SURVEY DATA: USE OF SCATTER PLOTS FOR DISPLAYING SCALE AND CONSISTENCY FACTORS

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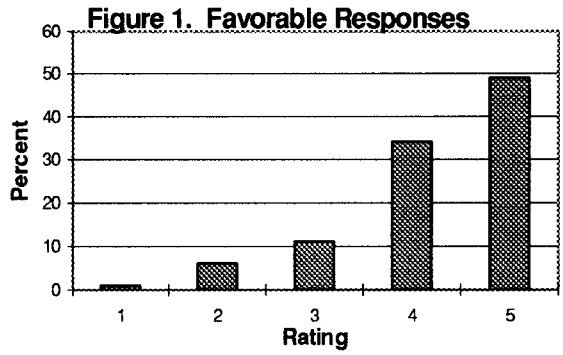
Abstract: It is a common practice for companies to conduct employee satisfaction surveys. These studies provide employees with an opportunity to express their views to a series of questions covering various aspects of the work environment. In analyzing and reporting results from these studies, measures of scale such as the mean or median ranking of collective responses are often the only summary reported. However, it is also possible to calculate a measure of spread, such as the standard deviation, for the same responses. This measure can be viewed as an indicator of the *consistency* in ratings for each question. We show that a scatter plot of the consistency measure versus the average rating can be used effectively to reveal relative agreement among respondents. Patterns in the scatter plot can be very helpful in pinpointing specific issues needing attention.

1. Introduction

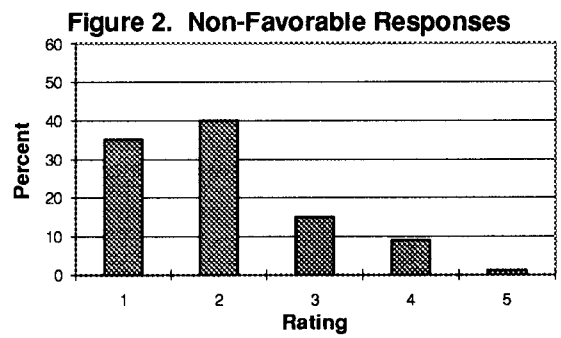
Consider survey data in which responses to questions are given as an integer rating. On a scale of 1 to 5, for example, 5 may represent a favorable answer and 1, not favorable, or 5 reflects strong agreement and 1 is strong disagreement. Although there are many possible analytical and graphical ways to analyze such data, the most common approach is to average the ratings for each question among respondents. Then, based on the average ratings, specific questions are selected for review or action. However, there is another important consideration involving the degree of consistency or agreement among respondents to the questions. In this paper, we show that the inclusion of the standard deviation among responses to a question can reveal interesting facets of the survey, especially when simple scatter plots are used to correlate measures of favorableness and consistency.

2. Measures of Location

Measures of location are used to assess the favorableness of the responses. If a scale of 1 to 5 is employed, with 5 indicating positive views, then the most favorable responses typically include a high percentage of 4s and 5s, and a low percentage of 1s and 2s. Figure 1 is a histogram of a possible outcome to an individual question, showing percent of responses by category, that might indicate a favorable collective rating.



Non-favorable responses would show the converse. See Figure 2 below as an example.



The distributions of responses to each question may be categorized using numerical measures such as the average which indicate the location of the center. The average rating is obtained by multiplying the percent in each category by the category value.

For example, suppose responses for a question were as shown below:

Rating	1	2	3	4	5
Percent	1	1	12	45	41

Then the average rating would be

$$(1x1+2x1+3x12+4x45+5x41)/100 = 4.24.$$

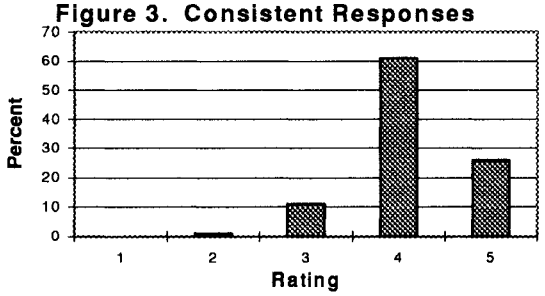
The questions could be sorted by the average ratings, where the lowest average is considered least favorable

and the highest average, most favorable. If there were a large numbers of questions, we could focus our attention on the five questions which obtained the highest average rating and the five which received the lowest.

3. Measures of Spread

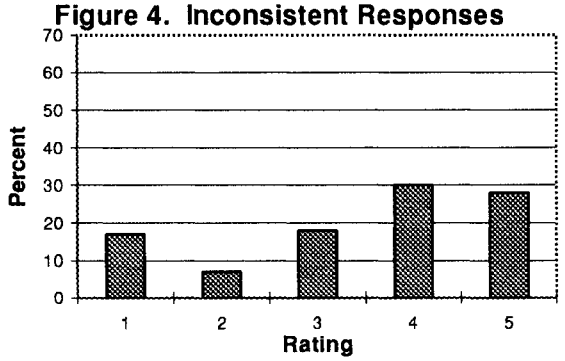
The standard deviation of responses can be used to measure the spread (variation or agreement) in the data. If the previous scale of 1 to 5 is employed, then the most consistent responses would show a clustering of responses around a given rating. Figure 3 below is an example that indicates relative consistency in responses to a given question.

