Western Science

WESTERN SCIENCE SPEAKS PODCAST
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EPISODE TITLE

Halloween: Fright Night Explained

PODCAST SUMMARY

Our Halloween Special of Western Science Speaks includes Western University researchers Dr. Liana Zanette, Dr. Yolanda Hedberg, and Dr. Lyle Muller. Our guests join the show to talk about how fear evolved, varies across species, and how it stays with us. We also reveal the chemistry of candy and everything you need to know before biting into your Halloween haul. Don't be scared, tune in to hear the fright night explained!

INTERVIEW

Henry Standage 0:32
Hey, I'm your host, Henry Standage and thank you for joining us for the Halloween edition of Western Science Speaks. We have an absolutely stacked episode for you today. To start, we're going to be talking with Liana Zanette from the Department of Biology about how fear evolved, and how it varies across different species and individuals within those species. Afterwards, we'll be with Yolanda Hedberg for a briefing on the chemistry of candy - everything you need to know before you go trick or treating in the future or bring your kids trick or treating. Then to end, a conversation with neuroscientist Lyle Muller regarding how fear stays in the brain, and the different ways that can manifest in our day to day lives. Fear is something we all live with and the guests on this shows episode understand it in a palatable way. And I know I personally left these conversations with the new perspective on what I'd always perceived as shortcomings in how I'm wired. This is a jam-packed show. So, let's hop into our first section of fright explained with Liana Zanette.

All right, Liana Zanette is here. Thanks for joining us Liana. You're here to discuss your research pertaining to how different species of wildlife exhibit and react to fear. So how does somebody with your ecological and biological research background define fear?

Liana Zanette 1:57
Yeah, so fear is meant to keep you alive, to prevent you from dying immediately from something like a predator attack. And so, any sort of life-threatening event can begin the physiological and behavioral fear responses that we see.

Henry Standage 2:17
How does the perception of fear change across different species?

Liana Zanette 2:22
Fear is really one of those unifying forces that connect all taxonomic groups of animals, whether we're talking about the smallest little single celled thing, up to humans, because all of us have an evolutionary history where we have been confronted with predators. And so, across species, it's actually the behavioral responses, some of the physiological responses and many of the neurobiological responses are all quite similar. We call that conserved across species, taxonomic groups, it's really quite amazing. It's really a unifying force. Now, the modalities that that animals use in order to perceive a predator or a threat in the environment, the strength of the modality that they rely on might vary across species. So, everything will use, you know, if you have ears, and if you have eyes, they'll use their ears and eyes and noses in order to gain information about whether or not there's a threat in the environment. Some species might rely more on vision, some might rely more on sound. But generally, everything

has something that they use or a combination of modalities that they use to perceive predators in the environment or a life-threatening event.

Henry Standage 3:44
It's really interesting that you're describing fear as this good thing that is inherently required for any species to survive. Because in some human cultures or social circles, fears perceived as a weakness, and you're telling us that it's really the opposite. But if fear is this important evolutionary trait, why does it occasionally foster lower birth rates in some species?

Liana Zanette 4:09
Well, yes, fear does allow you to survive another day. But it does carry costs. And these costs are usually referred to as trade offs. Because there's something like a predator in the environment. I mean, we've seen you know, birds at bird feeders, and if there's a predator that comes close to the feeder, you know what the bird does, right? It stops feeding, it leaves the feeder right away and ducks to cover. And that means that it won't get taken by the predator because it exhibited this fear response. And so that's really great. But at the same time, it does carry that cost in terms of reduced foraging, and the less you feed, and if this is happening chronically over a long period of time, it means it's going to accumulate. And so it's because of these kinds of behavioral trade offs, that we can see massive reductions in the number of offspring that animals are able to produce, simply because they're not there, they're looking for predators, instead of looking for food, so they're getting less food, they're able to produce fewer offspring, they're less able to provision those offspring. And so that that can reduce the number that they produce over a season.

Henry Standage 5:29
Do you have an example of an animal that's prone to overcompensating for fear?

Liana Zanette 5:35
So, we've done experiments where we've done sounds of predators for a bird, and other birds heard non predator sounds. And in response to that over breeding season, the adult parents fed less so they laid fewer eggs, fewer eggs hatched, fewer offspring were provisioned. And so fewer, fewer of them made it out of the nest. So, you know, that's the response on average. And there's individual variation. I mean, we've done experiments in South Africa. And this is sort of what we're finding at a community level. So, we look across 33 different mammal species. And we play lion sounds, we're playing the sounds of humans, and overall, across the community, all of those species run mostly when they hear humans, but there's some species that are an exception. So, things like elephants, they don't really care. hippos, they don't really care. So, there is there is some variation across species, for sure.

Henry Standage 6:35
Now, I do want to talk to you about that variability between humans, because I think everybody has a thrill seeker in their life, somebody who chases that adrenaline of being frightened, what would you estimate is the difference?

