















# Supplemental metiarial for Vis in motion: A Research Agenda and Two Evaluations





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TABLE 1: Proportions and stimuli used in Experiment-Speed and Experiment-Trajectory at the size displayed on participants' screens.

Proportions	Donuts	Bars
0%		
18%		
32%		
43%		
58%		
72%		
83%		

## 1 STUDIES ON VISUALIZATION IN MOTION

### 1.1 Study Parameters and Variables

**Choice of Visualization Representations:** We chose donut and bar charts for our experiments as they were both the most common representations in our design explorations. The charts were drawn at the same physical size in cm for each participant. For Donut , we set the inner diameter to 0.75 cm and the outer diameter to 1 cm. This sizing would encircle soccer balls with a diameter of 0.5 cm on the screen which was the most frequent soccer ball sizes according to our video analysis. Bar  covered the same physical area as Donut  with a width of 0.25 cm (equaling to the thickness of Donut  slice) and a length of 2.36 cm, see Table 1. In each chart, the target slice was colored in #E90738 and the other slice in #C3C1C1 to make the target warmer and higher chroma than the other part of the chart and to have an appropriate contrast ratio (4.61) with the white background.

**Choice of Movement Speeds:** To determine ecologically valid speed values and chart size, we analyzed the LaLiga 2019/2020

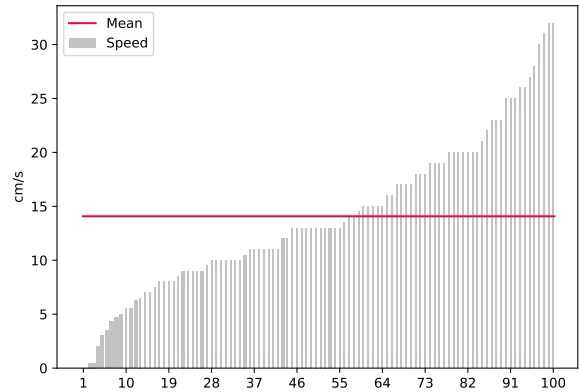


Fig. 1: Average physical speeds in cm/s for 100 pairs of data points, sorted by speed. And the mean of these 100 data points. The width of every single bar represents the time taken between the soccer start and end position.




Barcelona 5-2 Mallorca soccer match [1] in full screen on a 27-inch 4K screen. We selected 100 random start positions from a player kick and recorded both the start and end positions of the soccer ball relative to the screen as well as the timepoints of start and end. From this data we calculated the average physical speed of the soccer ball on the screen as an approximation using a linear trajectory between start and end points (Figure 1). For each movement we also measured the average diameter of the soccer ball. The selected 100 pairs of start and end points included scenes with and without camera movement, hits and misses on goal, close-ups, and slow-motion replays. Among these 100 pairs of data, the minimum speed was 0.4 cm/s, the maximum speed was 32 cm/s, and the average speed of these 100 pairs of data was 14.08 cm/s. We then converted the highest speed, the lowest speed, and the average speed to the most popular screen sizes (Table 2). From these measurements we chose the following conditions: Slow  speed as 15 cm/s which is around the average speed for a 27-inch screen and Fast  speed as 30 cm/s which is around the fastest speed for 27-inch screens and close to an average speed on TVs of 65-inch. In the Experiment-1 we also included a Static  condition as a baseline in which the stimulus did not move on the screen. Each moving or static stimulus was shown on the screen for 1600 ms.

TABLE 2: Our recorded soccer speeds in cm/s converted to diverse screen sizes

Screen size	Highest speed	Lowest speed	Average speed
13-inch	15.41	0.19	6.78
14-inch	16.59	0.21	7.30
15-inch	17.78	0.22	7.82
16-inch	18.96	0.24	8.34
17-inch	20.15	0.25	8.87
22-inch	26.07	0.33	11.47
24-inch	28.44	0.36	12.52
27-inch	32.00	0.40	14.08
28-inch	33.19	0.41	14.06
32-inch	37.93	0.47	16.69
40-inch	47.41	0.59	20.86
43-inch	50.96	0.64	22.42
55-inch	65.19	0.81	28.68
65-inch	77.04	0.96	33.90
108-inch	128.00	1.60	56.32

## 1.2 Demonstration of Study’s User Interaction

Here we provide a link to an example video that demonstrates our study process and user interactions: <https://osf.io/wmcd2/>.

## 1.3 Links to Evaluations

Here are the links to try our online studies.

**Experiment-Speed-Donut:** [https://motion.isenberg.cc/study1\\_speed\\_donut/index.php?PROLIFIC=False](https://motion.isenberg.cc/study1_speed_donut/index.php?PROLIFIC=False)

**Experiment-Speed-Bar:** [https://motion.isenberg.cc/study1\\_speed\\_bar/index.php?PROLIFIC=False](https://motion.isenberg.cc/study1_speed_bar/index.php?PROLIFIC=False)

**Experiment-Trajectory-Donut:** [https://motion.isenberg.cc/study2\\_trajectory\\_donut/index.php?PROLIFIC=False](https://motion.isenberg.cc/study2_trajectory_donut/index.php?PROLIFIC=False)

**Experiment-Trajectory-Bar:** [https://motion.isenberg.cc/study2\\_trajectory\\_bar/index.php?PROLIFIC=False](https://motion.isenberg.cc/study2_trajectory_bar/index.php?PROLIFIC=False)

## 2 EXPERIMENT-SPEED (DONUT / BAR) RESULTS: THE EFFECT OF SPEED ON READING ACCURACY

### 2.1 Speed per Representation

Figure 2 illustrates true errors of every single proportion per speed for both representations.

