FEHLER

When Fate Unleashes a Rainbow

by Melissa Gerr

> **Man 1**: (surprised) Oh my God, wait, wait, this is red? Oh my god that's pink? (friend answers) yeah…
>
> **Man 2**: Is this purple?
> **Woman**: Yes!
> **Man 2**: What the f**k? Holy s**t! Oh my God…
>
> **Girl**: Oh my God, like this looks pretty similar – but this pink!
> **Mother**: And so Mindy puts on her glasses,
> **Father**: It's like the Wizard of Oz!
> **Daughter**: [*emotional*] Holy Crap! Oh my gosh! [*crying*]

Melissa Gerr: The internet is full of videos documenting reactions like these, and honestly – it's addictive, I could watch them for hours. They are the reactions from people who are seeing color through EnChroma glasses for the first time. EnChroma glasses enable people who are color blind – or more accurately, who have color vision deficiency – to see the world in full color. And it can be mind-blowing.

> **Man 3**: Whoa, that is not what I expected everything to look like. Everything is a lot brighter than I thought it was.
> **Woman**: Anything seem different?
> **Man 4**: (laughing in disbelief) Your bag – it's SUPER green!
>
> **Man 5**: Oh my God your hair's purple! [*laughing*]. Oh my God!

[Music]

Melissa Gerr: People with color vision deficiency pretty much spend their lives compensating – sometimes without even knowing it. It usually takes some kind of glaring mistake to disclose that a person doesn't see in a full color spectrum – like if an elementary school kid draws a purple tree instead of a green one. It seems almost fitting then, that the science behind EnChroma glasses was also discovered by mistake – but there was a lot of experimenting that led up to that happy accident. Donald McPherson, a glass scientist, an artist, and co-founder and chief scientist at EnChroma eyewear in Berkeley, California, tells the story:

Donald McPherson: You know I think there's a, Pasteur who said, "In the field of observation, chance only favors the mind which was prepared." …so I don't want to say that it was … it was… I was just in the right place with the education and how it happened is interesting because it ties back to my laser safety eyewear. So this company in Germany, and also the laser companies who are buying their glasses some of which were local told me that the laser surgeons were 'borrowing' the laser safety eyewear, in other words they were taking them home. And the reason they liked these glasses so much for surgery is that it helps them see what they're doing better. Not only did it block the laser wavelength, but it also helped differentiate tissue.

Melissa Gerr: Quick explanation here: those protective glasses McPherson designed – the filters were based on rare earth ions and glass and they have a very spiky spectral profile. That means that one of the spikes REALLY absorbed at the green laser wavelength – which was great for the surgeons, and another spike absorbed in the yellow wavelength. And it turned out that spike in the yellow caused a huge color enhancement, especially for greens and reds … The inability to distinguish between green and red is one of the most common types of color vision deficiency. We'll get more into what causes color vision deficiency later, but for now, listen to the rest of this story!

Donald McPherson: So the surgeons were reporting back that they were using the glasses as sunglasses. And they really loved them. So I naturally put on a pair of the sunglasses and I started wearing them and I was like this is really interesting, the world is highly saturated. Anything with chlorophyll in it looked really green, and reds and purples looked very intense, pinks were out of this world and I really liked them and I happen to be an avid Ultimate Frisbee player, and I was at a tournament in Santa Cruz, California, and my friend on the team borrowed my sunglasses and he said these are fantastic! And then he said, dude – because you know we're Frisbee players – he said, dude I can see the cones. And I was like, what are you talking about? And he said I'm colorblind and I've never seen the orange cones on the field. And I said, what do they look like and he said, fluorescent. And then I said what color is the grass – green – and I said what do they look like without the glasses on, and he said they're the same color, they're brown. And so of course because of my, my deep training in never passing up an opportunity that's an accident, I researched it.

Melissa Gerr: At first, McPherson didn't exactly understand how the glasses worked – but he knew they were doing something. After six months of research and consulting vision scientists, he submitted a grant and received funding from the National Institutes of Health. That allowed him to do clinical studies and optimize the technology. Eventually, EnChroma was born.

Donald McPherson: That was back in 2010. And here it is, ten years later, we still have the best product out there and it works and we have the at this point tens of thousands of testimonials and recently we've had some very good science done that supports our contention of not only that the glasses work but how they work and then some very new stuff, that there is a learning or training effect with the glasses.

Melissa Gerr: To the eye? A learning or training…it trains your eye?
Donald McPherson: Trains the brain.
Melissa Gerr: Trains the brain.
Donald McPherson: This has huge implications for early education. Because at that stage the brain is still plastic and it's learning colors.