Liana Zanette 6:49
Well, we do see that there is a lot of individual variation in the expression of these behavioral responses. So, for example, an experiment that we did where we were looking at birds, they had offspring that just left the nest, so they had yet really young birds that they still had to provision they had to provide with food for another few weeks until they became independent, and then the little, the little fledglings were radio tagged, so we were able to find them in the field. And then once we found them, we set up speakers that played predator sound for an hour, and then we played a non predator sound for an hour. And we looked at the parent's responses to the two different treatments. And what we find is that overall, parents reduced the amount of food that they provision their offspring by about three feedings per hour when they think that there's predators around. So that's a mean, but when we look at the variation across parents, it's really astronomical. Some parents when the predator sounds are on, they would not visit their offspring at all, zero in that whole hour, compared to when the non predator sound was on, but other parents could care less, right? I mean, they would just go in and they provision, provision, provision. And interestingly, it's the individual variation that we saw across these parents was related to whether

or not their offspring would survive to breeding age. So, if they were kind of really scared out of their minds, when they thought that there was a predator around and didn't feed their offspring, those offspring were more likely not to survive later on. So, you know, that really short term behavioral kind of essay allowed us to get a mean, but also allowed us to see that individual variation, that enormous individual variation across the birds that was related to survival. And the reason that there's individual variation is a great question, right? I mean, we know that if animals experience a life-threatening event, that can lead to permanent changes in the brain. And then you might become, you know, hyper vigilant, hypersensitive to any sort of threat that might be out there, compared to other individuals that have had less of an experience. So, it's thought that past experience, even for humans, really determines how you're going to respond to life threatening events. You know, not everybody gets Post Traumatic Stress Disorder, but 20% of people do. And, you know, it's thought that is related to that individual's previous early life experience. And so in the birds that I was talking about, where they were reared with parents that thought that there were lots of predators around, those parents produced fewer offspring, but you would expect that those offspring themselves if they do survive to breed in the following year, that they will be permanently affected by their previous rearing environment. So when we find those offspring when they become breeding age, and they, you know, they set up territories on their own, that the ones that were reared where their parents thought that there are lots of predators around, actually do sing fewer songs, compared to those that were reared in less threatening environment. And being able to sing lots of songs, is important for attracting mates, etc. All of these things develop depending on partly genes, but also partly because of your circumstances.

Henry Standage 10:37
So, you just told us that PTSD really does exist in animals, that life threatening events can change them in some fundamental way. And the single most fascinating question to me within all this stuff is how big a role someone's circumstances when they're young plays and how they ultimately develop. And that example of the birds who don't sing really gets at that.

Liana Zanette 11:00
Yeah, well, I mean, we're looking at these sorts of things. Also, in terms of because were interested in how humans frightened wildlife and the effects of that in the environment. And one thing we're doing is we're contrasting areas where animals are hunted quite heavily versus not, we would expect them to be more afraid and run more often if they think humans are around where humans are more lethal. So, these are the sorts of things that we're trying to test. And there's another group in Mozambique in Gorongosa Park, and what they've suggested is that the elephants there do actually have a type of post traumatic stress because in Gorongosa National Park, there is a 10 Year War of Independence with the Portuguese followed by a 20 year civil war, all very brutal, and in addition to having an impact on the humans out there, it also had a major impact on the wildlife, almost everything went extinct because people went in and poached it or ate it. And so, elephants were no different. elephants were heavily poached mostly for their tusks to get money for that - so people could eat, but also to buy arms, etc. And now today, the elephants they're trying to re-establish the ecosystem at Gorongosa National Park. And that involves implementing some ecotourism. And they're having a lot of troubles with ecotourism especially regarding the elephants because the elephants live a long time. And the matriarchs have a memory of humans killing their sisters and offspring. And also, many of them have bullet wounds in their ears and stuff like that. So, they have been attacked as well by humans. And so now, whenever these elephants see a human, they charge them and so it's like they recognize humans, they remember that humans were a significant threat. And as a result, even though eco tourists are completely benign, they still recognize humans as a threat, and they don't trust them whatsoever.

Henry Standage 13:02
Because of this experience they had with humans during the Civil War they now favor fight overflight. So that suggests that this fight or flight response is adaptable. Which leads me to my next question. As a civilian that has to coexist with animals like raccoons and skunks and squirrels here in Ontario. How scared are they of me? How can I make them feel more welcome? Even if I'm not that big a fan of them? Is there any chance that they don't see me as a threat?

Liana Zanette 13:36

No, they're afraid of you.

Henry Standage 13:39
That can't be changed?

Liana Zanette 13:41
No, no. Maybe if humans stopped killing these things, maybe that could be changed. But certainly, you know, everybody sees raccoons all over the place. But we've shown in experiments that medium sized carnivores because they're frequently persecuted by people, that is, people kill them for various reasons for their fur, because they consider them pests or whatever. That's the thing that those animals are most afraid of, it's not an apex predator, it's humans talking, and just talking. So just human presence is enough to scare these animals. And the reason that they're around though is because we do provide other things like shelter, and food. I mean, they do things to keep their distance, right. That's partly why they come out at night. We know raccoons, for example, if there's no predators around, they will forage day and night. If humans are around it's a whole other story. And they will mostly come out at night, so animals, even the ones that live with us, if they've been persecuted, they'll live with us, but they sure don't like us and they will do whatever they can in order to avoid contact with us like changing, you know, when they forage etc.

