THE SECOND C: Lab Dips—The First Circle of Hell (Part 1)

By Keith Hoover

Thus far in this series we have discussed choosing color inspirations, and described how a dyer converts a color inspiration into a specification. Now, we move to lab dips.

In Dante's *Inferno*, the First Circle of Hell is called Limbo and is populated with virtuous pagans. For our purposes, this analogy is not theological—rather, it points out that Limbo is a place not informed by a "Higher Authority." In short, "these virtuous pagans live forever in a place of their creation"—not unlike apparel brand color offices whose activities do not correspond to manufacturing. [1]

Today is the big day! Lab dips have arrived for evaluation. This first installment about lab dipping focuses on preparation. If you have ever painted a room, you know that more is required than just a bucket of paint and a brush. Do you have everything you need? Do you tape or use a straight edge guide for trim? What if you spill? So, let's review the preliminaries—what is needed before color assessment begins.

Self-Assessment

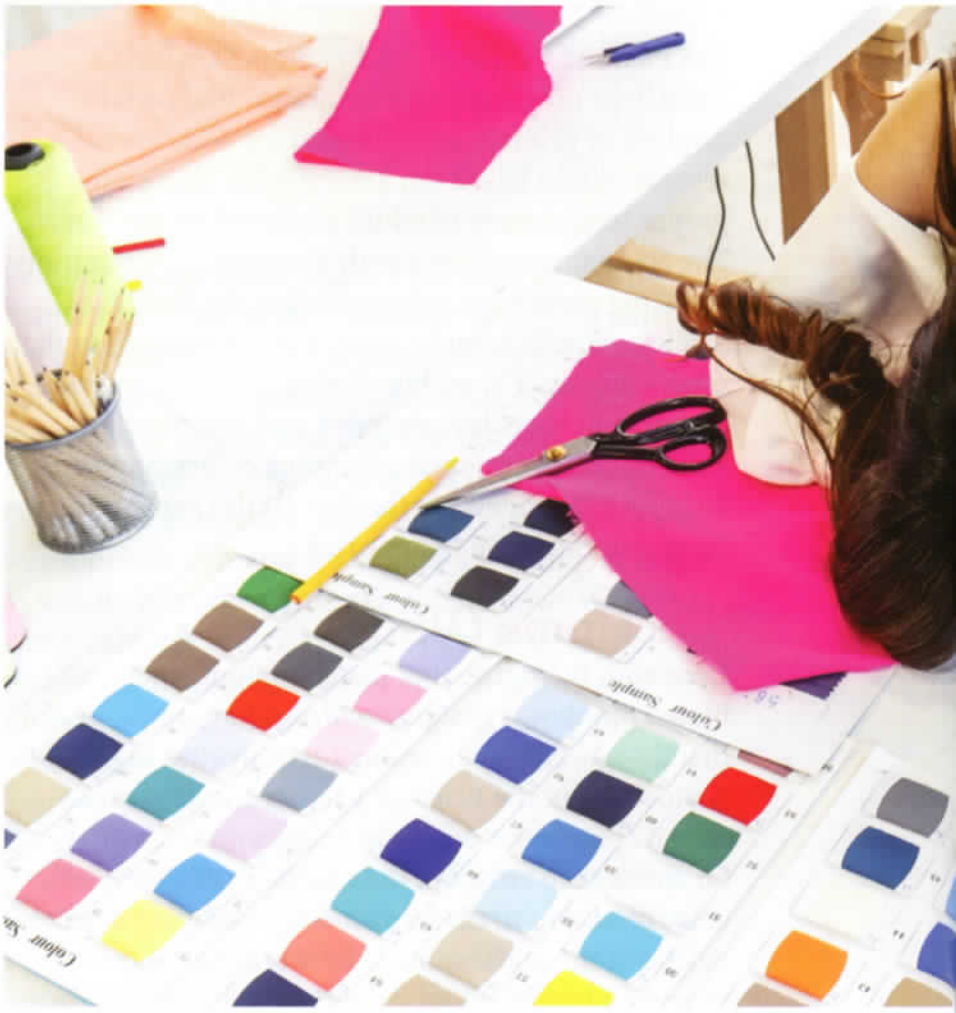
Is your color team competent? Can they perceive color normally? Do they understand acceptable color difference?

