

The Effects of Visual and Design Features on the Perception of Correlation in Scatterplots

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Abstract

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Lay abstract

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Declaration of originality

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Acknowledgements

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Chapter 1

Introduction

1.1 Research Motivation

1.2 Contributions

1.3 Included Publications

The research described in chapters 4, 5, 6, and 7 in this thesis is adapted from earlier publications, the last of which under review as of writing. To avoid repetition, information and discussion that would be repeated has been consolidated into the literature review and general methodology chapters. *Gabriel Strain* is the primary author of all included papers.

- *The Effects of Contrast on Correlation Perception in Scatterplots* [6] is reproduced in Chapter 4. Sections 4.4.2, 4.5.2, 4.4.3, 4.5.3, 4.4.4, 4.5.4, and 4.6 contain minimally altered parts of the published article.
- *Adjusting Point Size to Facilitate More Accurate Correlation Perception in Scatterplots* [5] is reproduced in Chapter 5. Sections 5.4.2, 5.4.3, 5.4.4, and 5.5 contain minimally altered parts of the published article.
- *Effects of Point Size and Opacity Adjustments in Scatterplots* [7] is reproduced in Chapter 6. Sections 6.4.2, 6.4.3, 6.4.4, and 6.5 contain minimally altered parts of the published article.
- *Effects of Alternative Scatterplot Designs on Belief (under review)* is reproduced in Chapter 7. Sections 7.4, 7.5.2, 7.5.3, 7.5.4, and 7.6 contain minimally altered parts of the published article.

1.4 Overview of Thesis

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Literature Review

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Chapter 3

General Methodology

3.1 Introduction

In this chapter we describe our research methodologies. Chapters 4, 5, and 6 share most aspects of experimental method, while the experiment described in chapter 7 differs substantially. Throughout this chapter, the reader should assume that we are referring to the entire body of experimental work this thesis describes. Methods that differ regarding the final experiment in chapter 7 are detailed along the way. In this chapter, we discuss our experimental designs, the tools we use to build and run our experiments, our approach to statistical analyses, and the computational methods and practices we employed particularly with regards to reproducibility and open science.

3.2 Experimental Methods

It is important to acknowledge that the way in which we conduct experiments influences what we find and the conclusions that we may draw from those findings. The decisions that lead us to designing experiments in certain ways must be based not only on theory, but also on the practical constraints imposed by external factors on the research team. Concerns such as time, convenience, and cost must be addressed, and a compromise between research that is *valuable* and research that is *doable* must be reached. We focused on pragmatism and impact throughout the course of this research project; happily, the research journey we embarked on resulted in methodologies that satisfied both principles. It is for this reason that we consider the framework we present to be a key contribution of this thesis.

3.2.1 Experimental Design

All but our final experiment utilised within-participants designs. Each participant saw all experimental stimuli and provided a judgement of correlation using a sliding scale between 0 and 1 (see Figure 3.1). Experiments 1 to 3 featured a single experimental factor of design, all with 4 levels corresponding to scatterplots with different design features. Experiment 4 employed a factorial 2×2 design. Experiment 5 is a departure from the shared experimental paradigm of the previous experiments, and features a 1 factor, 2 level between-participants design.

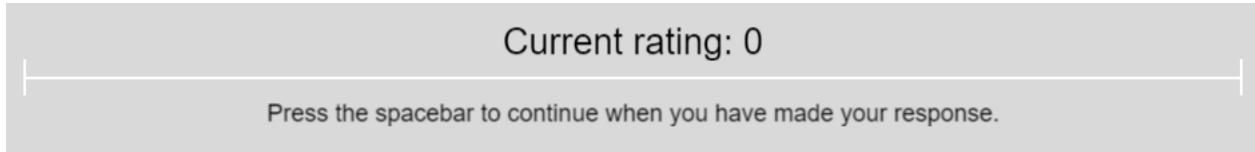


Figure 3.1. An example of the slider participants used to estimate correlation in experiments 1-4.

3.2.2 Tools for Testing

Whatever the design of our experiments, software plays a crucial role in allowing us to carry them out. Fortunately, at the time of writing, there is a wealth of tools available to facilitate the testing of visualisations both in traditional lab-based tests and in online experiments. As we adhere to the principles of open and reproducible research [2], we discount closed-source software, such as Gorilla [1] or E-prime [4], as these rely on paid licenses and do not allow us to share code with future researchers. We settled on using PsychoPy [[peirce_2019](#)] due to its open-source status, flexibility regarding graphical and code-based experimental design, and high level of timings accuracy [3]. Using such a open-source tool not only facilitated our own learning with regard to experiment building, but also enables to contribute further examples of visualisation studies by hosting the resulting experiments online for use and modification by future researchers.

We elected to pursue online testing throughout this thesis. Doing so is much quicker than carrying out in-person lab-based testing, meaning we can collect data from a much larger number of participants. This reduces the chances of detecting false positives during analysis and ensures adequate levels of power despite the potential for small effects sizes. Online testing also affords us access to diverse groups of participants across our populations of interest, especially when compared to the relatively homogeneous student populations usually accessed by doctoral researchers.

3.2.3 Creating Stimuli

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8.6 Limitations

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8.8 Closing Remarks

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- [5] Gabriel Strain, Andrew J. Stewart, Paul Warren, and Caroline Jay. “Adjusting Point Size to Facilitate More Accurate Correlation Perception in Scatterplots”. In: *2023 IEEE Vis X Vision*. Melbourne, Australia: IEEE, Oct. 2023, pp. 1–5. ISBN: 9798350329841. doi: 10.1109/VisXVision60716.2023.00006. (Visited on 02/15/2024) (cited on p. 14).
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Appendices

Appendix A

First appendix

A.1 Section in Appendix