Analysis on the Use of Viewing Filters to Determine Necessary Color Change in the Graphic Arts Industry

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ANALYSIS ON THE USE OF VIEWING FILTERS TO DETERMINE NECESSARY COLOR CHANGE IN THE GRAPHIC ARTS INDUSTRY

by

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A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in the School of Printing in the College of Graphic Arts and Photography of the Rochester Institute of Technology

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ABSTRACT

This thesis analyzes the effectiveness of the Kodak Color Print Viewing Filters. The first half discusses the problems people in the graphic arts encounter when working with color reproductions and points out the inadequacies of the proofing system currently in use. The second half focuses on the application of the viewing filters and their ability to improve the proofing system. This involves an experiment where twenty print buyers and twenty printers are tested on three test images. Half of the participants use the viewing filters, the other half do not. The results of the experiment indicate that viewing filters benefit buyers more than printers and are most helpful on images that have important memory colors.
INTRODUCTION

The introduction of new technology, materials, and machines for economic reasons has changed four-color process printing. The gradual elimination of the human element from many of the pre-press operations allows for greater predictability and control. Gray balance, tone reproduction, and color correction can be tailored for specific inks, paper, and press conditions without hand corrections. In short, printers can produce color reproductions more efficiently, more consistently, and with higher overall quality than ever before.

Yet, while the methods of producing color reproductions improves, the methods specifying exactly what colors should be reproduced remains, for the most part, unchanged.

The guidelines a printer follows for color usually boil down to a gut level feel he has acquired for his client's taste.\(^1\) Some customers like their colors highly saturated, others like less saturation, still others don't care what the colors look like as long as the featured product looks right. Whatever the preferences, the printer has to know and make the proper adjustments with his separations and printing. More importantly, the printer learns to translate comments from the customer such as "Needs a pinch more blue!" into a specific amount of change so as to get the desired effect.\(^2\) Implicit for the printer is a good understanding of the customer and a familiarity with the equipment and materials used to make the reproductions.
Even though the achievements of the above system are surprising, there is still an element of trial-and-error involved which usually necessitates more than one proof and possibly a few last minute press manipulations to get to the preferred sheet. In some cases, the print buyer has to approve a job he is not totally satisfied with in order to meet an inflexible deadline date. These added proofs and extra time on press are some of the reasons why four-color printing continues to be a manufacturing process with low productivity.\(^3\)

To a large extent, this poor proofing system could be improved if the buyer could see and specify the colors he wanted before any preparation steps take place.\(^4\) One means of doing this is to have the buyer use Kodak Color Print Viewing Filters.\(^5\) Here the buyer can see the effect an overall color correction will have by viewing the artwork or printed sheet through the appropriate filter. The major limitation with the viewing filters is they tinge the highlights more than the shadows but, provided this limitation is understood, the buyer can still get a good indication of how certain color changes will result.\(^6\)

The purpose of this study is to analyze the effectiveness of these viewing filters. An experiment was set up where twenty buyers and twenty printers were asked to look at three original transparencies, judge poorly balanced color prints to the transparencies, and explain to this experimenter what overall color changes were necessary to get to the preferred prints. Half of the buyers and printers used the viewing filters, the other half did not. The experiment was designed to answer the following questions:
1.) Can the participant reduce the number of proofs necessary for the desired prints when using the viewing filters?

2.) Can the participant get more satisfactory results when using the viewing filters?

3.) Can the participants use the viewing filters easily without adding extra time to their jobs?

The conclusions are statistically supported using the Two and Three Way ANOVA with Interaction techniques. Additional graphs and tables were used to clearly illustrate what was learned.

Whenever an analysis is done with the subject of color in the graphic arts industry, there are many difficulties. First, color as seen is constantly changing depending on the light source, object viewed, and viewer. Second, the terminologies used to describe color vary from individual to individual. And last, color produced in process printing is not the same color seen in real life. To understand and minimize these difficulties is essential before any accurate analysis can begin.
FOOTNOTES

1 Based on private interviews with George Herschel of Great Lakes Press, Jim Warden and Tom Vicers of Rumrill-Hoyt, and personal experience.

2 Off a press sheet from Rumrill-Hoyt, Inc., 1895 Mt. Hope Ave., Rochester, N.Y.


4 Ibid., p. 147.


6 Instructions to Kodak Color Print Viewing Kit, Publication No. R-25 (Eastman Kodak Company, 1980).

SOME BASIC CONCEPTS IN COLOR

Color can be described as the visual effect which is caused by the spectral composition of light emitted, transmitted, or reflected by objects. Color and light, therefore, are inseparable and a study of the physical basis of color requires a preliminary understanding of light.

Light is one of many forms of radiant energy. Some of the other varieties of well known radiant energy are radio waves, infra-red rays, ultra-violet rays, X-rays, and cosmic rays. Light differs from other forms of radiant energy with the important quality of stimulating the nerves of the eyes and producing the sensation of sight. With intense illumination, light rays with waves as short as 350 nm. and as long as 900 nm. can produce effects which are just visible. If the rays found in sunlight are separated by means of a prism from the shortest to the longest, the corresponding optical effects would produce the sensation of violet into blue, green, yellow, and red. Colored sensations are produced when less than the complete mixture of light strikes the eye.

So color has no material existence. The wavelength of the light is the stimulus responsible for the perception of a particular color. For instance, reflected light of wavelength 550 nm. is not in itself green, but the reaction caused by it on the eyes of a normal person produces the sensation which is called green.

Observers with normal vision are called normal trichromats, which means they require three primary colors (red, green, and blue) to produce all
the other colors. By mixing together different proportions of the primary colors, any other color can be produced.

The Eye and Brain

The eye, the sensory receptor of light, is capable of detecting at least three properties of light. These are:

1.) The direction from which light has come, which gives an individual the ability to distinguish shape, size, and texture.

2.) The amount or intensity of light, which leads to the perception of contrast between, say, an object and its background.

3.) The quality or wavelength of light or, to put it another way, color.

The lens at the front of the eye does not pass light of the shortest wavelength and is largely responsible for the termination of response at the violet end of the spectrum. The part of the eye most directly concerned with color vision is the retina at the back of the eyeball. This consists of a very complex layer of nerves, nerve endings, interconnections and light sensitive receptors called cones and rods. It is here that the conversion of light energy into chemical and electrical nerve energy takes place resulting in impulses to the cortex, or outer layer of the brain, producing the sensation of sight.

Sharpest Vision

If the eyes are held stationary, very little is really seen except within a few degrees of the direction of the eyes. When we are talking to a person two or three feet away, we cannot tell (except in a general way) what he is wearing. In order to do so we have to "look him all over." A normal person sees sharply a circular area in the field of view whose diameter is equal to three and a half percent of the distance. So sharpest
vision across a street that is thirty feet wide is only one foot in diameter. At ten feet away, the area is about four inches across. At reading distance (approximately twenty inches), the width is reduced to about three quarters of an inch, hence reading becomes a series of quick successive fixations.

**Metameric Match**

The quality of light used in a viewing area can make a difference on the appearance of colors. It is possible for an observer to detect a difference between two samples under daylight and not detect a difference when viewing the same two samples under tungsten lighting. The samples are described as giving a metameric match.\(^{10}\) Because the spectral composition of artificial light usually differs from that of daylight, the color rendering qualities will be different.

**Contrast Enhancement**

When two different shades of the same color are placed alongside each other, the visual impression is one where the contrast between the two shades is increased. This is known as contrast enhancement (or simultaneous contrast).\(^{11}\) When different hues are placed side by side, the change in the appearance of the colors is less dramatic but still noticeable.

**Color Blindness**

Color blind people lack the ability to detect certain primary colors; this varies from individual to individual. The most common are the red-green deficiencies.\(^{12}\) It was found in many European countries that around eight per cent of males have a certain degree of red-green color confusion, while less than one per cent of the women displayed the same problem.\(^{13}\) This is because the inheritance of certain forms of color blindness is
determined by sex-linked recessive genes. Generally, women carry the disposition to color blindness, whereas men exhibit the defect if given the necessary gene combination. 14

Several tests are used to detect the more common forms of color blindness such as the Holmgren Wool Test, Nagel Charts, Stilling Charts, Isihara Charts and American Optical Company Test. 15 In all cases, great pains are taken to design the test to prevent any concealing of defective vision by guessing or by discriminating light from dark.

What's apparent at this point is the human observer has very definite physical limitations to see accurately all the colors there are to see. If we are just talking about the normal observer, he is totally dependent on the illumination of the viewing area. If the illumination is poor, then his ability to discern an array of colors will be poor. But even when the illumination is good, there are limitations. The observer is unable to isolate colors and avoid the effects of simultaneous contrast. More importantly, the observer can't see everything due to his rather limited area of sharpest vision. So he is forced to paint a picture in his mind by selectively picking out certain details of a scene and interpolating the rest. The way in which the eyes are actually used is a complex mixture of intentions, desires, and interest.
FOOTNOTES


3 Ibid.


5 Frederick W. Clulow, p. 53.

6 Jules B. Davidoff, p. 15.


8 Ibid.

9 Ralph M. Evans, p. 59.

10 Frederick W. Clulow, p. 34.


12 Jules B. Davidoff, p. 61.

13 Ibid.

14 Ibid.

THE COMPLEXITIES OF PERCEPTION

The purpose of vision is to contribute information about the external world to the brain. Vision is strongly selective and guided almost entirely by what the observer wants to see. Having learned from experience, the observer uses vision in a way that will maximize the wanted detail and minimize the unwanted ones. This integration of the physical and psychological factors is called perception. The differences of perception between people can generally be broken up into what this author calls the short and long term differences.

Short-Term Differences

Short-term differences are of a temporary nature and usually require extreme conditions and sometimes special equipment to significantly alter perception. Afterimages, distortion of shapes, illusion of movement, or visual transformations are just some of the tricks that can be performed on the normal observer. But, provided the extreme conditions don't repeat themselves, the distortion in perception usually corrects itself.

Due to the unlikeliness of extreme conditions in normal viewing situations, the short-term differences are often of little consequence. There are three, though, which are more common and should be discussed briefly.

Adaptation

If one goes directly from the sunny out-of-doors into a movie theater showing a night scene of some coming attraction, the problem of adaptation is most apparent. The person has to stand in the back of the theater for a few minutes until his eyes adjust.
An experiment testing the time it took for a normal observer to detect the lowest intensity of light when put into darkness gave the results shown in Figure 1. The curve consists of two parts which represent the differences in sensitivity between the cones and rods of the eye. The cones are responsible for color vision and are less sensitive than rods, which are responsible for brightness in vision. As can be seen by the graph, color vision is entirely lost at lower levels of illumination.

Eye Strain

Perhaps the most common after-effect of vision is that of eye strain. The physical effect of eye strain can be a severe headache. But, in terms of perception, eye strain makes it difficult to change focus from one object to another at a different distance. There may also be a temporary blurring of vision or sense of confusion. Generally, the automatic process by which we have normal vision is lost and a different appreciation of the visual scene results. Often, light and bright colors become unpleasant to view in this condition.

Drugs

Drugs can alter perception in many ways, the extreme case would be LSD. There are milder drugs which are used more regularly and do have perceptual consequences. Any drug that produces delirium can also cause hallucinations. This includes bromide, caffeine, carbon monoxide, camphor and quinine. Drugs which depress the level of activity of an observer will make him generally less sensitive and less able to detect the presence of light. Major sedatives like barbituates, tranquilizers, and alcohol all have this effect. Any drug which increases arousal may improve the sensitivity of the observer, but the effects are not always reproducible.
FIGURE 1

Log intensity of light detected

Time in dark (minutes)

Darkness adaptation by the normal observer
Long-Term Differences

Long-term differences are of a more permanent nature and involve the psychological processes that impose order and meaning on what an observer sees. This is influenced by a variety of factors such as the observer's motivation, emotion, reasoning, recall, recognition, attention, and action. Even though psychologists are still very divided on whether the organization of perception is innate or learned, there are some tendencies that can be discussed as well as some specific examples that illustrate the unique differences between individuals. The two are closely interrelated but, for the sake of simplicity, will be handled separately in this paper.

Two Tendencies of Perceptual Organization

A significant tendency of perceptual organization is often referred to as the Gestalt Principle. Basically, Gestalt psychologists say a distinction is made between figure and ground in visual perception. The observer seeks a figure in a visual field which is perceived as a unit separate from the rest of the field. Colors play an important role in identifying this figure.

Color constancy is another perceptual tendency in which the observer sees the color of a surface as constant even though the illumination conditions might have changed. An example of this could be a dinner plate. Though a dinner plate itself does not change, its color on the retina can change considerably as the perceiver and plate move. Under extreme conditions, obviously, the experience of constancy breaks down.

Unique Differences Between Individuals

There are differences in perceiving among individuals, among classes of individuals and within the same individual from one occasion to another. A brief discussion on age, sex, and culture differences will illustrate some of these complexities.
A lot of evidence for age-related changes in perceiving have been gathered. It is interesting to note that between the ages of three and six, color appeals to children as much as does form. As they grow older, the potency of color perception recedes and in the adult life is greatly superseded by form perception. Thus mental color blindness develops. More importantly, though, as age increases the lens of the eye "yellows", increasing the absorption in the blue region and so tending to increase the wavelengths of the shortest light wave that can be seen.

It is difficult to determine whether the degree of differences related to sex is due to biological or cultural influences. But sex differences have shown to affect the scanning pattern of the observer. It was found that the eyes of young men moved twice as quickly in examining pictures of young women as they did when looking at ink blots. The inspection pattern of Leon Kroll's painting 'Morning on the Cape' was different for male and female observers. (see Figure 2) The upper pictures refer to a male observer and the lower to a female observer. The numbers represent the order of fixations and the symbols indicate attention. The oval symbols indicate normal attention, round symbols denote less attention, while square symbols denote increased attention. Though these scanning patterns are those of two individuals, they do reflect the general patterns of sex differences in looking at pictures not obviously sexual in content.

The environment people live in can influence the way they perceive. This is illustrated by a study pioneer psychologist W.H.R. Rivers did on the natives of Murray Island at the turn of the century. He discovered that, although the natives weren't color blind, they did display a degree
of insensitivity to the various shades of the color blue as compared with Europeans.  

How one views a scene is influenced by the forms he recognizes and the forms he seeks. This complex mixture of intentions, desires, and interest are the basis to the fact that no two people see things alike. The language that tries to bridge the gap of perceptual differences between two people offers little help because of the same problems with objectivity.
FIGURE 2

The analysis of the picture by a male observer.