Color Vision Variability

Most color offices require a candidate to pass the Farnsworth Munsell 100 Hue Test. In my experience, this test is counter-productive. First, it trains a colorist to look for "perceptible" color difference (the smallest difference that can be perceived) rather than "acceptable" color difference (the most color difference allowed). Second, the difference between the caps varies only in hue, something rarely seen in the real world of commercial color management. The only value I have seen in the test is that it shows colorists if they are weak in particular areas of color (like yellows or reds). One could make the case that such deficiencies should be a disqualification.

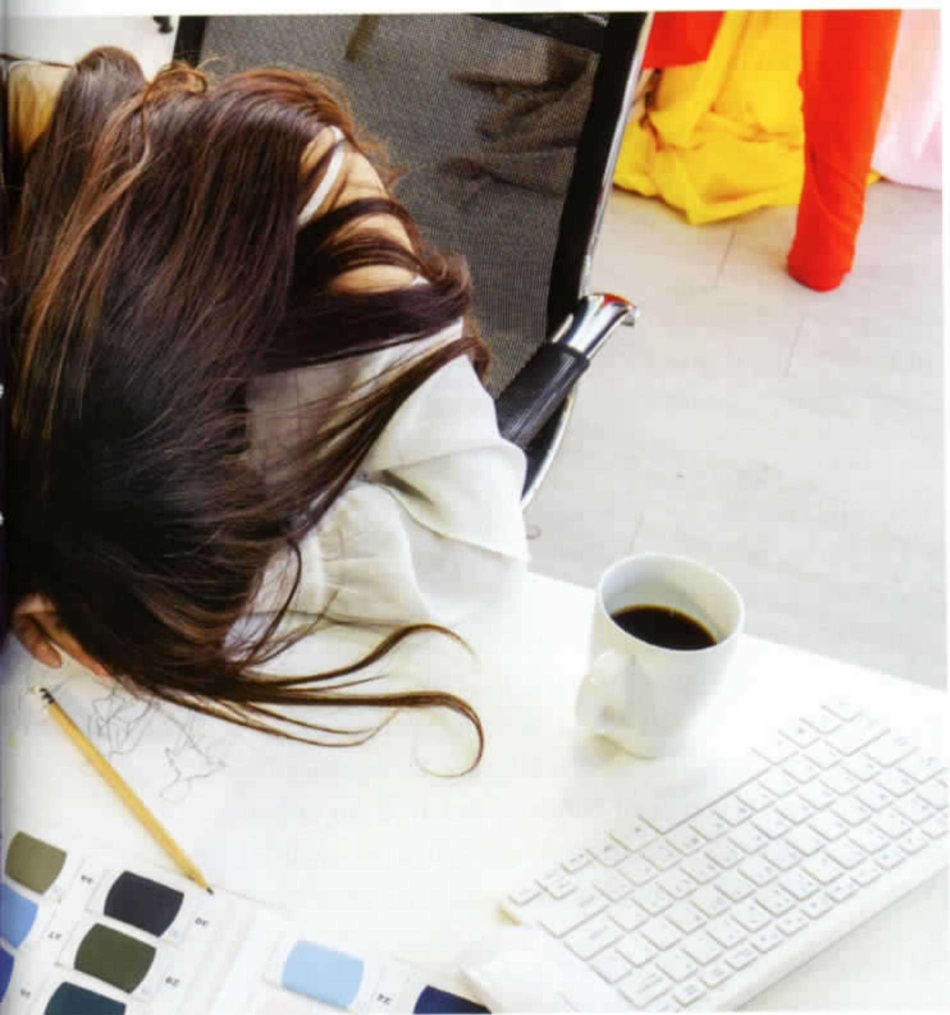
Perceptible vs. Acceptable Color Difference

Let's start with a seminal 2006 AATCC article on color, "Describing Color Differences: How Good Are Your Color Comments?" by Carol Revels. [2] Revels conducted a study at a major apparel brand to investigate the accuracy of color comments. One hundred and two employees responsible for some aspect of color accuracy visually evaluated 17 standard/submit pairs with known



color difference metrics and accepted, accepted with comments, or rejected them, providing color difference descriptions with each. The research demonstrated that color difference description accuracy diminished with color difference. In other words, the smaller the color difference, the less accurate the color comments.

