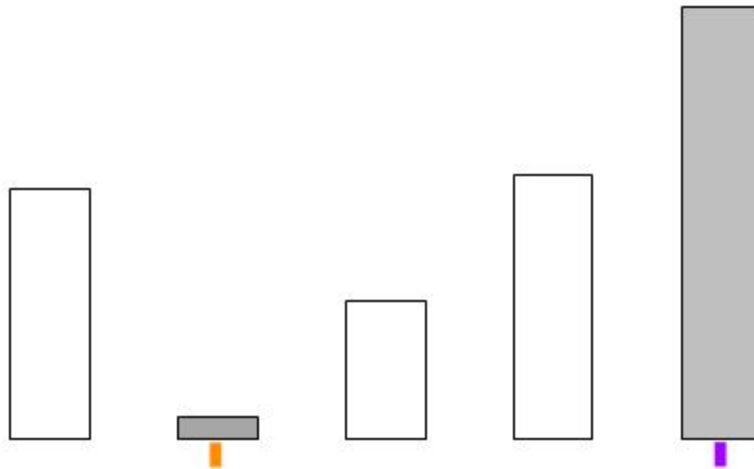


# The Effect of Time

*A Study of Time as it Relates to Graphical Perception*



**Ethan Schutzman**

12.11.2019

CS 525: Design and Analysis of Large Online Experiments

Professor Lane Harrison

## INTRODUCTION

This study set out to investigate the effect of time on human perception of graphics. The study is based off of the famous Cleveland & McGill (1984) that investigated human perception of percentage differences between charts.

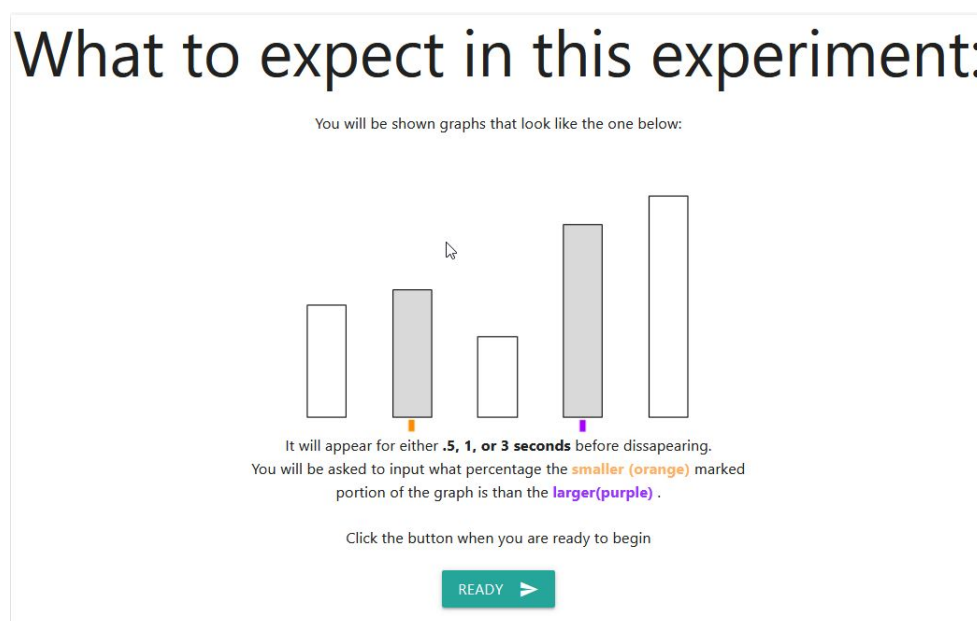
## Infrastructure

The experiment was written in Node.js and JavaScript and hosted on a DigitalOcean<sup>1</sup> droplet. Complete code can be found at <https://www.github.com/EHSchutzman/clevelandmcgill-final>. Complete analysis of data collected in this project can also be found in the repository,

## Methodology

This study closely adheres to the original study by Cleveland & McGill and the Heer & Bostock (2010) *Crowdsourcing Graphical Perception: Using Mechanical Turk to Assess Visualization Design*,<sup>2</sup> paper that paved the way for crowdsourcing graphical experiments.

Participants are served the study on Prolific<sup>3</sup>, a crowdsourcing platform that redirected them to the hosted experiment. Participants were then shown a training information pane as shown below:



<sup>1</sup> "DigitalOcean." <https://www.digitalocean.com/>. Accessed 9 Dec. 2019.

