Article ▸ The Power of Color: A Case Series

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ABSTRACT

Background: The use of colored light, filters, and therapeutic tinting dates back to the early years of optometry. It has been used by optometrists and other professionals throughout history for a variety of different reasons, including photophobia, near point stress, migraines, and dyslexia.

Case Series: A series of cases are presented where color is used to help patients resolve their visual disturbances. The patients who were identified are those suffering from photophobia, reading difficulties, and visual changes related to a vestibular condition. The colors are chosen using the Intuitive Colorimeter. This instrument is used to investigate the possible preferences for a specific color to reduce the patient's symptomatology. This is done logically and sequentially to explore color space in order to find the optimal precision tint for the relief of perceptual distortions.

Discussion: Tinting contact lenses and/or glasses for therapeutic reasons can be time consuming but can be a rewarding experience for both the clinician and the patient.

Keywords: color, contact lenses, Intuitive Colorimeter, tinting

Introduction

The question as to color's effects on the visual system has been discussed dating back to the late 1800s and early 1900s. Edwin Babbitt and Carl Loeb used colored light to treat physical and psychological conditions including jaundice, weaknesses in the body, ailments, and mental affective disorders.[1] In optometry, the use of color or chrome orthoptics began with William Henning's work in the 1920s. Henning exposed patients to colored light along with lenses to train functional vision problems.[2] In 1941, Harry Spitler published his work, *The Syntonic Principle*. He concluded that specific light frequencies affect cell biology, inherent electrical systems in the eye and brain, eye physiology, and emotional centers. Spitler proposed that certain frequencies of light could balance inherent regulatory centers in the brain and correct vision problems at near.[3] These visual problems range from accommodation and ocular motor dysfunction to visual information processing and visual field deficits. The syntonic model suggests that low energy/long wavelengths (red) stimulate the sympathetic nervous system, middle frequencies (green) balance physiology, and high energy/short wavelengths (blue) stimulate the parasympathetic nervous system.[4] In 1983, Helen Irlen proposed the existence of the condition she named the Scotopic Sensitivity Syndrome. The Irlen Method is a non-invasive system which uses colored overlays and/or filters to address the symptoms in subjects.[5] Many of these ideas are still practiced today.

The thought process for why color helps and the evidence that colored lenses have therapeutic potential are not new. However, the methods on how to achieve the desired color vary from one practitioner to the next. One instrument that enables an ophthalmic tint to be chosen according to a patient's subjective assessment of its effects on perception and visual comfort is the Intuitive Colorimeter (Figures 1 & 2). It allows easy manipulation of a light source through color space, changing wavelength and saturation. The Colorimeter is used to select an appropriate chromaticity by changing three parameters (hue, brightness, and saturation). Using the results, a suitable combination of colored lenses is selected. This case series includes three patients who presented with

