

Initial Eye Fixations and Eye Movements when Viewing Artistic Reproductions throughout Time

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Figure 1: Salvador Dali "The Last Supper"
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ABSTRACT

The analysis of initial eye-movements through fixations and clustering of eye movements is a relatively new idea to eye-tracking technologies. It is a topic of relevance when trying to make comparisons between works done by great masters and modern artists throughout Art History. The clustering aspects of this do not require to much analysis due to the proximity of the focal points obtained within a study, though fixation maps may require much more analysis involving elements such as the users fixation duration throughout a study [Wooding 2002]. The use of clustering is more effective in understanding the initial eye-movements of subjects and in understanding if their eyes are affected by abstractions in later reproductions of great works.

Keywords

Eye-movements, initial fixations, analysis, Regions of Interest, similarity between artistic works'.

1. INTRODUCTION

Throughout history many types of Art have been attempted and then remastered later in time. In comparison we see this in the movie industry now, when production companies digitally remaster an old movie or come out with a new production of an older movie with all the computer graphics, etc. to intrigue movie goers. Throughout Art History this has been seen through original works and artistic reproductions done by other artists later in time. Many times the original works have followed specific artistic rules of their time period, and the reproductions were given their own elements in order to gain certain interpretations from their viewers. Eye tracking can act as a potentially interesting way to track such differences. We can track viewers *eye-movements*

over original versions and remastered works, then make comparisons of them to show how components of the works draw the viewers' eye to particular *Regions of Interest*. This study involves works of "The Last Supper", and "The Pieta". The smaller number of subjects for this study allows for easier analysis and better understanding of the subjects progression through history. The idea of this data collection is to prove or disprove the following hypothesis:

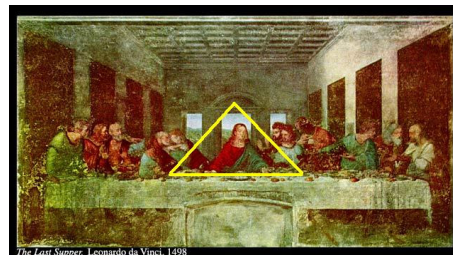


Figure 2: Da Vinci's "The Last Supper" w/
golden triangle drawn in.

(1) Art with a golden triangle present will cause the *initial fixations* of subjects' eyes to be within a given region within the triangle. Works without the triangle or done by newer artists with abstractions to lure subjects eyes away from the golden triangle, shall not have such regions.

(2) When given a post test of questions, subjects will remember their eyes going to places in which their fixations did not occur, based on abstractions or obscure items added to the images by the artists.



Figure 3: Bassano's "The Last Supper" w/ Areas of Interest Highlighted

(3) Areas of interest within original works or newer reproductions of original works will have some initial fixations due to an artist's achievement of their goal to lure viewers' eyes to these points.

Analysis of these hypotheses incorporates use raw data and an algorithm to calculate first few fixations on each image a participant views. Then these fixations can be mapped back onto the image and compared to the Regions of Interest explained above.

2. BACKGROUND

To understand these processes you must first understand if each single eye movement is a saccade or a fixation based off the data from the eye tracker. This goes back to earlier use of Hidden Markov models (HMMs) as a tool to predict if a movement is a saccade or a fixation [Salvucci and Goldberg 2000]. This gives a general idea of what saccades and fixations are and what they incorporate. Fixations are "pauses over informative regions of interest" and saccades are "rapid movements between fixations" [Salvucci and Goldberg 2000]. In terms of viewing images such as this, early studies showed that viewing motivation affects the gaze of a viewer [Buswell 1935]. Such motivations are seen in many artistic paintings in order to draw a viewers' gaze away from the norm, or to give a viewer their own interpretation of a painting. This was argued and partially proven in a paper entitled "Do people perceive what the design expresses?" [Hammer and Lengyel, 1989].

3. METHODOLOGY

3.1 Apparatus:



Figure 4: Tobii 1750 integrated with a switch and a Sun AMD 64 box.

3.1.1 Tobii 1750 eye tracker:

Has built in IR transmitters and camera inside 17" TFT monitor. Sampling Rate: will track both of users' eyes at approx. 50hz, which means 20 fps or 50 gaze points per second. The Accuracy of the Tobii 1750 is within 0.5 degree at 60cm, with a delay of 25-35 ms.



Figure 5: HP Pavilion N5470 Laptop for use with pretest and posttest data collection. (Also used for evaluation of data from pretest and posttest information).

