Unique Hues

Likhitha Nagahanumaiah; Rochester, New York, USA.

Abstract

The main objective of this lab is to learn to identify unique hue and nearby patches using method of constant stimuli and to build a GUI to determine if the patch is reddish or greenish and record the response. Analyze the data to get the psychometric curve and estimate the unique hues.

Introduction

'Unique hues' are defined as colors that are perceived to have no mixture of other colors. According to Hering's theory there are four unique hues, they are red, green, blue, and yellow [1]. Unique red is either yellowish or bluish but not greenish, unique green is either yellowish or bluish but not reddish [2]. Same way unique yellow can be either reddish or greenish but not bluish, and unique blue can be either reddish or greenish but not yellowish [2]. There is variability in selection of unique hue, this variability can be calculated by mean and range of variability according to gender, illumination condition and chroma [1]. For this experiment we use intraobserver variability when assessing perceptions of unique hues.

In a psychophysical task, the psychometric function ties an observer's performance to an independent variable, generally some physical property of a stimulus [3]. An integrated method for (1) fitting psychometric functions, (2) assessing goodness of fit, and (3) giving confidence intervals for function parameters and other estimates obtained from them for hypothesis testing [3].

Materials and Methods

In this laboratory simulation, we were asked to identify one unique hue from a set of patches and get 9 stimuli for blue hue and 9 stimuli for yellow hue. All these hues are plotted on the a* b* plot to see where the color aligns. Method of constant stimuli was asked to use for this experiment. A MATLAB GUI was built that displays the stimuli (for blue and yellow) and records the responses. The GUI is programmed to show all 9 stimuli for a given unique hue in random order, and present each hue in blocks (e.g., all blue hues in a random order, then all yellow hues in a random order). Repeated this experiment 10 times, therefore total of 180 trails responses are recorded and the response is used to draw a psychometric curve that estimates my unique hues.

Lightness, chroma and hue values for blue is given as 62,30 and 240. Total 35 patches are displayed to select unique hue and a hue which looks greenish and a hue which looks reddish, the selection is made sure that these hues are equally distanced from the unique hue. We process these values to get 9 blue stimuli by keeping unique hue in the center and is shown in Figure 1.

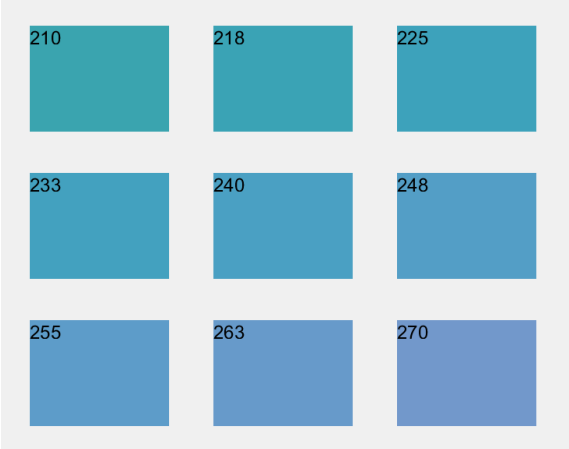

Figure 1. Unique blue stimuli's

The same analysis is due for yellow hue to get 9 yellow stimuli by keeping unique yellow at the center. Lch value of yellow is [70,50,85] shown in Figure 2.

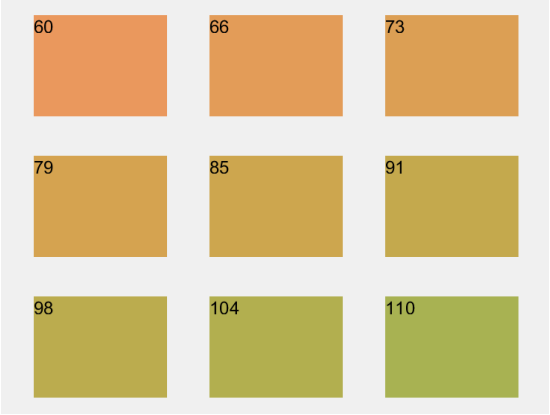

Figure 2. Unique yellow stimuli's

9 stimuli for both blue and yellow hue is plotted in CIELAB space to visualize the color arrangements and is shown in figure 3. X-axis gives a* that is greenish to reddish values. Y-axis gives b* that is yellowish to blueish values.

