Graphing Literacy in the Psychology Major

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Figure 1. Florence Nightingale's Polar Area (often referred to as the cox comb) graph depicted "The Causes of Mortality in the Army in the East" in the years 1854-55. The twelve sections represent the months in a year. The size of the section representing each month indicates the number of people who died in that particular month. The colors correspond to the different causes of death. (This adaptation of Nightingale's graph is courtesy of Worth Publishers)

The most enthusiastic statistician of all" (Porter, 1986 p. 67) among her energetic 19th century peers was Florence Nightingale, the first woman admitted as a Fellow of the Royal Statistical Society in England. Her popular legacy, of course, is the nursing legend. When the Crimean War broke out, Nightingale directed the entire nursing operation at the war front for the British Army. Her legend began to grow as she instituted practices of basic hygiene, such as changing the bed sheets when new patients entered the hospital. She documented every change that she made so that she could identify what worked and succeeded at dramatically reducing the mortality rate (Goldie, 1997).

Florence Nightingale's response to bureaucratic resistance was statistics, sometimes accompanied by withering sarcasm (Gill, 2005). Her response began with a simple innovation: She kept systematic records of what happened to patients. (We sometimes liken Florence Nightingale to the Count on *Sesame Street*, obsessively counting every variable she encountered.) Her simple act of using descriptive statistics to catalog daily life in the hospital had huge consequences and is credited by some as having saved the British Army during the Crimean War.

What can we learn from Florence Nightingale's use of statistics and graphs?

Graphing literacy: Learning the tools of graph construction. In recent years, a number of proficiencies have been championed in academia: writing, oral communication, and even numeracy have been integrated into university curricula, including in psychology. But so far, graphing literacy has been ignored as a mainstream literacy. Unfortunately, graphing often is perceived as a tedious, unimportant, or easily learned task. Yet, Florence Nightingale's story is just one of many that demonstrate the illumination that a beautiful graph can shed on its subject.

To attain high levels of clarity, the first step is to emphasize to the student the importance of following the rules for creating a graph — only then can students learn to break them with style and purpose. Conventions in graph construction have evolved precisely so that others can easily "read" the story the graph is telling without having to refer to any accompanying text. Within the psychology major, statistics and research methods are ideal courses in which to embed thorough instruction in graphing conventions, but a quick list of guidelines can be covered in almost any psychology course. Indeed, we have become convinced that the need for graphing literacy represents a critical skill that extends across disciplines and is a natural development of advances in computers, art, and the sciences. The first time that a graph shows up within a course's curriculum — in the text, a journal article, or a student's

presentation — distribute this simple seven-item checklist and have students size up the graph.

- Is there a clear, specific *title*?
- Do both axes have *labels* that identify the variables? Do all labels read left-to-right — even the one on the *y*-axis? If possible, has the graph-maker avoided a key that labels variables in a box separate from the graph?
- Are all *terms* on the graph the same terms that are used in the text that the graph accompanies? Have all abbreviations been eliminated?
- Are the *units of measurement* included in the title or data labels?
- Do the values on the *axes* either go down to zero, or have cut marks (double slashes) to indicate that they do not go down to zero?
- Are colors (preferably shades of grey) used in a simple, clear way?
- Has all *chartjunk* — moiré vibrations, grids, and ducks — been eliminated?

Figure 2. Some graphs allow therapists to compare the actual rate of improvement of a client in therapy with the expected rate given that client's characteristics. (Adapted from Lueger et al., 2001; Courtesy of Worth Publishers)

The last item admonishes against "chartjunk," a term coined by Edward Tufte (2001) that includes any extraneous features in the graph. Moiré vibrations refer to any of the patterns that computers provide as options to fill in bars; stick with subdued, solid colors. Grids refer to background patterns, almost like graph paper, on which the data representations, such as bars, are superimposed; these should never be in a final version of a graph. Ducks are features of the data that have been dressed up to be something other than merely data — for example, dollar signs superimposed above bars representing income; avoid these. Like learning to write clearly, learning how to construct graphs also requires the creators to think clearly and to re-examine what they really intend to communicate.

Including graph-related activities in class will teach students to become more automatic in their critical review of visual presentations that they encounter in their everyday lives. We'll present three effective activities in this article.

Activity 1: Using any graph that comes up in class, walk through the seven-item checklist described above. After a quick run-through of these items, ask students to paraphrase the story that the graph is telling. Have students work in pairs, and look only at the graph and its title — not at any written materials that might elaborate on the graphs — and write a sentence or two that capture the message of the graph in their own words. This task should be easy with a well-constructed graph. If it's hard, ask students how the graph creator might have altered the visual display to reduce ambiguity and communicate more effectively. Ask what Florence Nightingale would have done.

Florence Nightingale's creative graph construction: Persuasive innovation and life-saving tool

Nightingale's careful record keeping did not accomplish her mission on its own. She needed a graph to tell the story. Florence Nightingale invented a "polar-area" diagram, often now referred to as a "cox comb" graph, so named because it resembled the shape of a rooster's head. A recreation of this circular chart is shown in Figure 1, and it includes causes of death, numbers of deaths, and months of the year. This graph told her story more clearly and eloquently than descriptive statistics alone ever could.

