondering if your program would address **Tinnitus**/hyperacusis/hearing loss?

I have suffered so much from tinnitus and for so long. 1 out of every 10 is estimated to suffer from tinnitus. And a subset of people from that have completely unbearable tinnitus that prevents them from working and having a normal life. Tinnitus has no cure and no treatments even. Doctors know so little about this condition and sufferers are told "just live with it" which is very disheartening.

Neuroplasticity plays a big part in Tinnitus through current research but seems to be very negative since we seem to be adapting to sounds that we can't hear anymore. What role do you think neuroplasticity plays in Tinnitus and how would you stop neuroplasticity from worsening Tinnitus?

[Redaspe](#)

Great question! Are you familiar with other peripheral nerve stimulation for treating tinnitus?

<https://www.ata.org/news/news/vagus-nerve-stimulation-study-shows-positive-results-stopping-tinnitus>

--Kevin

Do you think BMI will have anything to offer in restoring vestibular function and hearing when it is lost due to 8th cranial nerve damage? I have balance issues and single sided deafness from vestibular schwannoma/acoustic neuroma which are considered irreparable. It would be good to think that might change in the future.

[accountnotfound](#)

Yes, and there are groups at Johns Hopkins U and elsewhere working on that. --Karim

Thank you so much for this AMA! I'm a student in both BME-Bioimaging/Bioelectricity and BIO-Neuroscience. As someone at the cutting edge of research, what tools/imaging techniques do you primarily use to measure and study input/output for sensorimotor activity? @koweiss To what extent do you believe that these long-lasting plastic changes in neural circuits can be achieved in the aging population in the foreseeable future, where muscle control can become an issue and neural plasticity has declined?

@OttoKev, what's the predicted lifespan for these multi-channel implantable devices? For example, if you were to directly implant such an interface in either the CNS or PNS, do you expect to need further surgeries for maintenance/replacement?

And lastly, how difficult is it to make it in your field?

[Aybarabara](#)

1- In my lab, we use implanted electrodes, optical fibers + fluorescence microscopy thru multi-photon laser scanning techniques to measure neural activity in vivo with cellular and sub cellular resolution and millisecond time scale. We also use optogenetics to study causal involvement of specific cell types/circuits in the observed behavior. 2- long lasting plastic changes in the aging population: great question! no answer yet because we still need to understand how neural circuits decline in the aging population so that we can combat it, possibly by inducing targeted plastic changes through technological means. --Karim

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[Aybarabara](#)

Great question! Lifespan of implanted devices is a very difficult question to answer with broad, general strokes. It is a very active area of investigation for my laboratory. We have many tools and techniques to quantify, characterize, and mitigate device-tissue efficacy decline. Are you interested in joining our research group? I am always interested in talking with people who would like to be involved in our field. --Kevin

- Can you see your research being used to supplement healthy adults' cognitive function in the near future? How feasible is it to prevent the degradation of, or to supplement the neuroplasticity of, healthy adults? (such as promoting faster learning?)
- When, in your opinion, are we going to see real-world useful (as in accuracy, sensitivity, and price) commercially available noninvasive neural input (such as computer mouse control)?
- Can you talk about your implementation? What kind of hardware are you using? Software/languages? What kind of sensors are you using? (implants?) How are you giving feedback? Are there papers/publications we can or should read?
- How are you measuring your progress? Can you give a summary of where you are at right now?
- Are your projects open source to any degree? Why/why not?

Also,

- What do you look for in applicants when hiring in your lab/department? How strict is DARPA on security clearance?
- What is the best way to get involved? Can I volunteer my services or intern?

[ArsenicAndRoses](#)

Many great questions, so pardon my brevity.

- 1) The program is designed to understand the mechanisms of PNS stimulation to understand if it can be safely applied to healthy adults.
- 2) Good question. Don't want to speculate.
- 3) We are performing set shifting cognitive behavioral studies using implantable neural interfaces. We do provide positive reinforcement for feedback. Many, many publications.
- 4) We have just started, so no progress to report yet.
- 5) We are academic scientists, so all of our results will be presented at conferences and published via journals.
- 6) I value enthusiasm, creativity, and a fascination to learn. DARPA does not regulate the personnel working on this project.

