Defense Centers of Excellence for Psychological Health and Traumatic Brain Injury (DCoE) Webinar Series

December 3, 2015, 1-2:30 p.m. (ET)

"Detrimental Effects of Blue Light from Electronics on Sleep"

Good afternoon, and thank you for joining us today for the DCoE Psychological Health December webinar. My name is Commander David S. Barry, Implementation Division Chief for the Deployment Health Clinical Center. I'll be your moderator for today's webinar.

Before we begin, let us review some webinar details. Live closed captioning is available through Federal Relay Conference Captioning. Please see the pod beneath the presentation slides. Should you experience technical difficulties, please visit dcoe.mil/webinars and click on the troubleshooting link under the monthly webinars heading. There may be an audio delay as we advance the slides in this presentation. Please be patient as the connection catches up with the speaker's comments. Today's presentation and resource list are available for download from the Files pod below.

The Continuing Education activity is provided to collaboration between DCoE and Professional Education Services Group. All who wish to obtain Continuing Education credit or a Certificate of Attendance and who meet eligibility requirements must complete the online CE evaluation. After the webinar please visit dcoe.tbs.tesgce.com to complete the online CE Evaluation and download or print your CE Certificate of Certificate of Attendance. The evaluation will be open through Thursday, December 17, 2015.

Throughout the webinar you are welcome to submit technical or content-related questions via the Q&A pod located on the screen. All questions will be anonymous. Please do not submit technical or content-related questions via the Chat pod. Participants are encouraged to chat amongst each other during the webinar using the Chat pod. Please refrain from marketing or promoting your organization or product in the Chat pod.

I'll now move on to today's webinar topic, Detrimental Effects of Blue Light From Electronics On Sleep. Light isn't just for vision. In addition to enabling us to see, light is the major synchronizer of our bodies' circadian rhythms to the local time on earth. Light can also induce an acute alerting effect on people. Lighting characteristics affecting vision are different than those affecting our biological rhythms and our acute alertness. Different types and levels of light can affect a person's ability to see clearly, identify people and objects, and drive safely.

Certain types of light applied at certain times of day can increase sleep efficiency of older adults and reduce symptoms of Seasonal Affective Disorder, or SAD, SAD, felt by many people during winter months. If applied at the wrong time, light can lead to circadian rhythm disruption, which has been linked to an increased risk for diseases and disorders. How and when lighting can be used to promote health and wellbeing of those suffering from circadian disorders will also be discussed.

At the conclusion of this webinar, participants will be able to demonstrate understanding of the circadian rhythm by identifying at least three ways to measure it, identify lighting (audio break) that affect shift workers' circadian rhythm, analyze symptomology of sleep and circadian rhythm disruption in military settings.

I would now like to introduce our presenter, Dr. Mariana Figueiro. Dr. Figueiro is the Light and Health Program Director at the Lighting Research Center and Professor at Rensselaer Polytechnic Institute. She conducts research on the effect of light on human health, circadian, photobiology, and lighting for older adults. Dr. Figueiro holds a Bachelor's in Architectural Engineering, a Master's in Lighting, and a Doctorate in Multidisciplinary Science. She is a recipient of the 2007 NYSTAR James D. Watson Award, the 2008 Office of Naval Research Young Investigator Award, and a 2010 Rensselaer James M. Tien '66 Early Career Award in 2013, she was elected Fellow of the Illuminating Engineering Society. She is the author of more than 60 scientific articles in her field of research. Her research is regularly featured in national media including the New York Times, The Wall Street Journal, Scientific America, The Economist, and NPR. She was speaker at Ted Med on September 12, 2014 at the Kennedy Center at Washington, D.C.

Please welcome Dr. Figueiro.

Thank you very much. I appreciate the invitation and I'm very happy to be here. We have worked with the Army in various in various projects. Not only the Army, but he Department of Defense in general. The Navy, the Army, the Air Force in different projects, so it's a pleasure to be here speaking to the Department of Defense.

I'm going to be taking about today, obviously not only about the detrimental effect of blue light as I was asked to do, but I expanded a little bit to give a brief overview of the health effects of light on humans. And one of the interesting things I think hopefully you will find from the presentation is that a lot of times we only talk about blue light, but other types of light, other colors of light can affect our alertness and our physiology, so I will be discussing a little bit more about that as well. So I will (inaudible) the slides.

Here are the general learning objectives. We're going to learn about the science which are the bases of circadian rhythms. What we call circadian phototransduction, which is how the retina converts light signals into neural signals for the circadian system. What are the lighting characteristics affecting these systems. And what are the effects of (inaudible) displays on acute (inaudible) expression, which is one circadian rhythm, and it's a very well-known circadian rhythm that all animals – or most of the animals – pretty much have.

We're also going to learn about the application, so I'm going to talk about how to use light to mitigate some of the symptoms of Seasonal Depression. Discuss a little bit about some work we had done with submariners and a project we did underway changing the lighting in submarines and looking at performance and (inaudible) to their shirt work. Delayed (inaudible) Disorder, which tends to be very common in teenagers, but there are a lot of people that can't fall asleep earlier and can't wake up earlier and that can be very disruptive. Shift workers and older adults, including the work we're doing with Alzheimer's disease patients. And then how to apply the knowledge, so what do you do for yourself or for somebody you know that might have some of these circadian sleep disorders.

For specific learning objectives, demonstrate understanding of circadian rhythms by identifying at least three ways to measure it, identify lighting characteristics that affect shift workers' circadian rhythms, and analyze symptomology of sleep and circadian disruption in military settings.

So with that I'll start on the background. Circadian rhythms are every rhythm in our body that repeats at approximately every 24 hours, (inaudible). A great example of circadian rhythms are the sleep-wake cycles. Unfortunately another great example is the post-lunch dip, so I might be getting some of those during the presentation, but what I always tell people is that it's probably a good thing to give a lecture at this time because if you fall asleep it's not going to be my fault, you just can't help it, so that's circadian rhythm and there's nothing you can do about it. But biomarkers, hormone production, performance, alertness, all of this, these follow patterns of peak and trough over the course of 24 hours. And they repeat over the course of successive days.

Circadian rhythms are influenced by exogenous and indogenous rhythms externally or internally we have a master clock that is generated and regulated by a biological pacemaker and it's located in the suprachiasmatic nuclei or SCN. In the absence of any external cues, we continue to have circadian rhythms. These rhythms are going to run with a period slightly greater than 24 hours. On average, it's about 24.2 hours in humans. So exogenous rhythms, which like dark patterns are the sort of the main synchronizer of circadian rhythms, the local time on earth, what they do is they influence the time you (inaudible) circadian rhythms so that we are entrained or synchronized with the local time on earth.

