AN ABSTRACT OF THE THESIS OF

LINDA LEE HANDORF for the degree of MASTER OF SCIENCE

in Clothing, Textiles and Related Arts presented on June 12, 1975

Title: EVALUATION OF COLOR CHANGE IN TEXTILES BY MIDDLE-AGED WOMEN

Redacted for Privacy

Abstract approved:

Janet L. Bubl

The purpose of this study was to assess reactions to and opinions about color and color performance by women ages 45 to 54 years. Hypotheses were developed to test relationships and differences between both perception and acceptance of color change and: 1) the three primary colors, 2) the two methods of sample presentation, 3) order in presentation of the single color level 5, and 4) how well the color was liked. Liking of the color of the original sample was compared to that of the faded samples. Average levels of acceptance were compared to the L22 and Celanese performance standards.

Interviews with 152 subjects were conducted under controlled conditions. Subjects were first shown single and then paired fabric samples. The samples used consisted of three intensely colored fabrics, red, blue, and yellow, with each color faded to five

different levels according to the Gray Scale. While viewing the samples, the subjects answered several questions concerning perception of color changes, wearing garments of that color in public, and how well the color was liked.

In comparing the percentages of perception and acceptance of color change, diverse differences for the three colors were evident. Thus, it was considered inappropriate to make comparisons among the three colors.

The percentage of subjects perceiving color change generally varied directly with the amount of color change for all three colors. The acceptance of color change in red varied inversely with the amount of color change. Irregular results occurred in acceptance of yellow for the single presentation, but acceptance generally varied inversely with the amount of color change in the paired presentation.

A significant number of subjects identified color differences in each color at level 5, where no difference actually existed. More subjects identified color differences at this level in the single presentation than in the paired.

The two methods of sample presentation, single and paired frames, differed significantly for both perception and acceptance. There was a higher percentage of perception at all faded levels for the paired presentation, but the degree of acceptance tended to be higher for the single presentation.

The order in which the level 5 sample was presented was found to have no significant effect on either perception or acceptance of color change in all colors.

Subjects who clearly liked a color differed from those who disliked it in the perception of color change only for the upper levels of red and level 3.5 of blue in the single presentation. The acceptance of color change as related to the degree a color was liked varied with the color and color level.

The acceptance of color change was found to be similar for both ways it was assessed: 1) the amount of color change (non-matching) and 2) harmonious blending.

Levels of acceptance were compared to those standards established by Celanese and the USA Performance Requirements, L22, and both generally appeared to be minimal when the responses of 75 percent of these subjects who identified color change were considered.

Mean scores of color preference indicated that for blue and red, the colors of the original samples were preferred to most of the faded samples, but just the opposite was true for yellow. Overall, blue was rated the highest in preference of the three colors, with red second, and yellow last.

Evaluation of Color Change in Textiles by Middle-Aged Women

by

Linda Lee Handorf

A THESIS

submitted to

Oregon State University

in partial fulfillment of
the requirements for the
degree of

Master of Science

Completed June 12, 1975

Commencement June, 1976

APPROVED:

Redacted for Privacy

Assistant Professor of Department of Clothing, Textiles and Related Arts in charge of major

Redacted for Privacy

Head of Department of Clothing, Textiles and Related Arts

Redacted for Privacy

Dean of Graduate School

Date thesis is presented June 12, 1975

Typed by Lyndalu Sikes for Linda Lee Handorf

ACKNOWLEDGEMENTS

The author would like to express her sincere appreciation to Mrs. Janet Bubl, her major professor, for her advice, guidance, and patience throughout the preparation of this thesis.

A special thanks is given to Dr. Kenneth Rowe, for his professional advice concerning the statistical design and interpretation of the data.

Without the assistance of many others, this study would not have been possible. The author thanks: Dr. Florence Petzel, Dr. Ruth Gates, Dr. Sylvia Lee, and Mrs. Mary Jane Grieve for their interest and helpful suggestions; Mr. Doug Spany for reviewing the manuscript; Dr. Carol Saslow for her assistance in the perceptual aspects; the subjects who participated in the study; and the Oregon Agricultural Experiment Station and the Oregon State University Computer Center for financial support.

The encouragement, support, and concern given by the writer's parents over the years are greatly appreciated.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

EVALUATION OF COLOR CHANGE IN TEXTILES BY MIDDLE-AGED WOMEN

INTRODUCTION

Change in color has been identified as one of the common problem areas of textile products (Labarthe, 1954; Myers, 1961; Steiniger and Dardis, 1971). Not only is the performance of color important when the intended use of a product is considered, but color is often a determining factor in the salability of a product. Color is usually the most obvious characteristic of a textile product, so it seems only natural that most consumers should rightfully be concerned with the appearance of the article.

In the related area of textile dyeing, the industry has recognized the need to consider the tolerance limits of consumers regarding color matching (Coates and Rigg, 1968; Marshall and Tough, 1968), but little has been done to actually determine what consumers will tolerate with regard to color and color performance in textiles.

Although various color performance standards do exist for textiles (USA Standard Performance Requirements for Textile Fabrics, L22, 1968; Celanese Performance Standards for Fortrel® Polyester Fabrics, 1966, and others), it appears that little has been done to ascertain how these standards rate with consumers, whether they are too low to be generally acceptable or are higher than are really necessary. In order to be useful to both industry and consumers, standards must be based on an understanding of what consumers expect in the performance and usage of the product (Smith, 1969). Standards should reflect the consumer's degree of acceptance or tolerance limits.

If color standards were based on an assessment of consumer opinion, both consumers and industry would benefit from the improvement.

This thesis is based on a similar study done at this institution by Carter, associated with the Western Regional Coordinating Committee project WRCC-9 (Carter, 1975). She investigated consumer perception and acceptance of color change in textile fabrics as related to age, sex, and socio-economic level. The socio-economic data Carter collected from the Corvallis sample was unsuitable for analytical use due to a small number of subjects in the upper and upper-lower class levels and the questionable influence of age on social status.

Based on Carter's work, this study was designed to concentrate on a single age and sex group. Women were chosen, since it was anticipated that they would be easier to contact and be more willing and able to participate in the study. The age group of 45 to 54 years was selected since it was assumed that this age group would be more likely to have an established social status. Socio-economic data were collected to be used only for descriptive purposes unless a fairly equal distribution of subjects was obtained in the sample. It was anticipated that this might not be the case, however, due to the economic characteristics of the Corvallis, Oregon area. An attempt to attain a more equal socio-economic distribution was made by extending the population area to the nearby community of Philomath.

Statement of the Problem

The central purpose of this study was to determine, with two different methods of sample presentation, at what level color change in textiles is actually evident to middle-aged women, and at what point they consider the color change unacceptable for use under certain conditions. Since reaction to color and to color change may be affected by other factors in addition to the obvious stimuli of the color specimens themselves, the intervening effects of different presentation methods, order of the presentation, and how well the colors were liked also were analyzed.

The study was based on these objectives:

A. to determine the level of perception of color change in selected fabrics by middle-aged women;

   1. to determine if a change in color will be perceived when no change has actually occurred;

2. to compare differences in the levels at which color change is perceived among the three primary colors;

3. to compare differences in the levels at which color change is perceived between two methods of sample presentation;

4. to determine the effect of order in presentation of the single color level 5 sample (original) on the level of preception of color change;

5. to determine if the level at which color change is perceived is affected by the degree the color is liked;

B. to determine at what level the color change in the selected fabrics becomes unacceptable for a specified use;

1. to compare acceptability of color change on two bases:

   a) amount of change in color when colors no longer match, and

   b) harmonious blending of the samples;

2. to compare average levels of acceptance to the L22 and Celanese performance standards;

3. to compare differences in the level of acceptance of color change among the three primary colors;

4. to compare differences in the level of acceptance of color change between two methods of sample presentation;

5. to determine the effect of order in presentation of the single color level 5 (original) sample on the level of acceptance of color change;

6. to determine if the level of acceptance is affected by the degree the color is liked;

C. to determine if the change in color is actually preferred to to the original color.

Hypotheses

The following experimental hypotheses were tested:

Hypothesis 1. The subjects will perceive no change in color when no change has actually occurred.

Hypothesis 2. The level at which color change is perceived will be similar for the three primary colors.

Hypothesis 3. There will be differences in the levels at which color change is perceived between the two methods of sample presentation.

Hypothesis 4. The perception of color change at each color level will not be affected by the order in which the single level 5 sample is shown.

Hypothesis 5. Subjects who like a color will differ from those who dislike a color in their perception of differences in color.

Hypothesis 6. Subjects will be more accepting of color change on the basis of harmonious blending than on the basis of the amount of color change when the colors no longer match.

Hypothesis 7. The subjects' standards of acceptance of color change will be equivalent to the L22 and Celanese performance standards for colorfastness to light, laundering, and drycleaning on similar fabrics.

Hypothesis 8. The subjects will be equally accepting of color change for the three primary colors.

Hypothesis 9. There will be differences in the acceptance of color change between the two methods of presentation.

Hypothesis 10. The acceptance of color change at each color level will not be affected by the order in which the single level 5 sample is shown.

Hypothesis 11. The subjects will be more accepting of color change if they like the color, and less accepting of color change if they dislike the color.

Hypothesis 12. The color of the original fabric will be preferred to that of the faded fabric.

Definitions

Color refers to the general overall effect and appearance of the sample stimulus, including hue, saturation, and brightness.

Perception refers to an observed sensation or awareness of the sample stimulus.

Acceptance refers to the deviation each individual will tolerate from the standard or original.

Blending refers to a color combination that appears harmonious to the observer.

Assumptions

The subjects answered the questions in the interview honestly and sincerely.

The subjects' answers were representative of their reactions in similar real life situations.

The subjects were able to transfer their feelings about the test samples' colors to the proposed clothing items.

The sample was normally distributed.

The testing methods and instruments were valid and reliable.

The subjects were representative of the broad spectrum of women consumers in the 45 to 54 year age group.

Limitations of the Study

These conditions may have limited the interpretation of this study:

1. the use of only three colors, red, yellow, and blue, and their respective intensities;
2. the use of only small fabric samples instead of actual garments;
3. the use of imaginary proposals of blouse and pants as clothing items with no pictorial representations;
4. the adjacency of fabric samples in the paired instrument making color differences easy to identify;
5. the tendency of subjects to base responses on previous samples, i.e., independence of each response could not be insured;
6. the separate presentation of single and paired samples, i.e., non-randomization;
7. subjects with experience in color were neither sought nor excluded; and
8. the use of the Dvorine Pseudo-Isochromatic Plates as only a general screening device for color blindness, therefore not insuring normal color vision for the entire sample.

REVIEW OF LITERATURE

Color Perception

The visual sensation of color is experienced by an individual when light waves stimulate the retinal receptors of the eye, and the image is transmitted by the optic nerve to the brain (Sheppard, 1968, pp. 6-8; Taylor, 1967).

The rods and cones located in the retina are the sensitive elements of the eye. The rods enable the eye to see primarily at night. The cones make day vision possible as well as the detection of difference between and within red, yellow, green, and blue. The cones also respond to light and dark (Taylor, 1967).

The transmission of a visual signal to the brain does not necessarily result in a definite conscious perception of a color sensation. The sensation of a color can be determined only from a description by the subject and is therefore a psychological and subjective function (Sheppard, 1968, p. 10).

Color Deficiencies

Most common theories on the perception of color suggest that there are three types of cone photoreceptors responsible for color vision in the retina. The most widely followed visual theory is that of Young-Helmholtz. This theory, as explained by Hurvich and Jameson (1969), suggests that each of the three cone photoreceptors contains a different photochemical substance with specific absorption abilities at different points on the spectrum. Each cone has its own specific nerve system and is correlated with one of the three fundamental color sensations, red, blue, or green. Varying amounts of these three color systems compound to form all visual sensations.

Individuals with normal color vision have all receptors functioning properly and are termed "normal trichromats" (Graham, 1965, p. 395). The absence or malfunction of one or more receptors results in defective color vision or color blindness, as it is often called. Different figures are quoted for the occurence of color deficiencies, but appear to vary with the degree of severity considered. Defective color vision is found in about one percent of the male population and one-tenth percent of the females according to Cornsweet (1970, p. 149). Stearns (Part 1, 1974) gives the higher figures of eight percent of males and four-tenths percent of females with some color deficiency. Wardell (1969) estimates that at the most, only 75 percent of American males have good red-green color vision. Of the remaining 25 percent, 6 to 10 percent of American males are defective in red-green vision only.

The three main types of defective color vision systems are protanopia (red weak), deutanopia (green weak), and tritanopia (blue weak). There are also individuals, termed monochromatic or totally color blind, who see everything as a variation of one color. Defective color vision can be caused by either an inherited, sex-linked characteristic, a disease, or toxic agent (Burnham, Hanes, and Bartleson, 1963).

Walls and Mathews (1952) stated that one out of every seven women carry at least one defective color gene. These women greatly outnumber the affected males. Although their color vision is usually good enough to pass most screening tests for color deficiencies, their color vision is seldom, if ever, absolutely normal. Therefore, they should be excluded, if possible, from color investigations requiring subjects with normal color vision.

Color Deficiency Testing

Most color blindness test plates were developed before the theory of color confusion was perfected and, therefore, are not capable of extensive analysis of color blindness. They are useful for efficient screening of serious cases of red-green color blindness, the most common type (Wardell, 1969). There are several tests for color deficiencies on the market, most using the color confusion principle.

The Dvorine Pseudo-Isochromatic Plates is one of several tests listed for use by all departments of the armed forces. An individual with a protanopic (red weak) deficiency has no chance of passing this test, while a deutanope has an eight percent chance. Normal color vision is indicated by a score of at least 14 correct responses. Five to eleven errors show a moderate deficiency in color vision, and twelve to fourteen errors indicate a severe color deficiency. This test is, however, not reliable enough to use in determining extent or type of color defects, but serves as only a general screen for fairly serious color defects (Paulson, 1973).

Each plate in the Dvorine Test is made up of an arrangement of small colored dots. One range of colors is selected for a background, and another range is used to form the numbers. The colors used are indistinguishable to color defective individuals, so that the number should appear invisible to them. Two of the plates are designed to distinguish protans from deutans by the use of double digit numbers on different colored backgrounds. The protans should be able to see only the second digit on the red-purple background, while the deutans should see only the first digit on the pink background (Paulson, 1973; Dvorine, 1953).

A nomenclature testing section is also included in the Dvorine Test to measure the subject's knowledge of the names of both saturated and unsaturated colors. Failure to pass this portion does not indicate color blindness, only faulty knowledge of color names (Dvorine, 1953).

The Ishihara Test for Color Blindness is produced in both 14 and 25 plate editions. Bird (1968) described these as good, rough screening devices for red-green deficiencies, but not reliable for indicating the extent or type of color defects. Establishing the number of errors for classification of color defectives seems to be the most difficult problem in using this test. It usually requires expert interpretation of results.

The Hardy-Rand-Rittler Pseudoisochromatic Plates were developed in an attempt to improve on some of the defects of the Ishihara Test. If used properly, the test gives more sophisticated results. Six screening plates make up the first portion of the test, and if any are missed, fourteen other plates are used to determine the extent and type of color defect (Wardell, 1969).

A small percentage of subjects with normal color vision may fail plate tests due to certain factors other than defective color vision. There may be a tendency to complete numbers on the plates such as reading a 3 as an 8. This could also be a function of the shape of certain numbers. There may also be visual defects present other than color (Paulson, 1973).

Measurement of Color and Color Differences

Most work in color before 1930 involved visual determinations. Since 1930, the science of colorimetry has been used more and more as recording spectrophotometers and computers have been developed (Stearns, Part 1, 1974).

Although visual assessments of color are generally quicker and less expensive, they are not always accurate. Even the use of several colorists does not increase accuracy, since there will usually be as many different judgments as colorists. Unless viewing conditions are held constant, visual assessments can vary greatly according to the viewing situation (Coates and Rigg, 1968).

Instrumental measurement of color differences is done with a colorimeter or spectrophotometer. Three parameters (X, Y, and Z), known as tristimulus values, are measured directly by the instrument. These are simply the amounts of three primaries needed to equate the color being matched or measured. The choice of primary colors does not matter as long as no two will match the third. The physical colors of the three filters used in a colorimeter are usually green, blue, and amber. The tristimulus values (X, Y, and Z) then should be converted to a meaningful unit of calculated color difference (Stearns, Part 1, 1974). Unfortunately:

> exposure of various specimens of different hues, values, and chromas that show changes of equal visual importance vary considerably in the numerical value as determined by a color difference formula (Stearns, Part 2, 1974, p. 75).

The American Association of Textile Chemists and Colorists (AATCC) has developed accelerated testing methods that attempt to predict textile performance; over thirty of these test methods involve color difference evaluations (Technical Manual of the AATCC, 1974).

A direct visual evaluation of color difference is recommended by the AATCC rather than instrumental evaluation. Visual evaluations are simpler, quicker, and require no expensive equipment. The use of Gray Scales to increase the reproducibility of color difference evaluation is advised by AATCC. The Gray Scale for Color Change is made up of nine pairs of gray chips arranged in successive series of contrasts. One specimen in each pair is a standard medium gray. The second specimen varies in each pair, becoming lighter with each step. Numerical ratings are assigned to each step beginning with 5 (no change) down through 4.5, 4, 3.5, 3, 2.5, 2, 1.5 and 1 (most change). The Gray Scale has been standardized by the use of instruments and the Adams-Nickerson chromatic value formula (Stearns, Part 2, 1974; Technical Manual of the AATCC, 1974).

> The Gray Scale for Color Change is used in the lightfastness test method, in that Step 4 color difference is the definition of "just appreciable" fading. To judge lightfastness, a comparison is made between a standard sample and the specimen under test, but the exposure to light is continued until standard sample shows a "just appreciable" fade. If the standard sample is a satisfactory commercial fabric, it is usually the same shade as the

> specimen, and the comparison for "more or less" fade is easy (Stearns, Part 2, 1974, p. 50).

In using the Gray Scale, the observer holds it near the standard sample and the specimen and determines which Gray Scale contrast appears most like the specimen pair contrast. Evaluation of brilliant colors is difficult, and observers often disagree on assessment (Stearns, Part 2, 1974).

Variables Associated With Color Perception

Age

Numerous studies have assessed the relationship between age and color perception. According to Wardell (1969), the best industrial color matchers are in the 25 to 30 year age group, but 50 percent of the customers in the United States are not in that age group.

One important factor believed to have an age effect on color vision is the degree of yellowing of the retina's macula area and of the crystalline lens. This yellowing condition seems to become increasingly apparent with age, and older colorists may be said to have a "red eye." Violets would tend to look redder to a 50 year old than to a 25 year old (Vogel, Stanziola, Auman, Lobb, and Tausendfreund, 1972).

