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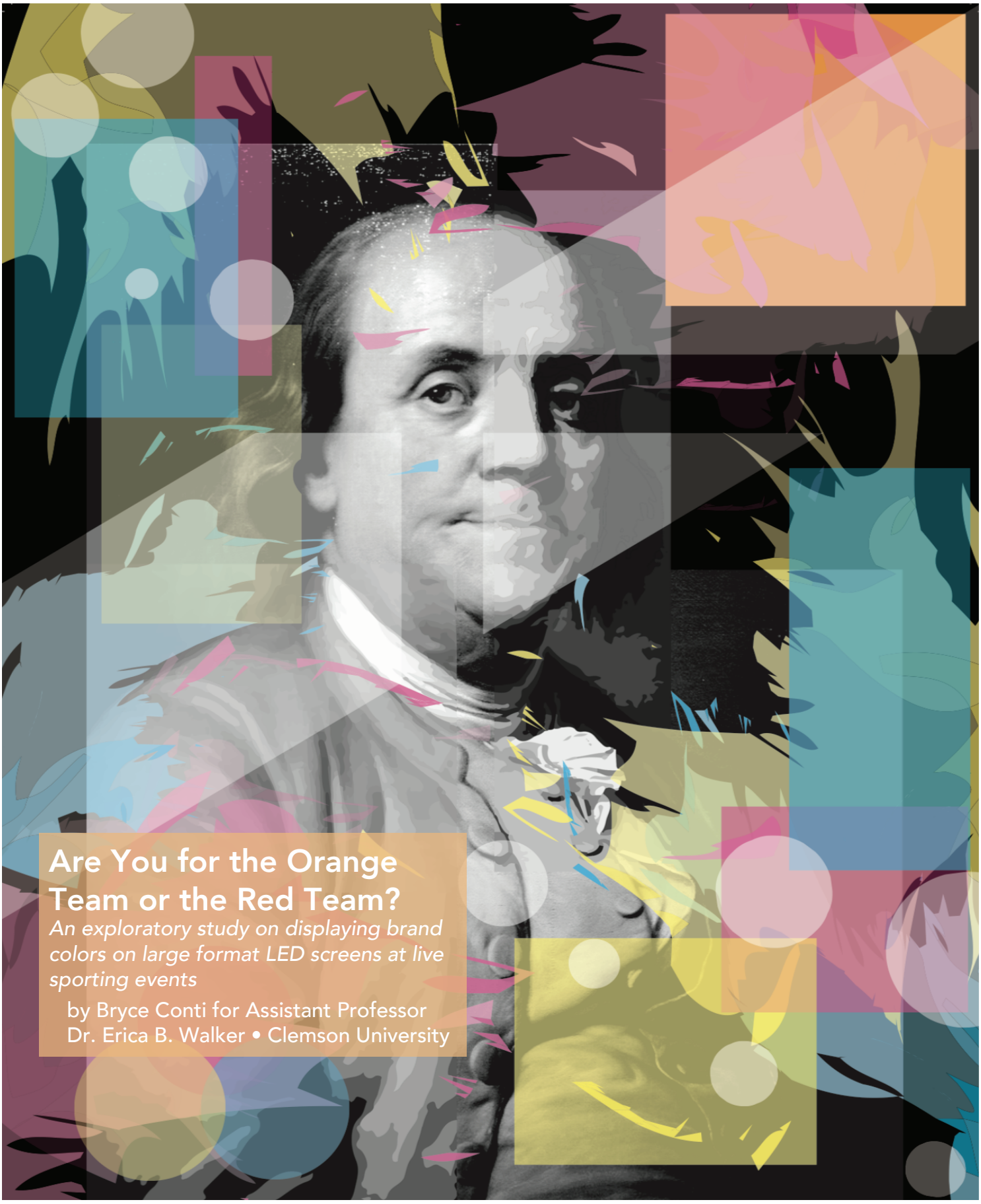

Are You for the Orange Team or the Red Team?

An exploratory study on displaying brand colors on large format LED screens at live sporting events

by Bryce Conti for Assistant Professor Dr. Erica B. Walker • Clemson University

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Are You for the Orange Team or the Red Team?

