The Face Symbol: Research Issues and Cartographic Potential

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Abstract:
The face symbol, developed by Herman Chernoff (1973), is possibly the seminal multivariate point symbol. Cartographically, the symbol has made an appearance several times, but it has often been criticized because designers tend to ignore two key symbol parameters: feature salience and natural correspondence. Feature salience is the concept of perceptually ordering facial features from those that produce the most noticeable changes to those that produce the least noticeable changes. Natural correspondence refers to designing face symbols so that the overall attitudinal labels of the symbols correspond to the overall physical meaning of the mapped data. It is argued here that feature salience and natural correspondence may be treated as special cases of visual attention in relation to symbol design. From this perspective, these symbols deserve a new look cartographically. This research reports on symbol variations, explores feature salience and natural correspondence, addresses user environments and tasks, and speculates on future experimental designs that may lead to more effective map use of this symbol.

Résumé:
Le symbole du visage, créé par Herman Chernoff (1973), est probablement le symbole à plusieurs variables fondamental. En cartographie, le symbole a fait plusieurs apparitions, mais il a souvent été critiqué parce que les concepteurs ont tendance à négliger deux paramètres clés: la prépondérance des caractéristiques et la correspondance naturelle. La prépondérance des caractéristiques signifie mettre en ordre les caractéristiques faciales perceptuelles, de celles qui produisent les changements les plus notables à celles qui produisent les changements les moins notables. La correspondance naturelle fait référence à la conception de symboles faciaux de manière à ce que les marques attitudinales générales des symboles correspondent à la signification physique générale des données cartographiées, Dans le présent article, on suppose que la prépondérance des caractéristiques et la correspondance naturelle peuvent être traitées comme des cas particuliers de l'attention visuelle, pour ce qui est de la conception des symboles. De ce point de vue, les symboles méritent d'être revus sur le plan cartographique. Dans l'article, l'auteur parle de la variation des symboles, de la prépondérance des caractéristiques et de la correspondance naturelle, des tâches et des cadres d'utilisation, et des concepts expérimentaux qui pourraient engendrer un meilleur emploi des symboles cartographiques.

Keywords:
cartography, multivariate symbols, Chernoff face, map design, attentional processes
Mots clés:
cartographie, symbole à plusieurs variables, visages de Chernoff, conception de cartes, processus attentionnel

Article:

INTRODUCTION

In 1973, Hermann Chernoff of Stanford University published an article in the Journal of the American Statistical Association that captured the imaginations of researchers across a broad range of disciplines (Chernoff 1973). This article, the result of a contract with the Office of Naval Research (Chernoff 1971), proposed using schematic faces as a means of visually displaying relationships in multivariate data sets. The basis for the Chernoff Face (Figure 1), in which up to 18 different facial features can be manipulated to highlight relationships among data sets, is the commonly held notion that we as humans have the unique ability to perceive and remember small changes in facial structure.

The Chernoff Face may have originated in statistics, but it has been used and studied over the decades by many disciplines interested in displaying and analysing multivariate data. Chernoff (1973), for instance, used his new design to create representations of (1) eight measures used in categorizing fossil data and (2) 12 measures used in mineral analysis. Figure 2a shows a subset of the face symbols used to represent a sequence of equally spaced core samples similar to the ones Chernoff mapped in his mineral study. These were used to identify critical changes occurring in the sequence of core analyses; for example, there is a noticeable change from core sample 4 to core sample 5 in this figure.

L.A. Bruckner (1978), of the Los Alamos Scientific Laboratory, used faces to represent variables related to offshore leasing by major oil companies and to display variations in quarterly bank data. In Figure 2b, a subset of symbols shows how facial variables may be manipulated to represent oil-company data; 15 different variables covering such topics as net bonus (face width), net acreage (face height), and number of leases (eye separation) are symbolized to help detect companies that have similar characteristics and to identify those that are outliers.

In the same year, G.C. McDonald and J.A. Ayers (1978) studied the potential of face symbols in a 16-variable

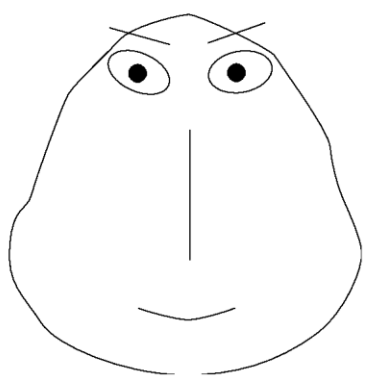

Figure 1. The Original Chernoff Face (after Chernoff 1973).

pollution and mortality study. Figure 2c shows a subset of four standard metropolitan statistical areas (SMSAs) similar to the ones they studied. SMSA 1 and SMSA 2 were clustered together in their study, as were SMSA 3 and SMSA 4; an examination of their mapping of variables to facial features reveals that SMSA 1 and SMSA 2 have lower pollution potential (mouth) and