3.1.2 Hp Pavilion N5470:

Machine to run simple pretest and posttest java programs to create simple text files for data evaluation and analysis stage.

3.1.3 Sun AMD 64 Machine Running on FxNet:

Used to run Tobii code for calibration and data collection from eye tracking monitor for later analysis and evaluation to prove or disprove hypotheses.

3.2 Stimulus:



Figure 6: Bassano's "The Last Supper" (what will be seen in presentation on Tobii).

Images including 5 paintings and 1 sculpture incorporating the golden triangle and abstractions through 550 years of art evolution. 3 paintings of "The Last Supper" (Leonardo Da Vinci, Bassano, and Salvador Dali), 1 sculpture of "The Pieta" (Michelangelo), as well as 2 paintings of "The Pieta" (Bellini, and Van Gogh).

3.3 Subjects:

Variety of college students with ages ranging from 18 to 35. Subjects group should include at most 10 subjects. Justification for 10 subjects is to get at least 2 of each age group, and both male and female subjects, so that any large deviations from the norm can be thrown out.

3.4 Experimental Design:

3.4.2 Variables:

In the analysis the variables are:

- (1) The presence or absence of the golden triangle in images. The golden triangle exists in Leonardo Da Vinci's "The Last Supper", and Michelangelo's "The Pieta".
- (2) The present or absence of abstractions within an image to distract a viewer. Abstractions exist in Dali's "The Last Supper" and Bassano's "The Last Supper".
- (3) The presence of regions of interest and their effect on the system. Regions of Interest exist in Bassano's "The Last Supper", Bellini's "The Pieta", and Van Gogh's "The Pieta".

I also want to know the measure of the variance of where the eyes' of a subject went compared to where they said they looked. There are 3 versions of "The Last Supper" and 3 of "The Pieta" even though Michelangelo's "The Pieta" has the golden triangle present as well as abstractions or *Regions of Interest*. The relevance of this for a comparison within one image is why this project has a 3X3 design with a slight complexity.



Figure 7: Michelangelo's "The Pieta" w/ points of interest highlighted with red circles.

3.5 Procedure(s):

3.5.1 Registration of User / Pretest:

User enters name, age, sex, and basic art interest information. Data is saved in a txt file under their first name followed by their last name .txt.

3.5.2 Eye Tracking Experiment:

User is calibrated on Tobii 1750. Then user views images on Tobii 1750. Images are done as a "free viewing task" meaning that the user is not asked about Regions of Interest or the golden triangle before viewing images so that thoughts will not affect their initial gazes. This matters because if they are told about these points in the

images, they may start looking for them when the image is shown rather than letting their eye go where they would naturally go when introduced to the image. Data is collected based on users eye movements for fixation data analysis later.

3.5.3 Posttest:

User enters name, and takes posttest of questions based on images they just viewed. These questions ask user where they looked within particular images. Abstractions are mentioned to see if abstract items were seen and if the users' eyes went where they thought they did throughout the study. This step is used for data analysis and evaluation after the experiment is over.

3.5.4 Analysis/Evaluation of Data:

The information from the pretest, posttest, and eye tracking experiment are reviewed. The initial 5 fixations from the eye tracking data are formed and compared to the *Regions of Interest* and to the points that the user specified seeing. Comparisons are made and compared to the hypotheses mentioned above to either prove to disprove them.

4. RESULTS:

4.1 Analysis Technique:

The Analysis within this project is handled by a java based text file evaluation program. Conversion.java runs through the raw data and breaks it up into the X and Y coordinates as well as timestamps. This makes the data easier to understand without the validation values, etc. Then the fixations.java program takes these files and converts them into the first 5 fixations for each user and image. This is done using a basic algorithm where we find the angle involved, determine if we have a fixation after 4 straight similar angles and X,Y coordinates with little variance between them. Then use a 5-tap filter to smooth the (X,Y) data so that the points do not seem shaky. The fixation points obtained from this can be compared to *Regions of Interest*, as well as to the golden triangle associated to particular images. The individual first fixations can also be compared to assumptions made by the participants in the post-test. Once comparisons are made, results can be compiled and a discussion based on predicted and obtained results from the study.

