Familiarity vs. Correctness: Arcs and Angles in Sunburst Charts

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ABSTRACT

A Sunburst chart visualizes hierarchical data as concentric rings. Similar to a pie chart, a Sunburst chart may be read through arc lengths or sector angles, but its multilevel nature makes arc lengths across levels unreliable as a visual variable. In this study, we designed Sunburst chart variations to test whether they affect chart reading performance. We found that the participants used arc lengths to read chart values, confirming a previous study. Other factors in the experiment suggested that the values in focus should be placed in adjacent layers and in quadrant III and IV as the participants tended to correctly read data values through angles instead.

1 INTRODUCTION

One of common structures in information visualization is hierarchical structure such as an organization charts, family trees, and directory trees. Typical charts for visualizing hierarchical data include trees, nested lists, icicle plots, and treemaps but they are limited in different ways. For example, branches in a large tree may overlap and hinder data reading.

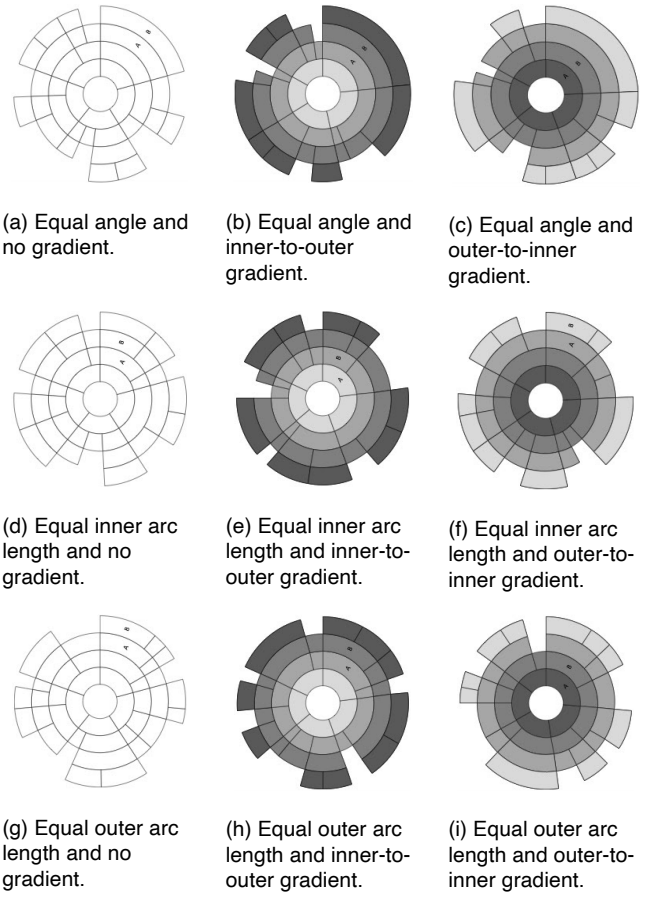
A space-filling visualization such as a Sunburst chart inherently has no overlapping. Each ring in a Sunburst chart represents each level in the data hierarchy. The innermost and outermost rings are the highest and lowest levels of the hierarchy, respectively. In an evaluation on space-filling visualizations for hierarchical data [1], the participants preferred a Sunburst chart because it was able to show a clear portrayal of hierarchical data structure.

In this study, we tested which factors affect the understanding of a Sunburst chart. According to Skau and Kosara [2], arc length was the most important encoding in pie charts and donut charts. We would like to confirm whether angle or arc length was more effective in reading data values in a Sunburst chart. On the same level, both visual variables should be equally correct, while angle is the only visual variable that is consistently accurate in a data comparison across hierarchical levels.

Inspired by other previous work [3, 4], other factors in the study are layer adjacency, quadrant, and gradient. These factors can be considered as potential factors to mitigate the effect of competing visual variables.

2 STUDY PROCEDURE

We generated 144 Sunburst charts that are combinations of four factors. Each Sunburst chart has no gradient or a light-to-dark gradient, either inner-to-outer or outer-to-inner gradient. Two portions in each chart were marked with letter A and B. They were equal in one of the tested visual variables: angle, inner arc length, or outer arc length.



(a) Equal angle and no gradient. (b) Equal angle and inner-to-outer gradient. (c) Equal angle and outer-to-inner gradient.

(d) Equal inner arc length and no gradient. (e) Equal inner arc length and inner-to-outer gradient. (f) Equal inner arc length and outer-to-inner gradient.

(g) Equal outer arc length and no gradient. (h) Equal outer arc length and inner-to-outer gradient. (i) Equal outer arc length and outer-to-inner gradient.

Figure 1: Examples of Sunburst charts in this study. Shown are only charts whose marked portions are in adjacent layers and in the first quadrant.