So this slide here shows examples of biological rhythms or circadian rhythms in humans. These are actually dated as we collected in our lab. We bring the subject into the lab before 7:00 in the morning and keep them in a dark room and awake until 9:00 the following day. And you see very beautiful rhythms. The blue curve is the melatonin rhythm. Melatonin is a hormone we produce at night and in darkness. And melatonin is actually used as a marker of the circadian systems because it's – the timing of melatonin production, it's very regular. We have very low light levels during the day, as you can see in the blue curve. Even if you are awake in a dark room, you are not going to be producing melatonin during the day. Melatonin starts rising about a couple of hours prior to our natural bedtime. So if you normally go to bed at 10:00 at night, about 8:00 in the evening your melatonin level starts rising above the threshold levels. It reaches a peak around middle of the night, early part of the night, close between 1:00 and 3:00 a.m., and then it starts coming back down in the morning. So this is a very regular rhythm. Melatonin, it's pretty much called the darkness hormone because it tells the body it's nighttime.

And one very interesting aspect about melatonin is that it can be suppressed by light exposure. So if you expose yourself to a certain amount of light at night or any time after the onset of melatonin in the evening, you're going to cease that melatonin production. And that's why for the theme of this presentation we were very interested in measuring the effects of (inaudible) displays on your melatonin levels.

Disruption of melatonin levels has been associated with a lot of maladies and diseases. We do know now that melatonin has an oncostatic effect that seems to protect against growth rates of certain types of cancer. It also gives the timing to the entire body. So your peripheral clock, your pancreas, liver, all parts of your body, know that it's nighttime because melatonin goes into the bloodstream and basically gives that nighttime message to the body. So if you disrupt that, you're disrupting that timing message to the body and you can lead to circadian disruption.

Other biomarkers that are not as much used because they are harder to collect. We can collect melatonin in saliva samples, blood samples or urine samples, so that can be done very easily in the lab, and a lot of times it can even be done in the field. Other biomarkers are core body temperature. Core body temperature tends to reach a peak in the late afternoon/early evening and a trough in the early morning, around 5:00 in the morning. In general, the minimum core body temperature occurs about two to three hours prior to your natural waking. And the reason why it's important to know because light exposure before or after the timing of the minimum core body temperature will have a different effect in your sleep time, and I'll explain that in a little bit.

Other biomarkers include cortisol concentration for example. We do know that our cortisol levels tend to be high and it reaches actually a peak about 30 to 45 minutes after we wake up. I call cortisol waking response, and it's really a signal that we have to transition from inactivity to activity, and then it comes back down and it remains low in the evening and starts rising a little bit more towards the end of the night and reaches a peak again after waking in the morning.

And alpha amylase concentration, which is the red curve, is also a biomarker. It's a salivary enzyme, and it's been linked to our fight-or flight system. So it's a marker of the sympathetic system.

So there are many ways that we can measure circadian rhythms, but the most common way tends to be the sleep-wake cycle, or rest-activity rhythms and melatonin concentration and cortisol concentrations which we can measure in saliva and blood samples easily.

As I mentioned, light is the major synchronizer of circadian rhythms to local position on earth. So if I travel from New York to Vienna, for example, it is the local time, it is the light-dark pattern in Vienna that will train me to the local time in Vienna. So light is the major synchronizer. There has been some work showing that exercise may have an effect on the timing of the biological clock, but that is not as strong as the light-dark pattern.

Another important agent that can change the timing of the biological clock is melatonin. There are melatonin pills you can take. And you can shift the timing of the biological clock.

But light-dark patterns, if delivered at the wrong time for many, many years, it can also be a major disrupter. Also if you don't expose yourself to enough light during the day, you can also suffer from circadian disruption. And we do know that circadian disruption has been associated with a series of maladies. From poor sleep – we all know that if we are not synchronized and we don't sleep well we tend to be very sleepy during the day. That tends to increase stress, sometimes feelings of anxiety and depression. There's been studies showing that circadian disruption is linked to increase smoking as well as increased risk for cardiovascular disease, Type 2 diabetes, and even cancer. There's been a lot of work done with shift workers, those who work rotating shifts, like two days on-three days off, three days on-one day off, those tend to have high risk of breast cancer and colorectal cancer later in life after working 20 or 30 years on rotating shifts. So clearly that circadian disruption is detrimental to health and wellbeing. And maintaining a regular melatonin rhythm seems to be very important for maintaining circadian entrainment or avoiding circadian disruption.

So we, at the Lighting Research Center, are very interested in the lighting characteristics affecting the circadian system. What kind of light affects the circadian system? So we have been looking at the quantity, the spectrum or the color of light, distribution timing and duration, how it affects visibility, how it affects circadian systems, and how we can combine this knowledge to develop lighting applications that would improve sleep in those suffering from circadian sleep disorders.

So in terms of the quantity of light, we do know that the circadian systems, as measured by acute melatonin suppression, will face shifting of the timing in which we start producing melatonin in the evening as higher thresholds and visibility. It's been shown under laboratory conditions that about 100 lux at eye level, which is vertical measured here close to the eye, is enough to suppress melatonin. To give you a ballpark number, 100 to 200 lux is about what you get in office lighting environment without windows, coming from the ceiling. Some offices you may get three to four hundred lux at the eye, but that's not as common. Typically you get between 100 and 200 lux at the eye.

So if you're exposed to that office lighting, for example, all night long, you might be at risk to suppress some of the melatonin. And to shift the timing of your biological clock.

Now, just for comparison, in terms of quantity, a nightlight that you have in your bathroom when you wake up in the middle of the night is enough for you to be able to see and navigate in the space, but that's not enough for you to suppress your melatonin levels or to affect your circadian system. So even though we know that lower levels of light can affect melatonin than we originally thought, these light levels are still higher than those needed for you to be able to see and navigate in the space.

In terms of spectral sensitivity or color of light, we do know that the circadian system is a blue sky detector. Circadian system is looking for blue light when it comes to acute melatonin suppression. So what that means is that you need the least amount of light to suppress melatonin when that light is blue. And by blue, I mean a peak at 460 nanometers, so it's really, really blue color light. There has been a lot of interesting work in this area where in the 1990s there's work with animal studies where they showed that if you have sort of silence the rods and cones, which are the classic photoreceptors in the retina that respond to light signals, so the animal was blind, that animal was still able to respond to light when it comes to the circadian system. Which means that if you give a pulse of light in the evening, the animal would delay the start of activity the following cycle.

