HELPING NON-STATISTICIANS VISUALIZE QUANTITATIVE RELATIONSHIPS: USING JMP'S UNIQUE VISUALIZATION TOOLS IN THE BUSINESS ENVIRONMENT

Palmer Morrel-Samuels
University of Michigan, Ann Arbor, Michigan, and
EDS Survey Services, Chelsea, Michigan

ABSTRACT Statistical analysis is becoming an increasingly prominent component in today's large corporations. Inferential statistics are explicitly recommended in the business literature on Total Quality Management, Strategic Planning, Organizational Learning, and Business Processing Re-engineering, to name but a few. However, analysis of quantitative data, particularly data from employee surveys, can seem opaque to executives who lack training in experimental psychology or statistics. The best approach to conveying such information in the business environment is to rely on a comprehensive set of visualization tools that includes animated 3-Dimensional scatter plots, color-keyed bar graphs, and fully partialled point-sensitive leverage plots where each respondent in a dataset an be identified. The discussion will devote special attention to the capabilities of JMP® software. Numerous JMP visualization tools will be demonstrated, and some of the recent psychological research on human visualization will be summarized.

INTRODUCTION Statistical analysis is taking an increasingly prominent place in today's business world. It is no longer uncommon to receive requests for employee surveys that can furnish margin-of-error estimates or reliability coefficients. And, at least in some sectors of business consulting, the emphasis on rigorous statistical analysis is pervasive. Authors recommend analyses that require inferential statistics in a wide array of business interventions that include Business Process Re-engineering (Hall, Rosenthal, & Wade, 1993), Change Management (Harrison & Pietri, 1991), Organizational Learning (Garvin, 1993), Strategic Management (Kaplan & Norton, 1992; 1993; 1996), Total Quality Management (Ferrazzi, 1993), long-term Strategic Planning (Hax & Majluf, 1991), and general business consulting (Kubr, 1986). No doubt, the benefits of statistical analysis gained increased attention and credibility when several prominent companies (e.g. Texas Instruments, AT&T, and IBM) credited statistics for their receipt of the Malcolm Baldrige National Quality Award (Barrier, 1994; Hodgetts, 1994; SAS Communications, 1993) The trend is not simply local; although not all recent Baldrige winners have relied on statistical analysis (Partlow, 1993), some companies outside the US have also pointed to recent quality-improvement awards (e.g., The European Quality Award) and attributed the positive change to reliance on statistics (Caulkin, 1994). Accordingly, the need to present and explain statistical analyses to members of the business community is growing at an almost breathlessly-fast pace.

VISUALIZATION TOOLS There are countless tools, both computer-based and unautomated, that can be used to help readers understand the results of a statistical test. But the needs of the business community are unique. When we have to present results from an inferential analysis to business people who lack training in statistics or experimental psychology a special set of requirements becomes engaged. First among these is the need to dispel the overwhelming assumption that statistics are either the prepotent hallmarks of everything important, or merely the empty shadow of trivial processes and events that have long-since vanished. Of course, neither extreme view is justified. Accordingly, visualization tools operating in the business environment must be able to provide direct evidence of a link between the variables of interest (e.g., leadership effectiveness, customer satisfaction, etc.) and readily identifiable measures of business performance (e.g., profitability, return on investment, missing inventory, etc.) that are commanding the attention of the sponsoring company.

REMOVING EXTRANEOUS EFFECTS One of the most effective means for maintaining a transparent connection with measures that have direct business utility is to partial out all extraneous effects. For example, if a survey shows that high profitability is consistently associated with a set of perceptual measures such as perceived leadership effectiveness, fairness in the workplace, and perceived communication, then a viable approach to reporting the results requires that audience members see the unique relationships between each of the "soft" attitudinal measures and the "hard" financial measure of interest, a relationship that can be examined while partialling out the effects of all other associated variables. Such an approach relies on hierarchic modeling (Cohen & Cohen, 1989), the process whereby a set of likely models is formulated to explain the relationships between variables in the dataset. Because it provides partial plots (also called partial residual plots, or leverage plots) by default in any multiple regression, JMP – SAS' exploratory statistical analysis tool for the MAC or PC platform -- makes it relatively straightforward to isolate effects. The end result is that simple scatter plots can be projected on a screen (using an LCD display panel, for example) during an executive briefing, and the researcher can be reasonably sure that audience members will be able to see the relationships in the data without becoming distracted by the statistical methods necessary for the isolation of those relationships (Tufte, 1983; 1991).