4.2 Eye Fixations:

4.2.1 Comparison to *Regions of Interest*:



Figure 8: Bassano's "The Last Supper" w/ Areas of Interest Highlighted

As seen from the comparisons of fixations to ROI, we can see that with some images such as the one above ROI played a large role in the initial fixations of experiment participants. Figure 8 gives a basic idea of what *Regions of Interest* are and how they are indicated in many instances. In this example I have circled the ROI's so that comparisons can be made between these areas and the fixations returned from my java data analysis programs. In order to find a good average fixation for each image based off multiple users a filter needs to be applied to the data. Similar to that used in data analysis, such as the 5 tap filter when smoothing the data collected in finding individual fixations. In comparison to the original "The Last Supper" by Leonardo Da Vinci, Bassano's remastering of the work no longer has a definitive golden triangle. Though one can still be seen in the image, it is not intended to pull a viewers eye to the central region of the painting. Through experimentation we have seen that ROI such as the ones shown above have given abstractions of other areas of interest for viewers' eyes to be attracted to. For example, my one female participant was not attracted to the central region of the painting at all during the entire experiment, and instead spent most of her time examining one of the lesser relevant ROI's that caught her interest. Here is a depiction of her first 5 fixations (1st red, 2nd yellow, 3rd blue, 4th pink, and 5th teal). Her scan path is represented by a green line.



Figure 9: "The Last Supper" w/ 1st 5 fixations showing extreme clustering within one *Region of Interest*.

In comparison to the top version of this image, we can see that the fixated region above is one of the lesser defined ROI's mentioned above. The first few fixations

are the only relevant ones in this experiment because I only want to know if the users gaze was initially brought to a *Region of Interest* or into a golden triangle region, etc.

4.2.2 Average Fixations in Comparison to *Regions of Interest*:

The Average fixations are based on all the users for each painting. These fixations can be biased because some of the users may look into completely different regions of the work, so the average X and Y components may end up being in an area of no interest. If this is so, we can Conclude that there was too much variance in data to make a significant comparison here. A filter will help make the data closer, but sometimes even a filter will not be enough to make it all relevant to itself.

4.2.3 1st Fixations in Comparison to predicted Fixations:

The use of 1st fixations and predicted fixation points helps us to see what the measure mentioned in the Variables section really is. If the predicted fixation area and the actual 1st fixation do vary, then we know that the participant was not actually attracted to what they thought they were within the painting. If they are the same we know that there was some cognitive thought going on when the initial fixation took place. In paintings that involved the golden triangle, such as "The Last Supper" by Da Vinci and "The Pieta" by Michelangelo, I asked participants what they could remember seeing. It was more of a cognitive remembering question. The surprising part was that most remembered objects within the *golden triangle* region and then their scan paths and initial fixations also fell within the given regions. With paintings that did not contain a *golden triangle* many of the responses were more based on ROI's and abstractions which the artists had added to the painting to redirect viewer's attentions. Once again the fixations tended to back this up again. For example, in Salvador Dali's "The Last Supper" the most remembered part of the painting was the crucifixion scene at the top of the painting and no Jesus in the middle as in the original where the *golden triangle* is present. When the data analysis for this painting was reviewed the majority of initial fixations were mapped to the sky area behind the table and to the mountainscape behind Jesus, but not to Jesus himself, or to the crucifixion up top. This helps proving hypothesis 2 from page 1, where subjects should remember their eyes going to places in which their fixations did not occur.

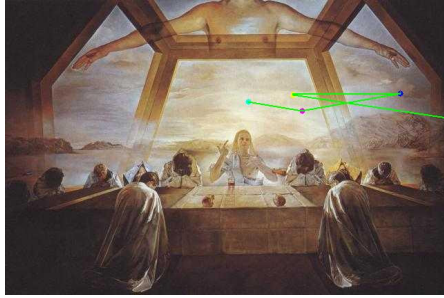


Figure 10: Salvador Dali's "The Last Supper" with first 5 fixations mapped onto it. 1st fixation was off image.

5. DISCUSSION:

In this study, different artistic representations of the same original works were considered by the participants in order to get initial eye fixations to try and prove some hypotheses. Participants were supposed to consider which parts of the paintings had more appeal to them and also suggest their previous knowledge of art history topics such as the *golden triangle* and *Regions of Interest*. By taking initial fixations and feedback from participants, a link between Art History and Computer Science could be made showing how manipulation of art through time allows multiple perceptions by the individual.

