PATTERN SYMMETRY AND COLORED REPETITION IN CULTURAL CONTEXTS

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Abstract—The application of a mathematical principle, symmetry, to an area so highly variable as human culture seems remarkable until one discovers that the principle uncovers hitherto unknown consistencies in human behavior. In Sec. 2, the types of analyses which have shown how symmetry is manifested in culture are discussed. However, not all patterns created by cultural groups maintain structural symmetry when combined with other stylistic aspects. In Sec. 3, colored patterns on pre-Columbian textiles from Peru, which have colorings inconsistent with their underlying structural symmetry are discussed.

1. INTRODUCTION

Symmetry is a type of order with specific geometric parameters. As a mathematical measure it has proved useful for the classification and comparison of patterns on cultural materials. Investigators have been able to study more systematically consistencies and changes in temporal and spatial aspects of design styles and to relate these shifts to other patterns of activity in a given culture.

In general it has been observed that (1) most designs produced by cultures throughout the world are symmetric, and (2) the designs in any given culture are organized by just a few symmetries rather than by all classes of the plane pattern symmetries (7 one-dimensional classes and 17 two-dimensional classes). We do not yet understand why there is preferred use of several symmetries, nor how these preferences relate to other activities in culture.

This paper will focus, however, on designs which, when colored, do not have symmetries identical with their original structural symmetries. That is, the colored design does not preserve the symmetries of the original uncolored design. We have described such colorings as "not consistent" with the structural symmetry. Such colorings may be repeated by another symmetry or they may have no symmetrical repeat scheme at all.

2. SYMMETRY IN CULTURAL ANALYSES

For many years anthropologists have utilized the concept of symmetry to describe both general aspects of the organization of cultural behavior and specific aspects of the structural organization of designs on material culture objects. Two types of treatment of symmetry are typical. One treatment implicitly infers the presence of symmetry by use of terms such as "balance" and "harmony" when describing the structure or association of activities, people, or things in culture. The other treatment explicitly uses the term "symmetry" but does not go beyond the popular conception of symmetry as bilateral reflection or rotation. In none of these latter studies except [2] are the specific plane pattern motion classes used.†

Perhaps the most famous and certainly one of the earliest important considerations of the symmetry in art forms is found in Franz Boas' Primitive Art[3]. Boas saw symmetry as a universal "formal" property in "the art of all times and all peoples"[3, p. 32], citing examples from body painting among the Andaman Islanders and designs on wood shields of the Australian aborigines, Pueblo pottery, and Peruvian textiles. Boas observed that "symmetrical arrangements to the right and left of a vertical axis"[3, p. 33] are most frequent because this is the orientation of the human body and most things in the natural world. But it is significant that even at this early date investigators like Boas noticed not only the symmetry but also the deviations from symmetry in design. Boas goes into some detail on the unusual repetitions of form and color on Peruvian textiles, a topic to which we will return later in this paper.

†This paper will treat only the classes of finite, one-dimensional, and two-dimensional infinite symmetries since these classes fully characterize designs found on flat or curved objects whose designs can be "unrolled" (i.e. ceramic vessels, carved wood drums, pipes, etc.).

Anthropological studies which enumerated the discrete plane pattern symmetries found on decorated material did not appear until the 1970s, even though the classes had been defined much earlier [eg. 8]. There were two notable exceptions. Brainerd's short paper [9] is pivotal because it was the first mention in the anthropological literature of how this type of classification might enable systematic comparative studies. Anna Shepard's seminal monograph, *The Symmetry of Abstract Design with Reference to Ceramic Decoration* [2], contained an explicit discussion of the symmetry classes, description of the classification procedure, and a detailed analysis of patterns from three cultural traditions.

During the 1970s a number of investigators in different disciplines coincidentally "rediscovered" symmetry analysis, both as a classificatory tool and as an aid in the discovery of consistencies and differences in cultural activities. Detailed descriptions of the symmetry classes were presented in Washburn [10] and Zaslow [11] and flow charts for their identification were presented in Crowe [12].

