CO-369

ANALYSIS OF THEMATIC MAP DESIGN IN THE GEOGRAPHICAL JOURNAL AND THE GEOGRAPHICAL REVIEW DURING THE TWENTIETH CENTURY

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INTRODUCTION

In developing a contribution entitled "Thematic Mapping" for *The History of Cartography* volume *Cartography in the Twentieth Century* (Monmonier forthcoming), we found a lack of controlled studies that analyzed changes in thematic map design over the course of the twentieth century. In response to this deficiency, we have analyzed changes in thematic map design for two journals that were published in the twentieth century: the *Annals of the Association of American Geographers* (*AAAG*) and *The Geographical Journal* (*GJ*) (Kessler and Slocum, 2011). One limitation of the latter study was that cartographers at the Royal Geographical Society (RGS) were involved in designing many of the maps for the *GJ* (Holland 1980), but there was not a similar cadre of cartographers for the *AAAG*. For the present research, we avoid this problem by comparing the *GJ* with *The Geographical Review* (*GR*); in the case of the *GR* many maps were designed by cartographers at the American Geographical Society (AGS; Wright 1952). A major conclusion of our comparison of the *AAAG* and the *GJ* was that maps did not exhibit the high quality of design that we might expect in professional geographic journals given geography's long interest in mapping and the importance of cartography to geography. We wondered whether maps published in the *GR* would lend further support to this conclusion.

RELATED RESEARCH

There are several studies that we considered relevant to our investigation. The studies touched upon the changes in thematic map design in geography journals and in maps and graphs more generally. Another body of research we examined was the introduction of novel statistical means to evaluate changes in thematic map design.

A study similar to ours, undertaken by Fitzsimons and Turner (2006), looked at changes in thematic map design over time; they examined changes in thematic map design from 1984-2005 for four geographical journals: the *AAAG*, the *GR*, the *Professional Geographer*, and *Urban Geography*. Fitzsimons and Turner did not conduct a detailed critique of maps, but did consider the role of various map elements (e.g., title, legend, and visual hierarchy) and found a "marked improvement…in the look of maps" over time, but like us they found that "poor design choices continue[d] to appear" (p. 10).

In surveying the broader history of statistical graphics and thematic mapping, Friendly (2008) divided the twentieth century into the Modern Dark Ages (1900–1950), the Rebirth of Data Visualization (1950-1975), and High-D, Interactive and Dynamic Visualization (1975-present). Friendly considered the Modern Dark Ages a period when there were few graphical innovations and there was an emphasis on numerical information. In our previous study (Kessler and Slocum), we found no support for Friendly's notion of a Dark Ages; although poorly designed maps were produced in the early twentieth century, there also were many well designed maps. We wondered how the *GR* would fare in this respect.

A body of research particularly relevant to the quantitative content analysis technique we used to evaluate thematic maps was described by Muehlenhaus (2010). Quantitative content analysis involves a "…systematic and replicable examination of symbols of communication [in our case maps], which have been assigned numeric values…" (Riffe, Lacy, and Ficoet al. 2008, 25), whereas qualitative content analysis utilizes nonnumeric data. In our study, we have used both quantitative and qualitative content analyses.

GOALS OF THE STUDY AND DEVELOPING HYPOTHESES

The major goal of the present study was to analyze changes in thematic map design for the *GR* and *GJ* over the twentieth century. Since thematic maps were examined in the context of particular articles, we developed three subordinate goals: to analyze the frequency with which maps appeared relative to other nontext material; to analyze the frequency with which thematic maps appeared relative to other kinds of maps; and to analyze the relative frequency with which various kinds of thematic maps appeared.

In our previous study, we hypothesized that there would be an improvement in map design over the course of the twentieth century due to improved drafting tools, the availability of computer-based methods, the availability of cartographic textbooks and coursework in cartography, and the role of journal editors in

stressing the importance of good map design. The first three of these hypotheses would apply to any journal, but the nature of the fourth would be a function of the presence of a cartographic editor or equivalent assistance. As we have indicated, many of the maps in the *GJ* were designed by professional cartographers, at least through the 1970s (Royal Geographical Society 2005, 27). From reading Wright (1952), it is clear that cartographers were heavily involved in the AGS, but it is not clear how often they assisted in designing maps for the *GR*. We also had hypothesized that the growth of positivism and quantitative geography in the 1950s and 1960s would lead to greater use of nontext information, and that the growth of nonpositivist views in the latter portion of the twentieth century would lead to less use of nontext information.

DATA COLLECTED

In order to analyze the frequency with which maps appeared relative to nontext material, we considered the following nontext categories: maps, tables, graphs, diagrams, photographs, remotely sensed images, drawings and paintings, and historical documents. To analyze the frequency with which thematic maps appeared relative to other kinds of maps, we divided maps into four categories: thematic maps, general reference maps, physical diagrams, and historical maps. Finally, to analyze the relative frequency with which various kinds of thematic maps appeared, we divided thematic maps into the following categories: cartogram, choropleth, dot, dasymetric, flow, isarithmic, prism/fishnet, proportional symbol, land use, geologic (including geomorphologic maps), and miscellaneous. In contrast to our previous study, we included maps in the dasymetric category if the map gave the appearance that it was produced using dasymetric methods.

