

Proportional Reasoning Across Formats

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Author Note

The authors made the following contributions. Vincent Espana: Conceptualization, Writing - Original Draft Preparation, Writing - Review & Editing.

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Introduction

Comparing proportions is sometimes very hard! But, even infants seem to be able to do it a little bit. The purpose of this science project was to better understand how well people compare proportions when the proportions are presented in different formats. By analyzing performance across different factors, we hope to identify if said factors affect proportional reasoning. Specifically, this study focuses on three research objectives. First, we examine whether average performance varies depending on format type. Second, we investigate whether average performance varies across numerator congruency status. Lastly, we explore the interaction between numerator congruency and format type to determine if congruency is affected by differences in formats.

The purpose of this class assignment is to take the R-code and plots we've been generating over the last several weeks and put it all together into one APA-formatted paper.

Methods

A total of 99 adults participated in the study. Participants were introduced to a story about how a magic ball and that the outcome (i.e., blue or orange) depended on the proportions. They were then asked to compare the proportions of different images. In other words, participants were shown two images of the same kind at the same time and asked to decide which image had a higher proportion of the shape (or dots) colored in blue. See Figure 1.

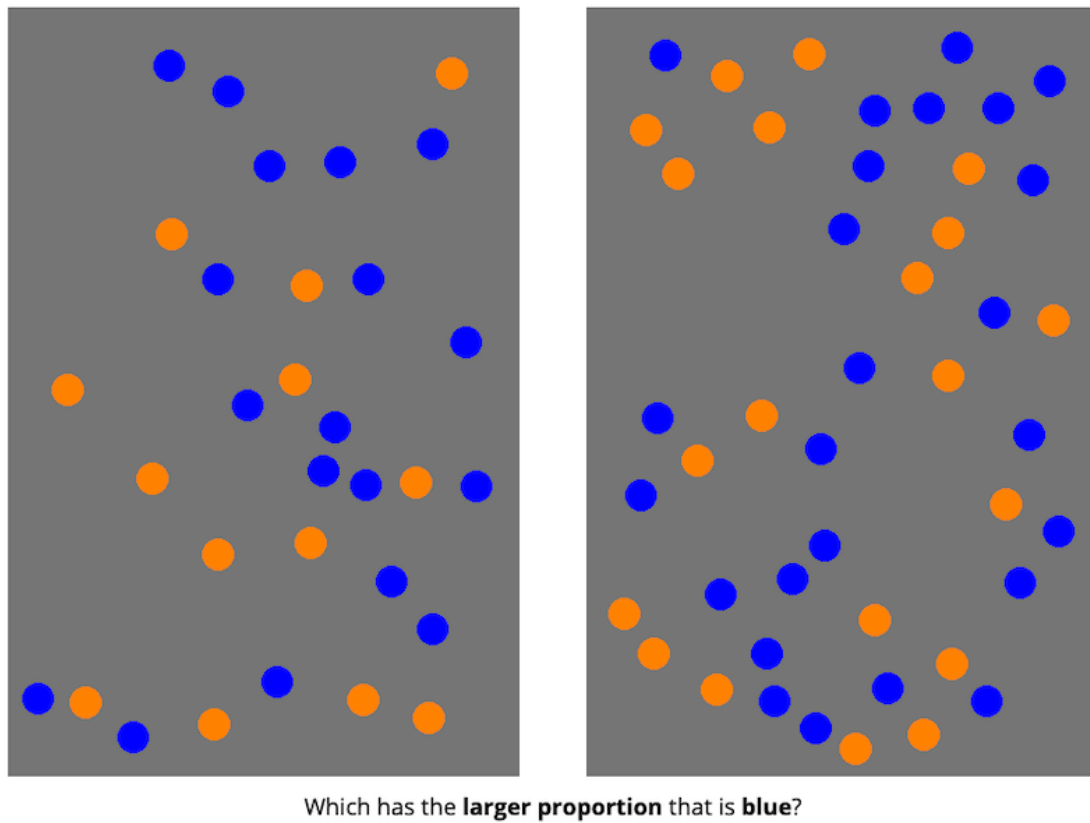


Figure 1. Example of Proportional Reasoning Task

Conditions

There were four different conditions that changed what kinds of images the participants saw. (See Figure 2)