Using these procedures a number of researchers produced descriptions of the structural foundation of a culture's design system. Such studies are typified by Crowe's studies of African art [13–15]; Campbell's study of Pueblo pottery [16]; Donnay and Donnay's analysis of Maori rafter patterns [17]; and Hargittai and Lengyel's description of Hungarian folk needlework [18,19].

Other investigators have used the regularities described by symmetry analysis to aid in the clarification and interpretation of cultural behavior patterns. Ascher and Ascher [20] showed that preferential use of several symmetries was consistent with their theory of "Inca Insistence"; Van Esterik [21] compared the symmetry rules for Ban Chiang pottery designs to language grammars as a form of coded information; Kent [22] correlated continuities and shifts in Anasazi prehistory with continuities and changes in symmetries of textile design; and Washburn applied symmetry analysis to Anasazi ceramics to study site associations [10,23], to Greek Neolithic ceramics in order to study changes in interaction spheres over space and time [24], and to California Indian basketry design to study correlations of structural homogeneity in design with language, marriage practices, and trade networks [25,26].

Still other investigators [27–32] have suggested that these regularities represent the expression of cognitively held organizational principles in the arrangements of forms and parts of forms in decorative design, house architecture, dance, music, village layout, etc.

The above is but a brief sampling of the types of applications of symmetry analysis. A more complete and detailed discussion can be found in [1]. The major thrust of the past research reviewed above has been the application of finite, one-dimensional and two-dimensional plane pattern symmetry classes to classify the structural organization of design motifs. Such classifications have revealed consistencies in use or changes in use of these structures over time and space in cultural contexts.

In contrast, this paper focuses on cultural patterns which are not symmetric. Textile designs from sites in pre-Columbian Peru form the basis for a pilot study which analyzes the impact of color on the symmetry of the design structure.

### 3. SYMMETRY AND COLORED REPETITION

Peruvian textiles have been the object of detailed analyses for many years. These studies have focused on materials and weaving techniques [33–37] or design motifs [38]. Styles have been defined in terms of temporal and spatial changes in these attributes.

While the capacities of the ancient Peruvian textile art remained nearly constant, period expressed itself in style; and style varied according to the favor accorded this or that technical process, as well as its decorative patterns and color combinations [36, p. 31].
In many symmetrically colored patterns the coloring is consistent with the underlying symmetry; that is, the colored symmetry is a coloring of the symmetry of the underlying structure. In other colored patterns, the coloring has no relation to the underlying symmetry of the structure of the pattern. On many Peruvian textiles the superimposition of color reduces the symmetry of the colored pattern to translation. This paper focuses on this type of colored symmetry using eight examples from the Ica Valley, Nazca, Paracas, and the highlands. However, before the patterns are described, it is necessary to discuss four features of layout used by the Peruvian weavers because these seem to be integrally involved in the design organization process.

First, although the design parts are structured along horizontally and vertically oriented axes, frequently the colorings make the pattern appear to be oriented on the diagonal. Sequences of a single predominant color or colors of similar hues move diagonally across the textile. Repetition of these diagonally oriented colors follows certain rhythmic sequences which are regular although they are not consistent with the isometries of the underlying pattern.

Second, to the Western observer accustomed to patterns arranged in an up/down orientation in a design field surrounded by a border, these patterns seem to be incomplete. There are a number of ways this aspect can be manifested.

(1) Frequently, although the textile itself is a complete piece of cloth, the pattern is repeated to the edges, leaving no border. This layout gives the appearance that the pattern continues beyond the edges of the cloth. For example, in Fig. 14 no motif has been truncated; the motif shapes and the design symmetry used to arrange them allow them to appear as complete motifs on the textile.

(2) There are patterns where the repeated motifs are truncated by the edges of the cloth. For example, in Fig. 11 both the asymmetric shape of the motif, and the symmetries used (glide reflection arranges motifs in offset layouts and thus creates patterns with "ragged edges"), combine to emphasize the appearance of pattern continuation beyond the cloth edges.

