

Chris Thorstenson, PhD: Psychology of Color

Psychology is about trying to gain a better understanding of all facets of the human mind – how and why do we think, feel, and behave in the ways that we do? In essence, Psychological scientists manipulate or observe some set of variables, and then see how those variables influence or interact with some other set of outcome variables that relate to people’s thoughts, feelings, and behavior.

By that definition, I think everyone has been a Psychological scientist to some extent throughout their lives - Most people have tried to understand variables that influence their own and others’ thoughts, feelings, and behavior. For example, “Will I feel better if I eat some ice cream?”, “What will motivate me to go to the gym?”, “What did my friends think about my new haircut?”. These examples might seem trivial, but we learn about the answers because throughout life we have tried different things and observed how they influence our thoughts, feelings, and behavior.

Personally, I became interested in pursuing Psychology once I realized that I could simply have questions about how we function (for example, “How do people use different colors to communicate about concepts like emotions?”), and then I could use scientific methods to conduct rigorous experiments to help answer those questions. Since then, I received my PhD in Social Psychology from the University of Rochester, where I started studying how people interpret emotions from color. I am currently a Post-Doctoral Researcher in the Department of Psychology and the Wisconsin Institute of Discovery at the University of Wisconsin-Madison, where I am continuing to study how we communicate about emotions using color. Next year I will be starting as a Professor in the Program of Color Science and Munsell Color Science Laboratory at the Rochester Institute of Technology.

Color Perception

Color perception fascinates me for a number of reasons. At first, color seems quite simple. Most people understand what color is at a basic level – we see colors everyday and we have words that group colors into categories: red, green, blue, and so on. However, the more you learn about color, the more complicated it becomes. For instance, color is not merely a property of objects (apples are not simply objects that are ‘red’). Instead, color is a perception that is influenced by a number of things, particularly the properties of the source of light, the properties of the object, and the properties of the eye and the brain.

First, light sources emit light with different amounts of energy at different wavelengths. This is why different kinds of light sources (the sun, a desk lamp, a computer monitor) might appear to have different ‘colors’. Then, that emitted light interacts with objects – for example sometimes the light reflects off of an object like an apple or continues to travel further like through the surface of a lake. The light that is reflected from an object also varies across different wavelengths and across lighting angles (all objects interact with light differently! – This is why the sky’s color looks different between daytime and sunset). Eventually, that reflected light reaches your eye, which filters and absorbs the light (which also depends on the wavelengths of the light AND the properties of the light-absorbing cells!). All of this

happens before the eye's cells send a signal to other parts of the brain (which further processes the signal in several different ways) and then 'becomes' a perception of color.

So, something as seemingly 'simple' as seeing color is actually an incredibly complex process with various considerations at each step. I think this complexity is one reason I find color perception so fascinating.

Color and Human Behavior

Perception is certainly just the first step of color's role in human psychology. Color can provide information about natural objects (We know to eat the ripe red strawberries and not the green ones, we can tell the difference between a lemon and lime by whether it is yellow or green). Color can influence our purchasing decisions (If we can choose between different versions of the same scarf, we usually base our decision on the color, even though the color doesn't affect how warm the scarf is). We have color preferences that affect how we decorate our homes and customize our digital media. We use color to navigate and infer the meaning of signals (we know whether we should stop or go at different colored stoplights, we know whether a device needs to be charged based on whether the blinking light is red or green). Choice of color in fashion differs depending on the planned setting (One might choose to wear a bright red dress on a date, but would not wear the same clothing at work).

Color is also not just about these categorical differences, but influences how we feel. Most industrial lighting in our workplaces (like 'cool-white-fluorescent') are meant to stimulate alertness, then we go home and turn on our 'warmer' lighting to be more relaxed. Similarly, this is why modern computer monitors and phone screens provide a 'blue light filter' to reduce certain spectra of light reaching our eyes at night to help transition to sleep. These are just a few examples, but it is clear that color impacts our thoughts, feelings, and behavior far beyond its initial perception.

Cultural Differences in Color Interpretation

Regarding cultural differences, I think most of the variation is in how different cultures learn to interpret various meanings in colors. In other words, I don't think that people from different cultures necessarily perceive colors differently – our mechanisms for seeing color depend on the light source, the objects, and the eye and brain in the same ways, which are the same across cultures (the only caveat here might be in the prevalence of colorblindness, which is more due to genetics than culture per se). However, beyond perception, we do tend to see some differences between cultures in how colors are interpreted and used in society (note that these examples – and summarizing cultural norms in general - are quite broad and there are certainly caveats and counter-examples that could be found).

