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STARS, BARS OR TABLES FOR BUSINESS STATISTICAL PRESENTATIONS?

ABSTRACT

Today most interactive systems use graphical and tabular displays. Much work has been done on comparing bar and line charts to tables, but little has focused on alternative graphics that have been described in the statistical literature for many years. A comparative study of different representations of financial and accounting information in a decision setting is presented using commonly known bar graphs (histograms) as a control. Bar graphics are found to provide faster but more inaccurate responses than tabular presentation of information in credit rating and industry classification decisions. While star graphics take more time they do however improve ability to making decisions which involve ranking such as relative credit risks. Thus all new graphics should be tested for speed and efficacy before they are incorporated in computerized decision support systems.

KEY WORDS: Computer graphics, statistical presentation, new graphics, star graphs, graphics for decision support systems.

I. INTRODUCTION

A number of researchers have begun to piece together a mosaic of the relationship between the way information is presented in a decision support system and its effect on the decision process. Mintzberg (1973) has presented an analysis of the task environment within which managers often operate. Keen and Scott-Morton (1978), contrast the manager's environment with that of the systems analyst and programmer usually entrusted with the design of information display systems. System developers often reach decisions after long periods of analysis and reflection and address problems one at a time. Managers, on the other hand, seem to prefer an environment in which multiple problems are addressed simultaneously. Keen and Scott-Morton suggest that the types of information display perceived as suitable by analysts and programmers may not be appropriate for the seemingly chaotic environment of managers. They point out that managerial decision support systems should present information in a manner in which it can be assimilated rapidly, and suggest such systems should be tailored to the information processing style of the individual user.

In an early proposal for research on information systems, Mason and Mitroff (1973) suggest the importance of the mode of presentation on the effectiveness of a decision support system. These ideas were tapped in series of experiments known as the "Minnesota experiments," Dickson, Desanctis and McBride (1973), which outlined the results of a series of nine formal experiments investigating the relationship between the type of decision, the decision maker, and the information system supporting the decision. The experimental variables included the presence of detailed or summarized data, hard copy or cathode ray tube terminal (CRT) output, and the use of decision aids. Dickson et al. reached the following conclusions:

1. On line CRT system output can lead to faster decisions and use of substantially less data than use of typed manuscript presentation.

2. Graphic output may have results similar to that of CRT systems and may even lead to better decision making.

3. Managers like to use interactive systems and their use enhances acceptance of information systems generally.

4. Information system designers need to be sensitive to individual differences in users; the relevant variables may differ by the type of problem and information system.

The work of Dickson has been continued by Lucas (1981) who contrasted the efficacy of graphic vs. tabular output for heuristic vs. analytic decision makers. Generally he found that hard copy terminals were preferable to CRT's and that graphic presentation was not as effective as tabular presentation. He suggested that the inability to use graphics may have resulted from insufficient training. Moreover, he found that using cognitive style as measured by the analytic heuristic questionnaire (AHQ) people with heuristic orientation did perform better with the graphic treatments than did analytics.

In their updates of the studies of graphics Dickson et al. (1986) have shown that the different types of presentations should be matched to the characteristics of the problem. In tasks for which accurate interpretation of values is important, tables are probably a better choice than graphs. For seeing time dependent patterns, graphics are a good choice of format. Where people are presented with a large amount of data and the goal is to recall some fairly specific facts about the data immediately after presentation, again graphs are a good choice of treatment (Dickson et al., 1986, p. 46).

This and other early studies are well reviewed by De Sanctis (1984). Other studies have appeared involving color (Benbasat and Dexter 1985 and 1986), mode of presentation (Lucas and Nielsen 1980), and task complexity (Remus 1984). Most recently, Remus (1987) has shown that problems with environments of low and intermediate complexity, as defined by Schroeder and Benbasat (1975), are best solved with graphical rather than tabular displays. Mackay and Villarreal (1987) claim the effectiveness of graphical and tabular displays changes with too many variables and find no major performance changes between the two types of display. These experiments focused on the contrast in the efficacy of graphic and tabular displays for narrow problem settings.

However, statisticians have developed different types of graphical displays for the presentation of multivariate data. A review of the history of graphics indicates that the use of graphical representation has its roots in the late 18th and early 19th century when Playfair and Crone introduced such techniques as pie graphs and bar graphs. Little in the way of new graphical techniques came along until the 1960's. Then, new graphic techniques were introduced by such individuals as Anderson (Glyphs), Andrews (see Feinberg 1979 - Andrews Function Curves), Chernoff (1973 - Chernoff Faces), Kleiner and Hartigan (1981 - Castles and Trees) and Feinberg (1979 - Bar Graphs). The purpose of these new techniques was to allow the presentation of multivariate data in plane figures and graphs (see, Abrams 1981, Chernoff 1973, Feinberg 1979, and Huff et al. 1981).

Figure 1

Some examples of the new graphic displays are in Figure 1. They are taken from an article by Kleiner and Hartigan in the June 1981 issue of the Journal of the American Statistical Association. The five types of displays (profiles, stars, glyphs, faces and boxes) are shown below for the same data, Republican votes in 6 presidential elections in six southern states.

It has been conjectured that these techniques provide for more effective graphic displays to present multifaceted data than simple graphic analysis can provide and have been highly recommended in the financial accounting and marketing literature (see for example Abrams 1981, Friend 1982, Huff, Mahajan and Black 1981, and Moriarity 1979). Yet as the number of graphic tools increases, the importance of studying their various performance increases since it is unreasonable to incorporate all graphic forms into a software package and require the decision maker to select the best form of presentation or to use all forms of presentation in the decision process, as is suggested by certain studies (see MacKay and Villarreal 1987). The purpose of the research reported in this paper is to study the relative efficacy of the stars graphic data presentation method, (second line in Figure 1) used in a computerized decision support environment, for the purpose of enabling managers to analyze and to classify financial information.