Figure 1: *The Intuitive Colorimeter*

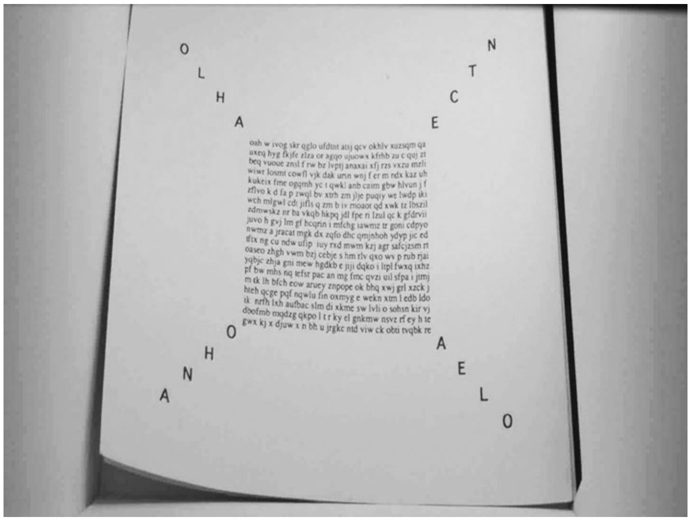

Figure 2: *Target inside the Intuitive Colorimeter*

Figure 3: *Soft Chrome tinting set*

Figure 4: *Pupil-only tinted contact lens*

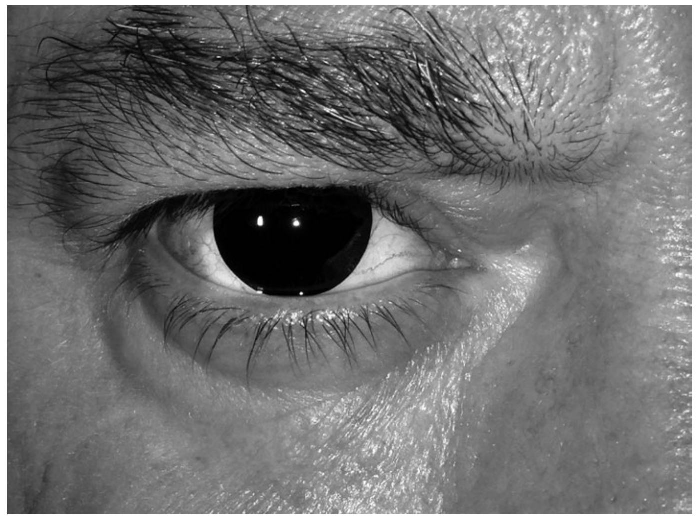

Figure 5: *Full diameter contact lens tint*

visual distortions (each of a different etiology) and were helped through the use of color.[6]

Case Series

Case #1:

DB was a 57-year-old male who presented to The Eye Center at Southern College of Optometry for migraines with auras that were triggered by fluorescent lighting. The patient wore dark sunglasses at work to help prevent the onset of his migraines. To help with the light levels at work, he had to remove every other lighting tube in the fluorescent fixture for relief or just shut off the auxiliary lighting altogether. DB was being seen by a neurologist for his headaches. The remainder of the patient's medical and ocular history was unremarkable. He was taking one 100 mg tablet of Imitrex for his migraines. He was allergic to aspartame, caffeine, cheese, MSG, and tryptophan.

Upon examination, the patient's uncorrected visual acuities were 20/20 OD, OS, OU, and all other preliminary testing was normal. Refraction revealed OD: +0.50-0.75x110, OS: -0.25-0.50x110, Add +2.00. All of his binocular testing was unremarkable. Anterior and posterior segment evaluations were both unremarkable.

Colorimetry was performed at the next visit using the Intuitive Colorimeter. With this patient it was a matter of finding the right tint to help relieve the onset of his migraines. Testing with the Colorimeter indicated sensitivity narrowed to 180 degrees (hue) at 32 degrees of saturation. This equated to a blue saturation on the color wheel. When the tint was decided upon, a color match was chosen for the tinting process. It is possible to match any Colorimeter setting with a stack of trial lenses so that the color appearance is identical, allowing for differences in brightness. Based on the colors that are preferred by the patient, it is then called into the lab with the appropriate specifications, where they are able to make up a pair of lenses with the appropriate tint. For DB, the color was initially placed into a pair of spectacles. The patient appreciated the color, but too much light was allowed to filter in from both the top and the sides of the lenses; he was still experiencing the migraines. The saturation was also not dark enough in the lenses. The next step was to apply the tint to a soft contact lens to move the color closer to the surface of his eye. Using the Soft Chrome In-Office Tint System (Figure 3), the lenses