**Proportions:** When looking at true errors (Figure 2: bottom) of specific proportions we have interesting tendencies for Bar —. For proportions less than 50%, participants tended to make smaller estimates (underestimate), while for proportions greater than 50%, participants tended to make larger estimates (overestimate). As the speed and proportion increased, the degree of estimation bias increased - getting further away from the exact answer, with the exception of 43%.

For Donut ○, when looking at true errors (Figure 2: top), the tendencies are less clear. For a few proportions (18% and 72% for all speeds, 32% for Static ▶ and Slow ▶) participants underestimated, whereas for the rest overestimated. The estimation bias on Donut ○ became larger as the speed increased, but there was no indication that the estimation bias became larger as the proportions increased, with the exception of 83%.

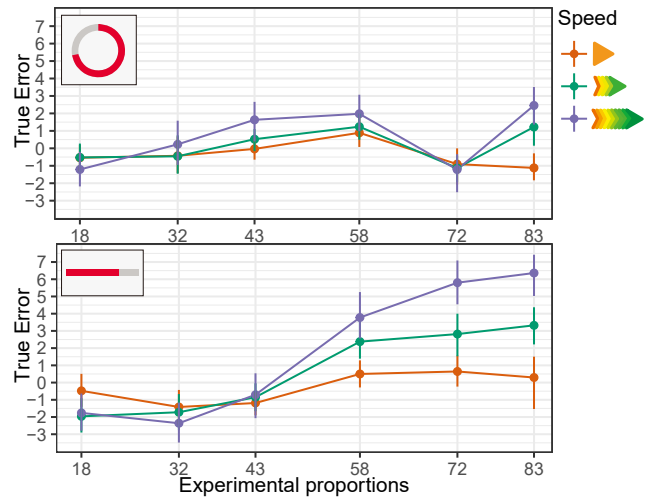


Fig. 2: Experiment-Speed true error results for Donut ○ (top) and Bar — (bottom) per proportion.

## 2.2 Strategies

Please check our strategy coding details here: <https://osf.io/2sdpe/>.

## 3 EXPERIMENT-TRAJECTORY (DONUT / BAR) RESULTS: THE EFFECT OF TRAJECTORY ON READING ACCURACY

### 3.1 Trajectory per Representation

Figure 3 represents true errors of every single proportion per speed × trajectory condition for both chart type.

**Proportions:** For Bar —, when looking at the true error (Figure 3: bottom) of specific proportions, participants again tended to underestimate for proportions less than 50% while overestimating for those greater than 50% for all speed × trajectory conditions.

The tendencies of Donut ○ are less clear, but we can still tell from the true error (Figure 3: top) that for all conditions participants underestimated 18% and 32% while overestimating 58% and 83%. For 43%, participants made smaller estimation when the stimuli moving in Irregular ↗ trajectories while making larger estimation when the stimuli moving in Linear — ones. For 72%, participants underestimated under Slow ▶ × Linear — condition while overestimating under rest conditions.

### 3.2 Strategies

Please check our strategy coding details here: <https://osf.io/2sdpe/>.

## ACKNOWLEDGMENTS

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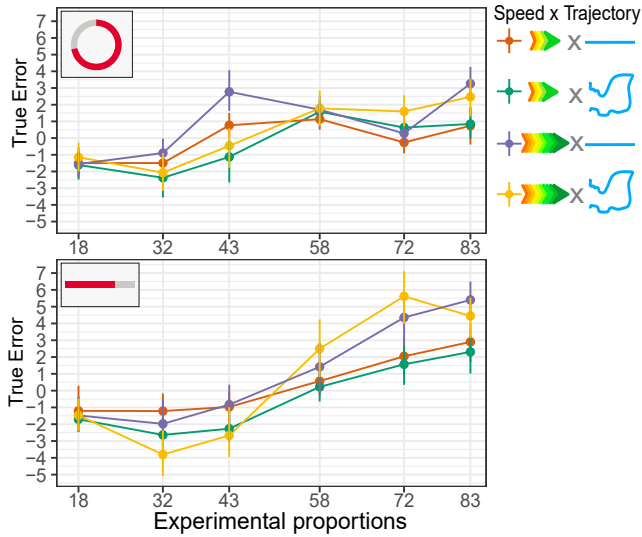




Fig. 3: Experiment-Trajectory true error results for Donut  (top) and Bar  (bottom) per proportion.

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## REFERENCES

- [1] FC Barcelone. Barça - Mallorca (2019/2020). <https://www.youtube.com/watch?v=rxslQS6KTS4> Accessed 08 2021.