<sup>2</sup> "Crowdsourcing Graphical Perception - Stanford Visualization ...." <http://vis.stanford.edu/files/2010-MTurk-CHI.pdf>. Accessed 9 Dec. 2019.

<sup>3</sup> "Prolific." <https://app.prolific.co/>. Accessed 9 Dec. 2019.

## Figure 1: Training Pane

Participants were all shown thirty graphs each with the same orange and purple markings next to the relevant data sections. The charts were shown for either one half second, one second, or three seconds. Data was collected and stored in a Firebase RealTime Database <sup>4</sup>.

## DATA

Forty participants were chosen by Prolific with no demographically restricting qualities meaning this study was sent on a first come first serve basis. The only restriction on the study was that the participant must be completing the study on a desktop computer or laptop. No mobile phones or tablets were allowed.

Once data was collected it was analyzed on several factors, on a per chart type basis, on a per time interval basis, and on a per chart type per time interval basis. Following the work of Cleveland & McGill researchers plotted the  $\text{Log}_2(\text{abs}(\text{expected\_answer} - \text{actual\_answer}) + 0.125)$ . The values are shown in the charts below. Full analysis scripts can be found at <https://github.com/EHSchutzman/clevelandmcgill-final/blob/master/analysis/analysis.pdf>

---

<sup>4</sup> "Firebase." <https://firebase.google.com/>. Accessed 9 Dec. 2019.