To evaluate the design of thematic maps, we sampled twenty maps from both journals at twenty-year intervals, using the base years of 1900, 1920, 1940, 1960, 1980, and 2000. If we did not find twenty maps in a base year, then we sampled from adjacent years. Once we had collected twenty maps for a particular twenty-year interval, we stopped examining articles for that interval. Thus, some intervals had relatively few articles (Table 1). Given the twenty maps for each time period, we analyzed a grand total of 240 maps (120 for each journal).

Table 1. Data collected for each journal for each twenty-year interval.*

Geographical Review

Base year	Range of years	Number of pages	Number of articles
1900	1899-1901	720	64
1920	1920	390	28
1940	1940	338	21
1960	1960	266	13
1980	1980	236	17
2000	1999-2000	877	45

Geographical Journal

Base year	Range of years	Number of pages	Number of articles
1900	1900-1901	1195	72
1920	1920	604	36
1940	1939-1940	844	55
1960	1960	317	27
1980	1979-1980	353	21
2000	1999-2000	366	26

*Results for the *GJ* are from p. 8 of Kessler and Slocum (2011)

To insure that one article did not carry undue weight, we stipulated that no more than two thematic maps could be selected from a single article. We also did not select two thematic maps from the same article if the maps had the same symbology and design. Thus, if an article contained four proportional symbol maps

of one design and two isarithmic maps of another design, we would select one proportional symbol map and one isarithmic map.

One key issue was determining how much of the article should be read in order to properly evaluate each map. Due to a time limitation, we did not read each article, but rather read the abstract and then focused on where the map was referenced in the article. Another issue was determining which map design guidelines should be utilized to evaluate each map. We utilized guidelines derived from Slocum et al.'s *Thematic Cartography and Geovisualization* (2009), but modified them so that they would be applicable throughout the twentieth century. The eleven map elements from our previous study for which we developed guidelines included Symbology, Legend, Basic Map Design, Lettering, Title and Caption, Base Information, Inset Maps, Scale, Projection, Orientation, and Source; details for these guidelines can be found in Appendix A of Kessler and Slocum. For the present study, we also considered the degree to which the map was referenced in the text (we term this the Map Referenced item). We used three categories for this item: 0 - Map is not referenced in the text; 1 - Map is referenced, but not clearly integrated with the text; and 2 - Map is referenced and integrated well with the text.

For the qualitative evaluations, we created a list of the twelve elements, with each element followed by a + or -; we then made positive or negative comments where appropriate. This approach made us think deeply about the design of each map and the comments were useful in interpreting our quantitative evaluations. For the quantitative evaluations, we created a set of nineteen items similar to the two shown in Figure 1. We also evaluated the overall design of each map on a ten-point scale, with 1 being the worst and 10 being the best possible designed map. Although content analysts argue against this, we felt that this approach was necessary to illustrate the negative impact that a single design guideline might have.

Figure 1. Examples of items used in the quantitative evaluations.

A. Logic of Symbology

For the particular technique (e.g., choropleth), logical design decisions were made (e.g., a logical progression of colors was used).

In this case, the following 5-point Likert-type scale was used.

1 Strongly disagree
2 Somewhat disagree
3 Neither agree nor disagree
4 Somewhat agree
5 Strongly agree

B. Location of Title

0 = No title (on map or in caption)
1 = Title appears on map
2 = Title appears in caption
3 = Elements of the title appear in both the map and caption

RESULTS

Frequency of Maps Relative to Other Nontext Material

To measure the frequency with which nontext material was used, we computed the percentage of all articles for a base year that included one or more occurrence of each nontext item (Figure 2). Not surprisingly, maps were the most frequently appearing nontext item in both journals. The scores for *GJ* exceeded 70 percent in all years, but those for the *GR* started at a low of 32.8 percent in 1900 (when the *GR* was known as the *Journal of the American Geographical Society*), reached a peak of 92.3 percent in 1960, and then decreased to 60.0 percent in 2000. The decrease in maps after 1960 may reflect the increasing prevalence of nonpositivist views, as we had hypothesized. One obvious trend in Figure 2 is the increased use of tables, with both journals increasing rapidly from 1960 to 1980, as we had hypothesized due to the growth of positivism. Interestingly, the use of tables declined after 1980, again possibly reflecting a greater prevalence of nonpositivist views. The trend for graphs for the *GJ* appears to match that for tables, but for the *GR* the peak for graphs is in 1940. The curves for photographs differ for the two journals, with the peak for the *GJ* occurring in 1940 (67.3 percent) and then dropping rapidly to a low of 15.4 percent in 2000. The curve for the *GR* is more varied, but interestingly there was an increase from 1980 to 2000. Although this might represent an increase in nonpositivist views, it is noteworthy that this increase did not occur for the *GJ*.