Melissa Gerr: About 15 million people in the U.S. and more than 300 million people worldwide have some type of color vision deficiency. It's found more often in men than women and it's usually genetic. So, here's color vision deficiency explained, in really super simple terms. There are three color-sensing cones in the eye – one for red, one for green, one for blue. Color sensation is processed – and experienced – when light reflects off of an object and enters the eye and the cones selectively respond to the signal. The signals are then sent to the brain where a series of visual processing events happen – to detect the color. A person with color vision deficiency has color-sensing cones that are too close together or that overlap, which ends up scrambling the signal to the brain, so the brain – and therefore the person – can't detect a color accurately.

> **Donald McPherson**: So what our filter does, is it selectively removes critical lengths of light to help reestablish a normal capture of photons, because you have to understand, the only thing that's wrong with someone who is colorblind is they have this shift in the photo pigment,
> **Melissa Gerr**: In the cones, the overlapping or almost overlapping.
> **Donald McPherson**: Yes, it's just that excess overlap. If you can restore something like the correct signal that's going to the brain, all those mechanisms that have evolved to detect color and process it, those are all intact. They have just for the most part, lain dormant.
> **Melissa Gerr**: I have seen the videos, which are all over the Internet, of people putting these, young people, older people, putting these glasses on for the first time why do you think and it's usually very emotional I mean sometimes very tearful, why do you think it's so emotional for people?
> **Donald McPherson**: It's a lot of sensation all at once. Whereas if you were a child you have maybe the first six years of your life to develop all of your color sense and this is happening very quickly in 5 or 10 or 15 minutes they're seeing all of these new things, and it's a lot of information that happens in a very short period of time. And I also feel that it it's moving because color is such a integral part of reality for humans. I mean everything is colored, and that in itself – to be able to see the full range of that or something approaching the full range of colors – is very emotional. And I also think that there's probably a bit of bitter sweetness that they haven't seen these things their whole life and there's just this sense of overwhelming happiness and gratitude but they're able to see it. So there's a lot to it.

Melissa Gerr: There's also a lot to the educational potential for EnChroma glasses. That possibility was not lost on Heather Knutson, a paraprofessional at the Southland School district in Adams, Minnesota. She works primarily with students that have special needs, but, like so many educators, she helps pretty much every student in whatever way she can.

> **Heather Knutson**: So we were in biology class and we had a chart up on the board and the colors that were being used on the chart were red, green, and blue dry erase markers and the student was to use a blue marker for what he was to write and he picked up the green one, and I caught him and I said hey you've got to use the blue one. And he looked around and kind of chuckled at a couple of his friends in class and he kinda looked down and got a sad look on his face and he said, Heather I'm colorblind I can't tell the difference between blue and green. And I felt horrible because I did not know at all – he was not one of my direct students – so it was purely by accident.
> **Melissa Gerr**: And did you have a conversation with him afterwards about it?
> **Heather Knutson**: I did, after class was dismissed and the bell rang I caught him and I said listen I'm really sorry I just didn't know and he said no, that's alright, he said

there's a lot of people that don't know – I've just always kind of dealt with it and he said me, and then he mentioned the names of a couple of the other students. We always have the running joke that we wouldn't we wouldn't know what color the flags were if somebody wouldn't have told us and I said so and so are colorblind too and he said yeah. So I then I asked our administration if it was ok if I asked the other kids – the other students – in our middle school/high school building about their vision. And it came to light that there were several kids.

Melissa Gerr: Knutson discovered there were almost 20 students who had color vision deficiency. There was one student who flunked a machine shop test that used color-coded wires, another who had been drawing rainbows the wrong way. And then she thought of all of those standardized school tests – the colored-coded charts, the highlighted words, the color-coded directions. She had seen the videos online of people trying on EnChroma glasses for the first time, but they didn't really mean much to her until now. So she raised the funds to buy a set of glasses for use at the school. They have a check out system that allows multiple students to have access to glasses whenever they need them. She hopes to expand it throughout the state – she's kind of taken it on as a mission of sorts.

Heather Knutson: For me personally a part of it comes from being a medical-needs mom, the other part of it from in the off-season of Education I am a landscaper, and I cannot possibly even imagine not seeing the colors of the world. I…it, it made me, when this first came to light when it first started – everything I looked at like from morning noon and night for about three weeks all I did all day long was go, what if I could tell what color that was, what if I didn't see that, what if – you know – it was just so many scenarios ran through my head and I went, I need to do something but… like I need to be able to help these kids to be able to enjoy the world the way the rest of us see it and that is with the color. It's kind of a little mind-boggling to wonder how these kids adapted through the years and how strong they must have been and how, how they must have created their own way of learning and adapting through the years, and if there's anything we can do as educators and parents and friends and aunts and uncles to make these kids' lives more fluid – not necessarily easier but more fluid – so that their rate of success is higher, jump on it.