Nightingale used innovation to create a compelling graph. Perhaps more importantly, she was active in her choices about how to present her story. Far too often, graphmakers are passive, accepting the choices they are offered. When creating graphs with software, we must remember that the software developers made a number of decisions for us. For example, a common default is to include a vertical label on the *y*-axis, requiring the consumer of the graph to turn her or his head to read the label. However, with most software, we can click on the label to choose a horizontal orientation. To tell our stories well, we must assert control over the script.

Activity 2: Provide data to your students and have them use software (e.g., Excel, SPSS) to create a graph, passively accepting the default choices of the software developer. You can use archival data (e.g., the mean numbers of season wins for the Red Sox and Yankees over the last 10 years) or student-generated data (e.g., mean scores for women and men on a measure such as those on outofservice.com). Have students critique the default graph using the seven-item checklist. Then have students "play" with the graph, changing defaults to make the graph adhere to these criteria. Have students swap graphs with one another and critique the improved graphs according to the criteria.

Harnessing the story-telling power of graphs: Misleading or clarifying? You and your students will likely encounter graphs organically in your course, whether in the text or in a student presentation. However, you can introduce particularly compelling or especially egregious graphs to illuminate psychological topics in any course. Here are two compelling applications of new ways to visualize data, followed by a misleading graph.

First, psychotherapy is typically discussed in several courses, including Introduction to Psychology, Psychopathology, Psychotherapy, and Psychological Testing courses. Clinical psychology researchers have developed graphing techniques to help therapists predict when the therapy process appears to be leading to a poor outcome by delineating an expected rate of recovery for a specific client, based on the characteristics of the client and her symptoms (Howard et al., 1996). A rendering of one such graph is shown in Figure 2 (Lueger et al., 2001). Based on her characteristics and symptoms, this patient is expected to show initial quick improvement, followed by more gradual, but steady, improvement. Her actual course of therapy, however, is a rapid decline, followed by a plateau, then a rapid improvement. This graph allows a therapist to determine how a client's *actual* rate of improvement compares to what would be expected for other individuals with similar characteristics. If therapy progresses more slowly than expected, then both the client and her therapist may be spurred to take action by the discrepancy in the graph. This graph clearly demonstrates that after her initial sharp decline, this client seems to be progressing toward the expected treatment response for someone like her. The therapist and client alike can use this graph to compare the client's progress to what is expected and initiate important discussions within therapy.

Figure 3. Chevrolet looks superior to its competitors in terms of years on the road, but only until you see that the y-axis starts at 95%! All of these brands do well by this measure.

A second use of visualizing data integrates psychology and geography because geographic information systems (GIS) enable us to layer psychological data sets on top of maps. Arousal mapping, for example, allows us to visually compare "fear surfaces" of perceived versus real danger in a park, neighborhood, or campus. We also can vividly portray the epidemiology of anything we can measure and locate on a map, such as the rates of depression relative to geographical features. GIS can even provide acoustic

feedback to non-sighted persons about their spatial environment, an innovation developed on the UC Santa Barbara campus with both practical and theoretical significance, including how we interpret various features of graph construction (see Golledge, 2002; Goodchild, 2000; Goodchild, 2006; Heth & Cornell, 2007; Hirtle, 1998; Montello, 2002). APA now offers an advanced training workshop in how geographic information systems can be applied to the behavioral sciences.

Along with compelling graphs, misleading graphs make great teaching tools and immediately sharpen students' ability to think critically. For example, graphs designed to persuade (a topic often taught in Introduction to Psychology, Social Psychology, or Organizational Psychology) are often like the ad in Figure 3 that states "more than 98 percent of all Chevy trucks sold in the last 10 years are still on the road." Before you run out and buy a Chevy truck, it pays to check out the *y*-axis, which begins at 95 percent. A trivial difference appears to be quite dramatic even though at least 95 percent of each of these brands of trucks is still on the road 10 years later. You can build a file of graphs from your own everyday reading that can be introduced into your courses and ask students to use the checklist to redesign a graph. Or just ask them what Florence Nightingale would think about this particular graph.

Persuasive Tools

Activity 3: After introducing wonderful or horrible graphs of your own, students often start bringing in graphs that they encounter. Encourage this behavior by rewarding students with extra credit for bringing in a particularly bad or good graph, along with their critiques using the seven-item checklist and a brief summary of the graph's message. Time permitting, have students present their graphs in class. Alternately, set up a Web site (e.g., on blackboard.com or another courseware tool) to post students' graphs and critiques.

Florence Nightingale's mission: Using statistics and graphs in her service to others: Florence Nightingale's graph was a powerfully persuasive tool. Perhaps it was her public relations savvy that inspired her to use the color red to represent deaths due to wounds, blue to represent deaths due to preventable causes, and black to represent deaths due to all other causes. The visual portrayal of so much blue compared to so little red, even in war time, forced the British government into a wide variety of health reforms. Many more people were dying due to preventable causes than were dying in battle! It was a brilliant, live-saving graph that was created out of her passion to let the data speak.

Perhaps Florence's "calling" provided such strength of character or perhaps she had learned something vital from the frustrations of her youth. Her response to bureaucratic frustration and resistance was not wasted emotion… but impassioned statistics! History has become both kinder and more precise to Florence Nightingale, a pioneering woman who was recognized then, and increasingly now, as the "passionate statistician" (Cook, 1913).