II. THE HYPOTHESES

While articles in the statistical journals have discussed the various new methods of data presentation and statistical packages are incorporating them into the software, few tests of the effects of these methods and their ability to enhance the rapid and accurate assessments of data have been presented. One study by MacKay and Villarreal (1987) found that Chernoff faces were not superior to tabular data in financial decisions. If other new graphic displays do not contribute to the ability to analyze situations and/or formulate decisions then they are mere exercises in creative drawing, deriving their prime importance from generating interest in statistical data. If they do contribute to the ability to analyze and make decisions, wider adoption by both the business and research community should be encouraged.

Along the lines of previous studies (Remus 1984 and 1987) the scope of the hypotheses will be limited to a particular problem class of low complexity. In our case we deal with two financial decisions requiring simple rankings and classifications. For the initial experiment it is hypothesized that:

1. The star graphic display would take more time than the tabular display for both problems.
2. The star graphic display would allow for more accurate answers for both problems.

Controls will be made for cognitive style, simple well known (bars) versus less well known (stars) forms of graphics, appropriate training in star graphics interpretation, and CRT use will be offered to keep these experiments consonant with the suggestions of previous experimenters in this field and yet allow for the revisions in experimental techniques suggested by Lucas (1981), Dickson et al. (1973), and DeSanctis (1984). Since a new form of graphics (the stars) was compared to tabular displays it was felt that unfamiliarity with the display might affect results. Therefore the same problem was also displayed using a familiar graphics form -- bar graphs for control purposes. The criteria, for the test are shown in Figure 1A.

Insert Figure 1A here

III. EXPERIMENTAL DESIGN

A. The Problems

Two financial and accounting problems were developed. One involved the classification of firms into the proper industrial group on the basis of an examination of the assets, liabilities and financial ratios of the firm. The second problem involved pattern recognition. The subjects were asked to rank and identify good and bad credit risks on the basis of answers to six questions frequently asked on credit applications.

The first problem was derived from a Harvard case, "The Case of the Unidentified Industries 1979" (Charles Williams 4-279-104). Each subject was presented with assets and liability data from balance sheets and selected ratios drawn from balance sheets and operating statements from firms in different industries. The subject was also given a list of the industries from which the firms were drawn. The problem was to match each firm with the appropriate industry by examining its financial data characteristics.

Each subject was also asked to solve another problem. The second problem, referred to as the Loan Risk problem, asks the subject to picture himself or herself as a manager in a savings and loan organization. The manager has been given financial data for nine loan applicants. The problem is to rank the applicants in order of the amount of risk involved. The three best risks are to be chosen and ranked and the three worst risks were to be chosen and ranked. The problem was composed by one of the researchers after consultation with several loan officers in local lending institutions and review of loan application forms. Previous studies using multivariate graphics had theorized that these never graphic representations (such as stars) were especially good for the recognition of patterns. Thus it was possible for anthropologists to classify teeth for apes, baboons, and chimpanzees (Feinberg 1979) using the patterns. Similarly the patterns for good and bad credit risks should become clear and easy to recognize by using multivariate graphical representations.

B. The Subjects

A brief description of the nature and purpose of the experiment was presented to several classes of MBA students in their final two trimesters at Southern Methodist University along with a request for volunteers. The criteria for selection of volunteers was that each one must have completed the

Finance and Accounting courses (the problems were related to these areas) and the initial computer class. A high degree of interest was expressed in the experiment; 103 students from a class of 150 voluntarily participated during the spring and summer sessions. Each of the students had been exposed to some amount of interactive terminal work, since an interactive financial planning language (IFPS) is taught in the required Management Information Science course.

C. The Resources

In order to compare subject behavior in response to graphical versus tabular information displays, we chose to use the same computer system, the same set of problems, the same set of menus and the same instructions to the subjects for both graphics and tabular displays.

Each terminal session consisted of two problem solving activities. The problems were composed to have a strong business orientation, hopefully representative of the type of problem a manager in business may be faced with on a daily basis. The interactive programs to display information about the problems and to record student responses were written by the investigators. The subjects received problem data in either tabular, bar graph or star graph form. An assistant was available to answer any questions regarding the computer, the software, or the data presentation.

D. The Star Graphic

In the star graphics representation, second line in Figure 1, a circle is divided into equal sectors. Each sector represents a particular value. For example, in the loan risk problem we have the sectors shown in Figure 2. If the amount is average the line goes to the circumference of the circle. If the number is below average the line is inside the circle if it is above average, the line is outside the circle. Contrast the two graphs in Figure 3.

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was much more complex, requiring three screens. The first presented asset data, the second liability data and the third selected ratios. The subject was offered a main menu from which to select either a "data display" or "input responses"; the program automatically returned to the main menu after each screen was displayed.

Figures 4, 5 & 6

The programs measured the times it took a subject to respond to a menu or a prompt. In addition, the programs counted the number of times each display was requested. The interval measurements were based on elapsed real time rather than CPU time to eliminate the effect of slower system response when many persons were using the computer. The program also tallied the number of correct responses for each problem.

V. RESULTS

A. Overall Characteristics of Subjects

A total of 103 subjects were tested using the same two problems (Loan Risk and Unidentified Industries Problems). Thirty three used tabular displays and thirty one did star graphics displays and 39 did bar graphics displays. Sixty percent of the subjects were male and 40% were female. The age of the subjects ranged from 22-39 with the mean age being 27. The average years of work experience were 4-1/2. Furthermore, approximately seventy one percent of the subjects said that they enjoyed math and they were good in mathematical subjects. All subjects had worked on computers and thus were familiar with work on terminals. About 50% said that they experience computer anxiety some of the time or most of the time. Forty-five percent said they never had any experience with computer graphics while 10 percent had had quite a bit of experience with computer graphics. Eighty percent said that they preferred graphic to tabular presentations. As far as the personality characteristics are concerned the subjects seem evenly split except that 69 percent tested as intuitive (like new problems) vs. 31 percent sensory (like a precise routine). Since all the students had completed one half to two thirds of the MBA program these subjects would be expected to understand the problems presented.

