Feature Integration Theory

Introduction to Cognitive Sciences

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Introduction to Cognitive Sciences

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Abstract

Features are integrated before the objects are made sense of. Taking for granted that features are integrated, I performed test as to what is the accuracy of subjects in recognizing random numbers generated in para-foveal cone, in both horizontal and vertical direction. I also checked users accuracy at recognizing the random numbers by varying the contrast ratio of the numbers with respect to the background. The results are pointing to the fact that we are better ate recognizing the objects in horizontal direction than in the vertical direction. Also contrast doesn't really affect the accuracy of recognition till about a certain threshold contrast given that the random numbers were flashed for a limited period of time.

Feature integration theory

> Features are registered early, automatically, and in parallel across the visual field, while objects are identified separately and only at a later stage, which requires focused attention. (Treisman & Gelade, 1980)

Features

There is an ongoing debate as to what might be called as features. Some examples of features as believed by majority of academic world are as follows:

- luminance
- color
- orientation
- motion detection
- velocity
- form

Domain of application

The feature integrations precede the object recognition and all interactions with the physical space around us are only next in line. Hence it becomes vital to study the feature integration. In my project I have not tried to study how the features are extracted. The features are extracted as explained elsewhere (Pelli, Melanie, & Najib, 2004). The present experiment is basically designed not to evaluate the process of feature integration but is designed keeping in mind that given (by whatever reasons) the features are integrated, how the integration of features is helping a person in his daily life, especially when he is reading. The present study takes into account the accuracy with which the subjects are able to recognize the random number flashed within the para-Foveal region of the eye.

Regions of visual acuity in the Eye

In the eye the visual acuity is divided into 3 regions called:

Foveal: Around 50% of all the neurons in the optic never come from this region. This region spans around a cone of 2 degrees. This region has maximum concentration of cone cells and it also has maximum acuity

Para-Foveal: In this region the concentration of cone cells is decreasing very rapidly but is still higher than that in the peripheral region of the eye. This region spans an annular region between 2-5 degrees. This is the region that I have marked for research in the study.

Peripheral: The region having least acuity spreads in the remaining region of visual cone.

Figure 1: Visual representation of the Foveal, Para-Foveal, Peripheral region of the Eye. Image source: http://eet.wikispaces.com/Eye+movement

What is so exciting about the para-Foveal region of the eye is that it is involved in the word recognition when we are reading fast. Since people have different reading speeds, if I assume that cognitive abilities do not pose any limitations to the speed with which a person can read then the onus is on eyes. In this case the visual recognition is responsible for the reading speed. The person having greater recognition ability in the para-Foveal region must have greater reading speed. This expectation motivated me to perform this experiment.

Visual Search

It is just a side not that of the below explained two kinds of Searches my experiment involved Parallel search because the Fixation was fixed at a point.

Serial Search:

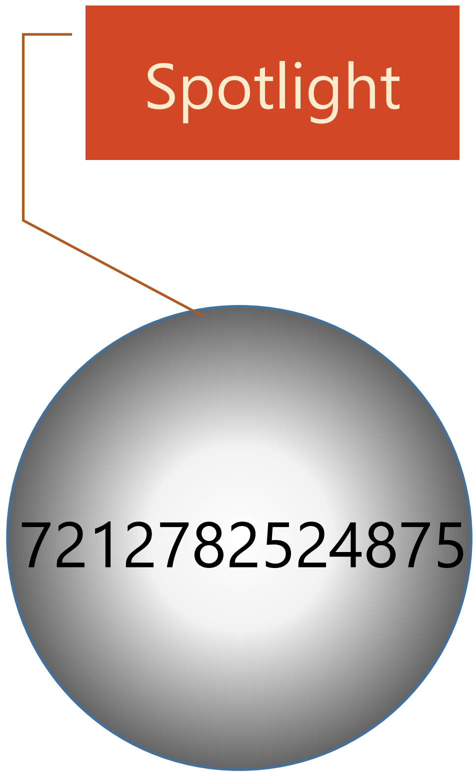
One item at a time is viewed. Once the target is found the search stops.

Parallel Search:

Here the entire scene is made sense of simultaneously. Here once the person performing the search is sure beyond a certain threshold, the search terminates.

Background Study

It has been proposed (Hagenaar & Van der Heijden, 1986) that there is a spotlight of the attention around the fixation point as shown in the following cartoon representation:



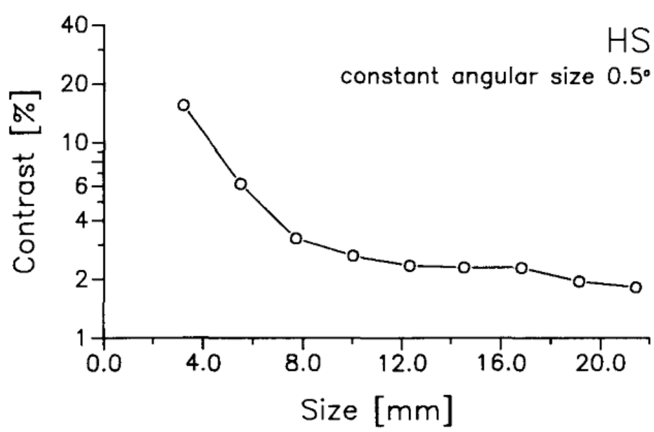
There have been studies related to the work done:

Experiments to verify the effect of the number of distractors

In this experiment Poder studied crowding and feature integration and tried to correlate it with the two types of attention. Here, however the emphasis was more on validating Feature integration theory. (Poder, 2006)

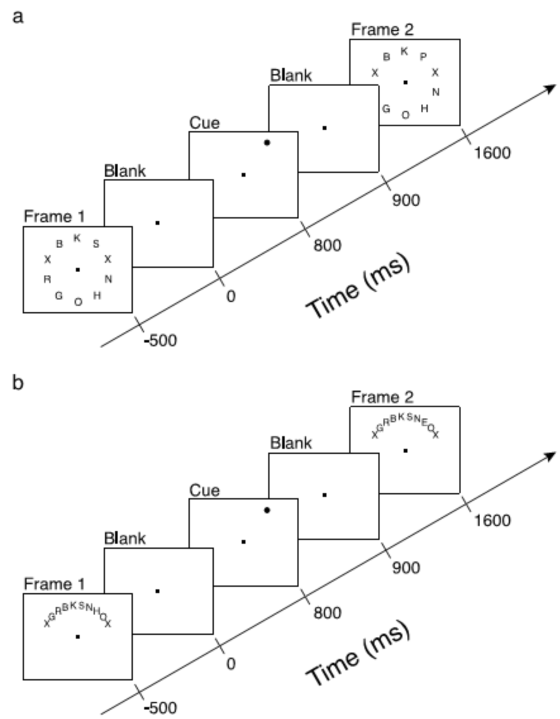
Experiments in contrast threshold

The study to determine how much contrast is required for 67% accuracy in recognizing numbers which lay directly in Foveal and para-Foveal region of the vision (Strasburger, Harvey Jr, & Rentschler, 1991). The study pertained to compare size of the target with the contrast ratio as shown in the graph attached.



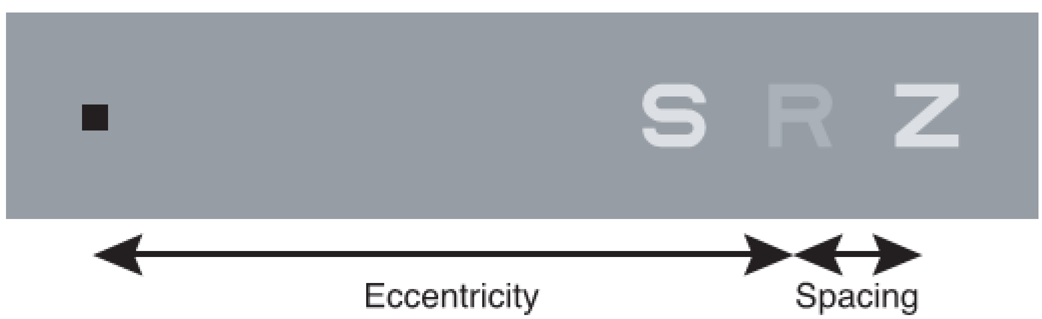
Experiments to get escape from crowding

This study is primarily looking at how recognition capacities are altered when the target to be is cued (Freeman & Pelli, 2007). This study is important because in my experiment too, the subject was cues as to where the random number was to be flashed. The technique of my experiment is inspired from this experiment. There was marked increase in the recognition capacity when the targets were cued.



Experiments in distinguishing feature integration from detection

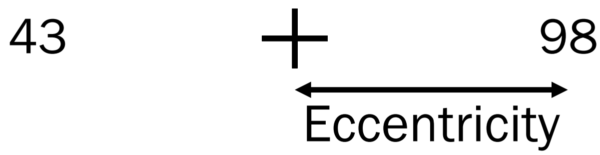
Studies in the effects of crowding on visual recognition showed a linear relationship between the eccentricities as defined in the picture below and critical spacing defined as the minimum spacing required to differentiate between the target and distractors (Pelli, Melanie, & Najib, 2004).



The study met high standards like it did the experiment only with Sloan alphabet comprising 10 letters (CDHKNORSVZ) at 80% contrast ratio. It showed that the minimum contrast was required for recognition of target. But all studies pertaining to the target size, contrast were with respect to the distractors, i.e. contrast here meant that the distractors vs. target contrast not background vs. target contrast as in my study. Also another thing to note that the study (Pelli, Melanie, & Najib, 2004) consists of studies only on the Left visual field. I have in my experiment considered all directions of left, right, up and down.

Experiment

With the given background research I made a few flash programs uploaded here.



I collected 7 UG students and asked them to fixate all the time at the fixation cross while some random numbers were being generated in the subject's para-Foveal cone. Since while writing the program I gave the eccentricity values in pixels, to convert the values into degrees the subject was made to sit in a position that is exactly 0.75 m away from the computer screen.