McLaren (1969) felt that yellowness of vision was possible to some extent at any age due to variations in the degree of macular pigmentation. Joerger (1969) supported this theory in his research, but still observed significant correlations between yellowness of vision and the average of age groups. Hunt (1971) also confirmed the idea of different amounts of yellow pigment being present in the macula region. He saw significant variations in color vision characteristics due to this fact, even among normal observers, and felt that they were caused by either chemical differences in the photosensitive pigments, or by physical differences in the cone structure. However, he does see this yellowness increasing with age, making it more difficult for older people to see some types of color differences.

Hue discrimination was found to be best in young adults and worse at other ages. The latter group was especially weak in perception of blue-greens and reds (Verriest, 1963).

Age appeared to be the only factor having any significant effect on color vision in the study by Vogel, et al. (1972). Subjects between 20 and 40 years of age showed more consistency as a group in seeing match points. After 40 years of age, the subjects were less consistent in picking match points.

Smith (1943) found a sharp decrease in color discrimination ability after the age of 60. He stated, however, that age differences may be due to attitudinal and learning factors rather than to receptor physiology. Chapanis (1950) did not entirely support this trend. He found that the very old did have more difficulty than the young in distinguishing and recognizing blue-green, blue, and violet colors, but found no significant evidence that color scores decrease with age.

Carter (1975) found only three significant values in assessing age in the perception and acceptance of color change in textiles. A decline in accuracy of perception of color change occurred with increasing age, and older people were the most likely to see a color difference where none actually existed. In some cases, acceptance of color change increased with increasing age.

Sex

Vogel, et al. (1972) found no significant differences in the average match point of males or females within any age group. Verriest (1963) also found no significant results between normal males and females. Smith (1943) also found no differences between males and females except at age 5 to 11 years where females scored over males of the same age.

In Carter's study (1975), men seemed to be slightly more accepting of color changes in clothing items to be worn at home, but nothing significant was found concerning the perception and general acceptance of color differences related to sex.

Social Influences

It was shown in research by Keasey, Walsh, and Moran (1969) that subjects will often allow their responses to be influenced by peers, usually more by someone of the same sex, instead of being independent in color perception.

Carter (1975) attempted to assess the effect of socio-economic status on perception and acceptance of color change, but was not able to evaluate this aspect conclusively due to limited class level sizes.

Training and Experience

Coates and Rigg (1968) described the visual responses of an experienced colorist as improving greatly with experience in quantatively describing color differences. Their visual responses in detecting color differences were similar to those of customers and did not much improve. In research by Vogel, et al. (1972), it was reported that experienced colorists as a group were no more consistent in their evaluations than others in the same age group.

It was reported by Smith (1943) that workers in the color field scored much higher than any other group and were consistently above average in their respective age groups. He associated superior color perception and discrimination with higher intelligence. This concept was reflected by Wardell (1969, p. 21), who stated that "color matching ability is favorably affected by intelligence, learning ability and zest for work connected with color."

Color Preferences

People tend to surround themselves with the colors they like best, and this may have some effect on their color perception. Of course, the preferred color may vary with the end use of the product.

Based on the combined results of 26 investigations, Burnham, et al. (1963) reported the weighted-average order of preferences from most to least preferred for the 6 common hues: 1) blue, 2) red, 3) green, 4) violet, 5) orange, and 6) yellow.

In determining consumer preferences in color for furniture, Turner and Edwards (1974) found that the cool hues were more strongly preferred over the warm hues, with the rank being (from most to least preferred): 1) blue, 2) green, 3) yellow, and 4) purple.

A sample of college age females studied by Stringer (1971) revealed blue as the favorite color, followed by yellow, orange, and green. Love (1973) also studied color preferences of college students. Blue was most preferred and yellow-green the least preferred in general, but when related specifically to clothing, over 50 percent of the subjects chose blue as their favorite color. Red was least preferred and purple ranked as the second least preferred color for clothing. In home furnishings, orange and brown were most preferred, while the reds and purples were least preferred.

Both males and females of over 65 years preferred blue most and yellow the least. There seemed to be a trend, especially in the males, of an increasing preference for more striking colors as age increased, perhaps explained by an over-all decline in sensitivity to color with age (Mather, Stare, and Breinin, 1971).

Bjerstedt (1960) felt that age could be an influencing factor in the preference for warm or cool colors. He studied 603 subjects over a wide range of ages and found that the younger ones preferred warmer colors; the older subjects preferred cooler colors.

In investigating the ability to detect perceivable hue differences and preferences, Love (1973), in general, found no difference in the discriminating ability by the subject for favorite and least favorite hues. However, in clothing, home furnishings, and car exteriors, favorite hues were significantly better discriminated when compared to least favorite hues, perhaps indicating better discrimination when specific product colors are available.

It was suggested by Duncan (1975) in a consumer evaluation of blouses for color change, that a consumer may have particular color preferences, and may not want to wear a disliked color regardless of the amount of color change.

Viewing Conditions and Methods

The color stimulus is the main consideration in color studies, but the appearance of this sample stimulus may vary according to several factors, including the surrounding objects or areas, the sizes and relative positions of objects, the observer's memory, and others. The control of the illumination and viewing conditions must be carefully maintained in any visual or instrumental color evaluation.

Because color is perceived over a wide range of illumination, the sensitivity of the eye varies according to the amount of light. If the light level is very low, all colors will disappear, and objects will be visible as various shades of black, gray, and white. If the light becomes too bright, most colors will seem to vary from the hue at medium intensities. A standard minimum light level of 50 footcandles is recommended by the AATCC for color evaluation (Stearns, Part 1, 1974).

Smith (1943) found that the ability to discriminate, between hues did not increase at illumination levels of over 10 footcandles, but a higher level of illumination is necessary for critical hue evaluation.

Burnham, Onley, and Witzel (1970) reported that subjects found the effect of contrast to be greater and the amount of perceived color difference to be larger, as color samples were pushed closer together. In this same color scaling study, the subjects tended to rate large color differences smaller than predicted and small color differences larger than predicted.

Large-sized viewing samples and uniform backgrounds of the same color were found to aid judgments of color difference in a study by Coates and Rigg (1968). They also suggested that differences in color were more easily perceived when there is no intervening color in contact with the samples. Graham (1965, p. 465) confirms these ideas concerning the effect of sample size, background color, and effect of an intervening color.

Norwick (1969) stated that one's judgment was affected by the distance of the sample from the eyes and the angle from which the sample was viewed.

The backing used behind a textile sample may affect the color seen by the subject. A white backing could reflect the light passing through the fabric, and a black backing could absorb the light rays. The AATCC test method suggests folding the fabric sample until it is opaque, before evaluating the color (Stearns, Part 1, 1974).

In the report of a study by Newhall, Burnham, and Clark (1957), comparisons between simultaneous and successive color matching were discussed. Simultaneous or paired matching (i.e., viewing samples at the same time) is a standard colorimetric practice, whereas successive or memory matching (i.e., one at a time) is a common practice by the consumer and is actually only half memory, since the subject has to remember only one of the colors. The two matching processes are so different that important differences in results were not surprising to the researchers. There was a higher variability of replicative matches with memory matches. The time required for memory matching was only half that needed for perceptual matching and was attributed to the subject's fear of losing the color memory.

There was also an increase in the apparent strength of the remembered colors, especially in higher purities and luminances. A prediction based on the principle of adaptation could be made to support either an increase or decrease in apparent hue, saturation, or brightness.

> If there were a brighter or dimmer color following the color to be remembered, the memory trace might become bright or dimmer by assimilation (Newhall, *et al.*, 1957, p. 44).

Research in other areas than color tend to support the possibility of this assimilation or adaptation principle, including the fields of lifted weights (Guilford and Park, 1931) and loudness of sound (Pratt, 1933), but there are no consistent predictions of which way (increase or decrease) this principle can be expected to work.

Color Performance Standards

Various standards have been established by different organizations for the purpose of evaluating products. Large mail order chains and some of the larger department stores in the United States maintain laboratories to develop standards for merchandise and to test products from various manufacturers (Labarthe, 1975).

Standards have been set up by the manufacturers of fibers and yarns for the fabric and apparel made from their fibers. Thus, the quality of the product is protected, since the sale of items under a certain trademark is not approved unless the manufacturer's standards are met (Labarthe, 1975).

The Celanse Fibers Performance Standards is one example of this information which is available to the public. In it, minimum standard requirements are specified for certain fibers and fabric constructions with the suggested end uses of each being considered. Special standards (which must be met before trademark licensing will be approved by the company) have been set up for a few fabrics (Fabric Performance Standards for Trademark Licensing, 1973).

Standards set up by Celanese, for a lightweight woven fabric (Fortrel® polyester) suitable for women's blouses, specify that it must not have less than a 3-4 Gray Scale rating according to AATCC test methods for colorfastness to light, when exposed for 20 standard fading hours. The colorfastness level is 3 to 3-4 for laundering (120°F.), and the level for drycleaning colorfastness is 3 (Celanese Performance Standards for Fortrel® Polyester Fabrics, 1966).

Many companies now use the L22 standards of the American National Standards Institute, Inc. as guidelines. These standards originated in 1952 due to the wide variations in the properties and performance of rayon and acetate after World War II (Labarthe, 1975). The latest revision of the standards, in 1968, covers 27 articles of women's and girls' apparel, 21 apparel items for men and boys, and 15 standards for home furnishings (L22, 1968).

The L22 standards state acceptable minimum performance figures for each apparel item. These standards are determined indirectly by actual consumer experience, through data based on consumer complaints submitted by commercial and department store testing laboratories, the American Institute of Laundering, and the National Association of Drycleaners (Labarthe, 1975). Each standard represents a general consensus among manufacturers, retailers, consumer groups, governmental agencies, and scientific, technical, and professional organizations (L22, 1968).

The L22 standards for colorfastness in women's and girls' woven blouse or dress fabrics specify that when exposed to light for 20 standard fading hours, fading should not be less than level 4 on the Gray Scale. The colorfastness level is class 4 for both laundering

(120°F.) and drycleaning. For women's and girls' woven sportswear fabrics (shorts, skirts, slacks), the colorfastness level is Gray Scale class 5 after exposure to 40 standard fading hours of light. For both laundering (120°F.) and drycleaning, the colorfastness level is class 4 according to the Gray Scales (L22, 1968, p. 11, 49).

Consumers and Color Performance

Color change constituted approximately 9 percent of complaints about women's blouses and 22 percent of complaints about women's dresses in a survey by Labarthe (1954). Myers (1961) identified color failure as a main cause of faulty performance in textile products. Fabric-caused color failures accounted for 47 percent of consumer complaints that were traceable to inherent fabric defects. Complaints about color changes in textile products were reported by 12 percent of the respondents in a survey by Steiniger and Dardis (1971).

The expectations of the consumer for performance and wear life are prerequisites for development of product standards of performance. Several writers have noted that the customer's acceptance of color difference tolerance limits are of extreme value and importance to the color industry, but very little has been done to find out just what the customer wants in terms of color performance.

Marshall and Tough (1968) noted that it is indeed the customer who ultimately decides what tolerance is acceptable. Norwick (1969) observed that regardless of what a machine or a colorist may report, acceptance is possible only if the colors match in the eyes of the consumer. He saw a great need to correlate consumer complaints with test scores of instruments and visual evaluations and to determine what the true levels of acceptance are.

Hunt (1971) felt that a basic distinction was needed between color differences that are perceptible and those that are acceptable. He also noted that very few data were available which were applicable to general practice in color. As a result, most color difference formulae are simply based on perceptibility.

PROCEDURE

Selection of Sample

The sample was to consist of a minimum of 150 females in the ten-year age range group of 45 to 54. Because the special viewing area used made it necessary for the subjects to come to the university, the sample was limited to those individuals living in the immediate Corvallis-Philomath area.

Subjects were randomly selected from the Benton County voters' registration files rather than from the telephone directory since it was necessary to determine the ages of the subjects before contacting them. The voters' registration files consist of cards for approximately 34,000 registered voters and are filed in 24 drawers. Thirty-six names with the appropriate ages and addresses were chosen from each of the 24 drawers, totaling 864 names or approximately 5-1/2 times the minimum sample size. The points of entry (front, middle, or back) into each drawer were predetermined by a table of random entry (Appendix A), with 12 cards pulled at each entry point that fit the sample description. Names that were not listed in the 1974/1975 Corvallis-Philomath telephone directory were eliminated from the sample.

The remaining names from each drawer were then assigned random numbers from a random number table and those numbered

1 through 12 from each drawer were mailed postcards briefly explaining the study (Appendix B). Six names (numbered 13) were chosen at random for the remaining cards. The prospective subjects were telephoned after two to three days and asked if they were willing to participate in the study. More detailed information was given on the study, and appointments were made for interviews at the university (Appendix C). The mailing and telephoning continued until interviews were set up with a minimum of 150 subjects.

A total of 294 postcards was mailed, and 269 of the subjects were personally contacted by telephone. There were 25 prospective subjects that were not reached for various reasons including disconnected telephones and no answer when called. There were 92 prospective subjects who declined to participate. During a 5-1/2 week period from February 13, 1975 to March 21, 1975, interviews were conducted with 152 subjects, about a 52 percent response rate.

Collection of Data

A 30 to 45 minute personal interview with each subject was used to collect all data. Before the interview, an information sheet describing the essence of the study was provided for the subject to read (Appendix D). In order to screen out any functionally color-defective vision, subjects were given the Dvorine Test for Color

Blindness. None of the subjects were eliminated from the study on this basis. General instructions were given verbally, prior to viewing the fabrics (Appendix E). The questionnaire shown in Appendix F was used in conjunction with viewing the fabrics, and the results were recorded on the response data sheet shown in Appendix G. During the first viewing session, the subject rated how well she liked each sample color, by using the instrument shown in Appendix H. Between the two short viewing sessions, the subject was asked to complete several questions about her family using the questionnaire in Appendix I and to record her answers on the sheet shown in Appendix J.

Viewing Test Method

Viewing Area

The interviews were conducted in the room used for viewing durable press fabrics as specified by the AATCC Test Method 124-1973 (Technical Manual of the AATCC, 1974, p. 167). A table covered with gray mat board and measuring 30 inches from the floor was placed in the center of the durable press viewing area board, directly under the fluorescent light. The light source was approximately 60 inches from the top of the table with illumination of 80 lumens. The interviewer and the subject sat directly across the table from each other, with the gray wall and the durable press viewing board to the subject's right (Appendix K). Black draperies formed the wall to the subject's left, and the wall behind the interviewer was painted black. The chairs were 18-1/2 inches from the floor, and the subject was seated a comfortable distance from the table during both viewing sessions. While the subject was viewing the fabric samples, the framed viewing instrument was kept flat on the table so it was always the same distance from the light source. It was placed parallel to the edge of the table and squarely in front of the subject. The subject was cautioned about moving around and was asked to maintain approximately the same body position for viewing each sample. Both the interviewer and the subject wore white blouses or white laboratory coats to prevent any possible interference due to other colors.

Viewing Instruments

The two instruments used for viewing the fabric samples were made from gray mat board (Appendix L). The first frame had a single opening for viewing only one sample at a time. It measured 9 by 11 inches, with a viewing window measuring 5 by 7 inches. The second frame measured 11 by 14 inches with a single window measuring 7 by 10 inches for viewing two adjacent samples. The two parts of both frames were hinged on one side with masking tape to permit insertion of the fabric samples.

The fabric samples measured 6 by 8 inches with the warp yarns running the length of each sample. Each sample was mounted on a piece of gray sign board measuring 6-7/8 by 10-7/8 inches with one lengthwise edge of each flush with one another. Samples mounted on the sign board were paired together by joining with masking tape, with the two fabric edges meeting in the center. This formed a hinge, allowing the samples to be folded in half for insertion into the single frame instrument and to be folded out flat for the paired frame. Identical samples were, thereby, used in both viewing instruments. A control sample and a test specimen were exposed simultaneously in the paired frame viewing instrument. A different original sample was used in each pair, and the locations (left or right) of the original sample were randomized in presenting the paired samples (for viewing). All samples were viewed from the direction of the lengthwise grain of the fabric.

Fabric Description

Intense shades of red, blue, and yellow lightweight woven fabrics of 65 percent polyester and 35 percent cotton with permanent press and soil release finishes were used in the study. Samples of the original fabrics are shown in Appendix M. All were produced by the same manufacturer under the same trade name and were purchased at the same time in a local fabric store.

Eight small specimens of each color, measuring 2-1/2 by 6 inches, were used as a reference for fading the actual samples used in this study. These specimens had previously been faded in the Fade-Ometer for a varying number of hours ranging from 20 to 320. The small specimens were mounted on pieces of gray sign board measuring 4 by 6-3/4 inches, leaving a 1/2 inch border around the fabric specimen. After being conditioned, these test specimens were randomly ordered and were analyzed by six people with previous experience with color and color scales. The color authorities were asked to compare each test specimen individually to its original and to determine the class rating of each (5, 4-5, 4, 3-4, 3, 2-3, 2, 1-2, 1) according to the Gray Scale for Evaluating Color Change. Appendix N contains a summary of test specimen analyses by the color authorities, which served as a guide to fade the larger test samples that were actually used in this study.

Two complete sets of fabric samples were processed. The 6 by 8 inch samples were mounted on 6-1/2 by 9 inch pieces of black sign board by machine stitching at either end. These were attached to the Fade-Ometer racks with paper clips so that the entire fabric sample was exposed. The standard hours of exposure in the Fade-Ometer for each sample are found in Appendix O, and tristimulus values and calculated color difference values from photometer readings are found in Appendix P. After fading, the best samples of the two sets were chosen for mounting as previously described. Each sample was labeled by a code which listed the color (R, B, or Y), a random number identifying the individual sample (0-10), and the level of color change according to the Gray Scale. A color level of 5 indicated unexposed or control samples. The levels ranged down through 4.5, 4, 3.5, 3, and 2. The identification code was located on the mounting board beside each sample so that the code was covered when samples were inserted into the frame. Codes were recorded on the Response Data Sheets as shown in Appendix G.

Liking of Color Test

With the exception of the first original in the single presentation, the subject was asked to rate how well she liked the color as the last step in viewing each individual sample. This was done by having the subject mark an X any place along a 100 millimeter line as shown in Appendix H. Only three points (Dislike Very Much, Neutral, and Like Very Much) were marked along the line for the subject's reference.