B. Overall Results of Tests

Menu displays from which the respondent could pick the next action were offered as frequently as desired. The average number of times that displays were requested for the loan risk problem was 8 and for the unidentified industries problem it was 11. The average time elapsed for the loan risk problem was 559 seconds (and it ranged from 98 to 1375 seconds) and for the unidentified industries seconds problem it was 1817 seconds (and the range was from 315 to 4911 seconds).

As far as correct scores were concerned in the loan risk problem the respondents were given one point for each poor credit risk identified (3) and one point for each good credit risk identified (3) and one point for putting the poor credit risks in proper order as well as one point for putting the good credit risks in proper order. Thus a total of 8 points was possible. Actual scores ranged from 3 to 8. Approximately 16 percent of the subjects had a perfect score and the mean score was 6. Most people found the good and bad risks but many couldn't rank order them.

The Unidentified Industries problem was more difficult. There were seven industries and only six matches could be made, the seventh industry having no match. A total of seven correct responses could be made. The mean number of correct matches was 2.9 and the number of correct matches varied from 0 to 6.

C. Accuracy

Since the most important dimensions of the test were the accuracy of results and the amount of time taken to reach a decision we will first analyze our results by relating presentation modes to accuracy.

When we look at accuracy for the classification of unidentified industries (Table IA) the tabular presentation is overall significantly more effective than either the stars or the bars. The star presentation is far less accurate than the tabular presentation 68% correctly identified 0,1 or 2 industries whereas only 24% were able to correctly identify 0,1 or 2 with the table presentation. When we compare (using a test of differences between proportions) the bar graphs and the star graphs on this type of presentation, however, there is no significant difference in the effectiveness for either of these graphic presentations. Thus, a problem which uses a number of criteria to evaluate each industry but where each industry has different criterion is not amenable to graphics presention. Perhaps efficacy, requires uniform decision criteria like those in the loan risk problem.

Table I

We turn now to the loan risk problem. Here we have six criteria for each loan risk measurement -- 3 assets and 3 liabilities which are considered the same for all loan risks. Here we find that overall the tables are a better tool for classifying risks. 76% scored 6-8 correct using tables compared to 39% for the stars and 11% for the bars. The way this problem was scored included 6 points for picking the 3 best and 3 worst credit risks, 1 point for putting the best credit risks in order from best to worst and 1 point for putting the three worst credit risks in order of bad to worst. Note that in this example 26% of those using the stars were able to correctly order the risks while only 6% of those using tables and 0% of those using bar graphs were able to do this. Thus, the special new graphics may be very effective to help individuals rank alternatives.

D. Time Elapsed

Now looking at time needed to arrive at a decision in the identification of industries problem use of the new graphics stars required far more time than either the bar graphs or the tabular presentation. These differences were significant at the .05 level using a χ^2 test (Table IIA). It is interesting to note that the tables and the familiar bar graphs took approximately the same time.

Table II

When loan risks were classified the shortest time was taken by those using the bar graphs, however, as we have seen in Table I these people tended to be the least accurate. The tabular displays took an intermediate amount of time and the star graphs required far more time than either the tabular or bar graph presentations although as we have seen above the stars afforded additional ability to rank risks (Table IIB).

In summary, from the time standpoint tables and bars seem to take equal time and sometimes bar graphs may take less viewing time than tables or the newer graphics. In this case, the stars presentation requires much more viewing time.

E. Other Variables

We also included a number of control variables in this study to see whether such things as cognitive style, mathematical and computer abilities, anxiety levels and demographic variables (age, sex) affected the speed and accuracy of decision making. As far as demographic characteristics are concerned, the sex of the subject does not relate to accuracy or elapsed time. Younger persons took less time to perform the credit risk identification, but about the same time to identify industries. Table III summarizes these results.

Table III

Various abilities that might relate to performance on these problems using star graphics versus tabular presentations were recorded. These included drafting experience, graphics experience, finance background, years of math studied, college statistics preparation, enjoyment of math and ability to play a musical instrument. The only variable that showed any relationship was ability to play a musical instrument. Those who played a musical instrument were faster at making decisions on both problems using any type of presentation. It may be that music constantly involves reading presentations (notes) and acting upon them. The next variable analyzed was anxiety about mathematics and anxiety about computers. The greater the computer anxiety the lower the accuracy for either the graphic or the tabular presentations. Math anxiety did not affect results.

Finally cognitive style was used as an intermediate variable. In terms of elapsed time cognitive style did not affect results. In terms of accuracy "thinking" people as opposed to "feeling" people did better on graphics presentations for the identification of industries. Thinking people are those who solve problems by setting up rules while feeling people are more likely to make judgments based on their feelings about the problem.

VI. Summary and Conclusions

In this study, the stars technique, a new graphics form was studied in terms of time needed for problem solution and accuracy. Two problems were used, one where all similar items showed the same pattern and another where pattern wasn't a crucial factor in the determination of outcomes. Controls for demographic variables, cognitive style, math and computer anxiety and abilities were used. In addition, a control group used familiar bar graphics or tables to solve the same problems. Generally, abilities and cognitive style showed little effect on results. Solutions took least time using tables. Bar graphs took less time than the newer star graph presentations. Overall, those using tables were more accurate than those who used any form of graphics, which indicates financial decisions may require different presentation forms than the production problems studied by Remus (1987). However, in the loan risk problem where pattern recognition was important in ranking credit risks the people who used the star presentation were significantly better at ranking risks than those who used tables or conventional bar graphs. Therefore the efficacy of different type of graphic and tabular decision support presentations relates to the type of problem for which it is used and suggests that the graphics should be studied in terms of the types of presentations where they could be most helpful before they are introduced in decision support systems.