DISPROVING ALTERNATIVE EXPLANATIONS An active dialogue is a crucial component in executive briefings where the results of a statistical analysis are summarized for a business group. This necessarily entails discussion of the relationships found in the dataset, and the examination of possible explanations for those relationships. Data visualization tools that are currently available in JMP's principle components factor analysis make it possible to facilitate such discussions. Specifically, JMP furnishes a rotating 3-dimensional plot of the factors extracted by the principle components algorithm. By rotating the display in space, it is possible to address questions concerning sampling adequacy in any principle components analysis. The tool is important because representativeness is always an issue when inferential statistical analysis is used in the business world: if the results are entirely self-evident then executives feel like they overpaid for the analysis; similarly, if results are entirely unexpected, then executives feel that they are being asked to accept a set of conclusions that doesn't have any intuitive foundation. It is a difficult balance that requires the ability to strike common themes, and nonetheless irrefutably rule out faulty explanations that may, in fact, be based on mistaken assumptions or simplistic stereotypes. If factor analysis is involved -- as well it should be when diagnosing workstyles, the corporate culture, or core capabilities -- then using a spinning 3-D factor plot is a crucial visualization tool.

CONTROLLING FOR CHANCE The main advantage of running a statistical analysis in the business environment is that inferential statistics condense extensive complexity down into elegant (and accurate) simplicity by applying straightforward tests that rule out the role of chance. Clearly, if the explosive proliferation of bar charts in the executive boardroom is any indication, this is the primary differentiator that makes it worthwhile to hire a statistician or experimental psychologist when it comes time to analyze human performance in the business environment. But none of this benefit will ever be realized if audience members in the business world don't clearly understand, or cannot fully recall, the conclusions of such analyses. Given the fact that classification colors, diamonds showing confidence intervals, and error bars are all available by default preference in JMP bar graphs (most notably in the FIT Y BY X option of the ANALYSIS menu), and given the fact that these graphical devices are especially recommended for complex datasets (Loftus, 1993) it makes sense to use JMP for effective and speedy data visualization.

COGNITIVE ASPECTS OF VISUALIZATION

Aside from following the principles of sound display design (especially those outlined in Tufte, 1983), it is sensible to remember a few findings from psychological research when creating statistical graphs for audiences comprised of non-statisticians. In this same forum last year I outlined the benefits of using interactive mental imagery, of placing crucial information at the top and bottom in a list, and of clustering data in units containing 7 to 9 elements (Morrel-Samuels, 1995). Recent work also justifies the following recommendations: 1) Because words are recalled best when accompanied by concrete imagery (Tracey, Betts & Ketsios, 1995) it is advisable to use as many concrete metaphors, similes, and examples as one's imagination and the briefing schedule allow; 2) Because associations that are novel and unexpected help audiences retrieve information from memory (Riefer & Rouder, 1992), it is sensible to trust your sense of humor -- if indeed it deserves to be trusted at *all* -- during the extemporaneous portions of your briefings; 3) Because mnemonic devices deliver their best enhancements to memory performance when they include a terse keyword (Konopak & Williams, 1988) it is advisable to lead audience members in active visualization of events that serve as examples for the relationships depicted in your graphics, and then to tag that mnemonic device with a spoken keyword that enhances the salience of the memory.

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Palmer Morrel-Samuels
EDS Survey Services
210 Park St., Chelsea, MI 48118
Tel: (313) 475-3145 palmer@umich.edu