Cultural Insights from Symmetry Studies

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Abstract

Washburn and Crowe have published texts and studies documenting the procedure for and application of the use of plane pattern symmetries to classify cultural patterns [8, 9]. This paper contrasts the difference in cultural insights gained between pattern studies that simply describe patterns by motif type and shape and those that describe the way motifs are repeated by plane pattern symmetries.

Culturally produced patterns can be described in many ways, each useful for different purposes. We describe how early pattern studies aimed at designers of textiles and wallpapers created classificatory groupings that were descriptively idiosyncratic, grouping patterns by motif similarities that are arranged by very different symmetries. We then cite several recent studies that illustrate how a symmetry rather than a motif similarity grouping reveals new insights from continuities, changes and preferential symmetry use that can enhance our understanding and interpretation of the material.

One of the best-known pattern studies is that of Archibald Christie, Pattern Design [1]. This 1929 edition is a revised version of the original 1910 study entitled Traditional Methods of Pattern Designing. The revised edition has been reprinted in its entirety by Dover Publications and so remains a very available example of an early comprehensive pattern study. Christie focused on illustrating how the rhythmic movement of element repetition, both naturalistic and geometric, has pervaded pattern from the earliest times. More recent improvements in the technology of pattern production, such as mechanized looms for woven textiles, have enabled the generation of an endless succession of different patterns.

Figure 1 *Left: Egyptian border, 16th century. Right: Persian rug border, 16th century. From* [1, *Figures* 183, 185 *respectively*]

Christie reduced the units that comprise pattern to two main types--*isolated* units (spots) and *continuous* units (stripes)--and showed how they have been used to expand designs into patterns by types of repetitions he labels as “powdering, striping, interlocking, interlacing, branching, and counterchanging” (reversing colors). It is essentially a historical survey that differentiates pattern structures only by general descriptive terms, such as stripes, borders, waves and chevrons and cross bands. While he showed how patterns repeated by the same symmetry can be created with many different motifs (Figure 1), it is not clear what we are to do with this recognition of common symmetries among designs from many different cultures and many different periods except, of course, appreciate them for their beautiful rhythmic appearance.

The pattern book Abstract Design: A Practical Manual on the Making of Patterns for the Use of Students Teachers Designers and Craftsmen by Amor Fenn [2] is, in contrast, dedicated to the explicit instruction of designers about the basics of pattern construction. However, although Fenn understands that repeating patterns are constructed on a geometric basis, he does not differentiate patterns by their generating symmetries but rather by the angles by which "enclosed shapes"—squares, circles, polygons—are juxtaposed and repeated. He considers the range of pattern arrangements on two kinds of layouts: borders and textiles. His borders generally correspond to one-dimensional band designs, and his textiles correspond to two-dimensional overall or wallpaper patterns. For designers he has provided line diagrams of numerous border and textile patterns, showing how simple units can be recombined and elaborated into very complex, decorative patterns.

However, Fenn describes his units in such a way that border bands called frets include examples generated by different symmetries. For example, No. 67 is a fret generated by bifold rotation and vertical reflection, *pma2*, while No. 68 is a fret generated only by bifold rotation, *p112*, and No. 79 is a fret generated by vertical and horizontal mirror reflections and bifold rotation, *pmm2* (Figure 2).

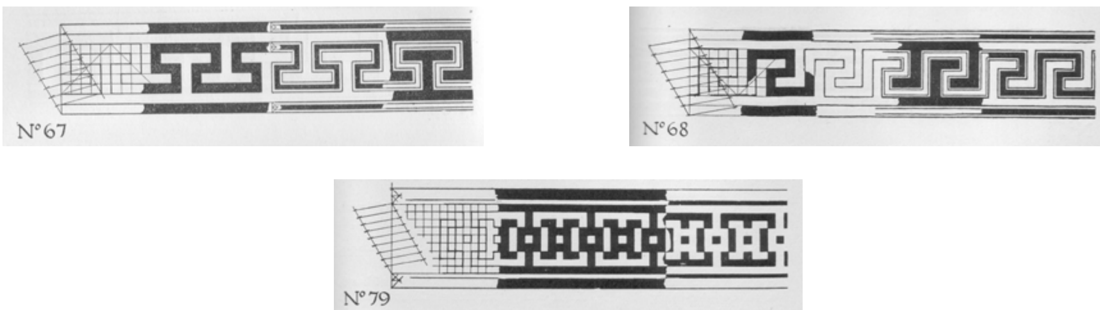


Figure 2 *Nos.* 67, *pma2*; ,68, *p112*; 79, *pmm2*. *From* [2]

In another example, interlacings can be arranged by several of the seven one-dimensional symmetries, such as by simple translation, *p111*, as on No. 106, and by bifold rotation, *p112*, as on No. 104 (Figure 3).

