# Shape Versus Color Recognition

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## ABSTRACT
In this experiment, we sought to find the difference between perception and fixation based on color as opposed to that centered around the shape of objects being searched for. Our goal was to determine the best way to separate a symbol from background noise on an image so that it can be easily found by someone searching for it. We believe the distinction between color and shape could potentially be a consideration when the ability of a user to quickly and reliably locate a feature on a document or image is important.

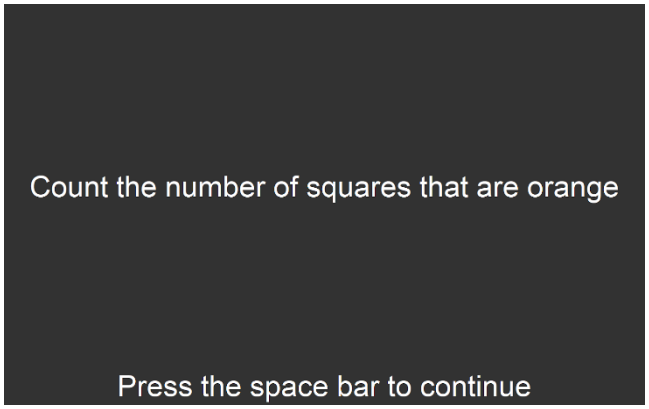
## Keywords
Shape; Color; Fixation; Pattern

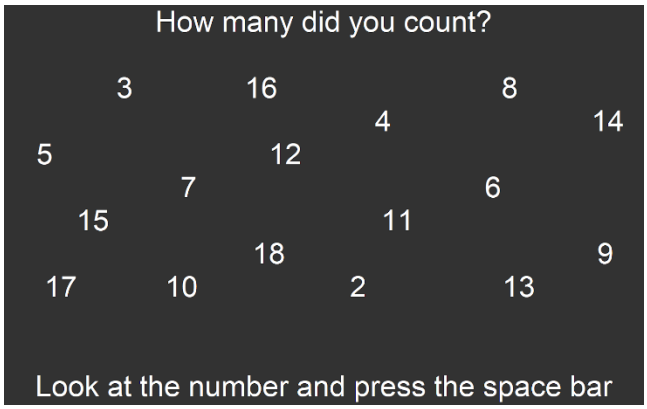
## 1. INTRODUCTION
When searching for objects on documents or in images, there are variations between whether a person tends to move their gaze around based around the shape of the objects or whether they tend to focus more on the color of the object. While there have been multiple studies done on this in the past, the purpose of this experiment is to determine whether participants will be more concerned with the color of objects or with the shape of the objects when searching through a variety of images.

## 2. BACKGROUND
In 1987, Pashler conducted a study of a similar design to determine detection response times for finding a particular color letter among others, while varying the size of the display they were searching, as well as having the target present or not. It was found that larger display sizes result in slower response times, which became even larger when the target was not present.[1] Dehaene also engaged in a similar study in 1989, but instead targets were told to search for a specific object of certain size, color, and orientation with a variety of distractors, instead of simply searching for a specific letter of a specific color. It was a large, green, vertical object or a small, red horizontal object, rather than a green letter.[2] However these studies focused on singling out a specific object, whereas this experiment will require a more thorough approach from the participants.

## 3. METHODOLOGY
### 3.1 Apparatus
Eye movements were recorded with a Gazepoint GP3 eye tracker which was mounted at the bottom of a computer monitor. Subjects could move their heads freely because the tracker was unobtrusive and did not have a physical point of contact with the subject. The eye tracker tracked the gaze of both eyes and the distance of the eyes from the screen. Eye movements were sampled at a rate of 150 Hz.

### 3.2 Stimulus
Participants were shown 30 different 5x8 fields of shapes containing squares and circles of two different colors with a random number of shapes of each given color and shape. Shapes are also placed in the field randomly for each stimulus image. Participants in the study were also shown a question before being shown the stimulus image that asked them to count the shape of a given color or a specifically colored shape. After viewing the stimulus, the participants were asked to report the number of shapes they saw by looking at a number on a following image. Afterwards, the next question is shown until all stimuli has been shown.






Examples of stimuli.

## 3.3 Subjects

The 10 subjects in our study were all Clemson students of various genders, areas of study, and quality of eyesight. Whether or not someone wore contacts or glasses was not a factor taken into consideration when selecting participants. The quality of participant's eyesight did not have any known impact on our experiment, as it was not relevant to the data we were collecting. Out of the 10 subjects in our study, we chose to omit subject 9's data due to large portions of the data being incomplete. This did not appear to have a significant impact on our results.