The analysis of the picture by a female observer.
FOOTNOTES


2 Ibid.


4 Ibid., p. 111.


6 Ibid., p. 44.

7 Ibid., p. 47.

8 Ibid., p. 45.

9 Ibid., p. 47.


12 Matthew Luckiesh, Color and Colors (Bridgeport, Conn.: Braunworth & Company, 1938), p. 84.

13 Jules B. Davidoff, p. 15.

14 Ibid., p. 84.
15 Ibid.

16 Ibid.

COLOR NAMES

If two people were to look at the same light blue color swatch under the same conditions, chances are they would both name the color of that swatch differently. One of the problems with color terminologies is there can be no simple connection between the physical qualities of a color and the actual perceptual sensation it produces for the viewer.\(^1\)

Milton Pearson, a color specialist who works for the Rochester Institute of Technology Research Corporation, did an experiment with his second year photographic science class which statistically shows how much people can differ when naming colors.\(^2\) Through the use of a monochrometer, he had his students identify what they thought to be red, orange, yellow, green, and blue. The results can be seen in Table 1.

In some industries (such as the ones that manufacture dyes, pigments, plastics, textiles and so on), the specification of colors is critical and creates a need for a precise color reference system. Today, the most internationally accepted system is the Munsell System, which is based on the notation of color by its three variables; hue, saturation, and brightness.\(^3\)

The limitation with any systematic approach in defining colors is they avoid the use of traditional, poetical, and emotional words which are less definite but often depict the actual character of the colors better.\(^4\) For example, a person doesn't want a highly saturated orange-red ... he wants a "Fiery red!" We can't ask that person to pick out a color in a standard
The results of Milt Pearson's Color Identification Test with his second year Photographic Science class on March 21, 1981.

* The units stand for wavelengths of light
* \( n \) equals the number of students tested

| COLOR | MIN  | RANGE | MAX  | \( \bar{x} \) | \( \sigma \) | \( n \) |
|-------|------|-------|------|...............|...........|-------|
| Red   | 624  | 55    | 679  | 644           | 14         | 18    |
| Orange| 592  | 34    | 626  | 605           | 8          | 18    |
| Yellow| 570  | 35    | 605  | 587           | 8          | 18    |
| Green | 515  | 54    | 569  | 541           | 13         | 18    |
| Blue  | 461  | 29    | 490  | 475           | 8          | 18    |
| UV    | -    | -     | -    | -             | -          | -     |
| IR    | 717  | 44    | 761  | 742           | 15         | 17    |
reference system because that alarming quality of red he is looking for depends very much on the relationship with the surrounding colors.

Color terminologies like perception have only one constant ... the subjectivity of the observer.
FOOTNOTES


2 Rochester Institute of Technology, Rochester, N.Y. 14623.


4 Matthew Luckiesh, p. 88.
COLOR OF FOUR-COLOR PROCESS PRINTING

A main characteristic of four-color printing is its primary reliance on the subtractive process to create the impression of varying colors. The cyan, magenta, and yellow process inks (black is not a color) act as filters which selectively absorb certain wavelengths of light reflecting off the surface of the paper. The usual application of these inks is through the use of very fine screens with either varying sized dots (letterpress and offset) or varying depth cells (gravure). The term used to describe the blending of dots into one multi-colored image is "mosaic fusion." As would be expected, going from an original artwork to an illusion of that artwork isn't always that simple.

Not Always a Colorimetric Match

The original copy a printer gets usually falls into one of the following categories:  

1.) original transparencies  
2.) transparencies of artists' originals  
3.) duplicate transparencies  
4.) color prints  
5.) artists' originals

With the exception of number five, all the copy are intermediates between the original subject and its reproduction. If the objective of the printed reproduction was to optimize color correction, gray balance, and tone reproduction so as to match the original copy as closely as possible, many
of the problems in the graphic arts industry today would be minimized. In general, though, reproduction requirements fall into one of three categories. In the first case, the original copy is to be reproduced as accurately as possible - this most commonly occurs with artwork. In the second, the original live scene, or some specific object in it, is to be reproduced accurately making the original copy merely an intermediate. In the third case, which does not lend itself to objective analysis, changes are to be made to correct faults in the copy, to improve the appearance of merchandise, or because of the art director's personal preference.

Facsimile color reproduction is not always necessary or desirable because there are certain colors that demand high accuracy and there are others where red is red and blue is blue no matter what the particular shade. The required accuracy also depends on the area occupied by a certain object in the picture and on the surrounding colors. The color reproduction of small objects can be handled much more carelessly than that of large objects. More importantly, the actual colors desired by the viewer can change depending on the adaptation of the viewers' eyes to different illuminations and the brightness range between the original and printed copy.

So there is no one way to specify the optimum relationship between an original and its reproduction. The conditions which best satisfy the viewers' acceptance of a reproduction need to be understood before any specifics on the optimum reproduction can be obtained.

Often, what the print buyer wants to reproduce is not the original but an idea in his mind which might not be clear until he has seen the first proof. This is illustrated by the fact that most accepted reproductions incorporate a lot of hue error, especially in the less important areas of the
picture, when compared to the real colors of the subjects involved. For Caucasian skin color, a sun tanned appearance is preferred to real skin color. Blue sky and blue water are usually preferred to the real life gray sky and gray water. There is the other extreme where samples of the actual merchandise are sent to the printer and he is expected to match them closely, even if the original artwork is inaccurate. Either way, the colors to be reproduced are different from the original artwork submitted.

In the case where the customer submits artwork that has exactly what he is looking for, there may be limitations. These include density range of the original being greater than the reproduction, colors outside the gamut of the reproduction system, changes in size between original and reproduction, differences in the viewing mode for transparencies, and others. All these reasons work against a simple colorimetric match of a reproduction to original artwork. The only exception to this would be when the original and reproduction are the same size and sharpness, viewed in the same light, and the original contains no color which cannot be matched by the reproduction process.

Ways to Avoid Color Problems

There are ways around these complications with printed color which allows the client to see what he'll get and decide on what he wants before any separations or proofs are made.

The most sophisticated and precise technique is to use a color previewer. The previewer allows the print buyer to see on a T.V. screen what his reproduction will look like and to make reasonable alterations. The previewer is designed to be used in conjunction with a scanner and to simulate a variety of preparation and production steps. These include
electronic color separations and color correction that compensate for paper characteristics, ink properties, and press gain and loss.

There are some limitations, though, to the previewer. First and foremost is the cost. A Hazeltine Previewer which provides a video display costs $60,000 while the Scitex Response 300, which can do electronic dot etching and be hooked up to any scanner, costs $1,000,000. Second, the equipment isn't portable and demands the printer and customer make color evaluations at a location where the facilities are available. Lastly there are arguments as to whether the colors on a T.V. screen which are produced by transmitted light and additive primary colors (red, green, blue) can totally simulate printing conditions which uses reflected light and subtractive primary colors (cyan, magenta, yellow). Certainly the effects of gloss would be hard to achieve on the previewers.

Another way around the complications of color is to use photographic prints which are the correct size and contain no colors or densities that can't be matched by the printing process. This way the customer can work out his own color preference right on the original artwork and know that what he sees is what he'll get. The main problem with this is it demands flexible and easily prepared prints with good detail. To date, there is no single product with all these characteristics. Dye transfer is flexible but slow and not sharp enough. Tripack papers are not flexible, fast or sharp. Cibachrome has sharpness but is not flexible or fast.

A final alternative is to have the customer use the Kodak Color Print Viewing Kit while viewing a transparency, artwork or printed copy to specify exactly what color he is looking for in the reproduction. For example, if a customer is looking at a print in which the grass is a little too
green, he might view it through a magenta filter of .10 density and say that is what he wants. Now the printer knows by what degree the grass is too green and can make alterations accordingly.

The kit consists of six holders, each of which has three gelatin filters of the same color in three different densities; .05, .10, and .20. The assortment of colors available with each kit are cyan, magenta, yellow, red, green, and blue. (See Figure 3) As was mentioned earlier in the Introduction, the major drawback with the filters is they add more density to the highlight of a picture than to the shadow. But, one can still get a good indication of color changes provided this limitation is understood.
This picture shows the assortment of viewing filters found in the Kodak Color Print Viewing Kit.
FOOTNOTES


4 Ibid.


6 Ibid., p. 49.


12 W.L. Rhodes, "Review of the Aims of Color Reproduction," Inter-
Society Color Council Proceedings 1971, January 31 - February 3, 1971, 
p. 133.

13 Elizabeth G. Berglund, "Color Analyzers - The Latest Wrinkle In 
Quality Control," American Printers and Lithographers, April 1979, Vol. 183, 
No. 1, pp. 50-51.

14 Miles Southworth, Color Separation Techniques (Livonia, N.Y.: Gra-

15 Private talk with Milton Pearson of the Research Corporation at 
Rochester Institute of Technology in Rochester, N.Y.

16 W.L. Rhodes, p. 137.

17 Joseph E. Kling, p. 10.

18 Instructions to Kodak Color Print Viewing Kit, Publication No. R-25 
(Eastman Kodak Company, 1980).
STATEMENT OF THE PROBLEM

No matter what the purpose may be (commercial, educational, entertainment), four-color process printing is designed to be viewed and reacted to by people, the most important of which is the print buyer. The print buyer, therefore, has to be satisfied by what he sees.

Several physical and psychological factors contribute to the way the buyer perceives the reproduction. He carries a mental picture on how the blue sky and flesh tones should look and knows which areas are critical. When the printed proof does not match his mental impression, he states that he does not like the result and may have difficulty explaining why.\(^1\) His conclusion regarding picture quality is made quickly, is reasonably accurate, and requires no conscious effort because the process is a subjective one.\(^2\)

The printer has to learn from the first proof and repeat one or more steps in the preparation process and proof again, sometimes again and again, before a satisfactory result is obtained. This costly and inefficient trial-and-error procedure is a major printing industry problem which needs to be eliminated.\(^3\)

New techniques and new equipment are needed to specify what colors are important so as to avoid the multiple proofs and added time on press. The key is to get the human subjectivity of the customer involved sooner and thus reduce guesswork by the printer. This trend has already begun with the rising popularity of visual previewers.\(^4\)
Although the advantages of previewers are great, there is a degree of inconvenience as was discussed earlier which handicaps their effectiveness. This author proposes that a good supplement to the previewers would be the Kodak Color Print Viewing Filter Kit, a tool widely used by color photographers.  

In color photography, viewing filters are used primarily with darkroom activities to assist the photographer in establishing gray balance with his prints. Often, ideal gray balance is not an ideal print, especially in the case where the picture has a blue or yellow cast due to the type of artificial lighting used. The filters then come in handy to determine how much more cyan, magenta, and yellow needs to be added (or subtracted) from the filter pack to achieve the effect the photographer is looking for. After the adjustment is made, the exposure time is recalibrated and a new print is made.

The principles of color photography and process color printing are very similar in that they both use the subtractive primary colors to form their images. Often the transparencies presented to the printer have the same blue or yellow cast which needs to be neutralized. This leads to problems, the colors the buyer thought he was going to get don't come out and a decision needs to be made on how to achieve what the customer is looking for. As discussed earlier, a customer can have a preference for colors that don't actually exist in the real photographed scene. Slight deviations from gray balance "make colors warmer," "make colors colder," and "give pleasing colors" that the customer wants. Rather than go through the trial-and-error procedures of altering the separations and making additional proofs to get what the customer prefers, the use of viewing
filters by the customer could more accurately specify what is wanted before any alterations are made.

When a local printer was asked why he didn't use filters with his customers, his response was, "I really think they'll confuse the customer more." Perhaps there is some truth to this statement, or perhaps the statement disguises an unfamiliarity with the general application of the filters. Whatever the case may be, the subject deserves more attention. With the cost of added proofs and extra time on press as high as it is today, any system that "could save a dime" is worth looking into.
FOOTNOTES


3 Ibid.


HYPOTHESES

As stated in the introduction, the purpose of this study is to determine whether the Kodak Color Print Viewing Filters are effective when used by print buyers and printers. The hypotheses, therefore, appropriate for a statistical analysis are as follows:

Hypothesis 1: When participants who use viewing filters are compared to those who do not use filters, there is no difference in the number of proofs needed to determine necessary color changes.

Hypothesis 2: When participants who use viewing filters are compared to those who do not use filters, there is no difference in the degree of satisfaction for the final print selected.

Hypothesis 3: When participants who use viewing filters are compared to those who do not use filters, there is no difference in the amount of time needed to determine necessary color changes.

Since the design of the experiment uses three transparencies with unrelated scenes as original artwork, a fourth hypothesis is necessary.

Hypothesis 4: The scenes of the test images have no influence on the results to this experiment.

The objective of the statistical analysis is to verify whether these hypotheses are true. If any of the first three hypotheses prove false, we can then conclude that the viewing filters are helpful. If the last hypothesis is false, we can conclude that each test image influenced the results of the experiment differently.
All these hypotheses are tested using statistical techniques appropriate for each situation.²
FOOTNOTES

1 Kodak Color Print Viewing Filter Kit, Made in U.S.A. for Eastman Kodak Company, Rochester, N.Y. 14650, TM. Registered U.S. Pat. Off. CAT 150 0735.

MATERIALS NECESSARY FOR THE EXPERIMENT

Ideally, original transparencies and actual press proofs of the separations to the transparencies should have been used to test the participants in this experiment. For economic reasons, this approach was not possible. An alternative method was to use a medium that closely simulates press proofs. This led to the use of color photographics prints.

Production of Transparencies

The original artwork for this experiment consists of three four by five inch duplicate transparencies (made from Vericolor Professional Short negatives) that were typical of what's used on printed jobs.\(^1\) Each transparency was unrelated to the next; one was an indoor portrait, another was a flower scene, and the last one was a trumpet.

Production of Test Images

For each transparency, a five by six and a quarter inch print was made (using the same VPS negative) on Ektacolor RC 74 N surface paper.\(^2\) In addition, a ring around of prints with a plus .05 cc red, green, blue, cyan, magenta, and yellow were made on the same paper emulsion.\(^3\) Filter pack recordings were made and the photographic paper was put into a safe place for later use. (The processing chemistry and temperatures were in control.)\(^4\)

The three groups of seven prints along with their appropriate transparencies were shown to a panel of experts and one print from each group was designated as the most commercially acceptable.\(^5\) (See Figure 4, 5,
and 6.) These most commercially acceptable prints then became the basis for a ring around as specified in Figure 7. Twenty prints were made of each transparency with one print designated as the starting point print. Each print was mounted on a separate piece of eight by nine and a quarter inch hot press white illustration board (smooth and semi-gloss finish).
FIGURE 4

Portrait Test Image
FIGURE 5

Flower Test Image
FIGURE 6

Trumpet Test Image
FIGURE 7

(Trumpet)
Starting print for
3rd transparency

Starting print for
1st transparency
(Portrait)

Starting print for
2nd transparency
(Flower)
List of Terms

A list of terms was necessary for the experiment in order to standardize the language used. The list of terms compiled by this author were as follows in Table 2.