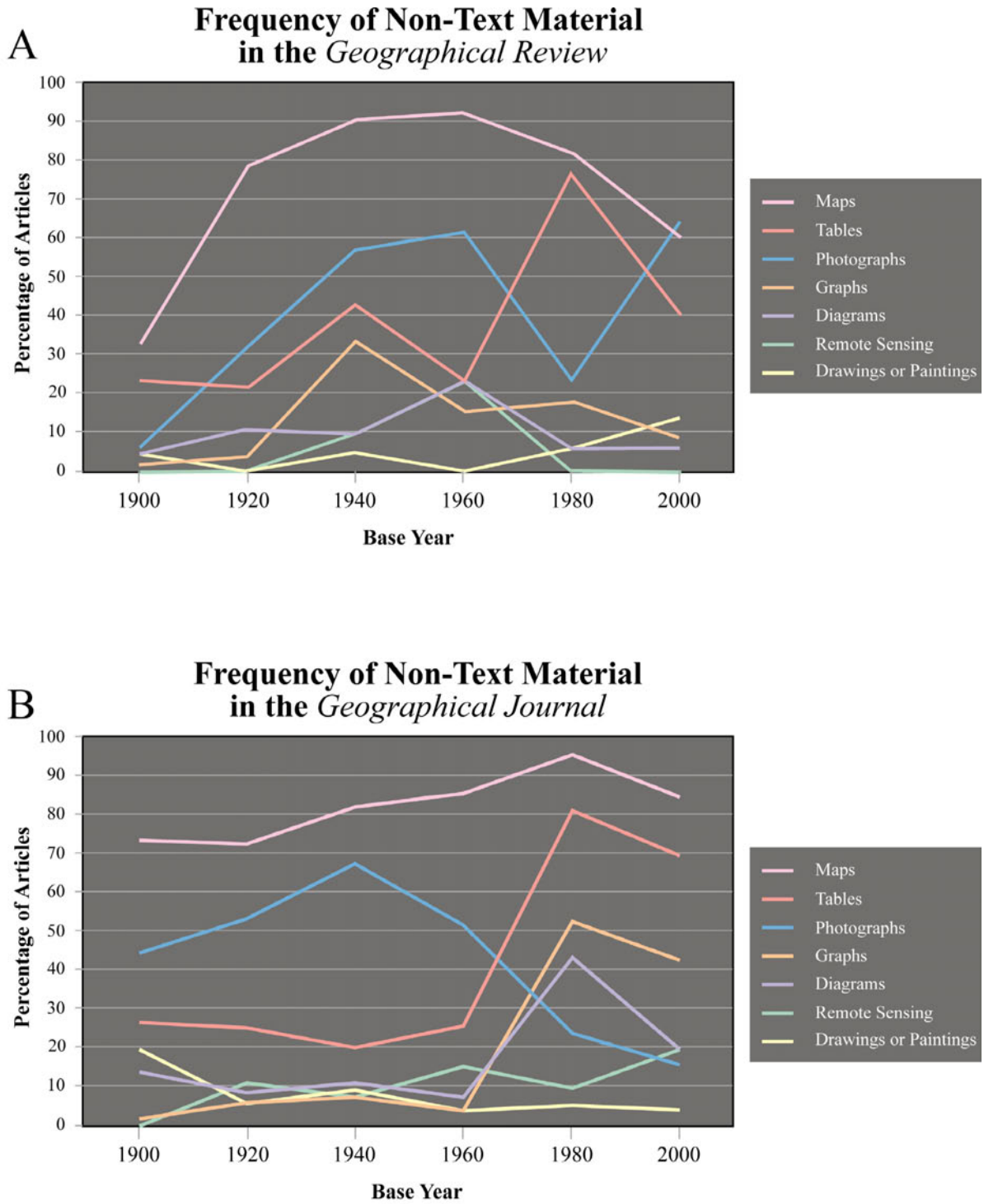

Figure 2. Frequency of nontext material in the *GR* and *GJ*. (Results for the *GJ* are from p. 12 of Kessler, F.C. and T.A. Slocum. 2011. Analysis of thematic maps published in two geographical journals in the twentieth century. *Annals of the Association of American Geographers* 101:1-26. The journal is accessible at http://www.infomaworld.com/.)

Frequency of Basic Kinds of Maps

Figure 3 displays the percentage of articles that contained each of the four basic kinds of maps we considered. Thematic and general reference maps clearly were much more common than physical diagrams and historical maps. The curves for thematic maps are quite different for the two journals. For the *GR*, the curve climbs from 1900 to 1960 (reaching a maximum value of 92.3, higher than any year of the *GJ*), but then drops precipitously to a low of just over 30 percent in 2000. In contrast, the curve for the *GJ* generally climbs from 1900 to 1980 and then drops slightly from 1980 to 2000. Here again one wonders to what extent a decrease in thematic maps for the *GR* represents an increasing prevalence of nonpositivist views? One trend for general reference maps is that the percentages were higher in all years

for the *GJ*, but it is also interesting that the peak for both journals occurred in 1940 (a value of 63.6 percent for the *GJ* and 57.1 percent for the *GR*).