Henry Standage 15:09
I would love to have some sort of handshake agreement with the skunks that lurk around my house, because I'm always super concerned, every time I'm leaving to go downtown to meet up with people.

Liana Zanette 15:18
I know, but they're more concerned about you, right? That's why you're concerned because you see them lifting their tail, they see a big predator coming along, they're going to lift their tail, right?

Henry Standage 15:29
What do you think it is about talking that they perceive as so terrifying?

Liana Zanette 15:34
It's a very reliable indicator that a human is around. Right? It's reliable. It's also useful because sound can really travel, and the human doesn't have to be right in front of you. So, it's just a reliable indicator of the presence of something that is quite lethal.

Henry Standage 15:57
Yeah, I was about to ask you how reliant these animals are on a visual presence, something that they can see. Because when I walk down a dark tunnel at night, not being able to see is much scarier than anything that could actually possibly be there right, the mystery of it, do animals experience that phenomenon at all?

Liana Zanette 16:18
Lots of things absolutely do rely on sound, especially in terms of wildlife probably. And there are some examples where species will be more afraid of certain things than others. So, for example, black capped chickadees, little chickadees that we see in the backyard. At our feeders and such, we know that if they see a predator in a tree, they do a mobbing call. So, they'll do chickadeedeedee. And that gets all the other chickadees doing chickadeedeedee. And then all the other species will get involved too. And then they mob the predator. And the reason they'll do this is because being able to know exactly where the predator is, it's considered sort of a downgraded kind of threat. Because if the chickadee knows where the predator is, then it's no longer really a threat, it can't sneak up on it and grab it, right. And so, they'll actually go up. I mean, some species like crows will, you know, hit things like bald eagles on the head and stuff like that, right? Because the threat is kind of limited because the chickadees know where they are. But if they hear the sound of a raptor or some sort of hawk, and they just hear the sound, but they don't know where the sound is coming from, they can't locate it, they do a completely different sort of response. Instead of being really mobile and jumping around and giving that call, they give a call, called the high z, it's a high pitch call that's thought to be not very easily located by anybody, it's hardly

given and then they freeze so they do the exact opposite. That's because they know there's a predator around, they heard it, they don't know exactly where it is. That means that the predator can sneak up on them. If they start to move, you know, they won't know what direction to fly if the predator comes after them, etc. So, they're more likely to die. So, they exhibit these completely different behaviors, even though it's a hawk in both cases. The knowing where the Hawk is versus not, makes a huge difference in the level of threat that that predator poses on the chickadees. And we also find that there's signatures of these different levels of threat in their brain as well. So when we give chickadees the sounds of predators, there's areas of their brain that are associated with fear that really light up if we show them a mount of a predator, you know, a stuffed Hawk, those areas of the brain are much less lit up, they definitely do have a way to differentiate different threat levels even for the same species of predator.

Henry Standage 19:09
Anytime a group of smaller animals' groups together to fight off predator I'm always just totally engrossed. I always find myself down the YouTube wormhole with like watching a pack of walruses fight off a polar bear.

Liana Zanette 19:22
Yeah, yeah, it's pretty cool. I mean, but you can experience it yourself. Go to Gibbons Park, you know that area where they're naturalizing it and there's loads of red winged blackbirds breeding there in the summertime, and they don't like people coming anywhere near, and so they'll smack you over the head.

Henry Standage 19:40
Okay, thanks for giving me plans for next summer. The Western geese I think embody that mob mentality you are referring to. But I want to ask you one last thing before we go. Humans evolved in a dangerous world where we had to develop fear. But in our modern world do you think fear is a totally necessary emotion to experience. Furthermore, if we had an apex predator introduced into our urban spaces, would we be able to snap back to our primal senses in a meaningful way?

Liana Zanette 20:12
The reason we don't have predators around and in many urban environments is because humans killed them, right. But nonetheless, there are still lots of urban environments where predators are allowed to roam around all across Europe all across, you know, when I think about British Columbia, where I've done a lot of work for all over the west side of Vancouver Island, and you know, their cities there and people just let cougars bears and wolves wander around all over British Columbia. It's the same thing. And so, you know, people live with large carnivores all over the world, you know, they don't necessarily need to be exterminated in urban areas. We would have to change our behaviors, though. Right. So, in Tofino on the west side of Vancouver Island, where there's still lots of cougars, bears and wolves, you know, they don't leave the garbage out, right? They put the garbage in bear boxes. So that discourages the bears from coming along. And, so there's changes in behavior that we would have to do in order to live with large carnivores, especially if they've been gone a long time. And we've forgotten how to do that. But the responses are all still there. And, you know, people don't have any troubles living with large carnivores in lots of different places.

Henry Standage 21:37
We'll end the interview there. But thanks so much for doing this. I hope people's main takeaway is that fear is a strength and not a weakness. The only thing we can control is our courage, and also how we treat fellow inhabitants of Earth and treat their fear with kindness. So, thank you, Liana.

