

Mapping Quality of Life with Chernoff Faces

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Abstract

Cartographers are interested in creating multivariate symbol maps as a creative expression of spatial information. In 1979, Dr. Eugene Turner produced a map entitled “Life in LA” using four variables. The award-winning map successfully captured the living conditions in the Los Angeles area. The success of the map was largely due to the use of “Chernoff faces” as its symbolism. The innovative application of Chernoff faces in map-making, unfortunately, has been largely forgotten. In a joint class project between Population Geography and Cartography, we encourage students to experiment with the use of Chernoff face in mapping the spatial distribution of “quality of life” in the United States. With six selected variables, students first use graphic software to create a series of Chernoff faces, which are then imported to ArcGIS. Maps generated with these symbols have been very effective in enhancing student understanding of living condition across the country.

In 1973, statistician Herman Chernoff published a paper, “The Use of Faces to Represent Points in k-Dimensional Space Graphically,” in the *Journal of the American Statistical Association* (Chernoff, 1973). In the paper, he encoded data in facial features, now known as Chernoff faces, to help viewers in detecting patterns, groupings, and correlations. Chernoff faces are simplified, cartoon-like faces that can be used to graphically display complex multivariate data. They draw upon the human mind’s innate ability to recognize small differences in facial characteristics and to assimilate many facial characteristics at once. Each of several variables (Figure 1) is assigned to a facial characteristic and a face is then generated for each condition (Figure 2).

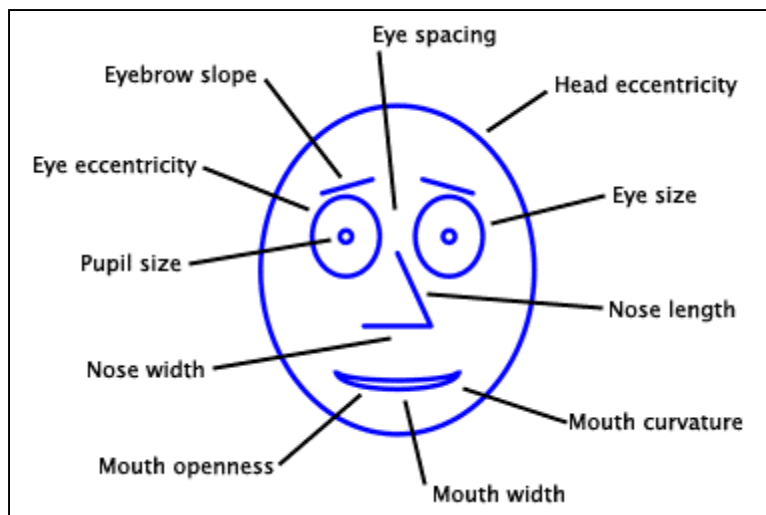


Figure 1. Facial variations

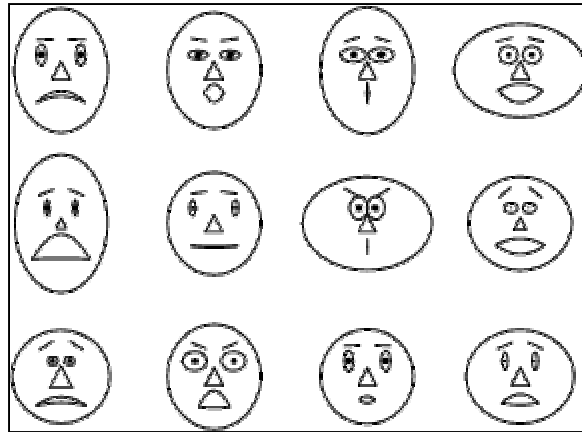


Figure 2. Combinations of facial variables forming Chernoff faces

Chernoff faces have been used widely in representing multivariate information. In 1979, Dr. Eugene Turner of California State University, Northridge produced a map entitled *Life in Los Angeles* with modified Chernoff faces (Tyner, 1992). In this map, four variables--affluence, unemployment rate, urban stresses, and percentage of white population — are presented by facial elements face shape, mouth curvature, eyebrow slope, and face color, respectively (Figure 3). The award-winning map successfully captured the living conditions in the Los Angeles area. The success of the map was largely due to the use of Chernoff faces as its symbolism. Turner described this map as “probably one of the most interesting maps I’ve created because the expressions evoke an emotional association with the data.” (www.csun.edu/%7Eehfgeg005/eturner/gallery/)