So everybody was very confused and said well how come an animal that is blind can still respond to that light. Ten years later, David Berson from Brown University discovered a new class of photoreceptor in the eye that is called intrinsically photosensitive retinal ganglion cells, or ipRGCs, and this new class of photoreceptor is the main photoreceptor that produces the signal from the retina to the biological clock. But this photoreceptor also receives input from the classical photoreceptors.

So we now know that there are three types of photoreceptors, rods, cones, and this new class of photoreceptors, participate in what we call circadian phototransaction, which is how the retina converts light signals into neural signals for the circadian system. And the peak sensitivity is around 450 nanometers, which is the short wavelength for blue light.

So we developed a mathematical model and then what we call a circadian stimulus calculator wherein if you have the spectral power of distribution of the light source, which is basically looking at what parts of the electromagnetic spectrum that that light source emits radiation, and you have the light level, you can calculate what the circadian stimulus of that light source is. And by circadian stimulus, that means that is how much melatonin will be suppressed if a person is exposed to that light for an hour. I'm not sure anybody would be interested in having that calculator, but if you are, it is available on our website, and I'll be happy to share the link in addition to the other links that we have already shared.

So here is just providing you with some light sources and how the different light sources will affect the circadian system. And what I want you to remember here in these tables is a lot of you that are going to be talking or hearing about circadian rhythms, you're going to hear a lot of people say, well, you need blue enriched light, or you need bluish-white light. And the reason is that these light sources that have more short wavelength content are going to be more potent at stimulating the circadian system. So you can reduce a little bit of the light levels and have the same effect on the circadian system if you use light sources that look for – like bluish-white light sources.

That's basically what this table is comparing the different light sources at different intensities, how can you increase the effectiveness, or decrease, depending on what you want to achieve. Because one thing we're learning is in the evening you want to decrease the impact on the circadian system. So you want to use warmer light sources at lower light levels. In the morning, you want to increase the impact on the circadian system, so you want to pick a bluish-white light source at higher light levels so you have higher impact.

But the bottom line is that what this calculator does, it gives you an idea of the light source that you're using in the space, how will that impact your circadian systems.

So now I'll get into one of the main topics of the talk today, which is what about those self-luminous displays? They emit light. They tend to use light emitting diodes, or LEDs, which are light sources that tend to have a peak at short wavelength. Do they affect the circadian system? And the answer is most likely. I can't say all of them will. But they do have a high potential for affecting the circadian system.

So we did this study. It was a three week study. Every Friday the subjects would come back to the lab. And one week they were supposed to – or they experienced the tablets at full brightness for two hours. The following week we did that in a counterbalanced way, but part of the subjects received each condition first. But the second condition was exposing themselves to the same iPad, but this time they were wearing those orange glasses. These orange glasses, what they do is they remove all the radiation below 530 nanometers. So even though you can see and read your iPad, your circadian system is almost blind because you are not getting enough radiation to affect the circadian system. So if you have to do work in self-luminous displays at night, for example, you might want to consider wearing those goggles because it protects you against those short wavelength or blue color light.

And then the third condition was a condition where we actually gave the subjects blue light. So we developed these like goggles. They emit blue light. So we knew that we were going to be suppressing melatonin, so this was sort of our true positive control while the orange glasses was our true negative control. With the blue glasses we knew we were going to suppress melatonin. With the orange glasses we knew we were not going to suppress melatonin. The question is what happens when you just expose yourself to the iPad.

So the subjects arrived at the lab around 10:30 at night. They remained in darkness so that their melatonin levels would rise. We collected a saliva sample just before they turned on the electronic devices, so in darkness. And then we collected another saliva sample an hour after they turned on the devices and two hours after they turned on the devices. And obviously at each week they experienced the device without anything, or with the orange glasses or with the blue glasses.

What we saw was very interesting. You have here the tablets – the first one was the tablets with the orange goggles. The second one was the tablets with the blue light goggles. And the third bar is the tablets only.

During the first hour, we only saw a significant reduction in melatonin levels, which are in the Y axis, when the subjects were exposed to the blue light, which is what we were expecting. There was no significant effect of the tablet after one hour exposure to it. But, after two hours we did see a significant reduction in melatonin levels. So there's a dose response here. The longer you stay on your tablet, the more likely you will see melatonin suppression. It was about a 23% - 22% suppression after two hours' exposure. So my recommendation would be turn off the self-luminous displays at least a couple of hours prior to your bedtime because that's when you start producing your melatonin. If you need to be exposed to it, either wear the orange goggles or damp down to a minimum brightness level or reverse polarity where you have a black background with white font so that you emit less light.

The other interesting thing is if subjects were seeing movies, we tended to see suppression because the background is darker. If the subject was doing Facebook, for example, the subject tended to have more brightness. So we actually had a device at the eye that collected the amount of light that they were getting with the iPads, and obviously, as expected, the higher the amount of light, the more suppression the subjects achieved.

We then repeated the study using CRT screens, or cathode ray tube. Those are the old type of computer monitors. I wish I had big mass screens, but we didn't have the money to buy them so we tried out with the old screens that we had in the lab that nobody wanted to use. But nevertheless we repeated the experiment, so we have the computer monitor only, we have the computer monitor plus the blue light goggles, and then the computer monitor with the orange goggles. And what we saw and expected, the greater suppression was with the blue light goggles. So when you're delivering blue light at the eye, you're going to suppress melatonin.

We did see about a 23% suppression with the computer screen. Again, highly variable depending on the type of tasks that the subjects were performing. It wasn't statistically significantly different because there was a huge variability among individuals, but we did see some people suppressing a lot and other people not suppressing. So my take on this study is that computer screens have a large potential to suppress melatonin, probably even greater than iPads, because they emit more light. And the bigger and brighter the screen, obviously the more likely it will be to suppress the melatonin levels.

Third study we did was television. We had the 70-inch TVs. This was actually Sharp sent us these TVs, and I always make a joke that went sent us the TVs to the lab, everybody wanted to be my friend because it was around Super Bowl, and I had those big 70-inches TV and everybody wanted to watch the game here because we had the TVs. Actually it wasn't hooked up, but suddenly I became the most popular person in the lab.

