Dashboard and Data Visualization Best Practices for OBI Applications

Tim Vlamis, Vlamis Software Solutions, Inc.
Vlamis Software Solutions, Inc.
Dan Vlamis, Vlamis Software Solutions, Inc.
Vlamis Software Solutions, Inc.

There is a lifetime of study in understanding visual perception and the representation of quantitative information and far more content than can be presented in a short paper or presentation. Reports, dashboards, and interactive BI displays all share the same issues of the most optimal way to present information so that it informs users and supports decision making. In this brief overview, we will highlight three key concepts: BI reports and dashboards should be viewed primarily as communication devices and both the principles of human cognition and the needs of the individual user should help guide their proper use; BI reports and dashboards are used either in the exploration of data or in the explanation of data; and, it's much easier to misuse BI tools than to use them well.

Computers are very powerful tools for manipulating large sets of data and performing all kinds of mathematical operations including aggregation, division, correlation, regression, K-means attribute clustering, Markov Logic Network construction, and more. However, it turns out that as human beings, we're not terribly good at seeing objects and translating them into numbers. Indeed, once there are more than about seven of something, we have a hard time counting exactly how many there are at a glance and settle for knowing that there are "a whole bunch". We're even worse at visualizing basic mathematical operations like addition, multiplication, and division. Visualizing complex mathematics takes a tremendous amount of time and practice, and like juggling while riding a unicycle, the average person can't do it easily. We humans are good, however, at other things such as finding patterns in raw visual data and constructing three-dimensional schemas; we dynamically interpret colors and light levels and the size and angle relationship of lines. We're good at understanding moving objects and motion in general; we're good at navigating landscapes; we're superb at recognizing patterns. In fact, we're so good at recognizing patterns that we insist on seeing them even when they're not there and often refuse to acknowledge a new pattern that violates an existing pattern. Our brains are optimized for helping us survive in the wild, but not for deciphering BI dashboards and reports.

The effective implementation of BI systems requires both knowing the basic principles of data communication and thinking critically about who is using a BI system, how they are using it, and what their needs and goals are. In his seminal work, "The Visual Display of Quantitative Information", Edward Tufte emphasizes five key principles: 1) Above all else show the data; 2) Maximize the data-ink ratio; 3) Erase non-data-ink; 4) Erase redundant data-ink; 5) Revise and edit.

If Tufte's advice is to be followed, no information that is not absolutely necessary for the contextual understanding of the data will be depicted. The general rule for BI displays is less is more. Eliminate as much visual clutter as possible and let the data present itself as simply as possible.

When precise values are required, it's generally better to show numbers in text rather than as a visualization of some type. Eliminate grid lines in tables or render them in a light grey. Basic tables are best used for data look up, not for data comparison. Other visualizations including charts and graphs are useful in comparisons and pattern recognition.

There are two books in particular that offer clear and accessible information on visual processing: "Visual Intelligence: How We Create What We See" by Donald Hoffman and "Information Visualization: Perception for Design" by Colin Ware. These books provide the scientific justification for the summary statements in this paper and our presentation.

While every school child is exposed to optical illusions and the ancient Athenians distorted virtually every edge and angle in their Parthenon to make them appear straight to the human eye more than 2500 years ago, we forget presentation of information must be designed carefully according to the way it is perceived.

Many of the built-in data visualization tools, like graphs, have suffered recently as computers have become more powerful. Software designers forgot that data visualization is a representation or a visual metaphor and the emphasis should be on making it as easy as possible for people to interpret and understand the information consistently and

accurately. Instead they got sidetracked by trying to represent physical objects, replicating cockpits and physical dashboards designed for very different purposes such as flying a plane, and by adding unnecessary design elements unrelated to analytic communication needs. The best example of this is the use of three-dimensional renderings of pie charts, bar graphs, and line graphs. Three-dimensional renderings do not add any quantitative content that is not present in two-dimensional renderings, and they misrepresent and distort values in order to add the illusion of depth.

Bar Chart: Bar charts depict the value of nominal data. Bar charts should start with zero and use a consistent scale (either linear or logarithmic.) The scale should be clear, particularly if a logarithmic scale is used. Bar charts are often used for comparison of the value of data items in a group with one another. Bars should be depicted as two-dimensional objects.

Pie Chart: Pie charts are used for the comparison of the size of individual data items in a set with the size of the whole set (most typically as percentages totaling 100%). Pie charts are not effective when too many items are included (more than seven or eight) and are best used for approximate relationships. Data visualization guru Stephen Few recommends avoiding the use of pie charts all together. Pie Charts should never be depicted as three dimensional objects since the relative size of pieces of a pie are distorted to achieve the illusion of perspective.

Line Chart: Line charts are best used to depict a pattern over a continuous range (such as time). Unlike bar charts, line charts can be valued within a range to highlight more granular detail without distorting the meaning of the chart. Any time a different data range is used, it should clearly marked. Line charts should maintain a rectangular shape (roughly according to the Golden Proportion or approximately 5:8). If the chart is excessively tall and narrow, the data will show an excessive amount of change. If the chart is short and wide, the change will be minimized.

Scatter Plot: Scatter plots depict single points at the intersection of two values, one along the x-axis and the other along the y-axis. Scatter plots can represent hundreds of individual data points and are use for seeing overall patterns in the comparison of two variables. Trend lines are often added to scatter plots.

Bubble Chart: Bubble charts are special type of scatter plot in which the size of the data point is representative of a third variable. Bubble charts greatly reduce the number of individual data points that can be depicted.