A separate test form was used for each sample so that ratings were as independent as possible. Each form measured about 2 by 8-1/2 inches, and all 18 forms were stapled together at one side to form a booklet. The subject was asked to turn to a new form before seeing the next fabric sample. The test forms were coded to correspond with the order of presentation of the samples, and contained only a letter indicating the color (R, Y, or B) and the random number meaningful to only the interviewer. During the trial set, the subject was instructed in detail to rate each color individually, i.e., independently of the original. The rating was to be general, and no application or use of the color was specified.

A numeric value for this rating was obtained by measuring in millimeters to the nearest whole number, from the neutral position to the cross point of the X. Either a positive or negative value was assigned to this number according to its relative position (left or right) to neutral. Neutral had a value of zero, and the remaining values could range from zero to either a negative or a positive 50.

Specific Test Procedure

The subject was provided with an Information Sheet to read before the interview began (Appendix D). The Dvorine Test for Color Blindness was administered, and then the subject was given verbal instructions (Appendix E) and shown the trial set for the Single Frame Presentation. Any questions were answered before beginning the actual testing. The individual samples were inserted into the Single Frame Viewing Instrument (Appendix L) below the subject's level of vision and then placed in front of the subject. The original color sample for one color was shown first and removed. The samples of various levels in that color group, including the control sample, were then presented in a random order. The order of presentation of the three color groups was also randomized for each subject. The random orders were determined by using a table of random numbers and were listed on each data response sheet. As each sample was shown, the interviewer first asked the subject if this sample looked different from the first one (the original) she saw. If an affirmative response was received, the second and third questions were asked. The subject then rated how well she liked that particular color using the form shown in Appendix H. Answers were recorded by the interviewer on a Data Response Sheet.

After viewing all the individual samples, the subject was given about a ten minute break. During this time she was offered some refreshment and was asked to answer a few questions about her family using the forms shown in Appendix I and J. The interviewer used this time to set up the samples in a predetermined random order for the next portion of the interview.

Following the break, the subject was shown a trial set for the paired samples, and after any necessary explanations, the 18 paired samples were presented to her. The pairs consisted of one unexposed (control) sample and either a faded test sample or another unexposed sample. The locations (left or right) of the control sample were randomized. As done with the previous single samples, the pairs were inserted into the viewing instrument (Appendix L) below the subject's level of vision so the samples were not seen by the subject until they were placed directly in front of her. The order of presentation of the paired samples was completely randomized for each subject by using a random number table and was noted on each data response sheet.

Demographic Data Measure

The McGuire and White Index of Social Status (McGuire and White, 1955) was the measure used to collect descriptive data from the sample. Because it was not convenient to assess each subject's dwelling area and house type, the short form of the index was used. It included a weighted assessment of the occupation (weight of 5), source of income (weight of 4), and education (weight of 3). Subjects responded to questions found in Appendix I by marking their answers on a data sheet (Appendix J).

Occupational status ratings of one to seven were assigned by referring to the listings in McGuire and White's Table of Occupations (McGuire and White, 1955, p. 7). The occupational status of the main wage earner for each family (i.e., the one producing the most income) was considered in each case. Married women could be assigned the status of either their own occupations or those of their husbands, depending on who has the greater income. Single, widowed, or divorced women were given the status of their own occupations. The McGuire and White Tables of Source of Income and Educational Attainment (McGuire and White, 1955, p. 8) were used in assigning appropriate values of one to seven to the source of income and level of education given by each subject.

The computation of total scores was done by multiplying the score for each characteristic by the corresponding weight, and totaling the three scores. Social class levels were then assigned by using the General Conversion Table for Status Indices (McGuire and White, 1955, p. 4).

Statistical Analyses

Chi-square distributions were used to evaluate differences in perception and acceptance for the two presentation methods, the six color levels, and the three primary colors. Responses for each question were classified into contingency tables, and results were analyzed using a five percent level of significance.

Confidence interval estimates and the 95 percent level were used to analyze values on perception at the color level 5 and on perception and acceptance for the three primary colors. The Z test for a standard normal distribution was also used to analyze perception and acceptance for each of the three primary colors and for how well a color was liked.

Graphs were used to describe relationships between percentages of perception and acceptance and order of color level presentation. Comparisons for preference of color level were made by computing t-tests.

RESULTS AND DISCUSSION OF DATA

Description of Sample

The sample consisted of 152 women in the 45 to 54 year age group selected at random from the Corvallis-Philomath area. This sample represented approximately 12 percent of a total of 1,273 of this age group and .43 percent of the total population of 35,153 listed for Corvallis (U.S. Department of Commerce, 1973). Over one-half or 52.8 percent of females who are 45 to 64 years old were shown to be employed in the Corvallis area (Corvallis Area Chamber of Commerce, 1970, p. 6). The only figures available for the Philomath area showed the total population at 4,313, with 2,152 females (U.S. Department of Commerce, 1973).

Based on scores for the main wage earner's occupation, education, and major source of income, the socio-economic class levels were assigned using the General Conversion Table for Status Indices (McGuire and White, 1955, p. 4). Only two subjects were grouped into the upper class level, ninety-five into the upper-middle class, thirty-one into the lower-middle class, and twenty-two into the upper lower class. Only two scores were found to fall into the lower-lower class. Of the 152 subjects, 133 were married, and 19 were either single, divorced, or widowed.

The demographic data were collected for descriptive purposes only, since it was anticipated that the data would be unsuitable for analytical use. This prediction stems from a publication listing 64.3 percent of the Corvallis population employed in white collar occupations and $11,362 as the mean income (Corvallis Area Chamber of Commerce, 1970, p. 1), as well as the study by Carter (1975).

Carter, using the Corvallis population as a sample source, found it impossible to use the socio-economic data in analyses due to the small number of subjects in the upper and upper-lower classes. She also questioned the possible influence of age on the socio-economic level. Carter's sample of 86 contained 17 females in the 45 to 54 year age group. None of these was in the upper, upper-lower, or lower-lower social class categories. The upper-middle class contained 11, and the lower middle class contained 6. These figures are significantly smaller than those of the present study, but this can be attributed to smaller sample size covering a wide range of ages used by Carter.

Perception and Acceptance of Color Change

At the beginning of this study, it was originally expected that the subjects would perceive and accept color changes in a similar manner for the three colors. It was immediately evident from an examination of the percentages of perception and acceptance that

Table 1. Chi-square tests for heterogeneity of effects of the color levels of three colors.

	Red	Yellow	Blue	Sum	Pooled	Heterogeneity
Degrees of Freedom	5	5	5	15	5	10
Perception						
Single Presentation	203.68***	93.08***	104.06***	400.82***	343.24***	57.58***
Paired Presentation	637.20***	644.99***	500.71***	1782.90***	1600.54***	182.36***
Acceptance: Non-match						
Single Presentation	46.19***	6.02	5.43	57.64***	30.36***	27.28**
Paired Presentation	154.46***	39.15***	85.97***	279.58***	212.84***	66.74***
Acceptance: Blending						
Single Presentation	28.01***	6.34	1.96	36.31**	10.50*	25.81**
Paired Presentation	159.97***	30.04***	97.97***	287.98***	214.82***	73.16***

*** Significant at .001 level of significance
** Significant at .01 level of significance
* Significant at .1 level of significance

there were diverse differences for the three colors. The heterogeneity was tested by computing chi-square values (Table 1) (Fisher, 1973, pp. 101-105). These tests might be considered comparable to tests of interaction between color and color levels. In all cases, the heterogeneity chi-square was very highly significant, confirming an impression of irregularity. This distinct inconsistency suggested that each color be considered individually, that comparisons across colors were inappropriate. Due to this effect of heterogeneity, hypotheses 2 and 8 were considered untestable in their proposed form.

Perception of Color Change in Red

At color level 5, where no difference existed between the two samples, 32.9 percent of the subjects identified a difference in the single presentation, while only 3.3 percent saw a difference in the paired presentation (Table 2).

Table 2. Red--Percentages and numbers of subjects perceiving color change by color level and presentation method (Question 1).

Color Level	Single Presentation %	N	Paired Presentation %	N
5	32.9	50	3.3	5
4.5	43.4	66	62.5	95
4	58.6	89	96.7	147
3.5	72.4	110	97.4	148
3	84.2	128	100.0	152
2	98.0	149	100.0	152

Based on Carter's (1975) findings where none of the subjects in this particular age group of 45 to 54 years (N = 17) observed any change in color at level 5 in the red paired samples, it was accordingly predicted for this study that the subjects would perceive no change in color when no change had actually occurred. Technically speaking, the expressed perception of color by one subject refutes this hypothesis. The percentages of subjects perceiving a difference at level 5 (estimates) and their 95 percent confidence limits are shown in Table 3. These results indicate that there was a real percentage of subjects who believed they saw a difference in color even though no difference existed.

Table 3. Red--Percentages and approximate 95% confidence limits of subjects perceiving color differences at level 5.

	Single Presentation	Paired Presentation
Estimate	32.9	3.3
Limits	25-41	1-8

The critical features are the substantial percentages of subjects who perceived a difference in the single presentation and the very small percentage that identified a difference in the paired presentation.

The percentage of subjects observing a change in color consistently increased with the degree of fading in both methods of sample presentation, but differences between the two are very apparent. According to the use of the Gray Scale, level 4 is considered to show the smallest perceptible change in color. However, in the paired presentation, 62.5 percent were able to perceive a difference at level 4.5, but only 43.4 percent saw a difference in the single presentation. Only at level 2 are the percentages comparable, when 98 percent identified a difference in the single presentation and 100 percent perceived a difference in the paired presentation.

When comparing paired samples, all of Carter's female subjects in the 45 to 54 year age group were able to perceive a color change at all faded levels except at 4.5. There, all but one saw a change in color (Carter, 1975).

It was evident by comparing percentages of subjects perceiving differences that there were clearly some differences between the two methods of presentation. This observation was confirmed by the highly significant (.001) chi-square value of 104.61. This supports hypothesis 3, that there are clearly significant differences between the two methods of sample presentation at all color levels of red. This difference probably could be mainly attributed to the memory factor, and confirmed previous findings by Newhall, _et al._ (1957) of high variability between memory and paired matching.

Liking of Color: Red

It had originally been expected that the subjects would like the color of the original (level 5) more than any of the faded levels. This proved to be generally the case for red (Table 4).

Table 4. Red--Mean scores and t-tests of color liking by color level.

	Color Levels						
	5	4.5	4	3.5	3	2	Mean
Liking Score	19.95	20.99	17.33	13.91	11.16	-3.86	13.25
t-value	--	-0.92	1.53	4.17**	4.29**	10.05**	

** Significant at .01 level of significance.

While level 4.5 was scored slightly higher than level 5, this difference was not significant as shown by t-tests in Table 4. Levels 4, 3.5, and 3 were liked fairly well, but scores decreased as the amount of fading increased. Only level 2 was scored on the negative side, indicating that the subjects definitely no longer liked this color. In general, red was liked fairly well, with a mean score of 13.25 on the positive range of zero to fifty.

Values for t (Table 4) at the 4.5 and 4 levels were not significant, indicating that these levels were liked approximately as well as the original. Significant values were found for levels 3.5, 3, and 2, indicating a greater liking for the original than for these three faded color levels.

Further evaluation was made of the effect of how well a color was liked on the perception of color change. Mean liking scores of red were calculated for each subject, and then the high 25 percent and the low 25 percent were extracted. This made two groups of thirty-eight subjects in each. One group clearly indicated liking of red in general, and the other group clearly indicated dislike of red. Table 5 shows that the lower 25 percent scores run from an extreme -47.17 to just barely positive 0.50. The upper 25 percent scores extend from the extreme positive end.

Table 5. Red--Range and means of high and low 25% liking scores.

	Range	Mean Score
Low 25%	-47.16 to +0.50	-15.22
High 25%	+49.33 to +28.16	+36.49

An examination of percentages of subjects who identified color differences at each color level showed that only at the three upper levels in the single presentation could any differences between the two groups be observed (Table 6). At level 5, the subjects who clearly liked red were significantly more likely than those not liking red, to identify a color change although none occurred. Significantly more of the upper 25 percent group also perceived color changes than the lower 25 percent group for levels 4.5 and 4, suggesting that those who like red would identify a change in color at these levels more often than those who dislike red. No real differences between the two groups could be seen for levels 3.5, 3, and 2, suggesting that both groups were fairly equal in their perception of color change. The paired frame presentation showed no significant differences between the two groups at any color level, suggesting that those subjects who clearly liked red were equally as likely as those who clearly disliked red to detect a change in color in paired samples.

Table 6. Red--Mean percentages and two-tailed Z-tests for subjects with highest and lowest liking scores who perceived color differences.

Color	Single Presentation			Paired Presentation		
Level	Low	High	Z	Low	High	Z
5	29.0	52.6	2.09*	5.3	2.6	0.59
4.5	29.0	65.8	3.20**	68.4	68.4	0
4	42.1	65.8	2.07*	94.7	100.0	1.42
3.5	68.4	68.4	0	100.0	97.4	1.01
3	76.3	84.2	0.86	100.0	100.0	0
2	100.0	97.4	1.01	100.0	100.0	0

** Significant at .01 level of significance
* Significant at .05 level of significance

Perception of Color Change in Yellow

The percentages of subjects perceiving color differences increased with the degree of fading in both the single and paired presentation (Table 7).

Table 7. Yellow--Percentage and numbers of subjects perceiving color change by color level and presentation method (Question 1).

Color Level	Single Presentation %	Single Presentation N	Paired Presentation %	Paired Presentation N
5	45.4	69	2.0	3
4.5	40.1	61	85.5	130
4	43.4	66	87.5	133
3.5	48.7	74	98.0	149
3	54.0	82	97.4	148
2	87.5	133	100.0	152

During the single presentation, almost one-half or 45.4 percent of the subjects reported seeing a difference in color at level 5 where no difference actually existed. This distinctly contrasts to the paired frame presentation, where only two percent or three people identified a difference in color where none existed. None of the 17 subjects of the age group of 45 to 54 years in the previous study by Carter (1975) observed any difference in color for the yellow paired samples at this level, so similar responses were anticipated for this study. The present results for paired samples cannot really be considered that different from Carter's findings, but the surprising results are in the single presentation, where it is evident that a significant number of subjects believed they saw a difference in color even though no difference existed.

Table 8 shows the percentages of subjects who perceived a difference at level 5 as estimated by this study and their 95 percent confidence limits. These indicate that a significant percentage of subjects will usually identify a difference at level 5 in the single presentation, but very few in the paired presentation will see a change in color.

Table 8. Yellow--Percentages and approximate 95% confidence limits of subjects perceiving color differences at level 5.

	Single Presentation	Paired Presentation
Estimate	45.4	2.0
Limits	37-54	<1-6

In the single frame presentation, there was really no significant increase in perception of a color change until level 2, the level of greatest change, where 87.5 percent identified a change. The Z-test shown in Table 9 confirms these observations. A similar percentage of subjects (85.5 percent) recognized a change in color immediately at level 4.5 for the paired samples. The percentage jumped to 98 percent at level 3.5. Finally, at level 2 in the paired frame presentation, the color change was recognized by all the subjects. A significant difference in perception from level 5 is evident at every level of the paired presentation and is confirmed by values in Table 9.

Table 9. Yellow--One-tailed Z-values for percentages of perception.

	Color Levels				
	4.5	4	3.5	3	2
Single	0.93	0.58	1.49	0.35	7.78**
Paired	14.69**	15.00**	16.75**	16.63**	17.10**

** Significant at .01 level of significance

All 17 of Carter's (1975) female subjects, aged 45 to 54, were able to perceive differences in paired samples at levels 2, 3, 3.5, and 4, but at level 4.5, only 14 could perceive a difference in color.

Comparisons of percentages of subjects who perceived color differences (Table 7) indicate immediately a distinct difference between the two methods of sample presentation for yellow. A very highly significant (.001) chi-square value of 192.32 statistically supported this observation. Hypothesis 3 is verified by this chi-square test, that there are very significant differences between the two methods of presentation at all color levels of yellow. Again, this difference could be accounted for by the memory factor as suggested and supported by Newhall, et al. (1957).

Liking of Color: Yellow

Initially, it was expected that the color of the original (level 5) would be preferred to the faded levels. However, as shown in Table 10, this hypothesis was not confirmed, and in fact, the opposite was found.

Table 10. Yellow--Mean scores and t-tests of color liking by color level.

	Color Levels						
	5	4.5	4	3.5	3	2	Mean
Liking Score	5.41	9.73	7.69	9.39	9.84	9.38	8.57
t-value	--	-4.20**	-2.51*	-3.50**	-3.76**	-2.33*	

** Significant at .01 level of significance
* Significant at .05 level of significance

Level 5 was scored lowest of any of the color levels, and indeed, significant negative t-values found in all cases indicate that each level in itself was preferred to the original color. Subjects often commented during the collection of data on the apparent brightness and orange cast of this original yellow sample. There seemed to be no real difference in these faded levels except for level 4 which was rated slightly lower than the others. Overall, yellow had a fairly low score of 8.57 on the positive zero to fifty scale.

It had been suspected that how well a color was liked might have some effect on a subject's perception of color change, but this did not seem to be true for yellow. In order to evaluate this aspect, the high and low 25 percent mean liking scores were separated, forming two groups of thirty-eight subjects each. The mean scores of the upper 25 percent showed that yellow was clearly liked by this group (Table 11). The lower 25 percent clearly disliked yellow, with a mean score of -25.48.

Table 11. Yellow--Range and means of high and low 25% liking score.

	Range	Mean Score
Low 25%	-49.83 to -7.00	-25.48
High 25%	+27.00 to +50.00	+38.98

Table 12 shows percentages of subjects from each group who perceived a color difference. In both the single and paired presentations, the percentages were similar for the high and low groups. This indicated that the subjects in these groups were equally likely to detect a color change whether or not they liked yellow. Although not proven significant, a slightly higher number of subjects who clearly liked yellow than those who did not, believed that they saw a difference in color at level 5 where none existed.

Table 12. Yellow--Mean percentages and two-tailed Z-tests for subjects with highest and lowest liking scores who perceived color differences.

Color Level	Single Presentation			Paired Presentation		
	Low	High	Z	Low	High	Z
5	23.7	42.1	1.71	0.2	0.6	0.59
4.5	39.5	47.4	0.69	68.4	68.4	0
4	55.3	73.7	1.68	97.4	97.4	0
3.5	52.6	68.4	1.41	100.0	94.7	1.42
3	81.6	79.0	0.29	100.0	100.0	0
2	100.0	94.7	1.42	100.0	100.0	0

Perception of Color Change in Blue

For both the single and paired presentations, the percentage of subjects perceiving a change in color generally increased as the degree of fading increased (Table 13).

Table 13. Blue--Percentages and numbers of subjects perceiving color change by color level and presentation method (Question 1).