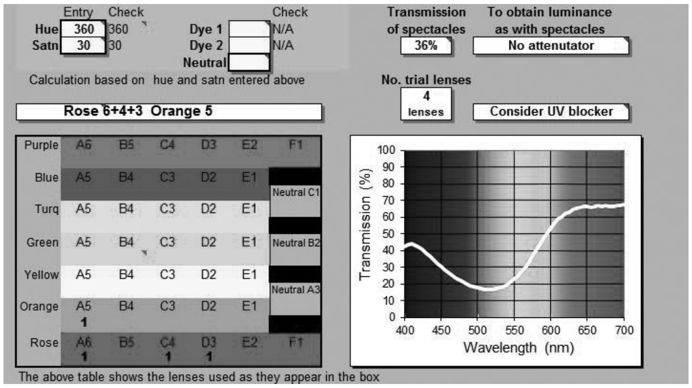

Figure 6: *Lens Excel spreadsheet*

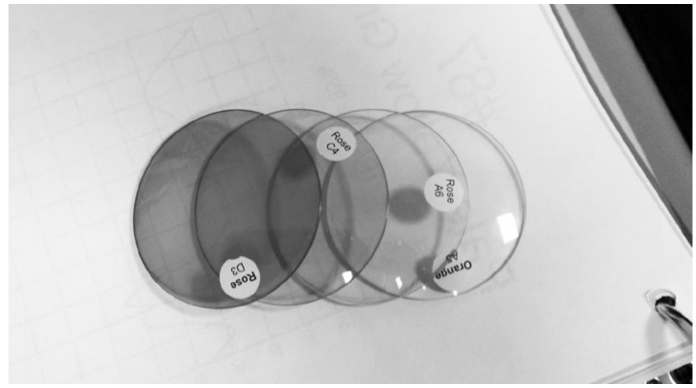

Figure 7: *AW combination of lenses*

Figure 8: AW and her tinted lenses

were tinted by a faculty member at the college. The tinting system kit includes: a choice of patterned templates to create pupil and iris combinations, the dyes, tinting equipment, and instructions.

The lens material used was Omafilcon-A with the lenses being BioMedic XC. Using the Recipe Guide, the color dye, the amount of activator, and the length of time were decided upon. To relieve the symptoms of the migraine a dark tint was required, and based upon the results of the Colorimeter, the blue tint was used. Two milliliters of activator solution were poured into a container, and 15 drops of blue dye were added. The solution was mixed with a syringe and transferred to a vial. The entire lens was left to tint for 45 minutes. They were then put into a heated neutralizing solution to prevent the dye from leaching out. Upon cooling, they were transferred to a multipurpose solution for storage.

The first lenses had only the pupil tinted to improve cosmesis (Figure 4). Though this attempt was promising, it turned out that they still let in too much light. The most successful tint pattern was a full lens diameter tint (Figure 5). The result was a profound change in the patient's life. When the patient inserted his lenses, he was able to wear them full time during the day and work in any lighting without getting the headaches. His acuity through the lenses was 20/20 OD, 20/25 OS, 20/20 OU.

A pair of tinted sunglasses was made up for DB as well (using the same color technique) to supplement his contact lenses. The patient stated, "I am not tired at the end of my work day due to the exposure to the fluorescent lighting, nor do I get migraines as easily. I can tolerate being at work, and I do not have to consider quitting my job. It is amazing, and I thank you again for what you have done for me (giving me a normal life back)."

Case #2

AW was a 12-year-old female who presented with reading problems. She was in the fourth grade and was homeschooled. She stated that stark white pages and white boards gave her headaches, so she read on tan colored tables. She enjoyed reading and denied problems with comprehension; however, she was struggling in school because of her headaches and visual disturbances. She was not taking any medication nor did she report any allergies.

Upon examination, the patient's corrected visual acuities were 20/25 OD, 20/25 OS in the distance and 20/40 OD, OS, OU at near. All other preliminary testing was normal. Refraction revealed OD: +0.50-0.50x100 and OS: +0.50 -0.75x080. Her MEM and stress-point retinoscopies were +1.50 OU and +2.50, respectively. Anterior and posterior segment were both unremarkable. After a binocular vision work-up, her accommodative testing was below normal. AW was given a +1.00 OU spectacle prescription for near work and was scheduled for color testing.

Colorimetry was performed using the Intuitive Colorimeter with the color spectrum narrowed to 360 degrees (hue) at 30% saturation. This equated to a rose color on the color wheel. After the patient's results were scored, a series of lenses were chosen by entering the combination in the lens spreadsheet (Figure 6), an Excel-based program that is provided by the company. The calculation is based on the hue and saturation that was recorded. These lenses are then selected and added together for the patient to view. The four lenses that were combined were Rose D3, Rose C4, Rose A6, and Orange A3 (Figure 7). AW was given the opportunity to compare the lenses under fluorescent light and in natural daylight. She sat