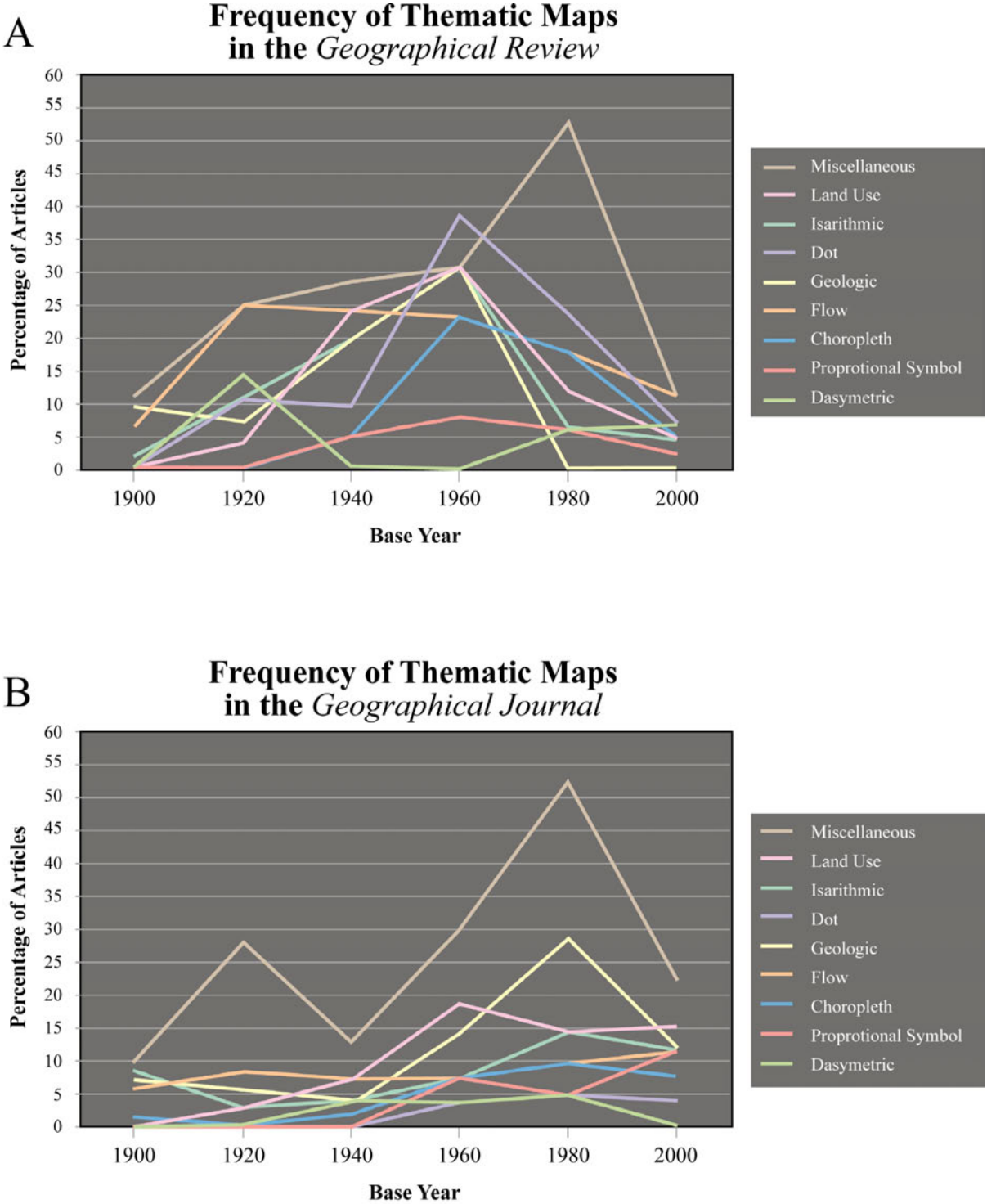

Figure 3. Frequency of basic kinds of maps. (Results for the *GJ* are from p. 13 of Kessler and Slocum.)

Frequency of Various Kinds of Thematic Maps

Figure 4 portrays the percentage of articles containing various kinds of thematic maps. One distinctive characteristic is that the miscellaneous category generally exceeded the other categories; thus, we found that many thematic maps did not fit our traditional thematic map categories. The one notable case where the miscellaneous category did not exceed the other categories was for dot maps for the *GR* in 1960, and this seemed to coincide with relatively higher percentages for other types of thematic maps (remember that 1960 was the peak year for thematic maps in the *GR*). One notable trend for the *GJ* was the peak for geologic maps in 1980; this appeared to be a result of a special issue that focused on the "Geomorphology

of the Mulu Hills." We found no occurrences of either cartograms or prism/fishnet maps, even though these methods were commonly taught in cartography and GIS classes in the latter portion of the twentieth century.