- divided blob: blue and orange were entirely separate
- integrated blob: one blob, divided to be part blue and part orange
- separated dots: blue and orange dots were on opposite sides of the image
- integrated dots: blue and orange dots were intermixed

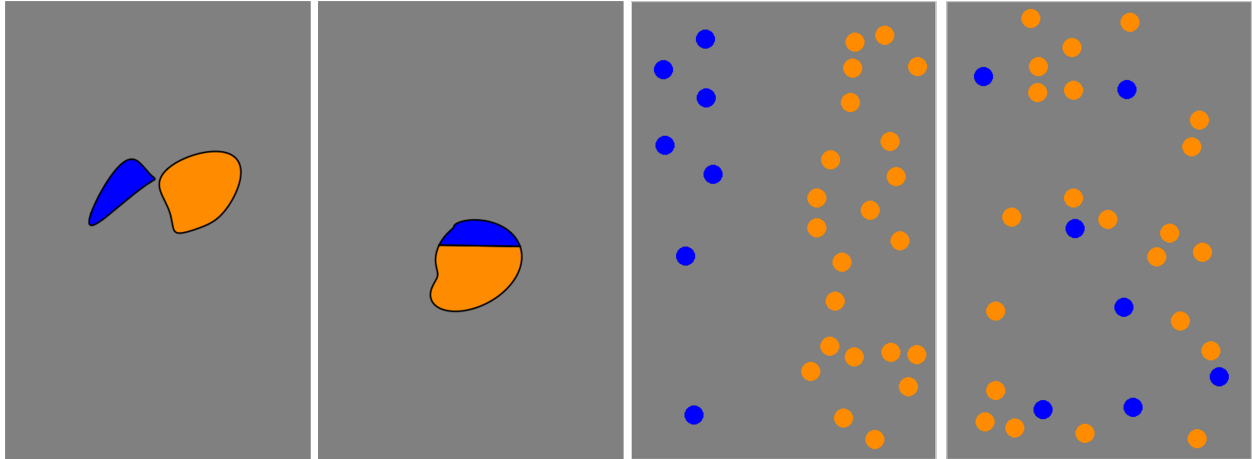


Figure 2. Example Images Per Condition

Data analysis

We used R (Version 4.4.1; R Core Team, 2024) and the R-packages *dplyr* (Version 1.1.4; Wickham, Francois, Henry, Muller, & Vaughan, 2023), *forcats* (Version 1.0.0; Wickham, 2023a), *ggplot2* (Version 3.5.1; Wickham, 2016), *lubridate* (Version 1.9.3; Grolemund & Wickham, 2011), *papaja* (Version 0.1.3; Aust & Barth, 2024), *purrr* (Version 1.0.2; Wickham & Henry, 2023), *readr* (Version 2.1.5; Wickham, Hester, & Bryan, 2024), *stringr* (Version 1.5.1; Wickham, 2023b), *tibble* (Version 3.2.1; Müller & Wickham, 2023), *tidyr* (Version 1.3.1; Wickham, Vaughan, & Girlich, 2024), *tidyverse* (Version 2.0.0; Wickham et al., 2019) and *tinylabels* (Version 0.2.4; Barth, 2023) for all our analyses.

Results

1. Does average performance vary across format type, ignoring all other aspects of the stimuli?

Figure 3 compares how accurately participants performed under each condition. It shows that stacked blob, and random dots have a even distribution, while shifted blob clusters to at higher and lower accuracy and separated dots cluster at lower accuracy. The

