Good News or Bad News First: Bias from Visualization Sequences

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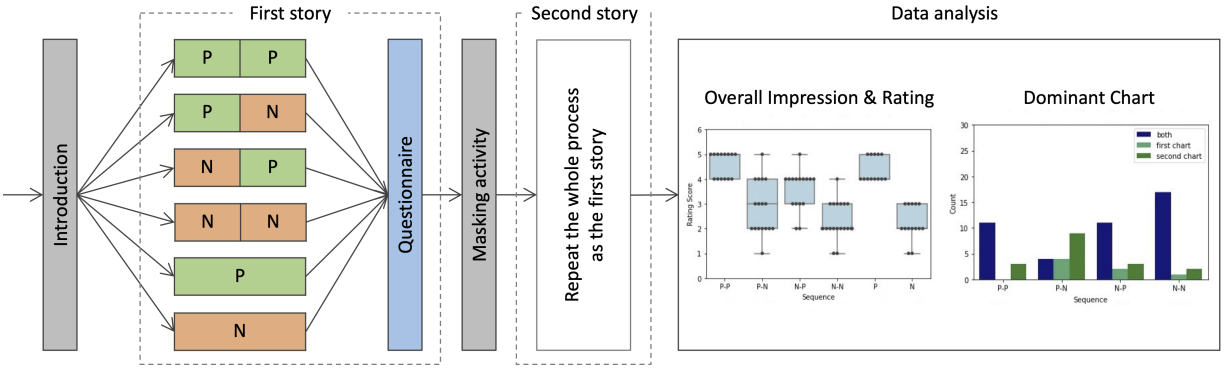

Figure 1: Our experiment showed different chart sequences to participants before a questionnaire. Each chart had either positive (P in green) or negative (N in orange) polarity toward its domain. Sequences of one chart were used as controls. Later came analyses of overall data impression difference and dominant chart in a sequence.

Abstract

Data visualization is useful for data-driven decision making but it is sensitive to perceptual and cognitive biases, which may lead to distorted conclusions and actions. Since data presentations are commonly shown in temporally sequential order, this study aims at identifying how chart sequences affect data perception and interpretation. We conducted an online survey with two stories in chart sequences which had two charts of either positive or negative polarity. The interplay of chart sequences and their accompanying stories seemed to have an impact on data perception. Certain conditions led to statistically significant perceptual differences. This study can be extended for future research aimed at developing guidelines for effective business presentations or data storytelling.

Index Terms: Human-centered computing—Visualization—Empirical studies in visualization; Human-centered computing—Visualization—Visualization theory, concepts and paradigms

1 Introduction

Data visualization can aid data exploration, analysis, and decision making. Ideally, a person should always see and understand data the same way, given the same visual representation. However, as visual perception plays a major role in data understanding and interpretation through visualization, it is vulnerable to various cognitive and perceptual biases.

A business meeting often features a PowerPoint presentation or, more generally, a slideshow presentation. Current visual perception may also change due to anticipated information. For example, if the first chart has a positive trend, the viewer may feel more positive toward the second chart despite its negative trend. Thus, the overall situation may seem better than the alternative that the first chart has a negative trend.

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Previous studies focused on data accuracy or knowledge gain from such chart sequences in data analysis tasks [1, 2]. Although Valdez et al. [5] studied the anchoring and priming effects, our study not only used a different visualization but also employed a higher-level task to measure overall impression of the same information in different orders.

When there was exactly one positive chart and one negative chart, the sequence could be an answer to a common phrase: "Good news or bad news first?". Studies showed that a majority would like to tell the good news first but would want to hear the bad news first [3, 4]. To the best of our knowledge, prior research on preference of polarity sequences had not been conducted with visually encoded stimuli.

2 Methodology

We prepared data sets and charts on two different domains: business and pandemic crisis. The two charts of each story were of different indicators. The first chart of the business story presented sales revenue and the second chart displayed customer satisfaction. For the pandemic crisis story, the indicators for the first and second charts were survival rate after vaccination and the number of proactive screening cases, respectively. All indicators are positive indicators whose higher values imply a better situation. All data in the charts were simulated merely to provide clear positive or negative trends and hence polarity, as shown in Fig. 2.

Given a two-chart sequence, there were four possible combinations. With one-chart sequences as control groups, there were six chart sequences in total: two charts of positive and positive polarity (P-P), two charts of positive and negative polarity (P-N), two charts of negative and positive polarity (N-P), two charts of negative and negative polarity (N-N), one chart of positive polarity (CP), and one chart of negative polarity (CN).

As shown in Fig. 1, each participant received two chart sequences of two different stories through an online survey. The story sequence was shuffled to reduce order effects. After seeing a chart sequence, participants evaluated their impression regarding the situation (Q1; 1 to 5 rating scale), rated the performance of the people in charge (Q2; 1 to 5 rating scale), and answered which chart they mainly used to evaluate the situation (Q3; the first chart, the second chart, or both charts).

