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00:06 Sarah Crespi: Welcome to the Science Podcast for July 26, 2019. I'm Sarah Crespi. In this week's show, we start with staff writer, Erik Stokstad. He's here to talk to us about breeding better bees in order to beat the Varroa mite, a pest that's decimated bee colonies around the world. And I talk with Philip Kragel about training an AI to decode the emotional content of images, with the ultimate aim of better understanding how the human visual system takes part in our emotions. And for this month's book segment, Kiki Sanford talks with author, Kate Eichhorn about her book, The End of Forgetting: Growing Up with Social Media.

00:53 SC: Now we have Erik Stokstad. He's a staff writer for Science, and he wrote this week about building a better bee, I guess you would say, breeding better bees, right, Erik?

01:03 Erik Stokstad: That's right.

01:04 SC: What's so wrong with the bees that we have now?

01:06 ES: Oh, they do a great job, Sarah. They are really good at what they do. The common honey bee, domesticated honey bee, that most beekeepers use is calm, doesn't sting much, it's true to the hive, the queen doesn't abandon the hive to go start another colony in your neighbor's chimney. They collect lots of nectar and pollen, great honey producers. They're really good at pollinating blueberries in Maine, almonds in California, some of these high value crops that need a lot of honey bees brought in at the flowering time. They're really impressive, and that's the result of decades, 100 more years of breeding effort.

01:51 SC: The big problem right now is not that they're not performing well or they're not friendly, it's that they are going away in a lot of cases.

02:00 ES: There is a high level of awareness that honey bee colonies faced a lot of challenges. There are a number of reasons why bee colonies will collapse. The number of workers will go down, and eventually, they just don't have enough to keep the system functioning, and so the colony is gone. Everyone's heard about pesticides, pesticides certainly are a stress on bees, declining diversity and number of kinds of flowers. Honey bees need a diverse diet, and so, changes in their habitat, that's also a stress for bees. There are a number of diseases. But the number one problem, the biggest problem for a bee colony is a parasitic mite, called the Varroa mite.

02:45 SC: What makes this Varroa mite so damaging to the colony?

02:50 ES: There's a common way the experts describe this, often they say, "Imagine a rat on your back or...

02:58 SC: Oh!

02:58 ES: Or attached to your thigh," and that gives you an idea of the size of this mite relative to the bee and the amount of damage, just by feeding on the bee, that it causes. Now, imagine that the rat has rabies.

03:13 SC: Oh!

03:13 ES: Well, bees don't get rabies of course, right? But bees do get very serious viral infections. They can just devastate the hive. And the Varroa mite is a reservoir for these viruses, and it, very successfully, passes those viruses onto the bees. That virus causes the developing bees to have deformed wings, so they can't fly. That's a death sentence for the bee and for the colony, if that virus gets out of control.

03:43 SC: This is something that hasn't always been a big pest or a big problem for beekeepers. Where did Varroa come from?

03:51 ES: Some time in the middle of the 20th century, another species of Varroa mite jumped from the Asian honey bee, with whom it had long co-evolved, to the European or Western, the common honey bee. And when it did that, when it had this new host, then it really started to cause problems, and it's spread around the world. And ever since, beekeepers have been struggling to control this mite.

04:21 SC: One thing that you can do to try to rid your colony of the mite is to spray it with certain pesticides.

04:27 ES: Yeah. So this is a kind of pesticide called the miticide. Some of them are quite effective at controlling the mite population.

04:38 SC: But... [chuckle]

04:38 ES: But like any weed killer or insecticide, there's resistance evolving, so several of these pesticides just don't work anymore. The best one still does, but the clock is ticking really for that strategy. Beekeepers really need something else.

05:00 SC: Let's talk about this grooming tactic that the bees have, that then the breeders wanna have, and so they can take care of some of this Varroa mite themselves.

05:10 ES: It's a really wonderful thing that the bees as the species have the behaviors, the ability, the genetics to control the mite themselves. So one way is to get those mites off the adult bees, and bees will... I got it. It makes you itch to see this.

05:31 SC: Yeah.