We begin with a short history of anthropologists who have studied the unusual color repeat systems used on Peruvian textiles.

As mentioned earlier, the unusual kinds of repeats in Peruvian textiles were first noted around the turn of the century. Charles Mead wrote a short article describing what he called the "six-unit design".

The six units of the design are of the same size and pattern, but each varies from the preceding and following one in the color or colors employed. This is the common form; but in some cases we find the design composed of three units of one color, followed by three of another, or four of one and two of another, etc. In every case the six-unit design is retained.

Had Mead examined a larger sample of cloths he would have noticed that not all Peruvian textiles are limited to this repeat cycle, as we shall see from the examples in this paper. Furthermore, although Mead is not explicit about this, the textile in his Plate XI shows both color and motif changing in series. He does note that the colors repeat along the diagonal, rather than along the vertical or horizontal axes of the textile.

Some years later Gladys Reichard investigated whether these "rhythm-units" of repeated colored motifs were present in the decoration of beadwork and embroidery from several subarctic Indian groups. She defined a rhythm-unit as "... a combination of motives, either of color or design, which is regularly or symmetrically repeated". For example, despite the failure for the colors on a colored beaded necklace to be systematically alternated, there was mirror symmetry between the right and left halves of the necklace, schematic No. 6. In addition, certain predominant colors were repeated less frequently and were positioned so as to fall on one of the repeats in the center of the pattern.

(3) Finally, truncated patterns can be created by certain weaving techniques. Crawford gives an example where the order of shedding the warps produces a design.

For this discussion the rectangular textiles are oriented with their longest edge horizontal. In this orientation the bands of identical color are positioned on the diagonal.

Certain technological processes can, however, produce diagonal stripes. In tie dying diagonal stripes can occur if the fabric is folded on the bias before being rolled, tied, and dyed.
within a motif. The decorative wefts pick up the warps of the plain weave background and create another pattern inside the motifs. Although this pattern appears to "run off" the edges of the fret and step motif in Fig. 1, it does not actually continue into the white background which is a simple plain weave. The white outline pattern is created only inside the motifs because the decorative dark wefts have picked up the background white warps.

Third, a problem associated with the incomplete aspect of these patterns arises when they are colored. Frequently, not enough repeats are shown to allow determination of whether there is symmetric repetition of colors. For example, the intact lower section of a fragmentary garment from the Ica Valley (Textile Museum #1966.7.37a) (Fig. 2) has three rows of units in \( p2 \) symmetry.\(^1\) Although some of the colors are unclear in this black and white photograph, the dark diagonal and the light diagonal series of units predominate, so that we might think that there is some kind of color alternation. However, the pattern ends at the textile edges before the dark or light white diagonals are repeated again. Although it is clear that motifs of the same color are arranged diagonally, not enough repeats are present for the analyst to identify the color repetition scheme. One could surmise that the black diagonal might begin in the next

\( ^1\)The different symmetry classes are named by the crystallographic plane pattern nomenclature for one color symmetries as listed in [39], for two color symmetries in [40], for three color symmetries in [41], and for four and high color symmetries in [42].
bifold unit in the upper right-hand column if the cloth were extended beyond the present right edge. However, there are other examples, such as the Paracas mantle described in this paper (Fig. 15), which do not have this black/white alternation, but apparently have, instead, a black/black/white/white alternation scheme.

Fourth, often details of the pattern, such as motifs on the costume of figures, are not precisely identical and so do not allow superposition, even though the general shape of the figures and their relative positions in the design suggest one of the symmetry classes. This is the case for the textiles discussed in Figs. 5 and 7, where details of the costume vary and so technically do not allow superpositions. We shall say that such designs have "apparent symmetry," a concept in keeping with psychological research[49] which indicates that viewers scan for major, fundamental aspects of form, such as symmetry, and "overlook" minor irregularities when making their initial identifications of a form. In this paper these detail variations have been noted and then ignored in order to discuss the interrelationship of the structural symmetry and colored symmetry.