Color Level	Single Presentation		Paired Presentation	
	%	N	%	N
5	34.9	53	5.9	9
4.5	48.7	74	40.8	62
4	52.0	79	56.6	86
3.5	65.8	100	98.0	149
3	63.8	97	95.4	145
2	88.2	134	100.0	152

At level 5 in the single presentation, 34.9 percent observed a difference in color where none existed, while 5.9 percent saw a difference in the paired presentation.

In Carter's (1975) study, none of the 45 to 54 year old female subjects perceived a change in color at level 5 for blue paired samples. The findings of the present study for the paired samples are only slightly different from Carter's, but the large percentage of subjects who perceived a difference in the single presentation is notable.

The percentages of subjects perceiving a difference at level 5 as estimated by this study and their 95 percent confidence limits (Table 14) indicate that there will usually be a real percentage of subjects who believe they see a difference in color even though no difference exists.

Table 14. Blue--Percentages and approximate 95% confidence limits of subjects perceiving color differences at level 5.

	Single Presentation	Paired Presentation
Estimate	34.9	5.9
Limits	27-43	3-12

Only small differences in perception were observed at levels 4.5 and 4 between the two methods of presentation; in fact, 12 more subjects reported seeing a color change in the single presentation at level 4.5, than for the paired presentation. However, at level 3.5, the difference between the two methods of presentation are marked, where 98 percent in the paired presentation identified a color change, compared to 65.8 percent in the single presentation. Even at level 2, where the greatest change in color occurred, 100 percent observed a change in color in the paired samples, while only 88.2 percent identified a change for the single presentation.

In Carter's (1975) study, all 17 subjects of this age group were able to perceive differences at every faded level when comparing blue paired samples.

It is obvious that there are some differences between the two methods of presentation by comparing percentages of subjects perceiving differences in color. This judgment is confirmed by a highly significant (.001) chi-square value of 102.61, supporting hypothesis 3 for blue, that significant differences do exist between the two methods of sample presentation. The memory factor is probably responsible for this difference.

Liking of Color: Blue

It was originally expected that the color of the level 5 sample (original) would be preferred to the faded levels, and this expectation was confirmed for blue (Table 15).

Table 15. Blue--Mean scores and t-tests of color liking by color level.

	Color Levels						
	5	4.5	4	3.5	3	2	Mean
Liking Score	27.15	25.00	24.63	24.86	22.82	17.64	23.68
t-value	--	2.04*	2.12*	2.32*	3.06**	5.79**	

** Significant at .01 level of significance
* Significant at .05 level of significance

While levels 4 and 3.5 were scored approximately the same, the color levels were liked less well as the amount of fading increased. The original sample (level 5) was rated higher than any of the other levels with a score of 27.15. Significant t-values at all color levels showed that, indeed, level 5 was definitely preferred over each of the faded levels. Overall, the color blue was fairly well liked with a mean score of 23.68 on a positive zero to fifty scale.

In order to test the effect of how well a color was liked on the perception of color change, the upper and lower 25 percent of the mean liking scores of the subjects were separated. Thus, one of the groups clearly indicated liking of blue, and the other group clearly not liking blue as well. The scores ranged from a -44.33 up to a positive 13.17 for the lower 25 percent, with a mean of -4.57 (Table 16). This range and mean seem fairly high for the lower 25 percent group, but blue was the most well liked color overall, which explains why the bulk of the scores are located on the positive side of the scale. The upper 25 percent group had a very high range.

Table 16. Blue--Range and means of high and low 25% liking scores.

	Range	Mean Score
Low 25%	-44.33 to +13.17	-4.57
High 25%	+38.83 to +50.00	+45.38

The values shown in Table 17 indicate that there were no important differences in perception between the lower and upper 25 percent groups. The only color level showing significant differences between the groups was level 3.5 in the single presentation. Although not proven significant, the subjects who clearly liked blue had a slightly higher percentage of perception of color differences at all levels in the single presentation than did those who did not like blue as well. Except for level 3.5 in the single frame presentation, those who liked blue were equally as likely as those who did not to identify a change in color.

Table 17. Blue--Mean percentages and two-tailed Z-tests for subjects with highest and lowest liking scores who perceived color differences.

Color Level	Single Presentation			Paired Presentation		
	Low	High	Z	Low	High	Z
5	31.6	34.2	0.24	5.3	5.3	0
4.5	42.1	50.0	0.69	60.5	57.9	0.23
4	50.0	63.2	1.15	97.4	94.7	0.58
3.5	57.9	79.0	1.97*	97.4	94.7	1.01
3	79.0	89.5	1.25	100.0	100.0	0
2	94.7	100.0	1.42	100.0	100.0	0

* Significant at .05 level of significance

Effect of Order of Level 5 Sample on Perception

It was expected that the order in which the single level 5 sample was presented would have no effect on the level of perception of color change. However, during the collection of data, it was observed by the interviewer that subjects' responses seemed to be varying according to the position the control (level 5) sample held in the order in the single presentation. This observation was often made for the yellow group. After the first original was shown to the subject and removed, the subject would often report the level 5 sample, upon seeing it again, to be "darker" or "more intense" than the first one.

In order to analyze this aspect, the mean percentages of perception were tabulated for each color level according to the order (first, second, . . . sixth) that level 5 was shown in each color group. These values are shown in graph form in Figures 1-3.

It is observed from these graphs that the percentage of perception generally increased as the degree of fading became more apparent. However, there are no consistent patterns in the percentages of perception for the position of level 5 across all three colors. It should be noted that only the position in order of the level 5 sample was considered, and that the relative positions of the other five samples were concluded to be beyond the realm of the present study, and therefore, not taken into account.

For each color, a great deal of interaction can be observed among the various color levels. For any significance of results to be realized, there should be a significant space and no interaction between the graph lines.

The most difference is seen in the percentages of perception at level 5 in yellow. Even though no change in color was actually present, only 15.4 percent of the subjects perceived a difference at this level when the level 5 sample was shown immediately after the first original. However, when the level 5 sample was shown second, 71.4 percent of the subjects reported seeing a difference when none actually existed. This phenomenon might be explained

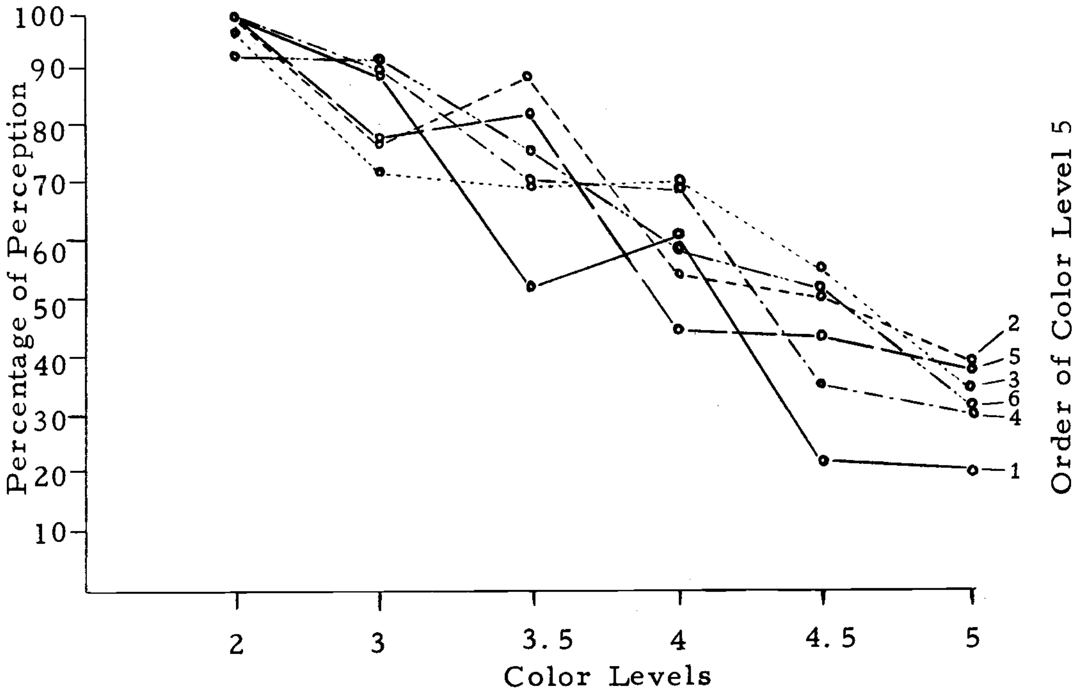


Figure 1. Single Red--Percentage of perception of color difference by color level according to order of color level 5.

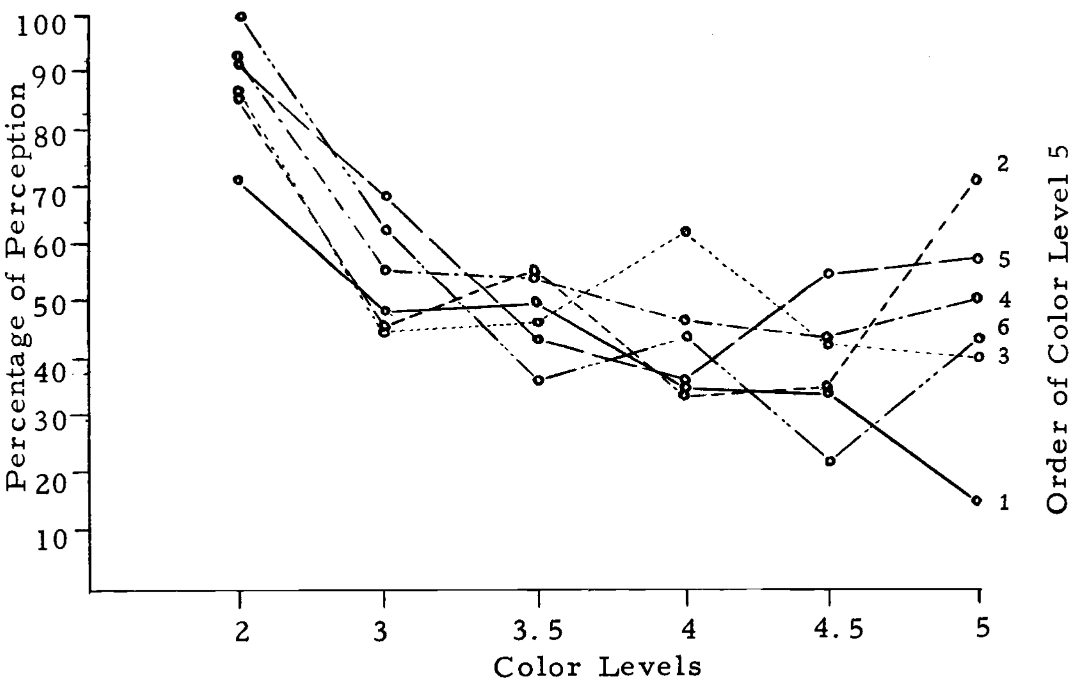


Figure 2. Single Yellow--Percentage of perception of color difference by color level according to order of color level 5.

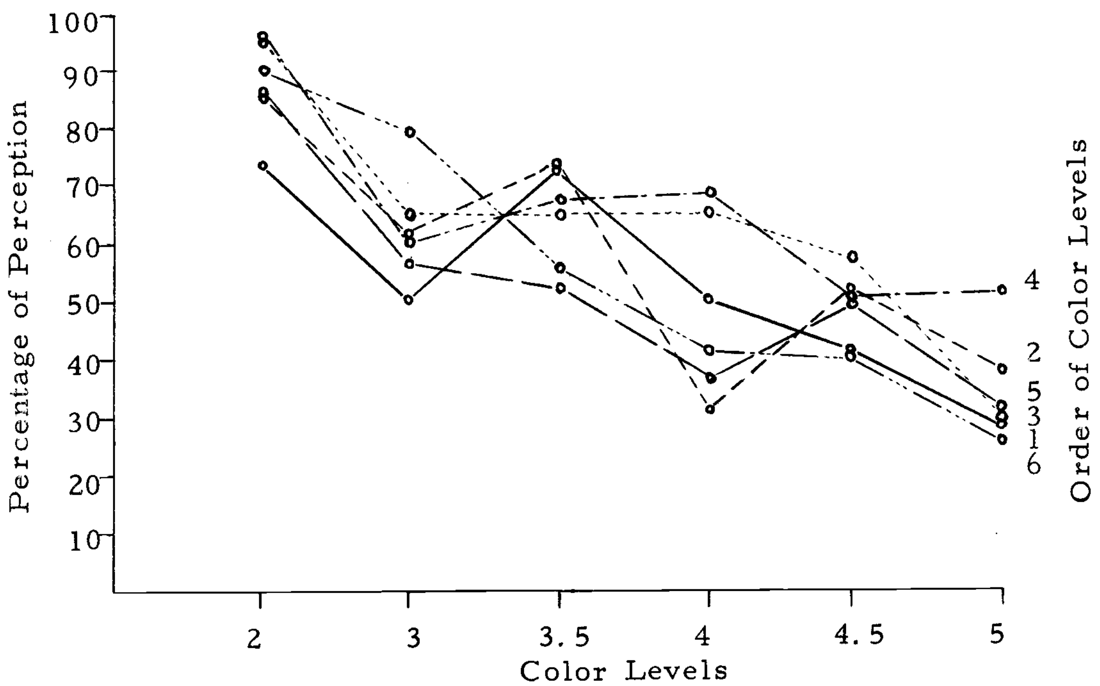


Figure 3. Single Blue--Percentage of perception of color difference by color level according to order of color level 5.

by the assimilation or adaption principle reported by Newhall, et al. (1957), which stated that the memory of the original could become either stronger or weaker by assimilation.

Due to the inconsistency of percentage patterns by order and the amount of interaction observed at the various levels, no significance could be found in the effect of order in presentation on the level at which color change is perceived. It was assumed then that order in presentation of the level 5 sample had no significant effect on perception, and that any differences were due to random chance.

Acceptance of Color Change in Red

In order to be able to assess the acceptability of color change, the subject must have been able to detect the change in color first, so the percentages of subjects shown in Table 18 represent the portion of those giving an affirmative answer to the first question. These exact numbers are also given since percentages for a small number, such as for level 5 in the paired samples, can be very misleading.

Table 18. Red--Percentages and numbers of subjects finding color change acceptable.

Color Level	Q2 Acceptability: Non-match				Q3 Acceptability: Blend			
	Single	N^s	Paired	N^p	Single	N^s	Paired	N^p
5	50.0	50	100.0	5	58.0	50	100.0	5
4.5	59.1	66	75.8	95	71.2	66	78.9	95
4	50.6	89	43.5	147	69.9	89	49.0	147
3.5	52.7	110	39.2	148	60.9	110	45.9	148
3	42.2	128	17.1	152	53.1	128	19.7	152
2	20.1	149	8.5	152	38.3	149	9.9	152

N^s = number who perceived a color change for single presentation.
N^p = number who perceived a color change for paired presentation.

In judging acceptability based on the amount of color change when the colors no longer match, the subjects were less accepting of the change in color as the amount of fading increased for both the single and paired samples. It is interesting to note that at level 5 where only one-half of those subjects, who believed that they saw a color change at this level (when no change actually occurred), indicated that they would not mind wearing the two original colors together in public. Only at levels 3 and 2 in the single presentation for Question 2 did the acceptability somewhat substantially decrease. An immediate decline was seen at level 4.5 in the paired presentation. These observations were confirmed by the negative Z values shown in Table 19.

Table 19. Red--One-tailed Z-tests for percentages of acceptance.

	Q2		Q3	
Color	Acceptability: Non-match		Acceptability: Blend	
Level	Single	Paired	Single	Paired
4.5	1.59	- 6.47	2.41**	- 5.98
4	0.10	-10.94	0.88	-10.20
3.5	0.48	-11.52	0.52	-10.61
3	-1.38	-14.67	-0.86	-14.27
2	-5.46	-16.00	-3.44	-15.79

** Significant at .01 level of significance.

It was predicted that acceptability would increase when the factor of harmonious blending of the samples was specifically considered. Indeed, a slight increase in the percentages is seen for

Question 3. In both the single and paired presentations, however, the change in color was evidently not great enough until levels 3 and 2 to give harmonious blending or even contrast, instead of appearing as an attempted match. In spite of the small increase in percentages from the basis of samples no longer matching to the consideration of blending, a chi-square test revealed no real differences between the two questions. The values of 3.66 for the single samples and 0.31 for the paired samples were not significant at either the .01 or .05 levels of significance. Since the judgment of "harmonious blending" is strictly a matter of personal opinion, it is possible that these subjects did not feel that these particular sample combinations blended well enough.

In fact, many of the subjects commented to the interviewer that they considered the less faded samples (levels 4.5 or 4) to still be too close to the original color to blend or give a definite contrast, while others found these higher levels acceptable. It was often stated that the red level 2 sample "looked faded," and a definite negative feeling was reflected in the liking scores for the faded color levels of red.

Because of the findings of differences in perception between the two methods of presentation, it was expected that similar findings would be made for acceptance. This was supported by highly significant (.001) chi-square values of 42.66 for acceptance based on the amount of change when samples no longer match, and 59.29 on the basis of blending. Thus, for red, the two methods of presentation caused significant differences in acceptance of color change.

Relationship of Liking to Acceptance of Color Change

Originally, it had been expected that subjects who liked red would be more accepting of changes in color than those who did not like it. This was tested in the same manner as was done for perception. The high and low 25 percent of liking scores for the color red were extracted and analyzed. The ranges and means of these scores can be seen in Table 5.

The original supposition appears to be proven untrue for several levels of red. As shown in Table 20, a greater percentage of the subjects who disliked red were more accepting of changes in color at all levels in the single presentation than the subjects who liked red. Significant Z-values for levels 4, 3.5, 3, and 2 confirm the indication of real differences between the two groups of subjects for both Questions 2 and 3 in the single presentation.

This same trend is observed in Table 21 for the paired presentation of red. A real difference between the high and low groups of subjects is indicated by significant Z-values at levels 4, 3.5, and 3 for both Questions 2 and 3.

Table 20. Single Red--Mean percentages and two-tailed Z-tests of subjects with highest and lowest liking scores finding color change acceptable.

Color Level	Q2 Acceptability: Non-match			Q3 Acceptability: Blend		
	Low	High	Z	Low	High	Z
5	54.5	45.0	0.50	72.7	55.0	0.97
4.5	72.7	48.0	1.37	72.7	64.0	0.51
4	75.0	18.0	2.93**	75.0	40.0	2.19*
3.5	80.8	15.4	4.70**	80.8	23.1	4.15**
3	65.5	21.9	3.43**	72.4	34.4	2.97**
2	36.8	5.4	3.30**	60.5	18.9	3.68**

** Significant at .01 level of significance
* Significant at .05 level of significance

Table 21. Paired Red--Mean percentages and two-tailed Z-tests of subjects with highest and lowest liking scores finding color change acceptable.