05:32 ES: But they'll shake vigorously to try and throw the mite off if it hasn't grasped onto them well enough. They'll use their legs or their jaws to try and get the mite off of their abdomen, if the

bee has the genetics for those behaviors. Some bees will just sit there and let the mite crawl over them. It's just, Oh.

05:54 SC: Oh.

05:55 ES: So that's one. Get the mites off the adult bees, the worker bees as they are going about their business in the colony. Now, what the mite wants to do, of course, the mite can only reproduce in the honey bee colony. It has to mate and reproduce there. So these adult mites are looking for the brood cells, where the bees raise their own young. They'll crawl in, and they'll lay their eggs inside. There's a baby bee in there. The bees seal up with wax when the bee larva is metamorphose and starting to metamorphose into an adult bee. The unlucky larvae have mite eggs inside their chamber, and those eggs hatch, and the young mite start to feed on the helpless larva.

06:44 ES: What do you do? Some bees have a behavior, it's called, "Varroa sensitive hygiene." Those bees, when they're monitoring the wax cells, can somehow tell that there's a reproducing mite inside the sealed wax cell, so they go along tapping their antennae trying to detect if there are mites inside the sealed wax cell. If they detect it, then they nibble a little hole, and other bees, which are responsible for keeping the hive clean, will see that little hole, they'll open it up, and they'll pull out the pupae and the mite eggs.

07:21 SC: So these tactics they could work to help the bees rid themselves of Varroa. But how does a beekeeper know or how do researchers looking into this know that it's actually going on, it seems like it's a subtle thing. Is a bee trying to get a mite off? Is a bee biting a little hole in a cell?

07:38 ES: Right. And they're doing all this in the dark. For the grooming behavior, you can take a sample of mites that have fallen out of the colony, the bees have groomed them off, and you can count the number of mites that are on the sticky piece of paper underneath your bee colony. And see how many dead mites are there, and see under a microscope, how many of them are missing their limbs, because those bees really aren't gonna show them any mercy, so they bite their legs off. And you can count how many legs are missing, and how many of the mites are missing legs, and that gives you an idea of how aggressive these bees are at grooming. If you wanna tell how good they are at removing the reproducing mites from the wax cells, to really clamp down on the reproduction of the mites, if you wanna assess that behavior, there are shortcuts, but really sort of the gold standard is to open up the wax cells, add in a certain number of mites so that you know how many mites that colony has got, let the bees do their thing, and then you come back, and you open them up, and you count how many mites are still in the wax cells.

08:49 SC: Oh, so you're just giving them a test.

08:51 ES: Exactly.

08:52 SC: One of the problems with breeding bees trying to select for certain traits is that you don't have a lot of control over who the queen are breeding with, because they do it really, really far from the nest. They go out, what is it, I don't know if it's 10 kilometers or 10 miles and have a breeding party out of the sight of the beekeepers. So what are some of the ways that beekeepers are trying to

control who the queen mates with? You mentioned something in your story about islands?

09:19 ES: Yeah, well you can think of islands, literally. In an island, beekeepers can know and control what other colonies the queens will be mating with. In Switzerland, they use isolated mountain valleys.

09:33 SC: This is a very effortful way to select... You gotta take your queen to an island and other people are taking drones or colonies to the island, and then they mate there.

09:44 ES: It helps to be organized, yes.

[laughter]

09:47 ES: And there are clubs, they have associations, most of them might be amateurs, especially in Europe.

09:53 SC: There's also a picture in this story of artificial insemination. Is that something that's widely practiced by beekeepers?

10:01 ES: It's not that widely practiced. It takes some skill to be able to anesthetize the queen, you put her on a little tube, and you use forceps to guide a pipette with the drone semen. But beekeepers learn how to do it if they're really serious about controlling the genetics of their colonies, that technique's been around for decades. Beekeepers have the tools to overcome the freewheeling mating of the queen.

10:31 SC: They have these behaviors, you want them... So how do we make sure that those behaviors get bred into new colonies?