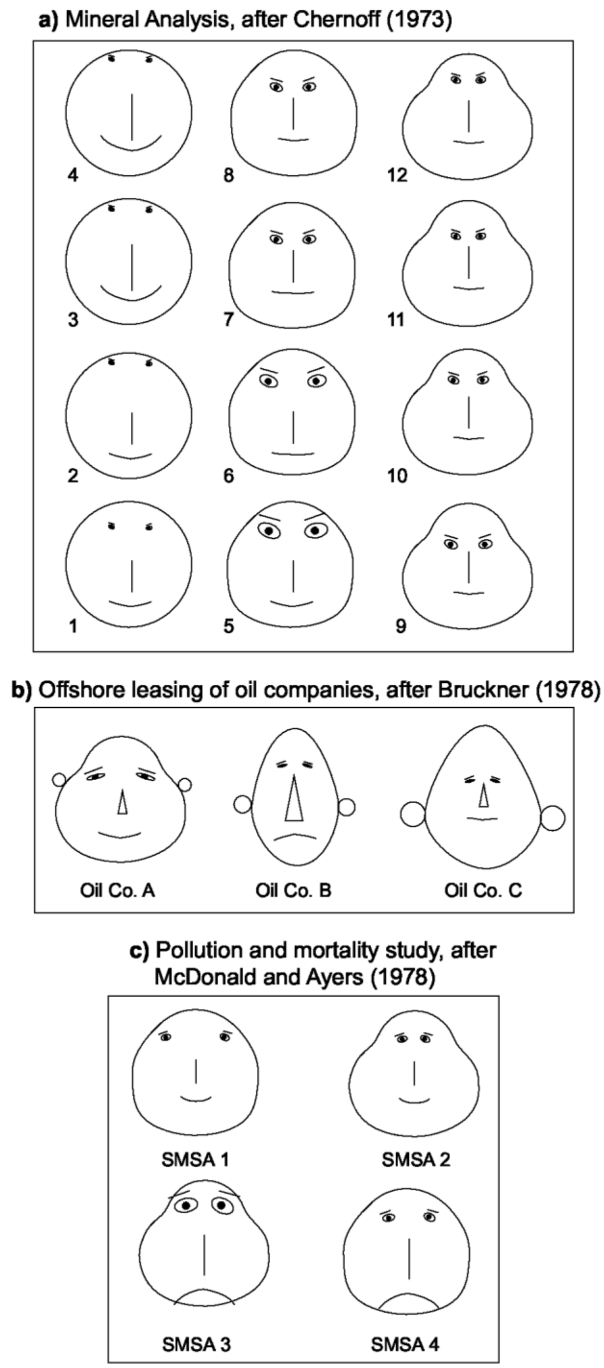

Figure 2. Three applications of the original Chernoff Face: (a) mineral data; (b) oil-company data; (c) pollution and mortality data.

lower mortality rates (nose). The eyes and associated parameters in this study generally represent several socio-economic parameters; for instance, SMSA 3 has a much higher population density than the other areas shown here, as indicated specifically by the size of the eyes. David Huff and William Black (1978) conducted a similar study, evaluating the effectiveness of face symbols in exploring urban and regional problems for 13 different metropolitan areas in the United States.

One of the first uses of the Chernoff Face as a map symbol was in 1977, when Eugene Turner of California State University at Northridge used faces to display socioeconomic variation for Los Angeles, California. His map (Figure 3) has become a seminal work in applied multivariate cartography, despite the fact that many do not care for the symbol in a map context because the facial expressions "evoke an emotional association with the data" (Turner 2005).

About the same time, Howard Wainer (1979) used Chernoff Faces on a map in Facing the Nation (see Figure 4). The map was embedded in an article whose purpose, in part, was to illustrate the symbolization technique using seven social indicators to highlight regional differences in the United States. In this map, the number of faces per state indicates population; other facial parameters represent such values as literacy rate (eye size), income (mouth curvature), homicide rate (nose width), and temperature (head shape).

FIGURE 3 IS OMITTED FROM THIS FORMATTED DOCUMENT

Figure 3. An early use of Chernoff Faces in map form (reprinted by permission of Eugene Turner).

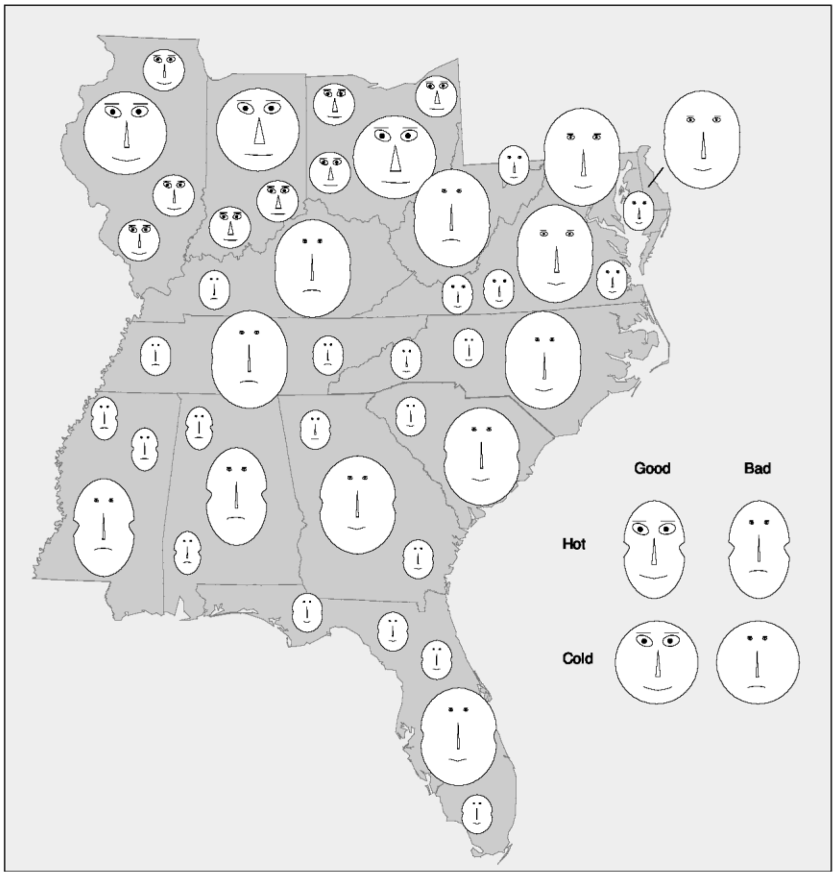

Figure 4. Mapping regional differences with Chernoff Faces (after Wainer 1979).

