

# Symmetry in European Folk Costumes

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*ABSTRACT: Ethnomathematics is an interdisciplinary field that explores subconscious and conscious expression of non-formal mathematics within cultures. To explore the mathematics of the designs on European folk costumes, we recorded images of the costumes of 73 cultures displayed in 167 museums throughout Europe, interviewed the directors and curators, and carried out research at the libraries of these museums. We analyze the frequency, similarities and differences in the designs of the 73 cultures, first comparing results culture-by-culture and then repeating the process after combining the cultures into families having characteristic commonalities and similarities of history.*

Keywords: European folk costumes, European folk dress, European regional costume, European regional dress, Ethnomathematics, symmetry, rotational symmetry, frieze symmetry, space-filling symmetry, classification of patterns, classification of design, Group Theory

## INTRODUCTION

This study investigates in detail the frequencies, similarities, and differences in the designs in folk costumes of 73 European cultures. We analyze the designs in each culture separately and then group the cultures into families to determine whether similarities in cultural backgrounds are related to similarities of design types. Immediately obvious is that the designs are dominated by symmetry. This powerful presence establishes symmetry as an important analysis tool, and our study is centered around this tool.

The study was carried out by a team consisting of an anthropologist, a language translator, and a mathematician. The choice of cultures was guided by the *Encyclopedia of World Cultures* and the time period of interest was 1870-1910 when many European cultures

experienced a maturing of their costume into the full displays that have become treasured and preserved in museums. The team made fifteen three-week trips between 1997 and 2014 to museums and archives throughout Europe, interviewing museum directors and curators and recording images of costumes. Pre-arranged contacts with these experts led to in-depth interviews and to informed guidance through their museums. On-site full costume recording, often including entry into display cases and visits to archives, legitimized a reliable culture-by-culture comparison.

From more than 200 hours of video images recorded at 167 museums, we built a database consisting of 18,686 design entries. For example, design # 8335, the third design on the right side of Fig. 1, has the following identifiers: Polish culture, adult, female, full costume, blouse, left side, shoulder, mid-level of impact, horizontal orientation. Mathematically, the symmetry for this design is Frieze Type #1.



**Figure 1.** Designs on a symmetry-rich costume, displaying four different frieze symmetries, two different rotational symmetries, a space-filling symmetry, and stripes. (Podlasie regional Polish costume, State Ethnographic Museum, Warsaw, Poland).

Since the goal is meaningful culture-by-culture comparisons, specialty clothing types available at only some museums were eliminated, including children's clothing, wedding dress, and widows' clothing. Urban clothes and clothing of the rich, famous, and royalty were excluded. Also inappropriate for this study were the occupation-specific clothing of priests, bakers, soldiers, and others. Curators occasionally informed us that a particular costume was on display for some unusual reason, and these too were eliminated. Only designs visible to the outside world were considered, so underclothing and nightdress were not considered.

The reason the costumes of Great Britain were not included was the result of a convincing interview with one of Europe's premier costume and textile curators, Naomi Tarrant of the National Museum of Scotland and author of *Why don't the English have a Folk Dress* [1]. English, Scottish, Welsh and Irish costumes are either occupation-specific or have been designed by known individuals, and in this sense did not evolve from the folk. Similar discussions with other experts led to the elimination from the study of the popular 20<sup>th</sup> century bunad costumes in Norway, of certain costumes in Iceland designed by Sigurður Guðmundsson, and of several well-known national costumes that are hybrid versions of regional costumes, invented for governmental or tourist interests.

The sequence of topics to be explored is:

Ethnomathematics Perspective

Planar Symmetries

Database Description: Impact Number (IN) and Percentage Number (PN)

The Broad View

The Mid View: Three Basic Symmetry Types

The Fine View: Women's Vests

Men's Vests

Women's Skirts & Dresses

Gender Differences (Men's Vests / Women's Vests),

Upper/Lower Body Differences (Women's Vests & Skirts)

Influence of Geographical Adjacency

Compatibility and Incompatibility of Various Symmetry Types

Viewing the Raw Data, and the Access Database

Appendix: Catalog of Cultures, and Museums Visited

## **ETHNOMATHEMATICS PERSPECTIVE**

Ethnomathematics is an interdisciplinary field that studies the subconscious and conscious expression of mathematics within cultures. Most ethnomathematics journal articles and books

investigate one or a few fascinating isolated connections between anthropology and mathematics, and generally do not make broad culture-by-culture comparisons. The goal of this project is innovative in that it is, to our knowledge, the first time a broad comparative survey has been carried out using specific mathematical measuring tools, uniformly applied to a very broad spectrum of cultures.

Our project introduces new concepts, new vocabulary, and new approaches, thereby providing a new observational viewpoint for costume and textile researchers.

## PLANAR SYMMETRIES

There are three general categories for symmetries in the plane: rotational, friezes, and space-filling. For a design to possess rotational symmetry its appearance must be invariant when



**Figure 2. Examples of the three general types of symmetries: rotational, friezes, space-filling.**

rotated about a central point through a given angle. There are two types of Rotational groups: Dihedral groups  $D_1, D_2, D_3$ , etc. have mirror reflections, and Cyclic groups  $C_2, C_3$ , etc. do not. For example, the letters S, Z, and N all are invariant under half turns but have no mirror reflections, so they are classified as Cyclic  $C_2$ , while H and I are Dihedral  $D_2$ . The operation of a half turn is called the generator of the group  $C_2$ .  $D_2$  has two generators: a half turn and a mirror reflection. A plus sign + is Dihedral  $D_4$ , as is the leftmost picture of Fig. 2; its generators consist of a quarter turn and a mirror reflection.

The second general type of symmetry group is a frieze, the designs of which consist of patterns that extend and repeat in one direction as in the middle picture of Fig. 2. Every frieze has a translation as one of its generators. Other optional generators are vertical mirrors, horizontal mirrors, and half turns. Another less-used generator is a glide reflection, which gives a footstep-like pattern. There are seven different frieze types: XXXX (possessing horizontal and vertical mirrors),  $\wedge\wedge\wedge$  (vertical mirrors and half turns), AAAA (vertical

mirrors and no half turns), EEEE (horizontal mirrors only), SSSS (half turns and no mirrors), pbbpb (glide reflections but no half turns or mirrors), and RRRR (translations only). Frieze designs commonly appear on belts and along edges of vests, jackets, skirts, dresses, aprons, and socks. There are seven Frieze groups.

The third general type of symmetry group is Space-Filling, which consists of patterns that repeat in two directions, as in the rightmost picture of Fig. 2, like wallpaper. There are 17 Space-Filling symmetry groups, and of these, three appear in at least 1% of the designs in our study.

Table 1 shows the distribution of the various symmetry types on designs of European folk costumes.

| Rotational Symmetry |           |      |             | Frieze Symmetry |             |      |           | Space-Filling Symmetry |           |  |  |
|---------------------|-----------|------|-------------|-----------------|-------------|------|-----------|------------------------|-----------|--|--|
| type                | frequency | type | frequency   | type            | frequency   | type | frequency | type                   | frequency |  |  |
| C2                  | 35 [26]   | D1   | 3448 [2127] | #1              | 3390 [2381] | p1   | 215 [196] | p3                     | 1 [1]     |  |  |
| C3                  | 2 [2]     | D2   | 466 [313]   | #2              | 1111 [803]  | pg   | 68 [59]   | p3m1                   | 0 [0]     |  |  |
| C4                  | 12 [10]   | D3   | 18 [11]     | #3              | 2898 [2198] | pm   | 105 [87]  | p31m                   | 2 [2]     |  |  |
| C5                  | 1 [1]     | D4   | 280 [198]   | #4              | 427 [290]   | cm   | 27 [25]   | p4                     | 20 [18]   |  |  |
| C6                  | 6 [4]     | D5   | 51 [41]     | #5              | 634 [433]   | p2   | 33 [21]   | p4g                    | 3 [2]     |  |  |
| C7                  | 2 [2]     | D6   | 140 [111]   | #6              | 262 [198]   | pgg  | 17 [16]   | p4m                    | 306 [254] |  |  |
| C8                  | 6 [4]     | D7   | 45 [39]     | #7              | 927 [781]   | pmg  | 37 [27]   | p6                     | 2 [2]     |  |  |
| C9                  | 0 [0]     | D8   | 131 [96]    |                 |             | pmm  | 619 [483] | p6m                    | 64 [61]   |  |  |
| C10                 | 2 [1]     | D9   | 24 [21]     |                 |             | cmm  | 76 [51]   |                        |           |  |  |
| C11                 | 1 [1]     | D10  | 36 [32]     |                 |             |      |           |                        |           |  |  |
| C12                 | 5 [4]     | D11  | 5 [5]       |                 |             |      |           |                        |           |  |  |
| Cn                  | 12 [5]    | D12  | 38 [33]     |                 |             |      |           |                        |           |  |  |
|                     |           | Dn   | 136 [106]   |                 |             |      |           |                        |           |  |  |

**TABLE 1. Number of appearances of the 49 symmetry types. Square brackets indicate women’s costumes alone.**

Planar symmetric designs can be classified using mathematical group theory (see many sources, for example [2]).

### THE CONCEPT OF ‘FOLK COSTUME’

Museum directors were almost all highly intrigued by the possibility of a culture-by-culture mathematical analysis of folk costumes; however, a couple of museum directors questioned whether the scope of our project was too broad. The con argument is that folk costumes vary from region to region, valley to valley, so widely that a phrase like ”typical Slovenian costume” has little meaning. Early in our project one director, whose museum was

temporarily closed for renovation, expressed her doubts while politely allowing us to photograph the few costumes that had not been packed up. We owe to this director the insight that whereas the phrase “typical costume of a culture” is problematic, the multifaceted phrase “traditional costume of a culture” has a different and broader meaning since a given culture can have several traditions. A few years later we returned to the wonderfully renovated museum, and this time the director’s reception was quite different: enthusiastic and highly positive – she volunteered to spend several hours with us in the archives, bringing out box after box and assembling costumes, giving detailed information about both costumes and the culture. She now found our more clearly defined project well worth her time and effort. This story illustrates how dependent this project was on the good will and generosity of directors and curators and how interaction with them helped shape the project. It was only with the help of more than a hundred such costume experts donating their time and expertise that the project progressed.

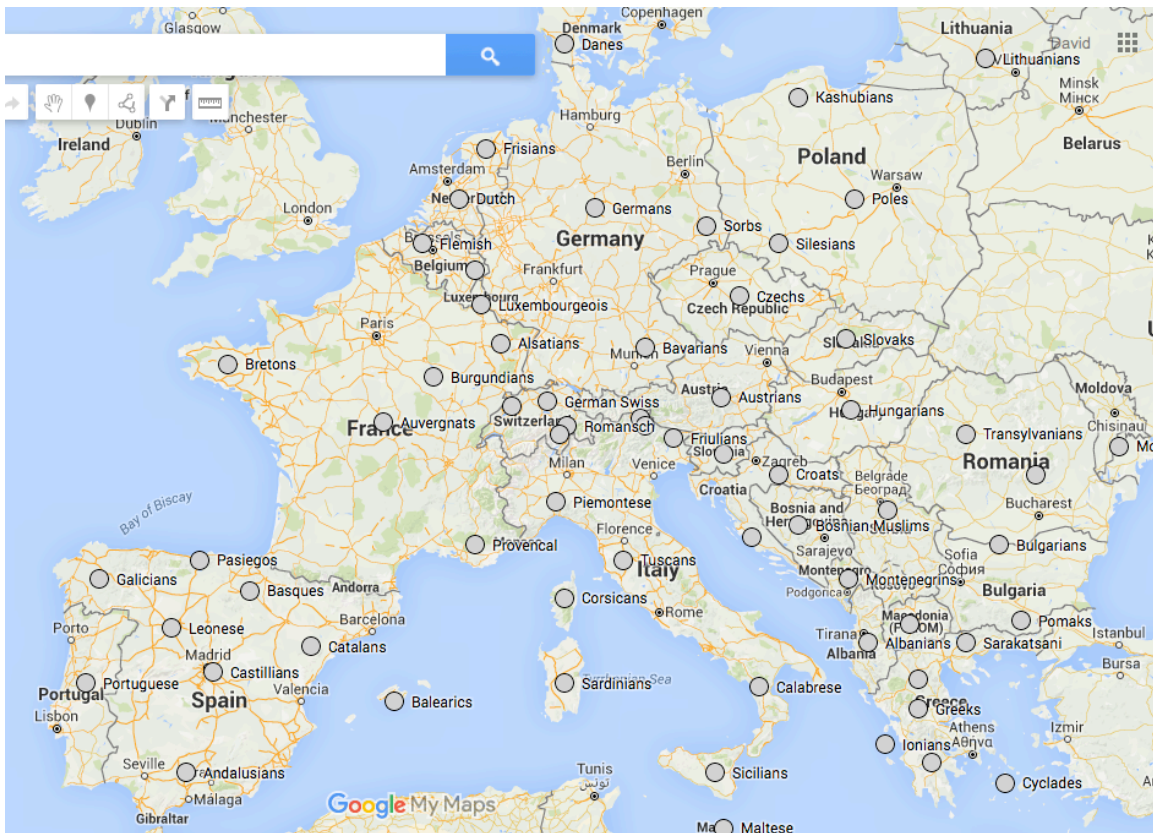
The pro argument: while it is true there is no exhaustive necessary-and-sufficient design criteria that define a costume as relating to a specific culture, this does not mean the term has no meaning. Certain words and concepts elude specific definition while having undeniable value. One recalls Wittgenstein’s well-known example of the concept of a game. There are board games, card games, ball games, Olympic games, children’s games, and more recently role-playing games, computer games and Pokéman Go. No necessary-and-sufficient criteria fit all these examples, but nevertheless we can recognize a game when we come across one. Wittgenstein concluded that to fully understand the definition of ‘game’, one needs to know the ways the concept fits into the whole culture. The same applies to a term like Dutch folk costume: the differences between the various folk costumes of the Dutch are so great that no single workable definition can be produced. Dutch folk costumes is a wittgensteinistic term not detachable from the context in which it appears. But if someone asks: ‘is this a Dutch folk costume?’ there is good reason to believe that a costume curator can respond with confidence.

## **DATABASE DESCRIPTION**

Each individual design was recorded on one of 18,686 forms. The form records the design number (1-18,686), the piece-of-clothing number (1 - 7943), and one of 18 clothing categories (blouse, belt, vest, etc.) or 15 specialty categories (ribbons, fringe, buttons, etc.). Each form also notes the gender, the level of importance of the design (minor, mid, or major), and one of

19 locations on the body (chest, arm, wrist, etc.), plus 14 general locators such as front, left side, bottom edge, and orientation. Each form also records the mathematical symmetry type of the design.

Our database, designed specifically for this project, makes it possible to answer queries and also presents informational lists, enabling each culture or grouping of cultures to be investigated. The analysis begins by building a cohort; for example, one can click on ‘all cultures’, ‘female’, then select ‘blouses’ and ‘left side’. Once the cohort is formed, the mathematical symmetry type of interest can be designated. The database then lists the cultures in the cohort ranked according to each culture’s impact number, IN.



**Figure 3. Locations of folk cultures included in the study. Outside the area of this map are Norway, Sweden, Finland, Saami, Iceland, Karelian, Estonian, Latvia, and Crete.**

### **IMPACT NUMBER (IN) AND PERCENTAGE NUMBER (PN)**

For a given design on a costume and a given symmetry type, like Rotational D4, there are three corresponding impact numbers: design, piece, and culture. The Impact Number for a *design* is its level of importance: if large and dominant the Impact Number is 3; if of middle

level of importance its Impact Number is 2; if small and of minor importance then 1. If the symmetry type in question (D4 in our case) does not appear on the design, then its Impact Number is 0. If the identical design appears elsewhere on the same piece of clothing, this raises the Impact Number of 1, 2, or 3 by +1. The Impact Number for a *piece* for a given symmetry type is the maximum of the Impact Numbers for the various designs on that piece that have the selected symmetry type (D4 in our case), again augmented by +1 when the piece has more than one design with the specified symmetry type, with the proviso that the highest Impact Number can never exceed 4. Intuitively the Impact Number for the piece is how loudly that piece of clothing shouts out that it possesses the symmetry type selected. At this point each piece in the cohort has an Impact Number for the selected symmetry type (D4 in our case). Finally, the D4 Impact Number of the *culture* is the average of the D4 Impact Numbers of the pieces in the cohort for that culture. It turns out to be useful to multiply by 10, so the perfect Impact Number is 40. An Impact Number  $IN=40$  for D4 symmetry for vests in a culture would mean that every vest in the culture has repeated major appearances of D4 symmetry. This culture IN is the number by which the cultures are ranked in the lists given by the database. To clarify, if the cohort consists of 8 vest pieces in culture A, then the D4 Impact Number IN for culture A is the average of the piece D4 Impact Numbers of the 8 vests.

