Characterization of Relative Human Visual Discrimination

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Background - Human Eye and Perception

- What is the threshold at which the human eye can no longer perceive a difference in size between two objects?

- Important for depth perception, imaging, and reading
- Weber - Fechner Law
  - *constant* = Δi/i
- Noticeable change in a stimulus is a constant ratio of the original stimulus
- The larger the object, the larger the perceivable size difference will be
- Light Intensity [1]

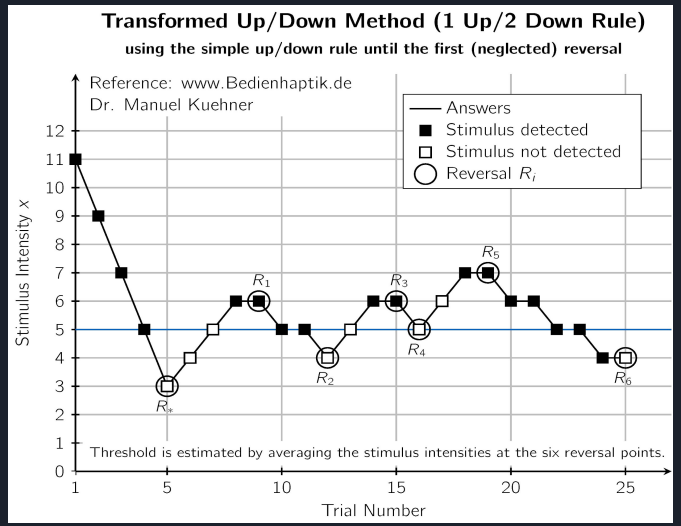
1. S. Hecht, "The visual discrimination of intensity and the Weber-Fechner law," *The Journal of general physiology,* vol. 7, no. 2, pp. 235-267, 1924.

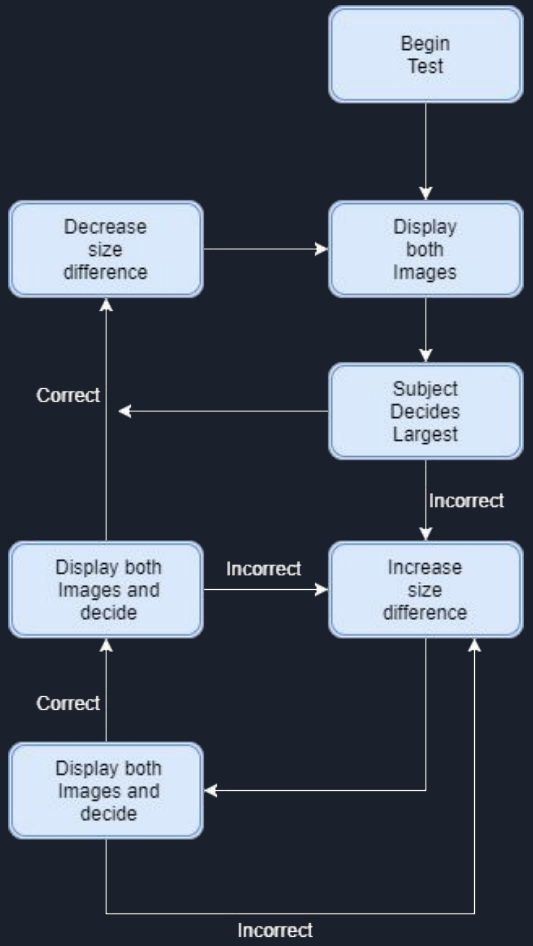
Hypothesis

Prediction: Just-noticeable difference (JND) will be the same despite any changes in the size of the sample.