### TABLE 2

<table>
<thead>
<tr>
<th>Direction of color change</th>
<th>Color</th>
<th>Degree of color change</th>
</tr>
</thead>
<tbody>
<tr>
<td>plus or minus</td>
<td>cyan</td>
<td>a little (.05 CC)</td>
</tr>
<tr>
<td></td>
<td>magent</td>
<td>a fair amount (.10 CC)</td>
</tr>
<tr>
<td></td>
<td>yellow</td>
<td></td>
</tr>
<tr>
<td></td>
<td>red</td>
<td>a lot (.20 CC)</td>
</tr>
<tr>
<td></td>
<td>green</td>
<td></td>
</tr>
<tr>
<td></td>
<td>blue</td>
<td></td>
</tr>
</tbody>
</table>

If there was any question as to which colors are represented by any of the color names, illustrations out of the Kodak Color Data Darkroom Guide was used. If there was any question on the terms to the degree of color change, references were made to similar changes found with the printed product.

**Viewing Filters**

The viewing filters used in this experiment were the Kodak Color Print Viewing Filter Kit bought at any camera store that sells darkroom supplies. In order to avoid any confusion with the photographic instructions written on the holders of the filters, a special sleeve was made for each filter out of Dietzgen White Universal Drawing Paper. On the sleeves there were instructions pertinent only to this experiment.

Four points were made on how to use the visual filters. They were as follows:
1.) Look only at the lighter middletones in the print by holding the filter away from the print so that the light falling on the print does not go through the filter first.  

2.) Quickly flick the filter in and out of line of vision to observe the color correction the filter makes.  

3.) Viewing filters will tinge the highlights excessively and the shadows insufficiently. Therefore, disregard these tonal extremities and judge the effect primarily on the basis of the middletones.  

4.) Each filter has three density levels. The light one is equivalent to a 'a little' (.05 CC) change in the light midtone areas, the dark one is equivalent to 'a lot' (.20 CC) and the one in between is 'a fair amount' (.10 CC).  

The transparencies with their appropriate prints, the list of terms, and the slightly revised viewing filters were the only materials necessary for this experiment.
FOOTNOTES

1 To be furnished by T.W. McFarlan, Photographer in Asheville, N.C.

2 Suggested by Mr. E. McCune of the Photographic Processing and Finishing Management Laboratory at Rochester Institute of Technology in Rochester, N.Y.


4 Confirmed by Lawrence E. Butler of Reflections, 2160 West Henrietta Road, Rochester, N.Y.

5 From the School of Photography, Rochester Institute of Technology, Rochester, New York. They are as follows: Professor Current (Instructor), Mr. Robert Iceland (Summer Instructor), Walter Dufresand (Professional Photographer), Stanley Lochoki (Lab Assistant), David Alison (Senior Year Student), and Richard Kunkle (Senior Year Student).

6 Kodak Color Print Viewing Filter Kit, Made in U.S.A. for Eastman Kodak Company, Rochester, N.Y. 14650, TM. Registered U.S. Pat. Off. CAT 14650, TM.


8 Instructions to Kodak Color Print Viewing Filter Kit, Publication No. R-25 (Eastman Kodak Company, 1980).

9 Ibid.

10 Ibid.

11 Ibid.
DESIGN OF THE EXPERIMENT

Viewing Area

The setting of the experiment was a transparency viewer inside a viewing booth, both of which met the standards of ANSI. The area around the viewing booth was inspected for any light source that could adversely affect the conditions in the booth.

Definition of the Population

Twenty buyers and twenty producers of four-color process printing were selected to participate in this experiment. Each of the participants were tested for normal color vision with the Isihara Charts.

Procedures of the Experiment

The procedures of the experiment simulated, as best as possible, the process the print buyer and printer go through to get to the color O.K.'d proof.

Since the proofing medium for this experiment were photographic prints, there was some uncertainty on whether the color changes asked for would have the same effect as on the printed sheet. This experimenter explained that, aside from the continuous tone imaging of prints and the screen imaging of press proofs, the two mediums are similar in response to overall color changes.

Each participant was assigned three tests (one on each test image) and instructed on when and when not to use the viewing filters. The order
of the test and the use of the viewing filters were random. Provided the first test was without filters, the procedures were as follows:

1.) Each participant was brought separately into the viewing area and presented a transparency and starting point print that was badly out of color balance.

2.) The participant was then told the purpose of the experiment is to determine what overall color changes are necessary to get the print to match the transparency as closely as possible. (As far as the experiment was concerned, there was no one print considered best. Each buyer had to decide for himself.)

3.) A list of terms (see Methodology) was then provided to the participant through which he was to give his instructions. Any questions that arose on the procedures of the experiment were answered at this point.

4.) Once the questions were answered, the starting time was checked discretely and the participant was told to look at the transparency in the viewer, judge the starting point print, and instruct this experimenter on how he wants the color changed overall. (See Figure 8)

*Note: For the British, the optimum way to look at a transparency is to put a border around it made of the same substrate used for the print.\(^4\) In the U.S., ANSI specifies that two inches or more white space around three sides of the transparency with proper illumination is best.\(^5\) In this experiment the participant was allowed to decide for himself.
This picture shows a participant working on the portrait test without using viewing filters.
5.) Once the participant gave the instructions, this experimenter responded one of two ways. Either he showed a second print along side the first that had the appropriate changes or he told the participant the change wouldn't work and another instruction was necessary. This process went on until the participant arrived at the print which he preferred. The total number of prints and no go responses necessary to get to the preferred print made up the data for number of proofs.

6.) While setting up the next experiment, the finish time was discretely noted and used as the data for amount of time.

Depending on how the tests were assigned, the participant was also asked to use the viewing filters. Here the procedures were slightly different. Instead of just telling this experimenter what changes should be made, the participant was asked to use the aid of the color print viewing filters (after a brief demonstration) before giving this experimenter instructions. With the exception of the viewing filters, the procedures were the same as before. (See Figure 9)

Once the participant finished the three tests, this experimenter shuffled up the twenty prints to the first test and had the participant pick out the ones that were acceptable. The participant was then told to arrange the acceptable prints in sequential order from best to worst. The position of the preferred print (from the first half of the experiment) was counted from the 'best' print. This was the data for the degree of satisfaction. The same procedures followed with the prints for the second and third tests.
This picture shows a participant working on the flower test with the aid of the viewing filters.
At the conclusion, each participant was told not to talk about what went on in order to avoid prejudicing the experiment.

**Statistical Analysis**

The statistical analysis consists of three parts; one on the number of proofs, a second on the degree of satisfaction, and a final one on the amount of time. For each part, three analyses were performed; one on the buyers, a second on the printers, and a third on the two groups combined. For each part, Two and Three Way ANOVA with Interaction techniques were used. Further analysis was used wherever appropriate to clearly define the significant differences.
FOOTNOTES


2 Isihara Charts were acquired from Dr. L. Stroebel at Rochester Institute of Technology, College of Graphic Arts and Photography.

3 Based on a conversation with Assoc. Professor Joe Noga at Rochester Institute of Technology, College of Graphic Arts and Photography.


PEOPLE SELECTED FOR THE EXPERIMENT

As was mentioned earlier, twenty buyers and twenty printers were needed for this experiment. All the people selected were actively involved with the same color separations tradehouse (Spectralith, Inc., 650 South Clark Street, Chicago, Illinois 60505) and they all played a part in the production of four-color separations.

The participants were tested for color blindness and one person had a slight deficiency with the red and green colors. Although this person had some trouble with the Portrait and Flower Tests, the problem was not severe enough to eliminate his results.

Buyers Selected for the Experiment

A more accurate definition of the buyers tested in this experiment would be people that have the final say on the colors of four-color separations. Roughly four kinds of buyers are significant. First is the buyer of color printing for an advertising firm whose concern, more often than not, is to make sure the colors project a particular kind of mood. Second is the buyer for a manufacturer whose concern is to match as closely as possible the actual colors of the products displayed. The third kind would be publishers whose concern is with the uniformity of pictures throughout a particular text. And finally, the fourth kind is the printer who farms out the color separations and is concerned with accurately conveying the color instructions he gets from his customer to the color separator.
A breakdown on the twenty buyers tested in this experiment is as follows:

Buyers for Advertisers

1.) Lynn Bement
    Frankel and Company
    111 East Wacker Drive
    Chicago, Ill. 60601

2.) Frae Blan
    Frankel and Company
    111 East Wacker Drive
    Chicago, Ill. 60601

3.) Ed Rose
    Frankel and Company
    111 East Wacker Drive
    Chicago, Ill. 60601

4.) Diane Norman
    Garfield-Linn and Company
    Advertising Marketing
    875 North Michigan Ave.
    Chicago, Ill. 60611

5.) Vivian West
    Keroff and Rosenberg
    444 North Wabash
    Chicago, Ill. 60611

6.) Paul Lambert
    Martin-Lambert
    650 South Clark
    Chicago, Ill. 60605

7.) Tom Lynch (self-employed artist)
    605 North Chestnut
    Arlington Heights, Ill. 60004

Buyers for Manufacturers

8.) John Cathers
    Monogram Models, Inc.
    8601 Waukegan Rd.
    Morton Grove, Ill. 60053

9.) Pam Cathers
    Monogram Models, Inc.
    8601 Waukegan Rd.
    Morton Grove, Ill. 60053
10.) Chou J. Chan
Monogram Models, Inc.
8601 Waukegan Rd.
Morton Grove, Ill. 60053

11.) Jon Malm
Montgomery Ward
Catalog Production Dept.
Montgomery Ward Plaza
Chicago, Ill. 60671

12.) Jim Sulis
Montgomery Ward
Catalog Production Dept.
Montgomery Ward Plaza
Chicago, Ill. 60671

13.) Rolf Rosseurg (works with Montgomery Ward)
Chicago Rotoprint Co.
4601 West Belmont Ave.
Chicago, Ill. 60644

Buyers for a Publisher

14.) John Babrick
World Book-Childcraft Int'l Inc.
Merchandise Mart Plaza
Chicago, Ill. 60654

15.) Julie Bomhoff
World Book-Childcraft Int'l Inc.
Merchandise Mart Plaza
Chicago, Ill. 60654

16.) Tom Kinney
World Book-Childcraft Int'l Inc.
Merchandise Mart Plaza
Chicago, Ill. 60654

17.) Barbara McDonald
World Book-Childcraft Int'l Inc.
Merchandise Mart Plaza
Chicago, Ill. 60654

Buyers for a Printer

18.) Carl Carlson
Mid City Lithographers, Inc.
229 Northfield Rd.
Northfield, Ill. 60093
With the exception of two cases, all the participants had at least three years of experience at their jobs and were considered authorities with color. The two exceptions were knowledgeable about color but generally held a trainee position.

Printers Selected for the Experiment

A more accurate definition of the printers selected for this experiment would be people who are involved in the actual production and printing of four-color separations. Roughly six kinds of people are significant. First is the salesman who receives the order for color separations from a customer. Second is the production coordinator who processes and follows up on the order. Third is the scanner (or camera) operator who actually does the color separations. Fourth is the dot etcher who corrects the color separations. Fifth is the pre-pressman who furnishes proofs before they go on press. And last is the pressman who makes the final product, a four-color press proof, which is submitted back to the customer. One thing which should be noted at this point is that the stripper is not part of the list. This experimenter feels that the stripper's function is not one of producing color separations but one of positioning color separations according to a specified layout. Therefore he has limited involvement in evaluating color and might not be a good participant in this experiment.
A breakdown on the twenty printers selected from Spectralight, Inc. for this experiment is as follows:

Salesmen

1.) Bob Granato
2.) Herb Harding
3.) Tom Kane
4.) John Mischitz
5.) Bob Pabrocki
6.) Stan Roscoe

Production Coordinators

7.) Rudi Bondora
8.) Jim Picman
9.) Larry Synakicwiiz

Camera Men

10.) Mike Keutelian (makes duplicate transparencies)
11.) John Blackwell (camera man)
12.) Gary Feidor (scanner)
13.) Mike Karlov (scanner)
14.) John Winston (scanner)
15.) Sam Kerkonian (quality control)

Dot Etcher

16.) Art Baulac

Pre-Pressman

17.) Kerakin Deltbian
Pressmen

18.) Dick Deck

19.) Luis Hernandez

20.) Ray Sargis

All the printers listed above had at least three years experience with their jobs.
DIFFICULTIES WITH THE EXPERIMENT

As would be expected, no experiment goes smoothly ... especially when testing professional people who have very hectic schedules. In order to, first, make the experiment more efficient so little time was wasted and, second, accommodate the buyers and printers so they weren't inconvenienced in any way, a few changes to the original design of the experiment were necessary.

Elimination of List of Terms

This experimenter discovered that to furnish a list of terms only complicated the experiment more. The new approach was to review the parameters of the experiment with the participant and then this experimenter would translate all the instructions received and use the list of terms as a reference. If there was any uncertainty, this experimenter asked questions about the instructions to make sure the right changes were made.

Limit to Color Instructions

In some cases, three color instructions were given at one time which this experimenter sometimes had a hard time resolving. If a difficulty was encountered, the participant was asked to limit himself to two color instructions.

Added Instructions On Viewing Filters

After explaining how the viewing filters worked, this experimenter noted that some of the participants had a difficult time getting started. To help these people along, it was suggested they first think
about what overall color corrections were necessary and then use the appropriate viewing filters to see what changes would result. Once the participants got started with the filters, they often became more relaxed with their application.

**A Problem With the Viewing Filters**

One buyer who was wearing glasses with Photo Gray lenses found the viewing filters totally ineffective while judging the starting point print for the trumpet. The data for her test on the trumpet was determined by averaging the scores of the other participants that took the same test. She was the only person that wore lenses with discoloration.

**Change in Viewing Area**

Many of the buyers and some of the printers tested were busy and unable to make the journey down to the viewing area designated for the experiment. So, this experimenter went to the viewing areas most convenient to the buyers. In these instances it was specified that viewing areas used had to be areas where color evaluations were normally made.

As it turns out, all the printers were tested in areas that met ANSI standards but only six out of the twenty buyers were tested under the same conditions. The other fourteen buyers were tested under varying conditions. Some were tested in rooms that had good Macbeth overhead lights while others were tested in rooms equipped only with fluorescent room lights. In all cases, either the Macbeth Prooflite 516 Standard Viewer or the Graphic Lite GTI Standard Viewer was used for the transparencies.

Although the change in viewing areas prevents this experimenter from making any assumptions on color preference for this particular group, the effectiveness of the viewing filters can still be judged. A positive aspect
of this change is that conditions used by the buyers in the tests were conditions they used regularly. So, if anything the experiment applies to more realistic conditions than was originally designed.

At the end of the experiment, a comparison was made between the buyers who took the tests in viewing booths that met ANSI standards versus those who did the experiment under varying conditions, no significant differences were detected. (See Appendix Two)

**Discrepancies Due to Contrast Problems**

The inherent contrast differences between the transparencies and the prints to all three test images led to some discrepancies between light and dark areas. (See Figure 10) For instance, if a person was judging the light green background area of the flower print to the same background area on the transparency, he would more likely than not choose a print with slightly more cyan than normal to match the transparency. The darker red flower in the foreground appeared to have too much cyan as a result of this decision. If another person focused on the flower, chances were he would settle for a warmer print which resulted in a background that appeared too yellow when compared to the transparency. This, of course, varied from one lighting condition to another. The participants had the same sort of trouble with the portrait but usually resolved the dilemma by concentrating on the fleshtones.