Quite separately from Impact Numbers is another simpler statistic. The percentage number PN is the percentage of pieces (say vests) in the culture possessing the specified mathematical symmetry type. For example, if 6 of the 8 vests in a culture display D4 symmetry then for D4 in that culture, the vest  $PN=75\%$ .

## **HOW THE DATABASE IS EMPLOYED**

The database does much more than produce the ranked lists. For example, relative to the French language, the selected cohort is automatically separated into three mutually exclusive subcohorts: one subcohort for the cultures in the cohort that have French as the main language, one for those with French as a secondary language, and one where French is not spoken. Each of these three subcohorts is then analyzed independently. Comparison of the Impact Numbers IN for these three subcohorts for the specified symmetry type reveals whether speaking French correlates with frequency of occurrence of the designated symmetry type. Similarly for Spanish, Italian, Finnish, German, Slavic, and Greek. The same is done



for religions. That is, the selected cohort is subdivided into strong Catholic, moderate Catholic, and non-Catholic subcohorts, and their Impact Numbers compared to reveal whether Catholicity correlates with the frequency of the selected symmetry type. Similarly for Muslim, Orthodox and Protestant. A similar analysis uses Percent Numbers in place of Impact Numbers.

The database has yet more extensive features. For any given cohort and any given mathematical symmetry type or combination of types, the database automatically analyzes each of 57 different subsets of the cohort. As a sample, we list here 3 of the 57 varieties: cultures from the cohort that are in the Adriatic area, cultures from areas occupied by the former Swedish Empire, and cultures located near Hanseatic League centers. Then for each of these 57 subsets, two statistics are produced: 1) the average of the IN for the selected symmetry type, and 2) the average of the PN. By comparing these statistics with the corresponding statistics for all 73 cultures, one can judge which of the 57 particular subgroupings have above average or below average use of the various mathematical symmetry types under consideration. In summary, any cohort and symmetry type can be explored quite explicitly for attribute signifiers.

This process provides considerable investigative freedom for exploring any desired cohort/symmetry combination. For example, the various mathematical *symmetry types* can be examined to identify which cultures predominate for each particular type of symmetry, and then the characteristics of these high rankers can be ascertained. Alternatively, a reverse analysis can be performed in which cohorts of *cultures* are analyzed to determine which symmetry types are strongly represented.

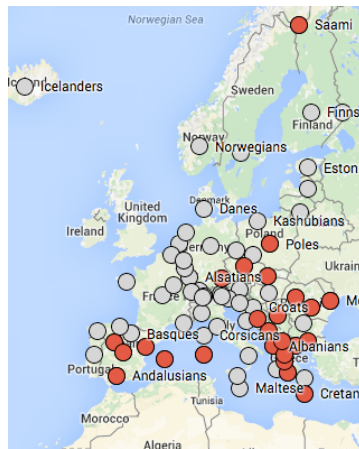
### **THE BROAD VIEW: THE MOST HIGHLY DECORATED CULTURES**

When all symmetry types are combined, the average Impact Number for the 73 cultures is 12.30, a useful baseline parameter. The most strongly decorated culture is Montenegrin with IN=23.69, followed in order by Leonese ↓, Albanian ↓, Moldovan, Peloponnesian, Romanian, Andalusian, Transylvanian, and Castilian ↑, each with IN>18.4. A down arrow indicates that men alone are ranked somewhat lower than the women. Next in order are Serbian, Cretan ↑, Sardinian ↓↓, Pomak, Czech, Polish ↑, Macedonian, Catalan ↑, Bavarian ↑↑, and Saami, by which point the Impact Number had dropped to 13.92, still above average. Double arrows indicate especially strong gender differentiation. The least decorated culture

was Provençal, preceded by German, Alsatian, Danish, and Swiss Italian. The 25 cultures with highest INs are indicated on Fig. 4.

The strongest religious grouping is the Muslim cultures (average IN=16.98) where Islam is the dominant religion. Also strong is the grouping of Orthodox cultures. In language groupings, the strongest are the Spanish language speakers (IN=16.09), Slavic language speakers, and Greek language speakers. Very highly decorated are the cultures in the former Bulgarian Empire, the former Byzantine Empire and the current Balkan cultures [3]. The IN is usually slightly higher for women than for men. An interesting countercurrent to this general phenomenon occurs in the grouping of Finnish language speakers: the men rank #1 in overall decoration while the women rank #20.

Cultures with strong display of symmetry tend to congregate (Fig. 4). There is a statistical way to measure how certain one can be that adjacency of strong displayers has not occurred merely by chance. Montenegro, which has one of the top 25 INs, has 5 of its 7



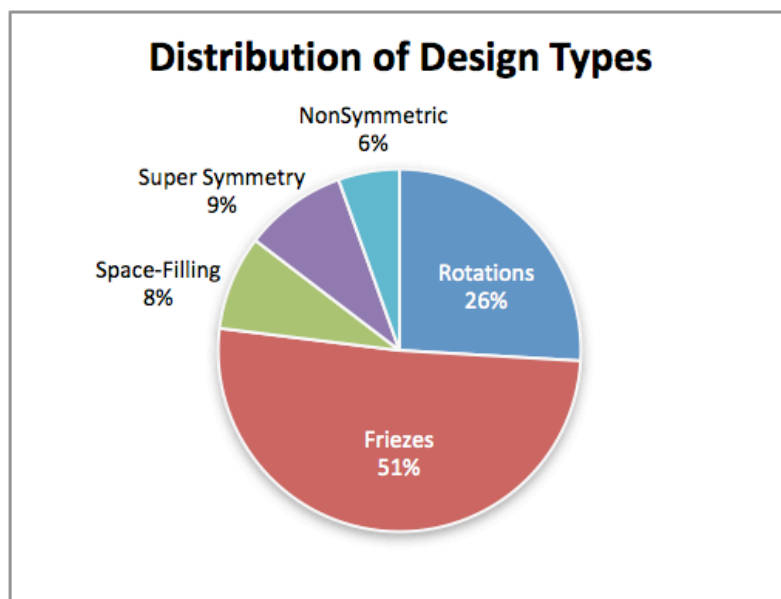
**Figure 4. The dark dots denote the cultures having the overall top 25 Impact Numbers (Saami is 25th). Notice the two areas of concentration, southeast and far southwest.**

*immediate neighboring* cultures appearing on the list of the 25 high-ranking cultures. We computed the likelihood, for any culture having 7 neighbors, that 5 (or more) of them would appear on a randomly generated list of 25, and found this had a likelihood of less than 4%, that is, it had a 96% certainty of not being by chance [4]. Similarly, Montenegro has 19 *immediate or once-removed neighbors*, and of these, 11 appeared on our list of 25, a not-by-chance certainty of >99%.

We repeated the same process for each of the top 25 cultures, and determined that the level of adjacency that occurred for 8 of the top 25 cultures had a not-by-chance certainty of >99%. To illustrate how impressive these numbers are, if one had lowered the bar from 99% to 90%, then finding one culture with this level of adjacency would not be surprising, but to have even one at the very high 99% level is quite surprising, and to have 8 out of the top 25 at this 99% level is essentially impossible to have occurred by chance. Succinctly expressed: adjacency plays a major role in the degree of decoration of folk costumes.

### **MID VIEW: DATA ANALYSIS OF THE THREE BASIC SYMMETRY TYPES**

Of the 18,686 recorded designs, the vast majority, 17,880 (94%) are symmetric: 4904 are Rotationally symmetric designs, 9649 are Friezes, and 1595 are Space-Filling, and in addition, 1578 designs are stripes and 154 are circles which are in a sense over-symmetric, stripes being super friezes, and undecorated circles being super rotation groups. Significantly, only 1032 of the designs we collected fail to have some kind of symmetry. The reason these numbers add up to 18,912 rather than 18,686 is that occasionally a design fits into more than one symmetry type.



**Figure 5. Frequency distribution of design types.**

We now investigate which cultures and groupings of cultures score high in Rotational symmetry, in Frieze symmetry, and in Space-Filling symmetry.

“High” means the culture’s IN is  $> 1.25$  times the all-cultures average IN.

“Higher” means the culture’s IN is  $> 1.5$  times the all-cultures average IN.

“Highest” means the culture’s IN is  $> 2$  times the all-cultures average IN.

For groupings of cultures instead of individual cultures, the cutoffs for Highest etc. are not quite as stringent, because larger groups do not need as high a deviation from an average to be significant.

### ***First Conglomerate type: Rotational Symmetries***

WOMEN: Rotational symmetries overall average IN=3.13, and average PN=42.5%.

Thumbnail Sketch: The Leonese culture makes the most use of Rotational symmetry with an extremely high IN=11.05, as compared with the average IN=3.13. The highest grouping of cultures is the Spanish-language speakers with IN=6.03. At the other extreme the Netherlandic grouping of cultures has a low IN=1.93 indicating they avoid Rotational symmetry. If only blouses, skirts, vests, jackets, aprons, and dresses are considered then this already low 1.93 slides to a miniscule 0.55, showing that on common clothing categories, Netherlanders almost completely avoid Rotational symmetry. The Swiss cultures are also quite low.

#### Individual cultures:

Highest: IN $>6.26$ : Leonese, Montenegrin

Higher: IN $>4.70$ : Albanian, Kashubian, Macedonian, Sarakatsani, Greek, Castilian, Bosnian Muslim, Peloponnese, Slovak, Norwegian

High: IN $>3.91$ : Ionian, Pasiego, Vlach, Icelandic, Serbian, Balearic, Maltese, Portuguese

Lowest: Swiss Italian, Danish, Frisian, Sicilian, Provençal, Auvergnat, Alsatian, Friulian, Walloon

#### Groupings of cultures:

Highest: IN $>4.54$ : Spanish language, Spain, Moorish influence, Greek language

Higher: IN $>3.97$ : Balkan, Bulgarian Empire, Byzantine Empire, Slav west, Ottoman Empire

High IN $>3.80$ : Scandinavian, Slav south, Slav language

High religious groups: Orthodox IN=3.98 and Muslim IN=4.86

Adjacencies: Of the 35 highest ranked cultures, 9 have considerably more adjacencies and once-removed adjacencies with the others in this high scoring contingent than could be expected to

have occurred by chance at the 96% level of confidence. This indicates a high level of adjacency among displays of Rotational symmetry.

MEN: Overall average IN=3.89 and overall average PN=47.5%.

Thumbnail Sketch: Men's numbers tend to be closer to each other than women's, with the result that no culture or group of cultures achieves the Highest rank. Peloponnese and Transylvanian share the lead for most display of Rotational symmetry at IN=6.59 and 6.54. The Peloponnese have PN=90.9% meaning over 90% of its clothing pieces (10 of 11) possess some type of Rotational symmetry, contrasted with PN=66.7% (26 of 39) for Transylvanian. Hungarian is also strong with IN=6.12 and PN=63.1% (41 of 65). The Netherlandic and all French-related groupings are low.

Individual cultures:

Highest: IN>7.78: none

Higher: IN>5.84: Peloponnese, Transylvanian, Hungarian, Jurassian, Polish

High: IN>4.86: Castilian, Slovak, Dalmatian, Cretan, Sarakatsani, Bavarian, Breton

Lowest: IN=0.0 for Lithuanian, Icelandic, Balearic. Also low: Provençal, Auvergnat, Burgundian, Walloon

Groupings of cultures:

Highest and Higher groupings: IN>5.84: none

High: IN>4.86: Greek language, Slav west, Polish/Lithuanian Empire, Russian connection

***Second Conglomerate Type: Frieze Symmetries***

WOMEN: Average IN=6.77 and average PN=68.5%.

Thumbnail Sketch: The Montenegrin culture has the highest IN=16.21. The strongest grouping is those cultures in the former Bulgarian Empire with IN=10.28. The Netherlandic grouping is the lowest with IN=3.88, and the Swiss, German and North Sea groupings are also low.

Individual Cultures:

Highest: IN>13.54: Montenegrin, Andalusian

Higher: IN>10.13: Transylvanian, Moldovan, Romanian, Albanian, Sarakatsani, Greek, Peloponnese, Vlach, Czech, Castilian, Slovak, Leonese

High:  $IN > 8.46$ : Bosnian Muslim, Dalmatian, Pomak, Bulgarian

Lowest: Provençal, Kashubian, Frisian, Galician, Friulian, Alsatian, Danish

Groupings of cultures:

Highest:  $IN > 13.54$ : none

Higher:  $IN > 10.43$ : Bulgarian Empire

High:  $IN > 8.46$ : Ottoman Empire, Greek language Balkan, Spanish language, Byzantine Empire, Adriatic, Slav south, Austro-Hung. Empire

High religious groups: Orthodox  $IN = 9.59$  and Muslim  $IN = 9.78$

Adjacencies: Of the 33 highest ranked cultures, 13 have more adjacencies than could be attributed to chance at the incredibly high 99.9% level of confidence, indicating that adjacency plays a strong role in the use of Frieze symmetry for women.

MEN: Average  $IN = 6.14$  and average  $PN = 61.6\%$ .

Thumbnail Sketch: The Moldovans, Icelanders and Romanians all have  $IN > 14.84$ . Two relatively strong groupings of cultures are the Orthodox religious and the Finnish language speakers, both with  $IN = 8.08$ . Particularly low groupings are the Swiss cultures, the Netherlandic cultures, and the Italian language speakers, all with  $IN < 2.93$ .

Individual cultures:

Highest:  $IN > 12.28$ : Moldovan, Icelandic, Romanian, Castilian, Transylvanian

Higher:  $IN > 9.21$ : Montenegrin, Balearic, Peloponnese, Saami, Bavarian, Andalusian, Catalan

High:  $IN > 7.68$ : Hungarian, Polish, Cretan, Albanian, Slovak, Bulgarian, Croatian, Czech

Lowest: Frisian, Jurassian, Piemontese, Provençal, Burgundian, Auvergnat, Friulian, Swiss Italian, Corsican, Flemish, Tuscan, Sicilian.

Groupings of cultures:

Highest and Higher:  $IN > 9.21$ : none

High:  $IN > 7.68$ : Finnish language, Spanish language, Bulgarian Empire, Ottoman Empire, Slav west

High religious groups: Orthodox and Muslim

Adjacency. Of the 31 highest ranked cultures, 12 have more adjacencies than could be attributed to chance at the 98% level of confidence, indicating that adjacency plays a significant role in the presence of Frieze designs for men.

### ***Third Conglomerate Type: Space-Filling Symmetries***

WOMEN: Average IN=1.43 and average PN=26.4%.

Thumbnail Sketch: The Walloons, Frisians, Karelians, and Tuscans make the most use of Space-Filling symmetry, each with IN>2.68. The strongest grouping is Netherlandic with IN=2.10. The weakest groupings are the Atlantic cultures, Spanish-speaking cultures, the Moorish-influenced cultures and Greek-language speakers, all with IN<0.91.

#### Individual Cultures:

Highest: IN>2.86: Walloons

Higher: IN>2.15: Frisian, Karelian, Tuscan, Auvergnat, Romanian, Balearic, Jurassian, Bosnian Muslim, Catalan, Friulian, Moldovan

High: IN>1.79: Slovene, Basque, Luxembourggeois, Croatian, Corsican, Pomak, Swiss Italian, Lithuanian, Cycladic, Sicilian, Sardinian, Provençal, Finnish, Bavarian

Lowest: Portuguese, Galician, Pasiego, Vlach, Sarakatsani, Calabrese, Macedonian, Kashubian

#### Groupings of cultures:

Highest or Higher: IN>2.15: none

High: IN>1.79: Netherlandic, Italian language French language, French Empire

MEN: Average IN=0.82 and average PN=15.2%.

Thumbnail Sketch: The Balearic culture IN=6.25 is extremely high compared with the average IN of 0.82. The Lithuanians have IN=3.75. The strongest groupings are the Netherlandic, Swiss, and the Spanish-speaking cultures, each with IN>1.43. Extremely low are the Slav west cultures at the very bottom with IN=0.24 and PN=4.6%, curiously contrasting with the Slav south at IN=1.09 and PN=15.9%. Other low ranking groupings are the Finnish and the Greek-speakers.

