BEYOND RECOGNITION

BY ALEXANDER GELFAND

Those suffering from prosopagnosia live in a bewildering world, inhabited by people whose faces are impossible to tell apart. Profoundly mysterious and virtually untreatable, the disease is leading neuroscience into uncharted nooks of the brain.

HEATHER SELLERS IS A TERRIFIC CONVERSATIONALIST.

She's attentive, she's engaging, and she makes constant eye contact. Within moments of meeting her, you'll feel as if you've known her for years.

Just don't be surprised if, the next time you see her, she has no idea who you are.

That was the case when Sellers came to The Rockefeller University in March to meet with Winrich Freiwald, head of the Laboratory of Neural Systems; and Christina Pressl, a physician who does clinical research in Freiwald's lab.

Sellers, a professor of English at the University of Southern Florida, had last seen Freiwald and Pressl just a few months earlier while speaking at a Rockefeller event. But while she recognized Freiwald on sight, she drew a complete blank on Pressl. "You have to tell me who you are," Sellers said, as Pressl wrapped her in a hug.

Sellers' vision is fine, and she is hardly an amnesiac. As a writer—she has published several books, including the memoir *You Don't Look Like Anyone I Know*—she

Illustration by Yuko Shimizu

demonstrates tremendous recall, painting scenes from her childhood replete with physical detail.

She is, however, severely face blind.

The technical term for her condition is prosopagnosia, from the Greek for "face" (*prosop*) and "lack of knowledge" (*agnosia*); and it is a disorder that Freiwald and Pressl are investigating on a variety of levels, and for a variety of purposes.

For one thing, figuring out why some people cannot recognize faces could lead to better tools for diagnosing and treating prosopagnosia, and to a more detailed picture of visual processing at large. But it could also result in a deeper understanding of how the brain organizes information and responds to stimuli in general—an understanding that could someday help explain and address numerous disorders of the mind.

Winrich Freiwald

Face recognition is an ideal model for understanding the brain's social, emotional, mnemonic, and cognitive functions.

NOTWITHSTANDING THE RATHER blunt literal meaning of the term, people who suffer from face blindness can in fact see faces; they just can't recognize them. Sellers, for example, does not see an amorphous blur between your ears while she is talking to you. But if she turns away and closes her eyes, she cannot form a coherent image of your face in her mind's eye. "I can't remember it at all, even for a second," she says. For Sellers, there is no such thing as a familiar face; not even her own, reflected in a mirror.

This does not mean, however, that Sellers is incapable of recognizing *people*. Like many developmental prosopagnosics—that is to say, individuals who were born with the condition, as opposed to those who acquired it through damage to the brain's temporal lobe—she has found ways of compensating. For example, she has a knack for identifying people by the way they walk; and the more non-facial clues she has, the better she does.

When Sellers recognized Freiwald in March, for instance, he was in his office—a clear contextual giveaway. He was also, as always, extremely tall. "Outliers are easy," Sellers says.

Pressl, alas, was in a room with five or six other women; and if picking a single face out of a crowd can be tough when you aren't prosopagnosic, imagine how difficult it must be when you are. To make matters worse—for Sellers, if not for her—Pressl has a highly symmetrical face. And as Sellers explains, their very lack of disproportion makes symmetrical faces even harder to place.

According to Brad Duchaine, a psychologist at Dartmouth who diagnosed Sellers, prosopagnosia comes in a variety of flavors. While all prosopagnosics have difficulty recognizing faces, some also have trouble with related tasks, such as identifying facial expressions. And the condition occurs with different degrees of severity, pointing toward what Freiwald calls a "face-blindness spectrum."

Prosopagnosia was once thought to be exceedingly rare, and almost always caused by brain damage. Today, however, experts believe that as many of two percent of the population, or six million people in the United States alone, may be face blind, with most cases being developmental. And the condition has profound consequences both for prosopagnosics themselves and for society at large.

Sellers emphasizes that even a mild case of face blindness can be socially devastating. In her memoir, she describes how her own extreme version made dating impossible, caused her to constantly mistake her ex-husband for a stranger, and led people she had known for years to assume she hated them because she was forever snubbing them. By the time she was diagnosed in her mid-thirties, she was so used to hiding her disability—and so ashamed of it—that it took her more than a year to come out publicly as a prosopagnosic. Having conquered her own fears, she now strives to help others, raising awareness of the condition and sharing coping strategies with fellow sufferers.

Freiwald, meanwhile, notes the implications for the criminal justice system. The London Metropolitan Police famously use so-called super recognizers, who are as adept at recognizing faces as prosopagnosics are not, to identify suspects on surveillance videos.

In this country, on the other hand, eyewitness misidentification accounts for more than 70 percent of the convictions overturned by DNA evidence. It's a statistic that suggests witnesses, not to mention police officers and border control agents, ought to have their face-recognition abilities evaluated as a matter of course.