With the trumpet, the participants encountered a slightly different problem. Here the designated changes in color balance were much more subtle than with the other test images. Unless one focused in certain key areas, like the trumpet valves, the changes were difficult to see. This experimenter has no explanation for this.
Measurements were made on a calibrated Macbeth TR 927 Transmission and Reflection Densitometer.
<table>
<thead>
<tr>
<th></th>
<th>Trans.</th>
<th>Print</th>
</tr>
</thead>
<tbody>
<tr>
<td>highlight -</td>
<td>.37</td>
<td>.30</td>
</tr>
<tr>
<td></td>
<td>.74</td>
<td>.67</td>
</tr>
<tr>
<td></td>
<td>1.33</td>
<td>1.14</td>
</tr>
<tr>
<td></td>
<td>1.39</td>
<td>1.21</td>
</tr>
<tr>
<td>shadow -</td>
<td>2.64</td>
<td>2.04</td>
</tr>
</tbody>
</table>

* Measurements were made on a calibrated Macbeth TR 927 Transmission and Reflection Densitometer.
It is interesting to compare the prints which were claimed to be the best by the participants. (See Table 3) There was more agreement with the portrait image because most of the participants concentrated on the fleshtones for color. With the trumpet and flower images there was less agreement because the participants concentrated on different areas in each picture.

To the best of this experimenter's knowledge, none of the changes discussed above handicapped the effectiveness of the experiment. Surprisingly, the order with which the tests were given had no significant effect on the results. (See Appendix Three) A few of the participants were anxious to get the tests over with due to other pending responsibilities; by and large, however, the cooperation was very good.
TABLE 3

Prints designated as being 'best' by the participants

**Portrait**

printers - 1,1,1,4,4,2,1,1,2,1,1,1,4,7,4,2,4,15,2

buyers - 3,2,1,1,1,5,1,4,19,19,1,1,1,1,1,4,15,4,1,4

Nineteen out of forty agreed to same print.

**Trumpet**

printers - 2,4,4,3,4,11,1,1,1,11,4,11,1,11,4,2,3,3,4

buyers - 1,3,3,2,3,3,4,11,2,2,2,4,1,4,1,4,14,11,3,4

Eleven out of forty agreed to same print.

**Flower**

printers - 4,5,5,1,6,6,6,6,6,4,5,6,5,6,2,6,3,15

buyers - 14,1,5,5,1,4,1,5,1,7,6,4,6,6,6,4,3,4,4,4

Thirteen out of forty agreed to same print.

* Figure 6 on page thirty-eight has the breakdown on these numbers.
STATISTICAL ANALYSIS

The raw data to this experiment can be seen in Appendix One. The analysis is broken into three parts; one on the Number of Proofs, a second on the Degree of Satisfaction, and a third on the Amount of Time. By and large, more than one test was performed in each part to more clearly define the significant differences. In all cases, the conclusions were made with ninety percent confidence.

**Number of Proofs**

Analysis of the Buyers

Model in question:

\[ X_{ijk} = \lambda + A_i + B_j + AB_{ij} + E_{k(ij)} \]

where

- \( \lambda \) represents average for population
- \( A_i \) represents the test images
- \( B_j \) represents the viewing filters
- \( AB_{ij} \) represents the interaction between test images and viewing filters
- \( E_{k(ij)} \) represents error
Compilation of Data:

### Factor $A_i$

<table>
<thead>
<tr>
<th>Portrait</th>
<th>Trumpet</th>
<th>Flower</th>
<th>$\bar{X}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>w/ filters</td>
<td>3 4 3 2 4</td>
<td>6 7 4 3 6</td>
<td>3 3 7 3 2</td>
</tr>
<tr>
<td>w/o filters</td>
<td>4 3 4 3 4</td>
<td>4 3 7 4 5</td>
<td>4 2 5 4 5</td>
</tr>
</tbody>
</table>

$\bar{X}$ is 3.4

### Factor $B_j$

| | 5 5 4 7 6 | 5 5 4 4 5 | 5 4 4 4 7 | 4.83 |
| w/o filters | 6 3 6 6 3 | 3 6 4 3 8 | 4 5 6 2 6 | 4.83 |
| $\bar{X}$ | 4.25 | 4.8 | 4.25 | 4.43 |

* The standard deviation for the data above is 1.454 with a ninety percent confidence interval of plus or minus .23 to each mean.

To Way ANOVA with Interaction Analysis:

<table>
<thead>
<tr>
<th>SOURCE</th>
<th>SUM OF SQUARE</th>
<th>D.F.</th>
<th>MEAN SQUARE</th>
<th>CALCULATED F RATIO</th>
<th>TABLE F RATIO</th>
<th>CONCLUSION</th>
</tr>
</thead>
<tbody>
<tr>
<td>$A_i$</td>
<td>4.0333</td>
<td>2</td>
<td>2.01665</td>
<td>1.0676</td>
<td>2.3932</td>
<td>Not Signif.</td>
</tr>
<tr>
<td>$B_j$</td>
<td>9.6</td>
<td>1</td>
<td>9.6</td>
<td>5.0824</td>
<td>2.7914</td>
<td>Significant</td>
</tr>
<tr>
<td>$A B_{ij}$</td>
<td>9.1</td>
<td>2</td>
<td>4.55</td>
<td>2.4088</td>
<td>2.3932</td>
<td>Significant</td>
</tr>
<tr>
<td>$E_{k(ij)}$</td>
<td>102</td>
<td>54</td>
<td>1.889</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>124.7333</td>
<td>59</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

* D.F. is Degrees of Freedom
Graph for Buyers:

Conclusion:

For buyers, viewing filters significantly reduced the number of proofs with two of the test images, the portrait and flower. With the trumpet, there was a slight increase in the number of proofs which was enough to make the interaction between test images and viewing filters significant.

Analysis of the Printers

Model in Question:

(same as before)

Compilation of Data:

\[
\begin{array}{c|c|c|c|c|c|c|c|c}
\text{Factor } A_i & \text{Portrait} & \text{Trumpet} & \text{Flower} & \bar{X} \\
\hline
\text{w/ filters} & 4 & 2 & 7 & 3 & 2 & 2 & 4 & 4 & 10 & 5 & 3 & 3 & 4 & 3 & 8 & 4.20 \\
\text{5} & 4 & 3 & 3 & 3 & 5 & 4 & 5 & 5 & 5 & 3 \\
\hline
\bar{X} \text{ is 3.6} & \bar{X} \text{ is 4.7} & \bar{X} \text{ is 4.3} \\
\end{array}
\]
Factor $B_j$

<table>
<thead>
<tr>
<th></th>
<th>6</th>
<th>4</th>
<th>3</th>
<th>4</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>w/o filters</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

$\bar{X}$ is 3.9

<table>
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<th>4</th>
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$\bar{X}$ is 4.7

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<td>3</td>
<td>4</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

$\bar{X}$ is 4.1

* The standard deviation for the data above is 1.552 with a ninety percent confidence interval of plus or minus .33 to each mean.

Two Way ANOVA with Interaction Analysis:

<table>
<thead>
<tr>
<th>SOURCE</th>
<th>SUM OF SQUARE</th>
<th>D.F.</th>
<th>MEAN SQUARE</th>
<th>CALCULATED $F$ RATIO</th>
<th>TABLE $F$ RATIO</th>
<th>CONCLUSION</th>
</tr>
</thead>
<tbody>
<tr>
<td>$B_j$</td>
<td>.0166</td>
<td>1</td>
<td>.0166</td>
<td>.0068</td>
<td>2.7914</td>
<td>Not Signif.</td>
</tr>
<tr>
<td>$A_B_{ij}$</td>
<td>.6337</td>
<td>2</td>
<td>.31685</td>
<td>.1291</td>
<td>2.3932</td>
<td>Not Signif.</td>
</tr>
<tr>
<td>$E_{k(ij)}$</td>
<td>132.5</td>
<td>54</td>
<td>2.45370</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>142.1833</td>
<td>59</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Graph for Printers:

![Graph showing number of proofs for Portrait, Trumpet, and Flower with filters and w/o filters]

- w/ filters
- w/o filters
Conclusion:

For printers, neither the viewing filters nor the test images significantly affected the number of proofs.

Analysis of the Entire Experiment

Model in question:

\[ X_{ijkl} = \bar{\eta} + A_i + B_j + C_k + A_B\ ij + A_C\ ik + B_C\ jk + A_B C\ ijk + E_{1(ijk)} \]

where

- \( \bar{\eta} \) represents average for population
- \( A_i \) represents the test images
- \( B_j \) represents the viewing filters
- \( C_k \) represents the participants (buyers and printers)
- \( A_B\ ij \) represents the interaction between test images and viewing filters
- \( A_C\ ik \) represents the interaction between test images and participants
- \( B_C\ jk \) represents the interaction between viewing filters and participants
- \( A_B C\ ijk \) represents the interaction between test images, viewing filters, and participants
- \( E_{1(ijk)} \) represents error
Compilation of Data:

<table>
<thead>
<tr>
<th>Factor A&lt;sub&gt;i&lt;/sub&gt;</th>
<th>Portrait</th>
<th>Trumpet</th>
<th>Flower</th>
<th>X</th>
</tr>
</thead>
<tbody>
<tr>
<td>w/ filters buyers</td>
<td>3 4 3 2 4</td>
<td>6 7 4 3 6</td>
<td>3 3 7 3 2</td>
<td>4.12</td>
</tr>
<tr>
<td>Factor C&lt;sub&gt;k&lt;/sub&gt; printers</td>
<td>4 3 4 3 4</td>
<td>4 3 7 4 5</td>
<td>4 2 5 4 5</td>
<td></td>
</tr>
<tr>
<td>w/o filters buyers</td>
<td>4 2 7 3 2</td>
<td>2 4 4 10 5</td>
<td>3 3 4 3 8</td>
<td></td>
</tr>
<tr>
<td>Factor B&lt;sub&gt;j&lt;/sub&gt; printers</td>
<td>5 4 3 3 3</td>
<td>3 6 4 3 6</td>
<td>5 4 5 5 3</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Factor B&lt;sub&gt;j&lt;/sub&gt;</th>
<th>5 5 4 7 6</th>
<th>5 5 4 4 5</th>
<th>5 4 4 4 7</th>
<th>4.53</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factor C&lt;sub&gt;k&lt;/sub&gt;</td>
<td>6 3 6 6 3</td>
<td>3 6 4 3 8</td>
<td>4 5 6 2 6</td>
<td></td>
</tr>
<tr>
<td>w/o filters X</td>
<td>3 4 4 3 4</td>
<td>6 6 4 4 4</td>
<td>6 3 4 4 3</td>
<td>4.32</td>
</tr>
</tbody>
</table>

* The standard deviation for the data above is 1.454 with a ninety percent confidence interval of plus or minus .23 to each mean.

Three Way ANOVA with Interaction Analysis:

<table>
<thead>
<tr>
<th>SOURCE</th>
<th>SUM OF SQUARE</th>
<th>D.F.</th>
<th>MEAN SQUARE</th>
<th>CALCULATED F RATIO</th>
<th>TABLE F&lt;sub&gt;0&lt;/sub&gt; RATIO</th>
<th>CONCLUSION</th>
</tr>
</thead>
<tbody>
<tr>
<td>A&lt;sub&gt;i&lt;/sub&gt;</td>
<td>11.85</td>
<td>2</td>
<td>5.925</td>
<td>2.7288</td>
<td>2.3473</td>
<td>Significant</td>
</tr>
<tr>
<td>B&lt;sub&gt;j&lt;/sub&gt;</td>
<td>5.2083</td>
<td>1</td>
<td>5.2083</td>
<td>2.3987</td>
<td>2.7478</td>
<td>Not Signif.</td>
</tr>
<tr>
<td>C&lt;sub&gt;k&lt;/sub&gt;</td>
<td>1.4083</td>
<td>1</td>
<td>1.4083</td>
<td>.6486</td>
<td>2.7478</td>
<td>Not Signif.</td>
</tr>
<tr>
<td>AB&lt;sub&gt;ijk&lt;/sub&gt;</td>
<td>6.1167</td>
<td>2</td>
<td>3.05835</td>
<td>1.4085</td>
<td>2.3473</td>
<td>Not Signif.</td>
</tr>
<tr>
<td>AC&lt;sub&gt;ik&lt;/sub&gt;</td>
<td>1.2167</td>
<td>2</td>
<td>.60835</td>
<td>.2802</td>
<td>2.3473</td>
<td>Not Signif.</td>
</tr>
<tr>
<td>BC&lt;sub&gt;jk&lt;/sub&gt;</td>
<td>4.4084</td>
<td>1</td>
<td>4.4084</td>
<td>2.0303</td>
<td>2.7478</td>
<td>Not Signif.</td>
</tr>
<tr>
<td>ABC&lt;sub&gt;ijk&lt;/sub&gt;</td>
<td>3.6166</td>
<td>2</td>
<td>1.8083</td>
<td>.8328</td>
<td>2.3473</td>
<td>Not Signif.</td>
</tr>
<tr>
<td>E&lt;sub&gt;1(ijk)&lt;/sub&gt;</td>
<td>234.5</td>
<td>108</td>
<td>2.1713</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>268.325</td>
<td>119</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* D.F. is Degrees of Freedom
Graph for Buyers and Printers:

Conclusion:

The test images used in this experiment significantly affected the number of proofs necessary to get the desired print.

Analysis of the Portrait

An analysis was applied to each of the test images and only the portrait had any significant results.

Model in question:

\[ X_{ijk} = \mu + A_i + B_j + AB_{ij} + E_{k(ij)} \]

where

\( \mu \) represents average for population

\( A_i \) represents the participants (buyers and printers)

\( B_j \) represents the viewing filters

\( AB_{ij} \) represents the interaction between participants and viewing filters

\( E_{k(ij)} \) represents error
Compilation of Data:

Factor $A_i$

<table>
<thead>
<tr>
<th>W/ filters</th>
<th>Printers</th>
<th>Buyers</th>
<th>$\bar{x}$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4 2 7 3 2</td>
<td>3 4 3 2 4</td>
<td>3.5</td>
</tr>
<tr>
<td>5 4 3 3 3</td>
<td>4 3 4 3 4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Factor $B_j$

<table>
<thead>
<tr>
<th>w/o filters</th>
<th>Printers</th>
<th>Buyers</th>
<th>$\bar{x}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>X is 3.6</td>
<td>6 4 3 4 4</td>
<td>5 5 4 7 6</td>
<td>4.5</td>
</tr>
<tr>
<td>3 4 4 3 4</td>
<td>6 3 6 6 3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$\bar{x}$ is 3.9  $\bar{x}$ is 5.1  4.0

* The standard deviation for the data above is 1.301 with a ninety percent confidence interval of plus or minus .35 to each mean.