For example, the /Y/ (yellow) in the necklace sequence outlined below[44, p. 192, schematic #12]

\[
\text{Y BR Y BR Y RB B Y RB Y BR Y BR Y RB Y BR Y BR Y BR}
\]

not only falls in the center of the line of beads, but demarcates the middle of a repeat sequence of the R (red) and B (blue) beads. Immediately on either side of the center /Y/ bead the red and blue beads are positioned so that it appears that a mirror reflection line is present across which bead colors are preserved: on the left of the /Y/ the RB reflects into the BR to the right of the /Y/. However, except for a set of beads on the left which are inconsistent in number, the other sets change colors across this center reflection line. This color reversal is in counterpoint to the preservation of the BR color sequence as the bead sets "translate" in a linear array from left to right.

Boas continued Mead and Reichard's work on color and repetition by examining systems of color repetition in very complex two-dimensional patterns. On several examples he showed how to correct "mistakes" where the color repeat sequence was not exactly followed in order to obtain a perfectly colored pattern[3, p. 48]. In light of the recent research of Brett-Smith[45], who has suggested that "irregularities" in Mali textiles were actually purposely included to offset the awesome powers of perfect "speech," and of Morris[46], who has shown that the "irregular" repeats in a Chamula huipil design actually depict the numbers of gods and worlds in the Mayan cosmology, the frequency and consistency in the type of "mistake" in Peruvian textiles should enjoin future researchers to investigate the possible relationship of this stylistic feature to other aspects of the cultural system.

Perhaps the most important work on color repetition, at least on Peruvian textiles, is an analysis by Cora Stafford[47] of one- and two-dimensional color repetition sequences, which she labels "surface patterns," on mantles, shawls, ponchos, loincloths, skirts and coca bags from the site of Paracas.

In the following analyses we shall show how symmetry analysis of the two-dimensional mantle patterns complements and enhances Stafford's studies of color repetitions. Use of symmetry principles to systematically describe the arrangements of the motifs avoids more subjective descriptions, such as Stafford's description of the relationships of pumas in a mantle (#32-30-30/45 Peabody Museum, Harvard): "... the large free motifs turn alternately right and left in vertical rows and also alternate up and down position in consecutive rows"[47, p. 40]. We can more simply describe this structure with the symmetry class designation \(pgg\). Additionally, we can determine whether the color repetition sequences which Stafford describes fall within one of the classes of color symmetry (see [40–42] for illustrations and lists of these classes).

We begin our discussion of the symmetry of color superposition schemes by describing an

\[\text{\textsuperscript{†}The fact that the other colors are not clear from this black and white photograph is a good warning to the reader always to analyze either color photographs or the actual object. Pre-Columbian weavers used a wide palette of colors, many of subtle hue changes which are not clearly distinguishable in black and white photographs. In this paper a schematic color repetition scheme is associated with each textile discussed.}\]
exception on a mantle from Paracas in the Brooklyn Museum collection (#34.1553, Fig. 3). Light blue/green, dark blue/green and gold birds on a dark green/blue wool background are structured by one color \( pg \) symmetry; the addition of colors results in a coloring of the class \( pg \), the three color class \( pg[3] \). Birds of the same three colors are also found on the bordering strip in a band arranged by one-dimensional glide reflection \( (p1a1) \).

Because the birds in the center design area change the direction they face every second row instead of every row, it at first appears that this design cannot be a symmetrical pattern. But, because the birds in each succeeding row are offset, vertical glide axes pass through every other bird. Thus the birds change direction as they move vertically along the glide axes to create a \( pg \) pattern. In the diagram in Fig. 4, vertical glide axes pass through, for example, \( q1, p2, q3, \) and \( p1 \). (The rows labeled \( p \) represent birds facing right and the rows labeled \( q \) represent birds facing left. The glide axis is represented by a dashed line.)