10:39 ES: Practically, the way you're doing it is with bee breeding, as we talked about earlier. So you're inseminating the queen, or you're using mating stations, so when you do that, you can come up with a queen and a colony that is good at producing mites, it's good at keeping the mites under control. If you really focus on one thing, breeding bees to beat back the mite, then you can't be as choosy about the other qualities of the hive, 'cause you have to pick that colony that was a really good and it might be one in 100. So that means that you can't be picky about how much honey they produce or how calm or aggressive they might be. So one challenge has been that breeders can come up with bees that are really good at mite resistance, but they fall short on these other qualities that beekeepers really want in their bees. So balancing all that out is, well, it's a numbers game, you just have to have enough colonies to select for and you have to do the work to measure all of these traits.

11:48 SC: Is this where whole genome read-outs of bees comes into play?

11:53 ES: Yeah. The vision there is that you could hand bee breeders and beekeepers a shortcut, a way to much more quickly assess whether a colony has the genes for resisting mites, and the genes for making a lot of honey, and the genes for being calm, and the genes for not swarming away out

of the hive. If you find genetic markers for all of those traits, in principle, you could come up with a genetic test. 23AndMe for bees, you download the results that say, "Your bees are good at this and this and this, but not this, so decide if you wanna take the semen from the drones and use it in your breeding program."

12:38 SC: It seems like this effort is really... It's backstabbing if the pesticides stop working against the mites.

12:44 ES: There's that, but beekeeping is very diverse. There are a lot of beekeepers who, they don't like to put chemicals in their hive, because they might be eating or selling the honey and its just that's not something that feels right to them. So having bees that can really have the behaviors to fight that mite themselves, that's a huge help.

13:06 SC: Okay, Eric, thanks so much.

13:07 ES: Hey, good to talk with you Sarah.

13:10 SC: Eric Stokstad is a Staff Writer for Science, you can find a link to his feature at sciencemag.org/podcast. Stay tuned for an interview with Philip Krigel on training in AI to suss out emotional content in images.

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13:29 SC: This week's episode is brought to you in part by KiwiCo. KiwiCo creates super cool hands-on projects for kids that make learning about STEAM fun. With a KiwiCo subscription each month the kid in your life will receive a fun, engaging new project which will help develop their creativity and confidence. The projects are designed to spark tinkering and learning in kids of all ages. All projects inspiration and activities are created by a team of product designers in-house in Mountain View, California, and rigorously tested by kids.

14:03 SC: Every crate includes all the supplies needed for that month's project. Detailed, easy-to-follow instructions and an educational magazine, to learn even more about that crate's theme. KiwiCo inspires kids to see themselves as makers and is on a mission to empower kids, not just to make a project, but to make a difference. KiwiCo is offering Science Magazine podcast listeners, the chance to try them for free. To redeem this offer and to learn more about their projects, for kids of all ages visit kiwico.com/magazine, that's kiwico.com/magazine.

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14:46 SC: Now we have Phillip Krigel, he's gonna talk about his Science Advances paper, that looks at training an AI or a neural net to recognize the emotional content of images. And how using a neural net like this and comparing it to activity in the human brain can help us get a better handle on how emotions work, in general. Hi Phillip.

15:09 Philip Krigel: Hi.

15:10 SC: Why is it useful to have a neural network model that can discriminate emotional content in images?

15:17 PK: So scientists often assume that emotion's the product of psychological processes like appraisals or construction, these mental events that are more than just sensory inputs.

15:29 SC: Yeah.

15:29 PK: And so, this model enables us to say, "Well how much information about emotion is contained just in the visual input alone."

15:36 SC: What can you do when you know that, what does that get you?

15:40 PK: Well, so if we have a model of how visual inputs relate to different emotions, we can map that onto the brain to understand what portions of the brain are processing this information, to see which neural pathways are involved and to identify potentially causal mechanisms and targets for manipulating different brain areas to see if we can disrupt emotional processing.

16:03 SC: Can you walk me through these different types of emotions?

16:06 PK: Right. So there are many components of what scientists would call emotional responses. And what these come from really are different measurement modalities. There's a lot of research looking at facial expressions, and scientists have argued that whether or not there's a set of facial expressions that can be universally recognized and labeled as different emotion categories, that could be considered evidence for different emotions. So that's one component of emotional responses.