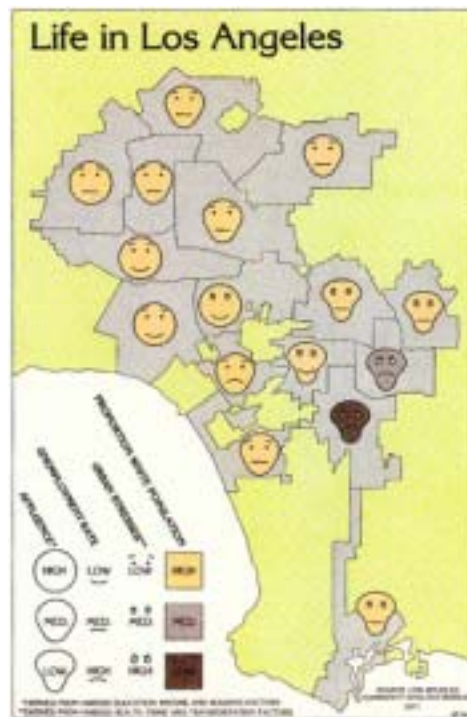


Figure 3. Dr. Eugene Turner’s award-winning map

Cartographers are always experimenting with methods of creating multivariate symbol maps as an expression of spatial information. Turner’s map is a milestone in thematic map-making. By using Chernoff faces, the complicated socio-economic phenomena are displayed in a simple and easy-to-understand manner. This innovative application of Chernoff faces in map-making, however, has been largely forgotten. One reason causing the rare use of Chernoff faces in map-making is probably the technical difficulties in processing. With the development of computer and GIS technology, the authors believe that we can create maps with Chernoff faces using available software such as ArcGIS.

At Department of Geography, Bowling Green State University, Ohio, Dr. Spinelli teaches a Population Geography class. In this class, students are required to complete a project entitled “Quality of Life in the United States.” In the project, students select a minimum of six variables related to their own ideas of what constitutes the quality of life and rank each state on each variable. Students who have taken Dr. Zhou’s Cartography class will normally make a choropleth map to sum up the quality of life for each state (Figure 4).