Liana Zanette 21:58
Thanks a lot for contacting me. Yeah. Bye.

Henry Standage 22:02
I hope you enjoyed that interview with Liana. If you want to hear another awesome talk she gave about her work. Check out the interview she did about fear with the BBC in 2013. Before we move on to Yolanda Hedberg, I wanted

to remind you guys to subscribe to the podcast and make sure you never miss a great discussion. If there's a topic you'd like us to investigate, let us know. Send an email to science@uwo.ca. Now, onto Yolanda Hedberg.

Yolanda Hedberg is here to talk to us about the chemistry of candy. Welcome to the show. And let me open by asking you this. I think a lot of consumers without a scientific background wrestle with the concept of chocolate having health benefits, is chocolate healthy? Or is it toxic? Or is it a bit of both?

Yolanda Hedberg 22:54
For chocolate, we have to distinguish - they have some good things in it. And they have some bad, bad things in it. And there are some chocolates that contain very high amounts of toxic metals. So, metals are generally in food, both good and bad. So, if they are in a certain concentration, they are very good. There are many persons, especially women that have a deficiency of metals, metals, like copper, cobalt, iron, they are very good for our health, because usually we have too little of it. So if these metals are contained at the right concentration in the food, it's very good for our health, but if they are too high, or if they are so called non essential metals, like lead is a good example, then they are just toxic, and they can induce a lot of diseases like brain damage and cancer. And in chocolate, the toxins are very different dependent on where you buy this from. So, if there are unfortunately not so many studies about that, but there are a few studies that show that for example, in Indian chocolate, you have very high amounts of lead and an Italian once you have very low amount of this. But I would say if you compare it in different regions, you get very big differences. And the reasons are that we have different polluted areas, it's again, where are these cocoa trees? Are they close to industrial polluted areas or not?

Henry Standage 24:29
It sounds like you're saying that yes, eating chocolate is genuinely good for you. You're going to be better off in the long run for indulging in it rather than completely staying away?

Yolanda Hedberg 24:41
You actually lower your blood pressure and get lower risk of cardiovascular diseases. And this has even been shown for chocolate that is not perceived as healthy. So even though the ones that have lower content of cocoa. But I should say that they're even more healthy alternatives to get these flavonoids, you should eat onions kale, grapes, berries, tomatoes, broccoli and peaches.

Henry Standage 25:14
And how does the surface chemistry of chocolate work?

Yolanda Hedberg 25:18
For all materials, what you need to know is that the atoms are ordered in a certain way. So that is called a crystal. And they can also be ordered a different way. It's like if you have cubes or hexagons, or whatever. So that is the order of different atoms. And depending on which order they have; they have different properties. And chocolate is not different. So, chocolate has different types of faces. And all of them have different properties like different melting temperatures, and so on. And you want to have a certain face. So, a certain face is the one that has exactly the right feeling in the mouth of this melting point. And it's also the one that looks nicest on the surface. And you need to make sure that it has been produced in a certain way and also stored in a certain way. So it keeps this face to avoid the surface changing, so you have to store them below 23 degrees C, and also not cycle the temperature, so you shouldn't take them in the fridge in and out so the face will change again, what happens when they change it's called fat bloom. So, the fat bloom is nothing else than certain crystals in micro size on the surface. And these are scattering the light so they look more rough and they look more white, maybe you have to remember some old chocolate they seem to have like a white surface that is nothing else than a certain fat crystal structure that is on the surface. It's nothing dangerous, you can still eat it, but it's not as good.

Henry Standage 27:05
For people who like fruity, chewy taffy candy such as Starbursts, Skittles, you're getting a lot of synthetic flavors, what are the consequences of making in an environmental sense, and ingesting in a personal human health sense, these fake flavors?

Yolanda Hedberg 27:24
Yeah, I think first we need to distinguish the flavors. Usually people distinguish the natural and the synthetic flavors. But actually, natural can mean anything like it can be extract from fruits, but it can also be produced by funghi or by bacteria. Synthetic flavors just mean they are produced in some kind of chemical way. There has been a case of a five-year-old girl that always when she ate colorful candies, she got a complete reaction like headaches and even got unconscious. The sweeteners are actually even more concerning. So, sweeteners like aspartame, they are in all these soft drinks like Coca Cola Zero, and all these sugar free products and sugar free means they have some kind of sweeteners. And several of these sweeteners have real health problems, like for example, aspartame has been shown to cause seizures, headache, and attention deficit disorders, and also, they can cause addiction.

Henry Standage 28:38
Yeah, what does the chemical makeup look like for those candies with stickier surfaces?