16:31 PK: Another is action tendencies, where if you see something, and a good example is disgust. You know, if you walk into a restroom... Spoiler, a warning here, you walk into a restroom, you see a soiled toilet. You're gonna respond in a certain way. You're gonna have that... That's an action tendency, right? And so, other components include peripheral physiological responding, which is like how sweaty, how heavy your breathing is. How increased your heart rate is, and things like that. So there are multiple components of emotion. Feelings and how we experience things and label events as discreet events is one component of that, and a lot of psychology often focuses on that. But I think specifying computational models that really just focus on the inputs and the outputs. But we can focus on these models and make them more objective and quantifiable, as opposed to being purely subjective, because what may elicit disgust for one person and they may report feeling disgusted, may or may not for someone else. And it can be hard to objectively model what exactly about that person made that come about?

17:34 SC: So why do you expect emotional content to be tied up with a visual system?

17:42 PK: So one of the core assumptions of these theories of emotion is that there are linkages between the environment and these different types of emotional behaviors. And so if there is a

causal link there, ultimately, it should be processed through sensory pathways in the visual system. In humans is one of the largest, and we have a lot of information there that we can link to other systems. And so, ultimately, it's a core assumption of many different theories that sensory systems should be involved in processing emotion.

18:11 SC: Okay. So you went to look for evidence of this by training a neural network. Can you talk about what you trained it to do?

18:19 PK: So when we developed this neural network, we didn't wanna start entirely from scratch, so we took a neural network model that was developed to identify different classes of objects, a network for detecting different types of emotional situations shouldn't be entirely different. So what we did is we took that Architecture for identifying objects, which has been shown to map on to the human visual system in an interesting and straightforward way, where earlier layers of the neural net map onto earlier regions in the visual system. So we can take a large section of this neural network model and keep it fixed. And then we can take the higher levels of this neural network closer to the output of the network which you might think of it as more closely related to higher order thinking, and we can map those on the different types of emotional situations instead of different types of objects.

19:06 SC: So where did you get the training materials for this?

19:09 PK: Very recently, in the last two or so years, a paper came out by Kallen and [19:14] ____ and they've been doing research on human responses to different types of stimuli, and which stimuli evoke different types of emotional responses. And they developed a very large stimulus set of video clips. These were pooled from online sources, and they have thousands of videos which we pooled, where we can extract frames from those video clips and use those to train this neural net model.

19:35 SC: You've already tested the set against humans, they've scored their emotional responses then you feed the set and the emotional responses into the neural net?

19:44 PK: Exactly.

19:44 SC: Okay. And so how did the neural net do with this set?

19:48 PK: In identifying which emotion of 20 different emotion categories an image from these video clips might belong to, we could identify 11 distinct clusters of emotions that were distinct from one another. So as an example, one of the clusters comprised images that were labeled by humans as being examples of adoration or amusement or joy, and our model could detect those and label those pretty accurately. So in a 20 way classification, the overall accuracy was around 23% which isn't clearly not near ceiling, but it's well above chance. So I think this is a great sort of proof of concept that machine learning really can link even just sensory features to different types of emotions.

20:30 SC: But don't humans have extra clues because they're watching video instead of looking at stills, they have sound and motion?

20:36 PK: Exactly. So that's one key assumption that's limiting the complexity of our model but also could be expanded upon, where our model just assumes every image is relatively independent and that there's nothing to be learned about context or dynamics. And that's clearly a limiting assumption and something we're looking to build on in the future. One little area I was exploring was applying this model to video clips that have sound, and I've used in past research, and one of them is a clip from... I'm not sure if you're familiar with it, but from The Shining, where it's got the little boy, the main character, walking down the hall, he's playing with toys and he's got a very cute looking Apollo sweater on. And that on its own is an adorable scene, and I'm using that... There's this kid that's playing, but it's got terrifying music playing in the background, and if you know about the context of that scene, you know that that's not the emotional response that should occur, is that you shouldn't be amused to that.

21:26 SC: Yeah, I was actually thinking about how novelty and surprise were difficult for the system to parse, and that doesn't surprise me because that is... Literally requires context, right? You need to know what is normal in order to know what is surprising.

21:43 PK: Yeah, exactly, I think it's just interesting. And that's I think demonstrates that limitation of this model is a good way of showing what could be improved and how these more computational explicit approaches, if we add recurrent layers in this model, we could learn, have the model learn about context and model-dynamics and maybe it would do better at surprise, and it could do better on those sets of videos. And so, using these approaches really makes these problems more explicit, more obvious and points the way towards future research.