So we built this setup where we had sort of a theater light setup where part of the subjects were sitting about six feet from the screen. The other part were sitting about nine feet from the screen. They came and they watched TV for about 90 minutes. We had them watch Toy Story. They watched Toy Story one, two, three, and then we repeated Toy Store one, so there was four experimental conditions, and one of them they watched the TV with the orange-tinted glasses, which was basically a control condition. The other two, we set the TV to 2,700k, which was very orange like, 6,500k, which is about a little bit more blue content in the screen, and the 12,000k, which has a lot of blue content in the screen. So as you increase those Kelvin temperature levels, which is the K, increase the amount of short wavelength that the screen is emitting. The three bars that you see on the graph are melatonin concentrations in darkness, so right before they started watching TV, 45 minutes and 90 minutes after they started watching TV.

And what we saw was that there was no significant suppression of melatonin with television. Melatonin levels continued to rise in all the experimental conditions suggesting that because you're sitting far away from the TV, even though the room looks bright, that brightness is not enough to suppress melatonin because you're not too close to the television.

So what's very interesting about computer screens, iPads, we have never done phones but we have done some calculations with phones, and we haven't seen evidence that phones may suppress melatonin. But definitely the tablets and the computer screens, they're very close to your eyes. You look at them very close to the eyes. And that's why you get so much light in the back of the eyes. So they can be very strong signals for affecting the circadian system.

Another important characteristic is timing. As I mentioned before, we have a minimum core body temperature which is about a couple – two to three hours prior to your natural waking. Any light that you expose yourself before the minimum core body temperature, that means evening hours and early part of the night, you're going to delay the timing of your sleep. Any light that you expose yourself after minimum core body temperature, that would be the morning hours, you are going to advance the timing of your sleep. So you're going to go to bed earlier and wake up earlier. So evening light delays the timing of your sleep. Morning light advances the timing of your sleep.

If you think about those computer screens and those self-luminous displays right before you go to bed, what happens is you are not only acutely suppressing your melatonin levels, but you're also delaying the timing of your sleep. First of all you're delaying the timing in which your body is getting the darkness signal, which is the melatonin. And second you're shifting the timing of your biological clock so that now everything is happening a little bit later so the following night you're going to also go to bed later.

So the one thing I do want to point out, for example, about the TV study is that we didn't see any acute suppression. But you may delay your sleep because you may be watching something very exciting, getting your brain very active, and that may delay your ability to fall asleep. So don't lose track that, obviously, falling asleep, there's various components of it, and light will affect one, but other things related to self-luminous displays may affect other parts of it.

This is a study that we did basically showing that yes, if you give people morning light, blue light, and you remove the evening blue light, you're going to help people go to bed earlier. On the other hand, if you give people evening blue light and you remove the morning blue light, you're going to delay the timing of the sleep. So we collected data in 33 subjects. Twenty-two were early subjects, so people who tend to go to bed early and wake up early, so they're larks. And 11 subjects were late subjects. They were what we call night owl subjects. And they experienced just two light conditions. One is what we call advancing, which they get blue light in the morning, evening orange goggles. And a delaying lighting intervention, which means they get orange goggles in the morning, blue light goggles in the evening. And what we saw was that after one week they were living their normal lives. The only difference is that they were waking up a little bit early, and they were getting those two lighting conditions. What we saw is that when they were experiencing the advancing lighting intervention, they advanced their timing of sleep by about two hours after one week of the light exposure. And they delayed, when they were exposed to the delaying lighting intervention, by about one hour.

I think that study was very important. First of all it showed that if you control evening and morning light you can shift the timing of the biological clock. So if you are somebody who goes to bed late and you want to start going to bed early, you can expose yourself to morning light. You can remove the evening light. And you will shift the timing of your biological clock.

But I want to point out, the biological clock is slow. It took them a whole week to shift only two hours in their sleep. So it's not something that you can do from one day to another. We have a very robust system that doesn't want to be fooled by any light exposure, so we really need to control morning and evening light to be able to accomplish that shift, which can be done, but it will be slow. And that's one of the things that I want people to keep in mind.

We are currently working with a technique which is very interesting. Some people don't want to get up and expose themselves to light in the morning, for example. So one possibility is you deliver light through closed eyelids when the person is asleep. And we have developed a technique to measure eyelid transmittance, and one of the important things is you have very little transmittance in the short wavelength region. Nature is very smart. You close your eyes, and you don't want to disrupt your circadian system. But because we're always fighting nature, what do we do? We develop a technology that delivers about 50,000 lux. Remember, you get in your office about 200 lux. We are delivering about 50,000 lux through closed eyelids when people are asleep. And we have been able to show that this can shift the timing of the biological clock. This was actually a study we did with older adults who tended to go to bed at 7:00 at night and wanted to stay up to play Bingo in the evening. We gave them those light masks. They slept with a light mask. The light was delivered early at night because that's when you delay the timing of your sleep. And we were able to successfully show that after one week they delayed their biological clock by about half an hour. We did not control the morning light in this study. That's why we only got half an hour instead of getting two hours. But I believe if we had given them the orange goggles in the morning with the light mask in the evening, we would have seen a greater effect of the (inaudible) shifting. But nevertheless, if you don't want to get up to get light exposure, you might want to consider wearing those light masks that will – if they are programmed to deliver a light at certain times at night so that it can delay or advance your circadian clock.

So just to summarize that first part, intensity and spectrum matters. Light is the major synchronizer of circadian rhythms to the local time on earth. Melatonin is used as a marker of the circadian clock. And short wavelength or blue light massively affects melatonin levels. But light levels is just as important. So it's not just about color of light, but also intensity. Do you want to affect the circadian system? If you want to increase the amount of light and move it to a short wavelength content. If you want to decrease the circadian system stimulation, you want to reduce the amount of light and use warmer color light sources.

Timing matters. The same light in the morning will have a different effect than that light in the evening. Okay. And the other thing that matters is photo(inaudible). It's very interesting that what the circadian system seems to be doing is the circadian system seems to be summing up all the light exposure that you get during the day, doing the sum at what time you got it, and giving you a net result. So it's very important for you to keep track of your entire light exposure so that you can either advance or delay, depending on what you are trying to accomplish.

I am going to intercede here. There's somebody asking about how can a person be naturally morning people or naturally evening people. This tends to be actually more genetic based. What's interesting is there is a lot of work being done with teenagers, which I'll cover in a minute, about the late sleep. Teenagers tend to go through when they go from pre-puberty to puberty, they tend to delay the timing of their sleep. But in general, it's more of a natural genetic. If your parents were night owls, you tend to be night owls, so that's sort of more of a genetic base than – obviously the environment helps, and it basically reinforces what your genes is telling you.