An exploratory study on displaying brand colors on large format LED screens at live sporting events

by Bryce Conti for Assistant Professor Dr. Erica B. Walker • Clemson University

Introduction

This study focuses on managing brand colors on large-format video displays during live sporting events. First, we will look at current research regarding large-format screens and explore the technologies used by screen manufacturers to adjust and maintain color accuracy in varying conditions. Viewers perceive color differently and this can be further impacted by ambient lighting. In order to understand viewer tolerance for the variation of recognizable brand colors, we will survey a population of Clemson fans in Littlejohn Coliseum (indoor basketball arena) and in Memorial Stadium (outdoor football stadium). Once viewer tolerance is established, the next step will be to determine which external and internal factors can and need to be controlled to increase accurate reproduction. Color management on video displays is impacted by many factors including the input source, the screen's built-in technology, and native gamut, and the ambient light at the facility which can range broadly based on the time of day and weather (for outdoor fields) to mixed-artificial lighting (for indoor facilities). By looking at each of these factors individually, we begin to determine a path to more predictable color consistency within this volatile setting. This research will be used to determine whether fans are able to identify differences in their favorite brand's colors. With further research, the results will be used to understand the most effective way to manage and correct the brand's color being displayed.

With brand awareness becoming a popular topic in the world of marketing and advertising, brands are determined to manage as many of the aspects that are associated with their brands as they can. Though there are many different assets within brand standards, and the one that stands out the most and is difficult to control is color. This is due to the various factors that go into managing a brand's colors. When managing color, there can be both input and output factors that can alter the way a consumer perceives the color. The results from this experiment are going to be used to determine the importance of color management in regards to brands on large digital displays, as well as determining the different ways to manage how a consumer perceives that color.

These ideas lead us to the main question of "Does the average fan/consumer notice color-inaccuracies on large format LED screens, specifically those at sporting events?" This overarching question will lead further experimentation to examine if it is important to the consumer that the colors being presented on these large screen have to align with a brand's color standards, or if the consumer trusts that the content that is being displayed is correct.

Phase 1: Exploratory Survey
Do comparisons across multiple screens and situations- indoor & outdoor, the age of screens, and types of footage (pre-recorded, animations, and live feed footage) and determine whether participants perceive that on the displays is brand-accurate color.

- Hypothesis 1: Participants who view the video content in Memorial Stadium and Littlejohn Coliseum are less likely to not notice the inaccurate Clemson orange color without prompt than those who are prompted to look at the difference in color.
- Hypothesis 2: Participants who view the video content in Memorial Stadium and Littlejohn Coliseum are more likely to notice the inaccurate Clemson orange color with prompt than those who are not prompted to look at the difference in color.
- Hypothesis 3: Participants who viewed the video in ambient lighting were less likely to notice color inaccuracies than those who viewed the videos in a controlled environment.

Phase 2: Examine potential variables

- Determine what (if any) factors allow us to better control the output of brand-specific colors (input devices, the screen settings, the ambient lighting or a combination of factors).
- Look at the input cameras: is there a difference in which one's create footage that is closest to true color? Do the cameras have the best possible settings to output to the screen?
- Look at the native gamut for each screen: is there a difference in what each screen is capable of attaining?
- Create profiles for different inputs: does this improve consistency and accuracy?
- Create export profiles for pre-created video content: does this improve consistency and accuracy?
- Create profiles for the screens themselves (if possible): does this improve accuracy across all device inputs?

Phase 3: Survey
Determine if the adjustments developed in Phase 2 improve the consistency of color management on large format screens by again surveying a population in both locations. Develop a systematic approach to creating and deploying screen-specific content that can be implemented by the team of professionals working the boards for the live sporting events.

Literature review

LED

Technology has greatly improved over the last 20 years, specifically with viewing displays. These improvements have to lead to the innovation and creation of better viewing and display capabilities when it comes to content. The LED screen has now become the industry norm for its versatile use as well as the quality of the image that it is able to reproduce. LEDs are plastic capsules containing a specific chemical compound on a microscopic wafer that emits light when subjected to an electrical current (de Ryckel, 2007). The emission of light depends on electrons flowing between the anode and cathode within an LED chip, and the color of the visual emission depends on the materials utilized. When several of these LED capsules put together to become a pixel. The pixels create a luminescence that is either red, green, or blue. Each pixel creates a piece of the larger display by having its own color and brightness. The higher the number of pixels present the higher the resolution is of that media on the display (de Ryckel, 2007).

For LED screens, the most important factor in an LED screen is the distance between different pixels, this is called the pixel pitch. Pixel Pitch is measured in millimeters and the overage pixel pitch for outdoor screens currently is 12–30mm, and 3–12mm for indoor screens. The screen and the viewing distance determines what the pixel pitch is, for example, if the viewer is watching the screen at a short distance, like watching tv you would want the pixel pitch to be much smaller than that of a sports arena display or a billboard. For the larger pixel pitch, the closer you get the more difficult it is to view what is being displayed (de Ryckel, 2007).