New graphics like the star representation seem to be useful in special situations such as pattern recognition (credit risk rankings). They do, however, require the decision maker to take more time than would be needed in using tabular forms or conventional forms such as bar graphs. Perhaps the excess time consumption arises because of the unfamiliarity of these techniques. Hence if new techniques are to be successfully implemented more <u>training</u> will be required.

It was interesting to note in the simple loan risk problem that relatively few of the MBA students were able to rank the risks in terms of degree of risk (.26% at most performed accurate credit rankings using the optimal presentation form). Most business situations require simultaneous evaluations and comparison of several alternatives. Thus our educational system (MBA and BBA) may not be paying sufficient attention to pattern recognition. Utilization of graphical decision support systems that compare patterns (such as stars) may help to overcome this deficiency.

We have developed a comprehensive study design to test the differing graphics for their effectiveness for decision support (Figure 7). The measurement criterion basically studies the <u>time</u> necessary to reach a decision and the <u>accuracy</u> of the decision. We have seen in this study that the star graphics is particulary useful for problems which involve recognition of similar patterns. It is often true that a particular style of graphics may be more effective for people with different types of abilities or different cognitive styles. Demographic factors such as age and sex may also be important. Other possibilities such as math anxiety may also influence effectiveness. These intervening variables should be included in any study of effectiveness.

Moreover, a new graphic technique should be tested against an older more conventional technique as well as a tabular presentation, as we did with the bar graphs. This form of controlled testing with different test groups should be applied to the new graphics such as profiles, graphs, faces and boxes

(Figure I) so that the most effective types of decision support systems could be devised. It would then be possible to develop a system of different sets of graphics which could be computer developed for different types of decision support systems.

Finally, when an effective presentation system for a given problem is devised, analysis of graph perception as suggested by Simkon and Hastie (1987) and Cleveland and McGill (1984), and Cleveland (1986) should be used to improve the proportions and other design elements of the graphics.

REFERENCES

Abrams, Bill, "With Computer Help, Marketing Professor Faces Up to Corporations Financial Data," Wall Street Journal, July 22, 1981, p. 1.

Benbasat, Izak and Albert S. Dexter, "An Investigation of the Effectiveness of Color and Graphical Information Presentation Under Varying Time Constraints," MIS Quarterly, Vol. 10, No. 1, March 1986, 1348-1364.

Benbasat, Izak and Albert S. Dexter, "An Experimental Evaluation of Graphical and Color-enhanced Information Presentation," Management Science, Vol. 31-11, November 1985, 1348-1364.

Chernoff, H., "Using Faces to Represent Points in K-Dimension Space Graphically," Journal of the American Statistical Association, Vol. 68, June 1973, 361-368.

Cleveland, William S. "Research in Statistical Graphics," Journal of The American Statistical Association, Vol. 82, No. 398, June 1987, 419-423.

Cleveland, William S. and Robert McGill. "Graphical Perception and Graphical Methods for Analyzing Scientific Data," Science, Vol. 229, 1984, pp. 828-822.

DeSanctis, Gerardine, "Computer Graphics as Decision Aids: Directions for Research," Decision Sciences, Vol. 15-4, 1984, 463-487.

Dickson, G., G. De Sanctis and D. J. McBride, "Understanding the Effectiveness of Computer Graphics for Decision Support: A Cumulation Experimental Approach," Communications of the ACM, Vol. 29, No. 1, January 1986, 40-47.

Dickson, G., J. A. Senn and N. Chervany, "Research in Management Information Systems," Management Science, Vol. 19, 1973, 913-922.

Feinberg, Stephen E., "Graphical Methods in Statistics," The American Statistician, Vol. 23, November 1979, 165-178.

Friend, David, "Graphics for Managers: The Distributed Approach," Datamation, July 1982.

Huff, David I., Vijay Mahajan and Wm. C. Black, "Facial Representation of Multivariate Data," Journal of Marketing, Vol. 45, Fall 1981, pp. 53-59.

Keene, P. G. W. and M. S. Scott-Morton. Decision Support Systems: An Organization Perspective. Reading, MA: Addison-Wesley, 1978.

Kleiner, B. and J. A. Hartigan, "Representing Points in Many Dimensions by Trees and Castles," Journal of the Americn Statistical Association, Vol. 76, June 1981, 260-275.

Lucas, H. C., "An Experimental Investigation of the Use of Computer Based Graphics in Decision Making," Management Science, Vol. 27, July 1981, 757-768.

Lucas, Henry C. and Norman R. Nielsen, "The Impact of the Mode of Information Presentation on Learning and Performance," Management Science, Vol. 26-10, October 1980, 892-993.

MacKay, David B. and Angeline Villarreal, "Performance Differences in the Use of Graphic and Tabular Displays of Multivariate Data," Decision Sciences, Vol. 18-6, 1987, 535-546.

Mason, R. I. and I. Mitroff, "A Program for Research on Management Information Systems," Management Science, Vol. 19, 1973, 475-487.

Mintzberg, H. The Nature of Managerial Work. New York: Harper Row, 1973.

Moriarity, S., "Communicating Financial Information Through Multidimensional Graphics," Journal of Accounting Research, Vol. 17, No. 1, 1979, 205-224.

Remus, William, "A Study of Graphical and Tabular Displays and Their Interaction with Environmental Complexity," Management Science, Vol. 33-9, September 1987, 1200-1204.

