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Colors and Mapping: The Right to Receive Information

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by

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ABSTRACT

Color is used in everything we see and do and it often can be used for effect and representation, particularly on maps and transportation signage. This study explores the issues that the color blind population exhibits when viewing these maps and signs. Seeing that 8% of the male population is afflicted with some form of color blindness, it is pertinent that research reflect these issues and take into consideration the Right to Receive Information for this population. A qualitative method using Photovoice and interviews was used to determine whether this population considers itself having a disability and what solutions can be found to assist with issues of seeing colors on transportation maps and signage. Results show that although half of the participants feel they have a disability, they do not want to be categorized with other disabilities or have restrictions placed on them. The overall consensus regarding maps was to use less colors and simplify. One solution to the issue of being able to read maps and signage was to instill the ColorADD Symbol System in the U.S. comprehensively.

This study provides insight to the issues faced by the color blind population regarding Right to Receive Information for maps and signage, including alternate solutions to providing color blind people with sufficient materials. The significance of this research can be used to provide safer transportation signage for driving and better maps for travelling.

CHAPTER ONE:

INTRODUCTION

Imagine you're visiting a friend in New York City. Taking the subway to his house, you look at the map unsure of which route to take. Each route is nicely color-coded, but unfortunately you're color blind. Figure 1 shows what the subway map looks like, and how you would see it as a color blind person. Many of the colors appear to be the same. If you're unfamiliar with the area, this could be an issue of accessibility for you, the color blind person.

Figure 1. Close-up view of New York Subway Map. The left image is the actual subway map. The right side is how a color blind person would view the subway map.

Color blindness is not being blind at all. It's only a different way of seeing colors (Bailey & Haddrill, 2011). There are several types of color blindness with the most common types being deuteranopia and protanopia, both referred to as red-green color blindness. For the purpose of this paper, the researcher will focus mainly on red-green color blindness. The

aim of the paper is to delineate the difficulties faced by color blind people, adapting the first amendment principle and theory of the right to receive information to an argument for the implementation of signage and mapping that is more accessible for color blind people.

The literature review will begin with an explanation of what color blindness is, how color blind people see colors differently, and statistical information on the affected population. There will be an analysis of colors as well as visual samples throughout so the reader will be able to clearly see the differences in vision between a color blind person and a person with normal vision. A narrative and phenomenological methodology section will provide research questions and explain, through photographs and interviews, how the inability to see certain colors in reading maps and signage can make it difficult for the color blind person to live a normal life. Final discussion will review the interview results and apply right to receive expression first amendment theory as well as to explain how color blindness can be considered an accessibility issue.

CHAPTER TWO:

REVIEW OF LITERATURE

Color Blindness Defined

Often it is thought that people who are color blind can only see in shades of grey. On the contrary, they *can* see color, but certain colors will appear washed out or similar to other colors (Bailey & Haddrill, 2011). Typically a person with red-green color blindness is able to clearly see blues and yellows, but reds and greens may appear as mossy greens or muddy browns and ochres. Certain homogeneous colors will appear as the same color. Figure 2 shows how a red-green color blind person would view colors of an image compared to how the image is truly colored. John Dalton, who discovered the condition of color blindness in 1794, also known as Daltonism, described how a can of red sealing wax appeared to be the same

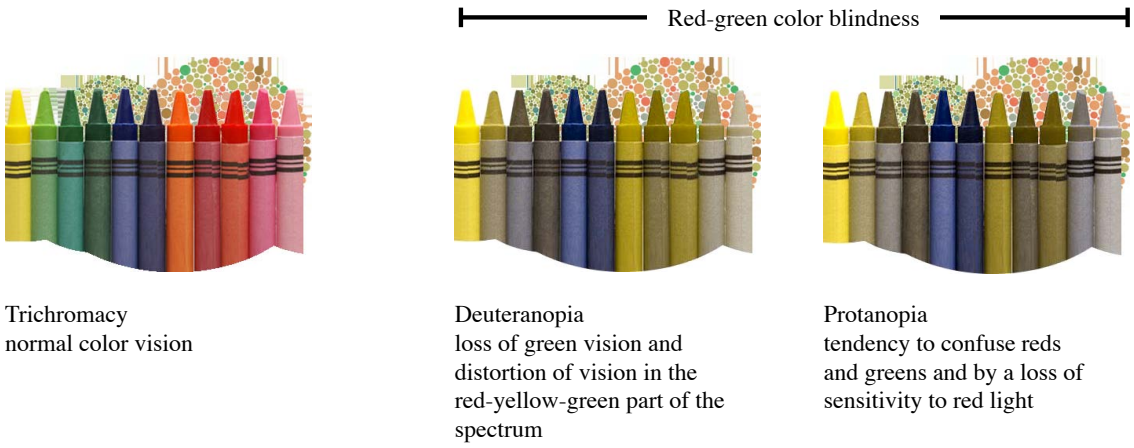


Figure 2. Normal color vision compared to red-green color blindness. The trichromacy image on the left shows how colors are viewed by a person with normal color vision. The middle and right images show how the same colors would be seen by a person with red-green color blindness.

color as a laurel leaf (Hunt, Dulai, Bowmaker & Mollon, 1995). In *Confessions of a Colour [sic] Blind Optometrist,* Dr. David Cockburn describes his difficulty in distinguishing currency, "I sometimes have difficulty in separating Australian currency notes because the $20 note is red and the $50 a yellowish colour [sic], which until writing this piece, I believed was green" (Cockburn 2004, p. 351).

This affliction can be mainly attributed to biological imperfections through genetics. Photosensitive cells in the eye are called rods and cones (Rigden, 1999). Rods are more sensitive to light, but do not distinguish colors, while the cones are responsible for color vision (Bailey & Haddrill, 2011). Fraser & Banks (2004) note that there are three cones in particular that recognize color wavelengths (Fraser & Banks, 2004). The L-cone allows for vision of longer wavelengths, such as red; the M-cone, medium wavelengths like green; and the S-cone for short wavelengths, as in blue. A person with red-green color blindness will have a deficiency in the L- or M-cones, therefore, reds and greens will appear differently (Fraser & Banks, 2004). The affliction is typically genetic, with the X chromosome being the carrier. In rare cases, non-genetic color vision defects can result from conditions such as Parkinson's disease, Kallman's Syndrome, and cataracts (Bailey & Haddrill, 2011).

Statistical Research on Color Blindness

Studies have shown that there are a significant number of people afflicted with color vision deficiency in one way or another. According to Prevent Blindness America, 8% of the male population suffers from some form of color vision deficiency, while less than 1% of females are affected (Bailey & Haddrill, 2011). Rigden states that only about 0.4% of females suffer from red-green color blindness (Rigden, 1999). There are over 250 million color blind people worldwide (Colour Blind Awareness, n.d.). These statistics indicate the importance

of considering color aspects when designing informational pieces such as maps, emergency notifications, and cautionary warnings. Yet, there is very little research that takes color blindness into consideration on these issues.

Color Meanings Defined

Color is used in everything we see and do and it often can be used for effect and representation. It would be pertinent to know some background about how colors are utilized in daily life and how they are perceived. This section will provide insight about primary and some complementary colors, as well as touch on hues, brightness, and values of color. Red, yellow, blue, orange, and green are common colors used in everyday life. We see these colors often in transportation and mapping.

The primary colors, as we've learned in our youth, are red, yellow and blue. Red, often used for its vividness, can signify death in some religions and cultures (Selius, 2010; Fraser & Banks, 2004). In nature, if paired with yellow or black, red can suggest poison or danger (Fraser & Banks, 2004). Stop signs, emergency vehicles, and warning labels are common items that utilize the color red. Maps often use red to signify certain roads, bus routes, or even traffic congestion on GPS maps.

Yellow can seem oppressive in high doses, but typically tends to be cheerful (Chijiiwa, 1987). Often associated with confidence, friendliness, and creativity (Fraser & Banks, 2004), yellow is also commonly used as a route symbol in mapping, cautionary signals, and in highlighting material for importance.