JACOB PRITCHARD

At the very least, Freiwald says, detectives and prosecutors could attend more carefully to the science of facial recognition when relying on eyewitness identification, a point made in a 2014 report by the National Academy of Sciences to which he contributed.

Meanwhile, that science continues to evolve. Duchaine explains that while researchers have parsed the general features and the overall sequence of events involved in normal face recognition, many of the details remain a mystery. And without a comprehensive and detailed understanding of how face recognition occurs under ordinary circumstances, face blindness remains hard to diagnose and difficult to treat.

Which is partly why the work that Freiwald and Pressl are undertaking is so crucial.

FACE BLINDNESS WAS first identified in the 19th century, but its neurological underpinnings didn't begin to emerge until much later.

In the 1980s, for example, research on monkeys showed that some of the neurons involved in visual processing responded only when the monkeys saw faces, as opposed to other kinds of objects (cars, spoons, oranges). And in the late 1990s, MIT neuroscientist Nancy Kanwisher used functional magnetic resonance imaging (fMRI) to demonstrate that a specific region of the human brain becomes active only in response to faces, as well.

It was Freiwald who successfully merged both lines of investigation a decade later, while working as a postdoc in Kanwisher's lab. He and his collaborator, Doris Tsao, who is now at Caltech, combined fMRI studies with recordings of individual neurons in the brains of macaques. These experiments revealed that a collection of small face-sensitive areas distributed throughout the temporal lobe—areas that he and Tsao dubbed "face patches"—were composed almost entirely of face-selective cells.

Since coming to Rockefeller in 2009, Freiwald has continued to combine imaging studies with recordings of individual cells to explore the brain's face-processing mechanisms.

His team has demonstrated that different face cells and patches perform different face-recognition tasks. Some cells, for example, respond only to faces seen in profile, while others specialize in detecting the differences in contrast that set the eyes apart from the forehead, nose, and cheeks. (Watching footage of a face cell in action is surreal: the cell's electrical activity is represented

Faces are special

The regions in the brain that respond to the sight of a face—called face patches—are separate from those tasked with recognizing other objects. Each face patch contributes to a different aspect of face perception, like responding to particular features or interpreting facial expressions.

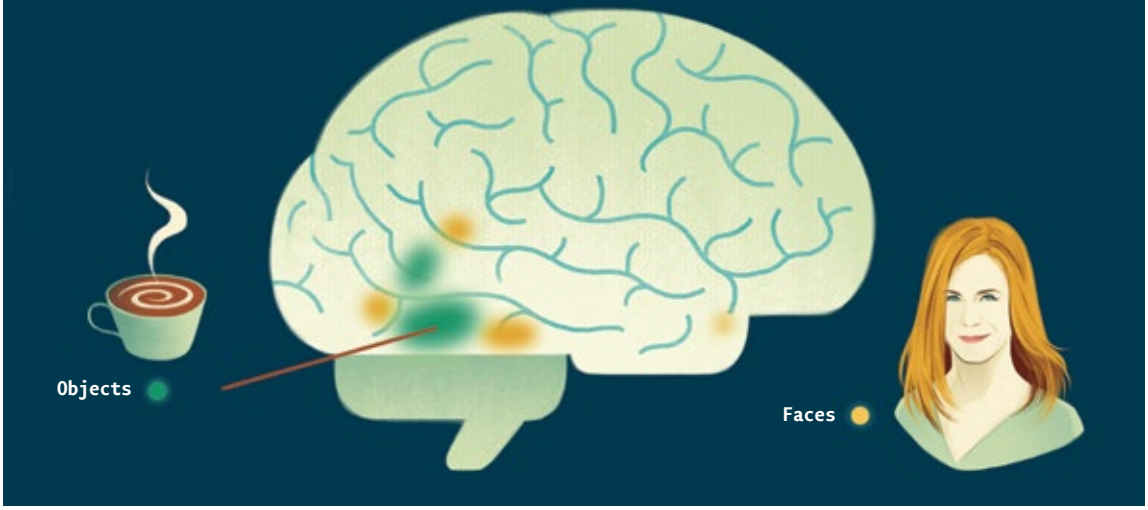

Illustration by Jasu Hu

sonically by a kind of crackling static; and while it seems incredible that a single neuron could be so discriminating as to squawk only when presented with a face in profile, the video does not lie.)

In addition, Freiwald and his colleagues recently discovered that some face patches respond to facial motion, while others react most strongly when shown faces and bodies together. They have also shown that most face patches communicate with one another, passing information from one part of the face-recognition network to the next like a neural bucket brigade. For familiar faces, the end result carries with it a wallop of information drawn from memory, as our brains conclude that we are looking at not just any visage, but at that of a particular individual with a specific identity (your mom, your dad, your boss). The appropriate reaction can then follow.