More recently, Chernoff Faces have been examined both in the context of map use (Nelson and Gilmartin 1996) and from the perspective of visual search processes (Nelson and others 1997). Elisabeth Nelson and Patricia Gilmartin (1996), for example, pitted the standard Chernoff Face against three other multivariate symbol designs in an experiment that tested symbol effectiveness in answering questions about local and regional spatial patterns on thematic maps displaying quality-of-life indicators. Nelson and others (1997) followed up by exploring the effectiveness of faces for highlighting bivariate data relationships within multivariate data by testing how effectively such relationships could be located in a map setting.

As recently as 2005, Daniel Montello and M. Violet Gray (2005, 30) suggest "pseudo-Chernoff faces" as a possible alternative to isolines for representing regional preference data. In their application, the face symbol is used not as a multivariate representation but as a holistic symbol that represents scores from a principal components analysis of state preference rankings. They note that

> the perception of unitary emotional expressions from faces is rapid and powerful, probably one reason they have been considered useful for the difficult problem of multivariate communication. A symbol system that so immediately communicates positive and negative emotions would, therefore, be exceptionally effective for communicating regional preference as a single quantity. (2005, 30)

William Cleveland (1987, 420) writes, “Inventing a graphical method is easy. Inventing one that works is difficult.” To this one might add that evaluating its usefulness may be a formidable challenge (Lee, Reilly, and Butavicius 2003). So it is with the Chernoff Face. For this symbol that people seem to either love or hate, with few professing neutrality, research has generated equally contradictory results regarding its usefulness as a multivariate display option. The purpose of this article is to synthesize this approximately 30-year log of research, which crosses disciplines, and to use that synthesis to highlight two key topics: major research issues surrounding the face symbol and future research avenues addressing those issues that may lead to increased effectiveness of this symbol in cartography.

From planning and transportation studies to climatological and environmental research, multivariate data is common in geographical applications (Edsall 2003). Transforming all these numbers into symbol form, particularly in a multivariate context, is a task so familiar to cartographers that we often do not appreciate its profoundness. Face symbols, as one of the seminal multivariate symbols developed for this task, deserve a closer look in a cartographic context. The sections that follow highlight face symbol variations; explore the major research issues of feature salience, natural correspondence, and user environment; and speculate on future experimental designs addressing these issues that may lead to more effective cartographic use of this multivariate symbol.

CONSTRUCTING THE CHERNOFF FACE

The original Chernoff Face is a cartoon, or schematic, face capable of displaying up to 18 different data variables (see Figure 1). The features of this face that can be used to show variation in data include such manipulations as the size of the face, size of the eyes, position of the eyebrows, eccentricity of the face outline, curvature of the mouth, and width of the mouth (see Table 1 for a complete list. For those data sets with less than eighteen variables, Chernoff (1973) suggests choosing constant values for the unused features. Although Chernoff Faces may be manually drawn, they are typically created using computer programs. To date, such programs have been individually written as special-purpose applications; there appears to be no generic software available for constructing these symbols, although there are Java applets on the Web that could, in theory, be downloaded and modified for personal use (Wiseman 1998).

In 1981, Bernhard Flury and Hans Riedwyl showed that Chernoff Faces could be modified to alleviate what they believed to be several disadvantages. One problem they noted was that some facial features tend to lose their visual effect when extreme values are mapped to other features in the original face; for example, the length of the nose on a standard Chernoff Face has the potential to affect several other facial features (see Figure 5). By expanding the construction of the face symbol to include the use of parametrized curves in addition to Chernoff’s straight lines and arcs of circles and ellipses, Flury and Riedwyl were able to overcome this limitation. They also took the step of dividing the face in two so that each half could be programmed separately, thereby increasing the number of variables from 18 to 36 and creating the ability to map paired comparisons with what they labelled “asymmetrical faces” (Figure 6).

To test their new symbol, the authors created three sets of face symbols that represented 17 anthropometrical measures collected from 20 pairs of twins (10 identical and 11 fraternal). Set A consisted of the traditional Chernoff Face; set B used symmetrical Flury-Riedwyl Faces; set C used one Flury-Riedwyl Face per twin set, with one half of the face assigned to each twin. Participants were then given the sets of faces in random order and asked to sort each set into two groups: identical

Table 1. Original parameters of Chernoff Faces (after Chernoff 1973)

Chernoff Faces: Original parameters
Radius to corner of face
Angle radius to horizontal
Vertical size of face
Eccentricity of upper face
Eccentricity of lower face
Length of nose
Vertical position of mouth
Curvature of mouth
Width of mouth
Vertical position of eyes
Separation of eyes
Slant of eyes
Eccentricity of eyes
Size of eyes
Position of pupils
Vertical position of eyebrows
Slant of eyebrows
Size of eyebrows

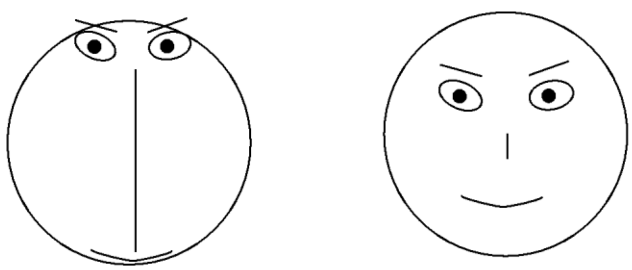

Figure 5. Design problems associated with mapping extreme data values (after Flury and Riedwyl 1981).

and fraternal. Subsequent analyses suggested that the Flury-Riedwyl Faces were sorted with significantly more accuracy than the Chernoff Faces. No significant differences were reported between symmetrical and asymmetrical Flury-Riedwyl Faces.