Blue is the second strongest color, behind red (Pastoureau, 2001). It is a neutral color, given least often as a disliked color and typically does not shock, offend or disgust people. It is most often chosen as a favorite color (Pastoureau, 2001). Blue, seen in emergency vehicle

lighting, isn't as often used for warnings, but rather in directional service signs, such as "phone" or "hospital" nearby, and handicap accessibility signage. It is commonly used on maps to symbolize bodies of water and bus routes.

Two complementary colors on the color wheel are orange and green. These colors are derived by mixing equal parts of two primary colors. Red and yellow together produce orange, while blue and yellow create green.

Orange is said to have qualities of optimism and progress (Fraser & Banks, 2004). Chijiiwa (1987) categorizes orange as a warm color that is also eye-catching and used often in safety, construction, and road signs (Chijiiwa, 1987).

Selius (2010) designates green as the easiest color for the eye to see (Selius, 2010). Although true in normal vision, this will not be case for an individual with red-green color blindness. For normal vision people, green is commonly seen in directional road signage, recycling signs, and symbolizes land areas on maps.

Hue and brightness play a vital role in viewing colors as well. Together, they are the main visual components of a color. Hue is the characteristic that distinguishes one color from another (Mahnke & Mahnke, 1987). In other words, hue is the actual color itself (Chijiiwa, 1987). According to Mahnke and Mahnke (1987), brightness differentiates a dark color from a light color. Brightness is determined by how much light is reflected off the color (Mahnke & Mahnke, 1987). Value is determined by the lightness or darkness of a color. Adding black or white to a color changes its value (Selius, 2010). For example, navy and royal could be considered different values of blue. Colors of similar values will be difficult for color blind people to see, as there is little contrast between the values.

Using colors individually on signage may not necessarily be an issue to a person who is

color blind. White lettering on a green sign can still be understood and read properly; the high contrast works. According to Cole and Lian (2006), people with color vision deficiency are less likely to notice the presence of road signs and traffic signals than those with normal vision (Cole & Lian, 2006). This is because the backgrounds of the signs don't contrast well with the lighting (Cole & Lian, 2006). According to Heitgerd, et al. (2008), cartographic cognition is how the human brain interprets spatial patterns and relations when viewing GIS maps (Heitgerd, et al., 2008). Cartographers suggest using 4-6 choropleths (i.e. shaded areas) to represent areas on maps so as to keep the mapping more simplistic for everyone (Heitgerd, et al., 2008). However, when multiple colors are intermixed on maps, it becomes difficult for a color blind person to determine the meaning of each color because the colors appear the same. Therefore, an alternate version should be available for people who cannot view the maps as intended.

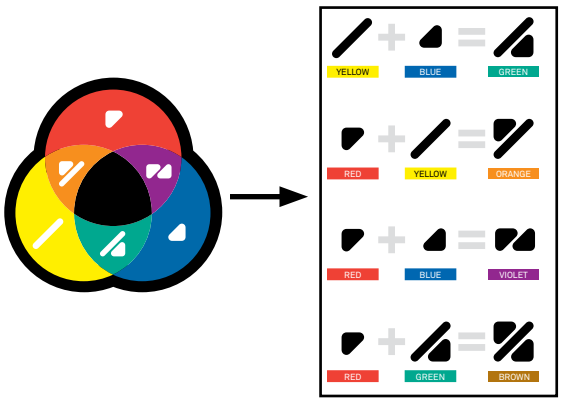
Color Blindness and Accessibility

In Australia, employers have to be cautious that they aren't excluding workers because of their inability to see color properly (Cole & Lian, 2006). Often in the workplace graphs and financial information is color coded. Australian employers must provide evidence that they are not discriminating against color blind workers by proving that the worker is not unable to reasonably fulfill the job requirements due to the impairment (Cole & Lian, 2006). Discrimination is allowed, however, where necessary for the safety of others (Cole & Lian, 2006).

In Portugal, there has been a realization that color blind people need better accessibility. A company called ColorADD has developed a set of standard symbols to coincide with colors so that the color blind population has a better understanding of what each color is representing when looking at maps and signage. Figure 3 shows the coding and how it is used by a color

blind individual. Currently, Kathryn Albany-Ward, founder of the U. K. based Colour [sic] Blind Awareness Organization, is working with ColorADD to introduce the color coding in London's Underground Subway system. It has been successfully managed onto the Porto Underground System in Portugal. The BBC Channel, also based in the U. K., produces a children's television show titled, *Chuggington*. Two of the characters, Hoot and Toot, are small trains attached at opposite ends. In one episode, Hoot tries to take the lead, only to find out that he is color blind and cannot make the proper deliveries (Ball & Bell, 2013). It is apparent that the topic of color blindness has gained sufficient importance to support a TV episode focussed on sensitizing school aged children to the issue.

In terms of safety, a study by Steward and Cole (1989) reported that out of 102 color blind participants, 29% had trouble distinguishing the colors of traffic signals, while 32% confused these lights with common street lights (Steward & Cole, 1989). In another study, it was found that color blind subjects had a longer response time to traffic signals than those with normal vision (Atchison, Pedersen, Dain, and Wood, 2003). This research proves that



ColorADD's symbol system representing the different colors

ColorADD's symbol system interpreting colors on maps

Figure 3. Color symbol system developed by ColorADD By seeing the symbol on the colored area, this helps a color blind person determining which color he's looking at. From there, the symbols can be "transferred" for uses on other items, such as maps.

more consequences exist for third party drivers and pedestrians. Besides these two studies, there is little current research on how color blind drivers can impact the safety of themselves and others around them given their impairment of the inability to identify and react to traffic signals.

Accessibility Laws and the Right to Receive Expression

Although accessibility laws in the U.S. discuss signage, there's little that ensures color blind people will have access to maps that they can actually comprehend. According to the Americans with Disabilities Act (ADA) Accessibility Guidelines for Buildings and Facilities (United States Access Board), building maps need to be tactile or provide audible cues for people with vision deficiency:

> "In building complexes where finding locations independently on a routine basis may be a necessity (for example, college campuses), tactile maps or prerecorded instructions can be very helpful to visually impaired people. Several maps and auditory instructions have been developed and tested for specific applications. The type of map or instructions used must be based on the information to be communicated, which depends highly on the type of buildings or users" (United States Access Board A4.30.1.)

However, there is no such requirement in relation to providing road and public transportation maps, bus schedules, and other color coded pieces that ensure safe travel for color blind people. On the other hand, the law may not see color blind people as having a disability. According to the Americans with Disabilities Act:

> An individual with a disability is defined by the ADA as a person who has a physical or mental impairment that substantially limits one or more major life activities [sic], a person who has a history or record of such an impairment, or a person who is perceived by others as having such an impairment. Sec. 12102.

[1]425 U.S. 748 (1976)

Some may say that color blind people can still "see" so they're not considered blind, and that this vision impairment may not necessarily "substantially limit one or more major life activities." However, color blind people have difficulty reading maps that facilitate travel from one place to another. Whether it is a road map or a subway map, the colors being used can be quite confusing to this population as shown in Figure 1 on page 1.

The First Amendment to the U.S. Constitution guarantees the right to receive information. If a person cannot access the information, then the guarantee loses its value (Mart, 2003). The case of *Virginia State Board of Pharmacy v. Virginia Citizen's Consumer Council*[1] involved consumers who wanted to know the cost of prescription drugs. The state, however, had a law prohibiting pharmacies from advertising such information (Mart, 2003; Lee, 1987). The Supreme Court held there was a first amendment right for consumers to receive information. The court said this was not based on the advertiser's right to speak, but on the public's right to receive information.

The color blind population should also have an equal right to receive information to that enjoyed by people with normal vision. The argument of this paper is that signage and maps that do not take into consideration the vision disabilities of color blind people, hindering their ability to receive information discriminates against these people. This group requires access to information that they can properly assimilate in travelling from one place to another. Using more accessible coding or different colors that are more discernible by this population, would ensure their equal ability to navigate government maintained roads and subways.