Remus, William, "An Empirical Investigation of the Impact of Graphical and Tabular Data Representations on Decision Making," Management Science, Vol. 30-5, May 1984, 533-542.

Schroeder, R. G. and I. Benbasat, "An Experimental Evaluation of the Relationship of Uncertainty in the Environment to Information Used by Decision Makers," Decision Sciences, Vol. 6-3, 1975, 556-567.

Simkin, David and Hastie, Reid. "An Information Processing Analysis of Graph Perception. Journal of the American Statatistical Association. Vol. 82, No. 398, June 1987, 454-466.

Table I

Number of Correct Answers
by Type of Presentation

A. Classification Unidentified Industries

Number of Correct Answers	Tabular		Stars		Bars	
0, 1 or 2	8	24%	21	68%	20	58%
3 or 4	23	70	6	19	12	35
5, 6 or 7	2	6	4	13	2	6
	33	100%	31	100%	34	100%

$\chi^2 = 13.720$, df = 2,* signif at .01 level

B. Classification of Loan Risks

Number of Correct Answers	Tabular		Stars		Bars	
Answers 0, 1, or 2	1	3%	0	0%	1	3%
3, 4 or 5	7	21	12	39	32	86
6	23	70	11	33	4	11
7 or 8	2	6	8	26	0	0
	33	100%	31	100%	37	100%

$\chi^2 = 32.901$, df = 2, signif at .01 level

*Rows were combined to insure that expected values in each cell were at least 5.

Table II

Total Time Elapsed by
Type of Presentation

A. Classification of Unidentified Industries

Seconds Elapsed	Tabular		Stars		Bars	
300-1398	15	46%	6	19%	17	50%
1399-1899	11	33	10	32	9	26
1900 and over*	7	21	15	49	8	24
	33	100%	31	100%	34	100%

χ^2 = 9.507, 4df., signif at .05 level

*Top time was 3006 seconds and minimal time was 311 seconds.

B. Classification of Loan Risks

Seconds Elapsed	Tabular		Stars		Bars	
300-1398	11	37%	11	36%	19	66%
1399-1899	14	47	10	32	5	17
1900 + *	5	16	10	32	5	17
	30	100%	31	100%	29	100%

$\chi 2$ = 9.855 df = 4, signif at .05 level

*Top time was 3373 seconds and minimal time was 360 seconds.

Table III

Relationship of Intermediate Variables to
Accuracy and Time Elapsed for Solution of
Different Problems Using Star Graphics vs. Tables

	Problem			
	Credit Risk		Unidentified Indistries	
Variables	Accuracy	Elapsed Time	Accuracy	Elapsed Time
Demographic				
Sex	NS	NS	NS	NS
Age	NS	Younger less time than older	NS	NS
Abilities				
Drafting Experience	NS	NS	NS	NS
Graphics Experience	NS	NS	NS	NS
Finance Background	NS	NS	NS	NS
Enjoys Math	NS	NS	NS	NS
Years of Math Studied	NS	NS	NS	NS
Took College Statistics	NS	NS	NS	NS
Played Musical Instruments	NS	Shorter	NS	Shorter
Anxiety Level				
Math Anxiety	NS	NS	NS	NS
Computer Anxiety (CYBERPHOBIA)	NS	NS	greater the anxiety, lower the score for all types of presentation	NS
Cognitive Style				
Extrovert vs. Introvert	NS	NS	NS	NS
Sensory vs. Intuitive	NS	NS	NS	NS
Thinking vs. Feeling	NS	NS	sig. Thinking does better than feeling for graphics	NS
Perception vs. Judging	NS	NS	NS	NS

NS non-significant at the .05 level using a Chi-Square test.