One example is that most Western cultures generally interpret red as 'bad' and green as 'good', while some Eastern cultures (China in particular) reverse these interpretations. This can be seen in how these colors are used to communicate information in society. For example, in Western stock markets, red is used to indicate that a stock value is dropping, while green is used to indicate that stock value is increasing. Likewise, in Western cultures, brides tend to wear white to weddings and people wear black to funerals. However, in China, brides tend to wear red to weddings and people wear white to funerals.

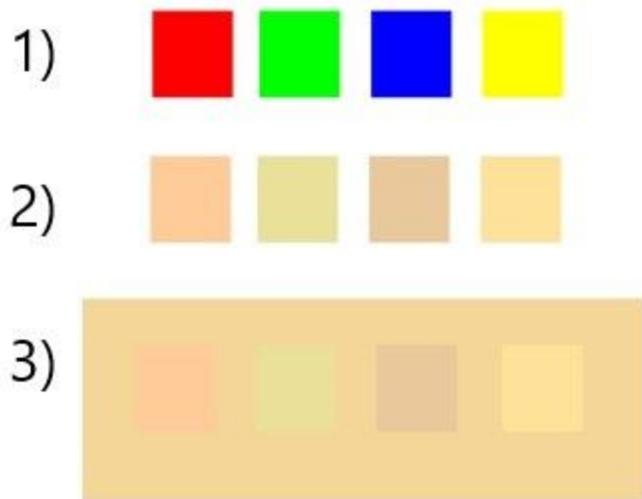
In Western society, red pens are widely used to mark errors (bad) when grading, while this is not the norm in China. So, you can imagine that this likely leads to cultural differences in how different colors are evaluated in terms of their meaning. Again, these are quite broad and simplified examples, but it should illustrate that colors are not innately 'bad' or 'good' (or anything), and that how we interpret colors is shaped by many things including the culture in which we live.

How Facial Coloration Impacts Social Perception.

My current research investigates how changes in facial coloration impact social perception. Let me try to unpack that statement a bit. The color of a person's face (and skin more generally) is mainly determined by three things: Melanin (which protects our body from harmful UV radiation but also suppresses vitamin D when exposed to the sun, and is responsible for how 'dark' or 'light' our skin is, which varies across humans), Carotenoids (which is influenced by diet and contributes some 'yellowness' to the skin), and Hemoglobin (which is influenced by both the amount and the oxygenation of the blood underneath the skin).

Both Melanin and Carotenoids are pretty stable over time (UV radiation can slightly change Melanin over hours to days, and dietary changes can slightly change Carotenoids over weeks), so skin coloration due to these two factors does not change that much. However, patterns of our blood flow (Hemoglobin) can change very rapidly (in a matter of seconds) due to our social states (things like experiencing emotion, being embarrassed, or being nervous or attracted to someone else on a first date). The best example of this would be blushing – When you are embarrassed, a rush of highly oxygenated blood flows to your face, making it appear redder. Interestingly, this blush is not the only way that blood flow changes and results in facial coloration change. Blood can rapidly become either more or less oxygenated, resulting in redder or greener skin. Blood can also rapidly become either increased or decreased in concentration, resulting in bluer or yellower skin. Because blood-flow rapidly changes in these different ways (with different combinations of these patterns across different emotions), our faces can actually change towards all of these different colors!

Now, these facial coloration changes are very subtle – the face doesn't become a 'full-fledged' red, green, blue, or yellow, like the colors here (1). Instead they change very slightly from the starting face color (2). As you can see, these are very small and you will probably say "that's crazy to call those red or green or yellow or blue!", and you are right. However, part of my research is understanding how we are able to detect and perceive these small color changes. It turns out, that one reason we are able to do this, is because only some patches of our face changes color when we experience emotion, and the rest of the surrounding areas stay the same starting color. This induces a visual effect called "simultaneous contrast", whereby the colors will appear different depending on other surrounding colors. When I simulate how this looks, then the colors appear more noticeable (3).