The most unusual aspect of this pattern is that the addition of colors results in a perfectly colored \( pg[3] \) pattern. Such examples, where the coloring actually results in a colored symmetry consistent with the structural symmetry, are unusual on Paracas textiles; most have colorings which are not symmetrical or which have no relation to the underlying symmetry. In this pattern the three colors \( (1, 2, 3 \text{ in Fig. 4}) \) are preserved along horizontal rows, but are changed along the vertical glide axes. The same coloring results if \( pairs \) of rows of birds facing the same direction are moved along the glide axes. For example, in Fig. 4, if row pair \( p3 \) and \( p2 \) is moved up so that \( p3 \) is superimposed on \( q1 \) and \( p2 \) is superimposed on \( q3 \), and, likewise, if

![Fig. 4. Schematic color scheme for Paracas mantle #34.1553 (Fig. 3)](image-url)
the row pair $q_1$ and $q_3$ is moved up so that $q_1$ is superimposed on $p_2$ and $q_3$ is superimposed on $p_1$, the coloring is consistent with $pg[3]$.

Glide reflection is a very common symmetry in Paracas textile design. The Paracas mantle in Fig. 5 (#34.1549, Brooklyn Museum) has human figures positioned along the long horizontal axis, each row alternating head-up and feet-up orientations. The snake (?) alternates curled positions on the left and right sides of the figure's feet. For the purposes of this discussion the focus is on the general position of the figures and the snake; other small differences in costume detail are ignored.

First, if the colors and a few irregularities in figure position along the left side of the mantle are not considered, the snake position alternates consistently from the left to the right side of the figure along vertical glide axes which pass through the figures. The figures alternate head-up/feet-up positions in successive vertical columns. There are horizontal glide axes between the figures in rows A and B, C and D, and E and F, but there are only points of rotation at the corners of the figure squares which superimpose the figures in rows B and C, D and E, and F and G (Fig. 6). The basic symmetry of this pattern is $pgg$.

The addition of colors, however, does not result in a colored $pgg$ pattern. The figures are of the same color along diagonals running from lower left to upper right, but are of different colors along diagonals running from lower right to upper left.

This pattern is similar to the beaded and embroidered examples described by Reichard in that one color is predominant and is positioned in the center of the design. In this pattern it is color 7, which passes diagonally through the center of the textile. The diagonal emphasis of
the coloring is superimposed upon a $pgg$ structure that has a vertical/horizontal orientation of the glide axes.

Another Paracas mantle (#16.32, Boston Museum of Fine Arts) (Fig. 7) has human figures also arranged in alternating feet-up/feet-down position similar to that in Fig. 5. Again we shall ignore the differences in costume detail except for the positions of the branch (?) which alternates position in the left and right hand of the figure. Although this layout appears identical to the pattern in Fig. 5, closer examination reveals that this pattern cannot be a $pgg$ pattern because there is also a vertical mirror reflection line (indicated by the solid line in Fig. 8) which divides the whole mantle design into two reflecting halves, but only for some of the rows. That is, for columns E and F, only figures in rows N, P, and R are holding branches in mirror reflection across the central vertical mirror axis. The figures in rows, S, O (except for figures on the left edge in column A), and M (except for figures on the left edge in column A and figures on the right edge in column J) all are holding their branches in the same hand throughout a given row. In any of the columns the figures move along glide axes which pass vertically through the figures, so that the hand holding the branch is reversed. The successive columns alternate figures feet-up and head-up (except for the figures in column A).

Colors are superimposed upon this pattern so that the diagonals are of alternating colors. Figure 8 displays the color scheme as recorded by Stafford. From lower right to upper left,

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Fig. 8. Schematic color scheme for Paracas mantle #16.32 (Fig. 7).
Alternating diagonals alternate colors 2 and 3 and colors 1 and 4. All four colors are present along all diagonals running from lower left to upper right. Although Stafford claimed that the color sequence 1342 characterized this pattern, there are many deviations from this repetition sequence, particularly along the edges. Because many Peruvian textiles have "irregularities" along the edges, such deviations may not be simple "mistakes."