## 3.4 Experimental Design

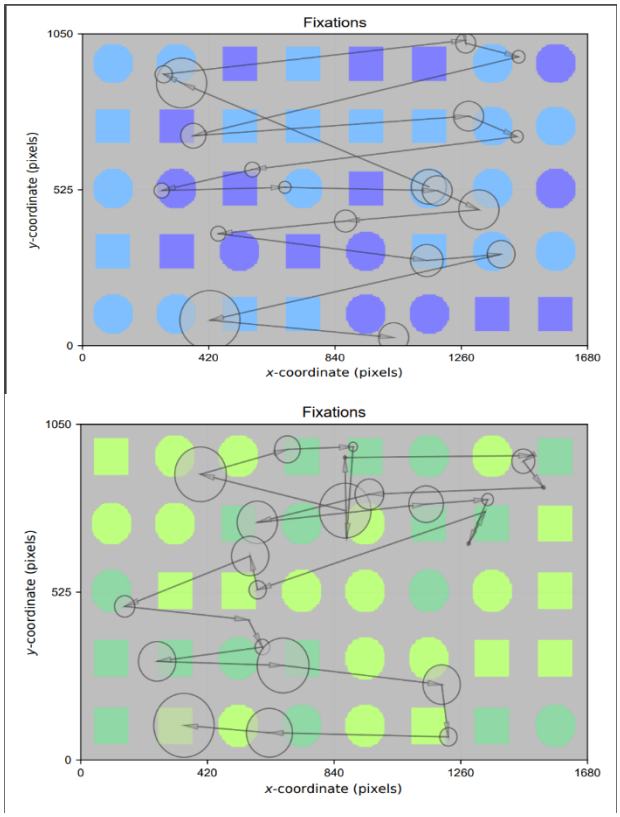
This study was done using a within-subjects design, so every subject in our study saw the same stimuli, which was randomly rearranged between participants using a random number generator.

## 3.5 Procedures

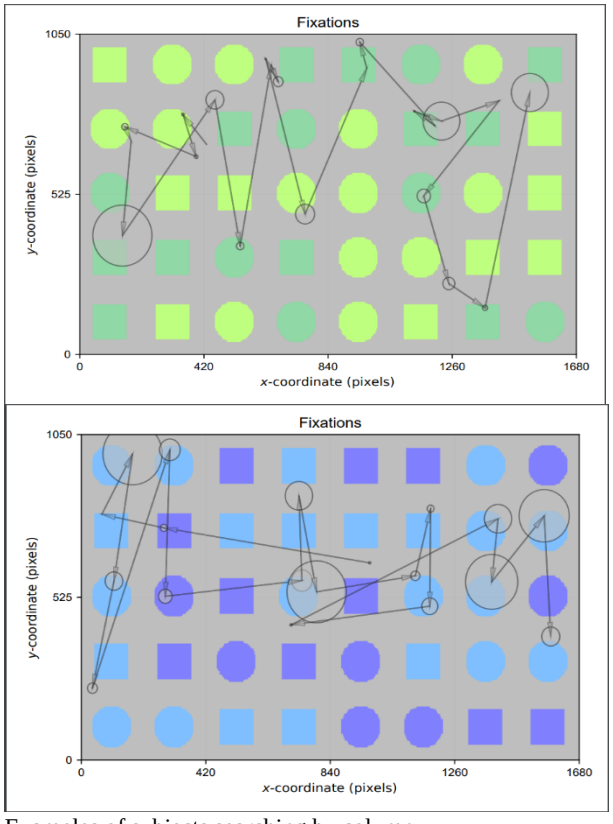
Subjects were asked to count the number of shapes of a color with either the color or shape stated first; i.e., "green squares" or "squares colored green" before being shown the stimulus. Questions were worded in two separate ways in case question wording had an impact on the results. They were instructed to count the number of shapes that match the criteria and then report the number of shapes they counted by looking at a number on the screen. The number of shapes reported by participants as well as the shapes they fixated on was recorded by the Gazepoint GP3 eye tracker in order to determine whether participants tended to focus on shape or color.