#### Individual Cultures:

Highest: IN>1.64: Balearic, Lithuanian, Andalusian, Bosnian Muslim, Walloon, Bavarian, Dalmatian, Sicilian, Provençal, Leonese, Danish, Swiss Italian, Sorbian

Higher: N>1.23: Maltese, Frisian, Montenegrin, Dutch, Alsatian, Finnish, Luxembourggeois, Basque

High: IN>0.98: Friulian, Serbian, Auvergnat, Calabrese, Ladin, German Swiss, Norwegian, Tuscan, Jurassian

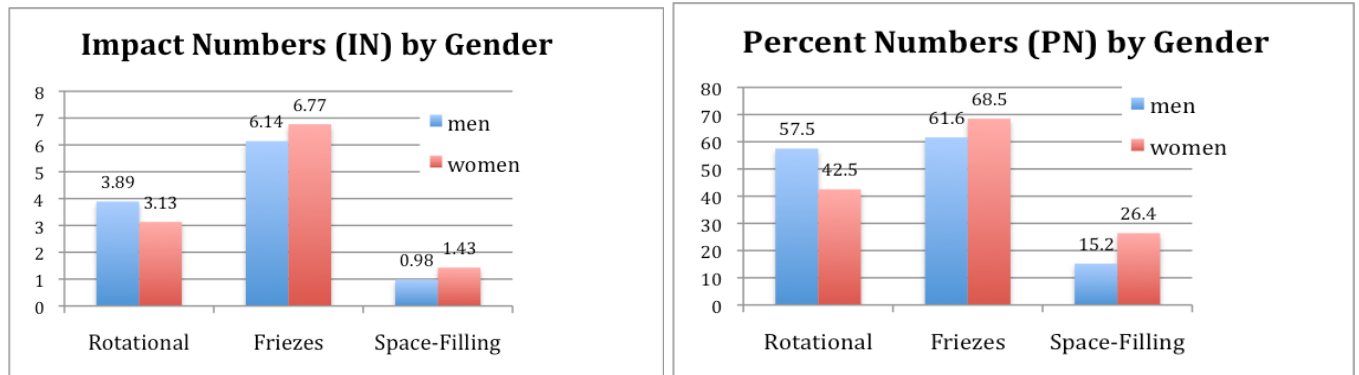
Lowest: IN=0.0: Transylvanian, Saami, Moldovan, Icelandic, Cycladic, Corsican Albanian.  
 Also low: Slovak, Portuguese, Kashubian, Czech

Groupings of cultures:

Highest: IN>1.64: none  
 Higher: IN>1.23: Netherlandic, Swiss, Spanish language, German, North Sea  
 High: IN>0.98: Hapburgs-Spanish, Prussian Empire, Spanish, Mediterranean, Slav south,  
 Italian language, French Empire, French language, Moorish influence  
 Moderately high religious groups: Muslims IN=1.00 and Protestant IN=0.97  
 Moderately high Terrain: Coastal cultures IN=1.06

**COMPARISON OF THE THREE CONGLOMERATE SYMMETRIES**

The average impact of Rotational symmetry is greater on men’s costumes than on women’s, as is the percentage of costumes possessing Rotational symmetry, while for Friezes and Space-Filling symmetries, the gender order is reversed.



**Figure 6. Conglomerate Impact Numbers and Percent Numbers by Gender.**

There is a very high degree of overlap between female strong users of Rotational symmetry and female strong users of Frieze symmetry. Of the top 12 cultures in these two categories, six cultures belong to both: Montenegrin, Albanian, Sarakatsani, Greek, Peloponnese, and Castillian. This stands in contrast to the men where there is only a single commonality: Peloponnese. For overlap between Rotational and Space-Filling, there is only one overlap for women (Bosnian Muslims), and only one (Dalmatian) for the men. For the Frieze/Space-Filling pairing, there is one overlap (Moldovan) for women, and for men also only one (Andalusian). For Rotational occurrences, the Peloponnese, Slovak, and Sarakatsani are



strong for both genders, while for Friezes, both genders are strong for Castilian, Transylvanian, Montenegrin, Romanian, Andalusian, Moldovan, and Peloponnese cultures. In terms of low rankings, Provençal ranks low for Rotational symmetry for both men and women and similarly for Frieze symmetry. Frisians and Friulians also rank generally low. Danish are low for both Rotational and Frieze symmetry for women, and Burgundian for men. Auvergnats are low for both men and women for Rotational symmetry, as are Walloons. For Portuguese, both men and women are low in Space-Filling.

Further differences surfaced relative to preferences of various symmetry types. Among the groupings of cultures, the triple B-O-S (Balkan, Bulgarian, Byzantine, Ottoman, Slav) [3] together with the religious M-O (Muslim, Orthodox) are consistently among the highest ranking in both Rotational and Frieze symmetry, but not Space-Filling symmetry, a circumstance inviting further investigation by researchers. Particularly low rankings for Rotational and Frieze symmetry occur for the grouping of Netherlandic cultures and the grouping of cultures in Switzerland, while for Space-Filling the lowest grouping is the Slav west cultures.

Some groupings have extremely high IN for one symmetry type and quite low for another. The poster child for such bipolarity is the Netherlandic grouping of cultures which for women ranks absolute lowest for both Rotational and Frieze symmetries, and also extremely low for men, but then switches to absolute highest for both men and women in Space-Filling symmetry. Similarly for women the Swiss cultures rank second from the bottom for both Rotations and Friezes (next to Netherlandic cultures), very low for men for Rotations and at the very bottom for Friezes, but second from the top in use of Space-Filling symmetry for men (next to the Netherlandic) and well in the top half for women. It was not unexpected that the cultures with Moorish influence (in Spain) rank relatively high in Space-Filling for men and relatively low for women.

Spanish speakers stand out as extremely high for men in all three symmetry types, and also for women for Friezes, but extremely low in use of Space-Filling symmetry for women. The cultures located in Finnish-related speaking areas (Finnish, Estonia, Saami, Karelian, Hungarian, Transylvania) are for men the absolute highest for Friezes, but almost at the bottom for Space-Filling. French and Italian speakers, after lying low for Rotations and Friezes, rose quite high for both men's and women's Space-Filling. The group of Greek-speaking cultures generally inclines towards joining the triple B-O-S group [3] but also

diverges from this collection on occasion, for instance lagging far behind in men's display of Friezes.

Adjacency of cultures plays a major role in the use of Rotational symmetry. This is also true of Frieze symmetry however not as quite as strongly.

### **PRELIMINARIES FOR THE FINE VIEW: LEVELING THE PLAYING FIELD**

To carry out meaningful intercultural comparisons, three choices are made to insure a level playing field. First, the use of Impact Numbers removes any advantage that one culture might have over another by simply having more costumes displayed, because IN scores are computed using averages, so 3 or 4 costumes have as much influence as 10 in determining the Impact Number for a particular type of symmetry for a culture. Second, only the symmetries appearing frequently enough to meet the earlier described 1% baseline threshold are considered. This includes symmetry types D1, D2, D4, all seven Friezes, and p1, pmm, and p4m. Third, comparisons take place for specific articles of clothing.

### **THE FINE GRAIN VIEW:**

#### **WOMEN'S VESTS: A SPECIAL CASE STUDY**

Level III contains the most interesting and most detailed analysis, focusing on such specific questions as: which are the cultures and groupings of cultures that favor Type #3 Friezes on women's vests, and then further investigating the common characteristics of these high-ranking cultures and groups of cultures in terms of language, religion, terrain, historical background, and neighboring cultures.

On the 1123 designs that appear on the 375 women's vests, the most commonly occurring symmetry type is Friezes: 56.1% of the overall vest design impact is due to Friezes. By comparison, Rotational designs with mirrors amount to 27.2%, and Space-Filling designs register 12.1%. There are very few Rotational designs without mirrors, 0.6%.

Vests for women have designs for 62 of the 73 cultures; 58 of these 62 have Friezes on their vests. The most common is Frieze Type #1 which appears on the women's vests of 51 cultures. The next most common is Frieze Type #3 that appears in 46 cultures, followed by Type #2. Least common of the Frieze Types is #6 that appeared in only 11 cultures.



Each row of Table 2a records that *individual* culture's level of presence of the 13 most common symmetry types. Reading down columns instead of across rows gives the reverse information. For example, the vertical D1 column reveals which cultures have the strongest D1 symmetry. Similarly, Table 2b gives information for *groupings* of cultures (as opposed to individual cultures).

Table 2b reveals a surprising phenomenon. For women's vests, the groupings of cultures that strongly display Friezes almost completely avoid significant use of Space-Filling designs, and vice versa although not quite as strongly. In contrast, the heavy Frieze users tend also to be heavy Rotational D1 and D2 users, but not necessarily vice versa. Also Rotational symmetry and Space-Filling symmetry tend to repel each other.

Frieze Type #1: 51 cultures. Average IN=2.80, and average PN=41.9%

Individual cultures:

Highest: Iceland, Castilian, Basque, Karelian, Transylvanian, Hungarian, Macedonian

Groupings of cultures:

Highest: Finnish language, Scandinavian

Lowest: Netherlandic, France, Italy, French language, Celtic connection

Frieze Type #2: 31 cultures. Average IN=1.32, and average PN=20.5%

Individual cultures:

Highest: Montenegrin, Romanian, Sicilian, Pomak, Transylvanian, Portuguese, Tyrolean, Bulgarian, Bosnian Muslim

Groupings of cultures:

Highest: Bulgarian Empire, Slav south, Ottoman Empire.

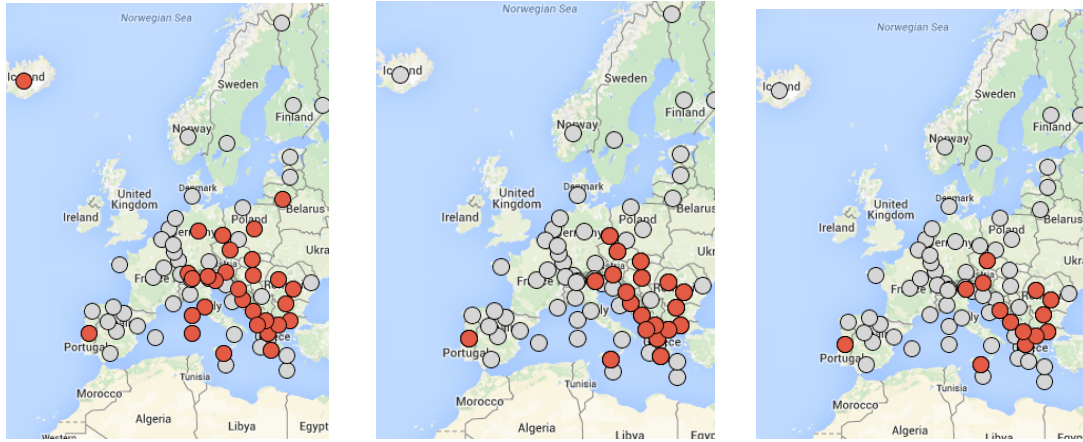
Lowest: any Spanish, Netherlandic, North Sea, Swedish Empire. English connection, Scandinavian

Religious: High: Orthodox IN=2.63, PN=34.5% (7 of 14 cultures display Frieze Type #2)

Low: Protestant IN=0.42, PN=9.0% (4 of 12 cultures)

Terrain: Moderately High: Mountain IN=1.52, PN=24.1 (14 of 25 cultures)

Low: Coastal IN=0.52, PN=9.3% (2 of 9 cultures)



**Figure 7. Women's vests, Frieze Type #2. The darker dots denote a) all 31 displayers, b) the top 20 displayers, the top 14 displayers**

Frieze Type #3: 46 cultures. Average IN=2.55 and average PN=36.8%

Individual cultures:

Highest: Pomak, Montenegrin, Transylvanian, Dalmatian, Sarakatsani, Greek, Bosnian Muslim, Latvian, Romanian, Sicilian, Croat, Bulgarian

Groupings of cultures:

Highest: Finnish language, Bulgarian Empire, Balkan Empire, Slav south

Lowest: Spanish language, Netherlandic, Spain

Religious: High: Muslim IN=5.96, PN=73.1% (3 of 3 cultures)

High: Orthodox IN=4.27, PN=51.7% \*8 of 14 cultures)

Low: Protestant IN=1.26, PN=22.5%% (8 of 12 cultures)

Frieze Type #4: 18 cultures. Average IN=0.37 and average PN=5.6%

Individual cultures:

Highest: Balearic, Montenegrin, Ladin, Albanian

Groupings of cultures:

Highest: Bulgarian Empire, Adriatic, Slav south, Ottoman Empire, Balkan Empire

Lowest: Spanish language, Finnish language, German language, Germany, France,

Polish/Lithuanian Empire, Swedish Empire, Prussian Empire, Russian connection

Religious and Terrain: The Protestants, Plateau dwellers, and Coastal dwellers rank low.

The Orthodox, Muslims, and the cultures with a Hilly terrain rank high.

Frieze Type #5: 26 cultures. Average IN=0.91 and average PN=13.3%

Individual cultures:

Highest: Pomak, Vlach, Slovenian, Transylvanian, Montenegrin, Albanian, Peloponnese, Jurassian, Serbian, Bosnian Muslim

Groupings of cultures:

Highest: Bulgarian Empire, Balkan, Adriatic, Ottoman Empire, Slav south, Greek language

Lowest: Spanish language, Netherlandic, France, North Sea, Polish/Lithuanian Empire, Swedish Empire

Religious: High: Muslim IN=3.46, PN=42.3 (3 of 3), Orthodox IN=1.64, PN=20.7% (7 of 14)

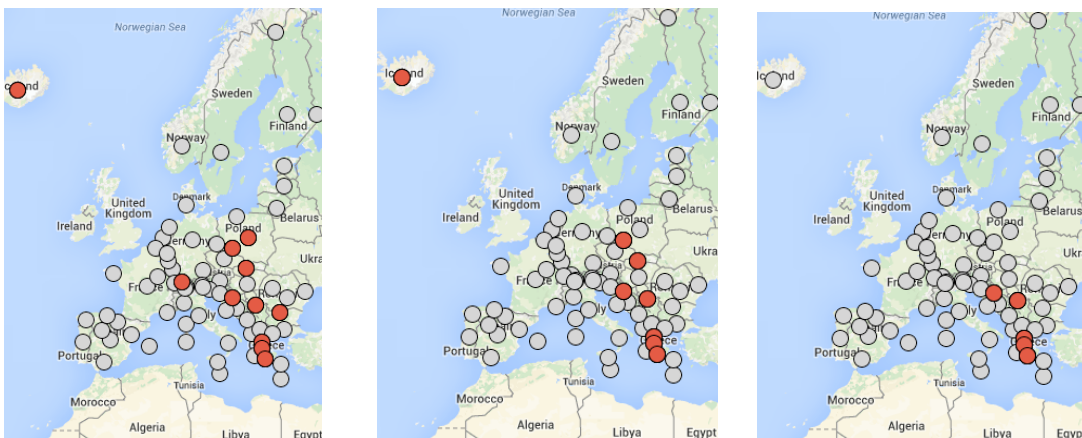
Low: Catholic IN=0.51, PN=9.1%, (12 of 46 cultures)

Terrain: High: Plateau IN=1.38, PN=23.7 (3 of 8), Mountain: IN=1.24, PN=19.1 (15 of 25)

Low: Coastal, IN=0.23, PN=2.3% (1 of 9 cultures), Plain IN=0.39, PN=6.3 (7 of 14)

Frieze Type #6: 11 cultures. Average IN=0.32 and average PN=3.5%

Individual cultures: Only one culture had more than one Type #6 design: Peloponnese



**Figure 8. Women's Vests, Frieze Type #6. The darker dots denote a) all 11 displayers, b) the top 8 displayers, c) the top 5 displayers**

Frieze Type #7: 27 cultures. Average IN=0.83 and average PN=12.3%

Individual cultures:

Highest: Slovak, Romanian, Albanian, Alsatian, Tyrolean

Groupings of cultures:

Higher: Slav west, Austro-Hungarian Empire, German language

Lowest: Swedish Empire, Scandinavian cultures, Greek language

Religious: High: Muslim IN=2.02, PN=23.1 (3 of 3 cultures)

All Friezes Types combined: 58 cultures. Average IN=9.25 and average PN=77.1%

Individual cultures:

Highest: Montenegrin IN=28.50, Transylvanian IN=27.50, Pomak IN=25.83, Vlach IN=21.25, Romanian IN=19.83

Groupings of cultures:

Higher: Bulgarian Empire IN=16.72, PN=93.8% (10 of 11 cultures), Finnish language IN=16.04, PN=83.5% (4 of 6 cultures with Saami as one of the omitted), Ottoman Empire IN=15.51, PN=90.1% (19 of 22 cultures), Balkan IN=15.38, PN=92.4% (13 of 16 cultures), Slav south IN=15.30, PN=94.8% (9 of 9 cultures), Adriatic IN=14.82, PN=95.2% (7 of 7 cultures)

Lowest: Netherlandic IN=1.87, any French, Swedish Empire, North Sea

Religion: High: Orthodox IN=15.09, Muslim IN=15.56

Rotational Type D1: 53 cultures. Average IN=3.18, and average PN=45.6%.