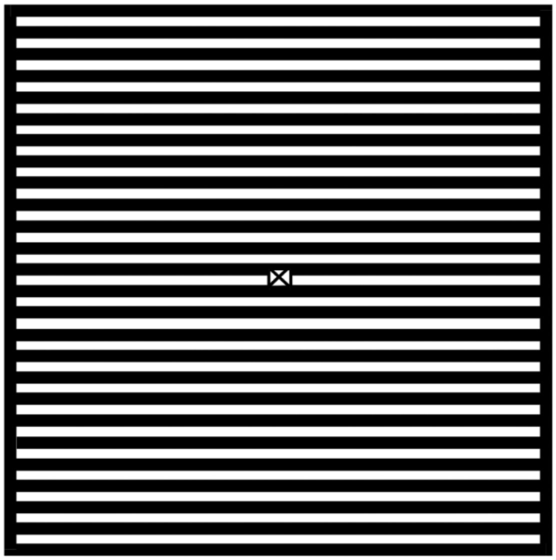

Figure 9: Binocular Dissonance Test

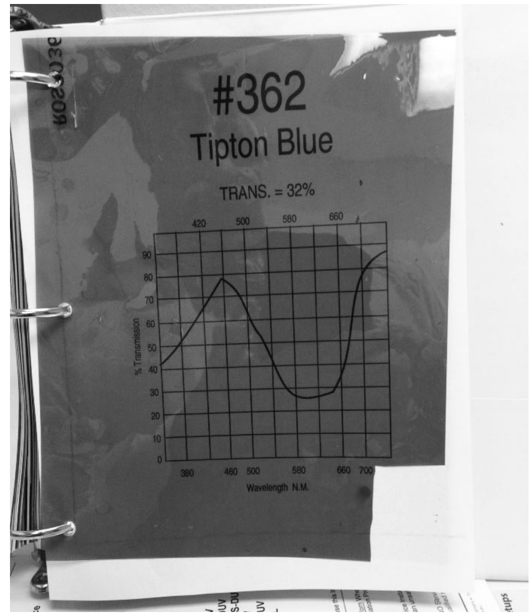

Figure 10: Blue tint for lenses

in a classroom where she observed a white board while trialing the colored lenses as well. Both the mother and the patient were in agreement and had spectacle lenses tinted with the appropriate color.

AW is now wearing her lenses and has minimal to no headaches while reading and/or viewing the whiteboard (Figure 8). Her schoolwork and mental focusing have improved tremendously. She loves her new lenses, and her parents have been very appreciative.

Case #3

AD was a 37-year-old female who suffered from vertigo and was diagnosed with Meniere's disease in March 2010. She worked as a receptionist in a two-story building. She stated that the vibrations on the second floor and certain lighting seemed to be triggering her events. She had decreased focus and balance and experienced visual disturbances that made her dizzy. These were accompanied by painful migraines that could last from a few minutes to a few hours. When she had one of these headaches, they could be as painful as 8 out of 10 and kept her immobilized for 48-72 hours. AD avoided television because of the flicker on the screen and spent most of the time in her bedroom with her lights off. She was sensitive to sunlight and wore dark fit-over sunglasses to help. She was taking diazepam and gabapentin for her migraines. She had no known allergies. The patient's best corrected visual acuities were 20/20 OD, OS, OU. All other preliminary testing was normal. Refraction revealed OD: +0.25-1.00x060, OS: +0.25-1.25x125, Add +1.75. Her binocular vision testing was unremarkable. Anterior and posterior segment were both unremarkable.

Colorimetry was performed using the Intuitive Colorimeter with the color spectrum narrowed to 180 at 30% saturation. This equated to a blue saturation on the color wheel. However, the patient was unsure of her responses. The colors presented were not prominent enough for her to notice any significant differences in the instrument. At this point, a color filter trial was performed using the Roscolux theatre lighting gels. This allows for a demonstration where the patient can hold the gels closer to the corneal plane and appreciate the colors and their effects away from the instrument. The Colorimeter provided the spectrum to allow us to know which colors were appropriate to trial for the patient. Each blue filter corresponded to a specific transmittance, allowing the practitioner to know how much light is getting through. The patient decided on Tipton Blue #362, which had a transmittance of 32%.

