

# Point Size and Correlation Perception in Scatterplots

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## ABSTRACT

Place abstract here.

**Index Terms:** Human-centered computing—Visualization—Empirical studies in visualization—; Human-centered computing—Human computer interaction (HCI)—Empirical studies in HCI—

## 1 PLACE INTRO HERE. DON'T FORGET TO PUT HYPOTHESES

## 2 RELATED WORK

### 2.1 Correlation Perception

see Strain et al for a brief review of the history of correlation perception testing with scatterplots

### 2.2 Point Size

Hong et al paper will be useful here

### 2.3 Dot Pitch and Crowdsourced Experiments

## 3 METHODOLOGY

### 3.1 Open Research Statement

The experiment was conducted according to the principles of open and reproducible research. All data and analysis code are available at [https://github.com/gjpstrain/size\\_contrast\\_and\\_scatterplots](https://github.com/gjpstrain/size_contrast_and_scatterplots). This repository contains instructions for building a docker image to fully reproduce the computational environment used, allowing for full replications of stimulus generation, analyses, and the paper itself. The experiment was pre-registered with the OSF (<https://osf.io/k4gd8>).

### 3.2 Participants

150 participants were recruited using the Prolific.co platform. Normal to corrected-to-normal vision and English fluency were required for participation. As in [?], and in accordance with previously published guidelines [?], participants were required to have completed at least 100 studies on Prolific, and were required to have a Prolific score of at least 100, indicating acceptance on at least 100/101 previously completed studies. Participants who took part in any of our previous studies were prevented from participating.

### 3.3 Stimuli

The data used to generate the scatterplots in the current study was identical to that in [?]. They were generated based on 45 uniformly distributed  $r$  values between 0.2 and 0.99. Scatterplot points were generated based on bivariate normal distributions with standard deviations of 1 in each direction. Each scatterplot had a 1:1 aspect ratio, was generated as a 1200 x 1200 pixel .png image, and was scaled up or down according to the participant's monitor. See section

2.3 for a more detailed discussion of precise point sizes and dot pitch in crowd-sourced experiments.

As in our previous study [?], we used equation 1 to map residuals to point sizes. We used a scaling factor of 4 and a constant of 0.2 to achieve a minimum point size of 12/13 pixels, which is consistent with the point size on a 1920 x 1080 monitor for both experiments in [?]. Again, see section 2.3 for a discussion of dot pitch. Scripts detailing scatterplot and mask generation can be found in the item preparation folder in the repository linked below.

$$point - size = 1 - b^R \quad (1)$$

### 3.4 Dot Pitch and Crowdsourced Experiments

In our previous study [?], we had no way of obtaining dot pitch or participant to monitor distance due to the online, crowdsourced nature of the experiments. Since then we have adopted a method for obtaining the height of a participant's monitor in inches [?]. Combining this with the monitor resolution fetched from Psychopy and assuming a widescreen 16:9 aspect ratio allows us to infer dot pitch and therefore the physical size of the points in our experiment. Mean dot pitch was 0.33 ( $SD = 0.06$ ). See section 4 for analyses including dot pitch as a predictor.

### 3.5 Visual Threshold Testing

It is key that our manipulation does not functionally remove data from the scatterplot, thus, in order to test that all our points were visible across a range of viewing contexts and on a range of apparatus, we included visual threshold testing prior to the experimental items in the study. Participants were shown six scatterplots with a number of points, and were asked to enter in a textbox how many points were being displayed. The points were the same size as the smallest points used in the experimental materials. 5% of participants were correct on 5 out of 6 visual threshold questions, while 95% were correct on 6 out of 6.

### 3.6 Design

The experiment used a fully repeated measures, within-participants design, with each participant seeing and responding to each of the 180 scatterplots in a randomised order. There were four scatterplots for each of the 45  $r$  values corresponding to the four levels of the size condition, examples of which can be seen in figure 1. Everything needed to run the experiment, including code, materials, instructions, and scripts, is hosted at [https://gitlab.pavlovlab.org/Strain/exp\\_size\\_only](https://gitlab.pavlovlab.org/Strain/exp_size_only).