Yolanda Hedberg 28:44
In some candy you don't want to have any crystal structure. So that is called amorphous and amorphous means that the atoms are not structured, they're like randomly ordered and that they also have a little bit bigger distance to each other. And that usually happens from like our daily life, the best example would be glass. Glass is nothing else other than an undercooled melt. So, it has been a melt and then it has been cooled really fast. So, it couldn't have time to order in a certain structure. And that is why glass is transparent. Candy's have a crystalline structure and so they're not transparent. Usually, they crystallize quite fast. But you can hinder this by having a higher boiling temperature of the sucrose and also by adding some other types of sugar like fructose and these are called the interference agents, and they interfere with the crystallization of the sucrose.

Henry Standage 29:55
What circumstances can cause a candy surface to rot or corrode over time?

Yolanda Hedberg 30:01
For everything that has to do with corrosion, it could be UV irradiation. So light, of course, that's why they always are wrapped into paper. But for chocolate, the most important part is the temperature. And of course, they are always exposed to air and air contains oxygen, and that is oxidizing everything.

Henry Standage 30:22
We're going to finish for the speed round, I'm going to ask you about a couple forms of candy and you'll touch on them briefly. And you can give a rating from one to five where one means that ethically environmentally and health wise, we can feel okay about eating or ingesting this. And five would mean stay clear. Let's start with gum.

Yolanda Hedberg 30:44
That depends on if it contains no sugar.

Henry Standage 30:47
I've got some right here.

Yolanda Hedberg 30:49
Check if it contains aspartame.

Henry Standage 30:52
Each piece contains 19 milligrams of aspartame.

Yolanda Hedberg 30:57
Yeah, see, I would stay away from it, five.

Henry Standage 31:01
...It's my favorite gum. Next - popcorn.

Yolanda Hedberg 31:07
So here, my husband would say one, and I say yes, if you don't sweeten it, and if you don't salt it,

Henry Standage 31:17
Taffy.

Yolanda Hedberg 31:18
Again, if it contains any of these sweeteners it's worse. So, let's give some kind of middle... three.

Henry Standage 31:28
Cotton candy.

Yolanda Hedberg 31:30
Yeah, so they always advertise that it has very low calories. And that's true, but it's just sugar. It just contains sugar. And I think that sugar content that it contains is more than double what you should eat every day. So, five

Henry Standage 31:51
Yeah, it's literally air seasoned with sugar. Chips.

Yolanda Hedberg 31:59
I personally like chips but they can contain this carcinogenic acrylamide but that depends on how they are produced. And I think today most of the manufacturers have some control over that. So, they are actually measuring the amount of acrylamide in their chips. So, I think today my dentist would say stay away completely from it. Because they just have too much contact with the teeth.

Henry Standage 32:32
Speaking of teeth, what kind of chemical reaction occurs between my teeth and the materials in candy when I bite down?

Yolanda Hedberg 32:41
Teeth are actually ceramic materials. So, one of the most beautiful ceramic materials that exists. So, plates and cups they if you let them fall to the floor, they will break but teeth are much tougher. And the reason is that even if they are of the same type of material, they have a certain structure and a platelet structure of this ceramic material, which consists of calcium phosphates, carbonates. And so, they have really nice mechanical properties for being ceramics. But still even if they are ceramics, they can be degraded by acids. And this is what happens. So, if you have a lot of exposure to candies, that sugar, the sugar itself is actually not destroying that teeth. But in the presence of bacteria. There is a lot of acid forms and this acid is degrading the teeth.

Henry Standage 33:47
Before we let you go as somebody with a thorough understanding of what candy is, in an organic sense. What does an ideal relationship with these sugary snacks look like?

Yolanda Hedberg 33:58
The best thing we can do is to think about healthy food, healthy daily exercise, clean air and education. These are the four factors that are influencing how long we will live. I never think that we should stop doing something that is unhealthy because you can get pretty fundamental about that and just say, oh, I never want to eat any candy or any sugar. I don't think we humans are made for this. We need some kind of stimuli. So, I think we need to be honest to ourselves and just try to balance all the risks.

Henry Standage 34:34

So, if a kid shows up at my front door on Halloween, you're saying I shouldn't give them celery.

Yolanda Hedberg 34:40
I think you should give them candy.

Henry Standage 34:44
All right, well, we'll wrap up there. But thanks so much.

Yolanda Hedberg 34:48
Yeah, you're welcome. Thank you.

Henry Standage 34:50
Thanks to Yolanda Hedberg for joining us. Before we go to our last interview of the day with Lyle Muller, what holiday special would you like to see us do next? Christmas, Groundhog Day, Canada Day? Let us know. And don't forget to share this episode with the people in your life who need to hear it.

Henry Standage
All right. Lyle Muller is here. Thanks for joining us. And your section is about how fear stays with us how it manages to carve out a permanent place in the brain. And later, we'll talk about some of the techniques being developed for helping our brain cope with traumatic memories. But I want to start here, what happens in the brain when we're scared by something?

Lyle Muller
That's a great question. We know that fear involves a range of brain areas working together. So, we know that it's places in the frontal cortex working with another set of regions that are in the limbic system. So, the area that is most well associated with fear is called the amygdala, which is this collection of nuclei that's really deep in the brain and plays important roles in emotion. It's probably best to say that this amygdala has a role in processing strong emotions, where fear might be the best example. Right, but the most recognizable example.