The image of a subject sitting is shown below. Also since the Experiment was to be conducted on the screen of the laptop which has a variable contrast with respect to the angle. Hence to get rid of this problem I took a rod up to the eye level of the subject and then taking an image with webcam that is embedded within the laptop screen. Taking this picture I first made a template which could be used to calibrate the screen angle. This process is shown in the following Images.

The Program sample display images showing the variation in the eccentricity is shown below:

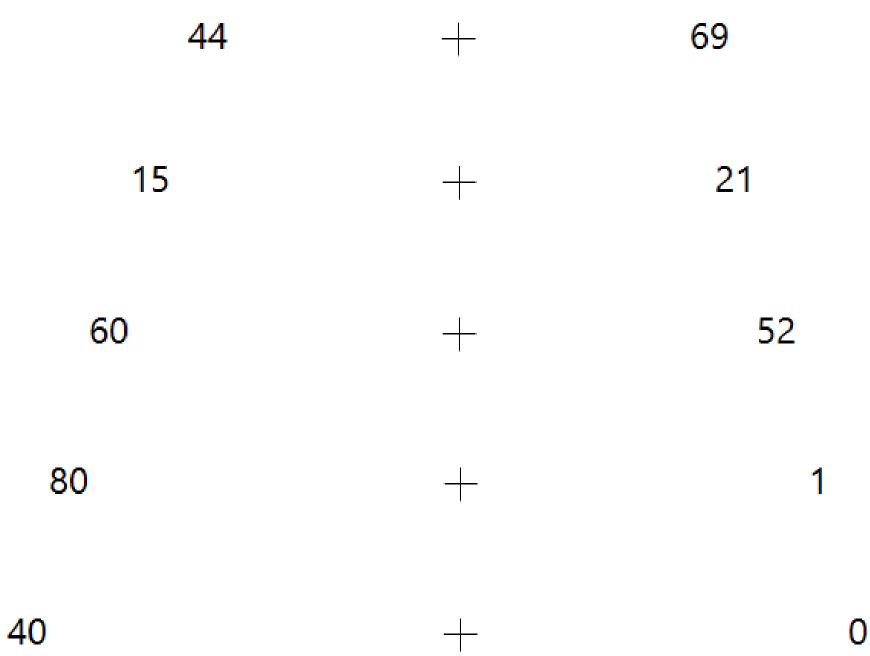


FIGURE 2: HORIZONTAL ECCENTRICITY

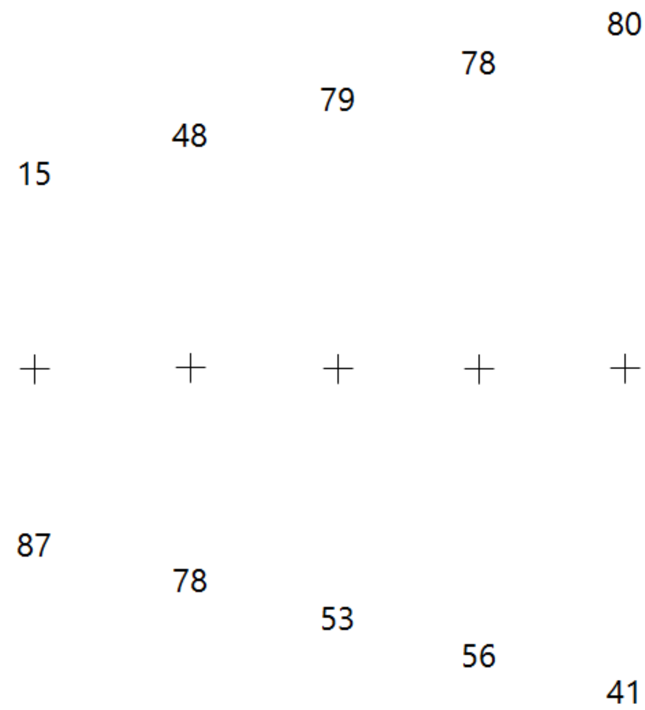


Figure 3: Vertical Eccentricity

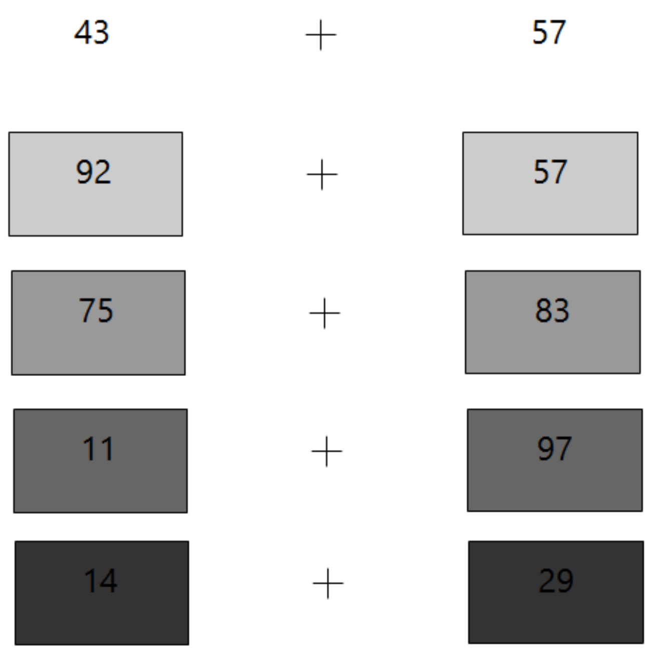
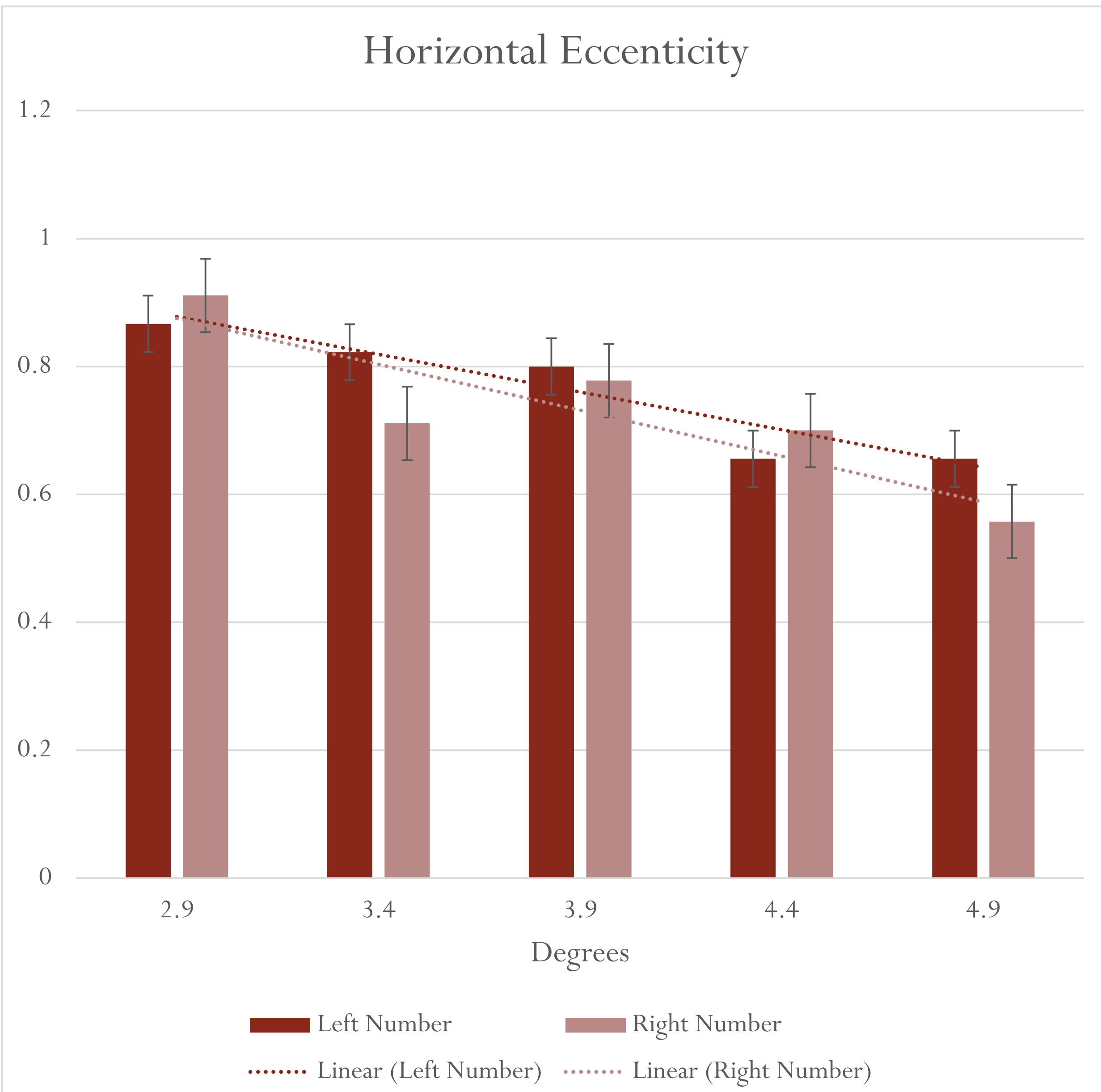