Results are based on 103 subjects

Figure 1

Journal of the American Statistical Association, June 1981

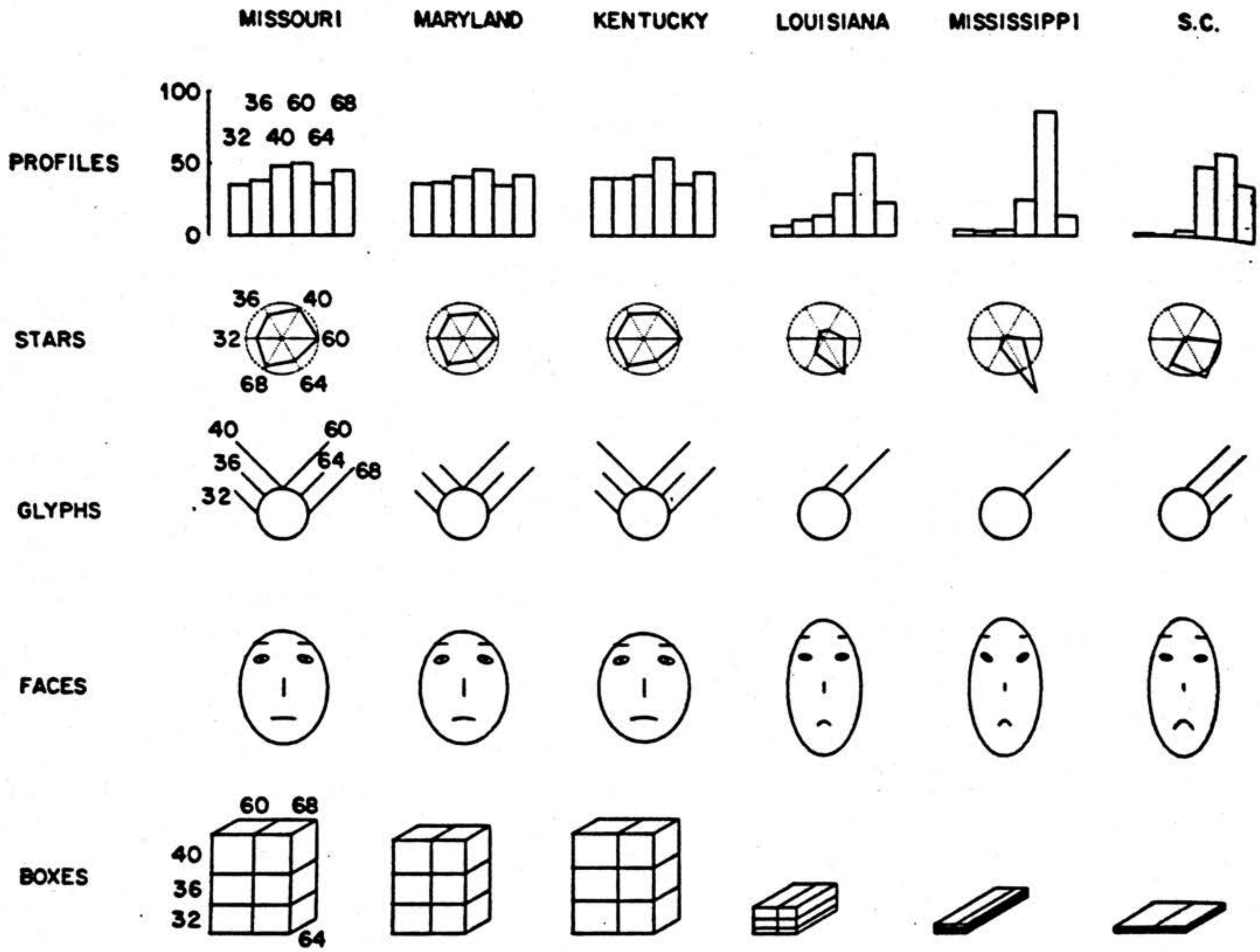


Figure 1. Profiles, Stars, Glyphs, Faces, and Boxes of Percentage of Republican Votes in Six Presidential Elections in Six Southern States. The Circles in the Stars Are Drawn at 50%. The Assignment of Variables to Facial Features in the Faces Is: 1932—Shape of Face; 1936—Length of Nose; 1940—Curvature of Mouth; 1960—Width of Mouth; 1964—Slant of Eyes; 1968—Length of Eyebrows

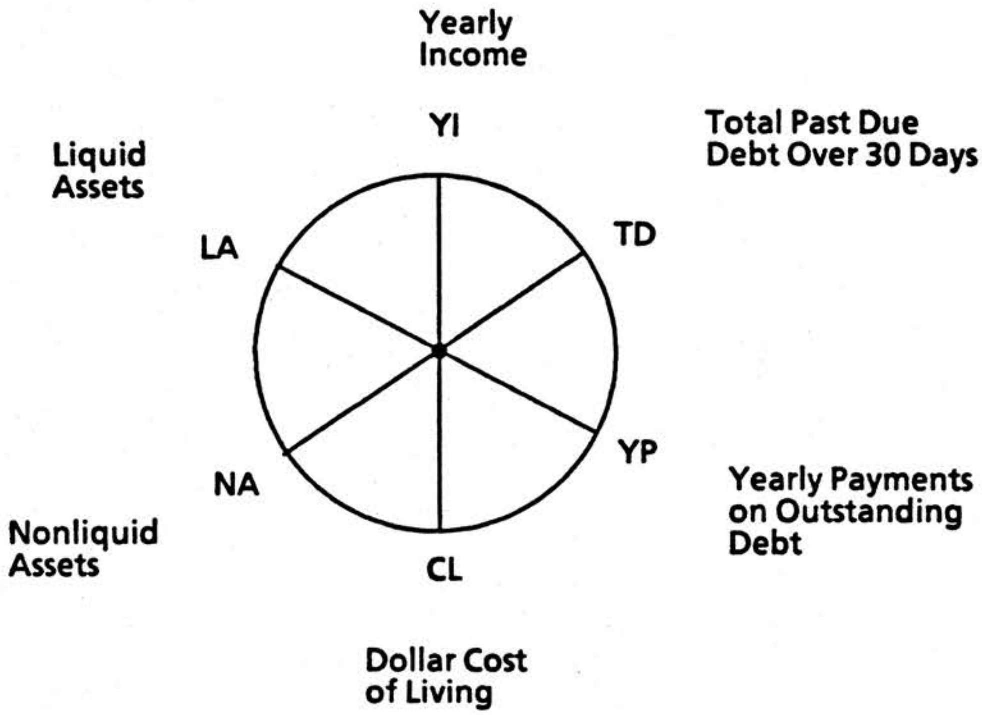
Figure 1A

Format for Study of Efficacy of New Graphics in Decision Support Systems

Criterion	Time (time to make decision)
	Accuracy (number of correct decisions)
Problem Situations	Pattern is important (credit risk problem)
	Pattern not important (differing patterns in unidentified industries pattern).
Intervening Variables	Demographic criteria (sex, age)
	Abilities - see Table III
	Anxieties - computer anxiety, math anxiety
	Cognitive Style - Extrovert vs. Introvert, Sensation vs Intuitive, Thinking vs Feeling, Perception vs Judgment
Test Groups	Tables vs New Graphics (stars)
	Tables vs Old Graphics (bars)
	New vs Old Graphics (stars vs bars)