The effect of the color was demonstrated using the Binocular Dissonance Test. According to Bowan,[7] certain individuals have neuro-physiological differences in the functioning of their visual cortex that results in a heightened sensitivity to striped patterns (Figure 9). The test is presented with a stimulus that looks like a square with stripes in the middle. The examiner asks what the patient sees. The response is judged on how the patient reacts to the striped pattern. Do they get nauseous or bothered by the pattern to the point where they have physical reactions (e.g., pulling back or pushing the target away, facial distortions)?[7] AD reacted poorly when viewing this test. She cringed and was not able to look at the pattern for more than 2-3 seconds without getting dizzy. The blue filter (Figure 10) was then placed in front of her, and she was asked if anything had changed. Instantaneously, she was able to appreciate the image on the test with no physical or mental reactions. The comfort and dramatic response were further indicators for prescribing this tint for the patient.

She had felt instantaneous relief and a feeling of comfort while looking through the tint. The patient started to cry in office, because she had never felt so hopeful. She stated, "Who would have thought, a simple blue color would have the ability

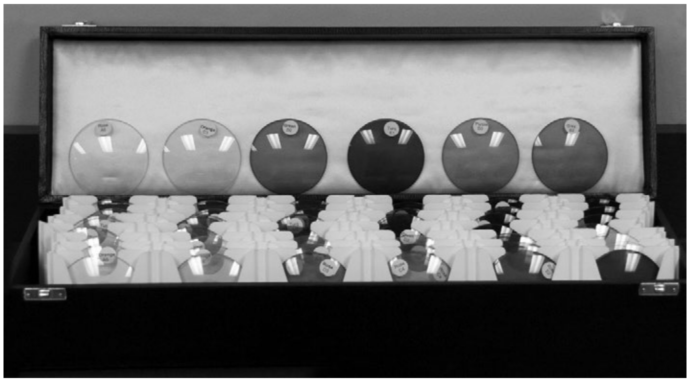

Figure 11: Colored lens trial set

to change my life forever!" Two pairs of glasses were made up for the patient: one for distance and one for near. Both pairs contained the Tipton blue tint. She is currently wearing the glasses full time and will be monitored at monthly progress exams to follow up on her symptoms. She plans on returning to her job in the next few months.

Discussion

Color is a visual perceptual property that is derived from the spectrum of light, which interacts in the eye with the spectral sensitivities of the light receptors. The science of color is called colorimetry. A colorimeter is a device used in colorimetry to determine or specify colors based on their wavelength. Visible light is the narrow range of electromagnetic waves in the wavelengths 400-700nm. The Intuitive Colorimeter is used to expose subjects to light limited to specific bands of hue, saturation, and intensity. This gives subjects the opportunity to view targets for extended periods of time in conditions that are highly controlled and repeatable.

The Intuitive Colorimeter changes three parameters of color: hue, saturation, and brightness. The patient views these colors through the machine, while the examiner changes them and then records the responses based on how they make the patient feel. The target that the patient observes is a block of text with random letters. This is used to create visual stress so that the examiner and the patient have something against which to measure. After the test condition is changed, the subject is asked to compare how they feel to the prior setting. Responses from "little to no change" to "major changes" are noted and recorded. The scale goes from a +2 to -2. The +2 is documented if the color is well received, while 0 is neutral and -2 is a negative response to the color as compared to the prior trial. The answers given are entered into a computer program (Lens) which produces a color combination unique to the patient's visual needs. The color is decided upon from a choice of over 100,000 different combinations (Figure 11). Based on the hue and saturation, the color is carefully chosen based on the wavelengths of the spectrum. The filter is then selected from a box of various colored filters and shown to the patient for evaluation. After it is trialed, the tints are then applied to the lenses in an optical tinting laboratory.[8]