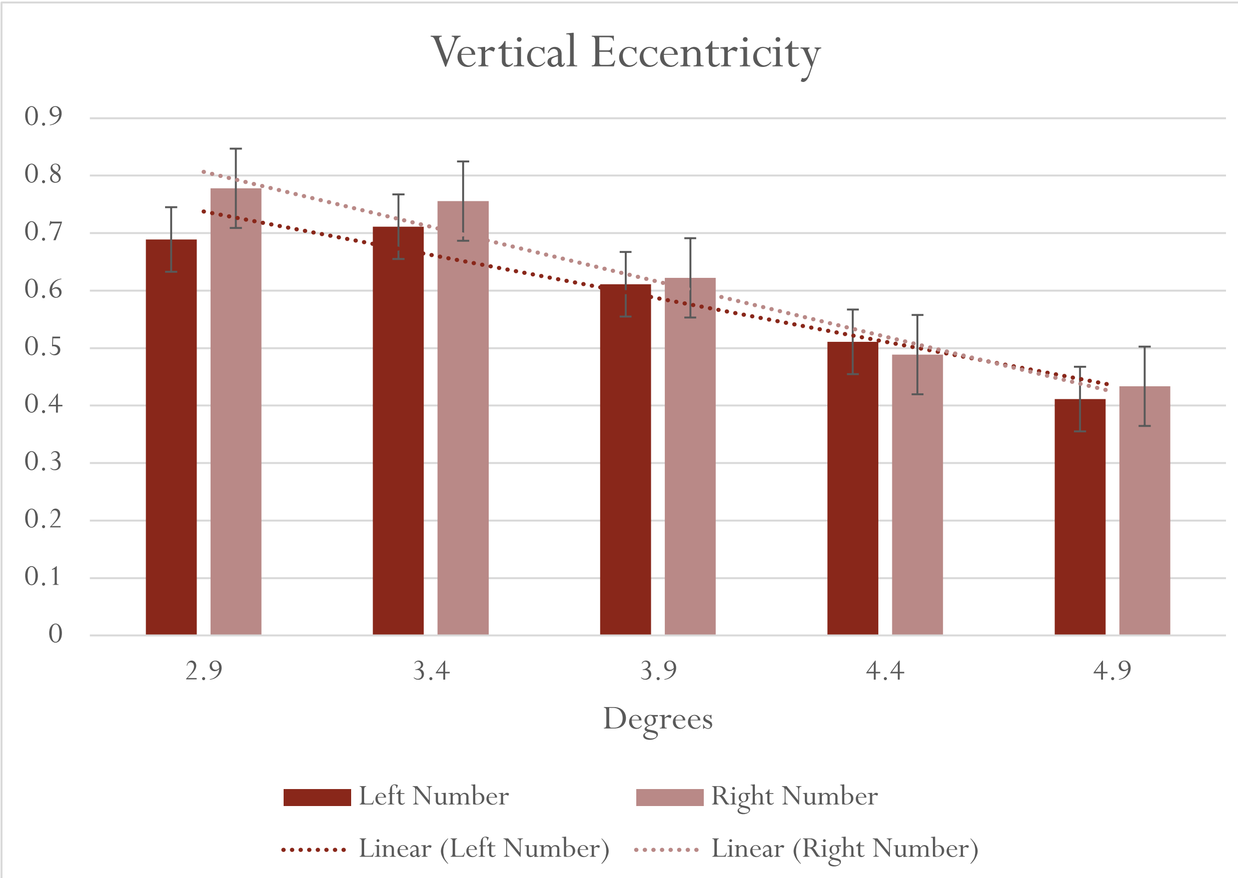
Figure 4: Contrast as Noise

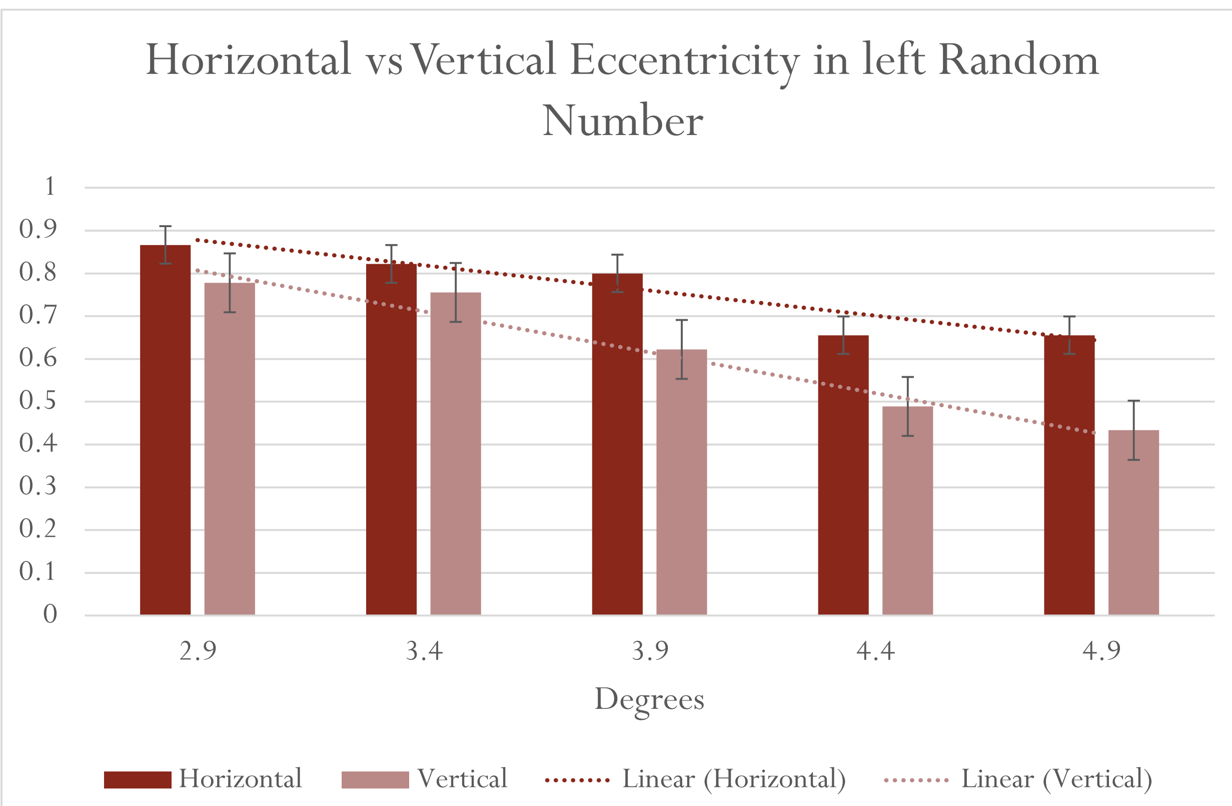
Table: Experimental Parameters	
Eccentricity in horizontal direction	2.9°, 3.4°, 3.9°, 4.4°, 4.9°.
Eccentricity in vertical direction	2.9°, 3.4°, 3.9°, 4.4°, 4.9°.
Contrast Ratio	1.0, 0.8, 0.6, 0.4, 0.2.