Two Way ANOVA with Interaction Analysis:

<table>
<thead>
<tr>
<th>SOURCE</th>
<th>SUM OF SQUARE</th>
<th>D.F.</th>
<th>MEAN SQUARE</th>
<th>CALCULATED F RATIO</th>
<th>TABLE F RATIO</th>
<th>CONCLUSION</th>
</tr>
</thead>
<tbody>
<tr>
<td>$A_i$</td>
<td>2.5</td>
<td>1</td>
<td>2.5</td>
<td>1.8519</td>
<td>2.8807</td>
<td>Not Signif.</td>
</tr>
<tr>
<td>$B_j$</td>
<td>10.0</td>
<td>1</td>
<td>10.0</td>
<td>7.4074</td>
<td>2.8807</td>
<td>Significant</td>
</tr>
<tr>
<td>$A_Bij$</td>
<td>4.9</td>
<td>1</td>
<td>4.9</td>
<td>3.6296</td>
<td>2.8807</td>
<td>Significant</td>
</tr>
<tr>
<td>$F_{k(ij)}$</td>
<td>48.6</td>
<td>36</td>
<td>1.35</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>66.0</td>
<td>39</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* D.F. is Degrees of Freedom
Graph for the Portrait:

Conclusion:

On the portrait, viewing filters significantly reduced the number of proofs for the buyers but not for the printers.

Degree of Satisfaction

Analysis of the Buyers

Model in question:

\[ X_{ijk} = \lambda + A_i + B_j + AB_{ij} + E_{k(ij)} \]

where

- \( \lambda \) represents average for population
- \( A_i \) represents the test images
- \( B_j \) represents the viewing filters
- \( AB_{ij} \) represents the interaction between test images and viewing filters
- \( E_{k(ij)} \) represents error
Compilation of Data:

Factor A<sub>i</sub>

<table>
<thead>
<tr>
<th>Portrait</th>
<th>Trumpet</th>
<th>Flower</th>
<th>( \bar{X} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>w/ filters ( \bar{X} ) is 1.6</td>
<td>w/o filters ( \bar{X} ) is 2.4</td>
<td>( \bar{X} ) is 2.0</td>
<td>2.43</td>
</tr>
</tbody>
</table>

Factor B<sub>j</sub>

<table>
<thead>
<tr>
<th>Portrait</th>
<th>Trumpet</th>
<th>Flower</th>
<th>( \bar{X} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>w/ filters ( \bar{X} ) is 3.1</td>
<td>w/o filters ( \bar{X} ) is 2.6</td>
<td>( \bar{X} ) is 2.85</td>
<td>2.63</td>
</tr>
</tbody>
</table>

Two Way ANOVA with Interaction Analysis:

<table>
<thead>
<tr>
<th>SOURCE</th>
<th>SUM OF SQUARE</th>
<th>D.F.</th>
<th>MEAN SQUARE</th>
<th>CALCULATED F RATIO</th>
<th>TABLE F&lt;sub&gt;0&lt;/sub&gt; RATIO</th>
<th>CONCLUSION</th>
</tr>
</thead>
<tbody>
<tr>
<td>A&lt;sub&gt;i&lt;/sub&gt;</td>
<td>8.6333</td>
<td>2</td>
<td>4.31665</td>
<td>2.7320</td>
<td>2.3932</td>
<td>Significant</td>
</tr>
<tr>
<td>B&lt;sub&gt;j&lt;/sub&gt;</td>
<td>.6000</td>
<td>1</td>
<td>.6000</td>
<td>.3797</td>
<td>2.7914</td>
<td>Not Signif.</td>
</tr>
<tr>
<td>AB&lt;sub&gt;ij&lt;/sub&gt;</td>
<td>4.3</td>
<td>2</td>
<td>2.15</td>
<td>1.3608</td>
<td>2.3932</td>
<td>Not Signif.</td>
</tr>
<tr>
<td>E&lt;sub&gt;k(ij)&lt;/sub&gt;</td>
<td>85.4</td>
<td>54</td>
<td>1.58</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>98.9333</td>
<td>59</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* D.F. is Degrees of Freedom

* The standard deviation for the data above is 1.295 with a ninety percent confidence interval of plus or minus .28 to each mean.
Graph for Buyers:

![Graph showing degree of satisfaction for buyers with and without filters.]

**Conclusion:**

The degree of satisfaction the buyers had for the final print selected was significantly affected by the test images.

**Analysis of the Printers**

**Model in Question:**

(same as before)

**Compilation of Data:**

<table>
<thead>
<tr>
<th></th>
<th>Portrait</th>
<th>Trumpet</th>
<th>Flower</th>
<th>( \bar{X} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>w/ filters</td>
<td>2 1 1 1 2 1</td>
<td>4 4 3 2 1</td>
<td>2 4 3 1 3</td>
<td>2.47</td>
</tr>
<tr>
<td>Factor B</td>
<td>1 1 1 1 4 3</td>
<td>1 1 4 4 3</td>
<td>3 4 2 4 4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( \bar{X} ) is 1.7</td>
<td>( \bar{X} ) is 2.7</td>
<td>( \bar{X} ) is 3.0</td>
<td></td>
</tr>
<tr>
<td>w/o filters</td>
<td>2 4 1 4 1</td>
<td>3 2 1 2 1</td>
<td>1 4 3 3 3</td>
<td>2.6</td>
</tr>
<tr>
<td></td>
<td>1 3 4 1 4</td>
<td>3 4 4 4 4</td>
<td>1 1 3 4 2</td>
<td></td>
</tr>
<tr>
<td>( \bar{X} )</td>
<td>( \bar{X} ) is 2.5</td>
<td>( \bar{X} ) is 2.8</td>
<td>( \bar{X} ) is 2.5</td>
<td>\bar{X} 2.1 2.75 2.75</td>
</tr>
</tbody>
</table>

* The standard deviation for the data above is 1.241 with a ninety percent confidence interval of plus or minus .27 to each mean.
Two Way ANOVA with Interaction Analysis:

<table>
<thead>
<tr>
<th>SOURCE</th>
<th>SUM OF SQUARE</th>
<th>D.F.</th>
<th>MEAN SQUARE</th>
<th>F RATIO</th>
<th>TABLE F RATIO</th>
<th>CONCLUSION</th>
</tr>
</thead>
<tbody>
<tr>
<td>A_i</td>
<td>5.63333</td>
<td>2</td>
<td>2.816665</td>
<td>1.8824</td>
<td>2.3932</td>
<td>Not Signif.</td>
</tr>
<tr>
<td>B_j</td>
<td>0.26666</td>
<td>1</td>
<td>0.26666</td>
<td>0.1782</td>
<td>2.7914</td>
<td>Not Signif.</td>
</tr>
<tr>
<td>AB_ij</td>
<td>4.23334</td>
<td>2</td>
<td>2.11667</td>
<td>1.4146</td>
<td>2.3932</td>
<td>Not Signif.</td>
</tr>
<tr>
<td>E_k(ij)</td>
<td>80.8</td>
<td>54</td>
<td>1.49629</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>90.9333</td>
<td>59</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* D.F. is Degrees of Freedom

Graph for Printers:

Conclusion:

For printers, there were no significant factors that affected the degree of satisfaction for the final prints.
Analysis of the Entire Experiment

Model in Question:

\[ x_{ijkl} = \mu + A_i + B_j + C_k + A_B_{ij} + A_C_{ik} + B_C_{jk} + A_B C_{ijk} + e_{1(ijk)} \]

where

\( \mu \) represents average for population

\( A_i \) represents the test images

\( B_j \) represents the viewing filters

\( C_k \) represents the participants (buyers and printers)

\( A_B_{ij} \) represents the interaction between test images and viewing filters

\( A_C_{ik} \) represents the interaction between test images and participants

\( B_C_{jk} \) represents the interaction between viewing filters and participants

\( A_B C_{ijk} \) represents the interaction between test images, viewing filters, and participants

\( e_{1(ijk)} \) represents error

Factor \( A_i \)

<table>
<thead>
<tr>
<th>Portrait w/ filters</th>
<th>Trumpet</th>
<th>Flower</th>
<th>( \bar{x} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>buyers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 1 1 2 1</td>
<td>2 3 4 4</td>
<td>2 1 2 2 3</td>
<td></td>
</tr>
<tr>
<td>1 1 1 4 2</td>
<td>1 4 1 4 4</td>
<td>2 4 4 4 2</td>
<td></td>
</tr>
<tr>
<td>2.45</td>
<td></td>
<td>2.75</td>
<td></td>
</tr>
</tbody>
</table>

Factor \( C_k \)

<table>
<thead>
<tr>
<th>Portrait buyers</th>
<th>Trumpet</th>
<th>Flower</th>
<th>( \bar{x} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 1 1 2 1</td>
<td>4 4 3 2 1</td>
<td>2 4 3 1 3</td>
<td></td>
</tr>
<tr>
<td>1 1 4 4 3</td>
<td>1 1 4 4 3</td>
<td>3 4 2 4 4</td>
<td></td>
</tr>
<tr>
<td>2.62</td>
<td></td>
<td>2.53</td>
<td></td>
</tr>
</tbody>
</table>

* The standard deviation for the data above is 1.263 with a ninety percent confidence interval of plus or minus .19 to each mean.
Three Way ANOVA with Interaction Analysis:

<table>
<thead>
<tr>
<th>SOURCE</th>
<th>SUM OF SQUARE</th>
<th>D.F.</th>
<th>MEAN SQUARE</th>
<th>CALCULATED F RATIO</th>
<th>TABLE F RATIO</th>
<th>CONCLUSION</th>
</tr>
</thead>
<tbody>
<tr>
<td>A_i</td>
<td>14.06667</td>
<td>2</td>
<td>7.0333</td>
<td>4.5704</td>
<td>2.3473</td>
<td>Significant</td>
</tr>
<tr>
<td>B_j</td>
<td>.83334</td>
<td>1</td>
<td>.83334</td>
<td>.5415</td>
<td>2.7478</td>
<td>Not Signif.</td>
</tr>
<tr>
<td>C_k</td>
<td>0.0</td>
<td>1</td>
<td>0.0</td>
<td>0.0</td>
<td>2.7478</td>
<td>Not Signif.</td>
</tr>
<tr>
<td>AB_{ij}</td>
<td>6.06666</td>
<td>2</td>
<td>3.03333</td>
<td>1.9711</td>
<td>2.3473</td>
<td>Not Signif.</td>
</tr>
<tr>
<td>AC_{ik}</td>
<td>.2</td>
<td>2</td>
<td>.1</td>
<td>.0650</td>
<td>2.3473</td>
<td>Not Signif.</td>
</tr>
<tr>
<td>BC_{jk}</td>
<td>.03333</td>
<td>1</td>
<td>.03333</td>
<td>.0216</td>
<td>2.7478</td>
<td>Not Signif.</td>
</tr>
<tr>
<td>ABC_{ijk}</td>
<td>2.46667</td>
<td>2</td>
<td>1.233335</td>
<td>.8014</td>
<td>2.3473</td>
<td>Not Signif.</td>
</tr>
<tr>
<td>E_{1(ijk)}</td>
<td>166.2</td>
<td>108</td>
<td>1.53889</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>189.86667</td>
<td>119</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* D.F. is Degrees of Freedom

Graph for Buyers and Printers:

Conclusion:

The test images used in this experiment significantly affected the degree of satisfaction for the final prints selected.
Analysis of the Portrait

An analysis was applied to each of the test images and only the portrait had any significant results.

Model in Question:

\[ X_{ijk} = \mu + A_i + B_j + AB_{ij} + E_{k(ij)} \]

where

- \( \mu \) represents average for population
- \( A_i \) represents the participants (buyers and printers)
- \( B_j \) represents the viewing filters
- \( AB_{ij} \) represents the interaction between participants and viewing filters
- \( E_{k(ij)} \) represents error

Compilation of Data:

<table>
<thead>
<tr>
<th>Factor ( A_i )</th>
<th>Printers</th>
<th>Buyers</th>
<th>( \bar{X} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>w/ filters</td>
<td>2 1 1 2 1</td>
<td>2 1 1 2 1</td>
<td>1.65</td>
</tr>
<tr>
<td></td>
<td>1 1 1 4 3</td>
<td>1 1 1 4 2</td>
<td></td>
</tr>
<tr>
<td>( \bar{X} )</td>
<td>is 1.7</td>
<td>is 1.6</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Factor ( B_j )</th>
<th>w/o filter</th>
<th>( \bar{X} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \bar{X} )</td>
<td>is 2.5</td>
<td>2.45</td>
</tr>
</tbody>
</table>

\[ \bar{X} = 2.1 \quad 2.0 \quad 2.05 \]

* The standard deviation for the data above is 1.260 with a ninety percent confidence interval of plus or minus .34 to each mean.
Missing Page
Two Way ANOVA with Interaction Analysis:

<table>
<thead>
<tr>
<th>SOURCE</th>
<th>SUM OF SQUARE</th>
<th>D.F.</th>
<th>MEAN SQUARE</th>
<th>CALCULATED F RATIO</th>
<th>TABLE F RATIO</th>
<th>CONCLUSION</th>
</tr>
</thead>
<tbody>
<tr>
<td>$A_i$</td>
<td>0.1</td>
<td>1</td>
<td>0.1</td>
<td>0.0650</td>
<td>2.8807</td>
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</tr>
<tr>
<td>$B_j$</td>
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<td>6.4</td>
<td>4.1588</td>
<td>2.8807</td>
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<tr>
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<td>0.0</td>
<td>0.0</td>
<td>2.8807</td>
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<tr>
<td>$E_k(ij)$</td>
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<td>36</td>
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<tr>
<td>TOTAL</td>
<td>61.9</td>
<td>39</td>
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</tbody>
</table>

* D.F. is Degrees of Freedom

Graph for the Portrait:

Conclusion:

For the portrait, viewing filters significantly improved the degree of satisfaction for the final print with buyers and printers.
Amount of Time Analysis

Analysis of Entire Experiment

Model in Question:

\[ x_{ijkl} = \bar{x} + A_i + B_j + C_k + AB_{ij} + AC_{ik} + BC_{jk} + ABC_{ijk} + E_{1(ijk)} \]

where

- \( \bar{x} \) represents average for population
- \( A_i \) represents the test images
- \( B_j \) represents the viewing filters
- \( C_k \) represents the participants (buyers and printers)
- \( AB_{ij} \) represents the interaction between test images and viewing filters
- \( AC_{ik} \) represents the interaction between test images and participants
- \( BC_{jk} \) represents the interaction between viewing filters and participants
- \( ABC_{ijk} \) represents the interaction between test images, viewing filters, and participants
- \( E_{1(ijk)} \) represents error