Individual cultures:

Highest: Castilian, Balearic, Montenegrin, Vlach, Jurassian, Romansch, Slovak, Portuguese

Groupings of cultures:

Highest: Spanish language, Spain, Moorish influence

Lowest: Netherlandic IN=0.0, French language IN=1.46, France IN=1.53

Religious: High: Muslim IN=5.10, PN=57.7%, (3 of 3 cultures)

Rotational Type D2: 20 cultures. Average IN=0.47 and average PN=7.7%

Individual cultures:

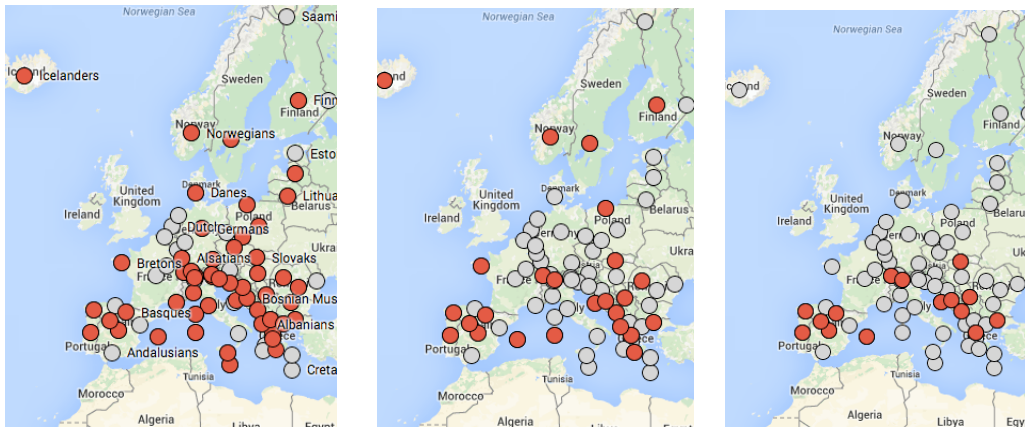
Highest: Balearic, Icelandic, Bosnian Muslim, Swedish. (Iceland is notable in that 7 of its 12 vests have this relatively rare symmetry type)

Groupings of cultures:

Highest: Scandinavian (4 of the 5 cultures, with only the Saami missing)

Lowest: French language, Netherlandic, Germany, Switzerland, Atlantic

There is not much of interest for other Rotational symmetries. The Croats, Icelanders and Albanians are more adventurous than other cultures with rarely used symmetries. Also worth noting is that 3 of the 5 Scandinavian cultures find D6 symmetry display-worthy.



**Figure 9. Women's vests, D1 symmetry. The darker dots denote a) all 53 displayers, b) the 25 top displayers, c) the 15 top displayers**

All Rotational Type D symmetries combined: 54 cultures. Average IN=4.49 and average PN=50.1%

Individual cultures:

Highest: Castilian IN=18.75, Leonese IN=17.50, Balearic IN=15.00, Slovak IN=14.29, Vlach IN=12.50, Montenegrin IN=11.0. Also strong: Icelandic, Romansch

Groupings of cultures:

Highest: Spanish language IN=18.1, Moorish influence IN=9.71, Scandinavian IN=7.50 (4 of 5 with Saami as the outlier), Adriatic IN=7.26

Lowest: Netherlandic IN=0.0, French language IN=1.88, Greek IN=2.07, Prussian IN=2.19

Space-Filling Type p1: 13 cultures. Average IN=0.23 and average PN=4.5%

Individual cultures:

Highest: Burgundian, Cyclades, Corsican, Danish

Groupings of cultures:

Highest: Scandinavian (4 of the 5 cultures, only the Saami missing), French Empire

Religious: No Muslim cultures and only 1 of 14 Orthodox cultures.

Space-Filling Type pmm: 15 cultures, Average IN=0.35 and average PN=8.0%

Individual cultures:

Highest: Frisian, Serbian, Croatian, Danish, Tyrolean, Swedish, Bulgarian, Lithuanian



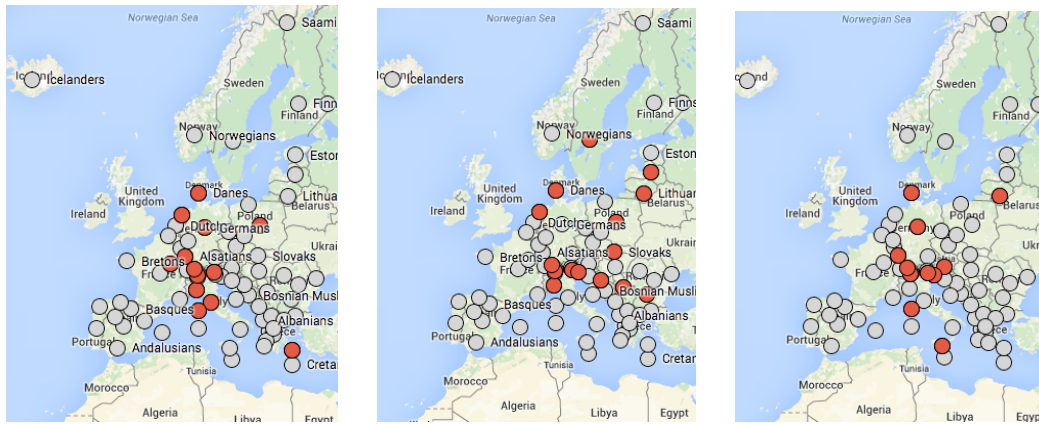
Groupings of cultures:

Highest: Scandinavian (4 of the 5 cultures, only the Saami missing), French Empire

Religious: Low: Muslim

Terrain: High: Plain IN=0.66, PN=14.5% (11 of 24 cultures)

Low: Hilly IN=0.09, PN=1.7% (only 2 of 30 cultures)



**Figure 10. Women's vests. Space-Filling.** The dark dots indicate a) all 15 p1 displayers, b) all 13 pmm displayers, c) all 11 p4m displayers. Notice that all three sets of dark dots lie farther north and west than was the case for Rotations and Friezes.

Space-Filling type p4m: 11 cultures. Average IN=0.18 and average PN=4.0%

Individual cultures:

Highest: Corsican, German, Lithuanian

Groupings of cultures:

High: German language, France

All Space-Filling Types combined: 44 cultures. Average IN=1.29 and average PN=27.2

Individual cultures:

Highest: Basque IN=5.00, Burgundian IN=5.00, Cycladic IN=5.00, Sicilian IN=4.38, Finnish IN=3.75, Corsican IN=3.12, Friulian IN=3.06, Alsatian IN=2.92, Danish IN=2.86, German IN=2.72. Also moderately strong: Ladin, Lithuanian

Groupings of cultures:

Higher: France IN=2.07, Norse connection IN=2.02, Prussian Empire IN=1.89, French Empire IN=1.86, Italian language IN=1.84, North Sea IN=1.83

Lowest: Spanish lang., Moorish influence, English connection, each with IN=0.0. Also low are Atlantic, Slav west, Spain

## SUMMARY OF WOMEN'S VESTS

The Broad View dealt with the general frequency and intensity of designs on costumes. In the Mid View the analysis was refined to the study of the three basic types of symmetry: Rotational, Frieze and Space-Filling. High and low rankings were listed, both for individual cultures and groupings of cultures. The triple B-O-S contingent [3] (Balkan cultures, Bulgarian Empire cultures, Byzantine Empire cultures, Ottoman Empire cultures, Slav cultures) together with the religious M-O contingent (Muslim cultures, Orthodox cultures) ranked high for both Rotational and the Frieze symmetries, however not for Space-Filling symmetry. Certain cultures distinguished themselves by ranking very high in some areas while very low in others. Gender differences and geographic proximity were addressed.

In the Fine-Grain View, an analysis for women's vests was performed. For Rotational symmetry, designs with mirror reflection are heavily favored over those without mirrors, no surprise since psychologists have determined that bilateral is the symmetry that the brain perceives most quickly. D1 symmetry ranks highest, followed by D2 then D4, then D8, increasing by powers of 2. All seven Frieze Types appear frequently, but only three, #1, #2, #3, possess mirror reflections orthogonal to the direction of the frieze, and these are the ones with highest impact numbers. Among the Space-Filling designs, the three with highest impact are p1, pmm, and p4m, the latter two again possessing mirror reflections.

We reemphasize an earlier result emerging from Table 2b: designs on women's vests comprise basically only three kinds of cultural groupings: 1) groupings that display both Friezes and D1/D2 symmetry but avoid Space-Filling, 2) groupings that almost exclusively display D1 symmetry, and 3) groupings that concentrate almost exclusively on Space-Filling designs. There are also 4 scattered 'weaklings' at the bottom of the chart and 12 more groupings of that do not appear on the chart at all since they fail to have  $\otimes$  or x or  $\bullet$ . This division of groupings of cultures into so few distinct possible types of use of symmetry is one of the most significant findings of the study, revealing a conscious or subconscious set of preference rules for European folk costumes. Restated: strong Frieze users tend to be strong Rotational users, but they avoid Space-Filling designs. Space-Fillers avoid both Friezes and

Rotational symmetries. Some D1/D2 users opt for Frieze use while others do not, but all avoid Space-Filling.

The Frieze breadth champion, the only perfect seven, is the grouping of cultures located in the area of the former Bulgarian Empire. Next come the other triple B-O-S groupings of cultures (Balkan, Byzantine Empire, Ottoman Empire, and Slavic) each displaying six of the seven Frieze Types. The grouping of Adriatic cultures also has six, but with not as much intensity as the triple B-O-S cultures. For D1 and D2 Rotational symmetries the triple B-O-S cultures again possess not only the most breadth but also most overall strength, along with the Scandinavian grouping and the Austro-Hungarian Empire grouping.

For individual cultures, the Montenegrins have the most Frieze breadth, displaying six of the seven Frieze types. Five types appear for the Transylvanian, Sarakatsani, Croat, Slovak, Bosnian Muslim, Bulgarian, Albanian, Greek, and Serbian cultures.

The grouping of cultures that most assiduously avoids display of Frieze symmetry on women's vests is by far the Netherlandic cultures, followed by almost anything France-related, cultures in areas occupied by the former Swedish Empire, and the North Sea cultures. For Rotational symmetry, the Netherlandic cultures again stood by far bottommost with  $IN=0.0$ .

In terms of terrain, Mountainous cultures rate high for Frieze Types #2 ( $\wedge\wedge\wedge\wedge$ ) and #5 (SSSSS), and Hilly cultures rank high for Type #4 (EEEEEE). It is tantalizing to wonder whether it is more than mere chance that cultures in Mountainous regions prefer the  $\wedge\wedge\wedge\wedge$  type Friezes. Plateau cultures rank consistently high for Frieze Type #5, not only for women's vests, but also for women's blouses, aprons, men's blouses, men's hats, women's hats, women's skirts and dresses. Again it is interesting to speculate on what inclined Plateau dwellers to so uniformly favor SSSSS Frieze Type designs.

Relative to religion, both Orthodox and Muslim cultures are strong users of Frieze Types #3, #4, and #5 on women's vests. The Orthodox cultures remain high for Type #6 whereas Muslim cultures surprisingly switch to quite low. Muslim cultures are strong in both Frieze Type #7 and Rotational Type D1. The Protestants rank low for Frieze Types #2, #3, and #4, while Catholics are low in Frieze Type #5. For Muslims there is a major contrast between the relatively high levels of display for Friezes and Rotational symmetries compared with the relatively low displays for Space-Filling, especially low for p1 and pmm. The Orthodox have a similar contrast, with a very low p1 ranking. For Orthodox cultures, if further subdivision

into strong Orthodox, mixed Orthodox, and non-Orthodox is made, then the respective use of Friezes is correspondingly strong, moderate and weak.

For rarely occurring symmetry types, the Albanians have considerably more display than expected in four types: C2, D9, D10 and p4 symmetries. The Friulians have an excess of cm, pm, and pmg symmetries, and the German Swiss of p2, cm, and pmg.

In terms of bipolarity for women's vests, the Netherlandic grouping of cultures is by far the lowest for combined Friezes, and also is the only grouping that presents  $IN=0.0$  for combined Rotational designs, but in extreme contrast is the absolute highest grouping for combined Space-Filling designs. The grouping of Spanish language cultures is also bipolar: very low in Frieze Types #2, #3, #4, and #5 and also for Space-Filling in general, but ranks absolute tops for combined Rotational designs. The Scandinavian cultures as a group are very low for Frieze Types #2 and #7 while being very high for Frieze Type #1, Rotational type D2, and Space-Filling types p1 and pmm. The Finnish grouping is low in Type #3 and high in D1. The German-speakers are low in Type #4 and high in Type #7 and p4m. The Greek cultures are low in #7 and high in #5. And finally, and very significantly, each of the triple B-O-S groupings is highly ranked for Friezes and Rotational symmetry but all are omitted altogether for Space-Filling symmetry in terms of  $\otimes$  or x or  $\bullet$  in Table 2b.

The Frieze Type #7 column in Table 2b has fewer entries than other frieze columns, and no  $\otimes$  entries at all. The explanation cannot be not due to a simple lack of frequency of Type #7 Friezes since its IN is 0.83, which while on the low side, is considerably higher than two other Frieze Types. More likely, this lack is since Type #7 is the only frieze with no mirror planes, no half turns, and no glide reflections - they are the mathematically boring friezes - as if no grouping of cultures found this type interesting enough (mathematically speaking) to specialize in its use.

As a final aside, while the Saami culture belongs to both the Scandinavian grouping and the Finnish language grouping, we have repeatedly seen that the Saami data runs counter to the other members of these groups, not surprising since the origins of the Saami differ from other peoples in the area. From a costume standpoint, it is a rogue culture, and it is worth noting that the data for the two groupings would be even stronger if Saami's membership were revoked.

A statistical test measuring the influence of geographical adjacency on symmetry type preferences was described in Level I. Later in the fine-grain analysis of women’s vests, we included adjacency maps. Table 3 shows such adjacency plays an extremely important role.

| All Friezes | All Rotation | All Space Filling | Friezes |    |    |    |    |    |    | Rotations |    |    | Space-Filling |     |     |
|-------------|--------------|-------------------|---------|----|----|----|----|----|----|-----------|----|----|---------------|-----|-----|
|             |              |                   | #1      | #2 | #3 | #4 | #5 | #6 | #7 | D1        | D2 | D4 | p1            | pmm | p4m |
| ☒           | ○            | ☑                 | ○       | ☒  | ☒  | ☒  | ☒  | ○  | ☑  |           |    |    | ☑             |     |     |

**TABLE 3. Influence of adjacency of cultures for symmetry types on women’s vests. ☒ and ☑ indicate an enormous influence for 7 or more cultures at the 99% and 95% level of significance respectively. Having 4, 5, or 6 cultures at a high rate still indicates strong influence of adjacency, and is denoted with ○.**

But there is something deeper to be learned. The leftmost map of Fig. 7 shows the location of all 31 displayers of Type #2 Friezes; the middle shows only the 20 highest-ranking cultures; the rightmost shows the top 14. Note that the more distant a culture is from a certain point (in our case near Croatia), the less strongly it displays Frieze Type #2. This center-of-gravity concept suggests a likely transmission of taste in design. All symmetry types have maps that are quite similar (Figs. 7, 8, and 9). For Type #6, Fig. 8 shows a flaring out in a single direction rather than general dispersion. For D1 symmetry, Fig. 9 exhibits two centers rather than one, with the interesting twist that a new north area comes to life late. For Friezes and Rotational symmetries the centers-of-gravity are located in southeast Europe, while for Space-Filling p1, pmm and p4m, Fig. 10 shows the centers of gravity have moved westerly and northerly, ending near the center of Europe. This provides a nice springboard for some artistically oriented costume researcher to explore whether there are specific designs that can be found to migrate. Our maps show where to look for migration and even the symmetry type of patterns on which to concentrate.

We investigated whether political or military interactions in the past influenced design choice, due to sumptuary laws or some follow-the-flag tendency, or a conscious or subconscious imitation through exchange of cultural artifacts. However political influence turned out to have no more effect than that expected by chance, and for military interactions, the influence was actually negative. A reasonable explanation is that members of folk cultures take considerable pride in their independence, and so are attentive to not copying the designs of outside political authority, and even more intent on avoiding the designs of their military occupiers.



include Greek language speakers, Finnish language speakers, cultures in the area of the former Ottoman Empire, Balkan cultures, and Slav west cultures. The Netherlandic cultures have no Type #1 Friezes at all; also low are Italian cultures, Italian language speakers, Spanish language speakers, and the Mediterranean cultures.