- JND = (compared size - base size)/(base size)
- Null: there is no difference despite any changes in size
- Alternative: there is a difference

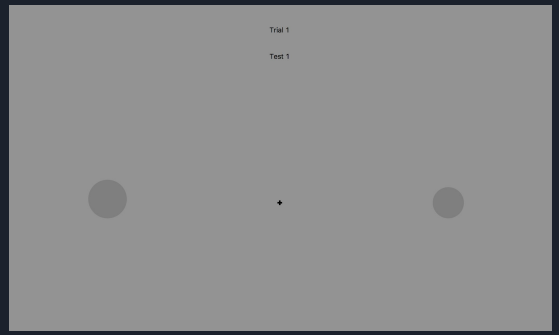
Methods





- Adaptive Staircase Method - quick, reliable
- Test Variables - Size of the dots
  - 3 dot sizes, 2 thresholds per size
- Subjects: 14 Northwestern students

Experimental Setup

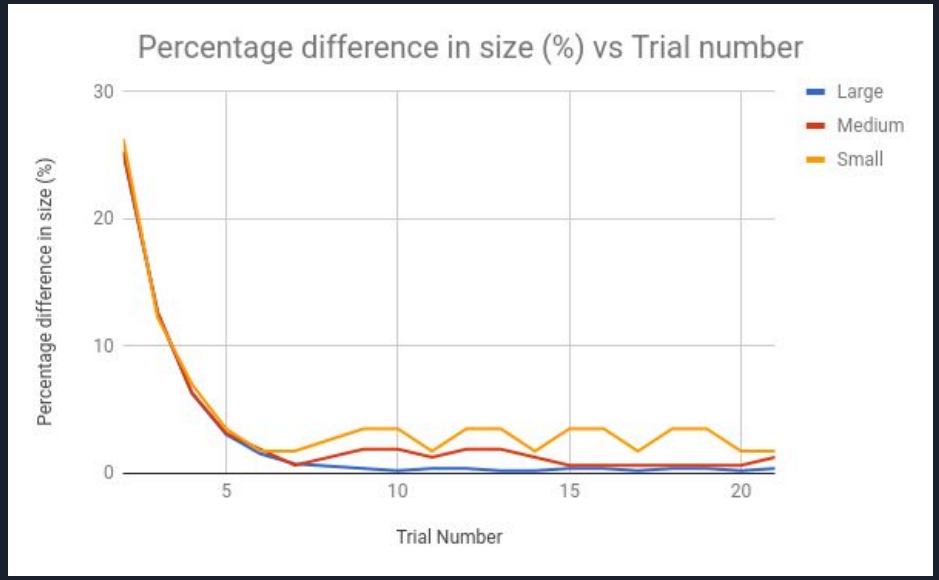


Small: 58 pixels diameter

Medium: 158 pixels diameter

Large: 528 pixels diameter

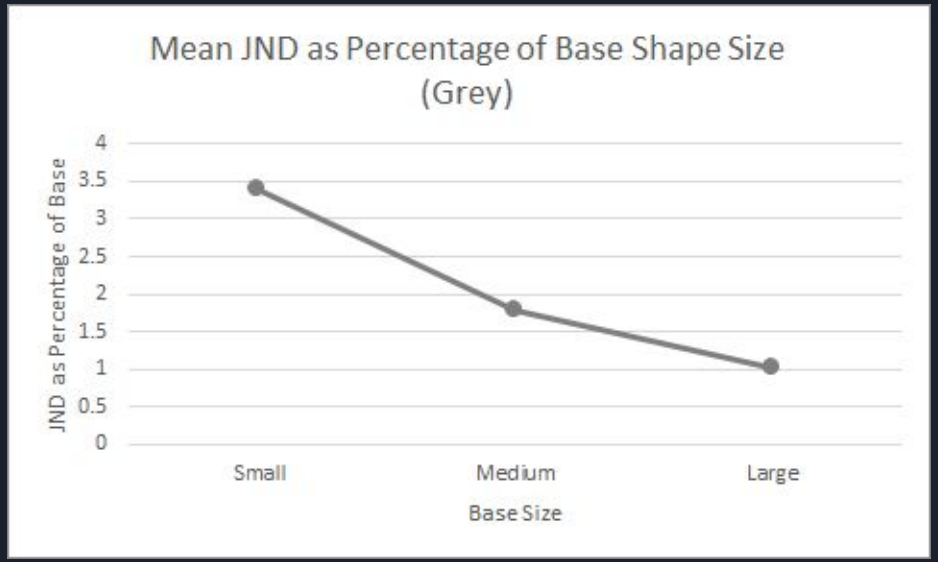
Results



Sample data set. Shows how the percentage difference in size evolves over time.