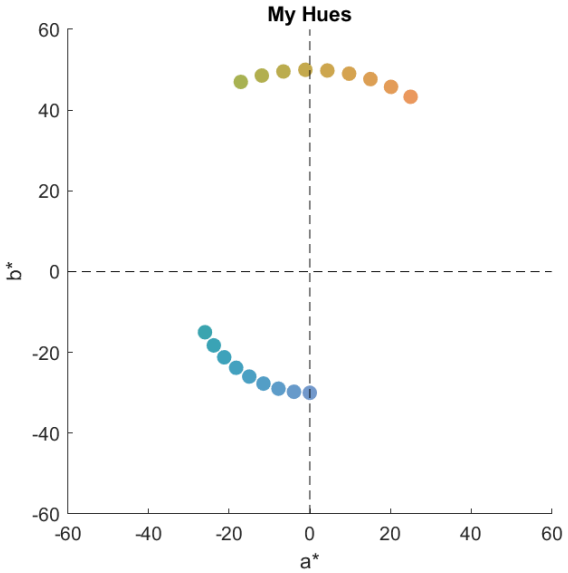

Figure 3. CIELAB representation of selected hues

Using these stimuli's GUI is created and response is recorded into .xls file and the data is used to derive psychometric function.

Results and Discussion

In figure 1 we see that hue value 240 is considered as unique blue, 210 looks greenish and 270 looks reddish. In figure 2 we see that hue value 85 is considered as unique yellow, 110 looks greenish and 60 looks reddish. From figure 3 we see that the blue hues and unique blue are shifted more towards the green. But the yellow unique hue seems to be almost equally distributed between greenish and reddish tint.

The GUI created were asked to record data based on reddish and greenish tint for each hue displayed by pressing either right arrow or left arrow and hue displayed were randomized and the first block of 9 blue hue stimuli's and second block of 9 yellow stimuli are displayed, therefore total of 18 responses are calculated for 1 trail. Like these 10 trails are conducted and total of 180 responses are recorded and stored into a excel file. Response 0 is coded for blue stimuli =90 responses, response 1 is coded for yellow stimuli =90 responses. These responses are parsed to calculate the statistics shown in table 1. and psychometric evaluation of each unique hues is determined.

	Hue	GroupCount	mean_Resp	std_Resp	numel_Resp
210	210	10	0	0	10
217.5	217.5	10	0	0	10
225	225	10	0	0	10
232.5	232.5	10	0.1	0.31623	10
240	240	10	0	0	10
247.5	247.5	10	0.5	0.52705	10
255	255	10	0.9	0.31623	10
262.5	262.5	10	1	0	10
270	270	10	1	0	10

Table 1. Statistics of blue hue

The relationship between the stimulus and response is plotted using a probit fit. The probit model is used to model dichotomous or binary outcome variables. In the probit model, the inverse standard normal distribution of the probability is modeled as a linear combination of the predictors. Glmval computes 95% confidence bounds for the predicted values. When the stats structure output of the glmfit function is specified, ciLo and ciHi are also returned [4].

ciLo and ciHi define a lower confidence bound of yfit-dylo, and an upper confidence bound of yfit+dyhi. Confidence bounds are non-simultaneous, and apply to the fitted curve, not to a new response. The psychometric curve is shown in figure 4.