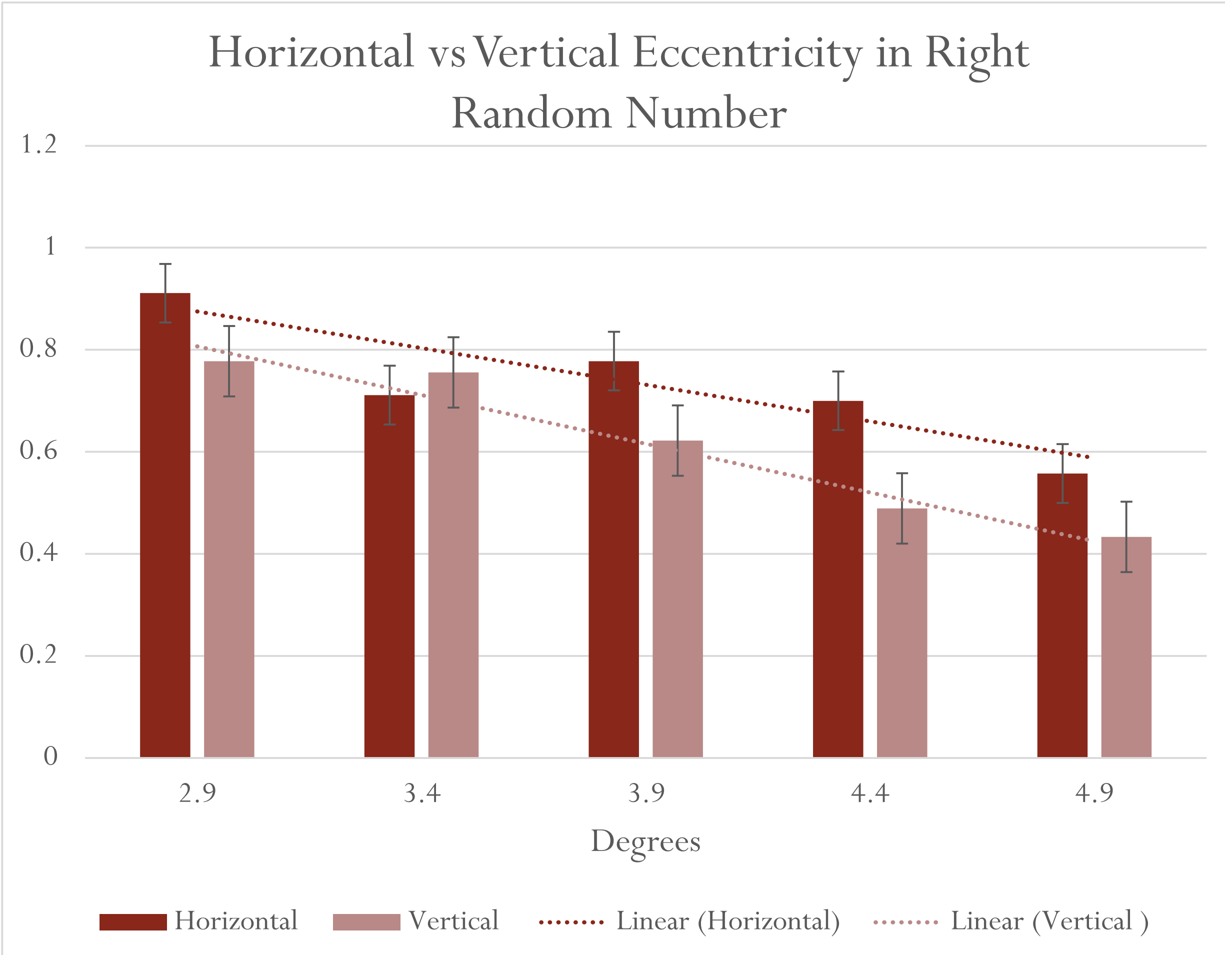
Results

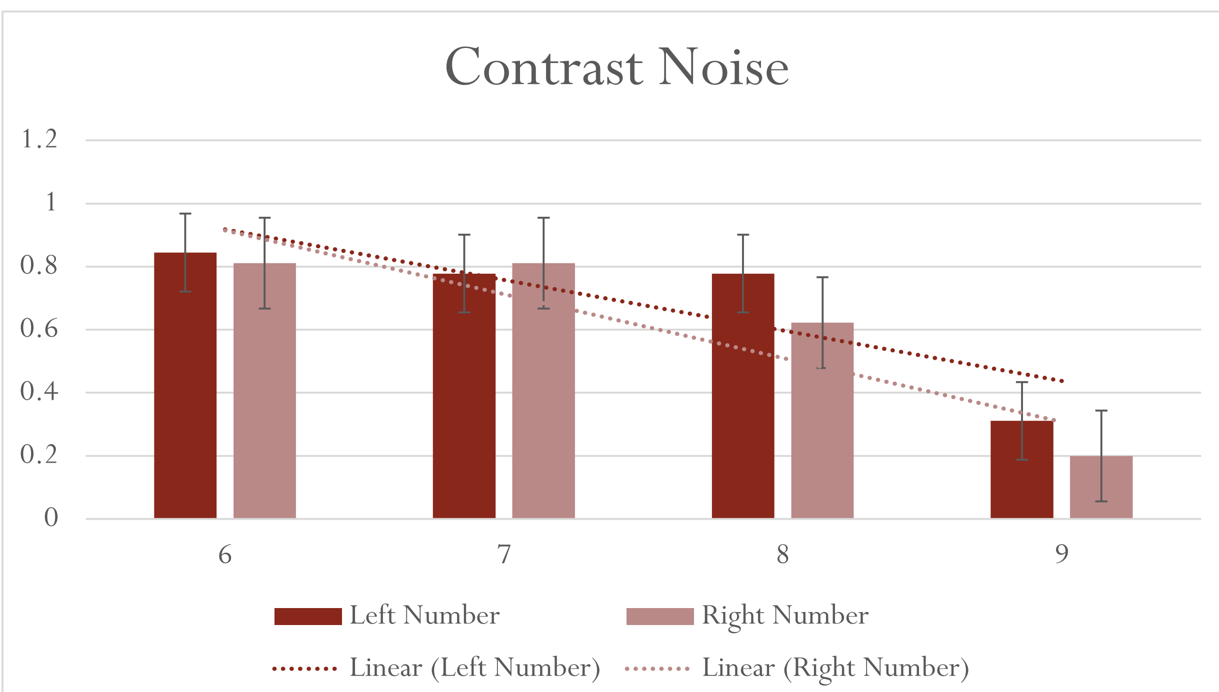
The following graphs sum up the Observations:

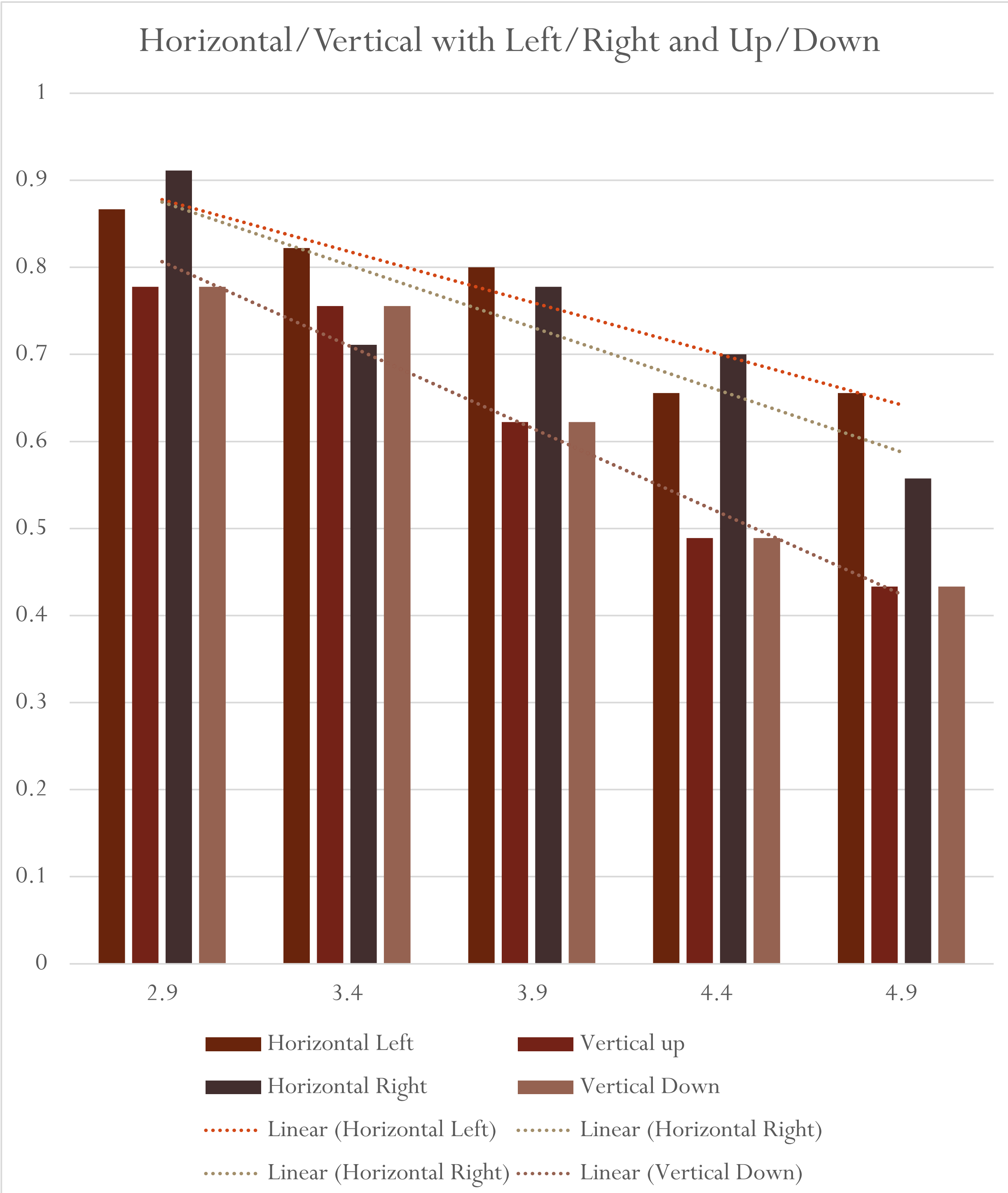



Vertical Eccentricity
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2.9
3.4
3.9
4.4
4.9
Degrees
Left Number
Right Number
Linear (Left Number)
Linear (Right Number)


Horizontal vs Vertical Eccentricity in left Random Number
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2.9
3.4
3.9
4.4
4.9
Degrees
Horizontal
Vertical
Linear (Horizontal)
Linear (Vertical)


Horizontal vs Vertical Eccentricity in Right Random Number
1.2
1
0.8
0.6
0.4
0.2
0
2.9
3.4
3.9
4.4
4.9
Degrees
Horizontal
Vertical
Linear (Horizontal)
Linear (Vertical)


Contrast Noise
1.2
1
0.8
0.6
0.4
0.2
0
6
7
8
9
Left Number
Right Number
Linear (Left Number)
Linear (Right Number)


Horizontal/Vertical with Left/Right and Up/Down
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2.9
3.4
3.9
4.4
4.9
Horizontal Left
Vertical up
Horizontal Right
Vertical Down
Linear (Horizontal Left)
Linear (Horizontal Right)
Linear (Horizontal Right)
Linear (Vertical Down)

Conclusions

One thing which is conclusive without any doubt is that the accuracies were always better in horizontal direction.

Left-Right was nearly symmetric in horizontal direction.

Bottom number was better recognized in vertical eccentricities, but this could be subjected to the experimental error because the error bars in the graphs seen are wider than the difference in the two datasets.

Hypothesis

Proposed region of visual acuity