22:12 SC: Well, let's turn to the brain part of the study. You also tried to look at the brain activity of people looking at a set of images, and then showed those same images to the neural net. Can you talk about what you were looking for and how those two different systems corresponded with each other?

22:33 PK: Right. So the idea of the imaging component of this study was to see if a neural network model trained on just video clips, if something learned by that model is consistent with how information is coded in human brain activity. And so it's important to note here that the neural net model, we didn't design it so it would fit with human neural measurement or FMRI measurement. But one way to test if this model, any aspect of it, the way the information is coded or how emotions might be represented in the model, that's consistent with human brain representation, is by finding associations between artificial neurons in this neural net model and measures of brain activity in humans. So to do that, we showed the neural net model and human participants the same set of images, and tried to find simple associations between patterns of brain activity and patterns of outputs from the neural network model.

23:24 SC: And what did you see when you made comparisons between those two things?

23:28 PK: What we found most strikingly was that distributed patterns of activity that span the entire occipital lobe are most consistent with the output of this neural network model.

23:39 SC: And occipital is where a majority of visual processing takes place?

23:43 PK: Right. Yeah, the back of the brain.

23:45 SC: We've been talking about the visual system and the region of the brain responsible for visual processing, but aren't there regions in the brain that we think of as being key to emotional processing? So how do those things both do emotional work?

24:01 PK: One brain region that's particularly well known and related to emotion is the amygdala. And it may be surprising that we didn't find that this model was best mapped onto the amygdala, but this shows really the strength of our modeling approach that we wanted a model of how visual inputs are related to different emotions. And so, we can constrain the type of information that we're studying with FMRI by using these computational approaches. You could think of it as applying a filter to our models so that we're only interested in visual information and visual content that's really very quite low level compared to multiple higher order processing, or higher cognitive processing.

24:39 SC: Now that you have this model, what can you do?

24:42 PK: It's nice to think of these neural network models in the context of emotion research as a more explicit way of saying, "Here's a series of transformations, where I can go from an image to something that's related to human feelings, or what humans might report experiencing in terms of emotions." Other theories of emotions, psychological theories of emotion, have terms like appraisal or construction or evaluation. They're conceptually meaningful and they guide research, but they're not so explicit in saying, "Here's a set of mathematical operations where we can go from point A to point B, and we can compare how well this model works to other models that we could specify." So this is making emotion research perhaps more quantifiable and more objective than past accounts.

25:25 SC: Why do you think this is an interesting area to study? And then particularly do you use artificial intelligence to do it?

25:31 PK: I think the lay person when they talk about emotion, they tend to lump all of these different sources of experience together, whether it's physiology, bodily reactions, action tendencies or just probably what's most dominant in their language about it is how they feel. This neural network model doesn't have feelings, it may produce predictions that don't tend to be that intuitive all the time. It may work very well on examples that sort of fit our culture says these emotion term should be used, but it's a more quantitative approach that can lead to new predictions about how emotional behavior might occur in ways that are less intuitive than focusing on feelings, and introspection.

26:09 SC: Thank you so much for talking with me.

26:11 PK: Thanks so much, yeah.

26:12 SC: Thank you. Philip Kragel is a post-doctoral fellow at the Institute of Cognitive Science at the University of Colorado Boulder. You can find a link to his science advances paper at

sciencemag.org/podcasts. Don't forget to stick around for this month's book segment with Kate Eichhorn. She discusses her book The End Of Forgetting: Growing Up With Social Media, with host Kiki Sanford.

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26:40 Kiki Sanford: Welcome to the book segment of the Science Podcast. I'm Dr. Kiki Sanford, and this month, I had the pleasure of speaking with Dr. Kate Eichhorn, an associate professor of culture and media and director and departmental advisor for both culture and media at the New School in New York about her latest book called, The End of Forgetting: Growing up with Social Media. It takes a look at how the persistence of information on the internet endangers, not only the innocence of childhood, but also our identities as adults. Thank you for joining me and for doing this interview with me today.

27:17 Kate Eichhorn: Thank you.