Compilation of Data:

<table>
<thead>
<tr>
<th>Factor A_i</th>
<th>Portrait</th>
<th>Trumpet</th>
<th>Flower</th>
<th>X</th>
</tr>
</thead>
<tbody>
<tr>
<td>w/ filters</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>buyers</td>
<td>8 11 5 3 3</td>
<td>10 10 7 4 8</td>
<td>4 4 9 11 2</td>
<td>6.1</td>
</tr>
<tr>
<td>printlers</td>
<td>5 2 6 4 13</td>
<td>6 4 7 4 7</td>
<td>5 3 4 5 6</td>
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</tr>
<tr>
<td>w/o filters</td>
<td>2 4 5 5 4</td>
<td>6 4 9 7 2</td>
<td>8 3 6 3 2</td>
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</tr>
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<td>Factor C_k</td>
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<td></td>
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<tr>
<td>buyers</td>
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<td>4 7 4 5 6</td>
<td>5 5 4 3 5</td>
<td>4.53</td>
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<td>7 4 4 4 2</td>
<td>2 4 2 1 7</td>
<td>5 4 5 1 6</td>
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</tbody>
</table>

* The standard deviation for the data above is 2.682 with a ninety percent confidence interval of plus or minus .41 to each mean.
Three Way ANOVA with Interaction Analysis:

<table>
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<tr>
<th>SOURCE</th>
<th>SUM OF SQUARE</th>
<th>D.F.</th>
<th>MEAN SQUARE</th>
<th>CALCULATED F RATIO</th>
<th>TABLE F RATIO</th>
<th>CONCLUSION</th>
</tr>
</thead>
<tbody>
<tr>
<td>A&lt;sub&gt;i&lt;/sub&gt;</td>
<td>24.2667</td>
<td>2</td>
<td>12.1335</td>
<td>1.8155</td>
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<td>Not Signif.</td>
</tr>
<tr>
<td>B&lt;sub&gt;j&lt;/sub&gt;</td>
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<tr>
<td>C&lt;sub&gt;k&lt;/sub&gt;</td>
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<td>4.0334</td>
<td>.6035</td>
<td>2.7478</td>
<td>Not Signif.</td>
</tr>
<tr>
<td>AB&lt;sub&gt;ij&lt;/sub&gt;</td>
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<td>2</td>
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<td>.0948</td>
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</tr>
<tr>
<td>AC&lt;sub&gt;ik&lt;/sub&gt;</td>
<td>20.8666</td>
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<td>10.4333</td>
<td>1.5611</td>
<td>2.3473</td>
<td>Not Signif.</td>
</tr>
<tr>
<td>BC&lt;sub&gt;jk&lt;/sub&gt;</td>
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<td>.8332</td>
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<tr>
<td>E&lt;sub&gt;1(ijk)&lt;/sub&gt;</td>
<td>721.8</td>
<td></td>
<td>6.6833</td>
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<td></td>
</tr>
</tbody>
</table>

TOTAL | 855.9667 | 119 |

* D.F. is Degrees of Freedom

Graph for Buyers and Printers:

- [Graph Image]

- ○ - buyers w/ filters
- ● - buyers w/o filters
- □ - printers w/ filters
- ■ - printers w/o filters

Amount of Time (in minutes)

<table>
<thead>
<tr>
<th>Portrait</th>
<th>Trumpet</th>
<th>Flower</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(6.0) (6.0) (6.7) (6.8) (7.0) (5.7) (5.3) (4.8) (4.2) (4.8) (4.3) (4.3) (3.9) (4.3)
Conclusion:

The average amount of time for both the buyers and the printers was significantly increased when using viewing filters.

Summary

To simplify the results of this experiment, the original hypotheses are restated below and their conclusions follow.

Hypothesis 1: When participants who use viewing filters are compared to those who do not use filters, there is no difference in the number of proofs needed to determine necessary color changes.

Conclusion: This hypothesis was true in all cases but one. The one case that was not true involved just the buyers judging the portrait. Here the buyers were able to significantly reduce the number of proofs necessary when using viewing filters.

Hypothesis 2: When participants who use viewing filters are compared to those who do not use filters, there is no difference in the degree of satisfaction for the final print selected.

Conclusion: This hypothesis was true in all cases but one. The one case that was not true involved both buyers and printers judging the portrait. Here they were able to significantly improve the degree of satisfaction felt for the final print when using viewing filters.

Hypothesis 3: When participants who use viewing filters are compared to those who do not use filters, there is no difference in the amount of time needed to determine necessary color changes.

Conclusion: This hypothesis was false in all cases. Both the buyers and the printers significantly increased the amount of time needed to get desired results.
Hypothesis 4: The scenes of the test images have no influence on the results to this experiment.

Conclusion: This hypothesis was false in all cases but one. The two cases where the test images did affect the results of the experiment were the number of proofs and degrees of satisfaction. Generally, scores were better with the portrait than with the other two test images. The only case where the test images did not affect the results of the experiment was on the amount of time.
DISCUSSION

As stated in the Introduction, the purpose of the experiment was to determine how effective Kodak Color Print Viewing Filters can be when used by print buyers and printers. As it turns out, viewing filters were helpful in some situations but not in others. The following discussion elaborates on this.

Test Images

The most significant factor to the entire experiment were the test images. Some were easy for the participants to resolve while others were more difficult. As a result, the average number of proofs, degree of satisfaction, and amount of time varied greatly from one test image to the next.

Viewing Filters

The effectiveness of the viewing filters varied depending on the image being corrected and the person using the filters. For the portrait, viewing filters proved valuable. They not only reduced the number of proofs for the buyers but they also improved the degree of satisfaction for both buyers and printers. For the trumpet, viewing filters were of no help to either group. Finally, for the flower, viewing filters only helped to reduce the number of proofs for the buyers. Otherwise, they were ineffective.

In all cases, viewing filters increased the average amount of time for evaluating the prints from a little less than one minute to a little over two minutes. Certainly, if several images were involved, this increase in
time would add up and probably be a real inconvenience. But, with only a few images involved, this increase in time becomes relatively insignificant.

Although viewing filters were not always helpful, they did not, with the exception of time, handicap anybody's performance. At no point did they significantly increase the number of proofs or lessen the degree of satisfaction.

The Participants

The performance of the buyers and the printers were similar on the number of proofs and the degree of satisfaction. The only significant exception was the portrait test without viewing filters where the printers generally performed better. The performance of the two groups varied greatly, though, on the amount of time. The printers were more erratic than the buyers and, on the average, took more time.

Another significant difference observed by this experimenter was on the use of color terminologies. In particular, when the buyers used the word 'blue' they often juxtaposed its meaning with the colors blue and cyan. The printers, on the other hand, consistently used the word 'blue' to mean cyan.

Memory Colors

When comparing the averages with and without viewing filters on each test image, an interesting pattern evolves as seen in the following table.
The portrait which had the most obvious memory colors with its gray background and fleshtones had better results. Not only were the participants more critical (as measured by Degree of Satisfaction), they were better with the color correction process (as measured by Number of Proofs) and they took less time (as measured by Amount of Time). With this same image, the participants who used viewing filters did significantly better than those without filters. This pattern also appears with more subtlety on the two remaining test images. Scores were generally better with the flower, which had a vague reference to green grass, than with the trumpet, which had no memory colors.

The better results on the images with memory colors reinforces what was discussed earlier in the chapter on the Color of Four-Color Process Printing.

The discussion was on the fact that accurate color reproductions are not
always necessary or desirable because there are certain colors that demand high accuracy and there are others where red is red and blue is blue no matter what the particular shade. In this particular experiment, the memory colors were the greatest concern to the participants and demanded the most accuracy.

This improved performance with viewing filters on the memory colors can probably be attributed to two factors. First, the memory colors provided a focus point where the participants consistently judged the same area as they went through the color correction process. Secondly, the memory colors were generally in the lighter midtone range where viewing filters are most effective.

Summary

With some images, viewing filters improved the performance of buyers and printers to determine necessary color change. With other images, they were totally ineffective. Generally, viewing filters benefitted the buyers more than the printers and were most helpful on images that had important memory colors. With the exception of time, viewing filters did not handicap the performance of the buyers and printers.
CONCLUSION

This experimenter makes the following conclusions on the use of viewing filters by print buyers and printers.

Conclusion 1: The effectiveness of the viewing filters to reduce the number of proofs varies depending on the image being corrected and the individual using the filters. Generally, viewing filters are more helpful to buyers when judging memory colors.

Conclusion 2: The effectiveness of the viewing filters to improve the degree of satisfaction for the final print also varies depending on the image being corrected and the individual using the filters. Generally, viewing filters are more helpful to buyers and printers when judging memory colors.

Conclusion 3: The amount of time needed to determine necessary color change is longer when using the viewing filters.

Conclusion 4: The test images greatly influence the ability of the participants to determine necessary color change with and without the viewing filters.

With the exception of time, the filters do not adversely affect the performance of either buyers or printers.
RECOMMENDATIONS

The opinion of this author is that the application of viewing filters in the graphic arts industry should be pursued. Although this study showed that the viewing filters were not always helpful, it also showed that viewing filters did no harm. This is a valid point. Nobody has anything to lose, with the exception of time, in using the filters.

If the viewing filters are used on a continuous basis, the user might develop a better understanding of the advantages and disadvantages and use them more intelligently. One of the main reasons why viewing filters work so well for photographers is due to the immediate feedback of darkroom procedures. A photographer is able to judge a bad print with the filters, make the adjustments in the enlarger, expose, and develop a new print within ten minutes. After a short period of time, the photographer makes a correlation between what he sees through the filters and how the change will result on the print. People in the graphic arts industry don't have the advantage of immediate feedback. None the less, there is feedback and there is potential to be more familiar with the application of the viewing filters.

A good follow-up study to this thesis would be to measure the effects of practice on one's performance in using viewing filters. No doubt, one of the major difficulties with the filters is they tinge the highlights excessively and the shadows insufficiently. Because of this limitation,
beginners can be confused and misled. This author feels the only way to work around this is through practice. Eventually, the user becomes familiar with what areas of a picture are best to judge and how the changes will result.

Another area to investigate would be the effectiveness of viewing filters on different kinds of memory colors. This study indicates that viewing filters help with fleshtones. Would they be equally as effective with green grass and blue skies?

A final suggestion for an investigation would be the test images themselves. This study indicates that some images are easier than others for people to correct. Why is this so? Is there a way to distinguish the easy-to-correct from the more difficult? If so, what would be the best technique for correcting the more difficult images? These questions can go on.

One should keep in mind that tailoring the procedures of an experiment to accommodate the real world does not necessarily discredit the results. As shown in Appendix Two and Three of this experiment, changing the viewing conditions and giving the participants more than one test did not have any significant consequence. If anything, these accommodations give the results of this experiment more credence.

Any study which tries to discover new ways of improving the color correction process in the graphic arts industry deserves attention. The average cost of operating one cromalin processor, laminator, and operator is $25.40 per hour. The average cost of operating a 3M Transfer Key Proofing System is $25.33 per hour.1 Of course, these figures don't account for

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any of the materials necessary to actually make the proofs. This would vary depending on the number and size of the proofs produced. Without even getting into the cost for a four-color proofing press or dot etching, one can easily understand that making four-color proofs is expensive and any technique that avoids making proofs is helpful. The technique of using viewing filters has worked well in photography, there is no reason why the same technique should not work well in the graphic arts. As was mentioned earlier in the paper, any system that "could save a dime" is worth looking into.
APPENDIX ONE

The tests to this experiment were randomly assigned to each participant, the results of which are presented below. Not all the participants were tested in viewing areas that met ANSI standards. Those that were are indicated by a star (*).

To understand how data was derived from these tests for the Statistical Analysis, one should reread the chapter on the Design of the Experiment. The Sequence of Prints section indicates the series of prints the participant went through to get the one he preferred the most. This print is the one with the quotes (" "). The Degree of Satisfaction section ranks the three most acceptable prints (out of the twenty) from best to worst.

Information on which person took which three tests is strictly confidential.

Figure Three on page thirty-five has the breakdown on all the numbers listed.

Test Results for the Buyers

Buyer #1

First Test: Portrait without viewing filters
Sequence of Prints - 20,10,12,"4"
Amount of Time - 4 minutes
Degree of Satisfaction - 3,1,-

Second Test: Trumpet without viewing filters
Sequence of Prints - 20,3,1,"4"
Amount of Time - 5 minutes
Degree of Satisfaction - 1,4,6

Third Test: Flower with filters
Sequence of Prints - 20,14,"5"
Amount of Time - 11 minutes
Degree of Satisfaction - 14,5,4
Buyer #2

First Test: Flower without viewing filters
Sequence of Prints - 20,12,18,"5"
Amount of Time - 3 minutes
Degree of Satisfaction - 1,5,15

Second Test: Trumpet with viewing filters
Sequence of Prints - 20,1,"2"
Amount of Time - 4 minutes
Degree of Satisfaction - 3,1,7

Third Test: Portrait with viewing filters
Sequence of Prints - 20,18,"1"
Amount of Time - 3 minutes
Degree of Satisfaction - 2,1,-

Buyer #3

First Test: Flower without viewing filters
Sequence of Prints - 20,"14",15,13
Amount of Time - 4 minutes
Degree of Satisfaction - 5,1,14

Second Test: Trumpet with viewing filters
Sequence of Prints - 20,14,"1",2
Amount of Time - 7 minutes
Degree of Satisfaction - 3,4,11

Third Test: Portrait without viewing filters
Sequence of Prints - 20,14,16
Amount of Time - 4 minutes
Degree of Satisfaction - 1,2,4

* Buyer #4

First Test: Trumpet with viewing filters
Sequence of Prints - 20,18,17,7,6,1,"4"
Amount of Time - 10 minutes
Degree of Satisfaction - 2,3,4

Second Test: Portrait with viewing filters
Sequence of Prints - 20,2,"1"
Amount of Time - 5 minutes
Degree of Satisfaction - 1,2,4

Third Test: Flower with viewing filters
Sequence of Prints - 20,16,N/G,14,N/G,16,"1"
Amount of Time - 9 minutes
Degree of Satisfaction - 5,1,3

* Buyer #5

First Test: Portrait without viewing filters
Sequence of Prints - 20,12,5,4,"1"
Amount of Time - 5 minutes
Degree of Satisfaction - 1,7,2
Second Test: Trumpet without viewing filters
Sequence of Prints - 20,2,3,"2"
Amount of Time - 4 minutes
Degree of Satisfaction - 3,11,4

Third Test: Flower with viewing filters
Sequence of Prints - 20,15,"1"
Amount of Time - 4 minutes
Degree of Satisfaction - 1,6,7

Buyer #6

First Test: Portrait without viewing filters
Sequence of Prints - 20,10,12,1,3,"2"
Amount of Time - 4 minutes
Degree of Satisfaction - 5,1,4