Figure 3 *Nos.* 104, *p112*; 106, *p111*. *From* [2]

For overall wallpaper and textile patterns Fenn bases his discussion on the repeated unit, such as squares, hexagons, and undulate lines. He shows how these are arranged so that, in some cases, the units completely cover space, as in drop patterns such as No. 296. In other cases, they appear to cover the surface as closely spaced or intertwined leaf and flower elements, as in No. 358. Although these two examples render quite different decorative effects, both Nos. 296 and 358 are organized and repeated by symmetry *cmm* (Figure 4).

The issue is: In what way(s) is a symmetry classification of pattern superior to the descriptive ones based on motif shape and/or shared rhythmic repetition configurations as exemplified above? The descriptive classifications group pattern by similarity in motif appearance regardless of underlying differences in symmetrical structure. This approach focuses on the decorative features of design. In contrast, we have set aside interest in the way pattern *decorates*, an issue that may well be a Western preoccupation, and instead queried how pattern *informs.* We have found that a focus on symmetrical structure rather than motif enables us to explore how cultures without writing systems use pattern in different kinds of information transmitting capacities. We present here several examples of studies that demonstrate how symmetry differences in pattern correspond to important ethnic differences and geographical interaction patterns as well as to environmental changes that stimulated major social adaptations.

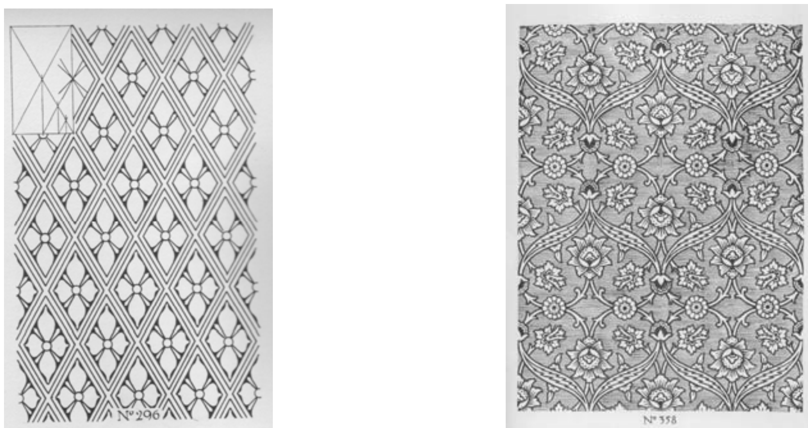
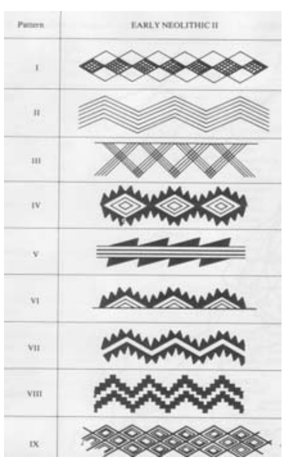
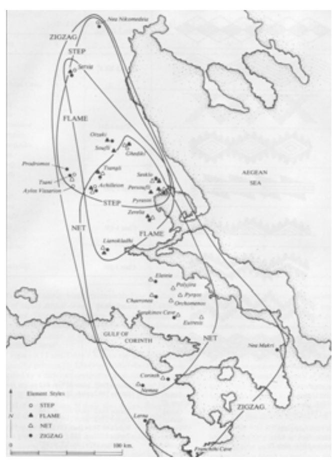


Figure 4 *Nos.* 296, 358 *have cmm symmetry. From* [2]

We begin with an archaeological study of decorated pottery made during the Neolithic on sites throughout mainland Greece [3]. Art historians have often described the red/on/cream designs on the Early Neolithic ceramics and the incised designs on Late Neolithic ceramics in terms of four motifs: flames, triangles, zigzags, or nets (Figure 5).