Although no empirical testing seems to have been conducted to date, B.T. Kabulov (1992) proposed several other changes in the construction of face symbols that he believed would increase users' accuracy and speed in estimating data values and relationships (see Figure 7). One of the proposed changes was to generalize the data sets prior to symbolization; instead of mapping unclassed interval/ratio data, Kabulov suggested grouping data into three or four classes, then mapping those classes with ordinal designations (e.g., "excellent," "good," "satisfactory," and "unsatisfactory"). This allows changes in facial features to be recognized more easily (i.e., four possible degrees of curvature for a mouth as opposed to the minute changes required to classify each observation uniquely); it also provides symbol users with a verbal tag for those changes, which should be easier to remember than numerical ranges. The disadvantage, of course, is loss of detail.

Kabulov also suggested that some facial features be held constant to make changes in other features easier to discern. Holding pupil, eyelid, and nostril positions constant, for instance, should help increase users' accuracy in estimating the degree of eyelid openness. Other features he suggested holding constant include facial outline, eyebrow length, and moustache length. Facial outline is an interesting choice to hold constant. Changes in facial outlines tend to be quite noticeable. At the same time, there are at least two problems with not holding this parameter constant: first, because the outline is the container for the other facial features, changing its shape can markedly affect the other parameters; second, changes in facial outline, as Turner has shown in his 1977 map, have the ability to project unwanted social/ethnic connotations (see Figure 3).

Kabulov's faces are particularly interesting because of the new features he uses for mapping data – number of moustache whiskers, angle of inclination of hair and eyebrows, and degree of disappearance of ears (see Table 2 for a complete list). These features seem to further personalize the face symbol, and the expansion of features has the potential to help avoid unwanted connotations by offering more choices of features to use or to hold constant in data assignment. Like the Flury-Riedwyl faces, these may also be asymmetrical.

EMPIRICAL STUDIES OF FACE SYMBOLS

Symbol effectiveness is largely dependent on how well the design takes advantage of our natural ability to perceive, process, and retain information (Kosslyn 1985; Elman 1993). It is believed that face symbols may have an additional advantage in this arena because of our fundamental ability to detect and remember facial feature

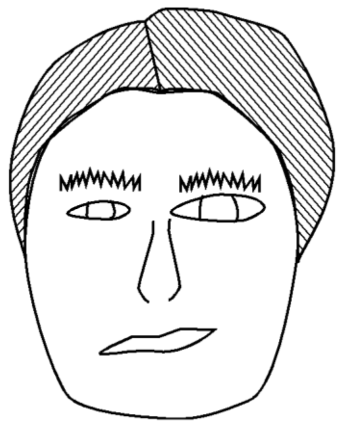

Figure 6. An updated, asymmetrical Face (after Flury and Riedwyl 1981).

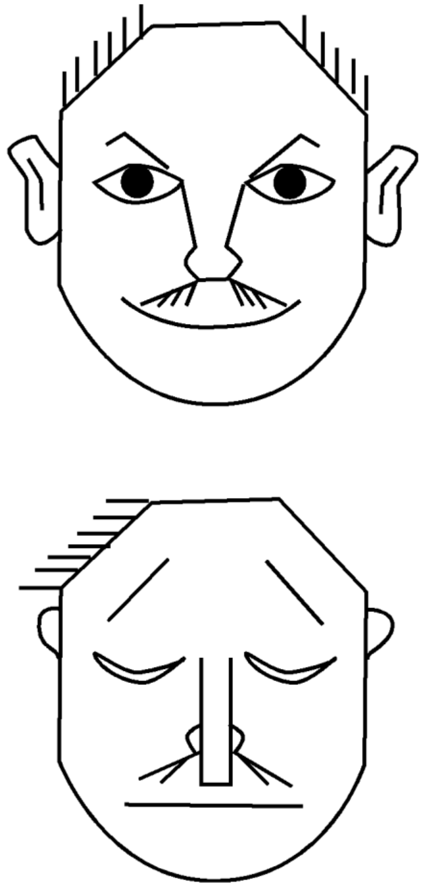

Figure 7. Kabulov Faces (after Kabulov 1992).

structures and changes. This advantage, coupled with the capitalization of our ability to recognize, classify, and remember patterns imparted to us visually, should result in a superior multivariate symbol design. Yet the wealth of research conducted on these symbols across disciplines suggests that there are several related issues that must be considered if faces are to provide an optimal graphic representation of multivariate data. Two of these issues – feature salience and natural correspondence – have received the bulk of attention from researchers. Both of these, however, are really subsets of a larger cognitive and perceptual research area: visual attention. Intermingling with the issues of feature salience and natural correspondence are the types of map tasks users are being asked to complete with these symbols and the user environment in which they are operating – research-oriented exploration or interpretation of presented research results.

Feature salience

One of the principal complaints about face symbols, across disciplines, is that perceived relationships among data sets are critically affected by which data set is assigned to which facial feature (Gnanadesikan 1977; Bruckner 1978; Fienberg 1979; Kleiner and Hartigan 1981;

Table 2. Parameters of the Kabulov Face (after Kabulov 1991)

Kabulov Faces: Parameters
Left eye – degree of opening
Right eye – degree of opening
Left eyebrow – angle of inclination
Right eyebrow – angle of inclination
Left whiskers – number of
Right whiskers – number of
Mouth curvature
Degree of baldness
Hair – angle of inclination
Left ear – degree of disappearance
Right ear – degree of disappearance

Jacob 1983; Lee and others 2003). The cause of this anomaly is feature salience, which may be defined as the perceptual ordering of facial features from those that produce the most noticeable changes to those that produce the least noticeable changes. The core problem is the transformation from data space to face space. Study after study has shown that the way in which data variables are assigned to facial features can affect the conclusions drawn in comparison and clustering tasks (Chernoff and Rizvi 1975; Huff and Black 1978; MacDonald and Ayers 1978; Naveh-Benjamin and Pachella 1982; Jacob 1983). One study, for instance, found that the random assignment of data variables to facial features affected error rates in subject classification by as much as 25% (Naveh-Benjamin and Pachella 1982).