Henry Standage
Okay, so it exists in the amygdala? How have we been able to study that historically, because I know when we met before, you mentioned how there have been these areas that we haven't known a lot about that in recent years, we've been able to discover a lot more

Lyle Muller
Yeah, traditionally, in neuroscience, we've recorded from single electrodes. So that's kind of like looking at the brain through a straw. There's all of this activity, it's like a whole symphony of players working together. And it's kind of like focusing on just the one violinist. Now what we're doing more and more in neuroscience has developed these really large-scale recording techniques. So instead of one electrode, maybe 10s, or hundreds, or even sometimes thousands of electrodes. And that's really exciting, because now we can kind of see the whole Symphony working together, for fear. Specifically, there's a lab at Western led by Julio Martinez Trujillo, who's using these large scale or larger scale, multi electrode recordings to understand amygdala circuits and exactly how they're related to fear. If you look at the one violinist or this one electrode activity, things looked a lot like noise. So, the brain has this constant, ongoing spontaneous activity that's just going around all of the different circuits, and we couldn't really explain it. But now as we're starting to record from more and more electrodes, instead of seeing these, you know, kind of meaningless noise patterns, we're starting to see this huge, orchestrated symphony of activity.

Henry Standage
How does the brain offload memories from one structure to another?

Lyle Muller

Yeah, so if you think about a scene from your life, right, so imagine you were camping somewhere in the mountains, and you had this experience or this memory of waking up. You know, when you're seeing the mountains, you're maybe smelling a campfire, we know that the memory footprint of this experience is formed in your hippocampus. So that's where it starts. And then during sleep later, it's transferred to the neocortex. So, you can think of the hippocampus as this kind of smaller set of neurons that is responsible for forming the memories. And the neocortex is this huge, huge network, where all your long-term memories are being stored. That's called the two-stage model of memory consolidation, where you have these memories of experience that happened during your day. And then through consolidation, they're integrated with old memories without losing or disrupting them.

Henry Standage
Yeah. And in modern human societies, we're not fighting for survival every day dangerous experiences are much fewer and far between. So, a lot of fears, actually memories of those experiences where we are scared for our life. And so, with PTSD, we're talking about an experience so frightening and overwhelming that it lurks in our brain for years, and the connections that trigger that event become too broad. Is it possible to remove that memory to stop the constant encoding of that experience we had?

Lyle Muller
One of the most interesting ideas that's coming from computational neuroscience historically, is that memories are likely highly distributed in the network of synaptic connections between neurons. So instead of a memory being stored in a single neuron, or in a small group of neurons, we think that the memories are actually stored in this really broad distributed brain network. And so, this idea actually was first conceived by a Canadian neuroscientist named Donald Hebb. And it wasn't really at first taken seriously by the neuroscience community. So, this is in the 1940s 1950s until a group of physicists in the 1960s and 1970s started working on these ideas and applying mathematical tools. So, to get to your point, the memories are so immersed in the synaptic network of cortex, it is really difficult to it seems like it's really difficult to remove a specific memory. But at the point of encoding, so during sleep in this process of memory consolidation, that's where we think that memories are most. It's most possible to target memories, or to modulate memory consolidation as it's happening as it's going from the hippocampus to the neocortex.

Yes, what happens while we're sleeping that process is able to happen. So effectively, if we go back to that example of camping, and you're in the mountains, you're having a visual experience of these trees that you're looking at or smelling a campfire. As you wake up, we know that the individual pieces of this memory are all stored in different cortical regions, all across the brain. And these become active during the process of recalling or remembering. So, for example, if you're thinking about a visual scene, your visual cortex, your very early visual areas light up. When you're having that memory, we need to kind of understand how this distributed brain network links together all the activity patterns when the memories are transferred from the hippocampus to the neocortex. So that touches on some work that we did. While I was at the Salk Institute in California, where we found a specific mechanism for how this might work in the brain. What we were studying was a specific sleep rhythm called sleep spindles. These are 11 to 15 hertz brain rhythms that occurred during sleep. And we were studying how they're organized across the cortex. We did this through a collaboration with a group of neurologists at Massachusetts General Hospital, where we were studying these rhythms in highly precise and local recordings made in the clinic as their neurologists were mapping the patient's brains for epileptic activity. And so during nights with normal sleep, where there weren't any seizures, we studied these rhythms, these sleep spindles. And while people had generally thought previously, that there was no real organization, to the pattern of these spindles across the brain, specifically, what people thought was that they were all synchronized, or that means that the rhythm is going up and down together at all points in the brain at the same time, using some computational techniques that we developed to analyze kind of movies of activity, we found that the spindles are actually organized in these really beautiful patterns of waves that rotate across the brain. And so it turns out that these waves travel at the speed, it takes neurons across distant points in the brain to communicate with each other. So if you're back here, in visual cortex, it takes some time to communicate to neurons in the frontal cortex. And these waves that are appearing during sleep, seem to be able to provide that highway, that link for visual cortex neurons

to link up with the frontal cortex neurons. We think that this is a mechanism for how the brain self organizes its activity to allow communication and linking parts, these different parts of remembered events, so visual, auditory, olfactory parts, between these neurons that are spread all across the brain.