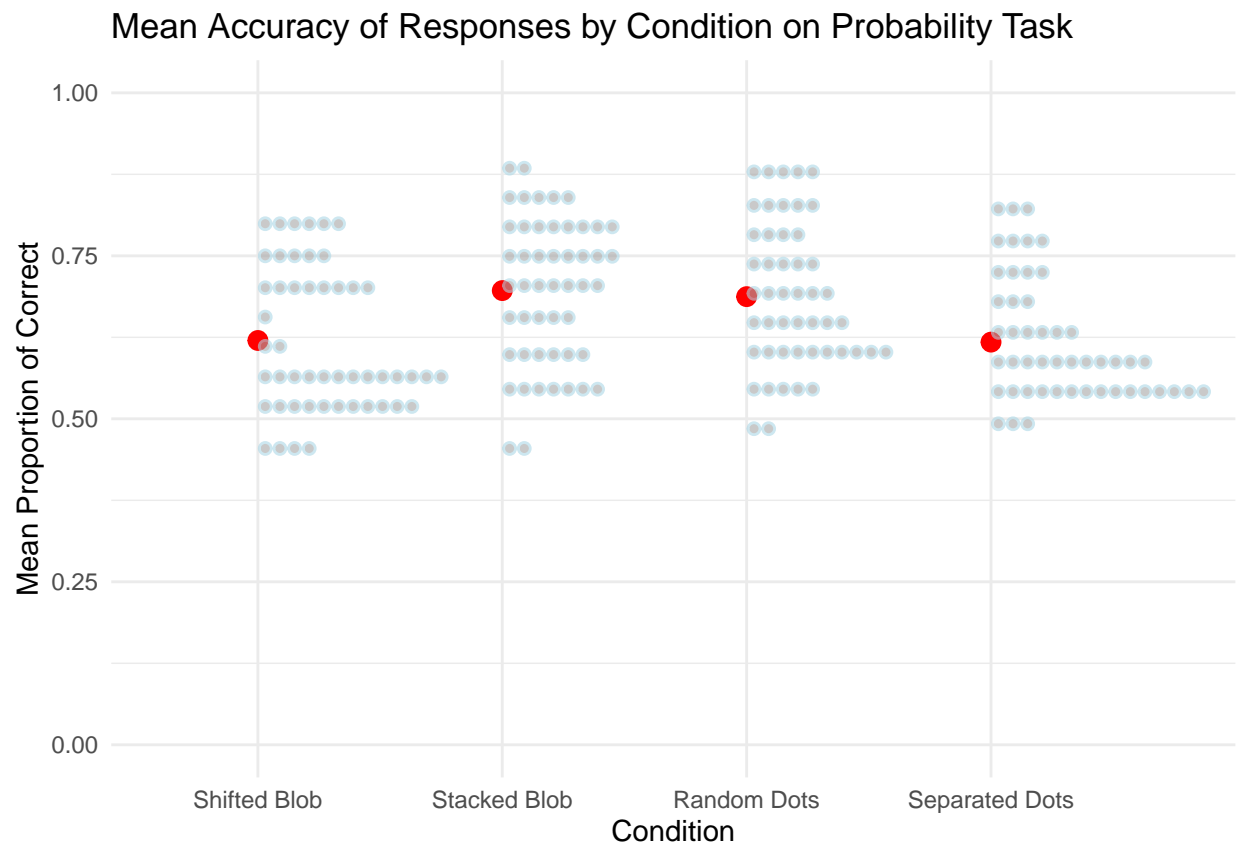


Figure 3. Mean Accuracy and Accuracy Variability across Conditions

means of these condition show that no condition is more significant than another as the means are relatively similar.

2. How are reaction time and accuracy related?

As seen in Figure 4, there is a positive relationship between the average reaction time and the proportion correct. When looking at the conditions individually, shifted blob and separated dots cluster toward a lower reaction time and a lower accuracy and stacked blob and random dots cluster toward a higher accuracy and higher reaction time.