It is important in designing these symbols, then, to rank the importance of the data variables being mapped in creating the composite face value and to match those rankings to similar rankings of facial feature importance. Several studies have been conducted to assess feature salience; most have used face pairs and similarity ratings to determine the perceptual importance of features. Results have been quite consistent, even across facial variations such as those between the original Chernoff Face and Flury-Riedwyl Faces. Highly salient features tend to be those facial features with an emotional component; mouth curvature and eye size are the two most salient (Huff and Black 1978; De Soete and De Corte 1985; De Soete 1986; MacGregor and Slovic 1986; Morris, Egbert, and Rheingans 2000). Less salient are those features that Robert Jacob (1978) identifies as tied not to emotive content but to identification (i.e., they contribute little to the feeling the face displays but are crucial in differentiating faces displaying similar feelings); these tend to be mouth position, eye separation, and ear position (Huff and Black 1978; De Soete and De Corte 1985). Eyebrows were noted often, and in varying categories, depending on the characteristic of the eyebrow being cited: eyebrow density (Flury-Riedwyl Faces) and eyebrow angles are noted as more salient, eyebrow position as less salient.

Donald MacGregor and Paul Slovic (1986), using a different approach in testing symbol utility, also found feature salience to have a significant impact on the effectiveness of the face symbol. They had participants perform a multi-cue task in which they were asked to estimate how long it took one to complete a marathon using four integrated cues assigned to different facial features. Two sets of faces were designed, one using facial features found to be highly salient in previous studies and one using features found to be less salient. The highly salient faces were found to be most effective, both for keeping track of cues and for using cues most effectively in making estimates. When data were reassigned to facial features previously found to be less salient, participants' performance dropped significantly.

Natural correspondence

Participants in a variety of experiments have self-reported that they associate faces with attitudinal labels (i.e., happy, sad, angry) when asked to use faces to complete different types of tasks (Jacob 1976, 1978; Dayton 1990). This suggests that if faces could be designed in such a way that their attitudinal labels correspond to the overall physical meaning of the mapped data, task efficiency would be enhanced. This is, in fact, exactly what

Jacob (1983) found when he tested users' ability to match faces to verbal personality profiles. By mapping profile variables (such as depression) onto the most appropriate facial feature (mouth curvature), he was able to create a set of faces each of which was suggestive of the profile it described. He then used these faces to show that users who were not trained in the use of face symbols could consistently match the correct face to the correct verbal profile when asked. He also showed that when data were arbitrarily mapped onto the face so that attitudinal labels did not match the composite meanings, this advantage disappeared.

Verbal personality-profile data seem a natural match for display using face symbols. The challenge from a geographic perspective is to create symbols from diverse types of data – physical, economic, demographic – that also would exploit this characteristic of natural correspondence, while at the same time taking advantage of feature salience to highlight the more important data sets or data relationships. Figure 8 is an example of how one might map economic diversity using these principles. In this particular instance, variables were ranked as to their level of importance in contributing to economic diversity and accordingly assigned to facial features, ranked by feature salience. In building these relationships, two basic criteria were kept in mind for the final map: first, the continuum ranged emotively from happy to neutral to

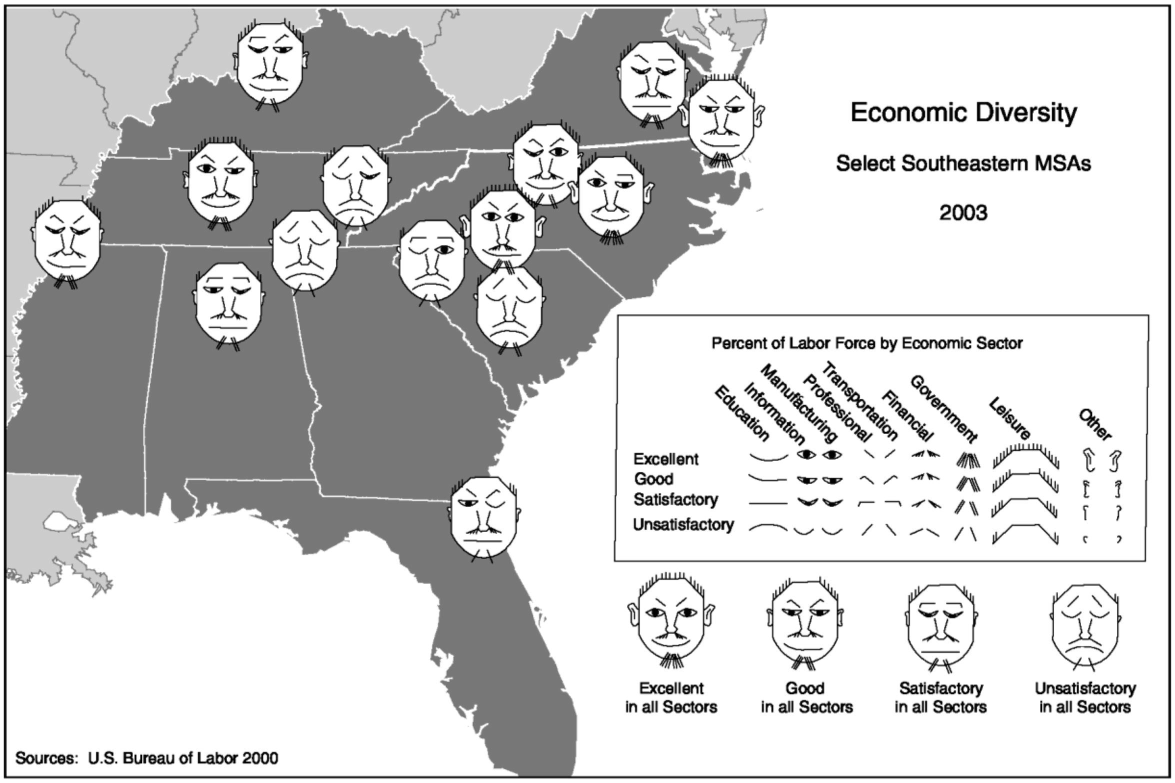

Figure 8. Map highlighting the use of Kabulov variations to display economic diversity.