7) Feel free to contact me. It would likely require living in Gainesville. --Kevin

to investigate how applying electrical stimulation to peripheral nerves can strengthen neuronal connections in the brain and accelerate learning.

Is there any evidence to suggest that brain health/stimulation also improves peripheral nerve function or slows development of peripheral neuropathy?

[dansvans72](#)

That is an excellent question! The brain and periphery are intimately linked, so global neural health is central to the question you ask. I think that there is some evidence of Deep Brain Stimulation having peripheral nerve function effects; however, I don't have any references to provide. Please let me know if you find any! --Kevin

I have a question about your implantable microdevices for interfacing with the nerves. I haven't really looked at the neural field in a long time, but I was under the impression that one problem with implanting electrodes or other devices is the buildup of a glial scar around the device, which then blocks it from interfacing with nerve. What strategies are you using to prevent this from occurring following long term implantation of your devices?

[kerovon](#)

Thanks for the question! That topic is of significant interest in my laboratory. We have many projects characterizing and mitigating the reactive tissue response to both central and peripheral neural implants. We anticipate trying to understand the efficacy vs. invasiveness of several implantation technologies. --Kevin

1. According to you, what are the most significant challenges with regards to creating a BMI?
2. @koweiss My understanding is that some of the most advanced prosthesis to date allows the user to control a member with their thoughts via implanted electrode micro-arrays. However, one of the biggest problem with these prosthesis is that of sensory feedback. How would you restore sense of touch of a long lost limb? Is there a maximum amount of time since limb loss where your method would be effective?
3. You might have heard of another DARPA project called TALOS, which aims to create powered exoskeleton suits for soldiers. What do you think of the feasibility of the project?

Many thanks for doing this AMA. Your field research is fascinating.

[Surcouf](#)

1- Depending on what the BMI will be used for. Getting the signals with enough information to last long enough to be measured if we're using invasive technology; Making it portable, and functioning in every day activity outside of the pristine lab environment, just to name a few. 2-This is an active project in my lab (as well as others). There is no maximum amount of time because if someone is still cognitively intact, they can learn to associate the artificial sensation about touch with the limb movement, even if areas of the brain that used to be associated with touch perception are no longer doing that. This is a hallmark of brain plasticity that my lab investigates. 3- Certainly feasible, the question is how you control it. --Karim

Hello and thank you for this AMA. I would like to ask what you yourselves see as what the next great breakthrough will be in your emerging fields of Neuroengineering and biotechnology? What are the challenges you face in making that breakthrough? Also, I would like to know what you think of private companies/ investors becoming involved, such as Elon Musk's new venture. Do you think that this will quicken the pace of advancement?

[Karmakomodo](#)

Given my lab's research interests I think that enabling higher fidelity and resolution interfacing will result in massive breakthroughs for both science and medical technology. Understanding the material, chemical, and electrical components limiting these next generation interfaces is paramount to achieving these breakthroughs.

Corporate interest and energy in this arena can only help quicken the pace! We are excited to help train the next generation of scientists and engineers that will be their next employees! --Kevin

Wow! Brain-computer technology is really amazing, but I've always wondered how far away we are from certain key milestones. First off, how long do you think it'll be before we're able to send information directly into the brain? For example, could we send signals about the IR spectrum down our optical nerve? And if we could, how does the brain learn to turn that information into something meaningful? Is this where your research would come in, like training wheels to help the brain adapt to the new stream of information? Or do you think we're still only at the stage of being able to get information *out* of the brain?

Phew, lots of questions I know, but it's a fascinating topic and there's too much I don't know!

[sausage\\_snake](#)

this is an active project in my lab - sending information to the brain that it can associate with ongoing cognitive and motor experience. Examples, resorting the sense of touch to someone who lost it but wants to explore and manipulate objects through a prosthetic limb. The brain's ability to adapt and learn is outstanding so we did not currently hit the limit, yet! --Karim

It seems that technology is increasing the potential powers of neurogenesis, especially for those post tbi or stroke. What do you see as the limits of such technology? Also, how close are we to electronic nootropic technologies for ADHD and similar pathologies?