The other part that I want to cover, it is not just about blue light. We tend to think about blue light for the circadian system, and we have done some work here in the lab where we're showing that red light has a very strong acute alerting effect. Because when you think about affecting people, light can affect the circadian system, and it can change the timing of your sleep, the timing of peaks and troughs of your biomarkers. But light can also have an acute alerting effect on people. In a study we have done here, you put people in a dim light room during the day, people are sleepy. They're miserable. And there seems to be a pathway in the brain that goes directly to your alerting system. And that pathway will respond to any color of light, which is one of the interesting work that we've been doing.

So this work started a few years ago. We published a paper in 2010 where we gave people red light and we gave people blue light. And we kept people in dim light rooms. And we compared the effect of the red light and the blue light. And by red I mean a 640 nanometers, so think about a traffic light red. And the blue is a blue, 470 nanometer light. And what we were able to – we measured in this case electroencephalogram, or EEG, which is we put scalp electrodes on the head and we measured brain activity. And what we saw was an increase in beta activity. Beta power is associated with cognition. And a decrease in alpha power. Alpha power is associated with sleepiness. So if you're feeling sleepy right now, and I put an electrode on your scalp, I will measure high levels of alpha. So we showed a decrease in alpha and an increase in beta, which both equals increase in alertness when we exposed people to both red light and blue light. And I have to admit I was surprised when I saw the results.

So we decided to replicate the study, and we did another study where we kept people awake for 27 hours. And we gave them 40 lux of the blue or the red light. And we showed that that light increased performance, and by performance what we measured was reaction time and the ability to have a small cognition, so basically you give them a pattern and they have to determine whether this is the right pattern or not. So we were looking at the score where they would respond correctly and how fast they would respond. And we looked at heart rate. And, again, this is the difference between remaining in darkness for one hour or being exposed to blue or red light for one hour. And what we saw is every time they were exposed to blue and red light, they had increase in heart rate at night and increase in performance also at night. So both red and blue light were affecting their heart rate and their performance levels.

But what's interesting is that only blue light, as expected, was affecting their melatonin levels. So if you look at the upper graph here, and you look at the daytime levels, melatonin levels are low. But if you look at the nighttime levels after darkness and red light, the melatonin levels are high. But there was a decrease in melatonin levels with the blue light, as expected.

We also saw an increase in cortisol levels at night with both blue and red lights. And we think it is that increase in cortisol level that is probably mediating that increase in heart rate and increase in performance.

But what was very interesting, and very important for application in this study is we may now have a light that may help shift workers or those staying awake at night increase their alertness similar to a cup of coffee without necessarily disrupting their circadian system because we're not going to be suppressing their melatonin levels. So I think that would be a very important sort of application, and we actually now have a grant from NIOSH, where we're going to be testing that red light in real life shift workers to see if we can increase their alertness similar to giving them a cup of coffee without disrupting their melatonin levels.

Here is another nighttime study that we did that was a third study that we did. That we compared the red light with just a white light. So we gave them light goggles that delivered either a warm color light at about 300 lux at the eye or the red light, and we saw that both the white and the red increased performance. In this case we're looking at reaction time on the Y axis, so a lower reaction time is better performance. So what we again saw that the white light suppressed melatonin but the red light did not suppress melatonin.

So we're seeing an increase in brain activity, an increase in performance without suppressing melatonin with the red light, which, again, we think there is important implication for shift workers.

Here is the same study where we showed the EEG, or electroencephalogram, and we saw a decrease in alpha and alpha-beta power. Both of them are associated with sleepiness, so you decrease the power in these ranges, you are increasing alertness. So we did see actually a stronger effect with the red light than we saw with the white light at night.

We then decided to replicate these studies during the daytime when you don't have melatonin production. And what we were able to show as that red light, similar to blue, or even a stronger stimulus than blue and similar to white light. It improved, again, this EEG data, so there was a reduction in alpha and alpha-beta power, which means that you are feeling more alert. And this is during the post-lunch dip. So right now if I passed out blue light goggles, or red light goggles, or white light goggles, you are going to see an increase in your alertness by exposing yourself to that kind of light in the middle of the day.

And we, again, saw a change in performance. So the graph on the left is reaction time, so lower reaction time means better performance. And they were faster with the red light. The graph on the right is the throughput, which takes into account reaction time and score, so a high throughput means better performance, and we saw better performance with the red light.

So we were able to replicate the nighttime studies into the daytime when there is no melatonin production. So clearly there's a separate pathway in the brain, that is linked to alertness, and it's not necessarily linked to acute melatonin suppression, which is what everybody thinks you need to do in order to improve performance and alertness with light.

So just to summarize, it's not just about blue light. Low to moderate levels of red light, which does not affect melatonin levels or face shift the timing of the circadian clock, to improve these objective and subjective measures of alertness, improve certain types of performance, and we did see an increase in cortisol levels at night. We could not see a very strong effect in the middle of the day, but we did see an increase in cortisol levels in the morning, early in the morning.

So now I'm going to briefly talk about the applications and how does that apply to you in the military or anybody that you know that may suffer from circadian sleep disorders.

So the first one is Seasonal Affective Disorders. We do know that light is actually a recognized treatment for Seasonal Affective Disorders, so if you're diagnosed with Seasonal Affective Disorder, some insurance companies will cover the cost of a light box. The exact mechanisms for Seasonal Affective Disorders are not – or are still under debate. There's competing hypotheses. One of them is (inaudible) delay hypothesis, which is the one that is mostly accepted, that because of the late dawn in the winter months you don't get the morning light to retrain your circadian system, you tend to be more (inaudible) delayed, and that tends to affect your mood and your wellbeing. There's serotonin hypothesis, where it seems like you tend to have a disregulation of your serotonin levels and that's associated with an increase in carbohydrate that you tend to eat more when you suffer from Seasonal Depression.

But regardless of the actual mechanism, it's been shown that morning light, and sometimes evening light, will help minimize symptoms of Seasonal Depression. So people tend to have about half an hour of 10,000 lux of a white light, or two hours or a 2,500 lux SEI of that same white light. Now people are moving more on to blue light boxes at 470 nanometers, and those are being more successful because you can reduce the amount of light and have the same effect on Seasonal Depression.

The other area that is – it's a new area, I personally have not worked with but I know of researchers that have worked with, some people are showing positive effects of using evening blue blockers to increase regularity of sleep and reduce mania in those who suffer from bipolar disorders. It is very interesting that in this case it is not giving light, but it's removing evening light seems to be very effective. I know that people are replicating these studies and trying to expand – this was a small case study. But it seems like the results are robust, and I think it's an area that is worth investigating.

So, again, my other point in this talk is not just about blue light, and it's not just about giving light, it's about giving and removing light at the right times.