27:17 KS: Can you give me a brief summary of the main idea of your book and how you came to write about it?

27:24 KE: Early on, since the mid-1990s, I've been doing research that broadly looks at the impact of new digital technologies, specifically on children and youth. I've also spent much of the last 20 years writing about archives and archiving. And so, this book brings together these two long-standing interests. A few years ago, I asked myself, "What comes after archiving?" And the first thing that popped into my head was forgetting. But if you talk to any archivist, they'll tell you that there's no archive without forgetting, that selection that the elimination of certain kinds of materials is what makes any archive functional.

28:00 KE: This book was really a continuation of my exploration of questions of archiving, and more broadly, media and memory. As someone who grew up in an era when you could re-invent yourself, you could leave home, reimagine who you were, try on different kinds of identities, try out different experiences with little risk, I felt that it would be quite horrifying to grow up right now. So the questions I was exploring is really what's at stake? What does it mean to have your childhood excessively documented and playing on an endless loop that you can't fully control? And where the project led me were to all these broader questions about the extent to which this is driven primarily by profit.

28:45 KS: Was coming to that realization significant for you?

28:49 KE: As a media studies scholar, I became increasingly hyper-aware of the fact that if there's one thing that's changed over the last 25 years, it's the ability of private enterprises to profit from our private lives, our every day, quotidian interactions. Historically, questions of labor were questions that we primarily talked about in relation to work that happened outside the home, with the exception that, okay, discussions about domestic labor. But now, those questions of profit and labor have seeped into everything that happens in the private-sphere, including interactions between children when they're sitting on their bed talking to a friend. That is a really profound shift.

29:38 KS: Are we at this point where the advancement of the technology is really posing a challenge for this kind of research, for the kind of work that you do?

29:47 KE: When I first started trying to understand things like virtual communities back in 1995, or '96, or '97, everything was moving so quickly, it was impossible to really do research on these emerging communities. It's easier to study what's happening now than it was 20 years ago, because we have more data, because certain kinds of patterns and trends have started to appear. We know that privacy is a huge issue. We know that questions of data mining are major concerns for many people. The kinds of questions that we were asking about children and youth also have changed radically since the emergence of the internet. And a lot of that has to do with the fact that the kinds of questions that we face now didn't exist in '95, or '96, or even 2000.

30:40 KS: Can you give some examples about how the questions about youth have changed and what we're seeing that is so different now?

30:47 KE: Our experience of the web now and our experience with the web 20 years ago are two very different things, because it was not yet a monetized space. It wasn't a space that was primarily driven by private enterprise, as it is now. Historically, children and youth had limited ability to document their own lives, and certainly limited ability to circulate images of their own lives. They might have had access to a Brownie camera or a Polaroid in the 60s and 70s, but it was still expensive to develop those photographs. Children and youth now have unprecedented access to the technologies required to document and circulate images of their own lives, because people can make money off that content. So that is a profound paradigm shift, not necessarily one that even people studying the web in the mid-90s, could have fully anticipated arriving by this time.

31:41 KE: In the book, I talk about the fact that, in the early 2000s, there was a time when first Facebook emerges, sites like Flickr, the photo sharing site emerges, very shortly thereafter they start to encourage people to tag those photographs. And that seemed like a very innocuous practice at first, and of course what it did was it laid the foundation for the emergence of facial recognition technologies. I think it's also very important for people to understand that it's kind of innocuous practices like tagging your friend or your aunt in photographs on a very large scale can be used to create technologies that will profoundly impact your lives. Finding ways to communicate that to a 12-year-old or a 14-year-old is a bit more challenging than one might think. And even many adults I think don't fully appreciate or understand how their quotidian every day online practices are part of this kind of broader machine.

32:40 KS: It brings me back to the idea behind your book of forgetting. So can you talk a bit about how the internet no longer lets us forget?

32:50 KE: Historically, people have thought about forgetting as the enemy of memory, as opposed to thinking about forgetting as something that is necessary, something that makes one's life more manageable, but also enables us to manage our social identities. There are many studies that have been done in the back, that people don't remember everything, but they particularly don't remember things that might harm or compromise their social identity. And so as we lose control of the ability

to forget and have certain parts of our lives forgotten, our ability to manage our social identities faces new challenges.