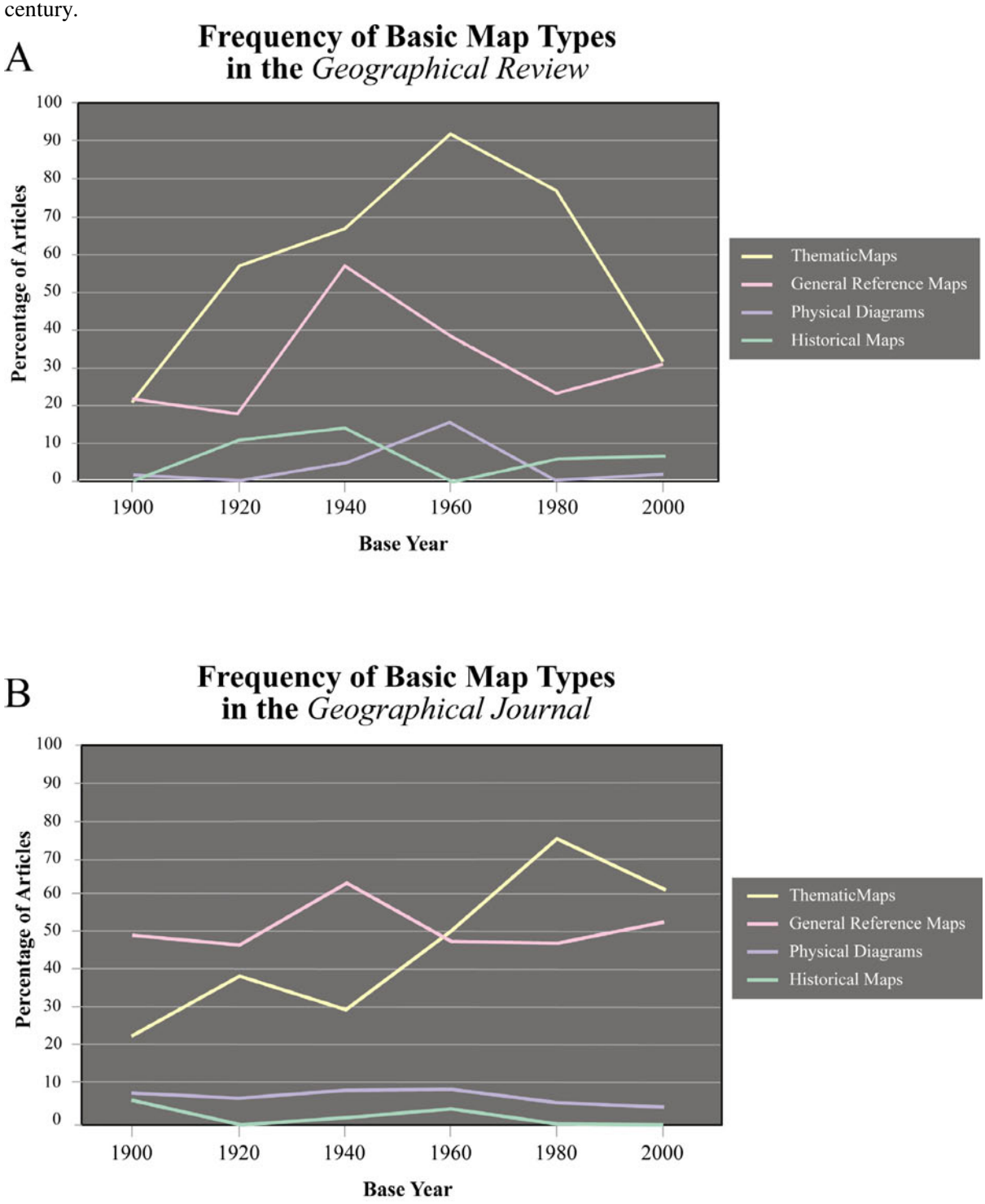

Figure 4. Frequency of various kinds of thematic maps. (Results for the *GJ* are largely from p. 14 of Kessler and Slocum.)

Evaluation of Individual Maps

The results of our overall analysis of the individual maps using the ten-point scale are shown in Figure 5. Note how the means for the *GJ* gradually increased over time, with the lowest appearing in 1900 (5.6) and the highest in 2000 (6.9). In contrast, the means for the *GR* increased rapidly from a low of 3.6 in 1900 to a high of 7.3 in 1940 and then were slightly lower than the 1940 mean for remaining years. The rapid increase from 1900 to 1920 is undoubtedly related to the renaming and restructuring of the *GR* during this

period. In 1900, it was known as the Journal of the *American Geographical Society* and in 1916 it became the *GR*.