The other application, and this was actually a work that we did with the Naval Research Medical Lab in Groton, Connecticut. We went underway. We replaced the lighting in submarines and we compared to a control light. And we looked at sleep. We collected melatonin levels. We also collected some performance tests. And what we found was that if you exposed submariners to a high-correlated color temperature light source, so a light source that would stimulate the circadian system more, they were more entrained to their watch, they were sleeping better, they had higher amplitude of melatonin, they self-reported feeling less sleepy. The only thing that we didn't find was they did not have better performance. But he reason why we think that happened was because we couldn't' counterbalance the conditions in the experiment because they were under way. So they saw the experimental conditions before they saw the control conditions. So by the time they got to the control conditions, there was a huge practice effect on the performance tests. So we think that they did better because of practice effect. But unfortunately that was the only thing that we couldn't show that was more positive.

The other area is, as I mentioned a little bit earlier, is Delayed Sleep Phase Disorder, or even teenagers who are not officially diagnosed with Delayed Sleep Phase Disorder, which is somebody that cannot fall asleep in social, normal, social societal times. They tend to fall asleep three to six hours later than desired bedtime. And if you give light in the morning and you remove light in the evening, you can shift the timing of the biological clock.

Now I do want to point out these are data from our lab. And these are also using self-luminous displays. One of the observations we had here was that teenagers, those between 13 and 17 years of age, they were more sensitive to light for acute melatonin suppression that people in their twenties or thirties. So we collected data at home, with teenagers between 15 and 17 years of age. And we looked at the acute melatonin suppression from self-luminous displays. When they were living their normal lives, they were just asked to expose themselves to any self-luminous displays for three hours prior bedtime. One time they had the orange glasses on, and one time they did not have the orange glasses on.

The graph that you see on the right are the three times. The first time they always had the orange glasses on for both conditions. The second time they did not have the orange glasses on. The solid line is without orange glasses. The dotted line is with orange glasses. And what we saw was after two hours of exposing themselves to self-luminous displays without orange glasses, that there was a significant melatonin suppression prepared to with orange glasses.

So what was most interesting is that we measured that light exposure, and we compared to the light exposure that people in their twenties were exposed to. And these kids were much more sensitive to light than the people in the twenties. So for the same amount of light, they suppressed twice as much their melatonin than those in their twenties. So what that is suggesting is that teenagers, they tend to go to bed later, and they make it worse by exposing themselves to self-luminous displays in the evening.

So one of the ways to help with minimizing that is wearing orange glasses at the right time. In the case of teenagers is in the evening hours. Exposing yourself to morning light, either through blue light goggles or going out to work. Or consider having the light mask which would deliver the light. It has to be after minimum core body temperature to advance the biological clock. But it could be while you were asleep. Because one of the problems is waking people up to get that light in the morning, so that might be a good practical solution for that.

The other application is shift work. And I already mentioned a little bit about that. Shift workers tend to be disrupted. The problem is that you want perky physicians and perky nurses when we go to the emergency room at 4:00 in the morning. Or we want perky people working at night. We know that light can help, blue light can help. But you have the negative effect of suppressing their melatonin using higher levels of light or blue light. So one solution would be to use the red light because you're going to increase alertness without necessarily disrupting their melatonin cycle, and that's something we're now testing in the field.

Obviously there's day shift workers. We know that morning light will help you maintain entrainment with the solar day. We know that morning light will increase the cortisol awakening response, so it will give you that signal that it's time for you to transition from inactivity to activity. We know that light can promote an alerting effect, especially during the post-lunch dip hours. And we know that daytime light levels – so if you're exposed to high light levels during the day, you are actually less sensitive to that evening light for suppressing melatonin. So it's good to be exposed to high amounts of light during the day, but we don't always get that in buildings. Sometimes we have deep core buildings. We have places where we can't have windows, especially in the Department of Defense. So how do we do that? So we could create scenarios where your cubicle or your own sort of desk space can deliver color changing light that would increase or decrease the amount of light for increasing entrainment with blue light or for increasing acute alertness with red light.

The final group of people I want to briefly talk about is Alzheimer's disease. I don't know if you know anybody with Alzheimer's, but one of the main issues with this group is that they don't have a consolidated sleep at night. They tend to be awake for two hours, asleep for three hours, and that's one of the main reasons why they are institutionalized.

So there has been work, that was work done in the Netherlands, where they show that if you expose Alzheimer's patients to 1,100 lux at the eye, that's ten times more than what you have in an office, for example, that he was able to show that there was synchronization of the rest-activity rhythms. So the black bar that you see on these three graphs, the top graph is before the light treatment. And if you look at the right side of this graph, these patients were only asleep for about between 2:00 a.m. to 5:00 a.m. He then exposed those subjects for four weeks to the light. And he was able to get them to sleep from 10:00 p.m. to 6:00 a.m. Then he removed the light, and what he was able to show was that they, again, went only sleeping two or three hours a night. So he clearly showed that light can increase the duration of sleep during the nighttime.

He then repeated that study for three-and-a-half years, and he showed that light exposure attenuated to cognitive deterioration by five percent, which was similar effect size as drugs. Ameliorated depressive symptoms by 19%, and attenuated the increase in functional limitation by over half. So light during the day can have a significant improvement in dementia patients, and that may include those with traumatic brain injury or even those with PTSD, so don't lose track of, you know, the application can be more than just patients with Alzheimer's.

We have done some work where we used 400 lux of a high correlated color temper, so a bluish white light source. We showed an increase in sleep efficiency from 80 to 84%. And I just want to make a point that there were other studies that showed that those who sleep 80% have a significant increase in amyloid deprivision in the brain compared to those who sleep 84%. Amyloid deprivision in the brain is the hallmark for Alzheimer's disease. So if you can reduce the amyloid deprivision by increasing your sleep efficiency with light, that is a big deal. Now I'm not saying we're curing Alzheimer's. I don't want to overstate that. But I think it could have very important practical applications.

We also saw a significant reduction in depressive symptoms in this population.

So one of the key issues that we've been working with is how you deliver light to Alzheimer's patients. So we've been developing these fixtures that you put in the room. We actually created a light table. This is a television that we converted into a light table. Alzheimer's patients tend to be sitting around light tables all day long. Give the light in a practical way for them.

Finally, that's the last part, and I think it's a peek into the future. I think lighting for circadian rhythms in the future will be personalized treatment. Now we're talking about you have a personal sensor that collects your personal light exposure, that talks to an algorithm on your phone or on your watch. And that will tell you when to get light and when to remove light.