LED also allows for a wider color gamut that produces more accurate colors than displays could previously provide. There is a correlation with the quality of the color being displayed and the age of the screen. LEDs age in various ways, so the quality of one LED may vary from the one right next to it due to the different decay curves of the red, greens, and blues. Essentially the more the LED display is used it will gradually lose brightness and

quality. LED screens have a far greater lifespan than LCD, plasma, and other display technology. In order to control the decay curve and the color shifts on the display, the LEDs need to be set at a lower power that will help in managing the quality of the colors being displayed (de Ryckel, 2007). On a backlit screen LEDs will age in various ways and will, therefore, need regular tuning to ensure that uniform brightness and color are being displayed. Foraging correction, an adaptive algorithm will have the ability to use the displays built-in color sensor to determine the current state of decay, and then by applying the predetermined algorithms, the display will create an accurate white-point that is being displayed ensuring that all colors being displayed are correct (O'Sullivan & Pantalone, 2009).

Color Gamut

As technology has evolved over the past sixty years, having one color gamut is no longer enough to produce the colors that are being demanded by both producers and viewers . Developments in color management within wider-color-gamut standards found in new technology including, 4K UHD TVs, laptops, cell phones, digital cinema, and other technology are now requiring two color gamuts to produce accurate colors of the desired media (Soneira, 2016). Content and displays have evolved as the technology has evolved which has allowed for both to stray away from the traditional primary colors of display. Many different gamuts have been created for specific applications and not all of these were built the same which leads to inconsistencies when it comes to color reproduction. The outermost area of a color gamut are typically viewed as the most saturated hue of a color. Most of the content that is being displayed to the viewer by screens is held within those the inner areas of a color gamut, therefore these colors must also be reproduced correctly even if they are not "pushing the boundaries" of a particular gamut (Soneira, 2016).

The standard RGB color gamut had many issues with re-producing the desired color. It was a system that required that the colors be within a gamut perfectly or else the colors are displayed either too saturated or undersaturated (Soneria, 2016). The standard RGB was used as the color gamut for the first HD TVs but by the time that those televisions were sold to consumers, the color gamut was already outdated for what the industry was able to reproduce (Brennesholtz, 2006). Since the development of the standard RGB color gamut, there have been two new developments to increase the gamut of color reproduction on screens. Adobe RGB used widely by professionals and other advanced imaging specialists who focus on the quality of the image that was being produced (Soneria, 2016). This color gamut was seventeen percent larger than that of the standard RGB gamut. The newest color gamut is called the DCI-P3 color gamut and is used by the movie industry and becoming the new standard for the new 4K UHD TV. DCI-P3 has a 26% larger gamut than that of its predecessor (Soneria, 2016)

Ambient Lighting with Color Gamuts

LED technology is the most popular choice for displaying media due to its ability to project a quality image under any lighting condition, this includes direct sunlight. Their ability to display media at optimal brightness attributes to its popularity at various outdoor events where the ambient lighting varies (de Ryckel, 2007). Color gamut seen on a screen is automatically reduced by ambient lighting that is cast onto the screen (Soneria, 2016). Many consumers believe that viewing content on a display that has a wider color gamut presents a better viewing experience when in reality the content they are viewing is more saturated than originally intended. These oversaturated colors may look brighter to the viewers but are not the intended colors leading to errors within the color management system (Soneria, 2016).

Issues with LED & Color Gamut

When a display is unable to produce a particular hue of a color, the screen selects the closest color to match the unreproducible color. This process eliminates the colors that are non reproducible, but desaturates the entire image so that the non reproducible colors become the most saturated colors in that image (Soneria, 2016). With further developments in creating a larger color gamut, several of the systems used to reproduce those colors were not able to create a "good" red color. An ultra-high-pressure (UHP) lamp with any standard three-color system (RGB) had no issues creating blue and green colors, but when reproducing reds the colors lacked saturation and brightness. This, in turn, sparked the development of the multiple primary color (MPC) system that incorporated five colors, and with MPC system and a UHP-lamp, there were significant differences in the

reds that were being displayed, as well as the ability to reproduce different shades of gold (Brennesholtz, 2006)

LED screens changed the industry by increasing the colors they were able to produce but also increasing the cost of the display. Research shows that consumers were willing to pay more for a "new design" of a display rather than focusing on the quality of an image. This became a marketing tool when introducing new color systems by also introducing new designs. The trends followed that the thinner and wider the television the better perceived quality (Kim & Semenza, 2012).