[KillerButterfly](#)

This is a very good question! That is definitely at the cutting edge of neurotechnology. It will be fascinating to see how technology can help with these questions. --Kevin

Thank you for doing this AMA and taking the time to respond as well.

My question would be, How much if any of your research has been / is planned to be geared towards the generally healthy and higher functioning members of society?

I.e. In many 'scholarly' circles now it is common practice to dose substances as minuscule as non essential amino acids (l-Theanine to increase Alpha wave cognition) up to dopamine modulators (modafinil) and it's always been common and popular to give yourself a boost with some caffeine from

various sources.

How much of your research do you think will transfer to this crowd of intellectuals? Do you think that cognitive enhancement of this sort is ethical? And also do you believe that These Electrical Stimulative techniques, or trans cranial electrical stimulation techniques are superior to aforementioned methodologies that are widely employed currently?

[HeruBaKhabRa](#)

Thanks for an outstanding question! As you state, people will likely adopt methodologies that they feel helps them achieve their goals. Our efforts in this program are to understand exactly what happens as you direct the neuroplasticity through direct peripheral neural stimulation. Hopefully, the knowledge of the mechanisms will help guide the safe and efficacious use of this technology. --Kevin

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[HeruBaKhabRa](#)

My lab's research always tries to increase the impact on the broader society and target larger populations, including healthy subjects. If device technology is available that consumers can readily use, it may be more beneficial in that it could be more personalized and more selective compared to substances. This program is about understanding the brain mechanisms of cognitive skill learning, for which cognitive enhancement is an issue that the DoD ethics team can advise us on. We will have to do the research before I can answer the question about whether electrical stimulation techniques are more effective than the widely employed methods currently. --Karim

Looking for a grad student?

Currently applying to medical school for second time, bioengineering phd is my back up.

Only partly joking about the grad student thing.

Anyway my real question is what advantages and disadvantages do you see in early career scientists who go to school for a PhD in bioengineering or other engineering disciplines focused on biological research vs a PhD trained in Biochemistry (my B.S.), neuroscience, or any other generic biological science degree or even a medical degree.

The position I'm in I would like to do MD/PhD but due to the competitive nature I want to consider all options.

Are there any bits of information you wish you had when you were in my shoes?

Also is there any advice you would like to give?

Thanks for doing this AMA, looking forward to your response.

[jandres42](#)

My lab is always recruiting!:) The one thing I'd say: being an MD to treat people is a great thing, but doing research to find solutions impacts a lot more people. Training in basic sciences and/or generic engineering disciplines is the best option, then following on that with a PhD in more applied science and/or engineering field such as neuroengineering is certainly the way to go. --Karim

I went through 6 rounds of ABVD Chemotherapy and now have debilitating memory problems and lost alot of my ability to work through complex problems inside my head. Is there current research going on in this area. Are there tools out there to improve the lives of people who have been affected by chemo in this way.

[shanesype](#)

This is a classical example of why Pharma therapy is not optimal, you gain on one end, but lose on others for two reasons: 1- it is not targeted (has side effects), and 2- it is not personalized. Device based approaches such as BMI or, more generally, neural-machine interfaces might address these limitations. There is research into enhancing/restoring lost/declining memory, and BMIs are active in that space. Check Ted Berger's work (<https://www.technologyreview.com/s/513681/memory-implants/>) --Karim

Thank you so much for doing this AMA. There are so many exciting developments in neuroscience right now that we all enjoy learning about.

I've read about multi-input, multi-output non-linear neural prosthetics, but only in the hippocampus. Do all neural prosthetics follow this design? If so, is the output accurate or is there a "ceiling" in what's been designed so far?

[liveloughloveup](#)

Not all follow this design - it all depends on what the implant needs to do, where it is targeted and the extent to which a specific number of input/output combination is needed to perform the desired function. --Karim

I have two questions:

- 1) Do you believe it is possible that the brain could be replaced with a bio-mechanically equivalent machine?
- 2) Do you think it is possible to download the "mind" to a bio-mechanical brain?