We're all individual people. We basically have different circadian clocks. Each of us has a different circadian clock, a different response to light. So we need individualized light treatment. And that's what a device like that would do. And in fact we just got a grant from the Department of Defense to develop a system that could be used by war fighters or even by those outside, you know, active duty but that have sleep problems so that they can have their own personal light treatment device.

So the idea here is let me show you how this device would work. This is what happens when you are without any light exposure, so when you are in complete darkness, this is what happens. You basically, if you look at this red down here, what you're seeing is every day your bedtime will delay by a little bit. This is because your circadian clock runs with a period slightly greater than 24 hours. So every day you're going to be ten minutes delayed, and that's what happens.

So here's what happens when you get morning light. Okay, when you get morning light, you tend to delay. And here comes this girl, which is your light treatment, that brings you back into phase. So if you were in a complete dark room every day and all you got was a morning pulse, you would be entrained. You probably would be miserable because you are in a dark room all day and you would be sleepy, but your circadian rhythms would be entrained. So this is what this example is.

So the next example would be – make it work here. It's not showing. There you go. This is a typical lighting profile. This is actually a personal light sensor that a person used at all times. And this is what people are exposed to. Very irregular light-dark exposures. And what we were able to show is that in general a person that has a normal life will be entrained. This person continues to be entrained, which is a good thing that you don't need to worry too much if you have a normal life, you're probably entrained.

So what we think is happening, and we're actually working with the Swedish energy agency – oops, let me go back here – is – I don't know why it went. That's okay. Maybe it's a delay. So what's happening here is we're working with the Swedish Healthy Home where what we think is happening is you have the sensor during the day. It collects all your data. When you get home, that talks to a (inaudible) in your home, that will then change the lighting – thank you for changing that. It will change the lighting in your home so that you're getting the amount of light you need to maintain entrainment or to go to bed early or go to bed late, depending on what you want to accomplish.

So just to summarize, light is a recognized treatment for Seasonal Depression. Lighting for older adults and dementia patients I think are ready for applications, and we're seeing very positive results.

Lighting for shift work, we have very robust data available from the lab, and we're now testing it in the field.

I think lighting for the general population – I don't think we can make big claims other than it will affect your performance a little bit. It will help you maintain alertness at night and during the day. And it is important to maintain your entrainment. And I think we're moving much more toward an individualized lighting solution where everybody will have their own cubicle that will change the lighting based on their personal needs.

So just to finalize the take-home messages.

Morning light will help you maintain entrainment. If anything, go outside for half an hour, walk after daybreak. That will help you maintain entrainment.

Avoid evening light. If you want to go to bed earlier, you want to minimize the amount of light you get in the evening.

A light can also serve as a cup of coffee and increase alertness during the day and at night. But it's not just about blue light.

And self-luminous displays should have the potential to suppress melatonin in the evening and delay your sleep. Turn them off about a couple of hours prior to desired bedtime. Reduce brightness of the screen. Reverse polarity on the screen. And get a lot of light during the day. This will minimize the effects of light in the evening.

Disruption of circadian rhythms by exposure to too much light at night or too little light during the day can disrupt sleep and circadian rhythms. Circadian disruption has been associated with health risks including diabetes, obesity, cancer and cardiovascular disease, so you want to minimize disruption as much as you can.

Indoor lights, especially home lighting, may be too dim during the day and too bright at night, so make sure you go outside or you stay by a window.

Keep a regular schedule. Go for a walk every day at the same time in the morning, and that should help you maintain entrainment.

And we don't hear, and I hate to say that, but a boring life may be a healthy life.

So with that I would like to thank the organizers. This was a very well organized webinar. And I would like to thank you for your attention.

Thank you for your presentation, Dr. Figueiro.

It is now time to answer questions from the audience. If you have not already done so, please submit questions via the Question pod located on the screen. We will respond to as many questions as time permits.

For our first question, what would you recommend for a patient who routinely doesn't feel ready for sleep until 1:00 a.m. to 3:00 a.m. and then only gets a few hours of sleep. And to couple that, what if this person is already minimizing their light at night?

Well, I recommend this person to get a lot of light in the morning. But I do caution about one thing. Morning is not clock time. Morning is a biological time. So you need to know what time is your minimal core body temperature. How do you find this out? What time do you naturally wake up without the alarm clock? And you subtract about two to three hours. So if you naturally wake up at mid-day, you don't want to get any light before 9:00 a.m. You want to get light after 9:00 a.m.

So the first thing is determine or estimate when your minimal body temperature is. Get a lot of light in the morning. And minimize the evening light. This is going to take a couple weeks before you start to see the effect. If you maintain that, you will phase shift your clock.

Again, there are social obligations, things that you can't do. But if you are willing to change the timing, and if you're willing to maintain that rigid light-dark pattern, you should be able to achieve that.

Thank you. Our next question is how do naps, brief or otherwise, impact your circadian rhythms?

That's a good question. It seems like naps – well, the only way it may impact is indirectly because when you're napping you're closing your eyes and you're not getting light at that biological time. So that may be an indirect effect. But what nap really does is nap affects your homeostatic system, which is another part of – the sleep-wake cycle is composed of two systems. One is the circadian system which sends you an alerting signal during the day and a sleepy signal at night. And then there's the homeostatic system which is really a sleep pressure system that it builds up over the course of the waking hours. When you nap, you really help reduce that sleep pressure that you accumulate over the course of the day. But in terms of changing a phase of your circadian clock, it will only change indirectly because it will change the amount of light you're getting while you are napping. If you do that close to the mid-day, it will have very little effect because you have least of the effect of light around this time of the day. So it won't directly affect your circadian timing, but it will indirectly because of your light-dark exposure.

Thank you. Our next question. Blind people have trouble sleeping as light does not regulate their sleep. Any options for blind folks?

Yeah. Let me start by saying that there are two types of blindness. There are some people who do not have the rods and cones so they can't see but they might still have the intrinsically photosensitive retinal ganglion cells. And that can help maintain entrainment. So the more blue light, because this photoreceptor is very sensitive to blue light, the better it would be.

Now for those who do not have any light perception, or have, for example, optic nerve damage or something like that, the only option that a lot of work has been done is taking melatonin pills. About half a milligram of melatonin has been shown to help with entrainment. Interestingly enough, remember that morning light makes you go to bed earlier. Evening melatonin makes you go to bed earlier. So melatonin has a counter effect – it's opposite than light's effect. But melatonin, exogenous melatonin, would be the only solution for that.

Thank you. Before we get to the next question, I do want to address – we have quite a few questions asking where can we purchase orange goggles or goggles that will assist. Unfortunately we cannot promote any products during this webinar. However, I do recommend that you check out the web. If you do a proper search you may be able to find quite a few of those type of goggles or glasses that were discussed and purchase them online.