## 4 RESULTS

include short discussion of modelling paradigm and justification for it

## 5 DISCUSSION

## ACKNOWLEDGMENTS

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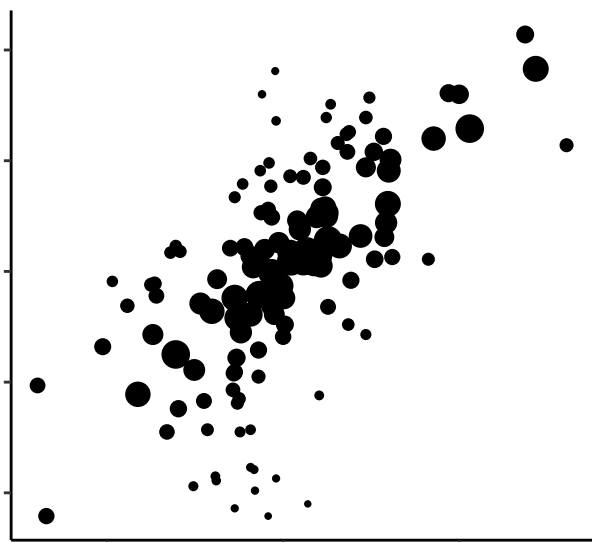
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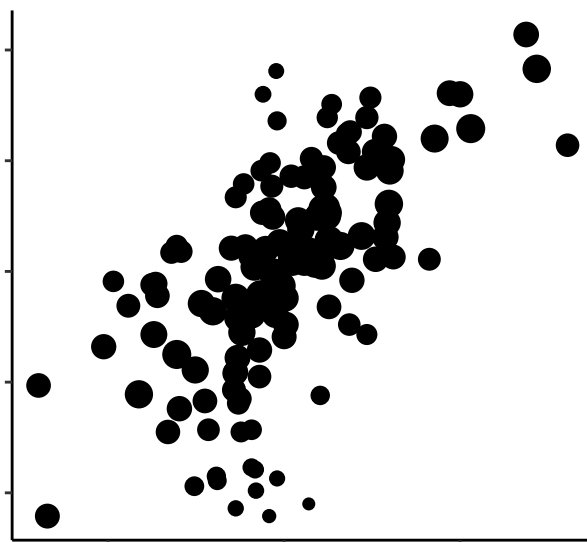
‡Paul.Warren@manchester.ac.uk

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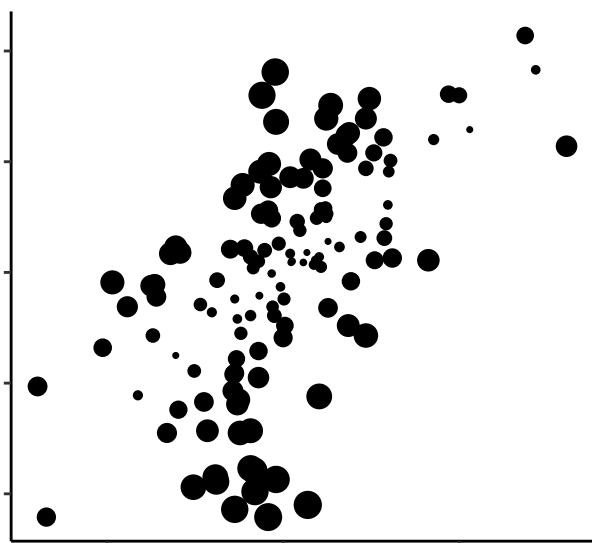
Non-linear Decay ( $b = 0.25$ )



Linear Decay



Inverted Non-linear Decay



Standard Size

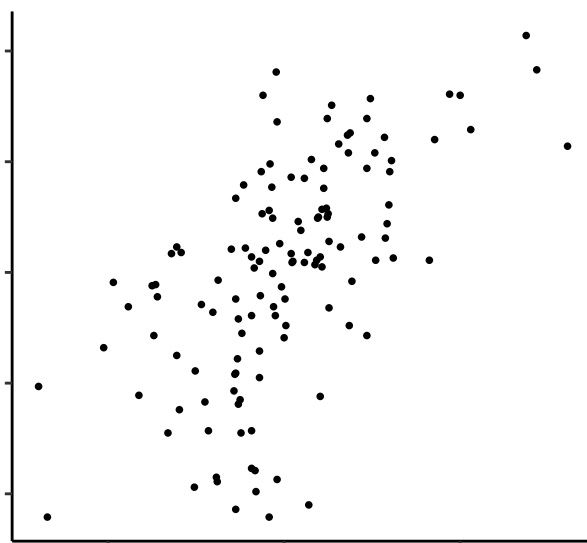


Figure 1: Four levels of the point size condition, demonstrated with an  $r$  value of 0.6