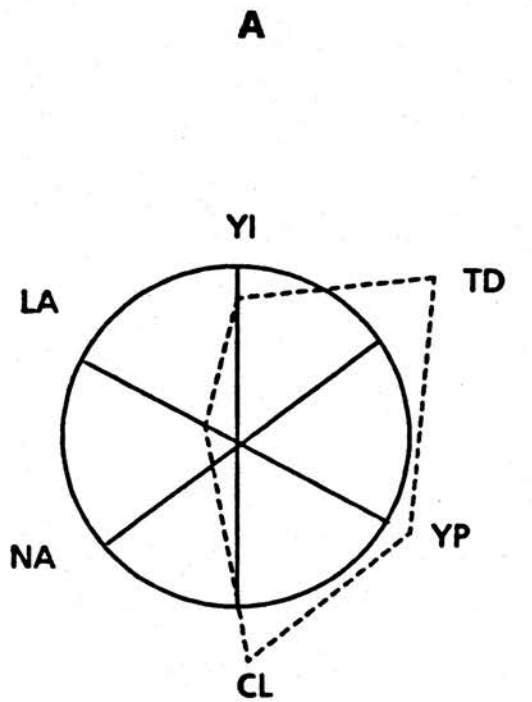
Figure 2 goes here

Figure 2

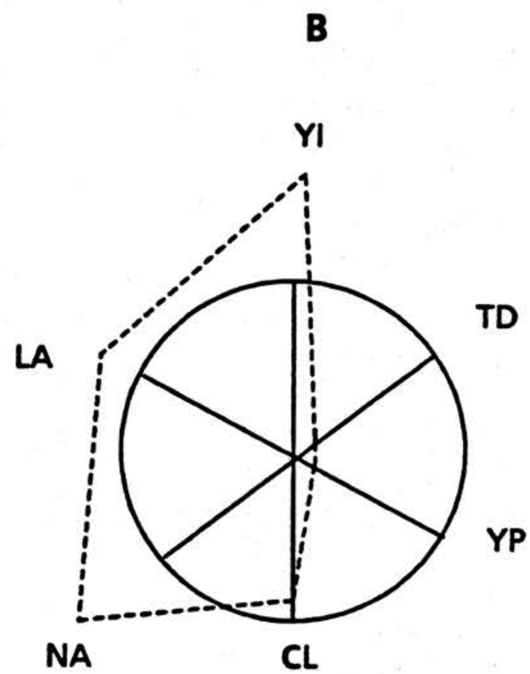


Yearly Income
YI
Total Past Due Debt Over 30 Days
TD
Yearly Payments on Outstanding Debt
YP
Dollar Cost of Living
CL
Nonliquid Assets
NA
Liquid Assets
LA

Figure 3



Graph A has no liquid assets (LA), no nonliquid assets (NA), yearly income (YI) is less than cost of living (CL) and there is considerable outstanding debt (TD, YP)



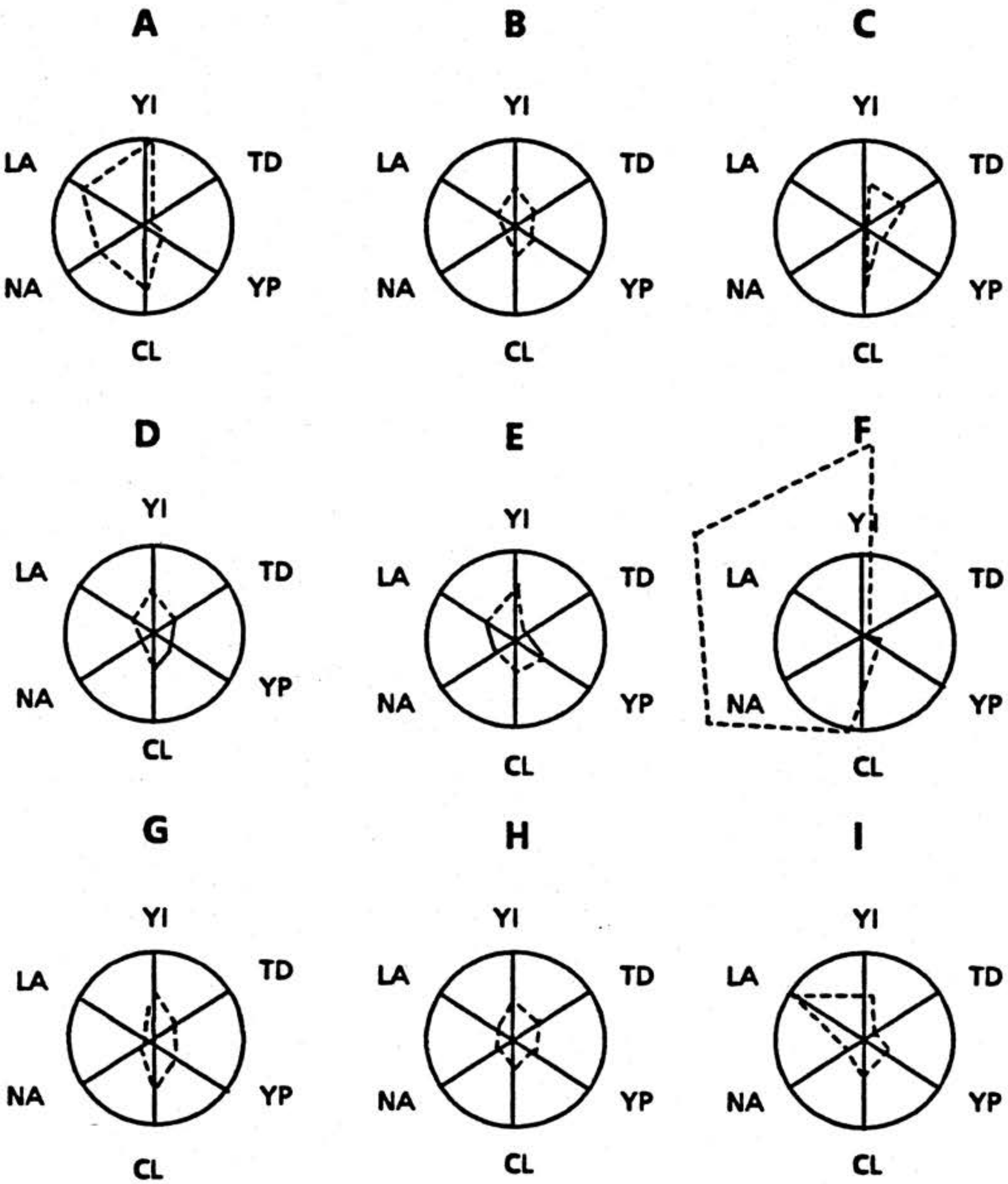
Graph B has high income (YI), high liquid assets (LA), high nonliquid assets (NA), low cost of living (CL) and no outstanding debt (YP, TD)