The marked portions were always in different levels, adjacent or not, but in the same quadrant, either quadrant I, II, III, or IV. Shown in Fig. 1 are the combinations of the marked visual variable and gradient and the variations of layer adjacency and quadrants are illustrated in Fig. 2 and 3, respectively.

We recruited 68 undergraduate students to participate in this study. The online study began with an instruction followed by demographic questions. Every page after the first page had a button to advance to the next page without a back button. Each page showed only one Sunburst chart (of all generated results) with two marked portions and the same question: "What is the relationship between A and B?" The answer choices per question were also the same: "A > B", "A < B", "A = B" and "Not sure". The order of the questions was random, and all participants were required to answer all questions.

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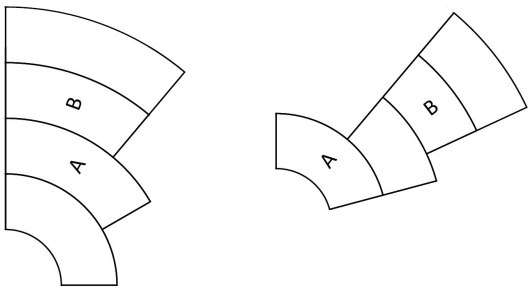

Figure 2: Parts of sunburst charts whose marked portions are in adjacent layers (left) and the other is not next to each other (right). Both have no gradient, and the marked segments are in the first quadrant.

3 Results and Discussion

Of all 68 participants, we discarded the answers from four participants because their answers were the same for all questions. In total, we had 64 participants who completed all answers.

The correct answer considered only the angular values of the portions. In other words, marked segments of the same inner or outer arch length were not equal. We normalized the number of correct answers per factor to fairly compare them.

Because the numbers of correct answers were not normally distributed, we used nonparametric techniques, namely Wilcoxon signed-rank test and Friedman test, for all analyses. Regarding angle or arc length as the main visual variable of a Sunburst chart, we got a significant result ($p < 0.0001$) indicating that most of the participants used arc length to read data values, confirming the previous study [2], despite the fact that angle was the correct information bearer in a Sunburst chart.

The gradient turned out to be irrelevant ($p = 0.175$) indicating that there are no significant data reading differences among Sunburst charts without gradient, with outer gradient, and with inner gradient. Marked data values in segments in adjacent layers were read more accurately than those in non-adjacent layers ($p = 0.007$). Different quadrants significantly affected data reading task ($p = 0.014$). While the left and right quadrants did not affect chart reading, marked portions in quadrant III and quadrant IV tend to be read through the correct visual variable (angle) more than those in quadrant I and quadrant II.

4 Discussion and Future Work

The results confirmed that the participants read data values in a Sunburst chart through arc length although angle is the intended way to read and compare data values. This could be the result of transferring the visual grammar of a pie and a donut chart to a Sunburst chart. Such knowledge transfer can be useful in other cases but harmful in this case.

To alleviate such problems, adjusting other factors may help. Our study leads us to recommend presenting data that require accurate comparison in adjacent layers in quadrant III and IV of a Sunburst chart.

One of the factors that affected chart reading in our study was the quadrant in where marked portions were. We conjecture that the participants were not used to reading data values in the lower quadrants, so they spent more time or were more careful while reading values from quadrant III and IV.

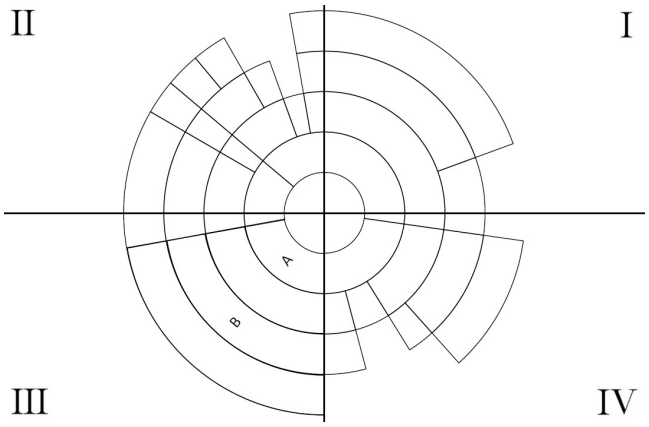

Figure 3: A Sunburst chart whose marked portions were in quadrant III as illustrated. This Sunburst chart has no gradient, and the marked segments are not adjacent.

For future work, we would like to explore the effect of interactive techniques such as InterRing [5] which may aid data reading in a Sunburst chart. We also want to understand why the lower quadrants affect chart reading. Other future work includes the effect of personal preferences and more complex tasks beyond data reading. On a broader term, we are interested in other cases that visual encoding knowledge transfer works and does not work. Our recommendations include intentionally impeding chart reading for better accuracy. Is such trade-off acceptable or unavoidable?

Acknowledgments

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