CHAPTER THREE

IMPORTANCE OF RESEARCH

Several organizations have posted information on websites to educate the public about color blindness. One site in particular that has several good points to consider is that of the Colour [sic] Blind Awareness Organization in the United Kingdom. This site reviews how companies can create better accessibility for the color blind population and urges these reforms. Regarding color blindness in the workplace, it was noted that companies need to take into consideration color vision deficiency or they may face lawsuits for not being accessibility compliant (Kivlehan, 2011). According to Kathryn Albany-Ward, a qualified chartered surveyor and founder of the Colour [sic] Blind Awareness Organization in the U.K., "The law has not yet been properly tested, but employment tribunal case law is growing" She adds, "it only takes one case in court [to set precedence] [sic]" (Kivlehan, 2011, p. 85).

The U.S. National Library of Medicine provides access to articles and research on various forms of color blindness as well as testing to determine the extent of an individual's affliction. Education regarding this topic is important, but research has failed to provide consistency on how people with color blindness are affected in everyday life. Besides a forum or two and a few blogs online, very few scholarly articles have been found that correlate research on color vision deficiency and how this population is affected by not being provided with alternate ways of viewing maps for travel. Since more than 12 million males in the U.S. are afflicted with some form of color blindness, research is needed to properly highlight the issues faced by color blind people in travel and to measure the inclusiveness and accessibility of this population.

CHAPTER FOUR:

RESEARCH QUESTIONS

In order to seek right to receive expression for color blind people regarding maps, it must first be determined whether, in fact, color blind people have a disability. Research must also provide answers to how issues can be solved by providing better material for this population. Hence, the following research questions have been developed:

RQ1: Does the color blind population consider itself to have a disability?

RQ2: What issues can be solved by creating better maps for color blind people?

RQ3: How can better materials be provided for the color blind population?

RQ4: What standards need to be established to assure that the color blind population's right to receive expression is protected?

CHAPTER FIVE:

METHOD

This research required using a narrative and phenomenological qualitative method. The narrative component utilized a concept called Participatory Photography, also known as Photovoice. Photovoice, developed by Caroline C. Wang, and Mary Ann Burris in 1994, is essentially research that involved the participant telling a story through the use of photographs (Wang & Burris, 1994). Wang and Burris used Photovoice to provide a means for women in China to influence policy in their country by documenting health issues via photography (Wang & Burris, 1994). This differs from photo journalism or photo documentation in that with Photovoice, the person taking the photos is the one affected by the issue. Therefore, the researcher gets the view from the subject, not the outsider (Wang & Burris, 1994).

The second component was a phenomenological study involving individual interviews, which were conducted for the purpose of establishing answers to the research questions proposed. The researcher set aside all opinion and experiences regarding the issues faced by the color blind population so as to obtain more description on experiences of the participants. This method was chosen to provide rich detail of common issues experienced by the color blind population associated with reading maps and signage. Interviewing also facilitated the determination of whether this population considers itself at a disadvantage regarding the right to receive expression.

Other countries such as Europe and Portugal have recognized the disadvantages that the color blind population experiences. In the United States it has yet to be determined whether color

blindness is, in fact, a disability and what issues this population faces.

Subject Selection

Subjects were obtained through posts on Facebook, as well as paper advertisements at the USF Eye Institute and the USF Marshall Student Center. Appendix A shows an example of the call for participants. Seven color blind males between the ages of 18 and 40 were interviewed either by online chat via Skype or in person. The age bracket 18-40 was chosen because 18-year-olds are considered adults and can participate in this type of research without parental consent, and according to the American Optometric Association, after the age of 40 adults begin experiencing eyesite deterioration due to the natural aging process (American Optometric Association, 2006-2013). Thus, the researcher decided to restrict the ages within this range. Also, as earlier indicated, males are the more dominant population affected with color blindness. Thus, the identified pool most affected will effectively reflect the population. Each interview took place in-person in a private room or via private Skype connection and was audio recorded. Interviews were conducted in a semi-structured manner in which the interviewer provided a set of questions, but maintained a casual, relaxed atmosphere (Berger, 2000).

While the researcher originally intended to interview ten people, she was only able to find nine who could pass the conditions. Of these nine, only seven stayed the course of the interview. Once a participant e-mailed the researcher expressing an interest in being interviewed, the researcher then e-mailed a link to an Ishihara Vision Plate test along with a consent form to be signed and returned prior to the interview appointment. Appendix B shows the Ishihara Vision Plate test and the test results. This test determined the extent of the color vision deficiency. The researcher did not diagnose color blindness, but used this test to determine eligibility for interviewing.

If the Ishihara test revealed color blindness, the researcher contacted the subject to set up a time and place (or Skype information) for the interview to take place. For each interview, the researcher gave a brief overview of the nature of the research as well as the purpose of the interview. Upon completion of each interview, the audio selections were transcribed to text and coded for similarities as well as entered into a database for comparison and clustering.

According to Creswell, data should be accumulated and "significant statements" should be exposed to develop clusters of meaning (Creswell, 2007). In other words, the researcher attempted to discover the common issues faced by the color blind participants as well as to determine whether this population considers itself to have a disability.

CHAPTER SIX:

RESULTS

Each of the seven participants was asked to take photographs of transportation items that they see in their normal day-to-day lives which cause them issues due to their color blindness. The photos were then e-mailed to the researcher for review and discussion during the interview process. Following the discussion of the photos were a series of interview questions pertaining to living with color blindness and the participant's views on whether color blindness should be considered a disability.

It became apparent to the researcher during the interview process that there were different levels of color blindness over the span of the participants. Through analyzing the interviews, the researcher deemed it necessary to categorize the participants as mild, medium or extreme in their color blindness condition. Three of the seven seemed to have a mild affliction (M1, M2, and M3). They have had issues at times of mis-labeling certain colors, however, they don't seem to be extremely affected in everyday life situations. Of the four remaining, two were categorized as having medium color blindness (Md1 and Md2) and two deemed extreme (E1 and E2). The two categorized as having medium color blindness both experienced issues with shades and values of colors looking the same (i.e. yellows and oranges appeared similar, and blues and purples appeared similar). The two most extreme cases had problems determining the differences between almost all colors discussed. The designations were not scientific, but determined by the researcher on the basis of the responses and used in order to facilitate ease of reference for purposes of the research.

Photovoice Results

The participants who exhibited the mildest form of color blindness did not submit photos. In discussion, all three subjects noted that they were unsure of what to photograph because their color blindness was a natural part of their lives. What they believed they saw, they believed to be normal. Nothing seemed to cause an issue or appear out of the ordinary.

Both subjects who had a medium form of color blindness provided photographs of maps. One map submitted had only black and blue bus routes (see Figure 4). The subject stated that

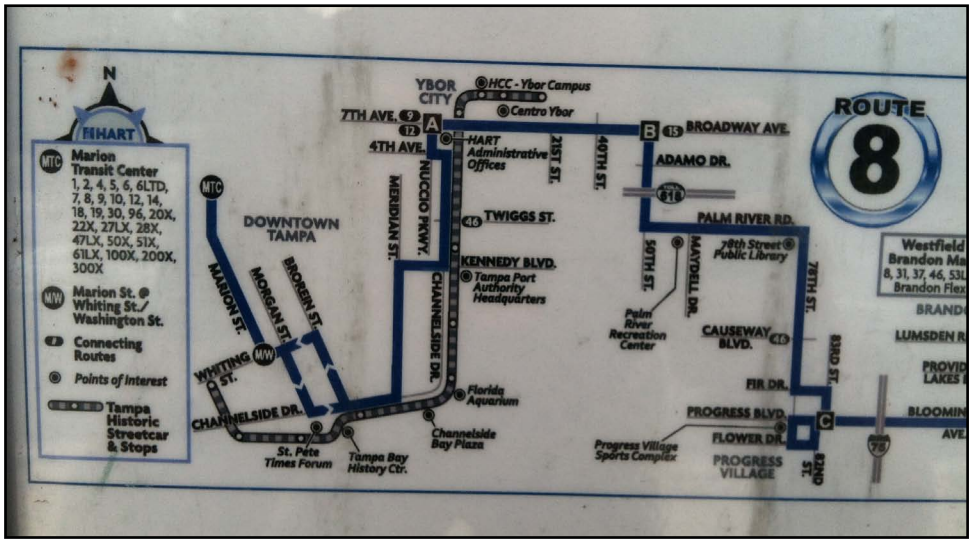


Figure 4. Photo of bus route provided by a subject categorized with medium color blindness.

while he felt he could read the map for travel purposes, the colors appeared to be turquoise to him. The other medium color blind subject who provided two USF campus maps (see Figure 5) had issues identifying buildings because they were so close in color to other areas on the maps. Ironically, one of the campus maps also happened to be a map that the researcher intended to discuss in the interview process. As expected, the most extreme difficulties were faced by the two interviewees identified as having more extreme color blind issues.