Melissa Gerr: And, in fact, EnChroma has jumped on it. Here again is co-founder and chief scientist Donald McPherson:

Donald McPherson: I was curious, I ran across this paper in which they had done this double blind study, and had vision scientists and psychologists sort of observe classrooms, and they didn't know who was colorblind and the teachers didn't know. And what they found is that kids who were color-blind were treated a little differently, and I remember reading this and this getting very upset about that because I had already heard it from dozens of adults that I would ask them what was your childhood experience like and they would always zero in on the school experience where they had been singled out for coloring something wrong, or just not being able to follow an instruction, and it never crossed the teacher's mind that they were color blind. And in this article they mentioned that in some extreme cases color-blind children had reduced performance and were put into special education programs. And that was just too much for me. So I became very curious about that and I started researching like, well who's doing the testing and I just assumed it was every 50 states in the United States, and it was only eleven. And then they don't do much once they have that information they just, it's just a statistic, it isn't like they have a prosthetic or they

work with the teachers – there's nothing, nothing that's happening. And I'm like, okay, we as a company have to make that part of our mission to find a solution for that.

Melissa Gerr: McPherson said about 80 percent of information in a classroom is visual, and most of that is color-coded. And say, you open up a textbook – the people who can see the color-coding understand it faster. They don't waste extra neural energy – or time – processing the information because they have those extra cues.

Donald McPherson: So we want to level the playing field. We want to have it so that everybody can see the information. So imagine in a classroom you have lighting that creates the same filtering effect. So in that case, if you're color normal, it won't make any difference to you, things might look a little brighter, but if you're color deficient, the colors will be perceptible.
Melissa Gerr: and you can make, you're talking about a whole room, you're talking about so everyone in there could see that.
Donald McPherson: Yes. So you don't really need to know who's color-blind, you don't need to single them out, you just basically modify the lighting system, and everybody's got an equal shot.
Melissa Gerr: And that is something that you were working on or that you have …
Donald McPherson: Yes we will – we have it we have it perfected, we were going to launch it this year and we don't know now with the COVID-19 exactly when it'll get to the marketplace, but it will be quick because we've already worked out all the finer details. And the other thing is that the lighting system augments the glasses. So if you're color-blind and you're a kid and you're sitting at your desk and if you're wearing the indoor glasses they're very mild color and you have the light on your desk you can see everything. They assist each other. So we have a lot of things in the works like that, just creating accessibility through technology.

Melissa Gerr: EnChroma doesn't stop with education. You can use EnChroma glasses at some major museums around the country to experience works of art in full color. There are also EnChroma lens-adapted scenic viewers at the overlooks in several state and national parks – they allow visitors to see the full range of of nature's beauty. Meanwhile, McPherson continues to invent and adapt – and he isn't shy about admitting he has a whole backroom of failed experiments that likely will lead him to his next success. But it requires curiosity, a prepared mind, and the bravery to be willing to make a mistake or two in order to arrive at the next discovery. McPherson acknowledges many creative thinkers, in many disciplines, whose work he's built upon for his own research – including Johann Wolfgang von Goethe.

Donald McPherson: So Goethe, he was absolutely crazy – he was so brilliant. He was interested in the psychological impact of different colors on mood and emotion. And of course we all know that's kind of at the heart of color design nowadays. And he also proposed, unlike Newton, that darkness was an active ingredient of color. So, and this is the crazy thing, when I read this, I was just amazed because when you think of colors you think of them always sort of being equal, but it's not true. There are colors that are more saturated than other colors. For instance if you add a drop of blue or a drop of red to a liquid, you don't have to add very much before you can see it, right? Say you put food color in – blue or red – if you put a drop of yellow in you can't see it. You can add tons of yellow before you can see it – so that means that yellow is the most desaturated color – this is what he said about yellow he said, this is the color nearest the light. I mean it's amazing that he had these insights.
Melissa Gerr: Oh, I see.

Donald McPherson: He also took Newton's color wheel and he added magenta, because he realized that it was incomplete without magenta. And then he arranged the colors in such a way that if you cross from one color on the wheel, through the white point to the opposite side, you get its complement. And not only that, but you can't look at the color without seeing its complement – well what's that? Well that's an after image. And it's also anticipating Hering's opponency theory of color. Right? So this guy, was so far out ahead of everybody…
Melissa Gerr: Wow, yeah. *[both laugh]*
Donald McPherson: He's just a giant. The reason he's not studied more in color theory, is he never actually developed a theory. He was just sort of was interested in the psychological effects of color. But he did lay the groundwork for more modern understanding of color. In fact you could say he almost was the true father of the field of color vision because he's the one who started making the connection between what the sensation is and how we perceive it and react to it.

Man: [*teary and emotional*] I put these on, and I can see like shades of green and things that I couldn't see before. I've never seen the sky so blue in all of my life. I had no idea the sky was that beautiful.

Melissa Gerr: This is Melissa Gerr. A special thank you goes out to the curious mind of Don McPherson at EnChroma, to the tenacity of educator Heather Knutson at the Southland School District in Adams, Minnesota, and to all of those people who have been brave enough to open their eyes to a big new full-color world. And last but not least, thanks to the divine inspiration of Johann Wolfgang von Goethe who said: "By seeking and blundering we learn."

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