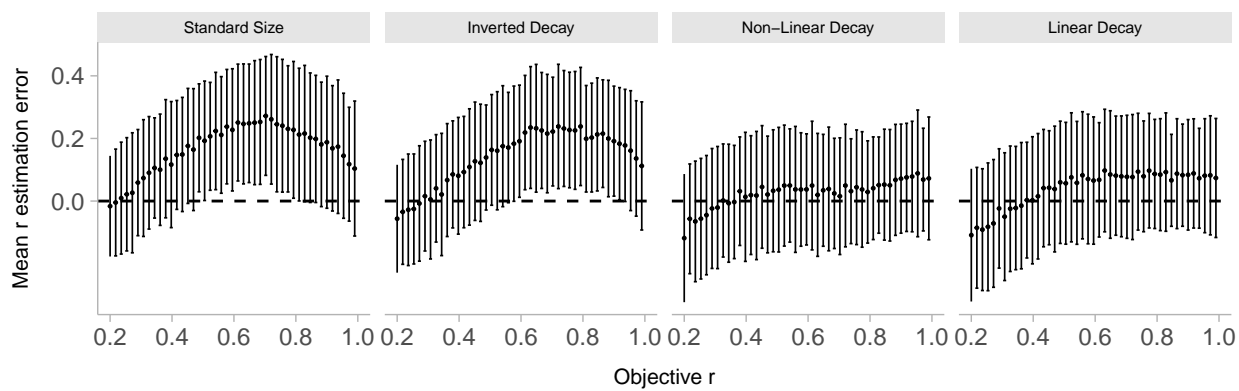


Figure 2: hello

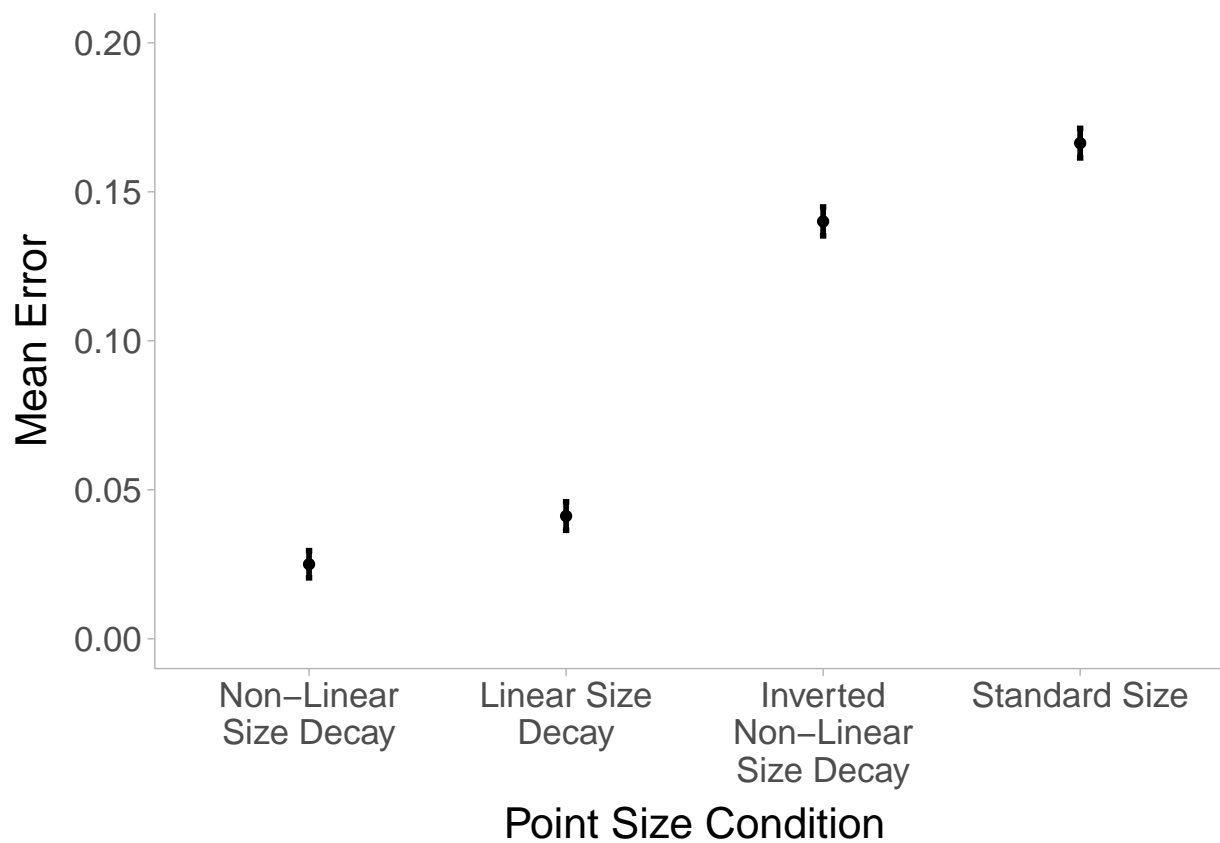


Figure 3: hello