Figure 5. Two photos of maps provided by a subject categorized with medium color blindness.

One of the more extreme color blind subjects provided a photograph of a stop sign (see Figure 6A). In discussing this, he stated that the green trees located behind the stop sign appeared to be the same color as the red sign to him. This had caused him to be issued a traffic ticket when he had failed to stop. Two other photos (see Figure 6, B&C) presented by the same subject were of traffic and vehicle lights. With respect to the vehicle lights, during inclement weather some lights appeared non-existent to him. Regarding the traffic signal lights, he said:

> "... I see the green as white and then I see the red and yellow as orange... I know the top one's red, the middle one's yellow, and the last one, the bottom one's green. So I stop at everything except the white one."

The most extreme color blind subject provided a variety of photos. The most relevant to the study presented were photos of a GPS map (see Figure 7A), a flashing yellow light (see Figure 7B), and a portable bathroom door (see Figure 7C). In the photo of the GPS map, he said the roads appeared to be a similar color to the main route as depicted on the GPS minutely thicker than the other roads. Because of this, he said that he couldn't decipher which road he was to follow to arrive at his destination. The second photo had a yellow flashing light at a four

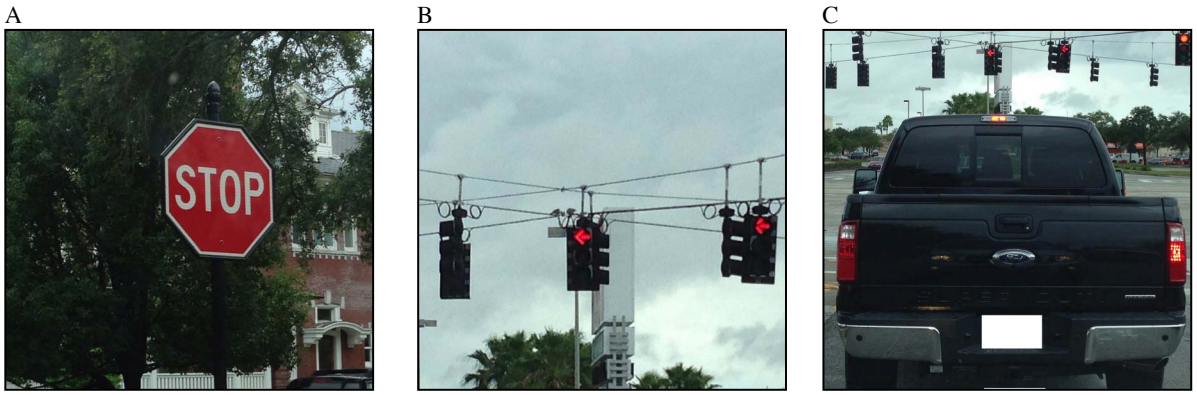


Figure 6. Photo of a stop sign (A), street lights (B), and vehicle lights (C) provided by a subject categorized with extreme color blindness.

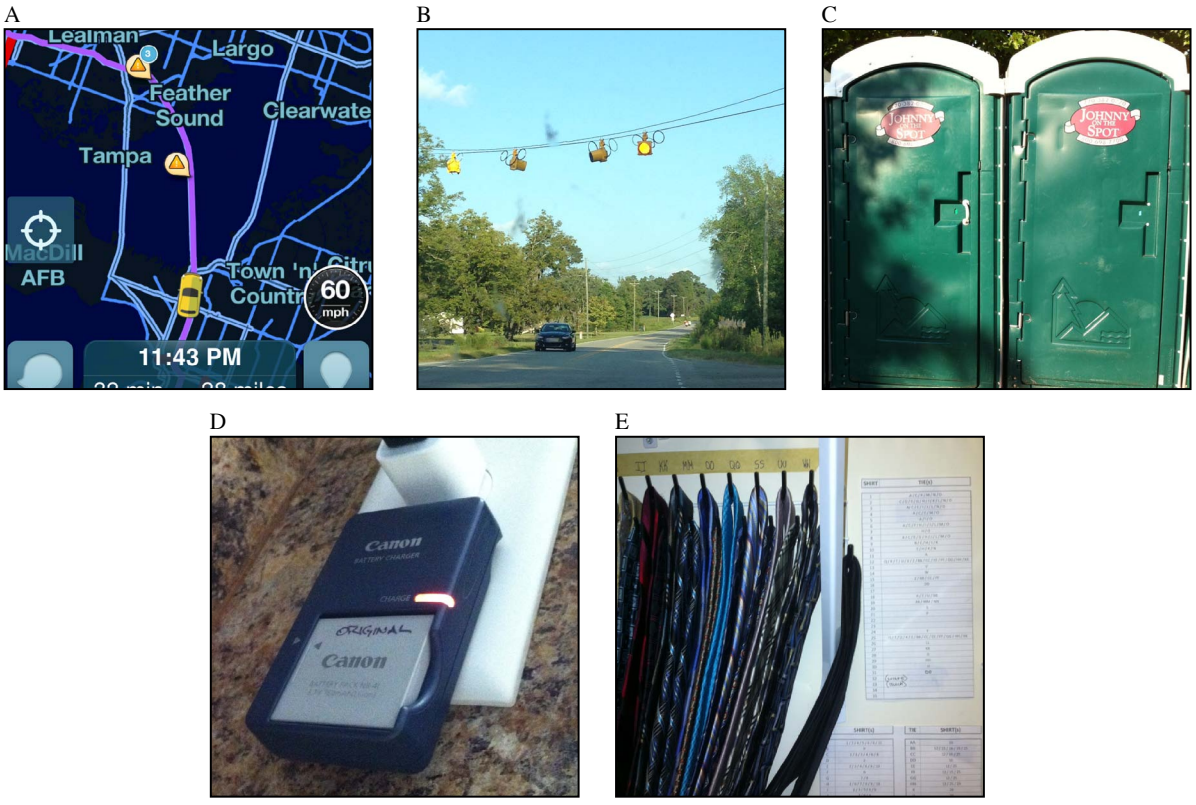


Figure 7. Photo of a GPS map (A), street lights (B), portable bathroom door (C), electronic device (D), and subject's closet (E) provided by a subject categorized with extreme color blindness.

way intersection. When asked if he had trouble seeing the light because the container holding the light was also yellow, he said that wasn't the issue. Flashing yellow means to proceed with caution while flashing red means to come to a complete stop before proceeding. He took the photo because the flashing yellow and reds lights both appeared the same to him—an orange color. In relation to the photo of the portable bathroom door, as well as airplane bathrooms, the signage is usually presented as red for occupied and green for unoccupied. The participant could not distinguish between these two colors. As a side note, this subject also provided imagery of electronic devices (see Figure 7D) which, again, he was unable to determine whether or not they were charged or even working properly because the lights to provide this information were red and green which seemed the same to him. The subject also provided a bonus photograph of his closet (see Figure 7E). With help from his family, his shirts and ties are alpha-numerically coded with a wall chart to assist him in choosing his wardrobe for the day.