Color Level	Q2 Acceptability: Non-match			Q3 Acceptability: Blend		
	Low	High	Z	Low	High	Z
5	100.0	100.0	0	100.0	100.0	0
4.5	84.6	65.4	1.60	88.5	69.3	1.70
4	52.8	28.9	2.09*	58.3	34.2	2.08*
3.5	55.3	18.9	3.25**	57.9	27.0	2.71**
3	31.6	7.9	2.60**	34.2	7.9	2.80**
2	13.2	5.3	1.20	13.2	5.3	1.20

** Significant at .01 level of significance
* Significant at .05 level of significance

Perhaps this difference between the two groups of subjects could be explained by suggesting that those subjects who liked red would therefore be more critical about any changes in color that they considered to be derogatory. Perhaps a change in color was not that important to those who did not like red.

Acceptance of Color Change in Yellow

Table 22 shows the percentages of subjects finding the color change they identified in the first question to be acceptable for wearing.

In the single presentation of Question 2, only 44.9 percent of the 69 subjects indicated acceptance of the color change they believed that they saw in level 5 where none existed. This contrasted to the paired presentation where two out of three subjects were accepting of the color change at level 5. Similar figures were found for acceptance based on blending (Question 3).

The acceptance of color change in the single presentation for Question 2 generally increased as the degree of fading became greater. Significant Z-tests (Table 23) showed that levels 4 and 3 were found more acceptable than the original. The acceptance decreased at level 2, but was still higher than that of the original. The paired presentation for this question also showed some faded levels to be more acceptable than the original. The acceptance

Table 22. Yellow--Percentages and numbers of subjects finding color change acceptable.

Color Level	Q2 Acceptability: Non-match				Q3 Acceptability: Blend			
	Single	N^s	Paired	N^p	Single	N^s	Paired	N^p
5	44.9	69	66.7	3	58.0	69	66.7	3
4.5	49.2	61	80.0	130	62.3	61	82.3	130
4	54.5	66	78.9	133	63.6	66	83.5	133
3.5	54.0	74	70.5	149	67.6	74	77.8	149
3	63.4	82	62.8	148	74.4	82	71.6	148
2	51.1	133	50.7	152	70.7	133	59.2	152

N^s = number who perceived a color change for single presentation.

N^p = number who perceived a color change for paired presentation.

Table 23. Yellow--One-tailed Z-tests for percentages of acceptance.

Color Level	Q2 Acceptability: Non-match		Q3 Acceptability: Blend	
	Single	Paired	Single	Paired
4.5	0.74	2.62**	1.48	3.13**
4	1.68*	2.41**	1.01	3.38**
3.5	1.59	0.71	1.73*	2.18**
3	3.24**	-0.70	3.03**	0.93
2	-1.08	2.83	2.31*	-1.35

** Significant at .01 level of significance

* Significant at .05 level of significance

immediately increased at level 4.5, decreased slightly at 4, and continued to decrease at level 3.5. It appeared that just enough fading at level 4.5 removed the extreme brightness and orange cast to make it more acceptable than some of the lower levels.

For Question 3, Z-tests showed levels 3.5, 3, and 2 to be more acceptable than the original in the single presentation, but in the paired presentation, levels 4.5, 4, and 3.5 were shown to be more acceptable than the original.

Comparison of percentages of acceptance in the individual levels for Questions 2 and 3 generally show slight increases for acceptance based on blending of yellow. However, chi-square values confirmed that no significant differences existed between the two questions. The values of 0.61 for the single samples and 0.54 for the paired samples were not significant at either the .01 or .05 levels.

Generally, the percentages for the paired sample presentation were larger than for the single presentation, but due to the inconsistencies, the real differences between the two methods were difficult to predict. However, chi-square values of high significance (.001) were computed and indicated that for the acceptance of yellow, significant differences did exist for the two presentation methods. The values found were 78.26 and 92.17 for acceptance percentages in questions 2 and 3, respectively.

Relationship of Liking to Acceptance of Color Change

It had been predicted that subjects who indicated that they liked yellow would show more acceptance of color change than those who did not like yellow. This was analyzed by sorting out the highest and lowest 25 percent of liking scores for yellow. Table 11 shows the ranges and means of these scores.

The percentages of subjects in the single presentation of yellow (Table 24) seemed to be inconsistent for Question 2; but for Question 3, the subjects who disliked yellow seemed to be slightly more accepting of color change at all levels although there was no significant difference between the two groups of subjects. In the paired samples (Table 25), no real differences were evident here either. However, at levels 4.5, 4, 3.5, and 3 in Question 2, those subjects who disliked yellow seemed to be slightly more accepting of color change.

The absence of any significant Z-values suggested that generally, those subjects who liked yellow and those who disliked yellow tended to be similar in their acceptance of changes in color.

Table 24. Single Yellow--Mean percentages and two-tailed Z-tests of subjects with highest and lowest liking scores finding color change acceptable.

Color Level	Q2 Acceptability: Non-match			Q3 Acceptability: Blend		
	Low	High	Z	Low	High	Z
5	55.6	43.7	0.57	47.4	38.9	0.27
4.5	46.7	61.1	0.83	65.5	50.0	0.41
4	66.7	46.4	1.41	70.0	65.4	0.92
3.5	50.0	50.0	0	66.7	53.6	0.33
3	45.2	50.0	0.38	73.3	66.7	1.14
2	21.0	22.2	0.12	55.6	50.0	0.74

Table 25. Paired Yellow--Mean percentages and two tailed Z-tests of subjects with highest and lowest liking scores finding color change acceptable.

Color Level	Q2 Acceptability: Non-match			Q3 Acceptability: Blend		
	Low	High	Z	Low	High	Z
5	100.0	100.0	0	100.0	100.0	0
4.5	76.9	74.6	0.71	84.6	80.8	0.37
4	37.8	35.1	0.24	35.1	43.2	0
3.5	42.1	38.9	0.28	38.9	52.6	0.95
3	15.8	7.9	1.07	7.9	18.4	0.97
2	5.3	5.3	0	5.3	7.9	0.46

Acceptance of Color Change in Blue

The percentages of subjects shown in Table 26 are the portion of those that identified a change in color and then assessed the acceptability of the color change.

Table 26. Blue--Percentages and numbers of subjects finding color change acceptable.

Color Level	Q2 Acceptability: Non-match				Q3 Acceptability: Blend			
	Single	N^s	Paired	N^p	Single	N^s	Paired	N^p
5	67.9	53	88.9	9	77.4	53	100.0	9
4.5	75.6	74	87.1	62	75.0	74	90.3	62
4	72.1	79	83.7	86	81.0	79	89.5	86
3.5	72.0	100	67.1	149	75.0	100	71.8	149
3	66.0	97	60.7	145	73.2	97	66.2	145
2	60.4	134	34.9	152	73.9	134	38.2	152

N^s = number who perceived a color change for single presentation,

N^p = number who perceived a color change for paired presentation.

For Question 2, the acceptance of the paired samples decreased consistently as the degree of fading increased. Only 34.9 percent found the change at level 2 acceptable, but never did the acceptance using the single presentation fall that low. Even at levels 3 and 2, over one-half still considered the color change to be acceptable.

According to Z-values (Table 27), only at these levels did a substantial decrease occur in those who found blue to be unacceptable.

The paired samples in Question 3 again decreased in acceptance from 100 percent at level 5 down to 38.2 percent at level 2, but acceptance during the single presentation was irregular. The percentages of acceptance were approximately the same for levels 4.5 and 3.5 and for levels 3 and 2. Although the percentages did decrease slightly with the degree of fading, this difference was not significant.

Table 27. Blue--One-tailed Z-tests for percentages of acceptance.

Color Level	Q2 Acceptability: Non-match		Q3 Acceptability: Blend	
	Single	Paired	Single	Paired
4.5	0.70	-0.48	-0.46	-7.86
4	0.80	-1.09	-0.78	-4.10
3.5	0.78	-4.58	-0.48	-7.06
3	-0.36	-5.66	-0.84	-7.86
2	-1.36	-5.67	-0.71	-11.66

It was originally expected that acceptability would increase when the factor of harmonious blending of the samples was considered individually in Question 3, and a slight increase in the percentages can be observed in Table 27 from Question 2 to Question 3.

However, the differences were very small, and chi-square values of 0.59 for the single presentation and 0.69 for the paired presentation confirmed that no significant differences did exist between Questions 2 and 3.

Because definite differences in percentages could be observed at most levels between the single and paired presentations, a statistically significant value was expected when these factors were tested. Chi-square values of 33.58 for Question 2 and 41.74 for Question 3, highly significant at the .001 level of significance, indicated distinct differences existing between the two methods of presentation for the acceptance of color change in blue.

Relationship of Liking to Acceptance of Color Change

It had been expected that subjects who indicated that they liked blue would show more acceptance of color changes than those who did not care for blue as well. This was tested by extracting the highest and lowest 25 percent of liking scores for blue. Table 16 shows the ranges and means of these scores.

Table 28 for the single presentation of blue shows inconsistent results between the two groups of subjects for the less faded levels in both Questions 2 and 3. A trend appeared at level 4 and continued on down for both Questions 2 and 3 that subjects who liked

Table 28. Single Blue--Mean percentages and two-tailed Z-tests of subjects with highest and lowest liking scores finding color change acceptable.

Color Level	Q2 Acceptability: Non-match			Q3 Acceptability: Blend		
	Low	High	Z	Low	High	Z
5	41.7	46.1	0.23	66.7	46.1	1.03
4.5	50.0	52.6	0.16	56.2	73.7	1.08
4	52.6	50.0	0.17	73.7	58.3	1.05
3.5	72.7	43.3	2.15*	81.8	50.0	2.36*
3	50.0	29.4	1.69	70.0	35.3	2.78**
2	22.2	7.9	1.73	55.6	23.7	2.80**

** Significant at .01 level of significance
* Significant at .05 level of significance

Table 29. Paired Blue--Mean percentages and two-tailed Z-tests of subjects with highest and lowest liking scores finding color change acceptable.

Color Level	Q2 Acceptability: Non-match			Q3 Acceptability: Blend		
	Low	High	Z	Low	High	Z
5	100.0	100.0	0	100.0	100.0	0
4.5	87.0	72.7	1.20	87.0	72.7	1.20
4	48.6	38.9	0.84	56.8	41.7	1.29
3.5	43.2	25.0	1.64	51.3	30.6	1.81
3	18.4	13.2	0.63	18.4	15.8	0.31
2	13.2	10.5	0.34	18.4	10.5	0.94

blue less well tended to be more accepting of changes in color than those who liked blue. These differences are shown to be significant for Question 3 in levels 3.5, 3, and 2, but only at level 3.5 in Question 2. Thus, in the single presentation of blue, subjects who liked blue less well were more accepting of the more extreme changes in color when blending was being considered.

In the paired presentation (Table 29), this same trend is observed at all faded levels. Although not significant, the subjects who liked blue less well seemed to be slightly more accepting of color change in the paired samples of blue.

Effect of Order of Level 5 Sample on Acceptance

It was anticipated that the order in presentation of the single level 5 (original) sample would have no significant effect on the acceptance of color change.

When the interviewer observed variances in responses during the collection of data, the responses seemed to be related to the order in which the subject saw the level 5 sample. It was predicted that, since some differences were observed for perception, some differences might also exist for acceptability according to the order in which the level 5 sample was seen.

The mean percentages of acceptability were tabulated for each color level according to the order (first, second, . . . sixth) that

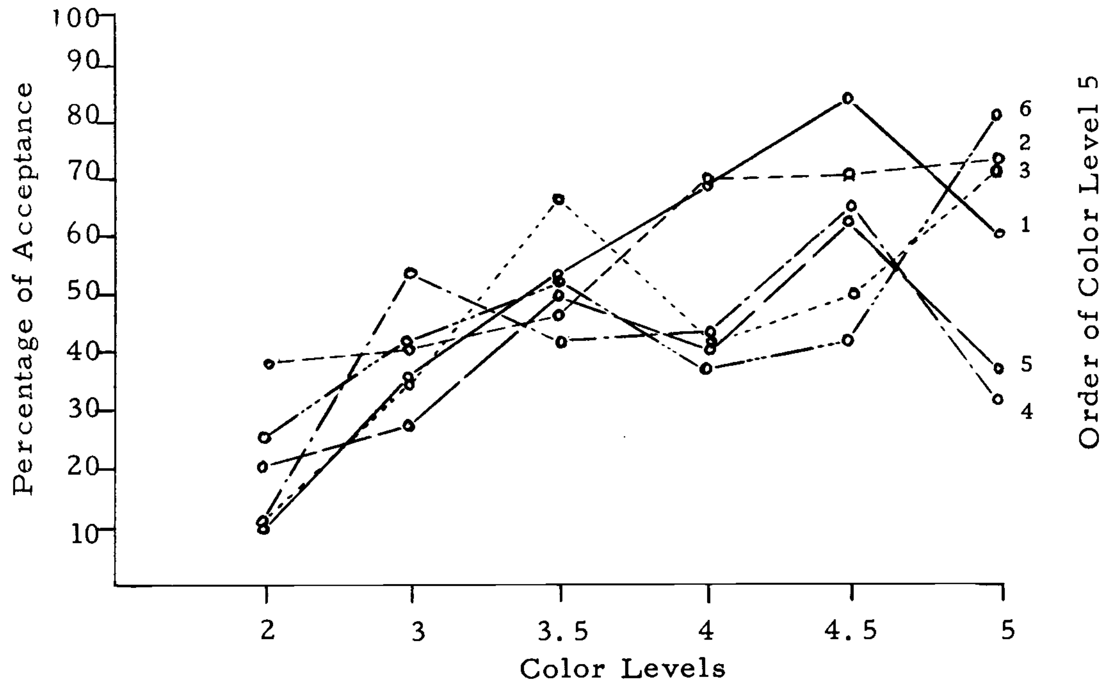


Figure 4. Single Red--Percentage of acceptance of color change (based on amount of color change) by color level according to order of level 5 sample.

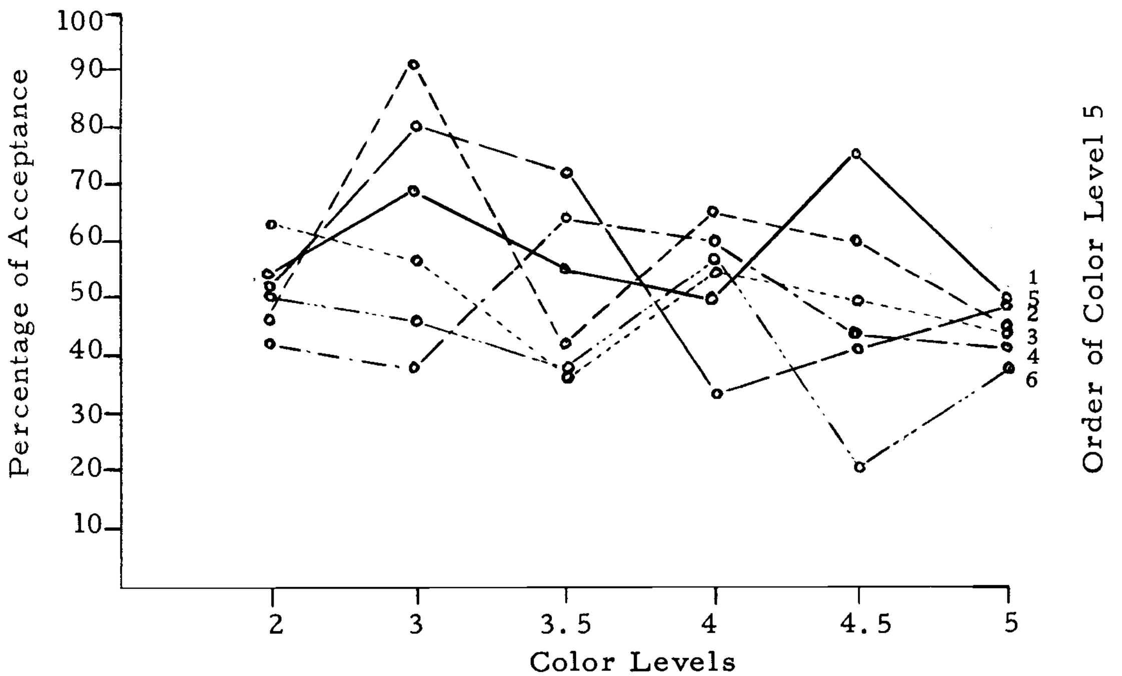


Figure 5. Single Yellow--Percentage of acceptance of color change (based on amount of color change) by color level according to order of level 5 sample.

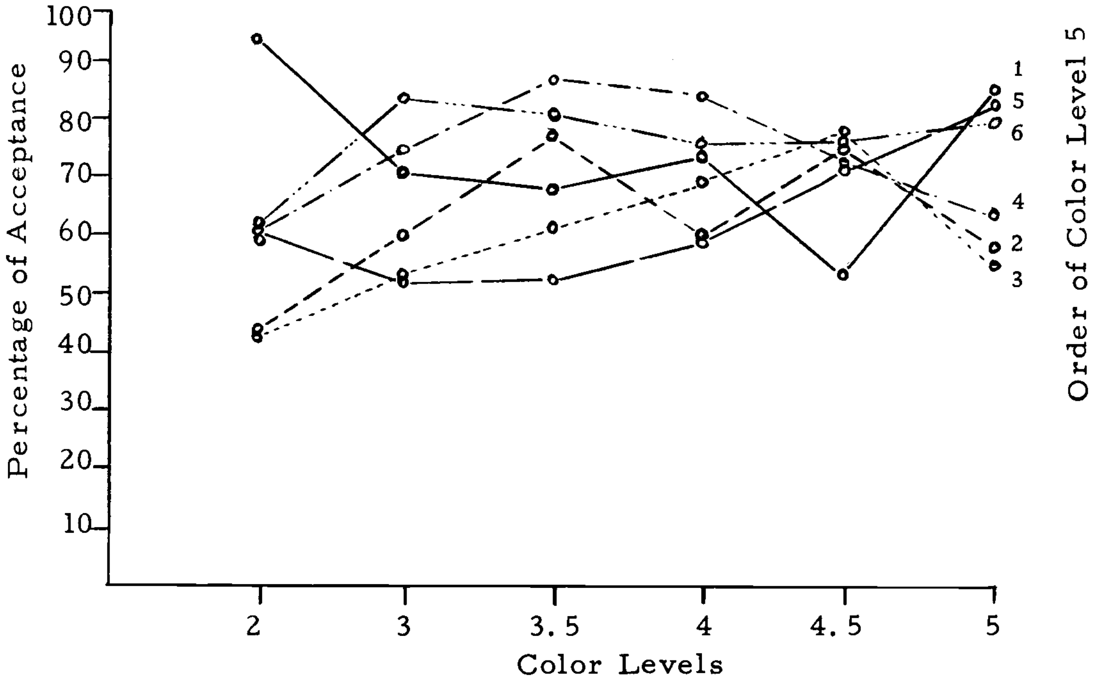


Figure 6. Single Blue--Percentage of acceptance of color change (based on amount of color change) by color level according to order of level 5 sample.