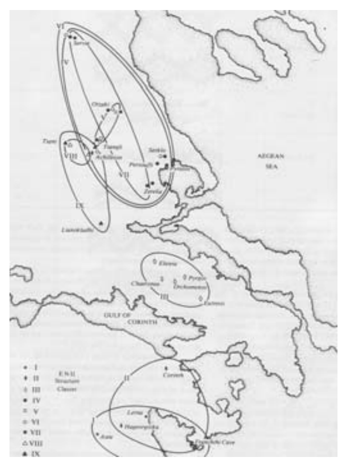


Figure 5 *(Left) The Four Motifs in Nine Patterns from the Early Neolithic, Greece. From* [3]
Figure 6 *(Center) Distribution of the Four Motif Styles in the Early Neolithic, Greece. From* [3]
Figure 7 *(Right) Distribution of the Nine Symmetry Configurations of the Four Motifs. From* [3].

A distributional study of these motifs shows them to occur on pottery from every area where Greece was occupied (Figure 6). However, if the motifs are described by the symmetries used to configure them into patterns, then an entirely different geographical distribution appears (Figure 7). That is, for example, if we trace the occurrence of all patterns composed of triangles during the Early Neolithic that have been typically called “flame” patterns by Classical archaeologists, we find that they are present throughout occupied Greece. In contrast if we use symmetry to distinguish among the configurations of these flame patterns we find that there are mutually exclusive, geographically separate enclaves of different flame patterns, each characterized by a different structural symmetry. Notably these enclaves are separated by mountain ranges or bodies of water, suggesting that geographic factors impeded free movement and interchange during this early period.

Interestingly, if we apply this same methodology to incised patterns from the Late Neolithic, we find a new distribution. Now, a centrally located site appears to have a number of patterns and symmetries, while the surrounding sites display only one or two patterns and symmetries. This new distribution correlates precisely with the beginnings of trade in the Aegean, suggesting that the central site with the greatest variety of patterned pottery was a market place as well as a bulking center where goods from outlying sites were brought in to be sold and later shipped throughout the Aegean. It would appear that here is an excellent example of the power of symmetry analysis to quickly highlight cultural spheres and changes in interaction routes over time and space.

We next examine an ethnographic study of designs on twined baskets from three Indian tribes in northern California, the Yurok, Karok, and Hupa [4]. While these peoples are all salmon fishers living in large villages along the swiftly flowing northern rivers of the Sierras, they speak mutually exclusive languages. Nevertheless, their common lifestyle has resulted in basket forms and designs that are difficult to differentiate in technique and pattern motif. In the 1930s Lila O'Neale of the University of California, Berkeley, visited a number of weavers with the object of studying the aesthetic principles that guided them as they produced their baskets [5]. She discovered a dichotomy between baskets that were said to be "good" and thus would be worn for tribal ceremonies and those that were "bad" that were made for sale to non-Indians, whether dealers, tourists or anthropologists. Notably, both the good and bad baskets were made with the *same* twined technology, raw materials, care in execution, and design motifs. The ONLY feature that distinguished the good and bad baskets was the difference in the symmetries that they used to make good and bad basket designs--the good designs being constructed exclusively by *p112* and *pma2* symmetries (Figure 8) and the bad designs being constructed by other symmetries (Figure 9). A blind sorting of basket hat images by the symmetries used to repeat the designs on them resulted in a perfect separation of the good basket hats made for traditional home use and the bad basket hats made to sell outside the tribal sphere.

(a)

(b)

Figure 9

Figure 8 *a: Hat with "good" p112 design From* [5, *Figure* 24a], b: *Hat with "good" pma2 design. From* [5, *Figure* 21a]

Figure 9 *Hat made for sale with "bad" p1a1 design. From* [5, *Figure* 22a]

It would appear that this case is an example of a deliberate decision by basket makers to use pattern structure, rather than motif, as a way to differentiate objects that carry designs appropriate for internal use versus those made to satisfy the desires of outside buyers for "traditional" crafts. Non-indigenous buyers, unfamiliar with the structural requirements for appropriate pattern, willingly buy any baskets that *appear* traditional on visible grounds—technique, materials, design elements---even though the configuration of the designs elements has no ethnic authenticity.