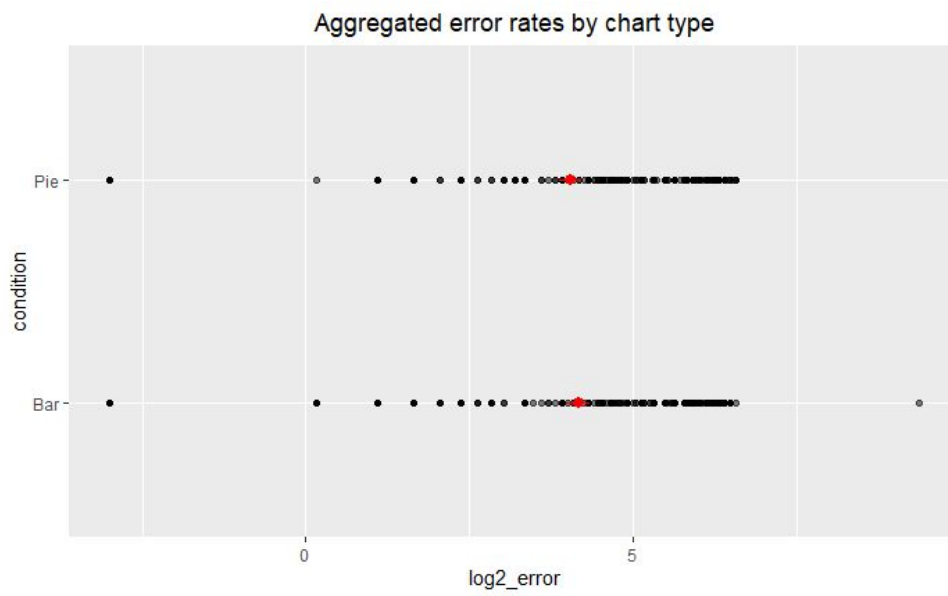


Figure 2: Error Rates by Chart Type

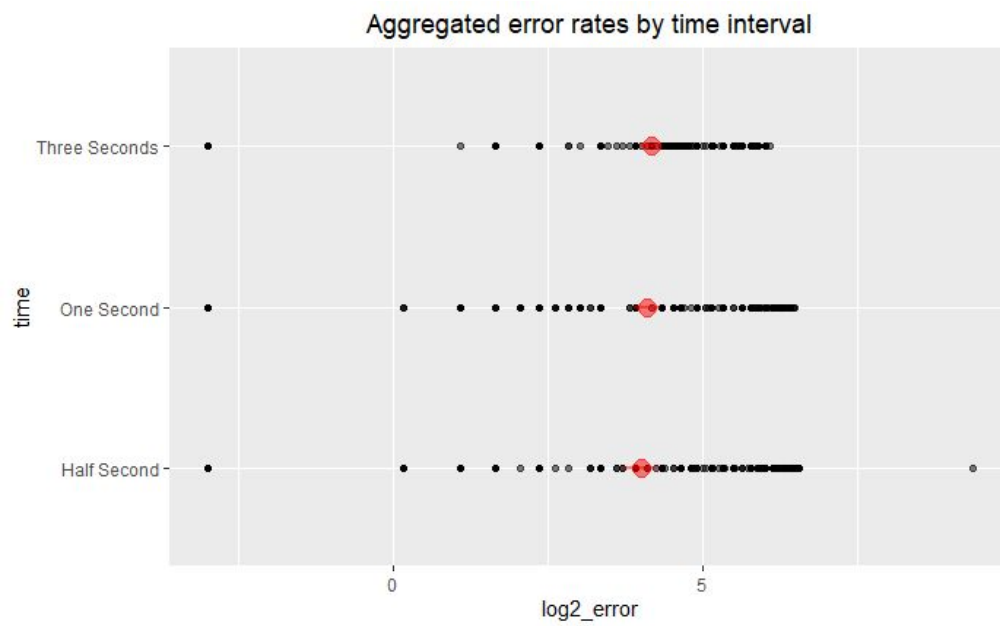


Figure 3: Error Rates by Time Interval

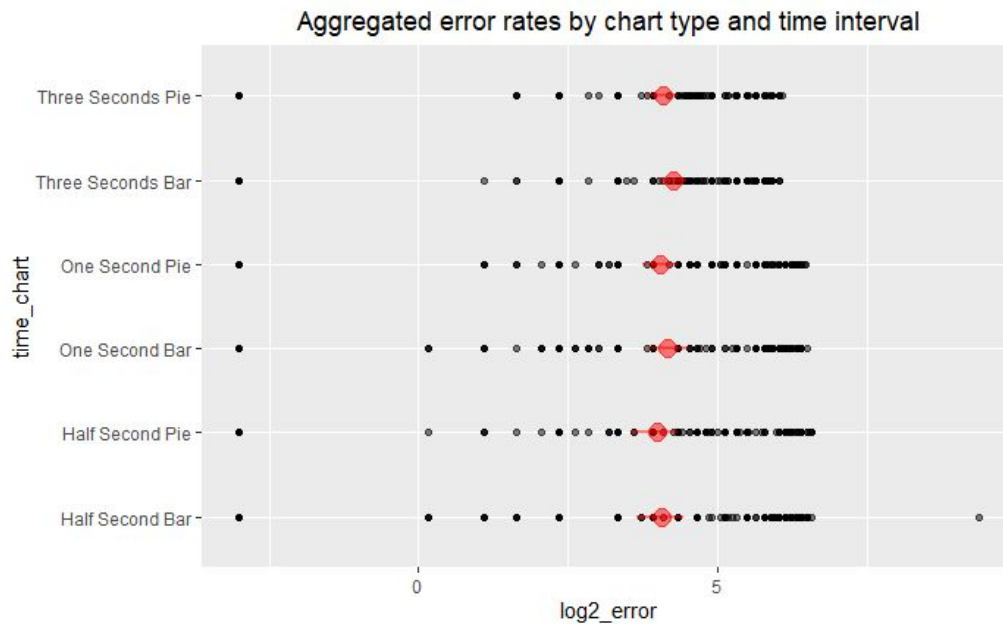


Figure 4: Error Rates by Chart Type and Time Interval

All chart types show roughly similar error distributions with similar confidence interval values.

## RESULTS

The similar confidence intervals lead to investigation of abnormal data. Shapiro tests were conducted on every condition value and all tests returned that the data was not normally distributed. This led to running Wilcoxon tests to determine whether or not each condition could be considered to come from the same continuous distribution. Based on p values of .002567 and .04591 we can conclude that the three bar chart distributions appear to be sampled from the same population. Interestingly though the only pie chart distributions that satisfy the Wilcoxon test are the half second and three second pie charts with a p value = .02119.

Forty participants were sampled for this experiment, and the results of the

participants were not visually distinctive indicating any clear benefit to these time intervals for perception. Intuitively we would believe that there should be a strong correlation between time and ability to perceive percentage differences. However there is no indication that a correlation exists to back confirm this intuition.

## CONCLUSION

This experiment could have shown a strong correlation between time and perception and perhaps they will in a future experiment. This experiment showed no clear correlation between time viewing a chart and the perception of the chart itself. More research can be done in the future to investigate time intervals to see if there is a threshold where time is a clear help or hindrance in perception. A potential shortcoming of this experiment was the charts themselves. There may be a better representation of the charts for presenting to participants on a web platform. Overall this experiment was a success. There is clearly room to improve research into the time-visualization space and a Cleveland & McGill style experiment was a good place to start.