Frieze Type #2. 26 cultures. The overall averages are IN=1.17 and PN=16.8%. The Highest-ranking cultures are Vlach (IN=8.75), Transylvanian (IN=6.25), Croat (IN=4.29) and also Macedonian, Sardinian and Slovak. Highest-ranking groupings of cultures include the Polish/Lithuanian Empire cultures, Slav west and Finnish language speakers. Higher groups are Bulgarian Empire, Balkan cultures, and cultures with an English connection. There is not a single Type #2 display on a man's vest among the Scandinavian cultures, the Netherlandic cultures, in Germany, in Switzerland, in the North Sea cultures, or in cultures in the area of the former Swedish Empire. The 12 strongly Protestant cultures display not a trace of Type #2 symmetry, while the Orthodox cultures are moderately high (IN=2.00) and include 10 of the 14 cultures.

Frieze Type #3: 46 cultures. Overall averages are IN=2.84 and PN=44.9%. Highest cultures are Transylvanian (IN=9.38), Greek (IN=8.75), Polish (8.75), Slovak (IN=8.12), and Serbian, Czech and Montenegrin. In groupings, the Slav west cultures achieved the Highest ranking. Cultures having Plateau terrain ranked quite high (IN=4.48 and PN=2.5%), with appearance on 6 of the 8 Plateau cultures. The Netherlandic cultures ranked lowest with an absolute zero; other low ranked cultures are anything Spanish, Italian-speakers, Swiss cultures, areas raided by the Norse, and cultures in Spain having Moorish influence. Plateau cultures are high (IN=4.48) with 6 out of 8 displaying.

Frieze Types #4, #5, and #6 are comparatively sparsely represented. Sparse cases were handled as follows: if a culture has fewer than two appearances of a given symmetry type, we make no mention of that culture relative to that symmetry type. The only exception to this rule is that if there is one and only one appearance of the symmetry type and it is on the one and only one vest in the culture, then it is recorded. This reduction rule reduces the count of relevant cultures for Frieze Types #4, #5, and #6 down from 15, 16 and 7 to 3, 7, and 1, sparse indeed. For Type #4, the strongest individual cultures are Czech, Cycladic, and Hungarian, and the groupings having the highest ranking are Slav west cultures, cultures with a Russian connection, and Greek-speaking cultures. For Type #5, the strongest cultures are Vlach,

Transylvanian, Bulgarian, Sarakatsani, Montenegrin, Cretan, and Breton. The highest groupings of cultures are those in the former Bulgarian Empire, the Greek-speakers, the Balkan cultures, those in the Ottoman Empire, Spanish-speakers, and those in areas of the former Byzantine Empire. The Protestants had a complete absence of Type #5, while the Orthodox ranked high. Cultures having a Plateau terrain ranked high. For Type #6, the strongest culture is Czech – the other 5 participating cultures have only one type #6 design each.

Frieze Type #7: 18 cultures. Overall averages are IN=0.78 and PN=10.2%. Highest impact cultures are Montenegrin (IN=6.43), Peloponnese (IN=4.17), Cycladic (IN=3.75), followed by Czech and Macedonian. Orthodox cultures were High (IN=2.17 and PN= 28.9%) with 6 of the 14 Orthodox cultures possessing this relatively uncommon Type #7. Highest groupings are the Bulgarian Empire, Slav language, and the Balkan cultures. Lowest groupings include anything French, Netherlandic, Scandinavians, Swiss, North Sea cultures, Swedish Empire, Germany, and those having an English connection. None of the 12 Protestant cultures displayed a Type #7 Frieze, while about half the Orthodox cultures did (IN=2.17).

All Frieze Types combined: 55 cultures. IN average of 9.27 and PN average of 81.8%. The Highest impact culture is Polish with an exceptionally high IN= 38.75 and PN=100%. Other Highest with PN=100% are Transylvania, Peloponnese, Czech, Montenegrin, Greek, and Vlach, each with IN>20.0 High with IN>15.0 are Macedonian, Slovak, and Serbian. In groupings, the Highest are cultures in the Polish/Lithuanian Empire, the Bulgarian Empire, and the Slav west cultures. High are the Balkan culture and the Slav language speakers. The lowest grouping is the Netherlandic cultures with IN=2.59, followed by the Swiss cultures, and the Italian language speakers. Next come the Mediterranean, Scandinavian, Spanish-speakers, and German-speakers. For religions, Orthodox are relatively high with IN=14.89 and Protestants are relatively low with IN=5.82.

Rotational D1 symmetry: 45 cultures. Overall averages are IN=3.00 and PN=48.5%, so almost half the men's vests have D1 symmetry. The Orthodox cultures have IN=4.45 and PN=62.2% which are both considerably higher than the average. The Protestants are low with IN=1.53 and PN=30.6%. For individual cultures, the Highest are Transylvania, Polish, Sicilian, Cycladic, Dalmatian, Peloponnese, Slovak, and Galician. The Highest grouping of cultures is Greek-speakers with IN=5.22, PN=78.3%; 5 of the 6 Greek-speaking cultures



display D1 symmetry. Also at the Highest level for groups are Finnish language cultures, the Ottoman Empire cultures, Slav west cultures, and cultures with a Russian connection. The Netherlandic cultures have absolutely no D1 designs on men's vests. Also low ranked groupings are the Swedish Empire cultures, Spanish-speakers, and cultures in Germany and France

The Rotational D2 and D4 symmetries are sparsely represented on men's vests, having low averages of  $IN=0.46$  and  $IN=0.24$  respectively. So there is not much to report. For D2 the Vlach, Transylvanian and Croat are worth mentioning as high, but many cultures and even groupings of cultures rank zero: Scandinavian, Netherlandic, North Sea, Swedish Empire, and cultures in areas of former Norse raids. The Protestants rank very low with  $IN=0.10$ . Relatively high groupings are cultures in the area of the former Polish/Lithuanian Empire and Slav west cultures. For D4 even less can be said, only that German Swiss and Bretons have two D4 appearances.

All Rotational D symmetries combined: 47 cultures. Overall averages  $IN=4.17$  and  $PN=54.0\%$ . Highest cultures are Transylvanian and Polish with  $IN=15.0$ , and Croat, Vlach, Galician, and Slovak. Higher are Montenegrin, Sicilian, Sarakatsani, Cycladic, Dalmatian, Peloponnese, Hungarian, and Cretan. Highest groupings are Polish/Lithuanian Empire cultures, Finnish language speakers, Ottoman Empire cultures, Greek-speakers, the Balkan cultures, and Slav west. Also High are the Byzantine Empire cultures, the Bulgarian Empire cultures, the Austro-Hungarian Empire cultures, the Slav-speakers, and cultures with a Russian connection. A grouping with absolutely no Rotational symmetry on men's vests is Netherlandic. Also low are Swedish Empire cultures, Spanish-speakers, cultures in Germany, the Scandinavian cultures, and North Sea cultures. French and Italian-speakers are relatively low. Protestants are low with  $IN=1.99$ , and Orthodox moderately high with  $IN=6.22$ .

Space-Filling Symmetry: None of the three most common Space-Filling symmetries,  $p1$ ,  $pmm$  and  $p4m$  makes more than 16 appearances on men's vests. For  $p1$ , there are 7 cultures with average  $IN=0.18$  and  $PN=4.0\%$ ; cultures worth mentioning are Jurassian, Luxembourgish, Leonese, and Swiss Italian. For  $pmm$  there are 12 cultures with average  $IN=0.39$  and  $PN=8.0\%$ . The Protestants ( $IN=1.12$  and  $PN=20.4\%$ ) are relatively (for  $pmm$ ) high with 4 of the 12 Protestant cultures displaying  $pmm$ . The Italian language speaking cultures average  $IN=1.29$  with 5 of the 7 such cultures displaying  $pmm$  symmetry. For  $p4m$

symmetry, IN=0.20 and PN=4.0. Ten cultures participate, but most have only one vest with pmm display. The Highest-ranking culture is Castilian followed by Danish.

All Space-Filling types combined. 35 cultures. IN average of 1.48 and PN average of 28.5%. However only about half of the 35 cultures had more than one piece showing Space-Filling symmetry. The Highest four cultures are Catalan, Finnish, Leonese and Luxembourgish. Also high are Balearic, Castilian, Jurassic, Danish, Swiss Italian, Sicilian, Calabrese, Provençal, and Andalusian. The strongest grouping consists of cultures in Spain with IN=3.52. Also high are Swiss cultures with IN=3.17 followed by Swedish, and the cultures of the Hapsburg Spanish Empire. Next come North Sea cultures, Scandinavian cultures, Mediterranean, Moorish influence, and Italian-speakers. Low groupings are Netherlandic and Greek-speakers having absolutely no Space-Filling designs on men's vests. Also low are Slav west, Balkan, Bulgarian Empire, Germany, and the Ottoman Empire. The Orthodox ranked low with IN=0.33 and the Protestants relatively high with IN=2.35, just the opposite of what has been the case in most earlier cases.

### **WOMEN'S SKIRTS/DRESSES: THE THIRD SPECIAL CASE**

By analyzing the designs on women's skirts and the lower half of dresses, and comparing them with the designs on women's vests, we can analyze the similarities and differences between the designs on the lower part of women's bodies with those on the upper part.

Frieze Type #1: Women's skirts/dresses: 55 cultures. Average IN=1.73 and PN=28.2%

Individual Cultures:

Highest: Maltese, Andalusian, Walloon, Dutch, Peloponnese, Saami, Greek,

Portuguese, Karelian

Groupings of Cultures:

Highest: Spanish language Swedish Empire., Polish/Lithuanian Empire, Greek language

Low: Alpine, Swiss cultures,

Religion: Orthodox cultures are relatively high.

Terrain: Plateau cultures are relatively high.



Frieze Type #2: 39 cultures. Average IN=0.59 and average PN=11.7%.

Individual Cultures:

Highest: Peloponnese, Vlach, Breton, Romanian, Bulgarian, Sarakatsani

Groupings of Cultures:

Highest: Greek language

Higher: Ottoman Empire, Balkan, Bulgarian Empire, Russian connection

Lowest: Netherlandic, North Sea, Scandinavian, Italy each have IN=0.0. Also low:

Swedish Empire

Religion: High: Orthodox IN=1.22, PN=23.6% (11 of 14 cultures)

Low: Protestant IN=0.09, PN=2.3% (2 of 12 cultures)

Frieze Type #3: 54 cultures. Average IN=1.42 and average PN=26.6%

Individual Cultures:

Highest: Leonese, Saami, Castilian, Juassians, Peloponnese, Bosnian Muslim,  
Icelandic, Transylvanian, Andalusian, Pomak, Macedonian

Groupings of Cultures

Highest: Spanish language, Spain, Moorish influence. Also high: Germany, Greek language

Lowest: Netherlandic, North Sea, Polish/Lithuanian Empire, Italy

Religion: High: Muslim IN=2.89, PN=46.2% (3 of 3 cultures)

High: Orthodox IN=1.99, PN=38.6% (11 of 14 cultures)

Terrain: High: Plateau IN=2.29, PN=36.2% (6 of 8 cultures)

Frieze Types #4 and #6 are displayed on only 15 and 10 cultures respectively. For Type #4, Albanians led with 3 of its 6 skirts/dresses, followed by Czech, Peloponnese and Latvian each with 2. For Type #6, Bretons had 2 of its 9 skirts/dresses, and Romanians had 2 of its 21

Frieze Type #5: 25 cultures. Average IN=0.35 and average PN=6.6%

Individual Cultures:

Highest: Moldovan, Andalusian, Galician, Ladin, Romanian, Latvian

Groupings of Cultures:

Highest: Moorish influence., Spanish language, Spain, Atlantic

Terrain: High: Plateau IN=0.64, PN=10.6% (4 of 8 cultures)

Frieze Type #7: 38 cultures. Average IN=0.82 and average PN=14.0%

Individual Cultures:

Highest: Bosnian Muslim, Montenegrin, Slovak, Alsatian, Catalan, Albanian, Czech, Sarakatsani, Andalusian, Hungarian, Serbian, Breton

Groupings of Cultures:

Highest: Germany. Also high: Bulgarian Empire, Ottoman Empire, Austro-Hungarian Empire

Lowest: Polish/Lithuanian Empire, Swedish Empire, Netherlandic, Switzerland

Religion: High: Muslim IN=1.64, PN=26.9% (3 of 3 cultures)

All Frieze Types combined. 57 cultures. Average IN=5.38, PN=64.8%.

Individual Cultures:

Highest: Andalusian (IN=14.58), Peloponnese (IN=13.91), Bosnian Muslim (IN=12.50), Saami (IN=12.50), Leonese (IN=11.50), Castilian (IN=11.25), Albanian (IN=10.83)

Higher: Sarakatsani, Walloon, Montenegrin, Portuguese, Romanian, Croat

Lowest: (each with IN=0.0): Balearic, Bavarian, Flemish, Frisian, Pasiego, Tyrolean.

Also low: Austrian, Corsican

Groupings of Cultures:

Highest: Spanish language (IN=11.18)

Higher: Moorish influence (IN=8.26), Greek language (IN=8.19), Balkan (IN=7.47), Ottoman Empire (IN=7.43)

High: Spain (IN=7.44), Ottoman Empire (7.43), Bulgarian Empire (IN=7.31)

Lower: Alpine (IN=2.31), Switzerland (IN=2.43)

Religion: Higher: Muslim (IN=8.46) (3 of 3 cultures), Orthodox (IN=7.38) (14 of 14 cultures)

Terrain: High: Plateau (IN=7.07) (7 of 8 cultures)

Rotational D1 symmetry: 25 cultures. Average IN=0.52 and average PN=7.8%

Individual Cultures:

Highest: Leonese, Macedonian, Montenegrin, Peloponnese, Serbian, Luxembourg, Austrian, Icelandic

Groupings of Cultures:

Highest: Spanish language, Balkan, Greek language, Spain, Bulgarian Empire, Moorish influence

Lowest: Five groupings have IN= 0.0: Netherlandic, North Sea, Slav west, Swedish Empire, Prussian Empire. Also very low are Italy, Italian language, Hanseatic League, Polish/Lithuanian Empire, Mediterranean, France, Norse connection, Finnish language

Religion: High: Orthodox IN=1.28, PN=15.7% (9 of 14 cultures)

Low: Protestant IN=0.17, IN=3.5% (Only 1 of 12 cultures)

Terrain: Low: Coastal IN=0.07, PN=1.5% (1 of 9 cultures)

Low: Plateau IN=0.16, PN=2.1%) (1 of 8 cultures)

All other Rotational symmetry types are only sparsely displayed. For D2, there are 7 cultures but only the Peloponnese with 3 of 16 skirts/dresses has more than a single skirts/dresses displaying a D2 design. For D4 only the Bosnian Muslim with 2 of 5 skirts/dresses and the Galician with 2 of 14 have more than a single skirts/dresses displaying D4. Muslim cultures are generally high.

All Rotational D symmetries combined. 35 cultures. IN=0.95, PN= 11.6%.

Individual Cultures:

Highest: Leonese (IN=0.50), Macedonian (IN=6.50), Bosnian Muslim (IN=5.00), Peloponnese (IN=3.75), Montenegrin (IN=3.50), Serbian (IN=3.46), Vlach (IN=3.00), Galician (IN=2.86), Portuguese (IN=2.81), Austrian (IN=2.50), Luxembourg (IN=2.00)

Higher: Breton, Icelandic,

Groupings of Cultures:

Highest: Spanish language (IN=3.38), Moorish influence (IN=2.72), Spain (IN=2.56), Atlantic (IN=2.29) Balkan (IN=1.81)

Higher: Greek language (IN=1.77), Slav south (IN=1.70), Bulgarian Empire (IN=1.63), Ottoman Empire (IN=1.58), Byzantine Empire (IN=1.41)

High: Hapsburg-Spanish Empire (IN=1.26), Spanish Empire (IN=1.28), Slav language (IN=1.22)

Lowest: Netherlandic (IN=0.0), North Sea (IN=0.0), Prussia (IN=0.0), Italy (IN=0.04), Italian language (IN=0.16), Mediterranean (IN=0.17), Hanseatic League

(IN=0.16), Swedish Empire (IN=0.23), Slav west (IN=0.24), Polish/Lithuanian Empire (IN=0.28)

Religion: Higher: Orthodox (IN=1.81)

Low: strong Protestant (IN=0.32), mod. Prot. (IN=0.48), non-Prot. (IN=1.20)

Terrain: Low: Coastal (IN=0.33)

Space-Filling p1 symmetry: 21 cultures. Average IN=0.25 and average PN=5.3%.