3. How does numerator congruency interact with format type?

Figure 5 compares the proportion correct per condition of congruent numerators and incongruent numerators. The graph shows that congruent proportions cluster towards a

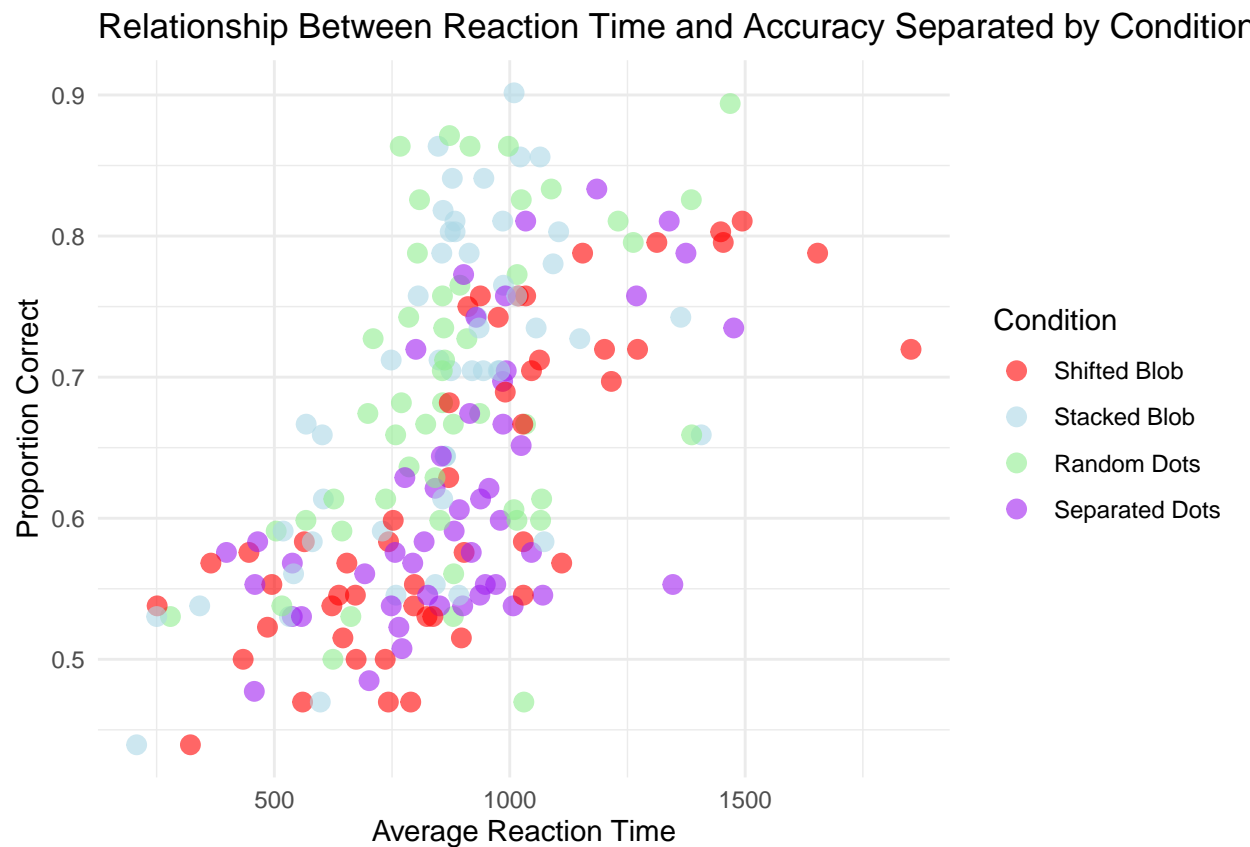


Figure 4. Scatter Plot of Reaction Time vs. Proportion Correct by Condition

higher accuracy while the incongruent proportions have a high variability and a low mean accuracy.

Discussion

Interpretation

1. Does average performance vary across format type?

Yes, average performance varies across format type, with stacked blob and random dots having a higher overall mean. However, as seen in Figure 3, there is not a significant difference between them.