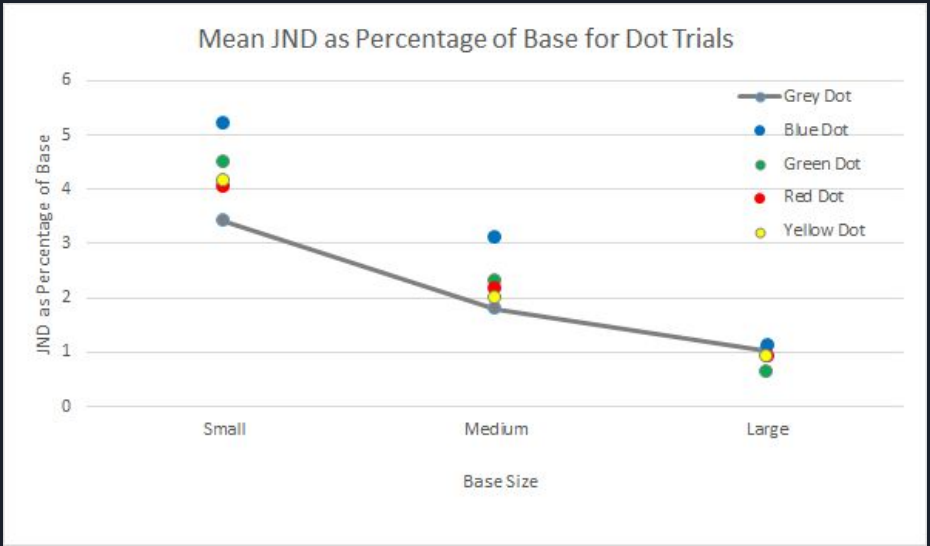
Results

1. There is a **consistent** downward trend of the mean JND as size increases for the grey circle



Results

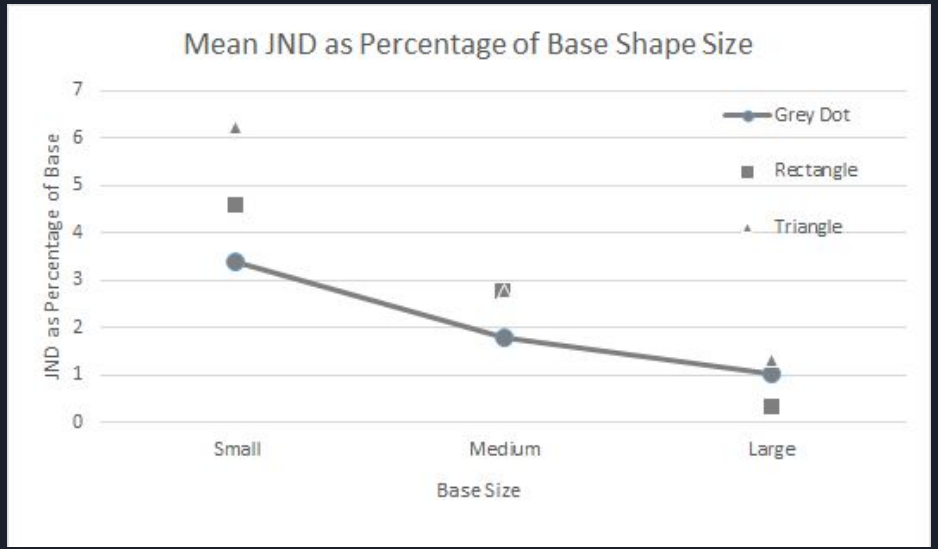
1. There is a **consistent** downward trend of the mean JND as size increases for the same color [1]



1. S. Robinson and J. Schmidt, "Fluorescent penetrant sensitivity and removability: what the eye can see, a fluorometer can measure," *Materials evaluation,* vol. 42, no. 8, pp. 1029-1034, 1984.