Henry Standage
And were you looking specifically at people dealing with PTSD, or just random samples.

Lyle Muller
So, these are patients that are undergoing treatment for epilepsy. But we think that this specific mechanism generalizes, to PTSD, for example. And so, if you had a traumatic experience, that memory of that traumatic experience is kind of locked in or repeated over the course of sleep than in the nights following. And so that turns out to be the critical time at which the memory is really formed and consolidated.

Henry Standage
That's interesting, because, say, I go to Disney World with my parents and have the best day ever, and I want to have a really vivid memory of that experience, it's probably good to get some really good sleeps the days following it. But with a traumatic memory, you can see why people would turn to alcohol and drugs to almost even if they're not doing it intentionally screw up that memory forming process, right?

Lyle Muller
Definitely. Yeah, we know that we know that those substances significantly impair sleep. And so, people can be self treating to disrupt those memory formations.

Exactly.

Henry Standage
Will going sober, help bring those memories back or is it really if you don't consolidate them in the immediate short term, they're kind of gone forever?

Lyle Muller
Modulating memories, it's very, very tricky. So, it's not like alcohol would be a very good way to modulate memories. So, going sober might not have a specific effect on that, right, it might be a good treatment mechanism, but not a way of preventing memory consolidation.

Henry Standage
As I said before, our current world is much less dangerous than the ones our ancestors evolved in. We were hunter gatherers, you know, fighting off tigers, and traveling long distances, in your opinion is the development of scary movies, or visiting haunted houses a symbol of an itch that we desire to be scratched.

Lyle Muller
I think that, so scary movies and haunted houses can be really fun. And so, it can be quite an exciting experience. But it can also for some people be actually traumatic. So, it points to how different individuals will consolidate experience very differently. That has to do with people's predisposition to fear and also how they consolidate the memories or integrate it into their experience.

Henry Standage
Now, you said scary movies and haunted houses are fun, they're really not in terms of what the creators of them are trying to do to us. Why would somebody's brain enjoy that?

Lyle Muller
We know that if you have an experience like fear, and that can involve a fight or flight mechanism, and you can actually get adrenaline from that. And so, adrenaline is highly exciting to the cortical circuits affected by that

hormone. So, if you have an adrenaline rush, not only do you, you know, have increased physiological response, but you actually have components of increased memory consolidation.

Henry Standage
Is PTSD, something that only humans are capable of having?

Lyle Muller
So, we know that fear is really deeply integrated into the circuits of the brain. The amygdala is really well connected with the hippocampus, which is part of what we call paleo cortex or old cortex. These circuits are, you know, important for all mammals. And we know that, for example, mice exhibit fear conditioning, really, really well.

Henry Standage
Because to me, PTSD, is an awakening to one's own mortality. And that's scary. It's very curious to think that an animal could experience that as well. Is there a point you can look at and go this is where you get PTSD on a level of how scared you were? Is it a gradient or a continuum? Or an all or none threshold thing?

Lyle Muller
I think at the individual level, it is an all or none thing. But there's so much variability between everyone's experience that it could be that very different experiences could lead to PTSD.

Henry Standage
Yeah, cause I'm interested to know if it's more nature or nurture, and that if you have a very privileged, easy upbringing, will something less objectively terrifying give you PTSD versus somebody with a very tough, you know, graphic upbringing, will they grow up a little bit tougher in terms of getting PTSD?

Lyle Muller
That's a great question. You know, so much of cognitive neuroscience is done in undergraduate student populations, and things like that. And so, one of the important things that's being discussed in cognitive neuroscience is how do we expand our testing to make more representative samples of the populations in, you know, not only Ontario, but Canada? And that's a question that people are really actively dealing with. So, I don't think we know the answer to that specifically, but I think that people are starting to really think about it deeply.

Henry Standage
Hmm. Cool.

Now I want to talk to you a little bit about virtual experiences. So that could be virtual reality, or that could even be watching a scary movie where you're forced to live through a character vicariously. Is there a difference in the activity in the brain of how we process a real-life experience versus a virtual experience?

Lyle Muller
That's a great question. There are examples where people have compared for example, rodents navigating on a real-life track versus a virtual reality track. And they do see that there are specific differences in the way the brain processes, navigational cues, the way the brain maps out the space, it does seem like virtual reality engages the same mechanisms of memory of cognitive processing, in a good enough way that we can think about it as a very rich environment for studying memory and consolidation and things like this. So, in collaborations here at Western, and with the university hospital or London Health Sciences Center, we are actively working on virtual reality experiences that clinical patients can participate in. To understand how, when they're navigating through virtual reality environments, how does their brain map out that environment. So, if you imagine playing a video game, and you're navigating through a city environment, how do your brain circuits actively taken all of this information? The visual experience, auditory cues in that video game - how does it stitch it all together into a into the neural circuits for remembering and planning out your route? So, we're actually actively doing that here at Western.