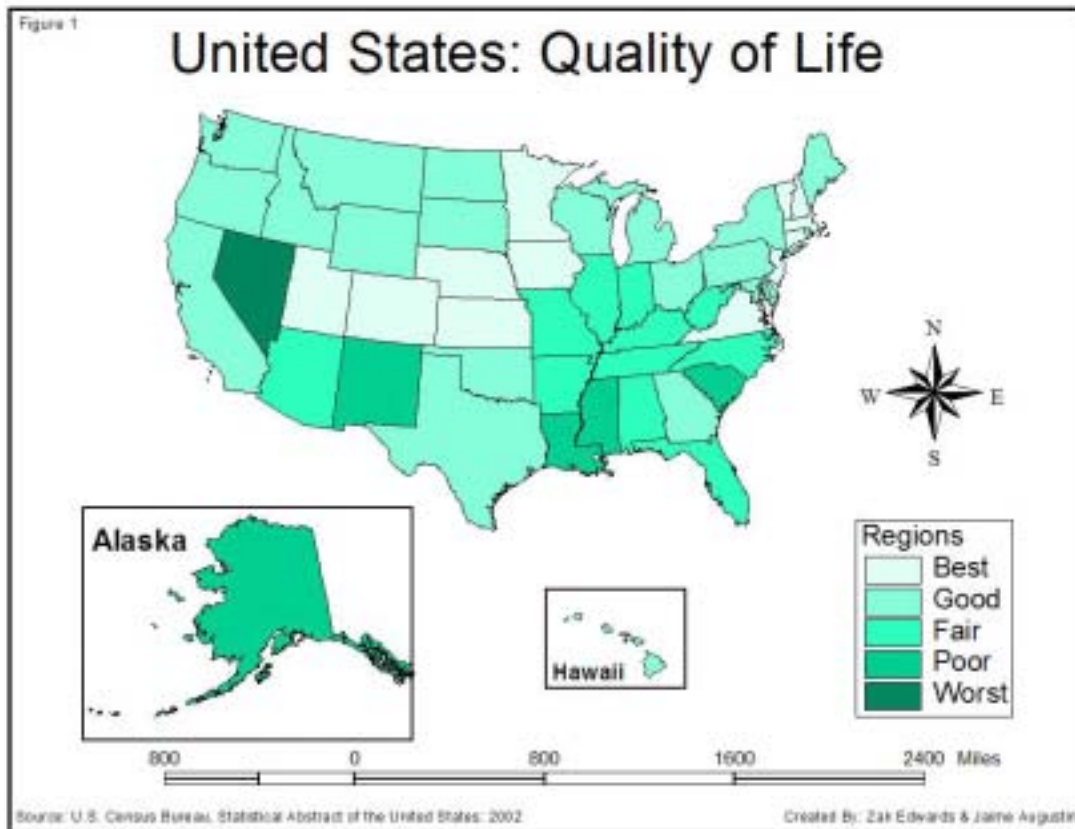


Figure 4. A typical choropleth map showing the quality of life

In Spring semester, 2004, the authors experimented using Chernoff faces to map the spatial distribution of “Quality of Life in the United States.” The data for this novel approach were randomly selected from student project. In this case, six variables--divorce

rate, percentage of population 25 years and older with at least a bachelor's degree, percentage of married women in the labor force, violent crime rate per 100,000 people, percentage of unemployed, and median family income—served as the parameters to indicate the quality of life.

By using ArcGIS, each variable was classified into three categories. The classification method is Natural Breaks. Six facial elements were designed to compose the Chernoff faces (Figure 5): color of the face (for college degree), amount of hair (for family income), arch of eyebrows (for women in work force), mouth curvature (for unemployment), nose size (for divorce), and ear size (for crime rate).

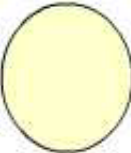





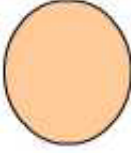

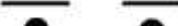



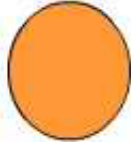





College Degree	Family Income	Women in Work Force	Unemploy Rate	Divorce Rate	Crime Rate
					
15-20 %	\$54000-65000	51-59 %	> 6 %	13-17 %	67-280
					
20-26 %	\$45000-54000	59-64 %	3-6 %	17-20 %	280-500
					
26-33 %	\$36000-45000	64-69 %	< 3 %	20-25 %	500-860

Figure 5. Six facial variations

The Chernoff faces were constructed with Macromedia's Flash software. Flash provides a relatively flexible environment for composing the Chernoff faces. Each facial variable formed three layers since each variable had three classes. Based on each state's six variable quantities, a desirable face was formed with six different layers. The specific faces were then exported as Enhanced Metafile (.emf) to be used as symbolism in ArcGIS. A Chernoff face for Ohio, for example, has class number 2 for all six facial elements (Figure 6).

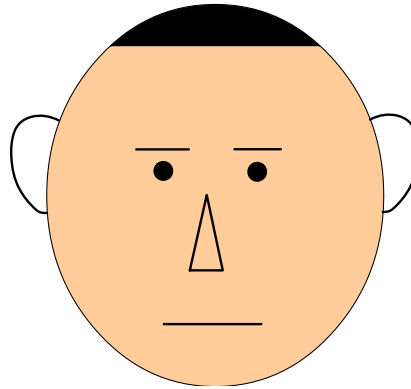


Figure 6. A Chernoff face for the state of Ohio

In ArcGIS, a point file was first generated to represent each state. The property of the point symbol was then modified into Picture Maker Symbol. According to each state's unique profile, a specific face was assigned to the point representing that state (Figure 7).