Growing Up with Color Blindness

In discussing how they were treated as color blind children growing up, no one said that they had been teased or treated much differently from the normal vision population, but they had been questioned at times about what they were able to see. Most of the subjects were told by a friend of their color blindness rather than being diagnosed by a medical provider. However, two subjects categorized with mild color blindness were unable to pursue their career choices in the military, while an extreme case couldn't obtain his pilot's license due to color blindness testing. One of the medium cases stated that his affliction is more of a problem in his adult life due to his choice of career in creative design. He finds it difficult to match colors requested for a particular project without using a color-number matching system by Pantone©. Another subject, categorized as extreme, works in the fashion industry and sometimes guesses about colors when

around others. If he chooses a product of the wrong color, he "plays it off" as if he's having a bad day rather than revealing his color blindness. The other extreme case said that his parents would wrap his holiday presents in metallic gold and blue, because most other colors appear in gray to him. The same participant also discussed a former teacher who agreed to grade his papers in blue because he couldn't decipher the corrections in red pen from his hand-written gray pencil. Three participants, one from each category, were questioned by friends and teachers when they used odd colors for projects or matched colors improperly.

Using Maps

Five of the participants (all but two mild cases) said that they rely on GPS for their choice of maps. Four of the participants, two with medium color blindness as well as the two with the extreme condition said that the GPS maps are much easier to understand because they use less colors.

Two maps were provided during the interview process for discussion and participant viewpoint. One was the USF Bull Runner Routes Map (Appendix C), used for bus transit throughout campus with three routes providing off-campus service. The other map was the USF Daily/Visitor Parking Map (Appendix D). This map provides users with an overview of campus sectioned by color-labeled districts.

The first map reviewed was the Bull Runner map (see Appendix C). This map furnishes information for transit on six different colored routes. Each route is assigned a letter on the key. However, the map itself only provides color routes. Five subjects (one mild, and both medium and extreme cases) had issues with the dashed lines in which multiple routes converge in a particular area. A medium afflicted subject commented that he wouldn't be able to tell which route to take on Alumni Drive and Leroy Collins Boulevard, which is the main entrance to

campus. All the subjects said the map was very confusing because of the mix of multiple colors used in conjunction with solid and dashed lines. One participant, with a mild case of color blindness used the outer-lying routes of the map to trace the route back toward the center (or specific location) on campus, and even then stated the closer in to campus, the more difficult it was to distinguish the routes. Another mildly color blind participant felt he was guessing at the route colors, and a third participant with extreme color blindness could only distinguish the blue and yellow routes. Table 1 shows the results of the difficulties faced by the color blind participants when viewing bus routes.

Table 1. Using Maps - USF Bull Runner Bus Map

Issue	**M1**	**M2**	**M3**	**Md1**	**Md2**	**E1**	**E2**
Difficulties with dashed lines (multiple routes)		•		•	•	•	•
Problems identifying routes due to colors				•	•	•	•
Unable to identify most of the colors						•	•
Confusion due to too many colors	•	•	•	•	•	•	•

The second map discussed was the Visitor Parking map (see Appendix D). This map provides an overview of campus showing where particular buildings and parking areas are located by using a color key for specified districts. The key lists each district within a color bar, denoting seven different colored districts: blue, gold, green, red, medium gray, dark gray, light purple, and yellow. The roads were also a third shade of lighter gray. The map, itself, includes color coded buildings which are also labeled by name. When asked to name a building in a particular district, one of the mildly afflicted participants said he was able to identify it because he read the names, without bothering to look at the colors. Searching for the building name rather than using the color coding for the area in which the building was located took extra time for identification. Overall, the gray colors (2) and the gold as well as the light purple appeared to be

too similar in color. One participant with a medium form of color blindness stated that it might be better to use "main" colors rather than various shades throughout. The other medium afflicted participant and the two extremely color blind subjects had much difficulty with the three shades of gray coloring. One of the extreme cases said:

> "... that's a different gray, so I would've said, 'ok, the darker gray must be a color that I can't find. [To] any normal person, gray is gray, but to me I'm going to struggle because I don't know if it's gray or if it's a color or what."

Another participant, with mild color blindness noted that the color bars on the key were too close together to identify what color he was looking at, however, the colors spread out on the map itself were more decipherable. Table 2 gives an overview of the many issues faced by the participants regarding this map.

Table 2. Using Maps - USF Daily/Visitor Parking Map

Issue	**M1**	**M2**	**M3**	**Md1**	**Md2**	**E1**	**E2**
Preferred to read names versus using colors	•						
Problems identifying different colors				•	•	•	•
Unable to identify most of the colors				•		•	•
Difficulty with grey coloring				•		•	•

When asked about their overall feelings about both maps, two of the mildly afflicted respondents and one of the medium cases all stated that the maps were annoying with too many colors and labeling. The visitor map was more difficult to read because the buildings were too small on the map with an overabundance of clutter.

Regarding issues he had using maps, one mildly color blind respondent stated that he has developed his own way of getting around the difficulty of colors by not using topographic maps and by using hybrid settings on cell phone maps and GPS devices. Three other subjects,

one in each category, noted that shades and variances of colors were the toughest part of maps to decipher, and that they usually needed extra time to review a map with this type of coloring. Five subjects (two mild, two medium, and one extreme case) said if they couldn't interpret a map they would simply ask someone to point out what they needed to find. Of these five, one of the mildly color blind subjects and one of the medium reported that they tried to memorize specific portions of the map where they would typically travel so as to avoid using the map again. Table 3 provides insight into the more troublesome areas pertaining to mapping and street signage for color blind people.

Table 3. Sundry Issues with Using Maps and Signage

Issue	**M1**	**M2**	**M3**	**Md1**	**Md2**	**E1**	**E2**
Annoyance due to too many colors and labels	•	•		•			
Relies mainly on GPS for mapping			•	•	•	•	•
Shades and variances of color cause most problems		•			•	•	
Asks for help when unable to read maps		•	•	•	•	•	
Memorizes part of maps to avoid using again		•		•			
Difficulty distinguishing colored lights	•	•	•			•	•
Difficulty reading signage						•	•

Color Blindness and Disability

Table 4 shows results of how color blind participants feel about their condition being considered a disability.

Three of the subjects, one mild case and both of those with extreme conditions, felt they were "absolutely" at a disadvantage compared to people with normal vision. Another medium categorized participant said that, although he knows he has trouble with colors, he doesn't feel disadvantaged. Four subjects (two mild, one medium, and one extreme) said they had concerns

Table 4. Color Blindness and Disability

Issue	M1	M2	M3	Md1	Md2	E1	E2
Feels disadvantaged compared to normal vision				•		•	•
Concerns of career opportunities	•		•	•			•
Feels color blindness is a form a disability				•		•	•
Positive reaction to color blindness being considered a legal disability		•		•	•	•	

about the implications of their color blindness for certain career choices such as aviation, military, and creative fields. However, none of the subjects felt they were being deprived of rights because of their inability to read road maps. Both of the participants with the extreme conditions of color blindness and one of the medium participants said that color blindness was indeed a disability. However, one of the mildly afflicted subjects felt it was more like being seeing-impaired rather than a full disability. When asked how they felt about color blindness being considered a disability by law, there were similar opinions. The same subject who felt it was more of an impairment said that it would be nice to have programs for people who are severely afflicted, but would not want restrictions placed upon him by a disability law:

> "...for someone like me who has minor color blindness to be considered a disabled person, I might be treated differently because of that, while I'm not now. For someone [who is] more severe, they could still get what they need for being impaired, being classified as impaired without being classified as disabled."

Another mildly afflicted subject also agreed that, while he knows that some others might have a more extreme case, he did not want color blindness to be classified as a full disability. Two subjects, one mildly color blind, the other medium, seemed not to really care, the latter said he probably wouldn't use the perks or advantages that would come with the classification anyway. One extreme subject was unsure about it, but was also concerned about restrictions being placed on him. The other extreme color blind subject stated:

> "It would make me happy, depending on what that entitles me to. I don't think I would struggle the same as somebody who's wheelchair bound or completely [with] vision or hearing loss... I would not feel comfortable in saying, 'Oh, I'm equal to other disabilities.' That's not appropriate. But are there challenges? Yeah. If the world said, 'to heck with you, figure it out on your own,' I would enjoy fighting that fight and say, 'You know what? I'm entitled to navigate the world just like anybody else.' And it wouldn't take much to add a number or use a different schematic."