Henry Standage
Yeah, because when I play a game, like Grand Theft Auto, I actually know the city well enough where I can go, I want to go to this part of the city. And I know the roads to take.

Lyle Muller
Exactly. And there's some cognitive map that's being called up in your hippocampus, and then being integrated with decision making circuits in other parts of the brain to make that plan to go through the city. So, we want to study exactly the neural circuits that are happening, right in that very moment. Because, again, you know, so much of what we're thinking about in neuroscience was derived from these single neuron, these single electrode recordings. And now that we're starting to see this orchestration of activity, when you are looking at multiple parts of the brain working together, now we think we can see a lot of structure where it looked a lot like noise before.

Henry Standage
I was telling you before that, I've played virtual games, where you put on the headset, and I have a fear of heights, and you go to the top of a building and the game is you just walk off a plank. And like it wasn't as scary as doing that in real life would have been, but it was still scary, it was still completely uncomfortable, despite being in an animated surrounding something that's clearly not real graphics or terrible by any means. But you can certainly tell the difference between real life and an animated Empire State Building setting.

Lyle Muller
I think it's a testament to how far the virtual reality headsets have come. I actually haven't tested any of the new generation of these headsets. But I'm actually really excited to look at those.

Henry Standage
The difference between them and video games is that you're going through it first person rather than third person. And you've just pointed out that we're still able to use some of the same tactics in our brain to cognitively map while looking at somebody through the third person, but once you change it to first person, I'm sure it becomes even more similar what goes on. Right?

Lyle Muller
It shows how flexible our brains are in terms of these mapping strategies and cognitive strategies.

Henry Standage
What relationship does REM play in fear memory?

Lyle Muller
So, we're just starting to ask these questions about what different sleep stages do in different cognitive aspects. One of the things that's emerged over the past couple of years is that non-REM sleep seems to play a really important role in the establishment or consolidation of episodic memory. So that's like the example of camping in the mountains. Whereas REM sleep seems to be really important for the establishment of fear memories. And it's really interesting that we don't really know what's going on, you know, the sleep stages are kind of a mystery to us still, what's the difference between deep slow wave non REM sleep, and this REM sleep where the brain looks like it's almost awake. But one of the things that's really starting to emerge is that fear memories are involved, in this REM sleep episodes, whereas episodic memories are involved in the non-REM episodes,

Henry Standage
When you get an answer, how will that change the way you treat people who are having problems with fear?

Lyle Muller
So, one of the things I'm most excited about is understanding the difference between the consolidation of episodic memory and fear memory. And I think that there may be connections between the two. That's really exciting because we haven't really thought about connections between the different sleep stages before and that is a

whole integrated process. And so that's what we're kind of looking at is, is there a way in which we can think about sleep is this Unified Process instead of just treating one specific aspect of it? Like, for example, Ambien is known to modulate certain aspects of non-REM sleep. Can we come up with new ways to think about sleep as a unified process? And does that lead to new ideas for treatment in the future?

Henry Standage
I think you've made it clear that scary events are the most memorable type of event that we can experience. Does that make us more likely to remember a Halloween from our childhood than a Christmas from our childhood, for example?

Lyle Muller
I think that what we're seeing in neuroscience, or what's emerging in the evidence here is that they're remembered in very different ways. So, they're processed in different ways, not only through circuits like the amygdala in terms of fear memory, more hippocampus, for episodic memories that might be a Christmas that you had as a child. But they're also consolidated in different ways. So, sleep works on a memory from Halloween or scary memory from Halloween differently than a good memory from Christmas. And so, we're starting to really unravel the cognitive processes by which these different types of memories are formed.

Henry Standage
I think most people the first horror movie they watch is the one that messes them up the most. Because as a genre of movies, it's very repetitive and that you can kind of figure out when you're going to get a jump scare. I think it makes a lot of sense that the films would become less memorable as you watch more horror movies. Could a person be clinically traumatized by a scary movie or Halloween prank?

Lyle Muller
One thing that is exciting about neuroscience in the next 10 years is that, like I was talking about looking at the activity of the brain through a straw. You know, if you can only see one small part of the activity, things look a lot like noise. It's hard to explain what's happening when you're only looking at this one violinist. And because of new developments, like the Brain Initiative in the States, which is a 10-year program that was started by President Obama in 2013. There's been this amazingly rapid advance in development of new large-scale technologies for neural recordings. And now we're starting to really see the benefit of that in neuroscience, where we're starting to analyze activity patterns, not from just one brain area at a time, but across multiple brain areas. And during really naturalistic behaviors, where neural circuits are shaping and forming these memories. So that's one thing that I'm really excited about in neuroscience and computational neuroscience, where we're developing the techniques to understand these activity patterns over the next 10 years.

Henry Standage
We'll finish there but that was great Lyle, thanks for your time.

That wraps up the Halloween edition of Western Science Speaks. Thanks again to liana Zanette, Yolanda Hedberg and Lyle Muller, and thanks to you for subscribing sharing and listening. I'm Henry Standage, have a wonderful Halloween, stay safe and we'll see you next time.