Second Test: Trumpet with viewing filters
Sequence of Prints - 20,N/G,16,"1"
Amount of Time - 4 minutes
Degree of Satisfaction - 3,7,12

Third Test: Flower without viewing filters
Sequence of Prints - 20,"14",N/G,15,5
Degree of Satisfaction - 4,3,5

Buyer #7

First Test: Trumpet without viewing filters
Sequence of Prints - 20,1,"4"
Amount of Time - 2 minutes
Degree of Satisfaction - 4,3,12

Second Test: Portrait with viewing filters
Sequence of Prints - 20,12,"1"
Amount of Time - 2 minutes
Degree of Satisfaction - 1,2,19

Third Test: Flower with viewing filters
Sequence of Prints - 20,"14",12,11,10
Amount of Time - 4 minutes
Degree of Satisfaction - 1,6,2

Buyer #8

First Test: Flower with viewing filters
Sequence of Prints - 20,"14",15,N/G,19
Amount of Time - 6 minutes
Degree of Satisfaction - 5,14,13

Second Test: Trumpet with viewing filters
Sequence of Prints - 20, gave up
Amount of Time - gave up
Degree of Satisfaction - 11,3,4

Third Test: Portrait without viewing filters
Sequence of Prints - 20,10,"1"
Amount of Time - 2 minutes
Degree of Satisfaction - 4,1,7
Buyer #9

First Test: Trumpe with viewing filters
Sequence of Prints - 20,N/G,18,N/G,N/G,"7"
Amount of Time - 10 minutes
Degree of Satisfaction - 2,7,1

Second Test: Flower without viewing filters
Sequence of Prints - 20,N/G,14,13,"5"
Amount of Time - 5 minutes
Degree of Satisfaction - 1,6,15

Third Test: Portrait with viewing filters
Sequence of Prints - 20,8,"2"
Amount of Time - 8 minutes
Degree of Satisfaction - 19,2,1

Buyer #10

First Test: Flower without viewing filters
Sequence of Prints - 20,16,6,"1"
Amount of Time - 5 minutes
Degree of Satisfaction - 7,6,2

Second Test: Trumpet without viewing filters
Sequence of Prints - 20,N/G,18,17,"19"
Amount of Time - 7 minutes
Degree of Satisfaction - 2,7,18

Third Test: Portrait with viewing filters
Sequence of Prints - 20,8,"19",7
Amount of Time - 11 minutes
Degree of Satisfaction - 19,1,2

Buyer #11

First Test: Portrait without viewing filters
Sequence of Prints - 20,8,2,"1",5
Amount of Time - 6 minutes
Degree of Satisfaction - 1,18,19

Second Test: Flower with viewing filters
Sequence of Prints - 20,N/G,"16"
Amount of Time - 4 minutes
Degree of Satisfaction - 6,16,15

Third Test: Trumpet without viewing filters
Sequence of Prints - 20,N/G,"18",N/G,7
Amount of Time - 4 minutes
Degree of Satisfaction - 2,3,1

* Buyer #12

First Test: Flower with viewing filters
Sequence of Prints - "20",N/G
Amount of Time - 3 minutes
Degree of Satisfaction - 4,3,-
<table>
<thead>
<tr>
<th>First Test</th>
<th>Second Test</th>
<th>Third Test</th>
</tr>
</thead>
<tbody>
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<td>Trumpet with viewing filters</td>
<td>Portrait without viewing filters</td>
<td>Portrait without viewing filters</td>
</tr>
<tr>
<td>Sequence of Prints - 20,16,&quot;6&quot;</td>
<td>Sequence of Prints - 20,&quot;4&quot;,5</td>
<td>Sequence of Prints - 20,16,15,14,5,&quot;1&quot;</td>
</tr>
<tr>
<td>Amount of Time - 4 minutes</td>
<td>Amount of Time - 4 minutes</td>
<td>Amount of Time - 7 minutes</td>
</tr>
<tr>
<td>Degree of Satisfaction - 4,1,12</td>
<td>Degree of Satisfaction - 4,1,12</td>
<td>Degree of Satisfaction - 1,4,-</td>
</tr>
</tbody>
</table>

* Buyer #13

<table>
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<th>Second Test</th>
<th>Third Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flower without viewing filters</td>
<td>Portrait with viewing filters</td>
<td>Trumpet with viewing filters</td>
</tr>
<tr>
<td>Sequence of Prints - 20,16,N/G,&quot;15&quot;</td>
<td>Sequence of Prints - 20,5,4,&quot;1&quot;</td>
<td>Sequence of Prints - 20,N/G,16,15,14,5,&quot;1&quot;</td>
</tr>
<tr>
<td>Amount of Time - 5 minutes</td>
<td>Amount of Time - 5 minutes</td>
<td>Amount of Time - 7 minutes</td>
</tr>
<tr>
<td>Degree of Satisfaction - 6,5,15</td>
<td>Degree of Satisfaction - 1,6,5</td>
<td>Degree of Satisfaction - 1,4,-</td>
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</table>

* Buyer #14

<table>
<thead>
<tr>
<th>First Test</th>
<th>Second Test</th>
<th>Third Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trumpet with viewing filters</td>
<td>Portrait without viewing filters</td>
<td>Flower with viewing filters</td>
</tr>
<tr>
<td>Sequence of prints - 20,8,9,&quot;4&quot;</td>
<td>Sequence of Prints - 20,10,12,N/G,11,&quot;4&quot;</td>
<td>Sequence of Prints - 20,N/G,14,&quot;1&quot;</td>
</tr>
<tr>
<td>Amount of Time - 6 minutes</td>
<td>Amount of Time - 7 minutes</td>
<td>Amount of Time - 5 minutes</td>
</tr>
<tr>
<td>Degree of Satisfaction - 4,1,7</td>
<td>Degree of Satisfaction - 1,6,5</td>
<td>Degree of Satisfaction - 6,1,16</td>
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* Buyer #15

<table>
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<tr>
<th>First Test</th>
<th>Second Test</th>
<th>Third Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flower with viewing filters</td>
<td>Trumpet without viewing filters</td>
<td>Portrait with viewing filters</td>
</tr>
<tr>
<td>Sequence of Prints - 20,&quot;14&quot;</td>
<td>Sequence of Prints - 20,17,6,5,&quot;1&quot;</td>
<td>Sequence of Prints - 20,12,18,&quot;1&quot;</td>
</tr>
<tr>
<td>Amount of Time - 2 minutes</td>
<td>Amount of Time - 6 minutes</td>
<td>Amount of Time - 3 minutes</td>
</tr>
<tr>
<td>Degree of Satisfaction - 6,5,14</td>
<td>Degree of Satisfaction - 1,7,6</td>
<td>Degree of Satisfaction - 1,5,7</td>
</tr>
</tbody>
</table>
Buyer #16

First Test: Flower with viewing filters
Sequence of Prints - 20,14,1,"3"
Amount of Time - 5 minutes
Degree of Satisfaction - 4,14,15

Second Test: Portrait without viewing filters
Sequence of Prints - 20,10,N/G,1,"4","11
Amount of Time - 4 minutes
Degree of Satisfaction - 4,13,3

Third Test: Trumpet without viewing filters
Sequence of Prints - 20,10,"3","11
Amount of Time - 2 minutes
Degree of Satisfaction - 4,12,1

Buyer #17

First Test: Portrait with viewing filters
Sequence of Prints - 20,"4","11
Amount of Time - 4 minutes
Degree of Satisfaction - 15,14,10

Second Test: Flower without viewing filters
Sequence of Prints - "20",N/G
Amount of Time - 1 minute
Degree of Satisfaction - 3,14,5

Third Test: Trumpet without viewing filters
Sequence of Prints - 20,"10","8
Amount of Time - 1 minute
Degree of Satisfaction - 14,4,10

Buyer #18

First Test: Flower without viewing filters
Sequence of Prints - 20,N/G,14,13,"4","12
Amount of Time - 6 minutes
Degree of Satisfaction - 4,5,6

Second Test: Trumpet without viewing filters
Sequence of Prints - 20,10,9,13,4,"11","3","12
Amount of Time - 7 minutes
Degree of Satisfaction - 11,12,1

Third Test: Portrait with viewing filters
Sequence of Prints - 20,8,3,"1"
Amount of Time - 13 minutes
Degree of Satisfaction - 4,1,13

Buyer #19

First Test: Trumpet with viewing filters
Sequence of Prints - 20,N/G,16,18,15,"7"
Amount of Time - 8 minutes
Degree of Satisfaction - 3,11,2
Second Test: Portrait without viewing filters
Sequence of Prints - 20,N/G,"4",1,3,11
Amount of Time - 3 minutes
Degree of Satisfaction - 1,4,2

Third Test: Flower without viewing filters
Sequence of Prints - 20,N/G,14,15,12,"4",1
Amount of Time - 5 minutes
Degree of Satisfaction - 4,5,13

Buyer #20

First Test: Flower without viewing filters
Sequence of Prints - 20,14,13,12,15,"5"
Amount of Time - 5 minutes
Degree of Satisfaction - 4,13,5

Second Test: Trumpet without viewing filters
Sequence of Prints - 20,8,1,14,5,"4"
Amount of Time - 4 minutes
Degree of Satisfaction - 4,11,3

Third Test: Portrait with viewing filters
Sequence of Prints - 20,10,1,"4"
Amount of Time - 6 minutes
Degree of Satisfaction - 4,12,5

Test Results for the Printers

* Printer #1

First Test: Trumpet with viewing filters
Sequence of Prints - 20,5,2,"1"
Amount of Time - 6 minutes
Degree of Satisfaction - 2,12,11

Second Test: Portrait without viewing filters
Sequence of Prints - 20,18,1,"4"
Amount of Time - 4 minutes
Degree of Satisfaction - 1,7,19

Third Test: Flower with viewing filters
Sequence of Prints - 20,"14",15
Amount of Time - 5 minutes
Degree of Satisfaction - 4,13,12

* Printer #2

First Test: Flower with viewing filters
Sequence of Prints - 20,14,"5"
Amount of Time - 6 minutes
Degree of Satisfaction - 5,1,6

Second Test: Trumpet without viewing filters
Sequence of Prints - 20,1,16,5,"4"
Amount of Time - 7 minutes
Degree of Satisfaction - 4,1,7
Third Test: Portrait without viewing filters
Sequence of Prints - 20,3,"1"
Amount of Time - 3 minutes
Degree of Satisfaction - 1,7,4

* Printer #3

First Test: Portrait with viewing filters
Sequence of Prints - 20,"1",4
Amount of Time - 7 minutes
Degree of Satisfaction - 1,2,19
Second Test: Flower without viewing filters
Sequence of Prints - 20,N/G,16,N/G,1,"5"
Amount of Time - 8 minutes
Degree of Satisfaction - 5,15,2
Third Test: Trumpet without viewing filters
Sequence of Prints - 20,10,2,"1"
Amount of Time - 5 minutes
Degree of Satisfaction - 4,12,1

* Printer #4

First Test: Trumpet with viewing filters
Sequence of Prints - 20,"11"
Amount of Time - 4 minutes
Degree of Satisfaction - 3,1,7
Second Test: Flower without viewing filters
Sequence of Prints - 20,16,7,2,"1"
Amount of Time - 8 minutes
Degree of Satisfaction - 1,6,5
Third Test: Portrait with viewing filters
Sequence of Prints - 20,18,7,"1"
Amount of Time - 8 minutes
Degree of Satisfaction - 4,1,19

* Printer #5

First Test: Trumpet with viewing filters
Sequence of Prints - 16,14,1,"4"
Amount of Time - 8 minutes
Degree of Satisfaction - 4,12,1
Second Test: Portrait without viewing filters
Sequence of Prints - 20,8,19,2,"1",5
Amount of Time - 7 minutes
Degree of Satisfaction - 4,1,-
Third Test: Flower with viewing filters
Sequence of Prints - 20,1,"5"
Amount of Time - 9 minutes
Degree of Satisfaction - 6,5,-
* Printer #6

First Test: Portrait without viewing filters
Sequence of Prints - 20,10,"1",3
Amount of Time - 4 minutes
Degree of Satisfaction - 2,19,1

Second Test: Trumpet without viewing filters
Sequence of Prints - 20,N/G,16,6,5,"4"
Amount of Time - 6 minutes
Degree of Satisfaction - 11,3,4

Third Test: Flower with viewing filters
Sequence of Prints - 20,18,20,N/G,18,1,14,"5"
Amount of Time - 7 minutes
Degree of Satisfaction - 6,1,5

* Printer #7

First Test: Portrait with viewing filters
Sequence of Prints - 20,1
Amount of Time - 2 minutes
Degree of Satisfaction - 1,2,3

Second Test: Flower without viewing filters
Sequence of Prints - 20,"6",5
Amount of Time - 3 minutes
Degree of Satisfaction - 6,1,7

Third Test: Trumpet with viewing filters
Sequence of Prints - 20,1,"3"
Amount of Time - 5 minutes
Degree of Satisfaction - 1,3,4

* Printer #8

First Test: Flower with viewing filters
Sequence of Prints - 20,14,15,"5"
Amount of Time - 6 minutes
Degree of Satisfaction - 6,1,5

Second Test: Portrait with viewing filters
Sequence of Prints - 20,"1"
Amount of Time - 2 minutes
Degree of Satisfaction - 1,2,13

Third Test: Trumpet without viewing filters
Sequence of Prints - 20,10,5,"4"
Amount of Time - 10 minutes
Degree of Satisfaction - 1,4,12

* Printer #9

First Test: Flower without viewing filters
Sequence of Prints - 20,12,"4"
Amount of Time - 4 minutes
Degree of Satisfaction - 6,1,5
Second Test: Trumpet without viewing filters
Sequence of Prints - 20,16,12,"3"
Amount of Time - 2 minutes
Degree of Satisfaction - 11,3,2

Third Test: Portrait without viewing filters
Sequence of Prints - 20,10,"1",3
Amount of Time - 3 minutes
Degree of Satisfaction - 2,4,1

* Printer #10

First Test: Portrait without viewing filters
Sequence of Prints - 20,N/G,12,"1"
Amount of Time - 2 minutes
Degree of Satisfaction - 1,19,7

Second Test: Flower without viewing filters
Sequence of Prints - 20,N/G,"14"
Amount of Time - 5 minutes
Degree of Satisfaction - 4,5,14

Third Test: Trumpet with viewing filters
Sequence of Prints - 20,16,6,"1"
Amount of Time - 5 minutes
Degree of Satisfaction - 4,12,1

* Printer #11

First Test: Trumpet with viewing filters
Sequence of Prints - 20,16,"1"
Amount of Time - 4 minutes
Degree of Satisfaction - 11,3,2

Second Test: Portrait with viewing filters
Sequence of Prints - 20,12,"1"
Amount of Time - 1 minute
Degree of Satisfaction - 1,4,3