When asked how others react and perceive their color blindness, four respondents (two mild and two medium) stated that most people are jovial and joke about their color blindness. All three subjects who were classified as the milder cases said that others think they see only in black and white or shades of gray, when, in fact, they do see some colors. The two with medium affliction said that others ask them to identify objects of different colors, as if testing their color blindness. One of the more extreme cases said that he tries not to tell many people about his condition because he is concerned that is could lead to questions about job performance. The other extreme case states that people find it curious, and therefore, he schools them on aspects of color blindness:

> "When you look around your room, your brain's putting labels on colors. You can't change it. You can't tell yourself that this is blue [points at red pen], your brain has put a label on it. I did the same thing. My eyes see the shade of gray, my brain has put a label on it that it's red. I can't change it."

Solutions

Another map that was shown to each subject was a symbol mapping system developed by ColorADD in Portugal (see Figure 3 on page 7). The researcher explained to the participants how the colors and symbols worked and asked their opinion of the system. They were also asked if they thought this might be a good alternative to color maps in the U.S. All subjects believed

that this symbol system was, in fact, a good idea. Three subjects, one belonging to each category, felt that the images made them feel a bit anxious and confused at first, but they could get used to it. Although he was open to this idea, one medium afflicted participant mentioned that the small symbols look a little too similar in shape and that, perhaps, letters could be used in place of them. Another medium afflicted subject, along with one of the extreme cases felt that it was absolutely great and that if children were raised in a system like this, it would be much better for the color blind population.

Following the discussion of this map, subjects were asked whether they had any other solutions that they believed would make maps and signage more accessible to color blind people. Both medium subjects and one mild subject suggested that symbols work well and and authorities should refrain from labeling maps by color. In cases where color was necessary, two respondents, one mild and the other medium, said using less colors and more contrasting colors rather than various shades would help. A mildly color blind subject suggested using numbers like a grid for areas, similar to what amusement parks use, while an extreme case said that providing a gray-scale version with pattern coding would be helpful.

At the end of each interview, the subjects were asked if they had anything new to add to the discussion that they had not already mentioned and that might assist in the research. One mildly afflicted respondent added that red and yellow lights gave him the most issues while driving, especially at night. Another, who was mildly color blind, said that blue neon and LCD lights appear to him as very blurry blobs. One of the extreme cases stated that colors have less impact for him and are not that important. He prefers to rely on shape, sound and taste. One of his concerns is color labeling of dangerous items. When a manufacturer uses red on a medicine bottle label to denote a danger, this subject cannot clearly see it. The red doesn't jump out like

it would for people with normal vision. He suggested using a skull and cross-bones or a similar symbol to designate danger.

CHAPTER SEVEN:

DISCUSSION

The Photovoice portion of the research provided good insight as to how color blind people see the world. Open discussion of traffic lights, signs and maps allowed the researcher to identify specific issues amongst this population. In regard to others' views of color blindness, it seems that the subjects believe that those who view colors normally have difficulty understanding what it's like to be color blind, but rather than experience a negative attitude they perhaps note there is a curiosity to learn more about how color blind people see and live their daily lives with this affliction. To the extent that color blind people are willing to explain their experiences, this could lead to greater empathy, at least among those persons who are in direct contact.

Regarding maps, the overall consensus is that less hues and values of colors should be used to denote areas and routes. Symbols, numbers and letters are the preferred choices. Multiple bus routes in one area was the most troublesome area of map readability. In one particular area of the Bull Runner map, there were yellow, green, brown, purple and red routes all in the same vicinity which caused much confusion. To most red-green color blind people, green, brown, purple, and red can appear very similar, with red and green being virtually the same color. Map complexity is another domain that leads to much disorientation. In addition to multiple colors, the Bull Runner map consists of solid bus route lines, dashed multiple bus route lines, directional arrows, and stop symbols. The buildings on the map are colored in gold with streets and some parking areas in gray. Overall, the map is cluttered and overwhelming. Simplified maps, for

instance, as used on GPS devices and cell phones, would be much easier to decipher. The Daily/ Visitor Parking map also needs to be simplified, participants said. This map containing eight different color areas, four of which look very similar to a color blind person, also contains building labels, and five different symbols for designated parking areas. Using three different shades of gray makes some of the areas appear the same, or in a color blind person's view, could be misconstrued as a "color" that he is unable to see. Most of the interviewees said that they would have to ask someone for help if they couldn't read the maps.

When discussing disability, half felt they had some form of disability, but would not classify their disability as being on the same level as other disabilities. Most were concerned about added restrictions if color blindness were to be a lawful disability, but also acknowledged that others with a more extreme condition might benefit from government assistance. Because of the different levels of affliction, the general position amongst participants was not to classify color blindness as a disability, but rather as an impairment.

All interviewees reacted positively to the color-symbol mapping solution devised by ColorADD. The overall feeling was not to just replace the colors with symbols, but to use them in conjunction while decreasing the amount of color and labeling used. The usage of numbers and letters was also approved as a means of increasing accessibility. Perhaps the government could standardize a template of guidelines for map and sign creators to utilize for implementation of better maps for all to view.

CHAPTER EIGHT:

CONCLUSION

Color blindness may be insignificant to most people who have no difficulty viewing an array of colors. Because color is used in everything we see and do, color blind people are severely underrepresented when planning and designing maps and signage for transportation. With more than 12 million males in the U.S. alone being afflicted with some form of color blindness, it should be clear that the issue is, however, a real one. Many of these people are unable to view maps and signage as intended. In certain conditions, such as driving, this could lead to serious injury. Perhaps a solution to this could be to provide symbols within the lights like the pictographs that are displayed in pedestrian walk signals. Through the research presented here, it is apparent that there are different levels of color blindness. Some have few issues determining what they can or cannot see, and simply use other means to get around it. Others who suffer from a more severe form of color blindness cannot distinguish between colors which could result in life altering responses such as the inability to differentiate colors of traffic lights and road signs.

Disability may be too strong a word to characterize the color blind population, certainly many of the respondents did not see themselves as disabled and were unwilling to be restricted by this label. However, these are impairments that create a significant level of safety issues when travelling. As mentioned above, street lights and signage can be confusing to someone who is color blind, especially with an extreme condition. Maps are difficult to interpret when

identifying objects, buildings, and transportation routes. The possibility of categorizing this population in relation to laws may be dependent upon the severity of their condition. Some subjects showed concern about restrictions being placed upon them as well.

Safety hazards in the community are identified and if there is also a constitutional right to receive information, failure to provide color blind people with the same information that others receive could be argued to be a breach of this constitutional right. One solution to the issue might be to give assistance to the color blind population without necessarily labeling them as disabled. Crosswalk signals have changed from words to pictographs to assist people who don't understand the English language or can't read, such as small children. Requiring maps and signage to be provided in alternative versions for people with color vision deficiencies could very well help everyone. Many maps and street signs can be confusing even to normal vision people. Simplification would be one of the better solutions.

Study Limitations and Further Research

The study of seven color blind people cannot be said to be representative of the population. There is often much difficulty in identifying color blind subjects as many people in this population are either unaware of their affliction, or they may be sensitive about being color blind. Although the interviews were in-depth, it may also be more pertinent in future studies to work with only the more severe cases, as this portion of the population expresses the most difficulty in viewing colors and hardship in travelling. A narrative study in which a day is spent with a color blind person could give much insight as to how they live with their affliction. Studying color blind subjects in a closed environment with experimental video driving conditions could also lead to solutions for this population's issues with traffic signals.

Another limitation of the study may be the choice of maps used during the interviews.