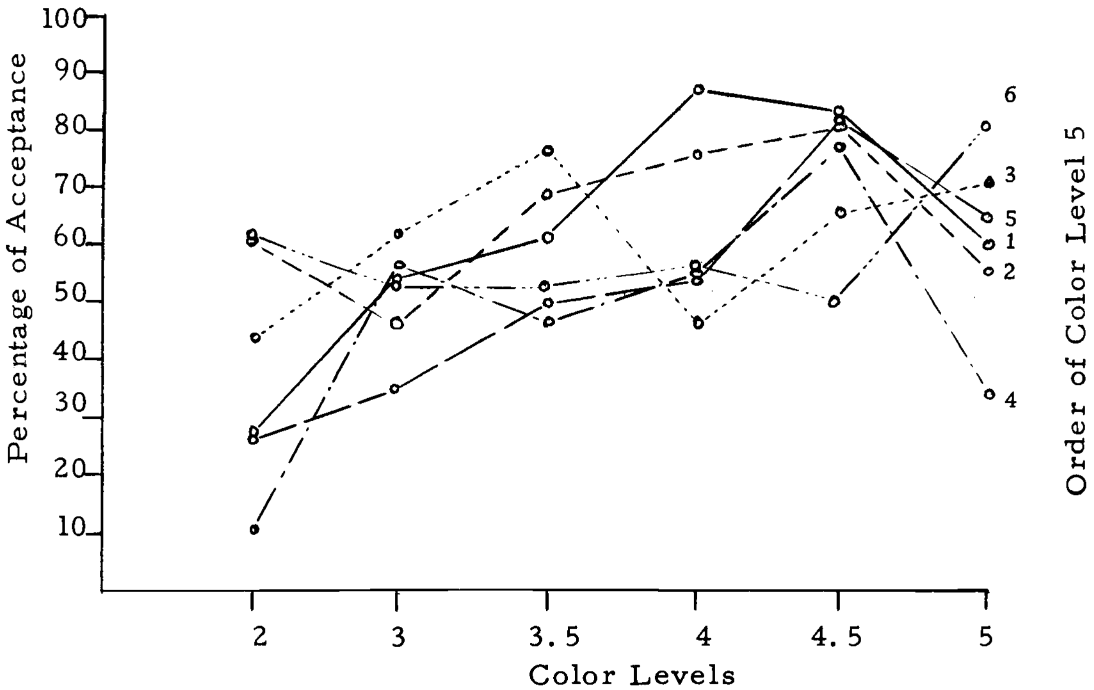


Figure 7. Single Red--Percentage of acceptance of color change (based on blending) by color level according to order of level 5 sample.

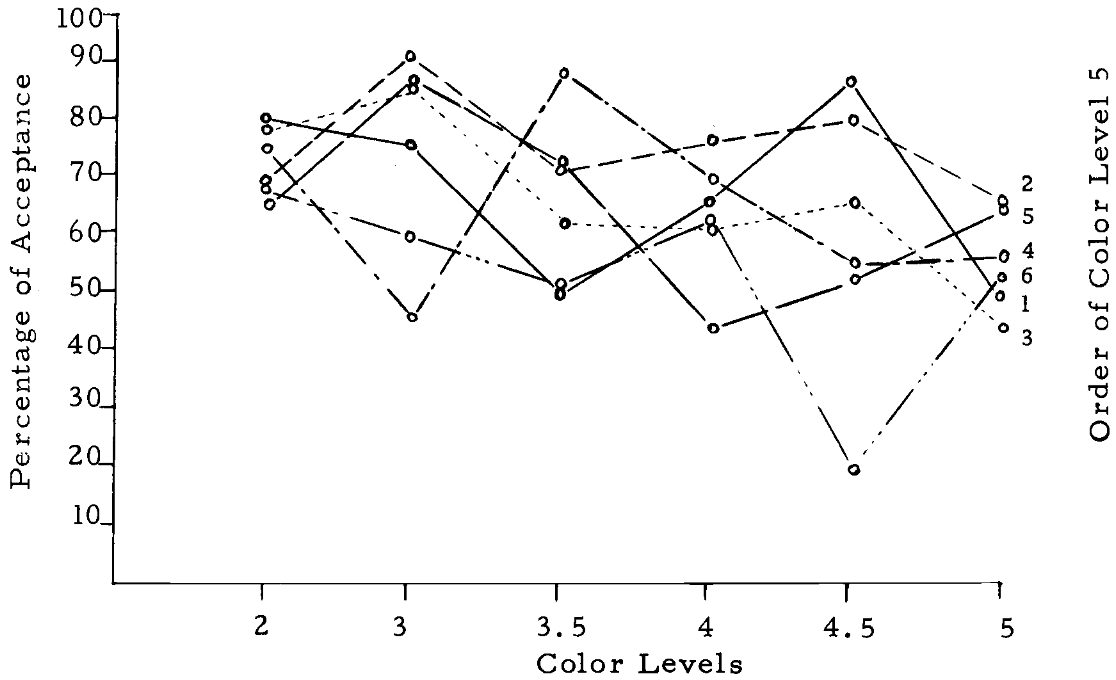


Figure 8. Single Yellow--Percentage of acceptance of color change (based on blending) by color level according to order of level 5 sample.

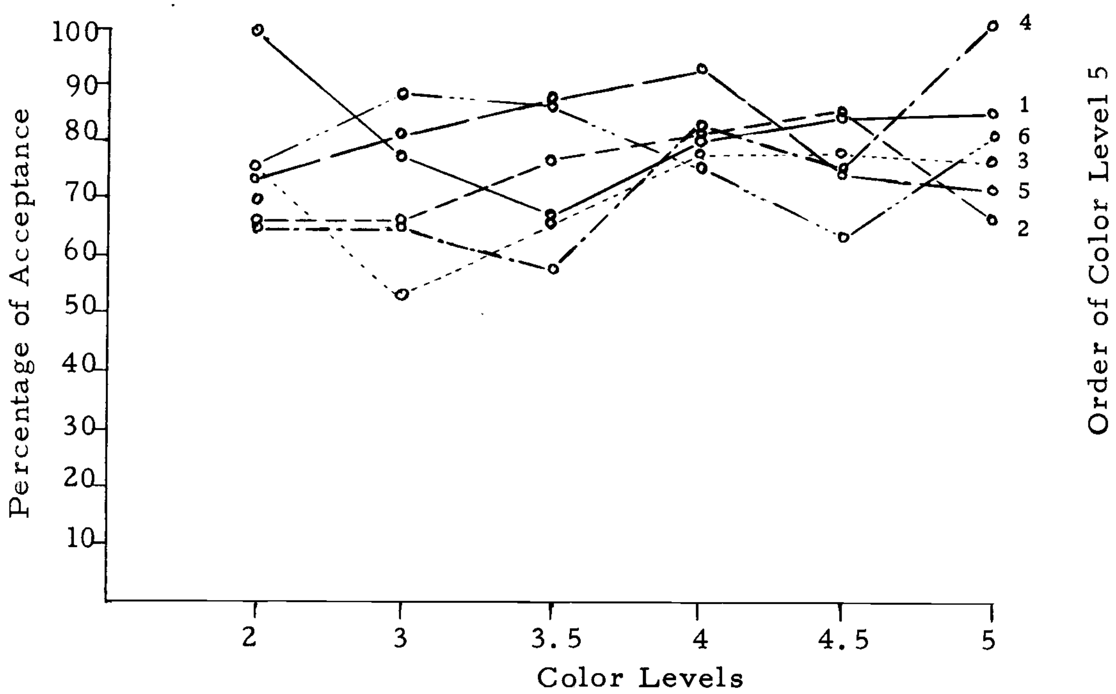


Figure 9. Single Blue--Percentage of acceptance of color change (based on blending) by color level according to order of level 5 sample.

the level 5 sample was shown in each color group. These values are shown in graph form in Figures 4, 5, and 6 for acceptability based on the amount of color change and in Figures 7, 8, and 9 for acceptability based on observed blending.

No significant variance in percentages of acceptability according to the color level could be seen in any of the three colors for either basis of acceptance. As was observed for perception, there was no consistent pattern in the percentages of acceptance according to the position of the level 5 sample. There was also a great deal of interaction noted among the various color levels. Due to these two factors, it must be concluded that the order in presentation of the level 5 sample had no significant effect of the acceptance of color change, and that any variance in responses was due to random chance.

Comparison of Acceptance to Established Fabric Performance Standards

It had been initially hypothesized that the standards indicated in this study by the percentages of subjects finding color change acceptable would not differ from those established L22 and Celanese fabric performance standards for colorfastness to light, laundering, and drycleaning.

The L22 and Celanese performance standards are listed in

Tables 30 and 31 for fabrics similar to those used in this study. Both blouse and sports weight fabric standards were included since the clothing items described in the interview included a blouse and pants.

The colorfastness to light standards established in the L22 and Celanese standards are based on 20 and 40 standard fading hours. In this study, various color levels are represented after 20 and 40 standard hours of fading as shown in Appendix O. After 20 hours of fading, yellow was between levels 3.5 and 3, and blue between levels 4.5 and 4. After approximately 40 hours, red was between levels 5 and 4.5, yellow was between levels 3 and 2, and blue between levels 4 and 3.5. Therefore, the yellow fabric did not meet any of the standards. The blue and red fabrics exceeded the Celanese standards and met the L22 standard for blouse fabric, but not for sportswear fabric. The red fabric surpassed the L22 standard for blouse fabric and was almost equivalent to that for sportswear fabric.

The standards a manufacturer uses for a particular item will depend on the percentage of complaints and returns he feels that he can absorb. Thus, quality standards may vary from item to item and from manufacturer to manufacturer. For the fabrics in this study, a majority (>50 percent) of the subjects found many of the lower levels of fading to be acceptable. However, it appears unlikely

Table 30. Standards for woven blouse fabrics by Gray Scale class level.

	Celanese[1]	L22[2]
Colorfastness to:		
Light (20 SFH)[3]	3.5	4
Laundering (120°F.)	3.5	4
Drycleaning	3.5	4

[1] Celanese Performance Standards for Fortrel® Polyester Fabrics, 1966, F-W103.

[2] L22.10.3-1968, p. 11

[3] SFH = Standard Fading Hours

Table 31. Standards for woven sportswear fabrics by Gray Scale class level.

	Celanese[1]	L22[2]
Colorfastness to:		
Light	3.5 (20SFH)[3]	5 (40 SFH)
Laundering (120°F.)	3.5	4
Drycleaning	3.5	4

[1] Celanses Performance Standards for Fortrel® Polyester Fabrics, 1966, F-W105.

[2] L22.10.32-1968, p. 49

[3] SFH = Standard Fading Hours

that a manufacturer would be willing to handle as much as 50 percent return or complaint rate.

In the single presentation of red, the highest percentage of acceptance was only 71.2 percent at level 4.5 for Question 3. Only slightly over 75 percent found the color change to be acceptable in the paired presentation at level 4.5.

The highest percentage of acceptance in the single presentation of yellow occurred at level 3 for both Questions 2 and 3, but neither exceeded 75 percent. The acceptability in the paired presentation was highest and over 75 percent at levels 4 and 4.5 for both Questions 2 and 3. This may have been due to the fact that the subjects preferred the faded fabrics to the original fabric color.

In the single presentation of blue, slightly over 75 percent found the change in color acceptable at level 4.5 in Question 2, but when blending (Question 3) was considered, 75 percent judged the color change acceptable as low as level 3.5. Over 80 percent found the color change acceptable at level 4 in the paired presentation of blue, with the percentage increasing when blending was considered (Question 3).

Subjects tended to be slightly more accepting of color change in yellow and blue than in red, and the percentages did seem to indicate that they were more likely to judge harmonious blending in yellow and blue than in red. It was verbally acknowledged by several subjects that the faded blue and yellows seemed to blend better than the reds, and this observation is supported by the data for Question 3.

Therefore, when considering the judgment of 75 percent of the subjects in this study who identified a color change, both the Celanese and L22 standards generally appear to be minimal standards. The Celanese standard level of 3.5 seemed to be slightly lower than these subjects judged necessary. The L22 standard of level 4 in most cases seemed to meet the general acceptance level for yellow and blue, but the standard of level 5 for sportswear fabric colorfastness to light seemed higher than these subjects judged acceptable.

However, it is always possible that the subjects might react differently to actual garments of their own or to fabrics of differing hue, value, intensity, texture, luster, or transparency.

RECOMMENDATIONS

Uses of the Present Study

Little research has been done in the area of investigating consumer expectations for textile color performance. This study adds support to the foundation for further research in this field and may serve as a guide for those interested in pursuing the subject.

The utility of standards for textile products is dependent on the basis of consumer expectations for performance. The findings of this study, representing one particular group of consumers, may be of value to manufacturers, retailers, consumer groups, governmental agencies, and scientific, technical, and professional organizations in the development of more appropriate textile product standards.

The textile industry, especially dyers and colorists, may find the present study of use in determining dyeing standards and tolerance limits for color matching.

Retailers may find these results useful for gaining insight into the consumption practices and dissatisfactions of consumers.

Improvement of the Present Study

This study could be improved by using actual garments or pictorial representations of garments for reference during the testing.

This would help to standardize the visual concepts of the subjects and perhaps give more reliable results.

The use of a more efficient screening test for color deficiencies might be helpful in eliminating any individuals with less than normal color vision. The Dvorine Test for Color Blindness was used because of its accessibility and ease of administration.

Suggestions for Further Research

Although this study attempted to avoid the inclusion of financial considerations in the subjects' responses by assessing feelings and values rather than probable actions, a study of the influence of the socio-economic aspect would be helpful to the textile industry. The sample would need to be selected from a population which would support an adequate, complete range of stratification.

Further investigation could be made into consumer reaction to colors other than those used in the present study and varying the saturations of these colors.

A different means of assessing how well a color is liked or the determination of favorite colors and color preferences could aid in the understanding of the effect of favored color on consumer reactions. The effect of texture might also be studied.

This study included only one age group of women. Additional information could be developed by in-depth investigation of other specific groups of consumers.

Other methods to research this area might be developed. These could include further work on the effect of presentation order, effects of viewing time on results, and the use of different viewing instruments. This study included the two extremes of presentation, i.e., side-by-side versus memory. In actual use of colored fabrics there may be varying degrees of separation and the effects of these could be researched.

SUMMARY

Statement of the Problem

Color performance has been identified as one of the common problem areas associated with textile products. Standards do exist for textile color performance, but little has been done to determine if these standards are meeting the needs of consumers.

In general, the purpose of this study was to assess reactions to and opinions about color and color performance by middle-aged women. Twelve hypotheses were developed to test relationships and differences between both perception and acceptance of color change and: 1) the three primary colors, 2) the two methods of sample presentation, 3) order in presentation of the single color level 5, and 4) how well the color is liked. Liking of the color of the original sample was compared to that of the faded samples. Average levels of acceptance were compared to the L22 and Celanese performance standards.

Procedure

The Benton County voters' registration file was used to randomly select a sample of women from 45 to 54 years old, living in the Corvallis-Philomath, Oregon area. Initial contact was made by postcards, and interviews were scheduled by telephone.

Each of the 152 subjects participated in a 30 to 45 minute interview under controlled conditions at the university. After passing a test for color deficiencies, the subject was first shown single fabric samples and later, paired samples. Between the single and paired sample presentations, demographic data were collected from the subjects for descriptive purposes.

The samples used consisted of three colored fabrics, red, blue, and yellow, with each color faded to five different levels according to the Gray Scale. In the single presentation, each color group was shown separately. The original was shown first and removed, followed by a random viewing of each of the five faded levels and a control sample. The paired presentation consisted of 18 randomly ordered pairs of an original and a faded or another original sample. While viewing the samples, the subject answered several questions concerning perception of color changes, wearing garments of that color in public, and how well the color was liked.

Results and Conclusions

From comparisons of the percentages of perception and acceptance, it was evident that there were diverse and irregular differences for the three colors. Highly significant chi-square tests for heterogeneity confirmed this distinct inconsistency and it was deemed inappropriate to make comparisons among the three colors of red, blue, and yellow. Therefore, specific conclusions were made for each color individually. The three colors were found to have several commonalities, as well as specific individual characteristics.

Red

1. In the single presentation, a majority (> 50 percent) of subjects did not identify a change in color until level 4, while in the paired presentation, most subjects identified the change as high as level 4.5.

2. The percentage of subjects identifying a change in color varied directly with the degree of fading.

3. The color of the red original was preferred to levels 3.5, 3, and 2.

4. Subjects who clearly liked red more often identified a difference in color for the single presentation at level 5 where no difference actually existed. This same group also perceived a change in color at levels 4.5 and 4 in the single presentation more often than did those subjects who disliked red. A similar percentage of perception at levels 3.5, 3, and 2 in the single presentation and at all levels in the paired presentation was found for those subjects who liked red and those who disliked it.

5. The color change was seen as acceptable to a majority of the subjects in the single presentation at level 3.5 for Question 2, but at level 3 for Question 3. In the paired presentation, a majority of the subjects found the change in color acceptable only at level 4.5 for both Questions 2 and 3.

6. The acceptance of color change in red varied inversely with the amount of color change for both the single and paired presentations.

7. Compared to the subjects who clearly liked red, those who disliked red were more accepting of a color change at levels 4, 3.5, 3, and 2 in the single presentation and at levels 4, 3.5, and 3 for the paired samples.

Yellow

1. Not until level 2, the level of greatest change, did a significant number of subjects perceive a change in color for the single presentation of yellow, but a majority perceived a change in color at level 3. This contrasts with the paired presentation, where a significant percentage of subjects perceived a difference at level 4.5.

2. The perception of color change generally increased with the degree of fading for both methods of presentation.

3. Each of the colors of the faded levels was preferred to the color of the yellow original. These results might be attributed

to the apparent brightness and orange cast of the original yellow.