Revels's research also showed that a surprisingly high number of wrong decisions were made. For instance, one of the standard/submit pairs was a single swatch of fabric cut in half. Of the participants in the color office, only 16 of 30 approved that standard/submit pair (13 approved with comments, and one rejected it). Only 29 in the group of 102 approved it straight up. Yikes!



As is the case with AATCC articles, this sparked an idea. Rather than test how good color comments are, could we test how good colorists' color acceptability decisions are? Forget comments—are the color experts competent?

So, a test was created composed of 150 standard/submit pairs—half measuring $<0.75\ DE_{CMC}$ and half measuring $>3.00DE_{CMC}$. Twenty colorists from the US and global color offices reviewed each pair for acceptability three times over the course of a week.

The results were evaluated by Donna Faber in MiniTab for reliability. In short, we found that the colorists did not agree with 1) the color difference numbers, 2) the other colorists' decisions, and 3) themselves (what was accepted on Monday was rejected on Friday). We saw groupings of false positives (approved bad matches), false negatives, (rejected good matches), and confusion (both false positives and negatives).

As a color manager, what should I do? Fire everyone? In this case, I had a safety valve. Faber, who evaluated the results, was not only an experienced colorist, but had been involved in research at Clemson involving the CMC color difference equation. She not only understood the math, but also

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the model that the equation was built around. She understood the visual color difference that the equation was derived to describe.

Faber had not taken the test in the first instance, so I asked her to take it. Her performance was excellent—she agreed with the numbers across the board and repeated her results over the course of three trials. This indicated that her familiarity with the CMC acceptability model might be the difference.

So, I assigned the colorists to spend a few hours each week reviewing digitally approved stored physical color samples. I wanted them to understand CMC acceptability. Delta E, of course, factors in differences of hue, lightness, and chromaticity, so not all 0.70's are the same. And, based on the minor color group, allowable differences in hue, lightness, and chromaticity vary. However, this exercise was not about learning the math, it was about group calibration.

Three months later, we repeated the test and saw marked improvement across the board. This reinforced the premise that *color acceptability can be trained.*

Sample Preparation

Aristotle said, "An unexamined life is not worth living" and I say, "An unprepared sample is not worth reviewing." (Wow, Dante and Aristotle both in the same article. Dude!)

However, it's true. Sample preparation is every bit as important as using the correct light source for evaluation. There are several variables to control.

Humidity/Moisture Content

The relative humidity (RH) of the environment determines the moisture content of a material. The colors of hydrophilic materials (materials that absorb water), like cotton, can change appearance based on RH. So, if either your color standards or lab dip samples are cotton (or another hydrophilic fiber), then the RH should be controlled through conditioning. Conventional lab conditioning requires 24 hours, which is impractical, so accelerated conditioners like the PGC CFM series are required at the brand color office.

There are different specs for RH. In 2003, Bill Sherrill at Archroma conducted a study showing that color appearance on cotton is stable between 45% and 55%, so 50% RH was recommended as the spec. The cotton industry, however, recommends that test samples be conditioned at 65% RH because cotton tests best in these conditions. Since all test labs are set up with the 65% RH spec, it is probably best to adopt it for color evaluation as well, even though any office or retail store with 65% RH probably has an HVAC problem.

RH varies by season and location. Most offices and stores measure under 50% - at one color office, it was typically 18% during the winter. Check with your color standards supplier and use the same conditioning spec when measuring color samples for comparison.

RH presents another problem at the dyehouse where ambient conditions are not the only culprit. Samples coming out of the lab dryer (or drying range) are bone dry. In order to maintain throughput, dyehouses must make fast color difference assessments, so accelerated conditioning is critically important. If you see dyers covering their mouths with fabric samples, it has nothing to do with Covid. They are applying the poor man's "quick conditioning" method by breathing into it (not recommended, but still prevalent).

Temperature

Some samples are thermochromic, that is, their color appearance changes with temperature. The industry spec is 72° F, which corresponds to most stores and offices. However, thermochromic behavior is especially a problem at high temperatures so adequate conditioning is necessary at the dyehouse when a sample is coming out of the dryer (and the ambient dyehouse temperature is never as cool as 72° F).