Figure 3. Consistent Responses



Least consistent responses would show the ratings spread out across categories, not clustered, indicating variation in ratings. Figure 4 is one example of a collection of inconsistent responses to a question.

Figure 4. Inconsistent Responses



Distributions may be categorized for consistency using a numerical measures such as the standard deviation, which quantifies the spread in the data. The standard deviation is the square root of the average of the squared deviations of the individual ratings from the average rating (see above) for that question.

For example, if the responses for a question were the same as before, that is,

Rating	1	2	3	4	5
Percent	1	1	12	45	41

then the average rating is 4.24 and the standard deviation is

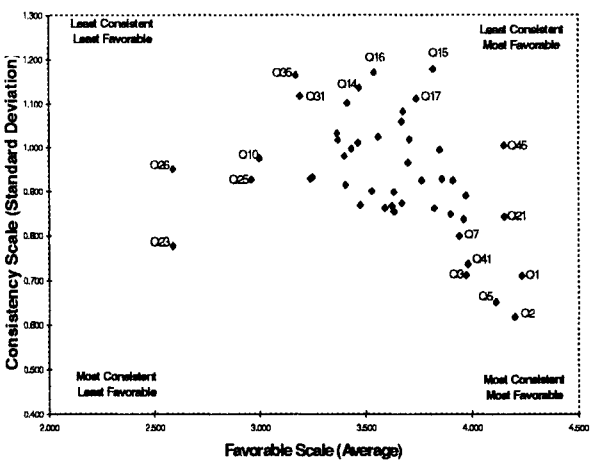
$$\text{SQRT}\{[1\text{x}(1\text{-}4.24)^2 + 1\text{x}(2\text{-}4.24)^2 + 12\text{x}(3\text{-}4.24)^2 + 45\text{x}(4\text{-}4.24)^2 + 41\text{x}(5\text{-}4.24)^2]/100\} = 0.776.$$

As done previously, the questions may be sorted by the standard deviation ratings. The lowest standard deviations indicate the most consistent responses or agreement and the highest standard deviations indicate the least consistent agreement. If there are a large numbers of questions, we could focus on the five questions which received the most consistent and the five which generated the least consistent ratings.

4. Scatter Plots

For a revealing two dimensional view, scatter plots can be very useful. Plotting the consistency ratings versus the favorable ratings for each question allows us to discover additional aspects not readily seen from individual comparisons. Figure 5 is an example of such a scatter plot. Patterns in the scatter plot can be very informative. For example, some questions may stand out as being very favorable and very consistent. Others may be very consistent and least favorable. In fact, the highest or lowest average ratings are associated with the least variation in responses. (See discussion in Appendix.) Alternatively, we may find a collection of questions of a particular type that show a high degree of inconsistency, indicating considerable variation among respondents. In fact, the least consistent responses are associated with average ratings in the middle of the rating categories. (See Appendix.)

Figure 5. Scatter Plot



By studying which questions are least consistent in the scatter plot, one may learn where additional action, such as training, is necessary.

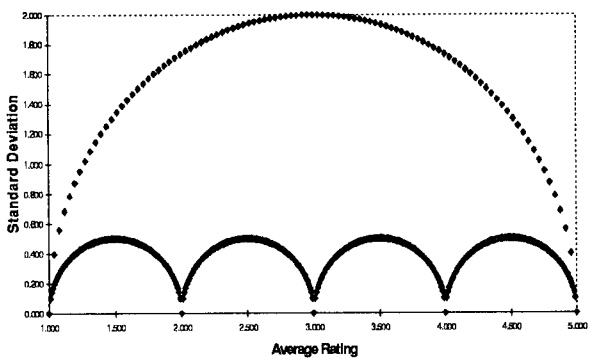
Summary

In summary, use of measures of consistency along with measures of location enhance analysis and facilitate interpretation. Two-dimensional scatter plots provide patterns that may contain valuable information and help focus attention on areas needing special consideration.

Appendix

There is correlation between the average response and the standard deviation. For example, to obtain the highest (or lowest) average rating, there must be considerable agreement in the data. A scatter plot of possible standard deviations versus corresponding average ratings will show roughly a "band" pattern, with the highest standard deviation associated with average ratings in the middle of the categories. Figure 6 illustrates this behavior.

Figure 6. Scatter Plot Band



If we use the same rating scale of 1 to 5, we see that the band peaks at an average rating of 3 and goes to zero at each end. Additionally, there are regions between average ratings where both a maximum and a minimum consistency rating are possible. For example, the minimum standard deviation for average ratings of 1.5, 2.5, 3.5, and 4.5 is 0.5, but the maximum are different. Note that the standard deviation can be near or at zero for any average rating near or at an integer value.

If we assume that the possible ratings are uniformly distributed throughout the categories, then it is easy to show that the mean rating is three and the standard deviation equals the square root of two, that is, approximately 1.4. In Figure 5, we see more consistent responses across all levels, indicating responses for this study are reflecting a higher degree of collective agreement than expected from a uniform, random distribution.