4. The percentages of perception were similar for those subjects who clearly liked yellow and those who disliked it.

5. All levels of yellow were considered acceptable by the majority of subjects in the single presentation for Question 2 and for Questions 3, except for levels 4.5 and 5 in Question 2. A majority of the subjects found all levels acceptable for both Questions 2 and 3 in the paired presentation.

6. The percentages of acceptance fluctuated in the single presentation, but a peak was noted at level 3 for both Questions 2 and 3. In the paired presentation, the percentage of acceptance generally increased as the degree of fading decreased until level 5. At this level, only one out of three subjects did not find the believed color change acceptable.

7. Those subjects who liked yellow and those who disliked yellow tended to be similar in their acceptance of changes in color.

Blue

1. A change in color was not identified by over 50 percent of the subjects until level 4 in both the single and paired presentations of blue.

2. The perception of color change generally increased with the degree of fading in both the single and paired presentations.

3. The color of the original sample was preferred to each of the faded levels.

4. Except for level 3.5 in the single presentation, those who liked blue were equal to those who did not like blue as well in the perception of color change.

5. In the single presentation of blue for Question 2, the majority found the change in color acceptable at level 2, the level of most change, but level 3 was still acceptable to the majority in the paired presentations. For Question 3, all levels were acceptable to a majority of the subjects in the single presentation, but for the paired presentation, level 3 was acceptable to most subjects.

6. Only for the paired presentation for both Questions 2 and 3 did the percentage of acceptance vary inversely with the amount of color change.

7. In the single presentation of blue, subjects who liked blue less well were more accepting of color changes only at levels 3.5, 3, and 2 for Question 3, but only at level 3.5 for Question 2. The two groups of subjects were similar in their acceptance in the paired presentation.

All Colors

Hypothesis 1. The subjects will perceive no change in color when no change has actually occurred. A significant number of subjects identified a change in color for all three colors at level 5, where no change existed. These percentages were much greater for the single presentation, but confidence limits indicated that a real percentage of subjects will usually believe they see a difference although none exists, even in the paired samples. Thus, hypothesis 1 was rejected.

Hypothesis 2. The level at which color change is perceived will be similar for the three primary colors. This hypothesis was considered to be untestable due to the diverse differences in the three colors as confirmed by chi-square tests of heterogeneity.

Hypothesis 3. There will be differences in the levels at which color change is perceived between the two methods of sample presentation. There were significant differences in perception observed between the two presentation methods. There was a higher percentage of perception at all faded color levels for the paired presentation as compared to the single presentation, but the single presentation produced a higher percentage of perception at level 5. Highly significant chi-square values confirmed this difference for all three colors. Thus, hypothesis 3 was accepted.

Hypothesis 4. The perception of color change at each color level will not be affected by the order in which the single level 5 sample is shown. The order in which the level 5 sample was presented was found to have no significant effect on the perception of color change in any of the three colors. It was assumed that any differences observed were due to random chance. Therefore, hypothesis 4 was accepted.

Hypothesis 5. Subjects who like a color will differ from those who dislike a color in their perception of differences in color. Subjects who clearly liked red more often identified a difference in color for the single presentation at levels 5, 4.5, and 4. However, a similar percentage of perception at levels 3.5, 3, and 2 in the single presentation and at all levels in the paired presentation was found for those subjects who liked red and those who disliked it. For yellow, the percentages of perception were similar for those subjects who clearly liked yellow and those who disliked it. Except for level 3.5 in the single presentation, those who liked blue were similar to those who did not like blue as well in the perception of color change. Thus, hypothesis 5 was accepted for only the single presentations of levels 5, 4.5, and 4 of red and level 3.5 of blue.

Hypothesis 6. Subjects will be more accepting of color change on the basis of harmonious blending than on the basis of the amount of color change when the colors no longer match. The acceptance of color change was found to be similar for both ways it was assessed (Questions 2 and 3). Therefore, hypothesis 6 was rejected.

Hypothesis 7. The subjects' standards of acceptance of color change will be equivalent to the L22 and Celanese performance standards for colorfastness to light, laundering, and drycleaning on similar fabrics. In general, both the Celanese and L22 standards appear to be minimal when considering the responses of 75 percent of the subjects in this study who identified a color change. The Celanese standard level of 3.5 seemed to be slightly lower than these subjects judged necessary. The L22 standard of level 4 generally seemed to meet the acceptance level for yellow and blue, but the standard of level 5 for sportswear fabric colorfastness to light seemed higher than these subjects judged acceptable. Therefore, hypothesis 7 was accepted for only the L22 standards when applied to yellow and blue.

Hypothesis 8. The subjects will be equally accepting of color change for the three primary colors. Because of the diverse differences in the three colors as confirmed by chi-square tests of heterogeneity, this hypothesis was considered untestable.

Hypothesis 9. There will be differences in the acceptance of color change between the two methods of presentation. Generally, there was a higher degree of acceptance for the single presentation than for the paired. These differences were confirmed by significant chi-square values. Thus, hypothesis 9 was accepted.

Hypothesis 10. The acceptance of color change at each color level will not be affected by the order in which the single level 5 sample is shown. The order in which the level 5 sample was presented was found to have no significant effect on the acceptance of color change in any of the three colors for either Question 2 or 3. It was assumed that any differences observed were due to random chance. Thus, hypothesis 10 was accepted.

Hypothesis 11. The subjects will be more accepting of color change if they like the color, and less accepting of color change if they dislike the color. Compared to the subjects who clearly liked red, those who disliked red were more accepting of color changes at levels 4, 3.5, 3, and 2 in the single presentation and at levels 4, 3.5, and 3 for the paired samples. Those subjects who liked yellow and those who disliked yellow tended to be similar in their acceptance of color changes. In the single presentation of blue, subjects who liked blue less well were more accepting of color changes only at levels 3.5, 3, and 2 for Question 3, but only at level 3.5 for Question 2. The two groups of subjects were similar in their acceptance of color change in blue for the paired presentation. Thus, hypothesis 11 was rejected for all colors.

Hypothesis 12. The color of the original fabric will be preferred to that of the faded fabric. Results of statistical analyses showed that the color of the red original was preferred to levels 3.5, 3, and 2 and although not significant, this was true of level 4 also. The color of the original blue sample was preferred to each of the faded blue levels. However, each of the colors of the faded levels was preferred to the color of the yellow original. Thus, hypothesis 12 was accepted for only red (levels 3.5, 3, and 2) and blue (all levels).

In general, no one color was disliked by the subjects; all three were rated positively on the scale of zero to fifty. Blue was rated highest, with a mean score of 23.68; red second, with a 13.25 mean score; and yellow last with a mean score of 8.57. This supports the general color preference findings discussed earlier.

BIBLIOGRAPHY

Bird, C. L. Experience with two editions of the Ishihara test for colour blindness. Journal of the Society of Dyers and Colourists, 1968, 84, 264-266.

Bjerstedt, Ake. Warm and cool color preferences and potential personality indications: preliminary note. Perceptual and Motor Skills, 1960, 10, 31-34.

Burnham, Robert W., Randall M. Hanes, and C. James Bartleson. Color: a guide to basic facts and concepts. New York: John Wiley and Sons, Inc., 1963, 249 p.

Burnham, Robert W., J. W. Onley, and R. F. Witzel. Exploratory investigation of perceptual color scaling. Journal of the Optical Society of America, 1970, 60, 1410-1420.

Carter, Susan G. Consumer perception and acceptance of color change. Unpublished master's thesis, Oregon State University, 1975.

Celanese Performance Standards for Fortrel® Polyester Fabrics. Technical Bulletin TBP 12. Celanese Fibers Marketing Company, Charlotte, North Carolina, December, 1966.

Chapanis, Alphonse. Relationships between age, visual acuity, and color vision. Human Biology, 1950, 22, 1-33.

Coates, E. and B. Rigg. An introduction to instrumental measurements of colour difference in relation to colour tolerance. Journal of the Society of Dyers and Colourists, 1968, 84, 462-467.

Cornsweet, Tom N. Visual Perception. New York: Academic Press, 1970, 475 p.

Corvallis Area Chamber of Commerce. General social and economic characteristics. U.S. Department of Commerce, Bureau of the Census, 1970 Census of the Population. Corvallis, Oregon, 1970, 18 p.

Duncan, Anne Elaine. Performance characteristics of a soil-release finish on polyester knit fabrics. Unpublished master's thesis, Oregon State University, 1975.

Dvorine, Israel. Dvorine Pseudo-Isochromatic Plates. New York: Harcourt, Brace, and World, Inc., 1953.

Fabric Performance Standards for Trademark Licensing. Celanese Fibers Marketing Company, Charlotte, North Carolina, 1973.

Fisher, Sir Ronald A. Statistical Methods for Research Workers. New York: Hafner Publishing Company, 1973, 362 p.

Graham, Clarence H. (Ed.). Vision and Visual Perception. New York: John Wiley and Sons, Inc., 1965, 637 p.

Guilford, J. P. and Dorothy G. Park. The effect of interpolated weights upon comparative judgments. American Journal of Psychology, 1931, 43, 589-599.

Hunt, R. W. G. Color measurement. Review of Progress in Coloration, 1971, 2, 11-19.

Hurvich, Leo M. and Dorthea Jameson. Human color perception. American Scientist, 1969, 57, 143-166.

Joerger, R. W. Simple test for determining yellowness of vision. Journal of the Society of Dyers and Colourists, 1969, 85, 318.

Keasey, Charles B., James A. Walsh, and Gary P. Moran. The effect of labeling as an informational social influence upon color perception. The Journal of Social Psychology, 1969, 79 (2), 195-202.

L22, see USA Standard Performance Requirements for Textile Fabrics.

Labarthe, Jules. Elements of Textiles. New York: Macmillan Publishing Company, Inc., 1975, 462 p.

________________. Ten thousand and one customer complaints. Textile Research Journal, 1954, 24, 328-342.

Love, Becky L. Hue difference detection. Unpublished master's thesis, Colorado State University, 1973.

Marshall, W. J. and D. Tough. Colour measurement and colour tolerance in relation to automation and instrumentation in textile dying. Journal of the Society of Dyers and Colourists, 1968, 84, 108-119.

Mather, James, Charlotte Stare, and Sharon Breinin. Color preference in a geriatric population. Gerontologist, 1971, 11 (4) part 1, 311-313.

McGuire, Carlson and George D. White. The measurement of social status. Research paper in Human Development no. 3 (revised). Austin, Texas: University of Texas, 1955, 10 p.

McLaren, K. A simple test for determining yellowness of vision. Journal of the Society of Dyers and Colourists, 1969, 85, 318.

Myers, Samuel L. Consumer complaints: a source of information for producers. American Dyestuff Reporter, 1961, 50, 167-170 and 189-190.

Newhall, S. M., R. W. Burnham, and Joyce R. Clark. Comparison of successive with simultaneous color matching. Journal of the Optical Society of America, 1957, 47, 43-56.

Norwick, Braham. Color quality control. American Dyestuff Reporter, 1969, 58 (5), 33-37.

Paulson, Helen M. Comparison of color vision tests used by the armed forces. In: Color Vision: Symposium conducted at the spring meeting of the National Research Council, 1971. Washington, D. C., National Academy of Sciences, 1973, 34-64.

Pratt, Carroll C. The time-error in psychophysical judgments. American Journal of Psychology, 1933, 45, 292-297.

Sheppard, Joseph J. Jr. Human Color Perception. New York: American Elsevier Publishing Company, 1968, 192 p.

Smith, Genevieve M. Quality control: textile product evaluation. American Dyestuff Reporter, 1969, 58 (1), 23-26.

Smith, Henry C. Age differences in color discrimination. Journal of General Psychology, 1943, 29, 191-226.

Stearns, E. I. Measurement of color and color differences. Part I. Textile Chemist and Colorist, 1974, 6, 38-49.

________________. Measurement of color and color differences. Part 2. Textile Chemist and Colorist, 1974, 6, 71-77.

Steiniger, Lynn B. and Rachel Dardis. Consumers' textile complaints. Textile Chemist and Colorist, 1971, 3, 161-165.

Stringer, Daisy P. Color preferences as related to social introversion-extroversion for a selected sample of college women home economics students. Unpublished master's thesis, San Fernando Valley State College, 1971.

Taylor, Marvin E. Color physics and color measurement. American Dyestuff Reporter, 1967, 56, 1032-1040.

Technical Manual of the American Association of Textile Chemists and Colorists. AATCC, Research Triangle Park, North Carolina, 50, 1974.

Turner, Carolyn S. and Kay P. Edwards. Determining consumer preference for furniture product characteristics. Home Economics Research Journal, 1974, 3 (1), 33-42.

USA Standard Performance Requirements for Textile Fabrics, L22-1968. American National Standards Institute, Inc., New York, 1968.

U.S. Department of Commerce, Bureau of the Census. 1970 Census of Population: Characteristics of the Population, Oregon, 1(39), January, 1973.

Verriest, G. Further studies on acquired deficiency of color discrimination. Journal of the Optical Society of America, 1963, 53 (1), 185-195.

Vogel, Theodore, Ralph A. Stanziola, John Auman, Kenneth M. Lobb, and Robert A. F. Tausendfreund (Deleware Valley ITPC Committee). Color . . . as we see it. Textile Chemist and Colorist, 1972, 4, 99-102.

Walls, Gordon L. and Ravenna W. Mathews. New means of studying color blindness and normal foveal color vision. University of California Publications in Psychology. Berkley, California: University of California Press, 1952, 7 (1), 1-172.

Wardell, Dwight L. Eyes right: the tests for color matching. American Dyestuff Reporter, 1969, 58 (13), 17-22.

APPENDICES

APPENDIX A

Random Points of Entry

Drawer Number	1st Entry Point	2nd Entry Point	3rd Entry Point
1	front	middle	back
2	front	middle	back
3	middle	front	back
4	front	back	middle
5	front	middle	back
6	front	middle	back
7	back	front	middle
8	middle	front	back
9	back	front	middle
10	front	back	middle
11	front	back	middle
12	middle	front	back
13	middle	back	front
14	front	middle	back
15	back	middle	front
16	front	middle	back
17	front	middle	back
18	middle	back	front
19	back	middle	front
20	front	middle	back
21	back	middle	front
22	front	middle	back
23	middle	front	back
24	back	front	middle

APPENDIX B

Postcard

Dear Consumer: January 20, 1975

I am a graduate student in Clothing, Textiles, and Related Arts at O.S.U. and am conducting a study on women's reactions to color in fabrics.

Your name was randomly selected as a member of the sample group from the Corvallis-Philomath population. I will be telephoning you soon to see if you can participate and to set up a 30-45 minute appointment for you to view the fabrics at the university.

Your help in this research will be greatly appreciated.

Sincerely,

Redacted for Privacy

Janet L. Bubl, Advisor

Redacted for Privacy

Linda Handorf

APPENDIX C

Telephone Conversation

Hello, Ms. __________. This is Linda Handorf. I sent you a postcard a few days ago about some research I am doing on color in fabrics. Will you be able to participate in my study?

Let me explain more about the study. This is a study of color change in fabrics. During the 30-45 minute interview, you will first be asked to complete a standard test for color blindness. The fabric samples will be shown to you in two short sessions, and while viewing the samples, you will be asked several questions concerning your perception of changes in color, wearing a garment of that color in public, and how well you like the color. There are no right or wrong answers to these questions. Between the two viewing sessions, you will be asked to answer a few questions about your family to be used for descriptive purposes. No names are used, you will be identified by only a number, and of course, all information you give is confidential.

What would be a convenient day and time for you to come to the university? Do you need a ride?

Do you know where the Home Economics building is located? You will need to come to room 223 which is on the west end of the building on the second floor. The people at the traffic gates will give you a permit to park on campus. Because the color of your clothing might affect how you view the fabrics, you may want to wear a white blouse of your own, or I will have a white jacket you can slip on over what you are wearing.

Thank you very much. I will look forward to seeing you on

___(day)_____, ___(date)____ at ___(time)____.

APPENDIX D

Information Sheet for Subjects

This is a study of color change in fabrics. You will first be asked to complete a standard test for color blindness. The fabric samples will be shown to you in two sessions. You will look at individual samples first and paired samples in the second session. While viewing each sample or pairs of samples, you will be asked several questions concerning your perception of changes in color, wearing a garment of that color in public, and how well you like the color. There are no right or wrong answers. There will be a short break between the two viewing sessions, during which time you will be asked to answer a few questions about your family for descriptive purposes. All information is strictly confidential, and you will be identified by only a number.

Any questions you have regarding procedures will be answered. You are free to withdraw and discontinue your participation in this study at any time. If you are interested in the results of this study which will be completed in June, you may request to be sent a post-card.

APPENDIX E

Interview Procedure

This is a study of color change in fabrics. In this first part of the viewing session, you will be shown three groups of colors, red, yellow, and blue. The first sample in each group will be the original color. Then six other individual samples of that same color group will be presented to you, which may or may not be the same as the first one. If it is not the same, the change in color may be due to ordinary use and care of the fabric, such as fading from washing or exposure to sun.

As an example of the fabrics and questions you will be asked, we will first go through a trial set. I will remind you that there are no right or wrong answers to the questions, so please give me your immediate reaction. You will be given about ten seconds to respond to each question. Find yourself a comfortable sitting position, and try to maintain the same position as you view each of the samples. The samples should remain flat on the table so that they are always the same distance from the light source.

(Present trial set of fabrics with the questions according to the procedure for the Single Frame Presentation.)

When "in public" is mentioned in any questions, it should be thought of as any situation around friends or other people, wherever people see you, but not a special social occasion. You should distinguish between what you would mind doing and what you might actually do. I am interested only in how you feel about the situation, not your resulting actions. Do you have any questions before we begin?

(Complete Single Frame Presentation.)

Now we will take a short break while I have you answer a few questions. Just mark your answers onto the answer sheet provided and be sure to ask if you have any question on interpretation. (During this time, the interviewer was setting up the fabric samples for the next portion of the interview.) Would you like some coffee or tea to drink?

In this last part, you will be shown several pairs of fabric samples. We will go through a trial set first. Again, you will be given about ten seconds to respond to each question.

(Present trial set for Paired Frame Presentation.)

The original sample may appear on either side, but will be pointed out if you identify a difference between the samples. The other sample may or may not be the same as the original. As before, this color change may be due to ordinary use and care of the fabric such as fading due to laundering or exposure to sunlight. Do you have any questions before we begin?

(Complete Paired Frame Presentation.)

Thank you for taking time to help me with this study. Your participation is greatly appreciated.

APPENDIX F

Survey Questions

Single Frame Presentation: (Original is showed to subject.) This is the original color for this color group. Suppose you had a matching blouse and pants that were both this color when you bought them, and you bought them to wear together as a set. The samples I will now show you may or may not be different from this original. (Show other samples one by one.)