Both maps depicted areas on the University of South Florida's Tampa campus. Five of the seven subjects are affiliated with USF and familiar with the campus layout. It became apparent in a few of the interviews that some answers may have been given because of this familiarity. The photo voice portion of the research could have been expanded as well. Each participant was asked to provide five specific photos. An additional study might provide for them to take as many photos as needed of anything concerning color blindness, not just transportation related. This way, we may get a better idea overall of the issues they face living with color blindness. This study is only one of very few that concerns color blindness and its effect on mapping and signage used in transportation. One area of additional research for color blindness would be to start by educating children about color blindness and instituting materials sensitive to this condition in school classrooms. If we can determine what resources could be best for color blind children, then perhaps a solution might emerge for all. Progressing through life with an established matrix, such as the ColorADD symbol system will become as second nature as the alphabet if we instill it during youth. Future researchers might also include the female population in their research on issues facing color blind people. Although color blindness is rare in females, they may react differently than males when viewing colors and trying to function with this impairment. Additionally, researching the companies that produce maps and signage could shed light on how the maps are developed. And, lastly, further research on developing cures or glasses specific to the needs of color blind people could also expand the knowledge needed to assist this population in dealing with everyday issues of being color blind.

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APPENDIX A:

ADVERTISEMENT USED TO SOLICIT SUBJECTS FOR RESEARCH STUDY.

COLOR BLIND PARTICIPANTS
NEEDED FOR COLOR MAPPING RESEARCH

- No experience or training necessary
- Color blind males between the ages of 18 and 40
- Must have access to a digital or Smartphone camera
- Be willing to take pictures of objects around you
- Must be available to interview in person or via Skype
- Must be willing to be audio recorded
- Must sign research consent form

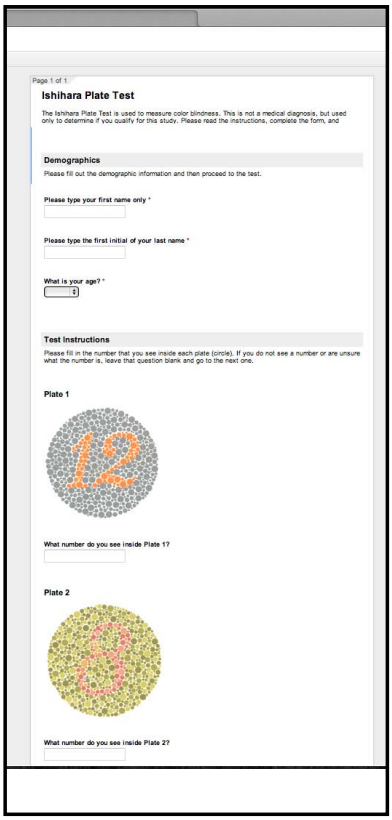
My name is Stephanie Skupien and I am a graduate researcher at the University of South Florida requesting color blind participants for a research study (USF IRB # Pro13569). The study will consist of subjects photographing items that cause them issues due to being color blind. Discussion of photos and interviewing will be used to determine if color blindness is a disability and if there are solutions to providing better maps and signage to this population. There is no incentive, monetary or other, for participation; you may request a copy of the research, once completed.

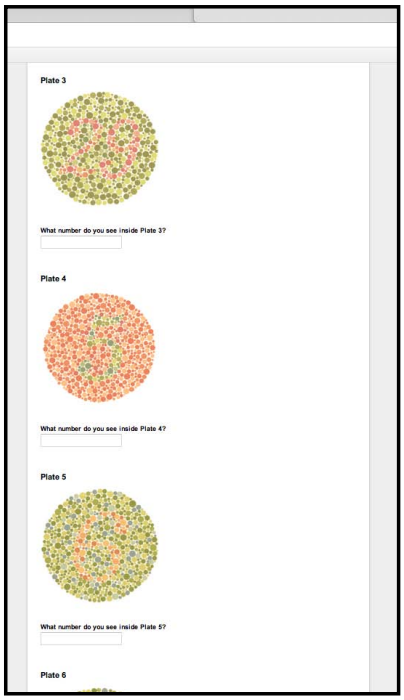
Interviews will take place in a private meeting room at the Marshall Student Center, USF Tampa campus or in a private chat via Skype. Time allotted for each interview will be up to 60 minutes.

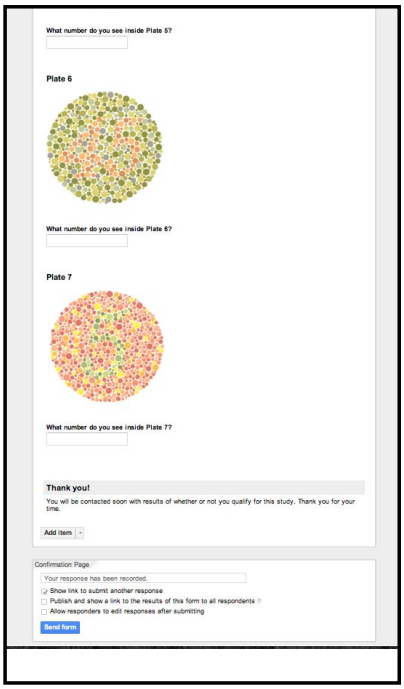
If you or someone you know might be interested in assisting in this color experiment, please contact me at **stephanieskupien@icloud.com**.

APPENDIX B:

ISHIHARA VISION PLATE TEST AND RESPONSES.







Ishihara (Responses)