But going on to our next question, do you ever suggest full spectrum light bulbs?

No. And the reason is there is no really clear definition of what full spectrum light is. To be quite honest, the only one that you would say is really full spectrum is daylight. Fluorescent light sources are not full spectrum by definition. And a lot of the ones that are marketed as such as fluorescent light sources. So I don't think there is an accepted definition for it. I think it's more a marketing than anything else. What I suggest to maximally affect the circadian system is increase the amount of short wavelength, whether it's just by going outside or by using light sources that have higher correlated color temperature, look more bluish white. Or obviously the narrow band light sources that have a peak close to 460 nanometers.

Okay. The next question, for our troops in forward combat zones, have there been any studies for those who utilize night vision goggles in combat situations?

I haven't done anything on that. Obviously we know that there's a reason why they use that, but I have not done any work, or I'm not aware of any work that has been done. I'm sure that there might be, but I am not aware of it.

The next question is are there any lighting recommendations for those diagnosed with chronic fatigue syndrome?

There aren't any official ones. I do want to say we are starting some work with cancer patients that are undergoing chemotherapy that suffer a lot from fatigue. And we are showing reduction in fatigue in these patients by giving them one hour of morning light. So whether the mechanisms are the same or not, we don't know. But we have seen successful application with cancer patients including after they're done with chemotherapy. For two or three months after, we still an effect of light on minimizing fatigue. So my hypothesis is that, you know, better entrainment by morning light could help with chronic disease.

Although we highly recommend that you put your questions in the Question box, we do have one in the Chat that seems quite interesting and mirrors some of the other questions that are in the Q&A. For those active duty or otherwise that are working in intel operations or are at desk jobs working at computers for over 12 or greater hours per day, how is that going to affect their circadian rhythms and what can you do to improve that?

Well, again, it will depend on how bright that screen is. And the time you're being exposed to that light. If it's during the day, it's actually not a bad thing. You want to increase the amount of light you're being exposed during the day, and the more the merrier. So the brighter your screen, the better. If it's at night, it may disrupt your circadian system just as it does with shift workers that might be working in operating room. The solution for that, it will really depend on what kind of task you're doing. If the color of the screen is something important, then it would be harder to filter whether it's with – and I want to say for the orange goggles, you could have filters on your computer screen that would have the same effect. And as you said, those things are on the web. You just look at anything that would reach – you ask for the spectral transmittance of those filters or those goggles, and it has to cut everything below 530 nanometers. So there's not a manufacturer or anything like that. The specification is you're looking for anything cutting below 530 nanometers. So for night shift workers, if you can do that, if you can filter out the screen, that would be a good solution. But if color is important, it's a problem because you are going to most likely be disrupting just like shift workers that have to work in operating rooms.

Thank you. We have time for a few more questions. And this one I'm going to choose because it rings home to me a little bit. What is the best color night light to use?

Oh. You can use warm white as long as it's low light level. There has been a lot of people publicizing red night lights. I personally don't think you need to have red night lights, and in fact with the work that we're doing with red light, you might actually be activating your different systems. If you use a incandescent color one, which is a warm color, low light levels, a lux at the eye, you will have plenty of light to navigate in the space and this will not be affecting your circadian system.

And for our next question, which I think would be a lot of our active duty individuals who exercise, may be wondering this question. What are your thoughts on exercise versus light exposure in the morning to improve or advance circadian rhythms?

Well, there has been some work with exercising in the evening and delaying the circadian system. There's a little bit of effect, not as strong as light. My opinion is you have to combine both, which means go outdoors for a run in the morning. You're getting your exercise in and you're getting your light exposure in, and you're doing both. Whether they reinforce each other or not, nobody has systematically looked at. But I think you have to do systematic study where you do the exercise in biological darkness and a combination and so on, and that hasn't been done. The only work that has been done is just looking at evening exercise, and they saw a small effect but definitely not as strong as light. So if you have to choose one, choose light. If you can do both, go for it.

Has light therapy been helpful with inflammatory conditions such as arthritis, fibromyalgia, so forth?

Well, I have to say I – and anybody who is interested in following up with that please contact me – I started working with the VA here in Albany. And we haven't been able to follow through just for logistic reasons, people moving on and so on. My hypotheses – and this is hypothesis based – is that we showed a very strong increase in cortisol levels with a red light at night. So I did a pilot study here, these are unpublished data, so it's just observational and unpublished study, where we delivered the red light through closed eyelids on the light mask, and we saw an increase in cortisol levels. So my hypothesis is that I'm wondering if people who suffer, for example, from rheumatoid arthritis, they tend to have the flare-ups and they tend to be very stiff at night because the cortisol levels, which are anti-inflammatories, are reduced at night. So the question is what if you increase the cortisol levels with light while you are asleep, can you minimize that inflammatory response in the middle of the night by inducing and increasing cortisol levels with light. Don't know the answer, but I think it's a really neat hypothesis to follow. So we did a pilot study with the light mask here, and we did show the increase in cortisol while people were asleep. I wanted to move that into the real life applications with VA subjects, but I haven't been able to follow through that. But maybe – maybe somebody has the population, happy to collaborate on that.

Well that ends our time for questions, so thank you for everybody who has submitted questions.

After the webinar, please visit dcoe.cds.pesgce.com to complete the online CE Evaluation and download or print your CE Certificate or Certificate of Attendance. The online CE Evaluation will be open through Thursday, December 17, 2015.

Thank you again to our presenter, Dr. Figueiro. Today's presentation will be archived in the monthly webinar section of the DCoE website. To help us improve future webinars, we encourage you to complete the feedback tool that will open in a separate browser on your computer. To access the presentation and resource list for this webinar, visit the DCoE website at dcoe.mil/webinars. A downloadable audio podcast of the edited transcript of the closed captioned text will be posted to that link.

The Chat function will remain open for an additional ten minutes after the conclusion of the webinar to permit the attendees to continue to network with each other.

The next DCoE TBI webinar, Defense and Veterans Brain Injury Center Head to Head Study: A Psychometric Comparison of Brief Computerized Neuropsychological Assessment Batteries, is scheduled for December 10, 2015, from 1:00 to 2:30 p.m. Eastern Standard Time.

The next DCoE Psychological Health webinar, Year In Review: Clinical Practice Guideline, 2016 Post Traumatic Stress Disorder, is scheduled for January 28, 2016 from 1:00 to 2:30 p.m. Eastern Standard Time.

Thank you again for attending, and have a great day.