1. Does this color look different from the first one you saw?

   YES NO If YES, continue:

2. If only the blouse changed to this color, would you mind wearing them together in public?

   YES NO

3. If the color of the blouse still blends with the color of the pants, would you mind wearing them together in public?

   YES NO

4. Liking of Color Test: Please indicate how well you like this color by placing an X anywhere along the line.

Paired Frame Presentation:

1. Do you see a difference in color between these two samples?

   YES NO If YES, continue:

2. If you had a blouse this color (point to original) that has matching pants, and only the blouse changed to this color (point to other sample), would you mind wearing them together in public?

   YES NO

3. If the blouse color (point to faded sample) still blends with the color of the pants (point to original), would you mind wearing them together in public?

YES NO

APPENDIX G

Response Data Sheet

Subject Code ____________

RESPONSE DATA SHEET

Color Order	Sample Order		Liking Score	Single Q1 Y	Single Q1 N	Single Q2 Y	Single Q2 N	Single Q3 Y	Single Q3 N	Order	Paired Q1 Y	Paired Q1 N	Paired Q2 Y	Paired Q2 N	Paired Q3 Y	Paired Q3 N
		R-0-5														
		R-8-4.5														
		R-7-4														
		R-6-3.5														
		R-2-3														
		R-4-2														
		Y-0-5														
		Y-2-4.5														
		Y-10-4														
		Y-6-3.5														
		Y-1-3														
		Y-8-2														
		B-0-5														
		B-8-4.5														
		B-7-4														
		B-3-3.5														
		B-6-3														
		B-1-2														

APPENDIX H

Liking of Color Test

Fabric Code ______________ Subject Code ____________

Please indicate how well you like this color by placing an X along this line.

Dislike Very Much	Neutral	Like Very Much

APPENDIX I

Demographic Data Questions

1. Who is the main wage earner in your family?
   a. husband
   b. wife
   c. welfare
   d. other (please specify) ______________________

2. What is the highest grade the main wage earner (as named above) completed in school?
   grade school 1 2 3 4 5 6 7 8
   high school 9 10 11 12
   college or university 1 2 3 4
   graduate school 1 or more years
   other (please specify) ______________________

   If college graduate, highest degree earned: ____________

3. What type of work does the main wage earner do? Describe his or her work as specifically as possible without giving the name of the company or business.

   For example:

   sawyer in a lumber mill
   high school teacher
   waitress
   retired college professor
   salesman for a book company
   department store sales clerk
   operates 160-acre farm
   unemployed

4. Which of the following statements best describes the working situation of the main wage earner?
   a. Works for someone, does <u>not</u> manage the business or farm.
   b. Works for someone, <u>does</u> manage the business or farm.
   c. Owns a business or farm, but hires someone else to manage it.
   d. Owns and manages his or her own business or farm.
   e. Retired

5. What is the main source of income of the main wage earner?
   a. inherited and invested
   b. invested income
   c. profits, fees
   d. salary, commission (monthly)
   e. weekly wages, piece work
   f. income from odd jobs
   g. social development or charity

APPENDIX J

Demographic Data Answer Sheet

1. a b c d ______________________________ (please specify)

2. grade school 1 2 3 4 5 6 7 8

   high school 9 10 11 12

   college or university 1 2 3 4 Highest degree ________

   graduate school 1 or more years

   other ____

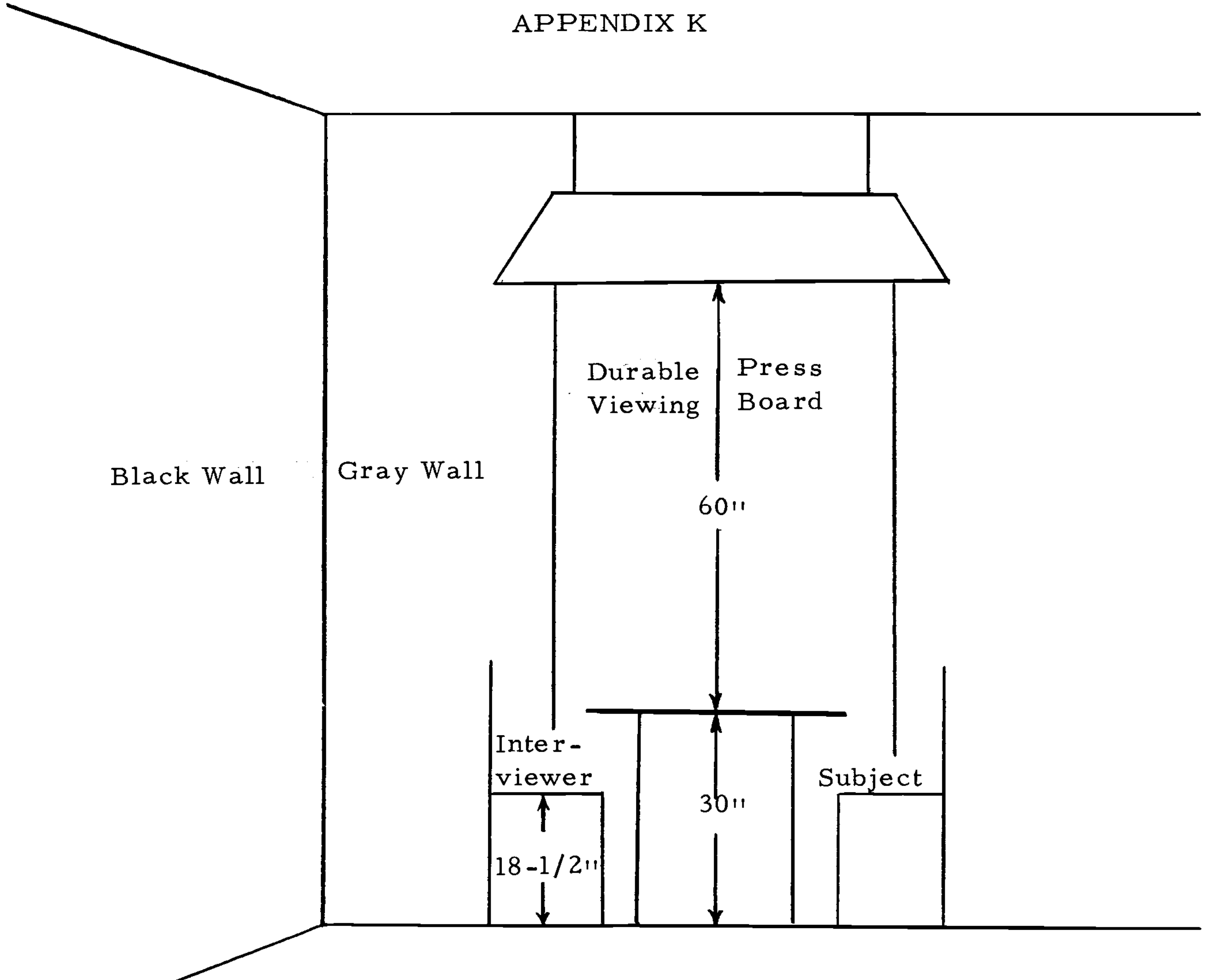
3. ____

   ____

4. a b c d e

5. a b c d e f g

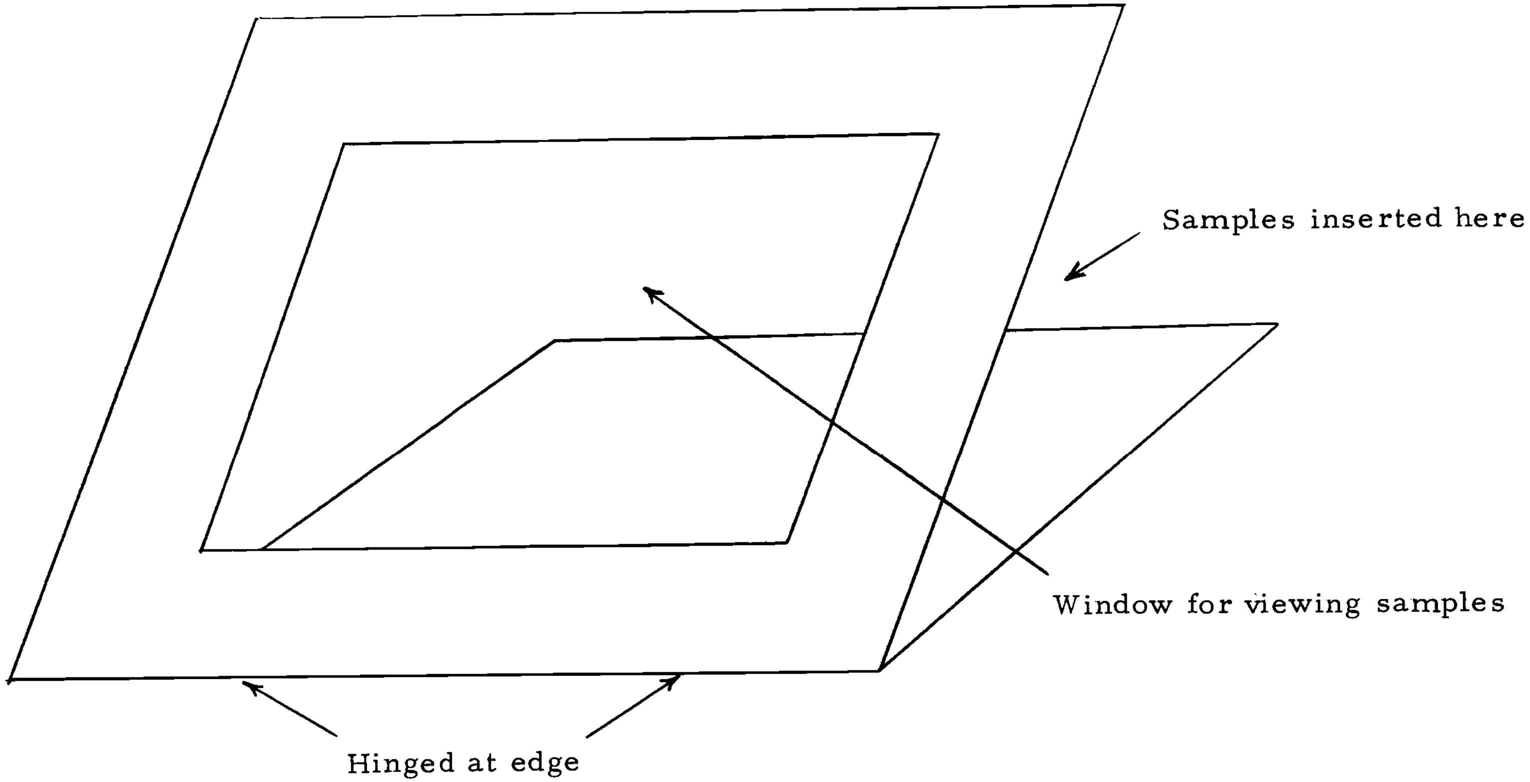
APPENDIX K



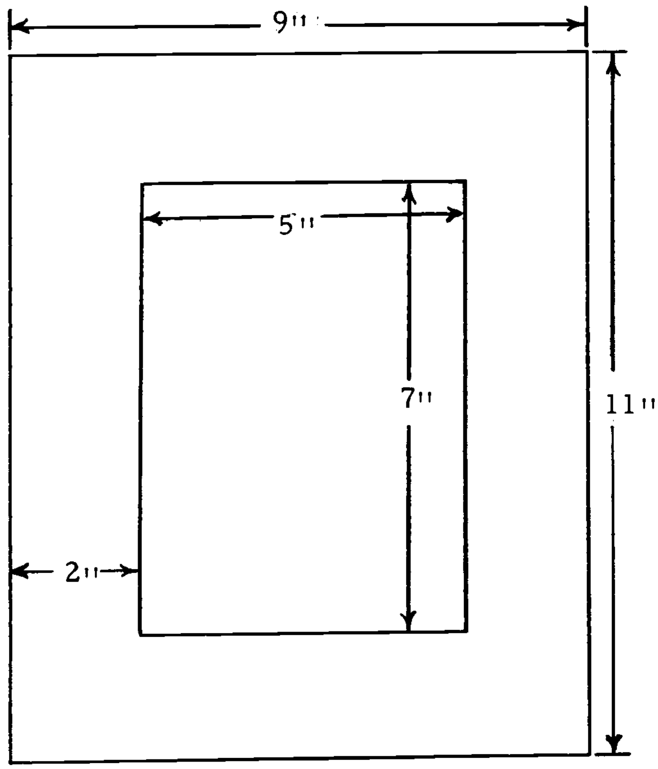
Viewing area as seen from black curtained wall.

APPENDIX L

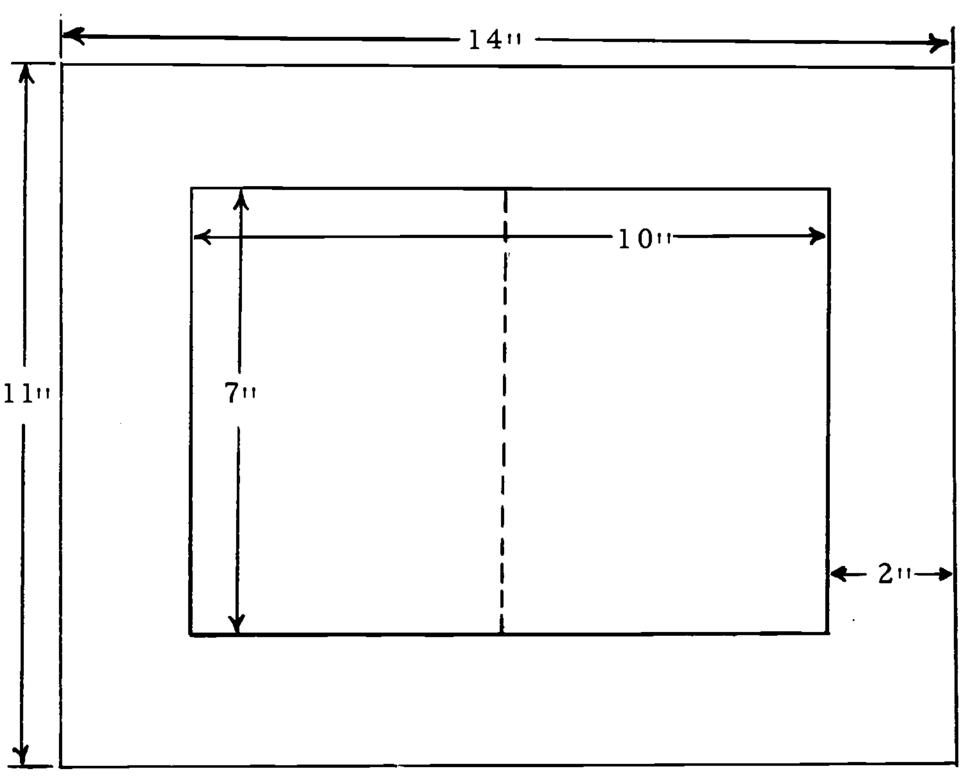
Viewing Instruments



Construction of viewing instruments



Single Frame Instrument

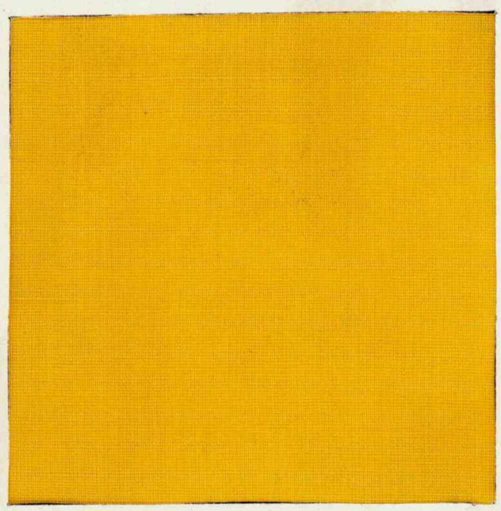


Paired Frame Instrument

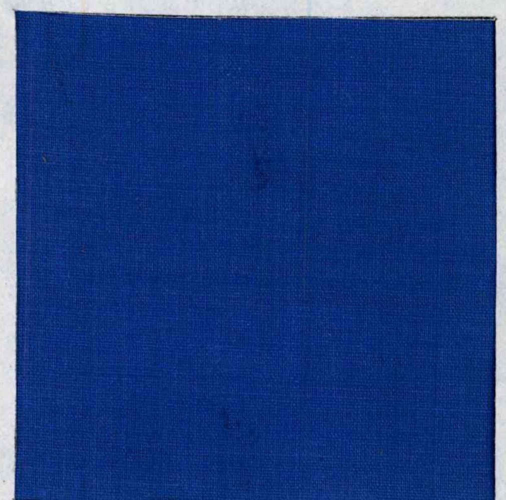
APPENDIX M

Original Fabric Samples

Red



Yellow



Blue

APPENDIX N

Analysis of Specimens by Color Authorities

Standard Fading Hours	Average Color Level Classification		
	Red	Blue	Yellow
276.55	1.8	1.5	1.3
207.41	2.2	1.7	1.7
172.84	2.4	2.0	1.8
138.28	2.4	2.1	2.1
103.71	3.0	2.4	2.5
69.14	3.8	3.1	2.8
51.85	4.4	3.5	2.8
34.57	4.5	3.5	3.2
17.28	5.0	4.5	4.0

APPENDIX O

Hours of Exposure in Fade-Ometer
(Standard Fading Hours)

Color Level	Red	Blue	Yellow
5	0	0	0
4.5	43.21	17.28	8.64
4	69.14	34.57	---[1]
3.5	86.42	51.85	17.28
3	103.71	69.14	34.57
2	207.41	138.28	138.28

[1] Data not available.

APPENDIX P

Tristimulus Values and Calculated Color Differences (ΔE)[1]

Color Level	Red				Yellow				Blue			
	X	Y	Z	ΔE	X	Y	Z	ΔE	X	Y	Z	ΔE
5	.240	.139	.060	.0031	.446	.498	.167	.1339	.130	.128	.376	.1525
4.5	.244	.143	.068	.1042	.449	.445	.177	.2798	.145	.143	.371	.1635
4	.248	.148	.079	.1848	.439	.430	.177	.4073	.145	.145	.369	.1949
3.5	.242	.145	.083	.2165	.443	.448	.182	.4903	.139	.137	.369	.2535
3	.238	.143	.073	.3782	.464	.465	.198	.5210	.144	.154	.369	.3618
2	.254	.160	.103	.4233	.482	.495	.250	.9576	.154	.157	.372	.4466

[1] ANLAB 42 Units