Individual Cultures:

Highest: Tyrolean, Frisian, Catalan, Cycladic, Corsican, Cretan

Groupings of Cultures:

Highest: French Empire, France, Venice Trade, German language Greek language,

Religion: Low: Muslim IN=0.0, PN=0.0% (0 of 3 cultures)

Terrain: High: Coastal IN=0.48, PN=10.3% (5 of 9 cultures)

Space-Filling pmm symmetry: 40 cultures. Average IN=1.02 and average PN=22.4%

Individual Cultures:

Highest: Estonian, Albanian, Dutch, Lithuanians Walloon, Provençal, Pomak,  
Burgundian, Friulian, Sardinian

Groupings of Cultures:

Highest: Swedish Empire, Polish/Lithuanian Empire, Finnish language

Higher: Netherlandic, Hanseatic League, Russian connection

Religion: High: Muslim IN=2.60, PN=46.2% (3 of 3 culture)

High: Protestant IN=1.51, PN=26.7 (6 of 12 cultures)

Low: Orthodox IN=0.57, IN=11.0% (7 of 14 cultures)

Space-Filling p4m symmetry: 16 cultures. IN=0.17, PN=3.6%.

Individual Cultures:

Highest: Pasiego, Norwegian, Peloponnese, Lithuanian, Walloon

Groupings of cultures

Higher: Polish/Lithuanian Empire, Hanseatic League, Atlantic, Spain, North Sea,  
Norse Raid

Lowest: (each with IN=0.0) Finnish language, Germany, Adriatic, Swedish Empire,  
English connection

All Space-Filling types combined. 62 cultures. Average IN=2.18 and average PN=45.7%

Individual Cultures:

Highest: Estonian (IN=6.79), Pasiego (IN=6.25), Lithuanian (IN=5.0), Auvergnat (IN=5.00), Bavarian (IN=5.00), Tyrolean (IN=5.00), Albanian (IN=5.00), Frisian (IN= 4.38)

Higher: Catalan, Friulian, Karelian, Norwegian, Burgundian, Dutch, Tuscan, Balearic, Finnish, Walloon

Groupings of Cultures:

Higher: Swedish Empire (IN=3.86), Polish/Lithuanian Empire (IN=3.85), Netherlandic (IN=3.68),

High: Hanseatic League, Russian connection, Norse connection, Finnish language, North Sea, French Empire

Lowest: Atlantic (IN=0.75), Moorish influence (IN=0.87), Spanish language (IN=1.12).

Also Low: Germany

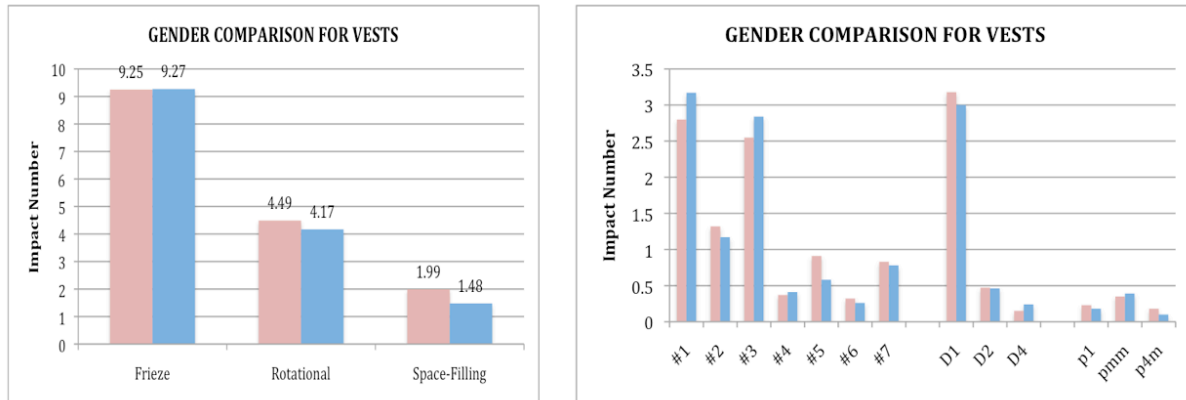
Religion: slightly high: Protestant (IN=2.97). 10 of 12 cultures

## **GENDER: COMPARING MEN'S VESTS WITH WOMEN'S VESTS**

Comparing men's vests with women's vests yields interesting results. For men's vests, Frieze Type #1 (IN=3.17 and PN= 46.7%) and Rotational symmetry D1 (IN=3.00 and PN=48.6%) are the two most highly favored symmetry types. The PN numbers show almost half the men's vests display each of these symmetry types. The third most displayed symmetry is Frieze Type #3 with IN=2.84 and PN= 44.9%. The numbers are similar to those for women's vests: D1 (IN=3.18 and PN=45.6%) and Frieze Type #1 (IN=2.80 and PN=41.9%) followed by Frieze Type #3 (IN=2.55 and PN=36.8%).

Fig. 11 shows general type-by-type similarity between the genders, with women making slightly more use of Rotational and Space-Filling symmetries than men.





**Figure 11. Gender Comparison for symmetry types for vests: women (red) and men (blue).**

For all Frieze types combined, men’s vests have 15 cultures at the High, Higher, or Highest ranking, and 10 of these 15 cultures similarly rank High, Higher, or Highest on women’s vests. Statistically one would expect an overlap of about 4, so 10 demonstrates a strong gender overlap related to which cultures favor displaying friezes in general.

Corresponding figures for all rotational symmetries combined are: 9 of the 16 High or above men’s vests cultures are High or above for women’s vests as opposed to the expected 4. For all Space-Filling combined, the numbers were not quite as convincing: 7 of the 20 High or above for men’s vests overlapped with the women’s as opposed to the expected 5.

Yet other gender similarities and differences can be found. There is not as much breadth of Frieze Types for men’s vests as there is for women’s vests. For women’s vests, the grouping of cultures located in the area of the former Bulgarian Empire strongly displays all seven Frieze Types, while the other four members of the triple B-O-S cultures (Bulgarian Empire, Balkan, Byzantine Empire, Ottoman Empire, and Slavic) each strongly displays six Frieze Types, as does the grouping of Adriatic cultures. By contrast, for men’s vests (Table 4) there is no grouping displaying seven Frieze Types, only one grouping, the Slavic language cultures, that displays six, and only two groupings, the Bulgarian Empire cultures and the Slav West cultures, display five. In Rotational symmetries for women, there are ten cultural groupings that are strong in both D1 and D2 display. Particularly strong, the triple B-O-S cultures again possess not only the most breadth but also the most overall strength, along with the Scandinavian grouping and the Austro-Hungarian Empire grouping. In contrast, for men’s vests, only two groupings, the Slav West cultures and the Balkan cultures, display both D1 and D2 strongly.

For individual cultures, in terms of breadth of Frieze Types for women's vests, the Montenegrin culture displays six Frieze Types. Nine other cultures, Transylvanian, Sarakatsani, Croat, Slovak, Bosnian Muslim, Bulgarian, Albanian, Greek, Serbian display five Frieze Types, and many more display four. For men's vests no culture displays six Frieze Types, only the Czechs display five, and only the Transylvanians and the Montenegrins display four. Not only is there less breadth, completely different cultures (except for the Montenegrins) display Frieze breadth.

The grouping of cultures that most strongly avoids display of Frieze symmetry on women's vests is by far the Netherlandic cultures, followed by almost anything France-related, cultures in areas occupied by the former Swedish Empire, and the North Sea cultures. For Rotational symmetry, the Netherlandic cultures again stood by far as bottommost with  $IN=0.0$ . For Space-Filling symmetry, many cultures and groupings of cultures had basically zero representation.

In contrast, for men's vests, the grouping of cultures that most avoids Friezes in general is the Swiss cultures. For Rotational symmetries, the Swedish Empire cultures had nearly zero  $IN$  and  $PN$ , and the German cultures, Spanish language speakers, Scandinavian cultures and North Sea cultures were also low. For Space-Filling, Greek cultures had zero  $IN$  and  $PN$  values.

Plateau cultures consistently rank high for Frieze Type #5, not only for both men's and women's vests, but also for men's and women's blouses, men's and women's hats, women's skirts, dresses and aprons. For women's vests, Mountain cultures rate high for Frieze Types #2 ( $\wedge\wedge\wedge\wedge$ ) and #5 (SSSSS), and hilly cultures rank high for Type #4 (EEEE). For men's vests, cultures with Plateau terrains ranked high for Frieze Types #3 (6 of the 8 Plateau cultures display this Type) and for Space-Filling symmetry type  $pmm$ . Coastal cultures ranked low for Frieze Type #4.

Relative to religion, for women's vests, Orthodox-based and Muslim-based cultures are both strong users of Frieze Types #3, #4, and #5, but their choices diverge for Type #6 where Orthodox remains high while Muslim surprisingly switches to quite low. In addition, Muslim cultures are strong in both Frieze Type #7 and Rotational D1. The Protestants rank low in display of Frieze Types #2, #3, and #4, while Catholics are quite low in Frieze Type #5. For Muslims there is a major contrast between the relatively high levels of display for Friezes and Rotational symmetries in general compared with the relatively low displays for

Space-Filling, especially low for p1 and pmm. The Orthodox have a similar contrast, with a very low p1 ranking. Of special interest is that if one subdivides cultures into strong Orthodox, mixed Orthodox, and non-Orthodox, then the use of Friezes is strong, moderate and weak, respectively.

For men's vests, Orthodox cultures are strong in Frieze Types #2, #4, #5, #7, and Rotational D1. Protestants are low in these same five types and also D2, but are relatively high in the Space-Filling pmm. The Orthodox rank quite high for all Friezes combined (IN=14.89) and all D Rotational symmetries combined (IN=6.22) but quite low for all Space-Filling symmetries combined (IN=0.33), just the reverse of the Protestants who were low for Friezes (IN=5.82) and Rotations (IN=1.99) while high in Space-Filling (IN=2.35).

We turn to users of rarely occurring symmetry types. For women's vests, the Albanians have considerably more display than expected for C2, D9, D10 and p4 symmetries. The Friulians have a relatively strong use of cm, pm, and pmg symmetries, and the German Swiss of p2, cm, and pmg. For men's vests, the Finnish display cmm to a degree far more than expected, as do the German Swiss for pg and pmg, and the Catalans for cm and cmm, and the Swiss Italians for pm and pmg.

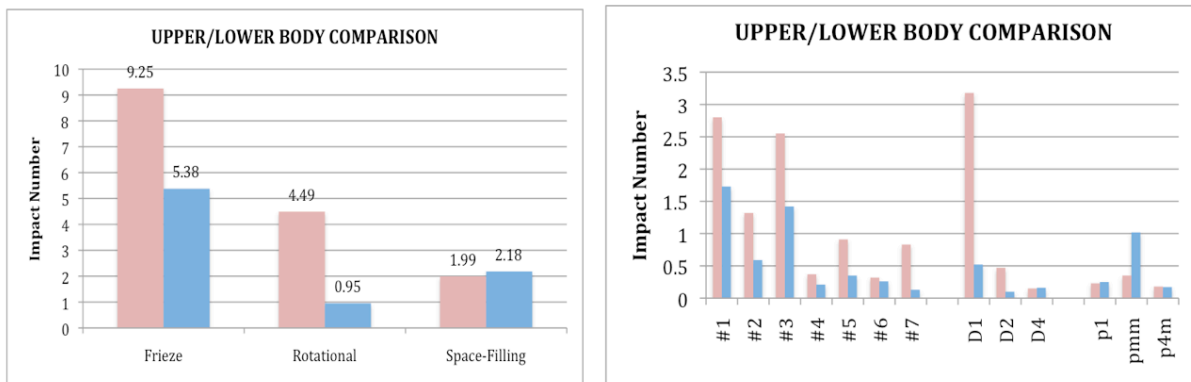
In terms of bipolarity, for women's vests, the Netherlandic grouping of cultures is by far the lowest among of all 57 groupings for combined Friezes, and also is the only grouping that presents IN=0.0 for combined Rotational designs, but in extreme contrast is the absolute highest grouping for combined Space-Filling designs. The grouping of Spanish language cultures is also bipolar: very low in Frieze Types #2, #3, #4, and #5 and also for Space-Filling in general, but rank absolute tops for combined Rotational designs. The Scandinavian cultures as a group are very low for Frieze Types #2 and #7 while being very high for Frieze Type #1, Rotational type D2, and Space-Filling types p1 and pmm. The Finnish grouping is low in type #3 and high in D1. The German-speakers are low in Type #4 and high in Type #7 and p4m. The Greek cultures are low in #7 and high in #5. Finally and very significantly, each of the triple B-O-S groupings is highly ranked for Friezes and Rotational symmetry but nearly omitted for Space-Filling symmetry in terms of ⊗ or x or • on the women's vests chart in Table 2.

For men's vests bipolarity, the grouping of Italian language speakers is very low in Frieze Types #1 and #3 while being very high in Space-Filling pmm. Swiss cultures are low in Frieze Types #3, #4, and #7 and high in Space-Filling p1. The Scandinavian grouping is

quite low in general Frieze Types and general Rotational types, but high for general Space-Filling.

**UPPER BODY/LOWER BODY:  
COMPARING WOMEN’S VESTS WITH WOMEN’S SKIRTS & DRESSES**

Fig. 12 illustrates some interesting differences between designs on women’s vests (above-waist) and women’s skirts/dresses (below-waist). The Frieze Impact Numbers for women’s vests are generally double that for skirts/dresses. This is the first piece of evidence that for women, designs on clothing on the lower part of the body attract a different kind of symmetry



**Figure 12. Upper Body/Lower Body Comparison: vests (red) and skirts / dresses (blue).**

than on the upper. The difference ratio is even higher for Rotational symmetry. However for Space-Filling symmetry, matters are significantly reversed: the appearance of Space-Filling symmetry on the lower body actually outscores that on the upper body.

D1 was the most favored symmetry type for both men’s and women’s vests. But for skirts/dresses this symmetry type has fallen all the way to 8<sup>th</sup> place (IN=0.52 and PN=7.8%). On the other hand, Frieze Types #1 (IN=1.73 and PN= 28.2%) and #3 (IN=1.42 and PN=26.6%) are very high for both clothing categories.

Just as was true with men’s and women’s vests, there is considerable overlap between cultures that strongly use friezes on vests and those that strongly use friezes on skirts/dresses. There are 21 cultures at the High, Higher, or Highest ranking for general use of friezes on below-waist skirts/dresses, and of these, 14 rank similarly High or above on above-waist women’s vests. Statistically one would expect an overlap of about 6 or 7, so 14 demonstrates an unusual amount preference overlap. The corresponding figures for all Rotational symmetries combined are similar: there are 14 cultures that are High or above in the

skirts/dresses cohort, and of these 8 are also High or above for women's vests, as opposed to the expected 4. However for all Space-Filling combined, the numbers show no significant degree of overlap between upper and lower use.

For Frieze Type breadth on skirts/dresses, only the Bulgarian and the Ottoman Empires have as many as five of the seven Frieze Types, and none of these registered as  $\otimes$ .

Relative to religion, skirts/dresses demonstrate both similarities and differences when compared with vests. The Orthodox and Muslim cultures rank high in frieze symmetry, with Orthodox especially high in Frieze Types #1, #2, #3, and the Muslims in #3, #4, and #7. The Protestants are low in #2, #4, and #6. In Rotational D1 symmetry, Orthodox cultures are high, Protestants and Catholics slightly low. In Space-Filling symmetry the situation is reversed with Protestant high and Orthodox low. The Coastal cultures and those with Plateau terrain were both low on D1 symmetry. Plateau cultures rank high for Frieze Types #3 and #5. If cultures are subdivided into strongly Protestant, moderate, and non-Protestant, the use of dihedral Rotational symmetry is inversely correlated: weak, moderate and strong.

In bipolarity of skirts/dresses clothing, the Polish/Lithuanian Empire grouping of cultures ranks high in Frieze Type #1 and Space-Filling pmm, and low in Frieze Types #3, #5, and Rotational symmetry D1. The Swedish Empire ranks high in Frieze Type #1 and pmm while low in Frieze Types #2, #7 and symmetry types D1 and p4m. The Netherlandic cultures are low in Frieze Types #2, #3, and Rotational D1, but high in Space-Filling type pmm. The North Sea cultures are low in Frieze Types #2, #3, and #7, while high in symmetry type p4m. Cultures in Germany are low in p4m while high in Frieze Types #3 and #7.