Results

1. There is a **consistent** downward trend of the mean JND as size increases for the same shape



Results: Statistical Analysis

Grey dots

- Statistically significant difference across different dot sizes

Varying colors

- Statistically significant difference within each color type for the large and small dot.

Varying shapes

- Statistically significant difference within each shape for large and small shapes.

Discussion: Trend

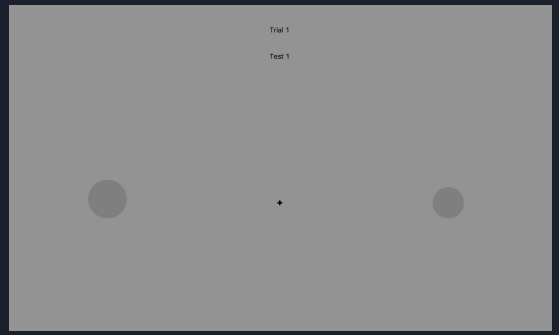
- JND decreases as size increases
- **The trend is statistically significant**, independent of size and shape
- People can spot a smaller percentage difference on a larger object
- However, Weber - Fechner Law predicts people will spot the same percentage difference regardless of size

Discussion

- Evaluation of Hypothesis - we were wrong, what can we conclude?
- Could it be biological tuning or testing setup?
- First: limitations
  - Cannot control biological factors
  - Pixels, screen size
- What can cause Weber-Fechner to be influenced?
- Pinpointing our sources of error
  - Screen edge is a visual reference [1]
  - Pixel Size
- New studies?

1. J. Weintraub, "Ebbinghaus illusion: context, contour, and age influence the judged size of a circle amidst circles," *Journal of Experimental Psychology: Human Perception and Performance,* vol. 5, no. 2, p. 353, 1979