A Paracas mantle (#34.1556, Brooklyn Museum) (Fig. 9) with figures arranged in \textit{pmg} symmetry, is colored with four colors: (1) gold body, (2) red body, (3) dark green body with green and gold head, and (4) dark green body with red and yellow head. Again ignore the small differences in details of the figures' costumes. Figure 10 shows Stafford's color repetition scheme.

The diagonal color arrangement, where diagonals from lower left to upper right alternate two colors but figures in diagonals from lower right to upper left alternate four colors, is not described by any of the 11 four-color \textit{pmg} color classes. There is no systematic change of colors across vertical mirror reflection lines which pass through the figures. The four colors alternate along the horizontal glide axes which run between rows of figures. This is a particularly clear example of how the underlying \textit{pmg} structural arrangement of the figures and the diagonal coloring is not related. It is as if the color repetition and the underlying symmetry of arrangements of figures were thought of as two different and separate design features. Again, it is notable that, especially along the left edge of this textile, there are significant deviations from the 1324 color sequence which Stafford observed.

This analysis of figurative patterns can be extended to geometric patterns. For example, the rather complicated asymmetric geometric motif repeated in a design on a small Nazca bag (Memorial Art Gallery, University of Rochester #74.79) (Fig. 11) has \textit{pg} structure.

This unit motif appears in three different colors: black (B), red (R), and yellow (Y). The entire scheme of the color repeats is shown in Fig. 12. The same color falls along diagonals running from lower left to upper right. The yellow diagonals predominate. This coloring, however, is not one of the two colorings of three-color symmetries of class \textit{pg}. The three colors change along any one vertical glide axis which passes through the columns of units. However, the fact that only some colors change along any glide axis which passes between any two columns of units means that the coloring is not consistent with the glide reflection symmetry.
Fig. 11. Bag, Nazca, Peru. Catalogue #74.79, Memorial Art Gallery, University of Rochester, Rochester, New York.

Fig. 12. Schematic color scheme for Nazca bag #74.79 (Fig. 11).
A repeat sequence of four colors incompatible with any of the four color symmetries is superimposed on a simple \( pmm \) rectangular checkerboard design on a tunic possibly from the highlands (\#1959.20.12, Textile Museum, Washington, D.C.). The color scheme of black (B), red (R), orange (O), and yellow (Y) is shown schematically in Fig. 13. (The vertical dashed line marks the center line of the tunic where two pieces of cloth were sewn together.)

The diagonal orientation of the coloring predominates. There is a series of three diagonals ascending from lower right to upper left which alternate black/red/black rectangles. Interspersed between these sets of colors is a diagonal of alternating orange and yellow rectangles which ascend from lower right to upper left. In effect this orange/yellow diagonal replaces one of the red diagonals in the red/black alternation sequence. Thus, there is definite regularity of repetition in this pattern. The coloring, however, only admits translation symmetry.

A very complex \( p4m \) pattern on a tunic, also possibly from the highlands (\#91.341, Textile Museum, Washington, D.C.) (Fig. 14) is colored with many similar hues. Two predominate:
single white-stepped units moving diagonally from lower left to upper right in two different orientations, and double black-stepped units combined in two different arrangements also moving diagonally from lower left to upper right. The underlying \( p4m \) structure of this pattern is clearly apparent if the textile is viewed on the diagonal with the tie-dyed white squares as centers of fourfold units. The pattern is not bordered but ‘runs off’ the edges. A sufficient portion of the pattern is repeated to reveal that the coloring is not consistent with the underlying \( p4m \) symmetry of the pattern.

Finally, the most complex pattern to be examined is on a mantle from Paracas in the collection of the Museo Nacional de Antropologia, Pueblo Libre, Peru (illustrated in [48], Fig. #373). In the orientation shown in the schematic drawing in Fig. 15 the three predominant (and a small section of the fourth) lines of black/white interlocking stepped units ascend diagonally from the lower right to the upper left. The black/white diagonals are separated from each other by four other pairs of colored interlocking stepped units. Since these four pairs are of four different color sets, the repeated sequence is five units (from left to right across the upper edge of the textile: blue/red; dark green/yellow; black/white; light green/pink; brown/tan).