File Edit View Insert Format Data Tools Form Help All changes saved in Drive

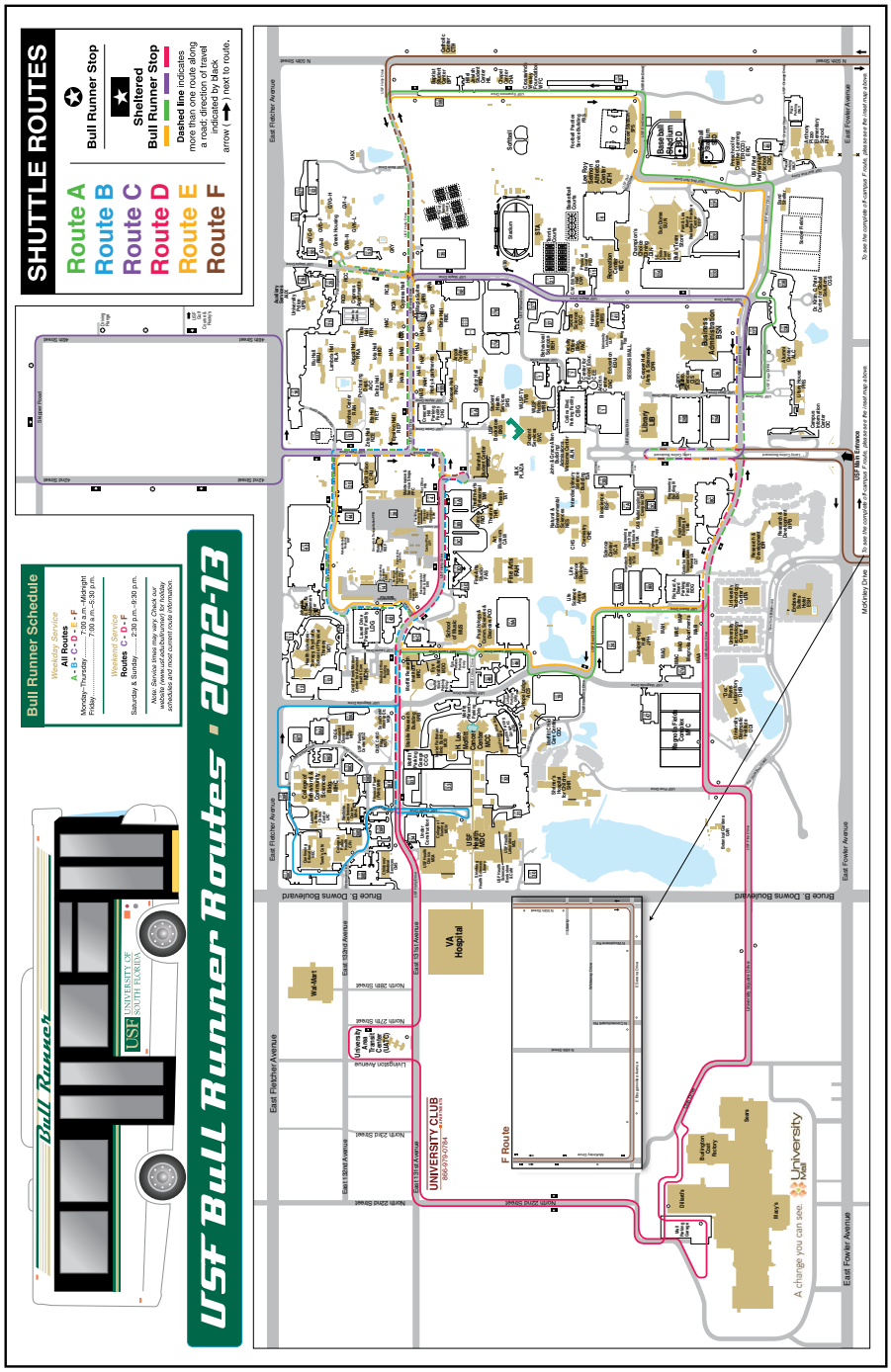
TwoSkups Skupien

Comments Share

	A	B	C	D	E	F	G	H	I	J	K
1	Timestamp	What number do you see inside Plate 1?	What number do you see inside Plate 2?	What number do you see inside Plate 3?	What number do you see inside Plate 4?	What number do you see inside Plate 5?	What number do you see inside Plate 6?	What number do you see inside Plate 7?	Please type your first name only	Please type the first initial of your last name	What is your age?
2	Redacted for privacy	12	3	20					Redacted for privacy		38-40
3		12	3								38-40
4		12	3?	23?	no idea	no idea	no idea	no idea			23-27
5		12	3	20	3	na	na	na			23-27
6		12	3	20	3	Nothing	Nothing	Nothing			18-22
7		12	3	20	2						23-27
8		12	3	20	2	Nothing	Nothing	Nothing			28-32
9											
10	Answers	12	8	29	5	6	45	5			
11											
12											
13											

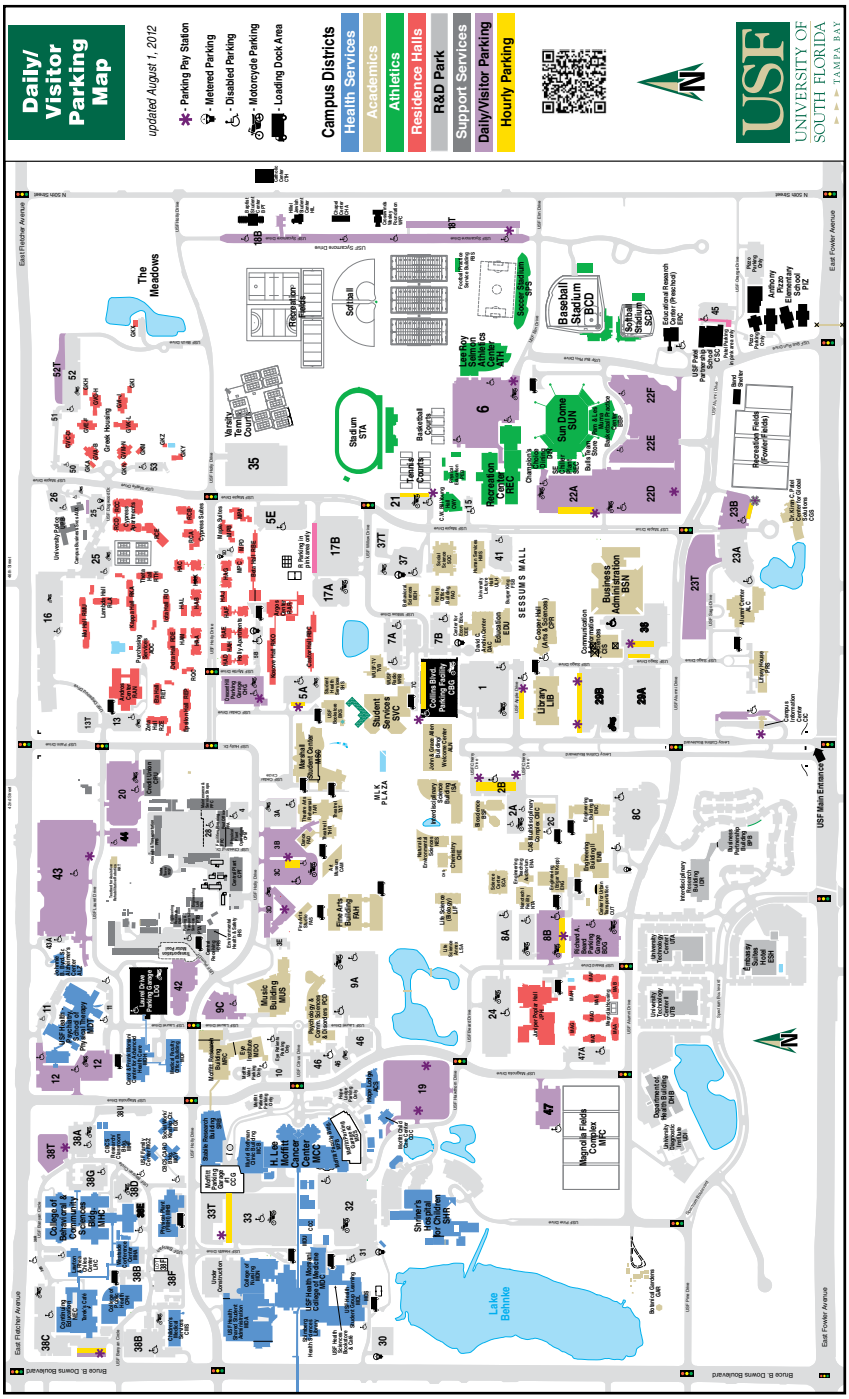
APPENDIX C:

USF BULL RUNNER ROUTES MAP



APPENDIX D:

USF DAILY/VISITOR PARKINGMAP



APPENDIX E:

IRB APPROVAL PAGE 1

USF
UNIVERSITY OF
SOUTH FLORIDA

RESEARCH INTEGRITY AND COMPLIANCE
Institutional Review Boards, FWA No. 00001669
12901 Bruce B. Downs Blvd., MDC035 • Tampa, FL 33612-4799
(813) 974-5638 • FAX (813) 974-7091

7/29/2013

Stephanie Skupien, B.S.
Mass Communication
4202 East Fowler Ave, CIS1040
Tampa, FL 33620

RE: **Expedited Approval for Initial Review**
IRB#: Pro00013569
Title: Colors and Mapping: The Right to Receive Information

Study Approval Period: 7/28/2013 to 7/28/2014

Dear Ms. Skupien:

On 7/28/2013, the Institutional Review Board (IRB) reviewed and **APPROVED** the above application and all documents outlined below.

Approved Item(s):
Protocol Document(s):
Protocol_Skupien.pdf

Consent/Assent Document(s)*:
InformedConsent_Skupien_V1_ 061513.pdf

*Please use only the official IRB stamped informed consent/assent document(s) found under the "Attachments" tab. Please note, these consent/assent document(s) are only valid during the approval period indicated at the top of the form(s).

It was the determination of the IRB that your study qualified for expedited review which includes activities that (1) present no more than minimal risk to human subjects, and (2) involve only procedures listed in one or more of the categories outlined below. The IRB may review research through the expedited review procedure authorized by 45CFR46.110 and 21 CFR 56.110. The research proposed in this study is categorized under the following expedited review category:

(6) Collection of data from voice, video, digital, or image recordings made for research purposes.

APPENDIX E:

IRB APPROVAL PAGE 2

(7) Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.

As the principal investigator of this study, it is your responsibility to conduct this study in accordance with IRB policies and procedures and as approved by the IRB. Any changes to the approved research must be submitted to the IRB for review and approval by an amendment.

We appreciate your dedication to the ethical conduct of human subject research at the University of South Florida and your continued commitment to human research protections. If you have any questions regarding this matter, please call 813-974-5638.

Sincerely,

Kristen Salomon, Ph.D., Vice Chairperson
USF Institutional Review Board