Method

Through the formal application process at Clemson University, this experiment did receive IRB clearance to test our experiment on volunteer participants. Participants will range from available students and faculty who were recruited in the Clemson area during the summer of 2018. These participants ages ranged from 18 to 40 years of age. The sample for this experiment was based on convenience. Recruitment methods included sending out on departmental email list services, including Clemson's College of Business, Clemson Graphic Communications Department, as well as the Graduate Student Government. Any student or faculty member who was available during the time of our facilities availability was accepted into the experiment.

Our sample size consisted of 49 responses. For this experiment, we tested participants in two different locations, some of the participants responded in both testing locations. Participants for this experiment also received a ten dollar Amazon gift card completing their session. If participants were tested at both locations, they received two gift cards.

For Phase I, we used a survey as the primary method for collecting the data. The survey, see appendix, allowed participants to rank the quality of the content they viewed on the screen, without giving away that the experiment is focused on color until the end of the survey. The results were analyzed as group averages, as well as by examining the individual's response to the video content.

For this experiment, we chose to use an exploratory design since previous research revealed that there is a lack of studies focused on brand color management on large LED platforms. Results from Phase I will inform further research in subsequent phases. This design also allows for flexibility within the experiment, with the potential to continue to evolve the research plan. For example, there is a scientific component written in phase II and III, but there is also the potential for a consumer behavior aspect if desired. Lastly, this design will allow the researchers to determine which variables to prioritize in the experiment.

The independent variables for this experiment are the videos that are being shown on the large format LED screens. For each of our locations, we showed three pieces of content, relevant to what the consumer would be watching in the respective sports arena. The dependent variable is the fan and/or the consumer's perception of the color being viewed. Controlled variables in this experiment include the LED screens used in both Memorial Stadium and Littlejohn Coliseum.

To conduct this phase of the research there will be at least three team members. Their roles are as followed:

Team Member 1: Content Control Room Coordinator

Team Member 2: Facilitator of Experimental Survey.

Team Member 3: Welcome Greeter and Escort to xperiment location.

Team Member 3 will stand at Gate 9 for Memorial Stadium and the door at the Burton Gallery in Littlejohn and wait for participants to arrive. Once participants arrive, Team Member 3 will escort participants from the entrance to the viewing area. For Memorial Stadium, the viewing area will be located in the West End Zone in Section W1, and in Littlejohn Coliseum, the viewing area will be in Section L132. Once in the viewing area and all participants have arrived Team Member 2 will distribute laptops and explain the procedure of the experiment. Instructing participants to fill out the informational part of the survey, and wait until after watching the designated clip to fill out the second, third, and fourth part of the survey. After participants are clear with how the experiment will function, Team Member 2 will signal to Team Member 1 via text to begin the video clips. Once the video clip is complete, participants will be asked to complete the designated portion of the survey for the clip. The process was repeated for the next two clips. Once all clips and associated surveys are completed, participants will be asked to complete one final survey regarding the content that was displayed. After completion, participants will receive monetary compensation

of a $10 gift card and Team Member 2 will escort the participants out of the designated facility.

Results

Overall results were split very evenly. When looking at the breakdown, the participants who selected live-game footage as the least accurate, were those who did not mention color or thought that it looked accurate in the footage. One of the participants had an interesting note: "the live game footage looked more accurate because it was direct footage." It could be hypothesized that this reveals the consumer's trust in a specific brand.

Most people used their environment in the stadium as the determinant if the orange they were viewing was the "correct" color. Of all the stadium participants, 42% of viewers referenced the stadium seats and the surrounding orange colors for comparison when looking at the color. One participant referenced how the color of the grass was inconsistent with the color of the grass on the live footage. Further research could be done to see if there is an easier determinant of color inaccuracies in the range of green light since that color is more prevalent in the visible color gamut.