# 4. RESULTS

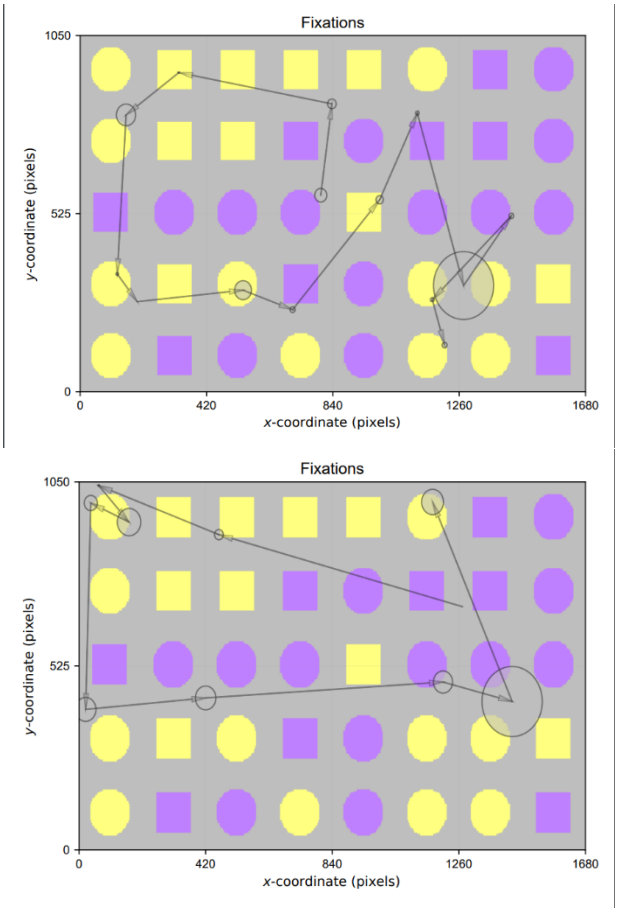
Subjects used three different search patterns to find shapes in the stimuli. We observed that three of the subjects primarily searched the field by row, often moving from left to right. The other six subjects searched mostly by column starting on a side and moving top to bottom. The third search pattern was a random search pattern that only three of the subjects used on only high contrasting stimuli.




Examples of subjects searching by row.




Examples of subjects searching by column.




Examples of the random search pattern.

This study primarily focused on whether subjects tended to focus on the color or the shape that they were asked to find. Fixations on either a wrong color or a wrong shape were the main point of interest, as a larger number of fixations on the wrong shape would indicate the subject focused on color, while a larger number of fixations on the wrong color would indicate the subject focused on shape. The data collected shows a trend of subjects fixating more on shapes that are the correct color, but the incorrect shape. On average, each subject would fixate on an incorrect shape roughly 1.6 more times than on the incorrect color. However, there was a relatively wide range, given that Subject 10 had an average of 2.9 more fixations on the incorrect shape and Subject 8 averaged 0.9 more fixations on the incorrect shape. While there were instances in the trials where subjects would fixate more on the incorrect color, they were not significant enough to overrule the observed trend in the data.

# 5. DISCUSSION

The trend in the data shows that subjects often fixated more on the incorrect shape rather than on the incorrect color. As such, it can be concluded that our subjects would typically search the stimuli for the color they were asked to look for, and then determine whether they had found the correct shape. For example, in the random search patterns that we observed, the subjects would glance around looking for a specific color, then fixate on a point and count the shapes around the point. This also happened when searching by row or column, as they would often times skip over the incorrect color, and then fixate on the shapes of the correct color.

In future experiments, it would be ideal to adjust the experiment in order to obtain quantitative data rather than qualitative data. This way, future experiments can focus on the amount of time the fixations were. While the data plots from the experiment did yield general results regarding fixations, i.e. longer fixations would produce a larger point on the plot, future experiments should also include concrete numbers highlighting the exact amount of time users spent fixated on certain points.

One way to improve the study would be to have the stimuli that the subjects were searching on a time. While they were instructed to count the shapes as quickly and accurately as possible, some subjects occasionally became very concerned with their accuracy and took much longer to search the stimuli than expected. They would continuously search back and forth over the image, going back over shapes they had already fixated on. This made the data more difficult to analyze because of the overlap of their initial search and their second accuracy-focused search.

Another improvement would be to have fewer total stimuli. We decided to have thirty stimuli to collect as much data as possible in case anything did not come out right. While this did get us more data, the large number of stimuli made the study take roughly seven minutes to participate in without factoring in the questionnaire, informed consent form, and the calibration. Participants often became tired halfway through, which caused them to begin fidgeting, resulting in some unusable data.

# 6. REFERENCES

[1] Pashler, Harold. 1987. Detecting conjunctions of color and form: Reassessing the serial search hypothesis. *Perception & Psychophysics* (1987), 191-201. DOI= https://doi.org/10.3758/BF03208218.

[2] Dehaene, Stanislas. 1989. Discriminability and dimensionality effects in visual search for featural conjunctions: A functional pop-out. *Perception & Psychophysics* (1989), 72-80. DOI= https://doi.org/10.3758/BF03208076.