Finally, my research investigates how people evaluate other people when they are undergoing these facial coloration changes. So far, I've found that facial coloration is a very impactful signal that can influence how we rate other people in terms of attractiveness, healthiness, personality, whether we want to approach them or not, and several different emotion categories. Altogether, my research helps us to understand why people might have certain color-emotion associations (red-anger and blue-sadness both can be seen on the face of people experiencing these emotions), why we use colors in emojis (if you look at your phone, most emojis have color on the face), and why we use colors to represent emotions in general. My future research goal is to see if we can use this knowledge and apply them to artificial social agents (like virtual avatars and social robots). For example, I am trying to see if we can incorporate colored lights into social robots (like Amazon Alexas) to make them look more emotionally expressive when they communicate with humans.

Skin Color Variations in Facial Coloration

Regarding participants in most of my research (people who are making these ratings) - they are largely a reflection of the recurring subject pool, which at the university where most of my studies took place, are mostly split between people identifying as white (approximately 50%) or asian (approximately 45%) with very few respondents identifying as black, pacific islander, or native american.

The target stimuli (images of people being rated) - I use various standardized image sets that are published and available to the scientific community, many of which are solely of white people, and only a few that are of people of color.

One of the most interesting (I think) things about the skin color demo that I showed (the part with the colored patches), is that those directions of color change (skin becoming redder, yellower, greener, or bluer) happens in reference to the baseline, or initial skin color. This means that regardless of someone's initial baseline skin color (which is due to Melanin in the skin), those changes that occur due to

blood-flow (Hemoglobin) occur in the same way physiologically. Research in this area has also shown that these face coloration changes (due to Hemoglobin) are similar across ethnic groups (and even across different non-human primate species that all have different baseline skin colors!)

Artists Using Color

Artists have used color to portray emotion since the dawn of art. Artists that want their subjects to appear more personable and attractive tend to use more saturated and vibrant colors. Artists that want to convey grief or sadness tend to make their subjects more desaturated with blues and grays. Outside of the artist, the display lighting can also affect how an image is perceived – Recall that I earlier talked about how one important factor of color appearance was the light source. Some display lights have spectral qualities that can make skin colors stand out and look more attractive. In many ways, I think artists were keenly aware of how color could impact the emotion of a subject or a scene long before this and related research was conducted. I prefer to think that artists have long been aware that color impacts emotion, and that we are only now beginning to scientifically understand *why* color can influence emotions in these ways.

Interpretation of Objects, Forms or Shapes Influenced By Variations of Color?

I think in many ways they can – if you can imagine an artist painting a landscape, their choice of color palette will influence the emotional content of the painting. If the artist uses bright, saturated colors, the painting might feel more cheery. Conversely, if the artist uses dull, grayer colors, the painting might feel more melancholy. There is also some research showing that people can effectively communicate emotions using neutral emojis that vary only in color. For example, if I sent someone a neutral emoji, but it was colored red, it would be interpreted as angry, whereas a blue emoji would be interpreted as sad. On the other hand, we still use color for many other things, like picking out our favorite clothes – I don't think that I would necessarily perceive that my red shirt looks angry. So, I do think that color can be used to communicate emotion on all sorts of objects, but that the interpretation will depend on what the object is, and what context it is being viewed under.

Impact of Color in Creating Moods in Cinema and Other Arts

I absolutely agree that color can be (and has been for a long time) used as a powerful tool to create moods in cinema. I think this is the case for the same reasons I mentioned earlier (about artists using different colors, saturation, lightness, to convey emotions). Often you will see that darker and desaturated scenes in film are the ones that are meant to provoke or convey more negative moods (like grief or sadness). The example in this video of conveying an “angry sunset” was a great example of how the choice of color palette can influence the mood of a scene. This is clearly true not only for film, but for other forms of visual arts. For example, in dance and live theatre, there are certainly similar considerations of the emotional meaning of costume, lighting, and set design.

Speaking of Pixar, if you consider the movie, "Inside Out", it was not at all a coincidence that the animators chose to color the character 'Anger' with red, 'Sadness' a dark blue, and so on. This was because certain colors are highly associated with these emotion categories. One important aspect highlighted in this video is that most people think of color as "hue" (for example blue and red). However, there is not a one-to-one matching of hues to emotions or moods because color is more than just hue, it is also saturation (or chroma) and value (or lightness). For example, you can have two colors that are the same hue (for example, 'blue') that vary on either value, saturation, or both. A highly saturated, light blue (like sky-blue) likely carries a different emotional meaning than a dark, desaturated blue (think of a dark grayish blue). So, when considering the emotional impact of a scene, one must consider the emotional impact of hue, saturation, and lightness together.