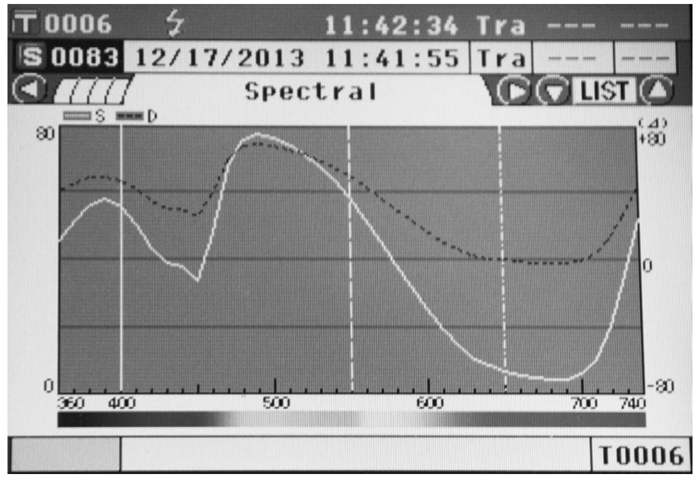

Figure 12: Transmission curves

The advantages for using this instrument are as follows: the color and depth of color can be varied independently, the variation is continuous rather than discrete, no colored surfaces are visible within the colorimeter, and the perceptual effects of color can be studied while the patient's eyes are color adapted.[8] The color spectrum can be altered by changing the hue, brightness, and saturation. The control over the intensity of the colors makes this device unique because it allows the patient to observe the entire visible spectrum. The colors are presented in a continuous manner, so there is a fluid presentation. This avoids forced choice and keeps the patient from getting nauseous. The device also allows the examiner to observe the patient's reactions to the color presented. This gives an objective measurement as to how the color is affecting the patient in addition to the subjective response they will give.

Another instrument that aids the clinician in the exploration of color is the spectrophotometer. This forms the basis for color measurement. It is an instrument that measures the amount of light absorbed, or the intensity of color of a given wavelength.[9] It can be used to measure transmittance, absorbance, or reflectance. With this device, it is possible to measure the tints that are applied to the lenses and quantitatively to analyze how much light is being transmitted through the lenses. This applies to contact lenses as well as spectacles. It provides feedback to the examiner to ensure that the lenses that the patient is wearing are as close to the actual color spectrum as possible (Figure 12). This enhances the success of the tinting process.

The dominant thought process behind colored lenses and therapeutic tinting is to form an alternative treatment option for patients who are suffering from visual disturbances regardless of their etiologies. It has been proposed that color works on the magnocellular pathway, which is more sensitive to short wavelengths of light. Spitler was the first to detail the biology of the non-optic tract showing that ocular light stimulation results in changing the physiology of the thalamus, hypothalamus, and pituitary gland. He also showed how specific light frequencies affect cell biology, inherent electrical systems in the eye and brain, eye physiology, ocular functions, and emotional centers. It was said that certain color frequencies could build or discharge electric potentials between organ systems in the body. Spitler explored the retinal-hypothalamic pathways in detail and proposed that certain frequencies of light could balance inherent regulatory centers in the brain and correct vision problems at their source. Some of these proposed problems were accommodative, vergence, and oculomotor in nature.[3,4]

Lieberman et al. put forth another possible explanation as to why colored tints may help migraine sufferers that has to do with the vascular supply. They proposed that "normal cerebral blood supply can be affected by repeated migraine attacks and can lead to the damaging of the visual pathways. Interference of blood supply to the visual neurons with high metabolic demands may be responsible for visual discomfort and selective color preference of migraine sufferers. The magnocellular pathways of V1 are more susceptible to ischemic damage and have specific color sensitivity; therefore certain colors may be neurologically less stressful and more effective for neural processing of these cells."

They go on to say that "the theory proposes that visual information is transmitted from photoreceptors and processed via three channels: a luminance channel and two color opponent channels. If one of these is selectively impaired, efficient information transmission can be restored by changing the output from the photoreceptors by wearing tinted lenses."[10,11]

Conclusion

Color is a powerful tool. Tinting contact lenses and/or glasses for therapeutic reasons can be time consuming but can be a rewarding experience for both the clinician and patient. The use of therapeutic tinting has existed for many years within the field of optometry, with many optometrists evolving their own methodologies. There are many people who struggle with visual disturbances on a daily basis. Whether it is light sensitivity, reading problems, or even visual sequelae related to vestibular issues, color has been shown to help many of these patients live a normal life. The use of color through filters and/or lenses should be considered for those who are struggling from visual disabilities. A single color can be the difference in changing someone's life for the better.

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