[\\_errata](#)

1) no 2) no --Karim

Is it possible to ever be free of Adderall type medications once on them and get the same benefits as on them when you are off them?

[DeerSpotter](#)

Pharmacologic treatment can be very successful, but can also have various side effects. Part of the reason is because of the systemic nature of drugs (when taken they tend to spread widely throughout the body). Neural stimulation has the potential advantage of being very targeted; consequently, we may be able to design devices and therapies that may approach or exceed traditional clinical therapies.  
--Kevin

What are your thoughts on the challenges/feasibility of imbuing prosthetic limbs with a somewhat dependable (even if only superficial) sensation of touch over the next decade or two?

[Graytis](#)

Check out the efforts at U Pitt, U Utah, and Case Western.

2 very different questions:

- 1) What materials engineering challenges do you foresee in whole-brain interfaces?
- 2) Do you see BMI's as a solution for humans to combat the automation of their jobs and thus, displacement?

Thank you for this AMA & go Gators!!!!

[manukepler](#)

Check out this paper: Sommakia, S, HC Lee, J Gaire, and KJ Otto. Materials approaches for modulating neural tissue responses to implanted microelectrodes through mechanical and biochemical means. *Current Opinion in Solid State & Materials Science*. 18 (6), 319-328, 2014. - See more at: <http://nprlab.org/publications/#sthash.dzVuUZLJ.dpuf>

The second question is probably better answered by Hollywood :-)

Go Gators!

Hi Karim, I'm curious about the ultimate goal you state. My CS/Neuro education stopped with undergrad, but it's my understanding that artificial neural networks are a pretty far cry off from mimicking the complexity of the neuron when it comes to messenger-regulated gene expression.

There has been a lot of development lately with regard to optimizing neural net code, but to me it just seems like a fundamentally different architecture, with the "processing power" of neurons so distributed.

There's definitely more we can learn from the most sophisticated piece of biological machinery known to man, but do you think we're going to achieve more success by trying to mimic the nervous system, by centralizing things on a few CPUs, or some combination?

Thank you for the interesting AMA!

[hephaestus](#)

In order to mimic a system, we have to first understand what its individual elements are and how they're all connected together. With the current level of knowledge, we cannot and perhaps will never

be able to mimic it, no matter how much we get sophisticated with tools/technology. But we can infer some underlying principles that can help guide the way we think about designing machines that learn (such as ANNs). Memory is an indispensable part of such systems, so learning how the brain organizes and maintains memories of different types is a good first step towards improving this design and not suffer catastrophic forgetting. Centralization may not be the best approach, but perhaps some hybrid combination of centralized and distributed architectures. The real question would be which processes to centralize versus ones to distribute, and the brain is a great asset to help us understand how to tackle this question. --Karim

Hi Karim, I'm curious about the ultimate goal you state. My CS/Neuro education stopped with undergrad, but it's my understanding that artificial neural networks are a pretty far cry off from mimicking the complexity of the neuron when it comes to messenger-regulated gene expression.

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Thank you for the interesting AMA!

[\\_hephaestus](#)

You might go check out the Neuromorphic literature. --Kevin

I'm really interested in these projects and neural engineering in general. I'm graduating this Saturday with my BSEE and was looking at going to UF for my MS. I have a relatively low gpa (2.9), so after I kill the GRE what other advice might you guys have to help me get in and be able to work on some of these cool projects?

[WhackKerouac](#)

Congratulations on graduation! Research experience may really urge some admissions committees in your favor. --Kevin

Hi, UCF Engineering student here with a quick question. Would applying an electrical stimulation to the peripheral nerves also accelerate learning in lets say somebody with Down Syndrome or another similar learning disability? Also, have you done any testing (animal or human) and could share some results? Thanks!

[iTooNumb](#)

If successful, peripheral neural stimulation can likely help with many neurological indications. It is already investigated for conditions such as depression, tinitius, and epilepsy. It will be intriguing to see how our results can help guide further clinical approaches. --Kevin