Fluorescence

Colors that reflect back more than 100% of light energy at a given wavelength are said to fluoresce. Some instances of this, like "neon" colors, are obvious (optically brightened whites will be covered in a future article). But not all colors that fluoresce are that obvious. Some conventional "non-neon" colors include fluorescing dye components (like "brilliant" reds in acid dyes). The color standard is not neon, so a fluorescent dye is not needed to match it (but is used nevertheless). It is not unusual for an optical brightening agent (OBA) to be extruded into polyester yarns, which adds fluorescence to color. All clothes washed with just about any home laundry detergent fluoresce because OBA's are added to the detergent. And that extra "brightness" affects the way we see color and the way color QC software processes color difference. So, it is important to vet your color standards and lab dip submits for fluorescence.

Vetting is easy. Place the sample under a black light (UV setting in a lightbox). If it glows, it is fluorescent. If it does not glow, it is not. No need to buy an expensive lightbox to check. There are many inexpensive black light sources available on the market.

So, with all color samples (including standards) vetted for fluorescence, now what? Here are the rules of thumb:

- A non-fluorescent sample can be compared (visually or digitally) to a non-fluorescent standard.
- A fluorescent sample can be compared (visually or digitally) to a fluorescent standard.
- Visually comparing a fluorescent sample to a non-fluorescent sample makes expressing color difference difficult.
- Never digitally compare a fluorescent sample to a non-fluorescent sample.

The biggest takeaway here is the last point—digitally comparing a fluorescent sample to a non-fluorescent standard. The extra energy content at specific wavelengths messes up the color difference calculations. This is probably the biggest culprit I have seen when a digital match does not look good—and it is probably the first thing to check.

Surface

Samples (solid colors, for this discussion) can display various surface attributes that affect the way they should be evaluated for color acceptability, including 1) sheerness, 2) sheen, involving a significant specular component (i.e., a cire finish), and 3) texture, involving the introduction of shadows (i.e., corduroy). It is important to categorize such samples and process them according to best practices that will be discussed in a future installment.

Sheerness—Sheer fabrics allow light or background color to be seen through the sample. The conventional wisdom is to fold the sample into as many layers as is necessary to achieve opacity. This can done by holding the folded sample up to a light or by measuring samples with multiple folds until the difference between the measurements is minimal.

Sheen—Samples exhibiting a "shiny surface" can be identified by viewing them from different angles. If the appearance is significantly lighter or darker from a given angle compared to another, then the sample has significant sheen.

Texture—Samples with raised fibers or yarns (e.g., corduroy, fleece, and terry cloth) introduce shadows that impact the Total Appearance [3, 4] of the sample. If the color of the fabric changes when it is compressed, then it displays significant texture.

Separating the Wheat from the Chaff

Once a process is in place to 1) validate colorists' performance and 2) control the sample variables, then you will be aligned with manufacturing (and one step closer to leaving Limbo). The next installment will discuss assessing labdips and commenting on their color difference for those poor, unfortunate souls tethered to a lightbox.

References

1. **https://www.cliffsnotes.com/literature/d/the-divine-comedy-inferno/summary-and-analysis/canto-iv** (accessed March 2022)
2. Revels, Carol Tomasino. 2006. "Describing Color Differences: How Good Are Your Color Comments?" *Proceedings of the Annual International Conference & Exhibition of AATCC.* P297 – 304. 8p. 9 Graphs.
3. CIE 175:2006 A Framework for the Measurement of Visual Appearance, Vienna.
4. Hunter R. S. and Harold H., *The Measurement of Appearance*, 2nd edition, John Wiley and Sons, New York (1987).

Keith Hoover, president of Black Swan Textiles, (**www.blackswantextiles.com**), implements manufacturing-centric digital processes for color and fabric development. He has implemented digital color management programs for Ralph Lauren, Target, Lands' End, JCPenney, and Under Armour, ultimately leading to a process that eliminated lab dips altogether. At Under Armour, Hoover championed the UA Lighthouse, driving digitalization and advanced manufacturing processes to explore local-for-local sourcing. He has worked hands-on in mills worldwide and is a frequent AATCC presenter. Black Swan recently developed BlackOPS Fabric Decoder (BFD), technology to digitize fabric, a key component for digitalization in the Fashion and Textile industry.