Apart from the 13 commonly appearing symmetry types, most other types of symmetry do not appear at all on skirts/dresses. The few that do, appear rarely. The Leonese culture plays a prominent role in the displays of these rare types. Most of the symmetries C2 through Cn (with  $n > 12$ ) fail to appear, the only exceptions being a solitary appearance for each of C2 and C7, and in both cases it is on a Leonese costume. D6 has 5 occurrences of which one is Leonese; D7 has 4 occurrences including one Leonese; and D8 has 4 occurrences and again one is Leonese. D3, D5, D9, D10, D11 fail to appear.

## **INFLUENCE OF GEOGRAPHICAL ADJACENCY**

The tendency for cultures in geographical proximity of one another to select similar types of symmetry is illustrated in Figs. 7, 8, 9, 10 and 13. In the Broad View section a statistical



**Figure 13. Men’s vests. Rotational D1 symmetry. The darker dots indicate the cultures having the top 22 INs. Notice the tendency of the strong users to congregate.**

algorithm was discussed that measures how certain one can be that such a tendency has not occurred merely by chance. Fig. 14 shows adjacency clearly plays a highly significant role in choice of symmetry types for a very large number of symmetry types and clothing types.

**a) Women’s Vests**

| All Friezes                         | All Rotation             | All Space Filling                   | Friezes                  |                                     |                                     |                                     |                                     |                          |                                     | Rotations |    |    | Space-Filling                       |     |     |
|-------------------------------------|--------------------------|-------------------------------------|--------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|--------------------------|-------------------------------------|-----------|----|----|-------------------------------------|-----|-----|
|                                     |                          |                                     | #1                       | #2                                  | #3                                  | #4                                  | #5                                  | #6                       | #7                                  | D1        | D2 | D4 | p1                                  | pmm | p4m |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> |           |    |    | <input checked="" type="checkbox"/> |     |     |

**b) Men’s Vests**

| All Friezes                         | All Rotation                        | All Space Filling        | Friezes                  |                                     |                                     |    |                                     |    |                                     | Rotations                           |    |    | Space-Filling                       |                          |                                     |
|-------------------------------------|-------------------------------------|--------------------------|--------------------------|-------------------------------------|-------------------------------------|----|-------------------------------------|----|-------------------------------------|-------------------------------------|----|----|-------------------------------------|--------------------------|-------------------------------------|
|                                     |                                     |                          | #1                       | #2                                  | #3                                  | #4 | #5                                  | #6 | #7                                  | D1                                  | D2 | D4 | p1                                  | pmm                      | p4m                                 |
| <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |    | <input checked="" type="checkbox"/> |    | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |    |    | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> |

**c) Women’s Skirts&Dresses**

| All Friezes                         | All Rotation                        | All Space Filling                   | Friezes |                                     |                                     |                          |                          |    |                                     | Rotations                           |                          |    | Space-Filling                       |                          |     |
|-------------------------------------|-------------------------------------|-------------------------------------|---------|-------------------------------------|-------------------------------------|--------------------------|--------------------------|----|-------------------------------------|-------------------------------------|--------------------------|----|-------------------------------------|--------------------------|-----|
|                                     |                                     |                                     | #1      | #2                                  | #3                                  | #4                       | #5                       | #6 | #7                                  | D1                                  | D2                       | D4 | p1                                  | pmm                      | p4m |
| <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |         | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |    | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> |    | <input checked="" type="checkbox"/> | <input type="checkbox"/> |     |

**Figure 14.  indicates strong influence of adjacency of cultures on the use of symmetry type for 7 or more cultures at the 99% level of significance.  refers to the 95% level of significance.  indicates strength at the 90% level. Strong influence for between 4 and 6 cultures is denoted with o .**

**COMPATIBILITY AND INCOMPATIBILITY OF VARIOUS SYMMETRY TYPES**

For men’s vests, the right side of Table 4 shows that of the 36 groupings of cultures that have moderate to heavy display of designs, three categories dominate: 1) Half of the first 18 groupings of cultures display both Friezes and Rotational D1/D2 but avoid Space-Filling

symmetry, 2) the other half are almost exclusively Frieze displayers, and 3) the next 12 groupings display almost exclusively Space-Filling symmetry. The remaining 6 at the bottom are not strong displayers of any type, but the symmetry they do display would fit them into category 1.

The right side of Table 2 shows that for women's vests, just as with men's vests, there are basically only three preferred mixes of symmetry: 1) groupings that use both Friezes and D1/D2 symmetry but avoid Space-Filling symmetry, 2) groupings that display almost exclusively D1 and occasionally D2 symmetry and 3) groupings that display almost exclusively Space-Filling designs. Note that categories 1) and 3) are the same for vests of both genders, while the second category is quite different.

Switching body position to below the waist, for women's skirts/dresses, the right side of Table 5 again reveals three basic kinds of cultural groupings: 1) Frieze users that use Rotational D1 or D4 or both, 2) Frieze users that use Space-Filling designs, and 3) exclusively Space-Filling users. Unlike for women's vests and for men's vests, there is no solely Rotational display; however, Space-Filling has become a prominent part of two categories, rather than just one.

There are eight possible combinations of the three symmetry categories of Friezes, Rotations and Space-Filling symmetries. For each of men's vests, women's vests, and women's skirts/dresses, only three of the eight combinations were represented to any significant degree, although the choice of which three varies slightly depending on body position and gender. In no case is there any significant use of cultural groupings that display only Friezes, and the pairing of Rotational and Space-Filling never has many adherents, and likewise for the pairing of Friezes and Space-Filling.

This strong division of groupings of cultures into so few distinct possible types of use of symmetry is a significant finding of this study, revealing a conscious or subconscious set of preference rules that applies to folk costumes throughout all of Europe.

## **CONCLUDING REMARKS**

One of the principal dilemmas in our society is the wide separation between those grounded in science/engineering fields, and those grounded in the humanities. One benefit of this project is that it contributes positively to easing this Two Cultures dilemma by building a bridge between the fields of mathematics, anthropology, and art.

The analysis methods employed for this project have introduced new concepts, new vocabulary, and new approaches, thereby providing a new mathematical observational viewpoint for costume and textile researchers. The tools developed may prove to be useful for costume researchers and others to help determine whether and when various cultures have interacted with one another in the past by comparing designs on their artifacts. These tools include 1) the use of mathematical group theory to sort designs into families, 2) the use of categories (57 in our case) to gain an understanding of the nature of these families, 3) the use of a progressive set of maps to provide a flipbook description of the spread of a design or concept, and 4) a simultaneous statistical tri-level analysis: fine-grain, mid, and broad. Our goal has been to present this new Ethnomathematical viewpoint.

### **THE RAW DATA SPREADSHEET AND THE ACCESS DATABASE**

An Excel spreadsheet listing the information recorded on each of the 18,686 costume designs can be viewed, downloaded, and explored at Deep Blue Data. All the usual Excel sorting possibilities are available, and in addition a useful filter has been installed. For example, to find the number of designs that are Frieze Type #1, go to the top of the frieze type 2 column (column AS), click on the drop-down arrow and unselect every option box except True (i.e. True should be turned on, all other choices turned off). Then in the lower left corner, one reads “1111 of 18686 records found”.

Much more sophisticated exploration can be carried out by downloading the rich and flexible Access Database. The terms used for this database were described in three earlier sections of this paper: Database Description, Impact Number (IN) and Percentage Number (PN), and How the Database is Employed. The database can be downloaded and explored at Deep Blue Data.

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**APPENDIX**  
**CATALOG OF CULTURES**

The 73 European cultures included in the study are listed, together with the names of museums visited that displayed folk costumes for that culture. The geographic locations of cultures is given in Fig. 2.

**Albanian**

1. Ethnographic Museum of Vlora, Albania
2. Gjrokaster Ethnographic Museum, Gjrokaster, Albania
3. Beratti Museu, Beratti, Albania
4. Ethnic costume shop, Beratti, Albania
5. Intenational Folk Dance Festival in Vlora, Albania
6. Ethnographic Museum, Kruje, Albania
7. Costume shops in Kruje, Albania
8. National Museum of Macedonia, Skopje, Macedonia (Gordon Nikolov, Program Director)
9. National Museum of Montenegro Cetinje, Montenegro (Maja Dragicevic, Director, Peter, Director of Ethnology)

**Alsatian**

1. Costume Store: Maison Bossert Costume d'Alsacu, Strasbourg, France
2. Musee Alsacien, Strasbourg (Annette Haber), France

**Andalusian**

1. Museo del Traje, Madrid, Spain, second visit (Irene Seco Serra, Conservadora de Indumentaria Popular), first visit (Manuel Berges, and Concha Herrane)
2. Poble Espanol, Barcelona (Silvia Ventosa, researcher, and Delors Llopart, director)

**Austrian**

1. Volkskunstmuseum, Graz, Austria (Roswitha Orac-Stripperger, director)
2. Ethnographic Museum, Vienna, Austria

**Auvergnats**

1. Musee Regional d'Auvergne, Riom, France (Anne Chanonat, Director)
2. Musee des Arts, Metiers et Traditions Populaires du Massif Central, Saint Dideir-en-Velay, France (Georges Dubouchet, Conservateur, G.de Fraissinette, Responsible)

**Balearic**

1. Museo del Traje, Madrid, Spain, return trip (Irene Seco Serra, Conservadora de Indumentaria Popular)

**Basque**

1. Basque Costume at a wedding ceremony and dance exhibition, Pamplona, Spain
2. Musee Basque, Bayonne, France

3. Basque costumes at a wedding ceremony and dance exhibition, Pamplona, Spain
4. Poble Espanol, Barcelona, Spain (Silvia Ventosa, researcher, and Delors Llopart, director)
5. Museo del Traje, Madrid, Spain, return trip (Irene Seco Serra, Conservadora de Indumentaria Popular)

### **Bavarian**

1. Trachten-Informationszentrum, Benediktbeuern, Germany (Alexander Wandinger, leiter)
2. Germanisches National Museum, Nürnberg, Germany (Dr. Jutta Zander-Seidel)

### **Bosnian Muslim**

1. Ethnographic Museum, Belgrade, Serbia (Mirjana Menkovic, Vilma Niskanovic, Vera Momcilovic, costume curators, Velibor Stojakovic, manager)
2. Ethnographic Museum of Croatia, Zagreb, Croatia (Damodar Frián, Director)

### **Breton**

1. Musée du Costume Breton, Sainte-Anne-d'Auray, France
2. Musée Départemental Breton, Quimper, France (Margareth Le Guellec-Dabrowska, Conservateur)

### **Bulgarian**

1. Nacionalen Etnografski Muzej, Sofia, Bulgaria (Dr. Nadezhda Teneva, Anita Komitska, Veska Borisova)
2. Ethnografski Muzej, Plovdiv, Bulgaria
3. Elhoven Ethnographic Museum, Elhoven, Bulgaria
4. Ethnographic museum of Varna, Varna, Bulgaria
5. Gagauz Museum, Knvarno, Bulgaria
6. National Museum of Ethnography, Warsaw, Poland (Patrik Pawlaczyk costume conservator)

### **Burgundian**

1. Musée de la Vie Bourguignonne, Dijon, France (Christine Peres, Curator, and Madeleine Blondel, Conservateur en Chef)

### **Calabrese**

1. Istituto Centrale per la de antropologia a Museo Nazionale delle Arti e Tradizioni Popolari, Rome, Italy (Paolo Maria Guarrera)
2. Museo del Costume Museum, Tiriolo, Italy (Wanda Ferro, Presidente delle Provincie)
3. Hotel Due Mari, Tiriolo, Italy has old costumes on display

### **Castilian**

1. Museo del Traje, Madrid, Spain, second visit (Irene Seco Serra, Conservadora de Indumentaria Popular), first visit (Manuel Berges, and Concha Herrane)
2. Poble Espanol, Barcelona, Spain (Silvia Ventosa, researcher, and Delors Llopart, director)

### **Catalan**

1. Museo del Traje, Madrid, Spain, second visit (Irene Seco Serra, Conservadora de Indumentaria Popular), first visit (Manuel Berges, and Concha Herrane)
2. Museu Textil i d'Indumentaria, Institut de Cultura de Barcelona, Barcelona, Spain (Rosa M.Martin, directora)
3. Poble Espanol, Barcelona, Spain (Silvia Ventosa, researcher, and Delors Llopart, director)

### **Corsican**

1. Musée du Costume corse, Canari, Corsica, France (Yves Pellegrini, Director, M. Bertoni, mayor)

### **Cretan**

1. Chania Folk Costume Museum, Chania, Crete, Greece
2. Historical and Folk Art Museum, Rethymon, Crete, Greece
3. Historical Museum of Crete, Heraklion, Greece (Angeliki Baltatzi, Curator)
4. Museum of Traditional Greek Costumes, Naousa, Paros, Greece (Konstantinos and Marouso Roussos)
5. Peloponnesian Folklore Foundation and Costume Museum, Nafplion, Greece (Ionna Papantoniou, director and president)

### **Croat**

1. Ethnographic Museum of Croatia, Zagreb, Croatia (Damodar Frián, Director)
2. Państwowe Muzeum Etnograficzne, Warsaw, Poland (Dr. Piskosz-Branekova and Jan Letowski)

### **Cycladic**

1. Museum of Traditional Greek Costumes, Naousa, Paros, Greece (Konstantinos and Marouso Roussos)
2. Lyceum of Greek Women on Syros, Syros, Greece (Christina Ligopsixaki-Dendrinou)
3. Benaki Museum, Athens, Greece
4. Research Centre of Greek Folklore Academy, Athens (Katerina Kamilaki, director, and Leftez Alexakis)

### **Czech**

1. Museum a Galerie Severního Plzeňského Mariánského Týnce, Kralovice Czech Republic
2. Pilsen Museum, Pilsen, Czech Republic (Daniel)
3. Národopisné muzeum (Ethnographic Museum), Prague, Czech Republic
4. Museum of Moravian Slovakia, Uherské Hradiště, Czech Republic (Rasticová Blanka, Dr. Ivo Frolec)
5. Museum of Velké Bilovice, Velké Bilovice, Czech Republic (Ivana Palková, Vladmira Sedlová)

### **Dalmatian**

1. Ethnographic Museum of Croatia, Zagreb, Croatia (Damodar Frián, Director)
2. Ethnographic Museum, Belgrade, Serbia (Mirjana Menković, Vilma Niskanović, Vera Momčilović, costume curators, Velibor Stojaković, manager)

### **Danes**

1. Nationalmuseet in Brede, Kgs Lyngby, Denmark
2. Kalundborg og Omegns Museum, Kalundborg, Denmark (Mads Findal Andreasen, director)
3. Fanø Skibsfarts-og Dragtsamling. Fanø, Denmark

### **Dutch**

1. Germanisches National Museum, Nürnberg, Germany (Dr. Jutta Zander-Seidel)
2. Openluchtmuseum, Arnhem, Netherlands (Monique and Jacco)
3. Zuiderzeemuseum, Enkhuizen, Netherlands

### **Estonian**

1. Estonian Open Air Museum (Festival), Tallinn
2. Estonian National Museum, Tartu (Jaanus Sillavere)

### **Finn**

1. National Museum of Finland, Helsinki, Finland (Raila Kataja)
2. National Costume Center of Finland, Jyväskylä (Ritva Hanninen, curator)
3. Museum of Northern Ostrobothnia, Oulu, Finland (Ulla Toppila and Sanna Eskola)

### **Flemish**

1. ModeMuseum of Antwerp, Antwerp, Belgium (Frieda Sorber)
2. Provincial Openluchtmuseum, Bokrijk, Belgium (Eddy Vos, Vos Feytons)

### **Frisian**

1. Fries Museum, Leeuwarden, Netherlands
2. De Gouden Leeuw, Nordhorn, Netherlands (Sytze Pilat, director)
3. Hidde Nijland Museum, Hindeloopen, Netherlands
4. Openluchtmuseum, Arnhem, Netherlands (Monique and Jacco)

### **Friulian**

1. Museo Carnico Friuli, Tolmezzo, Italy
2. Civico Museo di Storia e Arte (costumes in a separate building), Udine, Italy
3. Istituto Centrala per la de antropologia a Museo Nazionale delle Arti e Tradizioni Popolari, Rome, Italy (Paolo Maria Guarrera)