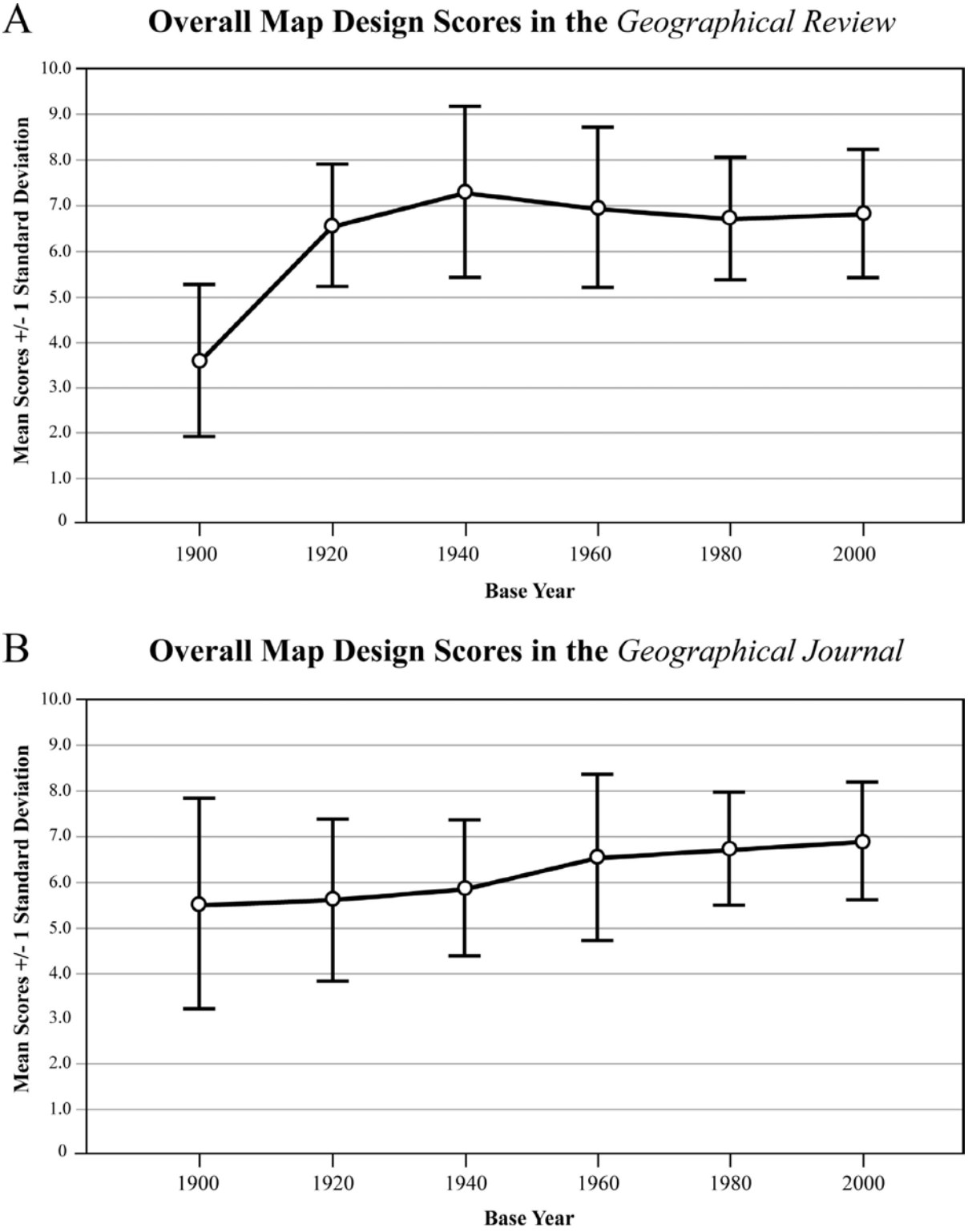

Figure 5. A summary of the overall map design mean and standard deviation measures for each journal for each base year. (Results for the *GJ* are from p. 15 of Kessler and Slocum.)

To examine the statistical significance of the data plotted in Figure 5, we conducted a two-way ANOVA, with the base year and journal as factors. Since the results revealed a significant interaction between the base year and journal ($p < 0.001$), we chose to use a difference-of-means test to see which years had significantly different means between the journals. We found that the mean was significantly higher for the *GJ* in 1900 ($p = 0.003$), and for the *GR* in 1940 ($p = 0.014$).

In examining Figure 5, you will also note the relatively large variation in our overall evaluation for each journal for each time period. This can be seen in more detail in Figure 6, where we have depicted the raw overall evaluation scores using dispersion graphs. Note that even when the mean is relatively high (as in 1940 for the *GR*), there are still a number of poorly designed maps (in this particular case, there were scores of 3.5 and 4.0).