The diagonal orientation of the design makes determination of the ‘coloring’ confusing. Examination of the two full repeats of five sets along the horizontal upper edge (from blue/red to brown/tan and from red/blue to tan/brown) reveals an apparent color reversal between the two repeats. However, the black/white diagonals are arranged so that the dominant features are the two sets of black/white, followed by the two sets of white/black units in translation across the fabric.

The diagonal appearance of this \( p2 \) pattern of interlocking stepped units suggests that there are almost four repeats, but actually only one entire diagonal section of five units is completely visible as it moves across the textile from lower right to upper left. The other three are only

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**Fig. 15.** Schematic color scheme of mantle, Paracas, Peru, Coll. of Museo Nacional de Antropologia, Pueblo Libre, Peru. Drawn by G. C. Bommelje.
Closer examination reveals that although the pattern is composed of units of many colors, the color alternation of the sets of five units is not either of the two color colorings of \( p2 \). Look first at the black/white stepped units. Both the lower left black/white diagonal (A) and the next middle black/white diagonal (B) have the black section on the bottom and white section on the top—a one-color translation from A to B, not a two-color bifold rotation from A to B. The next two diagonals C and D have the white section on the bottom and the black section on the top—again a one-color translation from C to D.

Viewed in its entirety there are four sets of five units each, albeit some are truncated by the fabric edges. Colors appear to change every two sets: black/white, black/white, white/black, white/white. There are no true color reversals; the pattern remains a one-color \( p2 \) pattern. Viewed in one orientation, the artist has reversed the colors in two successive sets of five units so that it "appears" as if there has been a 180° rotation and color change on every other set. But if the textile was actually rotated, the colors would stay the same. A true trompe l'oeil!

Clearly, the Peruvian weavers were experts at manipulating the coloring of complex symmetrical patterns by adding a predominant diagonal orientation and repeating large numbers of colors so that, although the designs are regularly colored, they are not consistent with the underlying two-dimensional symmetry.

It is possible, as Stafford[47] and O'Neale[37] point out, that the large number of colors may be a result of the visual discrimination of hues by 20th century analysts. Colors might have changed or faded so that some of the hues which appear to be different to us may have been "... equated in the minds of the workers. Colors occasionally used interchangeably are pink and gold, olive and golden brown, gold and golden brown, dark blue and dark green, red brown and gray. In all of these combinations except the last, the two colors are similar in hue and value"[47, p. 103]. Further studies of colored Peruvian textiles should be coordinated with studies of the discrimination of colors by present-day Peruvian weavers.

**SUMMARY**

In this paper I have discussed several examples of patterns which are structured by complex two-dimensional symmetries but which are colored so as to reduce the symmetry of the pattern, generally to simple translation. These textiles have structural styles which are not sets of preferred symmetries and their colorings, but involve more complex conjunctions of structural symmetry, "apparent symmetry," and colored repetition. The deviation from the structural order has been noted on decorated material in other cultural contexts, such as on designs on Cuna molas[50], Maori burial chests[51], and Cashinahua hammocks[52], although in these cases it was not caused by coloring. Much remains to be learned about the relationships of design structure with other aspects of what is generally called the design style of a culture, as well as with other beliefs and activities of culture. Here I have simply introduced the problem of the various kinds of interfacing of two aspects of style: structure and color.

**Acknowledgments**—Grateful thanks are extended to Don Crowe and Kate Kent for critical appraisal of the article. Figure 15 was drawn by Gerald Bommelje. The photographs are reproduced here through the courtesy of the Brooklyn Museum, the Boston Museum of Fine Arts, the American Museum of Natural History, The Textile Museum, and the Memorial Art Gallery.

**REFERENCES**