Color is a powerful visual clue and should be used consciously and sparingly. Colors will stand out immediately against a plain background but can easily be missed when bright and overly garish colors dominate the screen. The over reliance of bright colors is a major drawback of many BI dashboards and reports as bright colors should only be used in exceptional situations to call attention to unusual circumstances. Approximately 10 % of men and 1-2% of women have some form of color blindness. Red/green is the most common form of color blindness. Designs requiring the distinction of red and green are best avoided for general use. The more color is used, the less effective it is. Soft, muted colors are recommended for the vast majority of visualizations. www.colorbrewer2.org offers several selections of color palettes that are professionally designed. While Color Brewer was designed with map interfaces in mind, its color palettes are also good for most dashboard designs.

Motion draws the human eye more effectively than size, shape, color, pattern or any other visual characteristic. It is now possible in many dashboard systems to embed scrolling messages and incorporate moving displays of data. These displays will command attention and if the user requires constant monitoring of changing data, they can be extremely effective. However, using motion can also be distracting and call attention away from other important features of the dashboard interface. Make certain that motion is sparingly used so that the dashboard doesn't become distracting and annoying to the user community.

Most tables can be immediately improved through the removal of unnecessary gridlines. When tables were hand-drawn, gridlines enabled people to keep their columns and rows straight. Alignment is a more effective organizer of information than is the use of unnecessary gridlines. Place related information in close proximity and provide space between unrelated data. This will help the user understand the layout of tables more than trying to separate information through the use of lines. Highly contrasted display styles can also differentiate between different data sets.

The sheer amount of data available through most BI systems begs for the inclusion of a search interface on most table layouts. Requiring users to hunt for specific entries can often be easily avoided with a search interface that is surprisingly missing from many large implementations. While massive tables can be displayed, requiring users to

scroll excessively should be avoided. If scrolling is unavoidable, make sure that titles and headers are locked so that users can immediately see what the entry is associated with. Many tables suffer from the display of too much detail. Particularly for budgets and forecasts when future values are estimates, excessive detail not only clutters the interface, it implies a level of precision that cannot exist.

Conditional formatting asks the system to apply a format such as a background color to a table cell based on the results. This can vastly improve the user's ability to recognize a significant value as color draws the eye very effectively. However, a screen of blaring colors does little to impart meaning. The sparing use of soft colors can more easily attract attention to a particular value than can a screen of bright colors. Conditional formatting is especially powerful for data exploration when users are looking for anomalies or for patterns in the data. Be sure to logically sort both columns and rows in tables (avoid alphabetical sorts as they generally have no relationship to the data) when designing these "heat map" types of tables. Regular reports can often be improved by removing colors that do not highlight extraordinary information. It is best to avoid putting any text in color as it is more difficult to read.

We all know that BI systems provide value to organizations only when they are used. Calvin Mooers coined his famous Mooers' Law and its corollary in 1959.

An information retrieval system will tend not to be used whenever it is more painful and troublesome for a customer to have information than for him not to have it.

Where an information retrieval system tends not to be used, a more capable information retrieval system may tend to be used even less.

This reminds us that there may be a natural resistance to using BI systems in many situations. Compounding this, when BI systems poorly present or distort data, they ultimately lead to misuse, mistrust, or abandonment of the BI system. Proper visualizations and data presentation lead to business insights and build trust in the system as executives and managers begin to rely on it and improve their decision making ability. Effective BI interfaces also build a more coherent and consistent view of the business and its operational environment.

BI implementations typically require tremendous time and money, but also offer the potential for significant returns in comparison with the investment in developing and deploying the system. Most executives and managers have not had training in visualizing data and many may also not have had training in analysis techniques and thus are unlikely to do either properly by chance. In our experience, the most successful BI implementations "finish the project" by a stretching a relatively modest percentage of the total project budget over the first year of implementation. A series of classes on visualization and data analysis with executive users in combination with follow sessions (often one-on-one) reinforce the information and ensure that BI system is fully leveraged by the organization. This allows users to expand their use of the system more completely as what they can learn in initial training is limited. As they gain experience, they are able to learn more and leverage the tools in a more sophisticated and complete manner.

Recommended book list

Edward Tufte: "The Visual Display of Quantitative Information 2nd Edition", Graphics Press 2001

Edward Tufte: "Envisioning Information", Graphics Press 1990

Edward Tufte: "Visual Explanations: Images and Quantities, Explanations and Narratives", Graphics Press 1997

Stephen Few: "Show Me the Numbers: Designing Tables and Graphs to Enlighten", Analytics Press 2004

Stephen Few: "Information Dashboard Design: The Effective Visual Communication of Data", O'Reilly Media Inc. 2006

Stephen Few: "Now You See It: Simple Visualization Techniques for Quantitative Analysis" Analytics Press, 2009

Jane E. Miller: "The Chicago Guide to Writing About Numbers", University of Chicago Press 2004

Howard Wainer: "Graphic Discovery: A Trout in the Milk and Other Visual Adventures",

Howard Wainer: “How to Understand, Communicate, and Control Uncertainty through Graphical Display”, Princeton University Press, 2009

Donald D. Hoffman: “Visual Intelligence: How We Create What We See” W.W. Norton & Co. 2000

Colin Ware: “Information Visualization, Second Edition: Perception for Design” Morgan Kaufman Publications 2004

Stephen Kosslyn: “elements of GRAPH DESIGN” W.H. Freeman & Co 1994

Mark Changizi: “The Vision Revolution: How the Latest Research Overturns Everything We Thought We Knew About Human Vision” BenBella Books, 2009