### **Galician**

1. Museo do Pobo Galego, Santiago de Compostela (Luciano Garcia Além, director)
2. Museu del Mara in Betanzos, La Coruna (This museum absorbed Museo del Traje Gallego, and so has rooms of costumes) (Alfredo Erias, Biblioteca Municipal Castelao, Betanzos)
3. Poble Espanol, Barcelona (Silvia Ventosa, researcher, and Delors Llopart, director)
4. Museo del Traje, Madrid, Spain, second visit (Irene Seco Serra, Conservadora de Indumentaria Popular), first visit (Manuel Berges, and Concha Herrane)

### **German Swiss**

1. Germanisches National Museum, Nürnberg, Germany (Dr. Jutta Zander-Seidel)
2. Schweizerisches Landesmuseum Zurich, Zurich, Switzerland (Sigrid Pallmert, Kuratorin)

3. Historical Museum of Lucerne, Luzern, Switzerland (Peter Hofer, Hans Horat)
4. Musee Bibliotheque, Bulle, Switzerland

### **German**

1. Germanisches National Museum, Nürnberg, Germany (Dr. Jutta Zander-Seidel)
2. Schwarzwälder Trachtenmuseum, Haslach, Germany (Alois)
3. Schwarzwälder Freilichtmuseum, Gutach, Germany

### **Greek**

1. Museum of Traditional Greek Costumes, Naousa, Paros, Greece (Konstantinos and Marouso Roussos)
2. Research Centre of Greek Folklore Academy, Athens, Greece (Katerina Kamilaki, director, and Leftez Alexakis)
3. Lyceum Club of Greek Women, Athens
4. Benaki Museum, Athens, Greece

### **Hungarian**

1. Matyó Múzeum, Mesokovesd, Hungary (Andrea Halász, Director)
2. Dobo Istvan Castle Museum, Eger, Hungary (Dr. Tivadar Petercsak, Director)
3. Folk Art Museum, Budapest, Hungary (Dr. Zoltan Fejos, Director)
4. Museum of the Sarkosz (\*Decs Nagy Községi Faluház), Decs, Hungary (Decsi-Kiss András)
5. National Museum of Ethnography, Warsaw, Poland (Ptryk Pawlaczyk costume conservator)

### **Icelandic**

1. National Museum in Reykjavik, Iceland
2. Heimilsidnadarafnid Textile Museum, Blonduos, Iceland (Elin Sigurdardottir, Director)
3. Icelandic Costume Studio, Laufasvegi 2, 101 Reykjavik, Iceland, (Hildur ad Oddng)
4. Museum in a library in Akureyri with 3 costumes

### **Ionian**

1. Museum of Traditional Greek Costumes, Naousa, Paros, Greece (Konstantinos and Marouso Roussos)
2. Lyceum of Greek Women on Syros, Syros, Greece (Christina Ligopsixaki-Dendrinou)
3. Benaki Museum, Athens, Greece

### **Jurassian**

1. Musee Jurassien d'art et histoire, Delemont, Switzerland (Eva Racine, Marianne Droux)

### **Karelian**

1. National Museum of Finland, Helsinki, Finland (Raila Kataja)
2. Museum of North Karelia, Joensuu, Finland (Helena Kylmanen, Prof. Outi Suoranta)

### **Kashubian**

1. Muzeum Kaszubskie, Kartuzy, Poland
2. Muzeum Pomorza Srodkowego, Slupsk, Poland (David, ethnographer, anthropologist)
3. Panstwowe Muzeum Etnograficzne, Warsaw, Poland (Dr. Piskosz-Branekova and Jan Letowski)
4. Muzeum Etnograficzne, Torun, Poland (Kinga Turska-Skowronek and Janina Lukasiewicz)

### **Ladin**

1. Museo Ladin de Fassa, Vigo di Fassa, Italy (Monica Sommariva)
2. Museo di Storia, Usi, Costumi e Tradizioni della Gente Ladina, Livinallongo, Italy

### **Latvian**

1. National History Museum of Latvia, Riga, Latvia (Dr. Arnis Radins, director, Ilze Zingite)
2. National Costume Center of Latvia, Riga, Latvia
3. Latvian Ethnographic Museum, Riga, Latvia
4. Liepaja Museum, Liepaja, Latvia (Ilze Dobele)

### **Leonese**

1. Museo del Traje, Madrid, Spain second visit (Irene Seco Serra, Conservadora de Indumentaria Popular) first visit (Manuel Berges, and Concha Herrane)
2. Poble Espanol, Barcelona (Silvia Ventosa, researcher, and Delors Llopart, director)

### **Lithuanian**

1. Zidinys Gallery, Vilnius, Lithuania (Laimute Lukoseviciene, director)
2. Costume researcher, Migle Lebednikaite, with specialty in Lithuanian aprons was assigned by Laimute Lukoseviciene to accompany us to museums and galleries
3. National Gallery, Vilnius, Lithuania (Birute Kulnyte, director)
4. Trakai History Museum, Trakai, Lithuania (Irena Senuliene, curator)

### **Luxembourgish**

1. Folklor-Groupe "UUCHT-LA VEILLEE", Luxembourg-City, Luxembourg (Ferdy Dumont, secretary, Tilly Dumont)

### **Macedonians**

1. National Museum of Ethnography, Warsaw, Poland (Patryk Pawlaczyk costume conservator)
2. National Museum of Macedonia, Skopje, Macedonia (Gordon Nikolov, Program Director)
3. Benaki Museum, Athens, Greece

### **Maltese**

1. Gharb Folklore Museum of Malta Gharb, Gozo, Mal
2. Gozo Folklore Museum in the Citadel, Victoria, Gozo, Malta
3. Special Costume Exposition in Inquisitor's Palace, Valleta, Malta

### **Moldovans**

1. Folk Art Museum, Constantza, Romania
2. Special costume exhibition, Bucharest, Romania

### **Montenegrin**

1. National Museum of Montenegro Cetinje, Montenegro (Maja Dragicevic, Director, Peter, Director of Ethnology)
2. National Museum of Ethnography, Warsaw, Poland (Patrik Pawlaczyk costume conservator)
3. Ethnographic Museum, Belgrade, Serbia (Mirjana Menkovic, Vilma Niskanovic, Vera Momcilovic, costume curators, Velibor Stojakovic, manager)
4. National Museum of Macedonia, Skopje, Macedonia (Gordon Nikolov, Program Director)

### **Norwegians**

1. Norsk Folkemuseum, Oslo, Norway (Kari-Anne Pedersen, and Aagot Noss)
2. Fagernes Folkemuseum, Fagernes, Norway (Tordis Gjeure)
3. Sogn Folkemuseum, Sogndal, Norway (Oddlaus Hammer and Aud Ross Solberg)

### **Pasiegos**

1. Museo Etnografico de Cantabria, Spain Santander
2. Museo de las Villas Pasiegas, Vega de Pas, province Astoria, Spain
3. Poble Espanol, Barcelona (Silvia Ventosa, researcher, and Delors Llopart, director)
4. Museo del Traje, Madrid, Spain, second visit (Irene Seco Serra, Conservadora de Indumentaria Popular), first visit (Manuel Berges, and Concha Herrane)

### **Peloponnese**

1. Museum of Traditional Greek Costumes, Naousa, Paros, Greece (Konstantinos and Marouso Roussos)
2. Lyceum of Greek Women on Syros, Syros, Greece (Christina Ligopsixaki-Dendrinou)
3. Research Centre of Greek Folklore Academy, Athens (Katerina Kamilaki, director, and Leftez Alexakis)
4. Lyceum Club of Greek Women, Athens
5. Benaki Museum, Athens, Greece

### **Piemontese**

1. Museo Walser, Alagna Valsesia, Italy (Frank)
2. Museo del Costume e delle Tradizioni, Prigelato, Italy (Elisa Poncet, Director)
3. Istituto Centrala per la de antropologia a Museo Nazionale delle Arti e Tradizioni Popolari, Rome, Italy (Paolo Maria Guarrera)

### **Poles**

1. Muzeum Etnograficznego, Krakow, Poland (Andrzej Rataj, director)
2. Panstwowe Muzeum Etnograficzne, Warsaw, Poland (Dr. Piskosz-Branekova and Jan Letowski)
3. Muzeum Etnograficzne, Torun, Poland (Kinga Turska-Skowronek and Janina Lukasiewicz)
4. Tatra Museum, Zakopani, Poland

### **Pomaks**

1. Folklife and Ethnological Museum of Macedonia – Thrace, Thessaloniki, Greece (Aristea Korakau) ]
2. Ethnografski Muzej, Plovdiv, Bulgaria
3. Regional Museum of History and Ethnography, Gotse Delche, Bulgaria
4. Istoricheski Muzej Velingrad, Velingrad, , Bulgaria (George Kumanov)
5. Historical Museum, Smolyan , Bulgaria (Tanya Mareva, director)

### **Portuguese**

1. Museu de Arte Popular, Lisbon ( Madalena Farrajota Ataíde Garcia, conservadora)
2. Museu Nacional do Traje, Lisbon (Dina Caetano Dimas, curator)

### **Provençal**

1. Museon Arleton, Arles, France
2. Musee des Arts et Traditions Populaires de Moyenne-Provence, Dragnignan, France

### **Romanian**

1. Folk Art Museum, Constantza, Romania
2. Special costume exhibition, Bucharest, Romania
3. National Museum of the Romanian Peasant, Bucharest, Romania
4. Folk Art Museum, Budapest, Hungary (Dr. Zoltan Fejos, Director)

### **Romansch**

1. Romansch Museum (Raetische Museum), Chur, Switzerland

### **Saami**

1. Museum of Northern Ostrobothnia, Oulu, Finland
2. Giellagas Institute, U. of Oulu, Oulu, Finland (Veli-Pekka Lehtola, and Ante Aikio)
3. Arktikum Museum, Rovaniemi, Finland (Hanna Kylaniemi)
4. Library of the Provincial Museum of Lapland, Rovaniemi, Finland (Irene Piippola)
5. Nordiska Museet, Stockholm

### **Sarakatsani**

1. Sarakatsani Folklore Museum, Serres, Greece
2. Lyceum of Greek Women on Syros, Syros, Greece (Christina Ligopsixaki-Dendrinou)
3. Research Centre of Greek Folklore Academy, Athens (Katerina Kamilaki, director, and Leftez Alexakis)
4. Lyceum of Greek Women on Syros, Syros, Greece (Christina Ligopsixaki-Dendrinou)
5. National Museum of Macedonia, Skopje, Macedonia (Gordon Nikolov, Program Director)
6. Benaki Museum, Athens, Greece
7. Lyceum Club of Greek Women, Athens, Greece
8. Peloponnesian Folklore Foundation and Costume Museum, Nafplion, Greece (Ionna Papantoniou, director and president)



9. Folklife and Ethnological Museum of Macedonia – Thrace, Thessaloniki, Greece (Aristea Korakau)

### **Sardinian**

1. Museo Sardo di Antropologia ed Etnografia, Citadella U., Monserrato, Sardinia, Italy (Prof. Rosalba Floris, University of Cagliari, Director)
2. Museo della Vita e delle Tradizione Popolari, Nuoro, Sardinia, Italy
3. Istituto Centrala per la de antropologia a Museo Nazionale delle Arti e Tradizioni Popolari, Rome, Italy (Paolo Maria Guarrera)

### **Serb**

1. Ethnographic Museum, Belgrade, Serbia (Mirjana Menkovic, Vilma Niskanovic, Vera Momcilovic, costume curators, Velibor Stojakovic, manager)

### **Sicilian**

1. Museo del Costume e della mode Museum, Mirto, Sicily, Italy (Giovanni Portelli, director)
2. Museo del Costume, Scicli, Sicily, Italy (Giovanni Portelli, director)
3. Museo Etnografico G. Pitre, Palermo, Sicily, Italy (Eliana Calandra)

### **Silesian**

1. Muzeum Gornoslaskie, Bytom, Poland
2. Muzeum Etnograficzne, Wroclaw, Poland
3. Muzeum Etnograficznego, Krakow, Poland (Andrzej Rataj, director)
4. Panstwowe Muzeum Etnograficzne, Warsaw, Poland (Dr. Piskosz-Branekova and Jan Letowski)

### **Slovak**

1. Folk Art Museum, Budapest, Hungary (Dr. Zoltan Fejos, Director)
2. Museum of Moravian Slovakia, Uherske Hradiste, Czech Republic (Rasticova Blanka, Dr.Ivo Frolec)
3. Povazie Museum, Cicmany, Slovakia
4. Slovak National Museum in, Martin, Martin, Slovakia (Maria Halmova)
5. Vlastivedne Museum v Trebisov, Trebisov, Slovakia
6. Trnava Ethnographic Museum, Trnava, Slovakia

### **Slovene**

1. Slovenski Etnografski Musej, Ljubljana, Slovenia (Janja Zagar, director)
2. Loski Muzej (Loka Museum), Skorfja Loka, Slovenia
3. Gorenjski Museum, Kranj, Slovenia
4. Dejan Stimpfelj Folk Dance group, Ljubljana, Slovenia
5. Trebnje Gallery, Trebnje, Slovenia

### **Sorb**

1. Sorbisches Museum, Bautzen, Germany (T. Nawka, director)

### **Swede**

1. Dalarnas Museum, Dalarna, Sweden (Kerstin Ankert, curator)
2. Nordiska Museet, Stockholm, Sweden

### **Swiss-Italian**

1. Museo regionale delle Centrvillo, Intragna, Switzerland
2. Museo di Valmaggio, and archive, Cevio, Switzerland
3. Walserhaus Museum, Bosco Gurin, Switzerland
4. Museo di Blenio, Lottigna, Switzerland (Curatrice Patrizia Pusterla, Doris Quadrio)
5. Museo di Levantina, Giornico, Switzerland
6. Schweizerisches Landesmuseum Zurich, Zurich, Switzerland (Sigrid Pallmert, Kuratorin)

### **Tirolean**

1. Tiroler Volkskunst Museum, Innsbruck, Austria
2. Museo degli usi e costume della Prov. di Bolzano, Brunico Museo, Brunico, Italy (Alexandra Untersulzer)
3. Museo di Storia, Usi, Costumi e Tradizioni della Gente Ladina, Livinallongo, Italy

### **Transylvanian**

1. Folk Art Museum, Budapest, Hungary (Dr. Zoltan Fejos, Director)
2. Folk Art Museum, Constantza, Romania
3. Museul Etnografie ul Transilvanie, Cluj, Romania
4. Museul de Etnografie si Arta Populara, Baia Mare, Romania
5. Special costume exhibition, Bucharest, Romania
6. Museul de Etnografie si Arta Populara, Baia Mare, Romania

### **Tuscans**

1. Istituto Centrala per la de antropologia a Museo Nazionale delle Arti e Tradizioni Popolari, Rome, Italy (Paolo Maria Guarrera)

### **Vlachs**

1. Folklore and Ethnological Museum of Macedonia and Thrace, Thessoloniki, Greece (Dr. E. Miliadzidou-Ioannou, Director)
2. National Museum of Macedonia, Skopje, Macedonia (Gordon Nikolov, Program Director)
3. Folklife and Ethnological Museum of Macedonia – Thrace, Thessaloniki, Greece (Aristea Korakau)
4. Research Centre of Greek Folklore Academy, Athens (Katerina Kamilaki, director, and Leftez Alexakis)

### **Walloon**

1. Musee de la Vie Wallonne and archives, Liege, Belgium (Marie-Claude Thurion, conservatrice)

## REFERENCES

1. Tarrant, Naomi. (1986) Why don't the English have a Folk Dress, *Ethnografica Journal of the Peloponnesian Folklore Foundation*, 4-5: pp. 7-10.
2. Washburn, D. & Crowe, D. (1987) *Symmetries of Culture*. U. of Wash. Press, Seattle WA.
3. The area of the former Byzantine Empire includes the following cultures: Montenegrin, Albanian, Balearic, Peloponnesian, Bulgarian, Serbian, Bosnian Muslim, Greek, Pomak, Cretans, Dalmatian, Cyclades, Sarakatsani, Calabrese, Vlach, Macedonian, Croat, Sardinian, Ionian, Corsican, Sicilian, and Maltese.  
  
The area of the former Bulgarian Empire includes: Montenegrins, Romanian, Moldovan, Albanian, Bulgarian, Serbian, Greek, Pomak, Sarakatsani, Vlach, and Macedonian.  
  
The area of the former Ottoman Empire includes: Montenegrin, Romanian, Moldovan, Albanian, Peloponnesian, Bulgarian, Serbian, Bosnian Muslim, Greek, Pomak, Hungarian, Cretan, Dalmatian, Cyclades, Sarakatsani, Vlach, Macedonian, Croat, and Ionian.
4. Soloman, Frederick. (1987). *Probability and Stochastic Processes*. Englewood Cliffs, NJ: p.99.