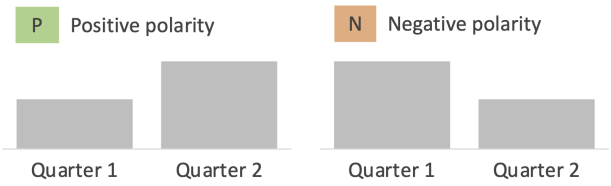

Figure 2: Bar charts of positive and negative polarity, respectively. The higher the bars were, the better the situation was. The polarity labels were not included in the experiment.

Although the answers to Q1 and Q2 should be correlated, Q2 was designed to decouple the query for overall data impression in Q1 from a plausible emotional response toward the people in charge of the situation, especially during the data collection period at the end of COVID-19 crisis. On the other hand, bad impressions might not lead to a pressure on the people in charge, the executive in the business story and the government in the pandemic crisis story, if the situation was considered as inevitable.

A data comprehension test and demographic questions were also included at the end of the survey. Before continuing to the second story, a masking activity was introduced to reduce the priming effect between stories. In this activity, participants had to read another 200-word passage, whose content was not related to any story.

3 Results

We had 95 and 81 participants for the business and pandemic stories, respectively, after discarding participants who did not answer all questions in the survey, completed the survey in less than one minute, or did not pass the data comprehension test. We conducted a joint analysis of the responses to Q1 and Q2 in the survey, whereas Q3 was analyzed separately.

3.1 Overall Impression and Performance Rating

The overall impression and performance rating scores decreased when there were more negative charts in a sequence. The P-P sequence led to a higher score than the P-N and N-P sequences which had a higher score than the N-N sequence. The P-P sequence and the control of one positive chart (CP), in which participants saw only one positive chart, appeared to be generally similar. So did the N-N sequence and the control of one negative chart (CN).

Since each participant had to complete the survey of both stories, the Kruskal-Wallis test, a nonparametric test equivalent to one-way ANOVA, was not used to statistically confirm the observations due to the independence assumption being violated. We decided to directly conduct a pairwise test with the Wilcoxson rank-sum test, a nonparametric alternative to the two-sample t-test, in order to compare the median scores across sequences and stories.

When we combined the scores from two stories, the control (CP and CN) sequences were not significantly different from the P-P and N-N sequences as expected. Moreover, the P-P sequence had a significantly higher median than the other sequences, except the CP sequence. The P-N and N-P sequences showed no significantly different medians for either overall impression and performance rating.

When we examined each story separately, the median performance rating score of the P-N sequence in the business story was significantly lower than the N-P sequence. The Wilcoxson's rank-sum test statistic was -1.99 with p-value of 0.046. There was no significant difference between the P-N and N-P sequences in the other conditions.

In the pandemic crisis story, the P-P sequence had a significantly lower overall impression score than the CP sequence. The pandemic crisis story was the only condition that the P-P and P-N sequences showed no significant median difference. Moreover, the P-P and N-N sequences had statistically lower medians in the pandemic crisis story than the business story, with p-values of 0.01 and 0.001, respectively.

3.2 Dominant Chart in Sequence

Since Q3 in the questionnaire could only be answered by the participants who were shown two charts, the control sequences (CP and CN) were excluded from this analysis. There were 68 and 55 participants who did not received the control sequences for the business and pandemic stories, respectively.

The participants selected either one of the charts in the P-N sequence as the dominant chart. Only 25% of the answers were "both" charts in the P-N sequence, in contrast to 65% to 75% in the other sequences. In the business story, the second chart or the chart with negative polarity was more dominant, while the opposite was true in the pandemic crisis story.

To statistically determine if the proportions of answers in Q3 were different, we created a contingency table and ran a chi-squared test. The null hypothesis was that the proportions of the first chart, the second chart, and both charts as dominant were equal. We found that all p-values of combined, business, and pandemic crisis conditions were less than 0.05 (< 0.01, 0.04, and < 0.01, respectively). The first and second charts were indeed not equally dominant in the P-N sequence.

However, after applying the Benjamini-Hochberg method to adjust the p-values, such effect remained solely in the business story but disappeared from the pandemic crisis story. This might be caused by small sample sizes in some subgroups and the statistical tests simply lacked power to detect their significant difference.

4 Conclusions and Future Work

Some combinations of chart sequences and background stories appeared to influence data perception. In the pandemic crisis story, the situation was evaluated as significantly worse than that of the same chart sequence in the business story. A sequence of positive and negative charts (P-N) resulted in an unfavorable evaluation of the people in charge of the business situation as the second or the negative chart was more dominant. Our future work includes an experiment with a longer chart sequence more commonly used in a business setting and data storytelling.

Acknowledgments

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