See the result I have a proposition that if it is always that there is a horizontal skew in the spotlight of attention this can be attributed to the fact that there are two eyes in the horizontal direction hence there is a possibility of an extended Foveal region and hence para-Foveal region this might also be a contributing factor as to why we read left to right or vice versa but never up down or vice versa. The proposed region of visual acuity are hence shown below in the following figure:

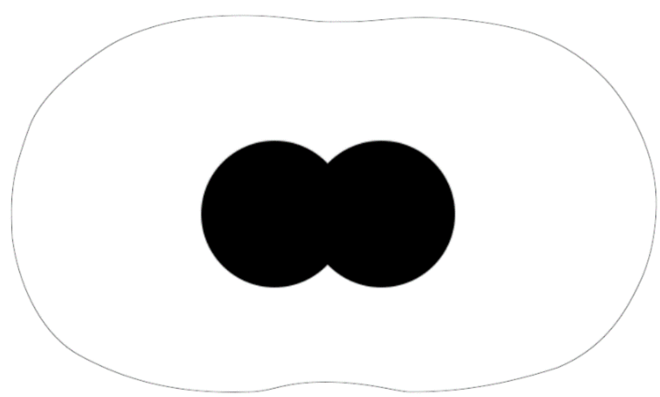


FIGURE 5: PROPOSED MODEL

The dark area depicts Foveal region and the white outlined enclosure region is the para-Foveal region.

There has not been a study that proves the above hypothesis, but this study if done at a larger scale is sure to support such a hypothesis.

Contrast ratio

It seems prudent to propose that the contrast is only acting as a drag force. I mean that when the contrast values went down there was no significant decrease in accuracy but real difference in the accuracy came only at a very low contrast ratio. The point where the fall is to occur I think is going to be shifted to the right in the graph 4 and it will shift to the left if the preview time of the number is decreased. However at really low contrast of 5%, there limitation will be eyes. The eye will be incapacitated to differentiate hence time effect will cease to operate. This of course is still a hypothesis and no study has been done to prove this point.

Summary

The results of the study point to differential horizontal, vertical regions of visual acuity and expected decrease in accuracy as the contrast went down.

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Next I would like to thanks Sashank Pisupati for valuable inputs in discussion at the time of poster presentation.

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