Due to limited access to both facilities and a small sample pool, many of the participants participated in both locations. The Littlejohn facility had testing in the morning while Memorial Stadium was later in the afternoon. On average, participants who picked the "accuracy of the color" option on the survey, chose that the animated graphic displayed the most accurate of colors. 55% of the participants noticed the color was not accurate, noting that it appeared either saturated or red-ish. 81% of those that noted inaccurate color were participants that have participated in both locations, so there is the question of whether or not they were looking for color the second time through the experiment. This further begs the question, "If instructed, many of the participants noticed the coloring was off but does the incorrect color hinder the experience of viewing content on large LED screens?" It could be hypothesized that participants that do notice the color inaccuracies would not be negatively affected by the overall quality of the content if the actual video content was enjoyable and added to the gameday experience.

In comparison, of those who were not previously tested at one of the facilities, 63% of participants did not comment on color after participating in the survey. These participants commented more on the quality in regards to "pixelation" of the video or animation on the screen. There may have been a misunderstanding of what the definitions of the words used on the survey meant. In regards to all of our participants, 39% referenced "pixelation" and resolution in their responses about negative impacts of the video. This was puzzling because all three of the clips shown were of the highest resolution for their respective screens, therefore future researchers should include definitions of what the various technical terms mean.

Discussion

Overall, the results revealed that over half of the participants did not notice the color discrepancies of Clemson orange, but instead focused on the quality of the video content. This could be due to the idea of what a brand embodies now, trust in the consumer, not only for the quality but that everything being presented from that brand is up to the standard of that brand. For the "quality aspect of the live-footage," the rating was at an average of 4.3 in Littlejohn Coliseum and 4.1 in Memorial Stadium. Which is very interesting when regarding the overall appearance of the presented color. Viewers were aware that color was a factor in the quality of the clip, mainly that the color had a red-ish hue, but overall ranked the clip at the higher end of the scale. Analysis did reveal that those participants who participated a second time were able to pick out the color differences, specifically with the game footage, with greater ease than those who did not partake in two sessions. With further experimentation, researchers could measure throughout the raw clip to see if the color that is being perceived is even within the brand standard of Clemson from camera to camera.

It could be argued that an average viewer trusts that the content that they consume is already aligned with the brand's standard. Furthermore, with the trust that is put in the Clemson University brand, as long as the consumer is getting the content, the average fan would not mind that the color is not exactly correct or might not even notice it. It could also be hypothesized that the surroundings play more of a role than the accuracy of the content itself. It would be interesting to look further into the environment of the surrounding screens and determine if it affects the outcome of the experiment. Further research on consumer trust could be evaluated, especially when looking at the "Clemson Orange" stadium seats that are throughout the stadium. Most of these seats, as well as most stadium seats, are a factory

standard of orange, though many of the participants used these environmental factors to determine if the color on the screen was accurate.

As discussed, the limitations of this experiment include both the limited access to the testing facilities, as well as the small sample pool. However, even with these limitations, we can still conclude that observers placed some importance in the color accuracy of the large display screens. There was also a limitation of the weather when conducting research in Memorial Stadium. There was full sun, cloud coverage, as well as a brief rain shower during the experiment that could have altered the results of those who participating due to the impact of varying ambient light. However, even outside of this study, outdoor stadiums do experience a broad range of weather and ambient lighting situations that can impact viewer experience.

For future research, there are two avenues that can be taken. There could be a route that follows Phase 2 of the original experimental. This could look at the color management in regards to the input and output of the content being displayed on the screens, and identifying if there is a way to more consistently manage the color being displayed. This might include a "filter" on cameras streaming the video content to automatically color correct the content, or having an algorithm within the screen to correct the various inputs that are being streamed on the displays.

There could also be a phase of the research examining consumer behavior and their psychological response to color. This could be broken down into brand trust, color awareness, and the environment. As discussed earlier, the trust in a brand could impact whether or not viewers notice the imperfections of a brand's color. Testing how much consumers trust a brand could lead to further insight into what brands need to focus on when it comes to brand standards and management. This could lead to the importance of brand color awareness and an understanding of when consumers are aware of inaccuracies to a brand's color. There are obvious differences between your typical spectrum colors, but if you were to alter a brands color slightly, would a consumer be able to tell the difference? Lastly, there is an opportunity to look at the consumer's behavior in various environments. For example, if a participant was in a dark room with just the screen would the results be different than one who was in a stadium next to other objects in the "brand colors." There are various ways that this initial research can help spearhead further experimentation to look at the effects of color management systems in large LED screens and what brands can do to ensure that their brand is being represented as accurately as possible.

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» Photos should be about 300 ppi to span one column (3-inches) or 2 columns (6.5-inches).

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» Tables will be formatted by the designer to fit in one column (3" wide) or across two columns (6.5" wide).

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