2. Does average performance vary across numerator congruency status?

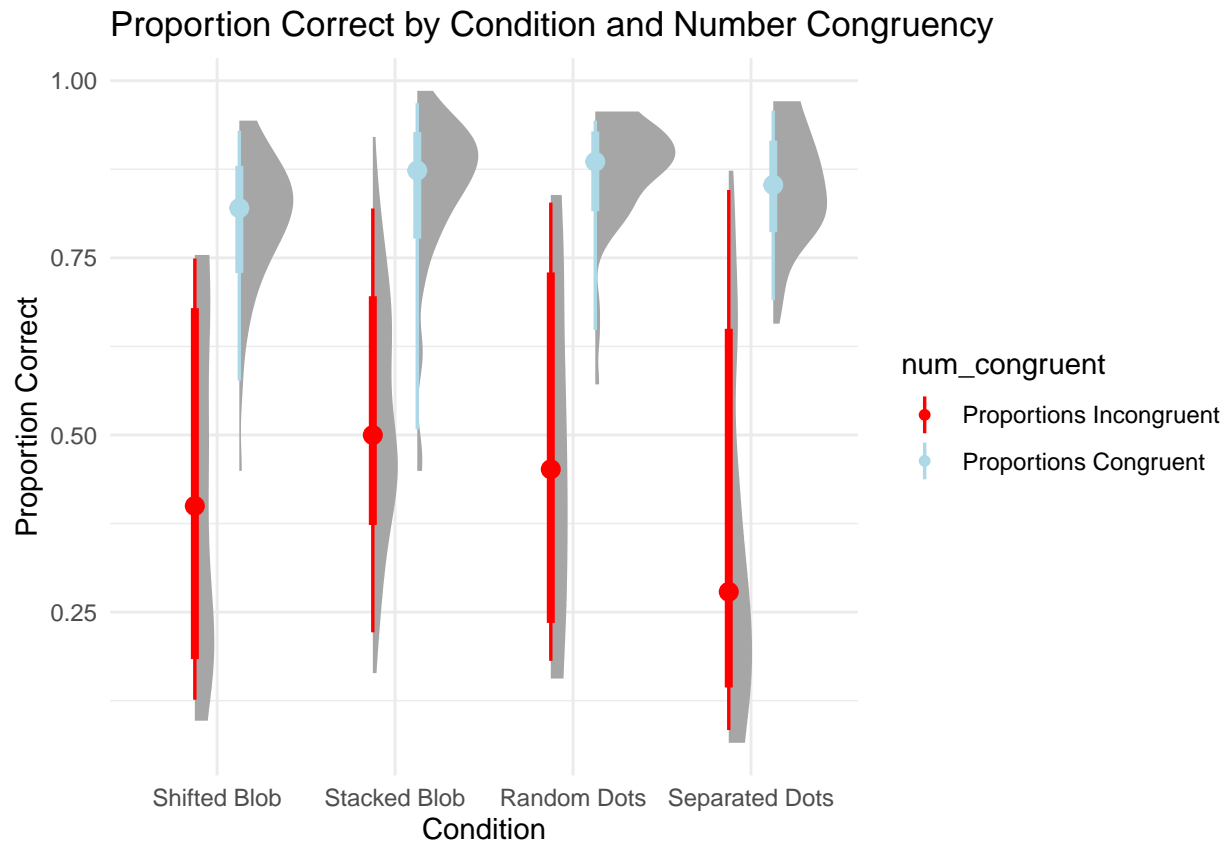


Figure 5. Mean Proportion Correct and Variability across Condition and Numerator Congruency

As seen in Figure 5, congruent proportions have a higher overall mean and better variability than incongruent proportions, thus alluding to a significant distinction.

3. Does numerator congruency vary across format type? (i.e., is there an interaction)

Figure 5 also suggests that there is an interaction, as the numerator congruency has variability across the different type. More specifically, congruency has the same trend across each condition, but the conditions seem to affect the mean of the incongruent proportions the most.

78 Conclusion

79 1. What was the most annoying or hardest thing about the assignment?

80 The most annoying part of the assignment was resizing Figure 2 to fit the poster
81 dimensions. I was using a different way to import it initially, but once I found a better
82 syntax, I was able to finally resize to fit the paper.

83 2. What was the most satisfying or fun thing about the assignment?

84 The most satisfying part of this assignment is seeing the final result as one cohesive
85 poster. Even though I did not specifically format each part of it, it is interesting to see how
86 our work can be implemented in a much better way than reformatting a Word document or
87 Google doc. The possibilities for creating seem endless!

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