sad, and these emotions were paired with overall SMSA performance; second, it was important that users be able to make paired comparisons between information and manufacturing labour forces within each city, and this was implemented by assigning each data set to one of the eyes, thus taking advantage of the asymmetrical potential of the symbol.

User environment

A symbol, particularly as its design grows more complex, may meet all cognitive and perceptual criteria of good design, but still fail to function effectively. This is because symbol function is dependent not only on taking advantage of our cognitive capacities but also on the type of information we seek (DeSanctis 1984). One way to approach the task for which a symbol may be designed is to begin by identifying its overarching goal. Is the symbol to be part of a display aimed at communicating results, decisions, or viewpoints, or will it be used to visualize data relationships for scientific analysis and exploration, a mode more geared toward researchers?

Face symbols have been studied in both contexts, with results definitely skewed toward exploratory visualization as the most effective venue for the symbol. Jacob (1976), for example, found faces useful in an exploratory environment, where they outperformed both numbers and polygons in facilitating a visual clustering analysis for nine related variables. In this instance, faces took longer to process than the other graphic forms, but they were consistently processed with a higher accuracy. Bruckner (1978) also noted, in his study using cluster analysis, that faces were not a useful symbol for making final decisions but were better suited for exploratory data analysis.

Operating in a more communications-oriented context, Nelson and Gilmartin (1996) added further data suggesting that, in communicating quality-of-life indicators, face symbols are less successful than other symbol designs from the perspective of processing times. In a study that examined four different symbols designed to answer geographic questions about both local and regional patterns as well as individual data values and multivariate data relationships, they found that faces consistently took the longest to process. They also noted, however, that the face symbol was used as accurately as others when no time constraints were imposed and that it was one of two symbols that seemed to enhance the processing of individual data values within a multivariate data context. One of the limitations of this study was the low number of data variables used for each symbol. Several have noted, beginning with Chernoff himself (1973, 365), that “if the useful information is in only a few of the variables, the presence of noise in many other variables may tend to diminish the ability to discern the useful information.”

The idea of face symbols’ being used effectively to process individual data values and bivariate relationships within multivariate data sets prompted Nelson and others (1997) to explore the efficiency with which users might locate such data in a map setting. They designed face symbols composed of four variables, mapped those symbols, and then asked study participants to find individual data values and bivariate combinations of data values using a standard search task. Of particular interest was assessing the role that different combinations of symbol dimensions (size, shape, etc.) and different combinations of facial features played in moderating search efficiency. While the authors found that all the searches required serial processing – a result since replicated by Morris and others (2000) and Lee and others (2003), both of whom also used four variables or fewer – feature searches (those in which the face consisted of a unique feature) were by far the easiest for subjects to perform. Nelson and others also demonstrated that hierarchical relationships can be manipulated within the face to increase search efficiency for searches in which the target does not have a unique feature.

VISUAL ATTENTION, CARTOGRAPHY, AND FUTURE RESEARCH AVENUES

While some studies, including that of MacGregor and Slovic (1986), suggest that faces may be a symbol whereby data variables are mapped into an integral as opposed to separable format, others seem to suggest just the opposite – that facial features are more efficiently processed separably (Huff and Black 1978; Dayton 1990; Nelson and Gilmartin 1996). This dichotomy still remains unresolved, and the lack of explanation for it hinders the use of this symbol in mapping. One perspective from which to address this problem is that of visual attention.

Feature-based attention and feature salience

Brian Scholl’s (2001) paper on objects and attention is a good place to begin this exploration. The literature on visual attention has a long history, and the composition of the underlying units of attention has been the subject of much debate. In studies of selective attention, for example, objects are considered to be composed of features or dimensions, such as colour, shape, size, and orientation. Empirical studies of these dimensions have resulted in a taxonomy of dimensional interactions that has been expanded, in recent years, to incorporate cartographic symbol dimensions and their interactions (Nelson 1999, 2000a, 2000b). Although Scholl (2001) does not cite selective attention specifically as an example of feature-based attention, the entire basis of the theory – that different combinations of object features or dimensions will produce different types of perceptual responses – implies that it is.

If findings like these could be extrapolated to the design of face symbols and combined with the concept of feature salience (i.e., examining combinations of emotive and identifiable dimensions in addition to the cartographer's traditional symbol dimensions), it should be possible to create symbols that are more easily processed from the perspective of comparing interrelationships among data sets – one of the goals of multivariate visualization. This idea of comparing data relationships within the symbol as well as between symbols is almost certainly complex, and it is likely geared more to an exploratory environment than to a presentation mode (Edsall 2003). With the emphasis on the goal of gaining insight into data relationships, face symbols might be evaluated by measuring how effective hypothesis generation is when using them. The measurement, of course, would be qualitative as opposed to quantitative; it might include focus-group interviews, as well as written commentary, following the use of an exploratory spatial data analysis system organized around face symbols. It would also be worthwhile to explore the more recent symbol designs in this context. Kabulov Faces, in particular, would seem to be a good choice, given their more realistic design, use of variety of basic cartographic visual variables, and asymmetrical capabilities.