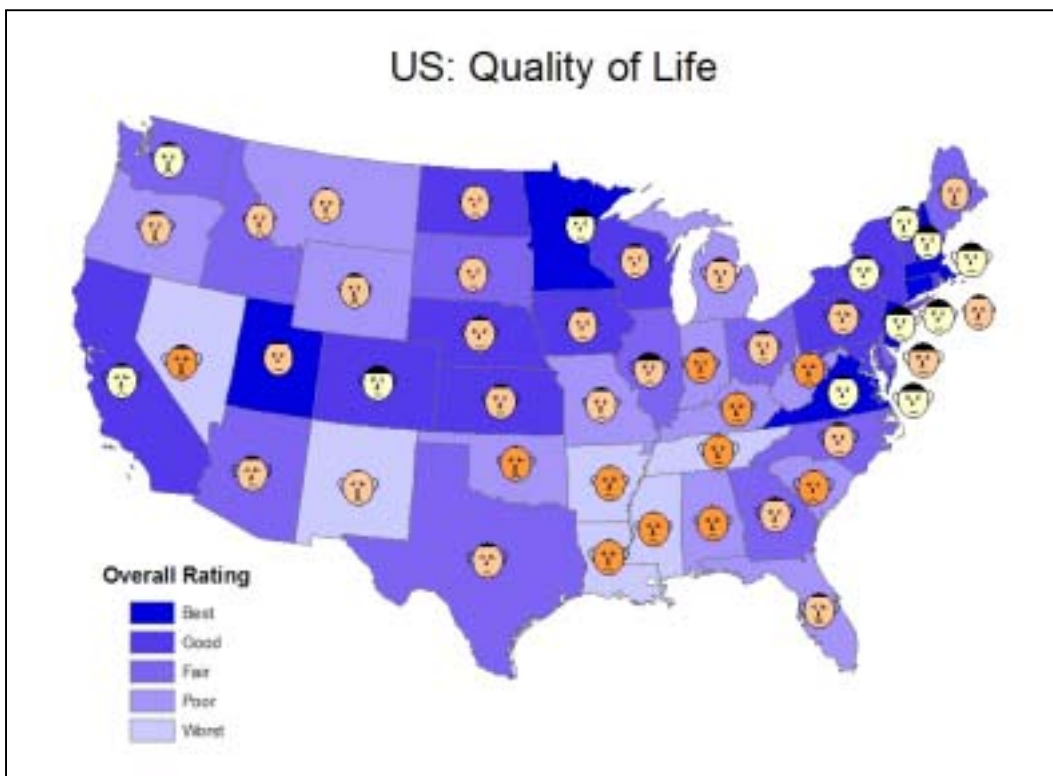


Figure 7. Quality of life map with Cheronff faces

Making a Chernoff face map to study quality of life provides a unique experience for instructors and students alike. This kind of map not only describes quality of life in a comprehensive sense, but also allows readers to measure elements composing the overall

quality. For students, a project like this allows them to make a complex, rather than a simple choropleth, map using ArcGIS technology.

The Chernoff face map displayed above, of course, is only an example. There are many factors that should be considered in future projects, e.g., how to select facial element for a specific quality of life variable, how many classes should be used for each variable, and how to find a better way to compose the faces. All of these questions require further study and experimentation.

References

Chernoff, Herman 1973. The use of faces to represent points in k-dimensional space graphically. *Journal of the American Statistical Association*, 68 (#342): 361-368.

www.csun.edu/%7Ehfgeg005/eturner/gallery/. Last accessed on May 20, 2004.

Tyner, Judith 1992. *Introduction to Thematic Cartography*. Englewood Cliffs, NJ: Prentice Hall.

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