Experimental Setup



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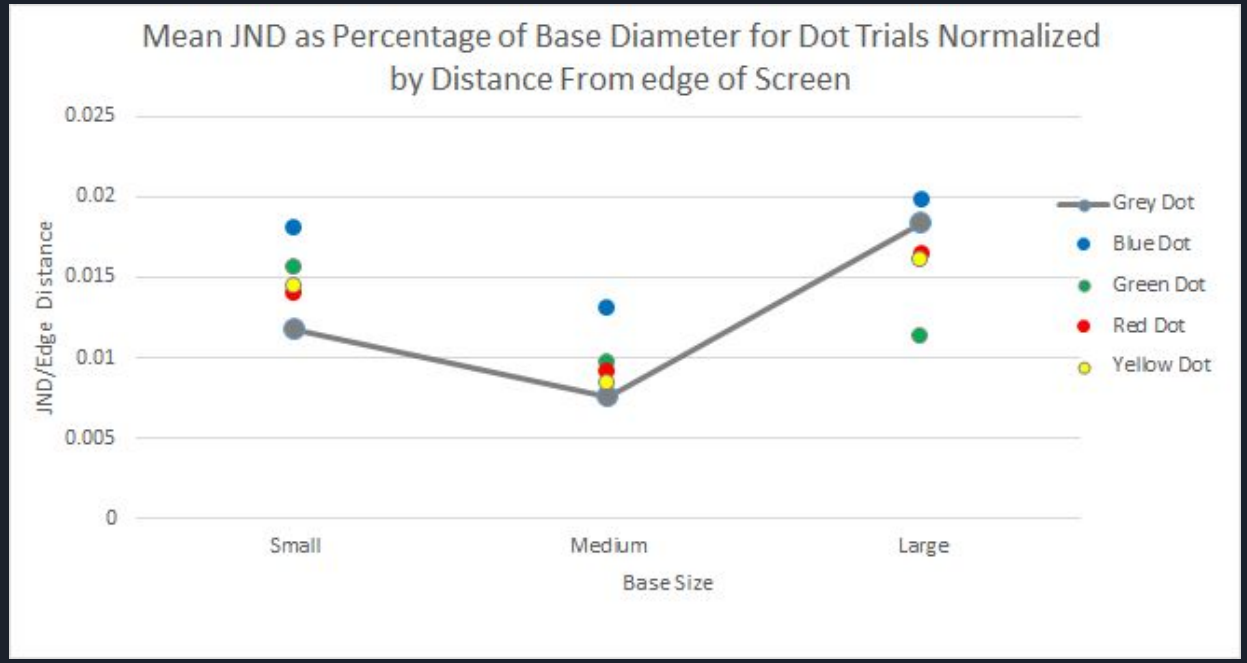
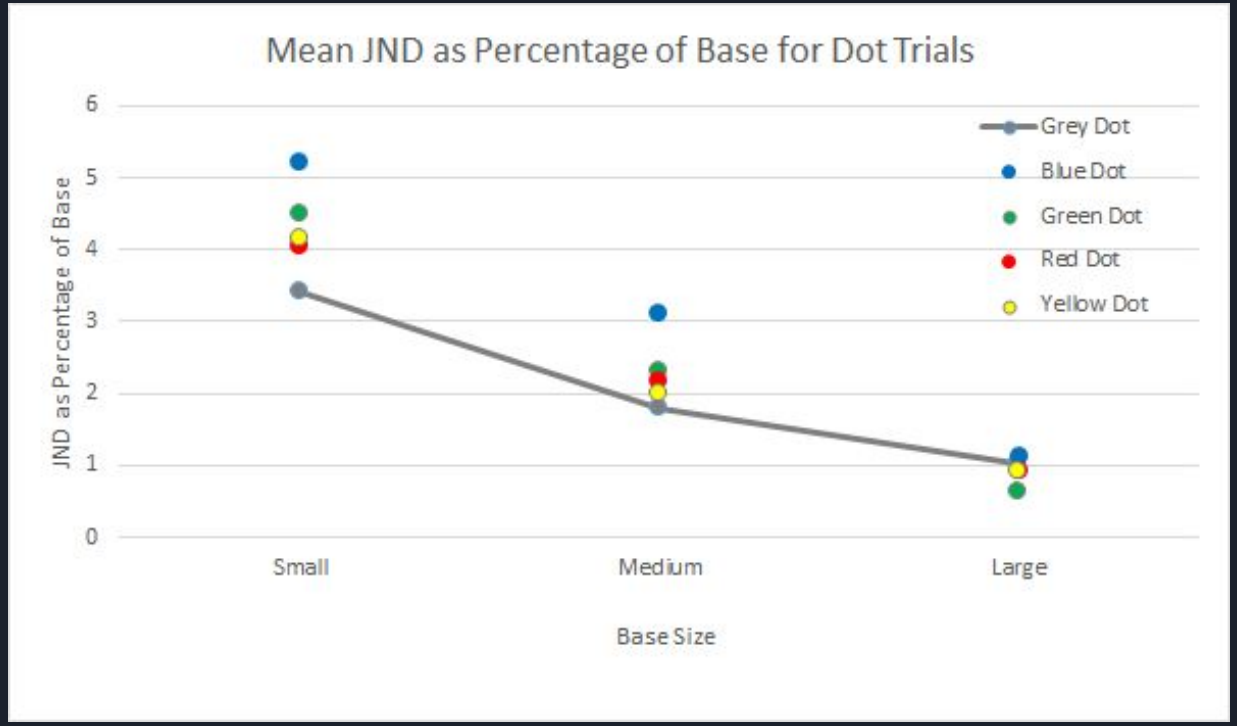
Potential for the Future