Another possibility might be to use applied problems to present users with a series of questions about the data at a given location or locations and ask them to answer that question using a yes/no format. In this more traditional set-up, both response times and accuracy rates could be recorded and empirically analysed. This scenario might be useful in assessing symbol effectiveness in both exploratory and presentational venues. In this way, separable, configural, and integral interactions between the symbol dimensions could be examined by constructing questions to mirror tasks used in selective attention studies. An example of such a question might be,

> Company X wants to locate a facility in your region, but one of their requirements is a base of employees already located there in the manufacturing realm. Is there a city with a good to excellent rating of labour available in this sector?

A question requiring the examination of two or more variables might be worded as follows:

> Company X wants to locate a facility in your region, but there are no cities that have a satisfying base of population in manufacturing. If the company can pull employees from the professional sector as long as educational levels are good to excellent and the number of employees in that sector is good to excellent, is there a city that would work for them?

In all the above scenarios, several sets of map symbols could be designed and tested, from those that have been found to work more effectively for looking at subsets of variables to those that have been found to communicate a more holistic view of an issue more effectively (see Figures 9 and 10). Face symbols could be designed using both recommended and non-recommended

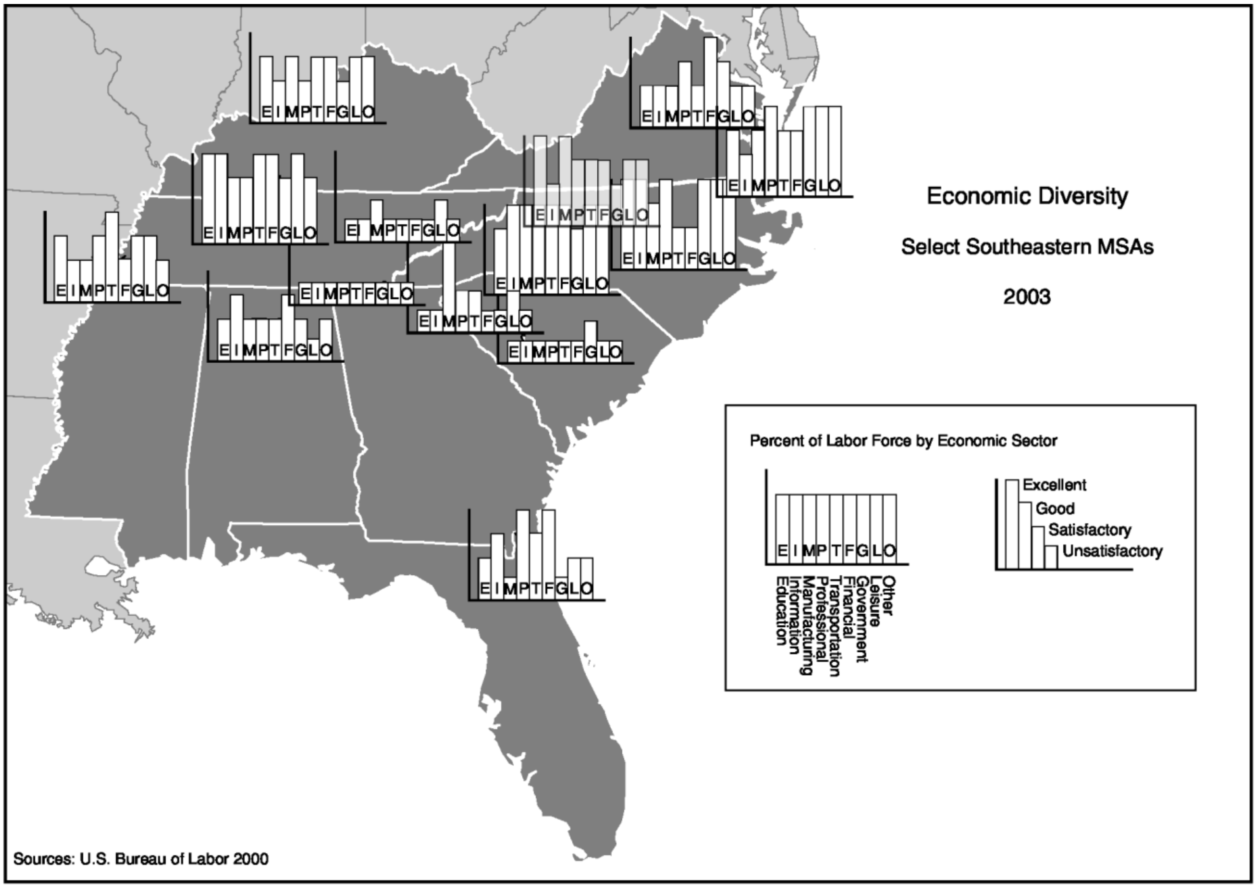

Figure 9. Bar symbols as a means of displaying economic diversity.

findings from feature-salience, natural-correspondence, and selective-attention studies to compare differences in map effectiveness. The results from these sets could form a baseline for cartographic applications and confirm or refute previous studies in abstract settings. Recommended designs could also be compared to other symbol designs that are purported to facilitate various types of perceptual interactions. Bar-graph symbols, for example, have been shown to be more efficient for processing multivariate data sets separably, while other types of glyph symbols are thought to produce integral interactions (Carswell and Wickens 1988). It is quite possible that face symbols, if designed with forethought, might be able to span the separable–integral continuum and provide cartographers with a symbol that could be used in multiple contexts.