33:28 KE: What we've lost control of already is our ability to control what comes from the past into the present. You might argue that in the past, someone could have taken out an embarrassing high school year book and shared those images with people. What's changed is, there is much more documentation than there was in the past. It's much easier to reproduce and circulate those images, and I feel like this has many implications, but that some people have more to lose than others.

33:57 KS: I am sure most adults today who grew up before the age of social media have experiences in their life that they are glad are not resurfacing because social media was not a thing. Can we contrast this to the child actors who paparazzi maybe follow them for the rest of their lives.

34:18 KE: Like we use child actors as really our only comparison from the past, because they're haunted by these images of their youth that keep recirculating. Theoretically this will become an increasingly common experience, because so many people growing up now have thousands of images of themselves and videos online, in circulation, by the time they graduated from high school. Moving forward, it seems likely that just as we've been able to successfully profit off of remembering, that we'll start to profit off of forgetting. And that people who can afford to have certain incriminating information deleted will be able to purchase that service and other people won't, that already exist to a certain extent. Very wealthy parents do hire people to manage their children's "digital footprint."

35:07 KS: This brings me to the issue of the data and how it is used by these various companies, how is the way the companies actually use our data changing the way that we interact with each other? Is it affecting that?

35:22 KE: Profoundly. One of the arguments that I make in the book is that if we go back to, let's say, the 1990s or 1980s, when I was growing up, teens loitered in public places, they might have hung out at the mall, but they weren't necessarily purchasing anything, and so they were considered a nuisance. Now, teens just hanging out online are creating valuable data for private companies. So we've been able to profit from something that for decades, maybe centuries was considered a societal problem and that has profoundly changed how teens interact? It means that they have free access to many technologies and technological platforms, because they're basically engaged in digital labor, when they're hanging out with their friends, 'cause they're generating content that then is mined and sold.

36:14 KS: You wrote this book a couple of years ago, have you seen anything change in the last couple of years? Especially with respect to Facebook and the news about its data sharing practices.

36:27 KE: People are definitely more aware now than they were two years ago about how their data is being used and abused on platforms such as Facebook. I think that there is a broader awareness that maybe it's not a great idea to share all your images of your infant or toddler online. So I think people's practices around image sharing in particular are maybe a bit more cautious. On the other hand, it's not just these platforms, social media platforms where people are sharing

information, there are so many less visible ways in which data is being collected on children and youth and shared, and people are making profit off that data, that are not even visible. So I do think there's a broader awareness but during that time, new technologies have emerged that maybe we're not thinking about yet.

37:19 KS: As we're thinking about moving into the future with this rapidly changing technology, there's always a new app, a new platform and even a new way that youth are using the existing platforms that are there. How do you think reflecting on the media is going to help change that relationship?

37:40 KE: I'm always surprised when I talk to students in my introductory media studies or cultural students courses, so these students are in their first or second year of university, maybe they're 18, 19 years old. Many of them know a lot about different social media platforms and understand virtually nothing about the content that they're generating, the data that is being collected and mined based on their everyday lives, they're sometimes quite shocked to find out the extent to which they've been participating in these industries since they were small children. And so it's really important for young people to not have restricted access to these tools, but to understand something about the uncompensated labor they're engaging in when they're using these platforms. There's lots of discussions that we need to have that could probably happen before they arrive on university campuses that would be useful.

38:37 KS: Thank you for joining me for this interview with Dr. Kate Eichhorn about her book, The End of Forgetting: Growing up with Social Media. I'm Dr. Kiki Sanford and I hope that you'll join us again next month for a peak between the pages of another science book.

[music]

38:53 SC: And that concludes this edition of the Science Podcast. If you have any comments or suggestions for the show, write to us at sciencepodcast@aaas.org. You can subscribe to the show on iTunes, Stitcher, many other places or you can listen on the Science website that's sciencemag.org/podcasts. There you'll also find links to the research and news discussed in the episode. To place an ad on the podcast contact midroll.com. The show was produced by Sarah Crespi and edited by Podigy. Jeffrey Cook composed the music. On behalf of Science magazine and its publisher AAAS, thanks for joining us.