Pressl, who trained as a radiologist, draws on these insights to investigate face recognition in people.

With help from NYU's Comprehensive Epilepsy Center, she is scanning the brains and testing the face recognition skills of individuals with temporal lobe epilepsy. By working with patients before and after they undergo brain surgery, Pressl is teasing out the effects of both the disease and its treatment on facial recognition, thereby gaining a deeper understanding of prosopagnosia as well.

She is also analyzing millions of patient records in hopes of arriving at a more accurate estimate of the number of prosopagnosics in the United States. And she is developing a shorter and hopefully more effective test for the condition, which can be surprisingly difficult to diagnose—in part because many doctors still aren't familiar with the disorder ("I did not learn about prosopagnosia in medical school," Pressl admits), and in part because there is no gold standard for identifying it. The first neurologist whom Sellers saw, for example, dismissed the idea that she could have such a supposedly rare ailment. And the second gave her a test that someone suffering from acquired prosopagnosia probably would have failed, but which she, thanks to her battery of coping skills, managed to pass.

By illuminating the neural mechanisms underlying face perception, Freiwald and Pressl hope to contribute to the development of new and better treatments. Current therapies for face blindness are limited to cognitive training exercises that require daily practice, offer

Christina Pressl conducts clinical work in the Freiwald lab.

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only modest benefits, and fade with time—hardly an appealing combination. "It's like going to the gym, and it doesn't stick. I'm not doing it," says Sellers.

Their investigations also promise to shed light on the basic organization of the brain itself, revealing how information moves through neural networks, for example, and how separate systems like visual perception, memory, and attention are integrated.

Yet the implications of their research could extend even further.

Face recognition plays a profound role in social interaction. The moment we set eyes on someone, we immediately begin assessing their attributes—their attentiveness, their mood, even their trustworthiness—based on their facial gestures and expressions, and we calibrate our responses accordingly.

What's more, the face-processing network and the various neural systems it touches upon, like memory and attention, all operate automatically: we return a smile, follow a person's gaze, infer their intent, and call up their personal file from our memory banks without any conscious thought. Yet unlike many of those systems, face recognition is localized in specific areas of the brain and is relatively easy to probe, making it an ideal model for understanding social, emotional, mnemonic, and cognitive function.

As a result, a thorough grasp of face recognition—and face blindness—could help scientists understand a whole range of disorders characterized by atypical social or emotional responses, including autism and some forms of mental illness.

"This really is an amazing opportunity to get deep into the brain mechanisms of our social and emotional minds," Freiwald says.

To capitalize on that opportunity, however, researchers must first figure out precisely how normal face recognition works, and how the process goes awry in prosopagnosia. And that, in turn, will require a solid grasp of the genetic basis of face blindness—something that scientists currently lack.

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According to Duchaine, roughly half of all developmental prosopagnosics report having family members who also have difficulty recognizing faces. Yet at present, researchers have no idea which genes might be responsible for causing the condition.

Moreover, because the facial-recognition network comprises many interconnected areas in the brain, the opportunities for disruption—for abnormalities in one face patch or another, or for faulty connections between patches—are vast. Any number of genes, acting independently or in concert, could potentially lead to the neural impairments that ultimately give rise to prosopagnosia in a particular individual.

To begin to explore the genetics, Freiwald, Pressl, and Duchaine are therefore collaborating on a study in which developmental prosopagnosics will have their genomes sequenced and their face-recognition abilities tested. The resulting data will ultimately be compared with that of a larger pool of unaffected people. This should allow the team to ferret out the specific genetic variants associated with face blindness.

That kind of information could eventually allow scientists to tell someone like Sellers precisely which genes and neural processes are responsible for her condition. And it would bring researchers that much closer to developing better tests and therapies for face blindness.

"That," Freiwald says, "would be an amazing level of understanding." ◎

YUKO SHIMIZU

About the artist

Illustrator **Yuko Shimizu** *on seeing and drawing faces*

Although Shimizu was born with prosopagnosia, it wasn't until way into adulthood that she discovered there was a name for her condition.

Growing up in Japan, she played Fuku Warai ("Lucky Laugh") with her family around each New Year: akin to pin-the-tail-on-the-donkey, blindfolded players try to place noses, eyes, and other features on an outline of a face, and comedy ensues. That's still what she thinks of when she tries to explain to people why she probably won't recognize them later: "I can see your face clearly," she says, "but its overall image won't stick." To remember it, she memorizes each feature individually, then pieces together the clues.

From her New York City studio, Shimizu has made art for everything from Pepsi cans and Gap t-shirts to articles in *The New York Times*, *Rolling Stone*, and *The New Yorker*. She often does portraits, but never from memory.

"To draw Brad Pitt, I would need tons of photos taken at different angles," she says. "To me, it would be the same as drawing an apple—a face is just another object drawn from observation."