Object-based attention and natural correspondence

The idea of identifying an attitudinal label with a face symbol turns the symbol completely around in terms of attention. Now, instead of selectively attending to symbol features, users are processing the symbol as a discrete object. The underlying unit of attention is changed, and with it the types of tasks a user might successfully complete, regardless of task environment (Scholl 2001).

There are at least two types of cartographic tasks that could be designed to explore face symbols from this attentional perspective: visual clustering and multi-cue judgement.

Maps using face symbols could be designed, for example, using both recommended and non-recommended findings in natural correspondence studies, and users asked to perform clustering tasks with each. If emotive facial features are the key to processing the symbols integrally, this should show up in the accuracy of participant results. Results could also be compared to computer-simulated objective clustering using correlation coefficients. Multi- cue judgements would require subjects to estimate the value of a location for some purpose. For example, symbols could be designed using variables that are related to industrial location potential for cities in the southeast United States. Once mapped, users could be asked to estimate a city's potential for industrial location using the composite facial symbol or to compare two or more cities and decide which one has the most potential. Accuracy and confidence measures could be used to assess differences between symbol designs. Again, these could also be compared to other symbols designed to perform as holistic measures.

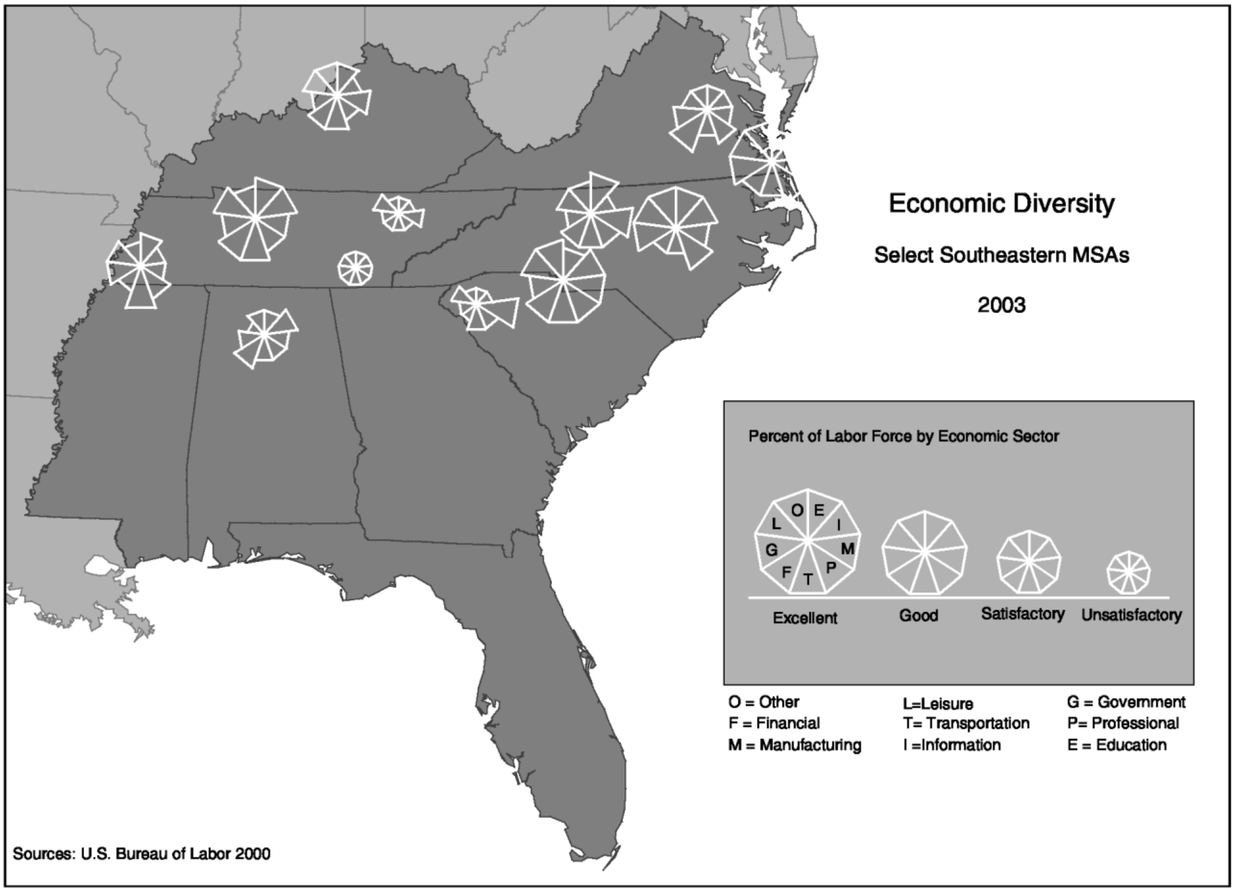

Figure 10. Glyph symbols as a means of displaying economic diversity.

CONCLUSIONS

The face symbol is possibly the seminal multivariate symbol across many varied disciplines. In geography and cartography, the symbol has made an appearance in several instances, but it has been widely criticized. Not only is it complex, but cartographers also fail to take advantage of feature salience and natural correspondence. Complexity is a given; all multivariate symbols are complex, because all must effectively deal with multiple data sets and their interrelationships. The question, then, is this: Are feature salience and natural correspondence symbol attributes that can give the face symbol an edge cartographically? It has been argued here that these concepts are really just special cases of visual attention, in which the underlying unit of attention changes depending on the task the symbol is being used to complete Therefore, it seems plausible that feature salience and natural correspondence could be used to take advantage of what is already known about visual attention and could be manipulated to increase the effectiveness of the symbol in different scenarios Traditional cognitive and perceptual map testing, in conjunction with the newer paradigms of hypothesis generation and focus groups, are just some ways to assess the merits of the unique features of this multivariate symbol

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