Third Test: Flower with viewing filters
Sequence of Prints - 20,N/G,14,"12",N/G
Amount of Time - 3 minutes
Degree of Satisfaction - 5,4,13

* Printer #12

First Test: Portrait without viewing filters
Sequence of Prints - 20,3,"1"
Amount of Time - 2 minutes
Degree of Satisfaction - 1,7,2

Second Test: Trumpet without viewing filters
Sequence of Prints - 20,18,N/G,17,6,"1"
Amount of Time - 5 minutes
Degree of Satisfaction - 1,7,4
<table>
<thead>
<tr>
<th>Printer #13</th>
<th>Flower without viewing filters</th>
<th>Sequence of Prints - 20,&quot;14&quot;</th>
<th>Amount of Time - 1 minute</th>
<th>Degree of Satisfaction - 6,5,14</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Test:</td>
<td>Flower with viewing filters</td>
<td>Sequence of Prints - 20,16,18,15,&quot;4&quot;</td>
<td>Amount of Time - 12 minutes</td>
<td>Degree of Satisfaction - 5,6,4</td>
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<tr>
<td>Second Test:</td>
<td>Trumpet with viewing filters</td>
<td>Sequence of Prints - 20,16,18,7,1,&quot;3&quot;</td>
<td>Amount of Time - 11 minutes</td>
<td>Degree of Satisfaction - 11,3,2</td>
</tr>
<tr>
<td>Third Test:</td>
<td>Portrait with viewing filters</td>
<td>Sequence of Prints - 20,10,8,13,&quot;4&quot;</td>
<td>Amount of Time - 8 minutes</td>
<td>Degree of Satisfaction - 4,1,7</td>
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</table>

<table>
<thead>
<tr>
<th>Printer #14</th>
<th>Flower with viewing filters</th>
<th>Sequence of Prints - 20,14,15,4,&quot;1&quot;</th>
<th>Amount of Time - 7 minutes</th>
<th>Degree of Satisfaction - 5,6,15</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Test:</td>
<td>Portrait without viewing filters</td>
<td>Sequence of Prints - 20,N/G,1,&quot;4&quot;</td>
<td>Amount of Time - 5 minutes</td>
<td>Degree of Satisfaction - 7,16,19</td>
</tr>
<tr>
<td>Second Test:</td>
<td>Trumpet without viewing filters</td>
<td>Sequence of Prints - 20,7,5,6,1,&quot;3&quot;</td>
<td>Amount of Time - 4 minutes</td>
<td>Degree of Satisfaction - 19,18,7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Printer #15</th>
<th>Portrait with viewing filters</th>
<th>Sequence of Prints - 20,16,12,13,15,5,&quot;1&quot;</th>
<th>Amount of Time - 8 minutes</th>
<th>Degree of Satisfaction - 4,1,13</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Test:</td>
<td>Flower without viewing filters</td>
<td>Sequence of Prints - 20,N/G,N/G,14,15,6,&quot;1&quot;,3</td>
<td>Amount of Time - 8 minutes</td>
<td>Degree of Satisfaction - 6,5,1</td>
</tr>
<tr>
<td>Second Test:</td>
<td>Trumpet with viewing filters</td>
<td>Sequence of Prints - 20,N/G,8,19,16,1,5,11,5,&quot;4&quot;</td>
<td>Amount of Time - 16 minutes</td>
<td>Degree of Satisfaction - 4,3,12</td>
</tr>
</tbody>
</table>
* Printer #16

First Test: Portrait without viewing filters
Sequence of Prints - 20,10,"2"
Amount of Time - 5 minutes
Degree of Satisfaction - 2,3,19

Second Test: Trumpet without viewing filters
Sequence of Prints - 20,19,"7",6
Amount of Time - 9 minutes
Degree of Satisfaction - 2,3,11

Third Test: Flower with viewing filters
Sequence of Prints - 20,4,7,"1"
Amount of Time - 7 minutes
Degree of Satisfaction - 2,1,7

* Printer #17

First Test: Flower without viewing filters
Sequence of Prints - 20,N/G,"14",12
Amount of Time - 6 minutes
Degree of Satisfaction - 5,4,14

Second Test: Trumpet without viewing filters
Sequence of Prints - 20,18,16,"1"
Amount of Time - 7 minutes
Degree of Satisfaction - 11,3,4

Third Test: Portrait with viewing filters
Sequence of Prints - 20,10,"3"
Amount of Time - 6 minutes
Degree of Satisfaction - 3,2,8

* Printer #18

First Test: Portrait with viewing filters
Sequence of Prints - 20,N/G,12,"13"
Amount of Time - 3 minutes
Degree of Satisfaction - 4,1,19

Second Test: Trumpet with viewing filters
Sequence of Prints - 20,N/G,18,"1"
Amount of Time - 3 minutes
Degree of Satisfaction - 4,1,19

Third Test: Flower without viewing filters
Sequence of Prints - 20,14,N/G,"13"
Amount of Time - 3 minutes
Degree of Satisfaction - 6,5,15

* Printer #19

First Test: Portrait without viewing filters
Sequence of Prints - 20,12,"1",4
Amount of Time - 4 minutes
Degree of Satisfaction - 15,5,9
Second Test: Trumpet without viewing filters
Sequence of Prints - 20,8,9,"10"
Amount of Time - 2 minutes
Degree of Satisfaction - 3,13,11

Third Test: Flower with viewing filters
Sequence of Prints - 20,"14",5
Amount of Time - 8 minutes
Degree of Satisfaction - 3,1,2

* Printer #20

First Test: Portrait with viewing filters
Sequence of Prints - 20,10,"1"
Amount of Time - 3 minutes
Degree of Satisfaction - 2,4,1

Second Test: Trumpet with viewing filters
Sequence of Prints - 20,16,N/G,14,1,"3"
Amount of Time - 6 minutes
Degree of Satisfaction - 4,11,3

Third Test: Flower without viewing filters
Sequence of Prints - 20,N/G,14
Amount of Time - 2 minutes
Degree of Satisfaction - 15,14,6
APPENDIX TWO

The purpose of this appendix is to determine whether changing the viewing conditions for the buyers had any adverse effect on the results of the experiment. The scores of the six buyers who were tested in the viewing booths that met ANSI standards (with and without filters) is compared with the scores of the buyers tested under varying conditions.

Number of Proofs Analysis

<table>
<thead>
<tr>
<th></th>
<th>ANSI Viewing Conditions</th>
<th>Varying Viewing Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Portrait</td>
<td>5 3 4 6 4 3 -</td>
<td>5 3 4 4 7 3 6</td>
</tr>
<tr>
<td></td>
<td>- - - - - -</td>
<td>3 6 4 3 6 3 4</td>
</tr>
<tr>
<td>( \bar{X} ) is</td>
<td>4.17</td>
<td>4.36</td>
</tr>
<tr>
<td>difference</td>
<td>not significant</td>
<td></td>
</tr>
<tr>
<td>Trumpet</td>
<td>4 7 5 4 7 3 -</td>
<td>5 6 5 4 4 3 4</td>
</tr>
<tr>
<td></td>
<td>- - - - - -</td>
<td>3 6 8 5 4 3 6</td>
</tr>
<tr>
<td>( \bar{X} ) is</td>
<td>5.0</td>
<td>4.71</td>
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<tr>
<td>difference</td>
<td>not significant</td>
<td></td>
</tr>
<tr>
<td>Flower</td>
<td>3 7 2 4 4 2 -</td>
<td>3 5 4 3 4 4 4</td>
</tr>
<tr>
<td></td>
<td>- - - - - -</td>
<td>2 7 6 5 5 5 6</td>
</tr>
<tr>
<td>( \bar{X} ) is</td>
<td>3.67</td>
<td>4.5</td>
</tr>
<tr>
<td>difference</td>
<td>is borderline</td>
<td></td>
</tr>
</tbody>
</table>

* The first level value (with a .05 significance) of the Multiple Range Test is .907.

Degree of Satisfaction Analysis

<table>
<thead>
<tr>
<th></th>
<th>ANSI Viewing Conditions</th>
<th>Varying Viewing Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Portrait</td>
<td>1 1 1 4 1 4 -</td>
<td>1 2 1 4 1 2 1</td>
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<tr>
<td></td>
<td>- - - - - -</td>
<td>4 2 2 2 4 1 1</td>
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<tr>
<td>( \bar{X} ) is</td>
<td>2.0</td>
<td>2.0</td>
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<tr>
<td>difference</td>
<td>not significant</td>
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</tbody>
</table>

### Trumpet

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<tr>
<th>4</th>
<th>7</th>
<th>5</th>
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<th>7</th>
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<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

$x$ is 5.0

difference not significant

<table>
<thead>
<tr>
<th>5</th>
<th>6</th>
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<th>4</th>
<th>4</th>
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<th>4</th>
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<tbody>
<tr>
<td>3</td>
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<td>8</td>
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<td>4</td>
<td>3</td>
<td>6</td>
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</table>

### Flower

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<tr>
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<th>2</th>
<th>3</th>
<th>4</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>

$x$ is 2.5

difference not significant

<table>
<thead>
<tr>
<th>2</th>
<th>4</th>
<th>4</th>
<th>2</th>
<th>3</th>
<th>2</th>
<th>4</th>
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<tbody>
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<td>4</td>
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<td>1</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>3</td>
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</tbody>
</table>

* The first level value (with a .05 significance) of the Multiple Range Test is .829.

### Amount of Time Analysis

<table>
<thead>
<tr>
<th></th>
<th>ANSI Viewing Conditions</th>
<th>Varying Viewing Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Portrait</strong></td>
<td>5 5 3 7 5 4 -</td>
<td>6 8 11 4 4 3 4</td>
</tr>
<tr>
<td></td>
<td>- - - - - -</td>
<td>4 3 13 2 4 2 6</td>
</tr>
</tbody>
</table>

$x$ is 4.83

difference not significant

|                  | 4 10 6 7 4 -          | 4 10 7 5 7 4 2           |
|                  | - - - - - -            | 1 8 7 7 4 2 4           |

$x$ is 6.17

difference not significant

|                  | 4 9 2 5 5 3 -          | 4 5 5 11 4 3 5           |
|                  | - - - - - -            | 1 5 6 6 4 4 5           |

*x* is 4.67

difference not significant

* The first level value (with a .05 significance) of the Multiple Range Test is 1.522.

### Conclusion

The scores of the buyers tested under varying conditions are not significantly different from those tested under ANSI conditions. There is a borderline case with the number of proofs analysis on the flower image. No doubt the buyers tested under varying viewing conditions might have had a harder time detecting the subtle changes in overall color balance under poor lighting. But since the significant difference is
not great and the tests are reasonably well distributed (See Appendix One), this experimenter finds no reason to be concerned about the changes in viewing conditions for the buyers.

As mentioned in the chapter on the Complexities of Perception, people can adapt to different viewing conditions at different levels of illumination quite quickly. Consequently, the similarities of the two groups as found in the analysis above is not surprising.
APPENDIX THREE

The purpose of this appendix is to determine whether giving each participant three tests was conducive towards a lower score on the third test due to learning from experience. The scores for all the tests (with and without viewing filters) are compiled according to the sequence in which they were given.

Number of Proofs Analysis

<table>
<thead>
<tr>
<th>First Test</th>
<th>Mean is 4.1</th>
</tr>
</thead>
<tbody>
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<td>5 6 4 4 4 4 4 3 6 6 5</td>
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</tr>
<tr>
<td>6 3 4 6 5 7 2 4 4 2</td>
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</tr>
<tr>
<td>2 3 3 4 4 4 2 4 3 4</td>
<td></td>
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<tr>
<td>3 3 5 5 7 3 4 4 3 3</td>
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<table>
<thead>
<tr>
<th>Second Test</th>
<th>Mean is 4.55</th>
</tr>
</thead>
<tbody>
<tr>
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</tr>
<tr>
<td>4 3 6 6 4 3 5 5 4 3</td>
<td></td>
</tr>
<tr>
<td>5 6 5 4 6 6 3 2 4 3</td>
<td></td>
</tr>
<tr>
<td>3 6 6 4 8 4 4 4 4 6</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Third Test</th>
<th>Mean is 4.35</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 3 4 3 7 3 3 7 4 3</td>
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<tr>
<td>5 5 4 4 3 7 4 4 7 3</td>
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</tr>
<tr>
<td>4 5 3 3 8 3 4 4 4</td>
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</tr>
<tr>
<td>5 2 5 6 10 4 3 4 3 3</td>
<td></td>
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* The first level value (with a .05 significance) of the Multiple Range Test is .666.1

The order with which the tests are given has no significant effect on the number of proofs.

Degree of Satisfaction Analysis

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<td>1 1 4 3 3 1 3 4 1</td>
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<td>1 3 4 2 1 3 4 4 3</td>
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<table>
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<tr>
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<td>1 2 4 3 4 4 4 4 3</td>
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<table>
<thead>
<tr>
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<th>Third Test</th>
<th>Mean is 2.35</th>
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<td>1 2 1 4 1 4</td>
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<td>1 1 4 2 3</td>
<td>2 2 4 3 4 3</td>
</tr>
<tr>
<td>4</td>
<td>3 1 4 1 2</td>
<td>1 4 4 2 2</td>
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* The first level value (with a .05 significance) of the Multiple Range Test is .561.

The order with which the tests are given has no significant effect on the degree of satisfaction for the final prints.

Amount of Time Analysis

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<thead>
<tr>
<th></th>
<th>First Test</th>
<th>Mean is 5.08</th>
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<td>2 5 5 5 10 2 6 5 3 3</td>
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<td>6</td>
<td>4 6 4 7 6 4 2 2 5 5</td>
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<td>2 1 2 7 8 5 6 3 4 3</td>
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<tr>
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<th>Second Test</th>
<th>Mean is 5.1</th>
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<td>5 1 5 8 9 7 3 2 6</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Second Test</th>
<th>Mean is 5.1</th>
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<tbody>
<tr>
<td>4</td>
<td>5 7 5 7 4 1 3 7 7</td>
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<tr>
<td>4</td>
<td>2 4 4 4 5 6 7 5 4</td>
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</tr>
<tr>
<td>8</td>
<td>8 7 4 7 6 3 2 2 5</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>5 1 5 8 9 7 3 2 6</td>
<td></td>
</tr>
</tbody>
</table>
The first level value (with a .05 significance) of the Multiple Range Test is 1.169.

The order with which the tests are given has no significant effect on the amount time necessary to get the preferred print.

Conclusion

The order with which the tests are given has no significant effect on the number of proofs, degree of satisfaction, or amount of time. This experimenter attributes the above findings to the design of the experiment. The test images and starting point prints were diversified enough so the participants could not easily make correlations from one test to the next.
BIBLIOGRAPHY


Styne, Alexander F. "Color and Appearance - Bridging the Gap From Concept to Product." *Color Research and Applications.* Vol. 1, No. 2 (Summer 1976).