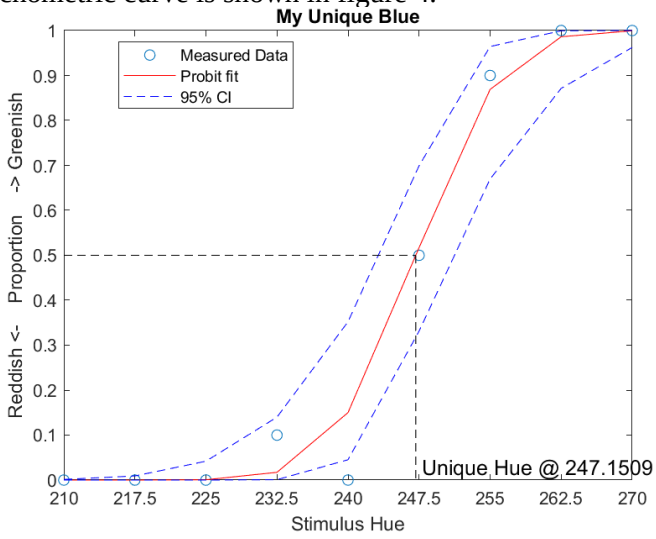

Figure 4. My unique blue

The selected unique blue was 240 after psychophysics experiments, we see that the unique blue for me is at 247.15. Also, the confidence interval is almost near the selected hue.

The same analysis is conducted for yellow hues, parsed from response data and the statics are shown in table 2 and psychometric evaluation for my unique yellow is shown in figure 5.

	Hue	GroupCount	mean_Resp	std_Resp	numel_Resp
60	60	10	1	0	10
66.25	66.25	10	1	0	10
72.5	72.5	10	1	0	10
78.75	78.75	10	1	0	10
85	85	10	0.8	0.42164	10
91.25	91.25	10	0.2	0.42164	10
97.5	97.5	10	0	0	10
103.75	103.75	10	0.1	0.31623	10
110	110	10	0	0	10

Table 2. Statistics of yellow hue

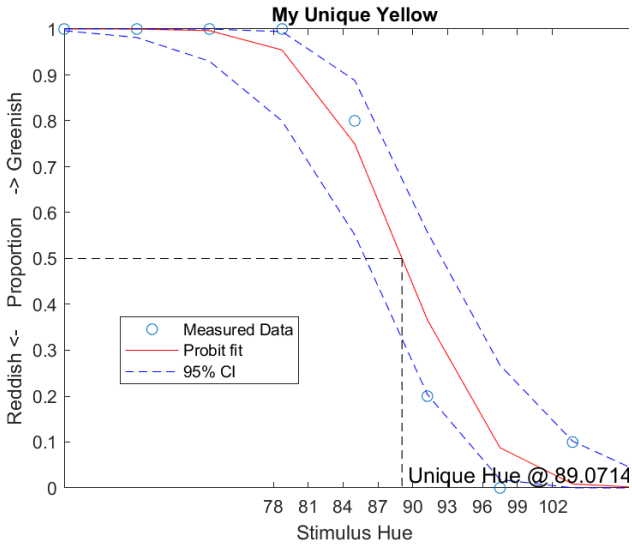

Figure 5. My unique yellow.

The selected unique yellow was 85 after psychophysics experiments, we see that the unique blue for me is at 89.0714.

Conclusion:

Therefore, by analyzing figure 4 and figure 5 we can say that unique hue selected versus unique hues obtained after experiment within the same observer we can say that there is observer variability even though the experiments were considered within the same observer. Therefore, we can expect more difference when there are different observers. We can also see that there is more unique hue difference for unique blue compared to unique yellow, we can say that unique yellow is easy to identify than unique blue. We can also conclude that everyone has different unique hues, and we can expect the results to be different from standard values. This can be explained as observer variability.

References

[1] R. Shamey, M. Zubair, and H. Cheema, "Unique hue stimulus selection using Munsell color chips under different chroma levels and illumination conditions," J. Opt. Soc. Am. A 36, 983-993 (2019).

[2] Mollon, J. D., & Jordan, G. (1997). On the nature of unique hues. *John Dalton's colour vision legacy*, 381-392.

[3] Wichmann, F. A., & Hill, N. J. (2001). The psychometric function: I. Fitting, sampling, and goodness of fit. *Perception & psychophysics*, *63*(8), 1293-1313.

[4] MATLAB documentation-glmval.