Figure 4

Tabular Display, Loan Risk Problem

INDICATOR	INDIVIDUAL (VALUES IN $1,000) A	B	C	D	E	F	G	H	I
Yearly income	50.0	20.0	20.0	20.0	28.0	75.0	25.0	22.5	25.0
Liquid Assets	40.0	9.0	0.0	10.0	15.0	90.0	2.0	12.0	50.0
Non-Liquid Assets	30.0	5.0	0.0	8.0	12.0	85.0	5.0	10.0	10.0
Cost of Living	32.5	20.0	30.0	17.5	24.0	47.0	25.0	20.0	22.0
Yearly Payments on Outstanding Debt	10.0	12.5	7.5	12.0	19.0	5.0	15.0	14.0	15.0
Total Past Due Debt Over 30 Days	2.5	10.0	20.0	14.0	7.0	0.0	15.0	15.0	5.0

Figure 5

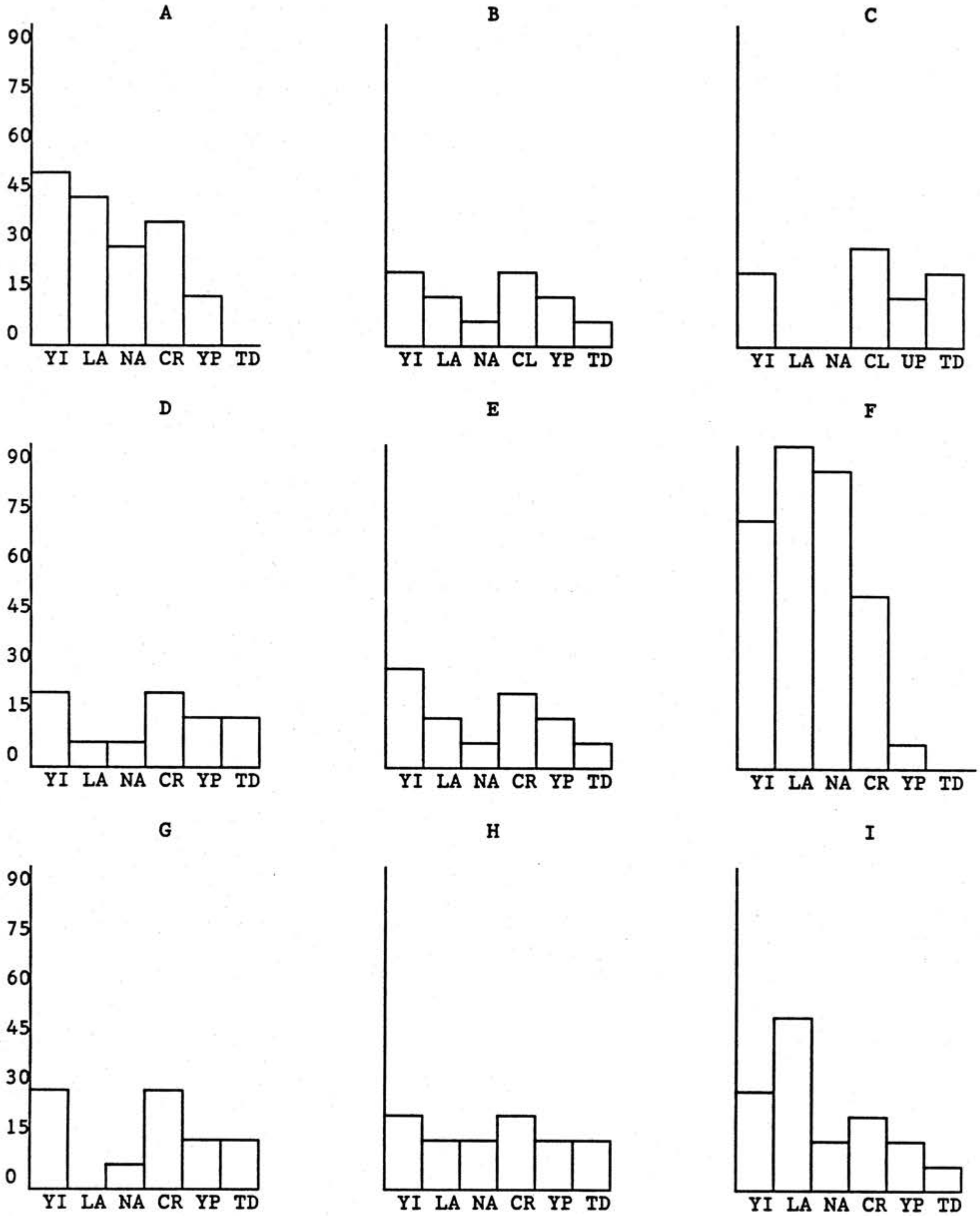


Circle Represents $50,000

- YI - Yearly Income
- LA - Liquid Assets
- NA - Non-Liquid Assets
- CL - Cost of Living
- YP - Yearly Pmts. on Outstanding Debt
- TD - Total Past Due Debt-Over 30 Days

Figure 6

Bars Graphical Display, Loan Risk Problem



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