The final example illustrates a correlation between environmental change and pattern structure change that seems to reflect the kinds of social configurations and changes therein that best organize communities of different size and subsistence regimes. The data comes from an extensive ongoing study of ceramic designs made by the prehistoric puebloan peoples known as the Anasazi in the American Southwest. Between AD 600 and 1600 these corn agriculturalists decorated their pottery with geometric designs. Figure 10 charts the changing use frequencies of five different symmetries over this 1000-year period, revealing clear shifts in the AD 800-900 period from *C2* and *D2* to *p112* and then in the post-AD 1175 period, from *p112* to designs that are asymmetric *C1* or have simple translational *p111* arrangements, and finally to designs that have mirror reflection arrangements, both in a finite *D2* arrangement or in banded *pm11* configurations.

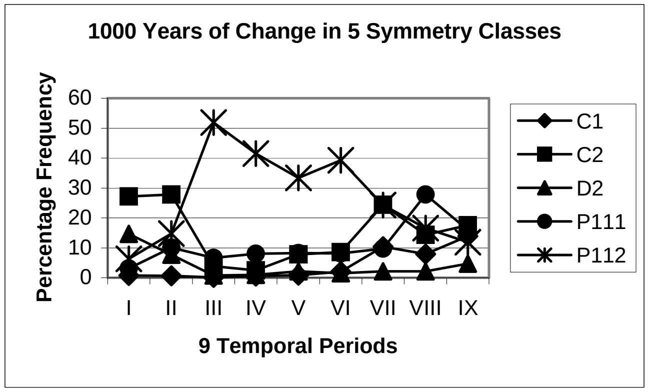


Figure 10 *Prevalence of five symmetries on Anasazi ceramics during nine periods. Period* I=AD625-795; II+825-890; III=920-1025; IV=1025-1100; V=1100-1175; VI=1175-1285; VII=1287-1400; VIII=1400-1480; IX=1490-1650.

Both shifts correspond to periods of environmental change severe enough to require changes in subsistence practices, habitation type and location, and social organization. During the first shift, cooler temperatures and lower rainfall forced people to abandon large pithouse villages on mesa tops whose inhabitants decorated pottery with C2 and D2 designs (Figures 11,12). They moved into smaller masonry pueblo units scattered adjacent to valley bottoms, floodplains or arroyo fans that could better capture the rainfall from the summer thunderstorm rainfall regime. A lengthy 400-year period of conditions generally favorable for this dry-farming corn agriculture lifeway ensued that enabled the spread of these small unit pueblo villages throughout the Four Corners area. The prevailing *p112* symmetry on the ceramic designs of this period (Figure 13) appears to be a structural metaphor of the simple reciprocities at all levels of society that maintained these small farming villages.

Figure 11 *(Left) C2 ceramic design. From* [6, *Figure* 17, #9622]
Figure 12 *(Right) D2 Ceramic design. From* [6, *Figure* 5, *center*]

But by the late 12th century successively longer droughts defeated even the best storage arrangements and massive areas were depopulated. In New Mexico people moved to the permanently watered tributaries of the northern Rio Grande where many of their descendents continue to live today. In Arizona, people moved to sites along the Little Colorado River and its tributaries as well as to sites adjacent to permanent springs, such as on the southern edge of Black Mesa where the Hopi live in 12 villages today. These locational shifts were accompanied by the development of new agricultural techniques. The mulched gravel fields and irrigated plots in sites along the Rio Grande enabled the growth of large populations and thus necessitated the development of new forms of social organization to organize these larger groups. We suspect that the rise of *D2* and other mirror reflection symmetries, such as the *pm11* design on the jar in Figure 14, reflects the development of the two-part moiety divisions of the pueblos.

Figure 13 *(Left) p112 ceramic design. From* [6, *Figure* 18, *top*]
Figure 14 *(Right) pm11 ceramic design. From* [7, *Plate* XXVII]

These studies have revealed clear correlations between design symmetry and patterns of interaction and trade, ethnic identity, environmental change and social organization. They suggest that the structural symmetries underlying designs and patterns may be more than compositional vehicles for creating pleasing decoration. Not only do the consistencies and changes in design symmetries appear to mirror correlations between key factors in the environmental and social domains, but also the symmetries themselves may have functioned in the past for their makers and users as visual displays of socially important information.

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