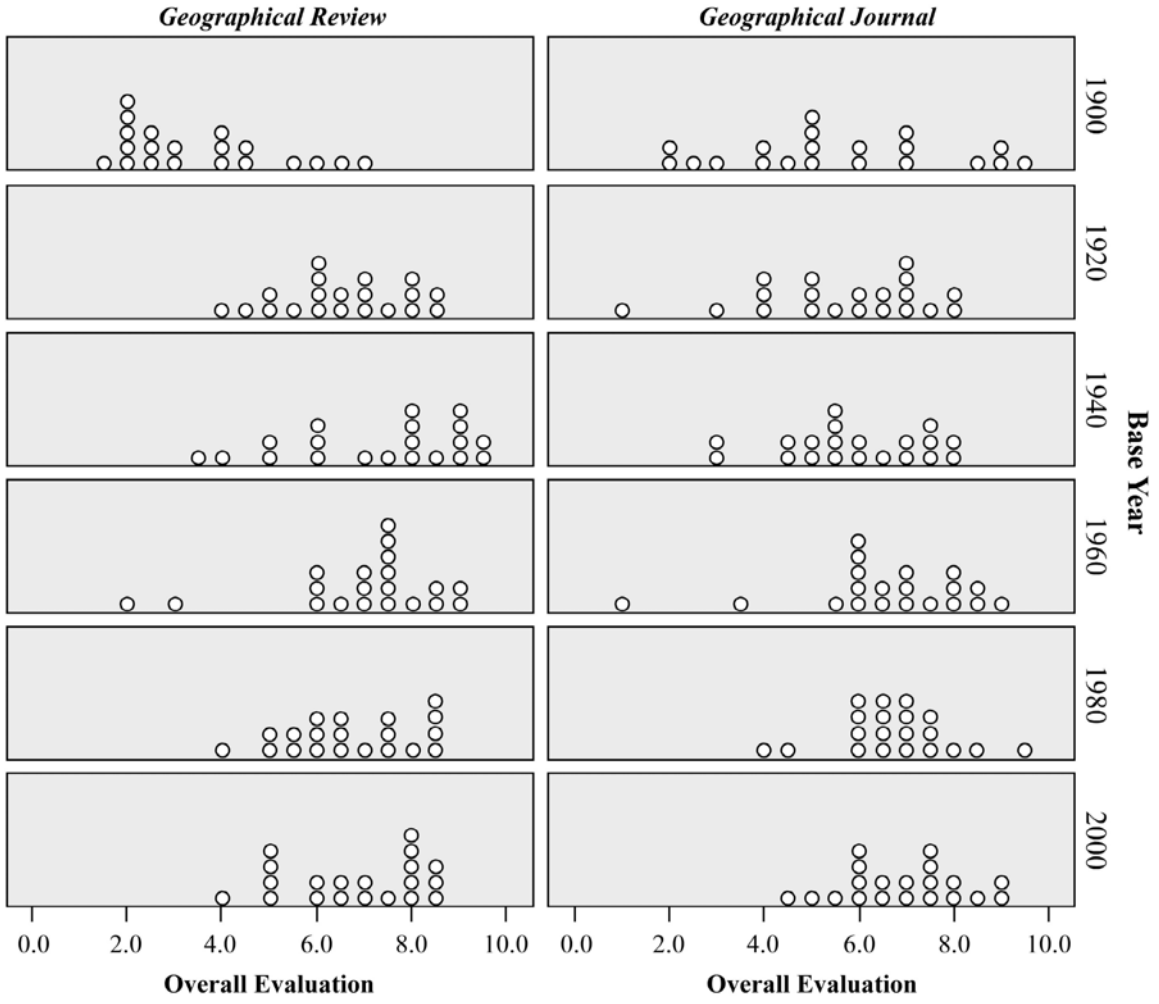

Figure 6. Dispersion graphs of the raw overall evaluation scores for all maps on the ten-point scale. (Results for the *GJ* are from p. 16 of Kessler and Slocum.)

We analyzed the set of nineteen items using contingency tables. We utilized Pearson's chi-square test for items not involving a Likert-type scale and a Gamma statistic for items involving a Likert-type scale. Since contingency table tests are sensitive to small expected values, we combined Likert categories 1 and 2 (those associated with poorly designed maps) and categories 4 and 5 (those associated with well-designed maps), and we combined data for 1900 and 1920, 1940 and 1960, and 1980 and 2000. To determine which cells contributed to relationships, we utilized adjusted residuals, focusing on residuals having an absolute value greater than 2 (Haberman 1973).

The results of the contingency table tests are shown in Tables 2 and 3. Due to a space limitation, we will discuss only those items that are statistically significant over time. Let's first consider three items for which there was a significant relationship between the item and time for both journals. Location of Title was highly significant for both journals ($p < 0.001$). In early years, there was a greater tendency for the title to appear on the map (in 1900 for the *GJ* and in 1920 for the *GR*). The situation in later years was a function of the journal. For the *GJ*, in 1980 and 2000 all titles appeared in the caption; for the *GR*, there was an increasing tendency for the title to appear in both the map and caption, with a peak in 2000. We felt that many of the maps could have been interpreted more readily if title information appeared in both the title and caption.

Table 2. Probability values associated with the chi-square tests[**]**

Item	*Geographical Review*	*Geographical Journal*
Location of Title	<0.001*	<0.001*
Orientation	<0.001*	0.008*
Source	0.001*	0.060
Legend Presence	<0.001*	0.230
Legend Units	0.088	0.607
Location of Map Title	0.005*	0.644
Inset Map for Location	0.013*	0.203
Inset Map for Complex Areas	0.154	0.434
Scale Essential	<0.001*	0.073

*Significant using a modified Bonferroni correction developed by Hochberg (1988); the overall α was set to 0.15.
** Results for the *GJ* are from p. 16 of Kessler and Slocum (2011).

Table 3. Probability values and gamma values associated with the gamma statistic[**]**

	Geographical Review		*Geographical Journal*	
Item	Prob-value	Gamma	Prob-value	Gamma
Visual Hierarchy	0.010*	0.304	0.290	0.134
Readability	<0.001*	0.844	<0.001*	0.662
Logic of Symbology	0.007*	0.329	0.582	0.070
Legend Theme	0.207	0.221	0.016	0.355
Legend Title	0.678	-0.214	0.174	0.383
Legend Design	0.103	0.344	0.056	0.392
Scale Meets Conventions	0.024	-0.601	0.794	0.076
Map Projection	0.463	-.176	0.148	-0.793
Title Directness	0.169	0.236	0.049	0.320
Map Referenced	0.070	.219	<0.001*	.623

*Significant using a modified Bonferroni correction developed by Hochberg (1988); the overall α was set to 0.15.
** Results for the *GJ* are from p. 18 of Kessler and Slocum (2011).

The results for Readability were also highly significant for both journals ($p < 0.001$). The adjusted residuals revealed a clear trend over time, with lettering for early years being difficult to read and lettering for later years being easy to read. We found that maps in 1900 and 1920 often could not be read without the aid of a magnifying glass. Early designers often drew maps at a large scale and then photographically reduced them to hide imperfections of hand drafting, and in this process did not plan for the final map size (Cook 2002, 141).

The results for Orientation were highly significant for the *GR* ($p < 0.001$) and slightly less significant for the *GJ* ($p = 0.008$). For both journals, it was common in 1900 and 1920 to use a grid to depict latitude and longitude. For the GR, there was a definite tendency in 1960 to depict latitude and longitude via tic marks. In later years, north arrows were more common (in 2000 for the *GJ* and in 1980 for the *GR*). 35.8% of *GR* maps and 36.7 percent of *GJ* maps had no indication of orientation. We had hoped to evaluate whether the specification of orientation was essential, but found this a difficult concept to evaluate.

Several items were significant for only one of the journals. The Map Referenced item was the only item that was significant for the *GJ* ($p < 0.001$), but not for the *GR* ($p = 0.070$). In the case of the *GJ*, in early years (most notably 1920) there was a tendency for the map not to be referenced in the text, while in later years there was a tendency for the map to be referenced and also integrated well with the text (the map was referenced and integrated well for 70.0 percent of the maps in 1960, 1980, and 2000). Although the results were not significant for the *GR*, the overall trends were similar to those for the *GJ*. Interestingly, though, maps were not as well integrated with the text in 2000 as in 1960 and 1980; in 2000, 60.0 percent of the *GR* maps were referenced but not clearly integrated with the text.