Takeaway

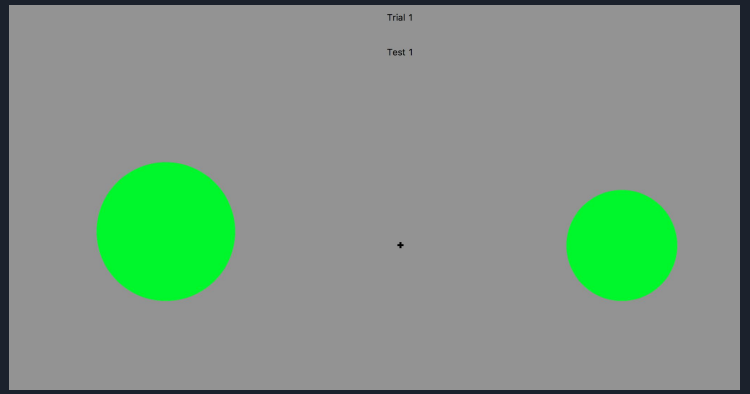
- The efficacy Weber-Fechner Law is reliant on the lack of surrounding factors
- The law cannot always be reliably used to guide design directions in applicable fields
- Future Steps would include further research into which factors affect this law

Takeaway Data



Supporting Slides


Trial 1
Test 1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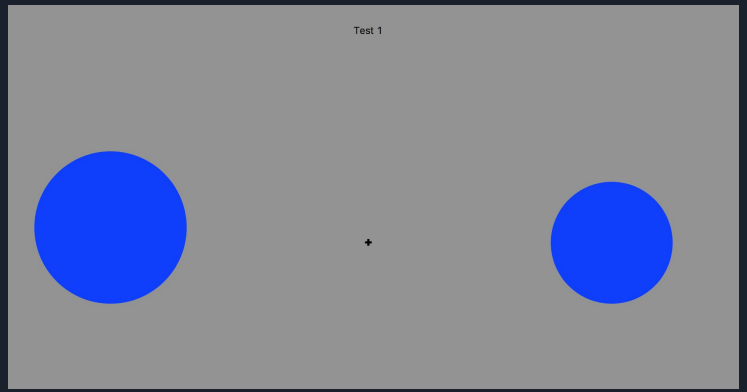
Test 1


Trial 1
Test 1


Trial 1
Test 1


Trial 1
Test 1

Results

1. There is a **statistically significant difference** ($p<0.05$) between different sizes.
2. Comparing across the grey dot, there was a **decreasing** trend of the percent difference threshold as size increases.

TABLE I
MEAN PERCENT DIFFERENCE THRESHOLDS AND DEVIATIONS (SD) FOR DOTS

Trial Color (Sample Size)	Small Mean(SD)	Medium Mean (SD)	Large Mean(SD)
Grey (22)	3.40 (1.60)*⁂	1.79 (0.96)*	1.03 (1.42)*⁑
Blue (8)	5.22 (2.61)⁂	3.10 (3.28)	1.11 (0.74)*
Green (8)	4.49 (1.86)⁂	2.30 (1.14)⁂	0.63 (0.24)*⁑
Red (8)	4.04 (1.89)⁂	2.17 (2.01)	0.92 (0.62)*
Yellow (8)	4.16 (1.58)*⁂	1.98 (0.95)*⁂	0.90 (0.31)*⁑

Statistically significant difference at 5% with small *, medium ⁑, or large ⁂ of same trial

Results

1. There is a **consistent** statistically significant difference between the large and small dots of each color.

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TABLE II

MEAN JND AND DEVIATIONS (SD) FOR SHAPES

Trial Shape (Sample Size)	Small Mean(SD)	Medium Mean (SD)	Large Mean(SD)
Grey Rectangle (8)	4.58 (1.33)⁂	2.74 (1.67)⁂	0.33 (0.07)*⁑
Grey Triangle (8)	6.22 (2.67)⁂	2.76 (2.00)	1.31 (0.49)*

Statistically significant difference at 5% with small *, medium ⁑, or large ⁂ of same trial