Seven items were significant for the *GR*, but not for the *GJ*. Those for Legend Presence ($p < 0.001$), Scale Essential ($p < 0.001$), and Logic of Symbology ($p = 0.007$) appeared to be significant as a result of poorly designed maps in 1900 for the *GR*. In 1900, 35.0 percent of the *GR* maps did not include a legend when one was necessary. In later years of the *GR*, legends were much more common; for instance, in 1980 100 percent of the maps fell in the category "legend present on map and necessary." Overall, 67.5 percent of *GR* maps and 72.5 percent of *GJ* maps fell in this category.

The Scale Essential item considered whether a scale was essential for interpreting the map theme(s) and whether a scale was included. In 1900, 55.0 percent of maps in the *GR* did not include a scale when one was essential, whereas in later years scales were more apt to be included when essential. Overall, 80.8 percent of maps in both journals fell in either the category "essential and included" or "essential, not included." Although in our own teaching we have found that we tend to deemphasize the importance of scales, this survey illustrates that scales are essential for a wide variety of thematic maps.

Logic of Symbology considered whether logical decisions were made in selecting the symbology. In 1900, 75.0 percent of *GR* maps fell in Likert categories 1 or 2 (those representing poorly designed maps). In no other year did these combined categories exceed 30.0 percent.

The significant result for Source for the *GR* ($p = 0.001$) was a function of several residuals that exceeded 2.0; particularly notable was that 40.0 percent of the maps in 1940 fell in the category "not included, but essential," while in 2000 70.0 percent of the maps fell in the category "included." More important, however, was the fact that a source was not included in 82.5 percent of *GR* maps and 73.3 percent of *GJ* maps. We felt that the maps could have been interpreted much easier if a source were explicitly specified on the map or in the caption, as opposed to being mentioned somewhere else in the article.

Location of Map Title appeared to be significant for the *GR* ($p = 0.005$) as a result of a slightly greater tendency for the title to appear "in a typical location near the top of the map" in 1980 and in the legend in 1960. Overall, when a title was included, it was most likely to occur near the top of the map and separate from the legend (57.6 percent for the *GR* and 45.0 percent for the *GJ*).

Visual Hierarchy dealt with the extent to which a suitable visual hierarchy was established. The significance of this item for the *GR* ($p = 0.010$) was partly a function of the poorly designed maps for 1900 (70.0 percent of them fell in Likert categories 1 or 2), but also because of well designed maps in 1940 (65 percent of maps fell in Likert categories 4 or 5). Recall that maps in 1940 for the *GR* received the highest overall rating on our 10-point scale; presumably, visual hierarchy was an important component of our overall rating.

Inset Map for Location dealt with whether an inset map was included that specified the location of the region focused on. The significant result for the *GR* in this case ($p = 0.013$) appeared to be a function of more insets appearing to be necessary and included in 2000 than in 1900 and 1920. More interesting was the fact that when we felt that an inset should be included, it seldom was (only 31.0 percent of *GR* and 7.9 percent of *GJ* maps included insets when we felt they should). The difference in these percentages may reflect our greater knowledge of North American geography, which was more likely a focus of articles in the *GR*.

DISCUSSION

The analysis tends to support the findings from our previous study. First, the analysis contradicts Friendly's notion of a Modern Dark Ages in the context of thematic map design. On average, the most poorly designed maps in the *GJ* did appear in the first half of the twentieth century, but there were many well designed maps in the *GJ* in this period. For the *GR*, the most poorly designed maps appeared in 1900, but there was a rapid improvement in 1920 and on average, the best designed maps appeared in 1940.

We hypothesized that there would be an improvement in map design over the course of the twentieth century due to improved drafting tools, the availability of computer-based methods, the availability of cartographic textbooks and coursework in cartography, and the role of journal editors in stressing the importance of good map design. Figure 5B suggests that there was a general improvement in map design

for the *GJ*, but the typical map was not well designed in 2000 (the score was 6.9 on our 10-point scale) and there was considerable variation in the quality of design. As we have just indicated, map design obviously did not improve for the *GR* over time. So why has map design not reached the level that we might have hoped? Our guess is that those designing maps for these journals have not had the cartographic training that would lead to good map design. Yes, cartographers were involved in creating maps for both of these journals, but our suspicion is that many of the maps were designed without the assistance of professional cartographers.

One limitation of the present study is that we sampled only twenty maps from each twenty-year interval and we stopped sampling articles once we had reached a twenty-map threshold. As a result, we had to combine categories in order to conduct our statistical analysis. In subsequent work, we hope to increase our sample size and create a sampling window around each twenty-year interval (i.e., sample maps from 1959 and 1961 when looking at the 1960 base year). Sampling more maps would mean that we would also sample more articles, thus strengthening the character of the curves shown in Figures 2-4.

Another limitation is that in this study and our previous one we have only examined geographical journals. One wonders what we would discover if we were to examine journals outside the discipline of geography. Although one might hypothesize that the design of maps outside geography would suffer, we may also find that those designing maps in other disciplines have much to offer.

CONCLUSION

Our results lend further support to the basic conclusion that maps in professional geographical journals do not exhibit the high quality of map design that we might expect in these journals. In our previous work, we suggested that a set of Web tutorials might be developed that would instruct authors on key aspects of maps design for journal articles. Hopefully, this is a niche that someone will fill in the near future so that when a similar analysis at the end of the twenty first century is conducted, we see a distinct improvement in map design in these journals.

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