The results of the experiment showed the following about my three hypothesis:

(1) In terms of Art involving the *golden triangle* being present. Most initial fixations occurred within the desired regions, and then spread outward from there. For example:

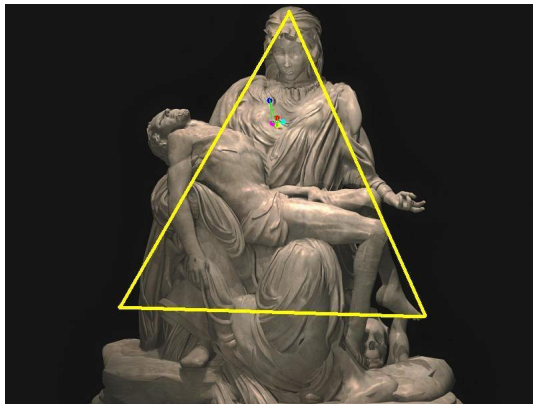


Figure 11: Michelangelo's "The Pieta" Example of good fixations within a ROI or within the true *golden triangle* Region of Interest.

In most cases the data lied within the "triangle", but in some instances, bad data, miscalibration errors, and other outside factors caused so-called bad data to get some mixed fixations. After having my convert.java and fixations.java codes took care of this "bad data", the remaining data was freed of points that lay off the screen. The other image that involved the *golden triangle* was Da Vinci's "The Last Supper" which was one of the first historical paintings to implement the *golden triangle* in the

early 1500's. After revisions of the participant's fixations from "The Last Supper", we see that all the fixations except for two landed within the *golden triangle* region. The two fixations that lied outside this region focused on a small *Region of Interest* where two of the disciples are conversing on the back side of the long table. So this leads us on to Hypothesis #3.

(3) In terms of *Regions of Interest*, the fixations in images such as Bassano's "The Last Supper", and Dali's "The Last Supper", both pull the viewers eye away from the central region. From the variations of fixations from user to user we can clearly see that with so many abstractions and ROI's within these images, each user can almost get their own interpretation or initial view of an image based off which ROI they fixate on first.

(2) In terms of hypothesis 2, most participants said that they saw the more mainstream or predictable parts of the paintings. The data on the other hand told a different story. For example, in Bassano's "The Last Supper" most participants said that they saw Jesus sitting in the middle, but the initial fixations showed that they actually fixated on the disciples sitting around the table, as well as the goat head sitting in the middle of the table. For another example, in Dali's "The Last Supper" most participants said that they were most focused on the crucifixion scene at the top, but most actually fixated on Jesus. This was a reverse situation here because Jesus was an abstraction himself because he was a blonde haired, non-typical figure in the middle of the painting. It is nice to see that people fixated on different things than what they remembered more specifically. It goes to show that sometimes cognitively people are thinking more about what they are seeing in their peripheral vision than what they are really fixating on. Figure 12 represents the fixations on one participants' study. This participant said that they remember mostly seeing Mary's face and the skull at the bottom of the sculpture.

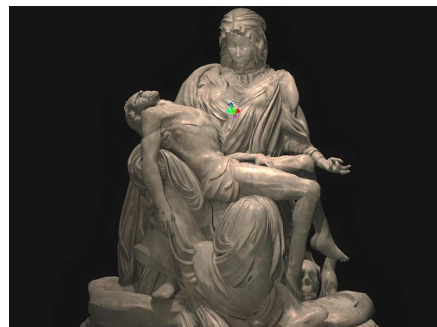


Figure 12: Michelangelo's "The Pieta" Example of good clustering of initial fixations.

6: POSSIBLE FUTURE WORK:

After this study and seeing how changes to original works can change people's perceptions of a work of art, I would love to try this study again with movie clips. Now that I see so many movie studios remastering their works, I wonder if adding computer generated graphics, etc. to a film takes away from the original perceptions by viewers. I know that when George Lucas remastered the original StarWars trilogy, it honestly ruined those movies for me because the graphics seemed so out of place. I know that feelings such as this actually led to animosity towards George Lucas and also led to my not seeing the other 3 StarWars movies until well after they were out on DVD. It's just a thought at this point though, but it would be a more interactive study with allot more applications.

7. IMAGES USED

"THE LAST SUPPER IMAGES"

Leonardo Da Vinci educational use permissions allowable from:

<http://www.sanford-artedventures.com/feedback.html>

Image obtained from link:

http://www.sanford-artedventures.com/play/leonardo/images/leo_last_supper_1.jpg

Bassano permissions: (organization for use of art for educational purposes only) Okay for use w/ reference:

<http://www.ibiblio.org/wm>

Image obtained from link:

<http://www.ibiblio.org/wm/paint/auth/bassano/last-supper/last-supper.jpg>

Salvador Dali permissions (permissions granted from Michael Delahunt):

<http://www.artlex.com> Copyrighted by [Michael Delahunt](#).

Image obtained from link:

http://www.artlex.com/ArtLex/c/Images/cenacle_dali.lg.jpg

"THE PIETA IMAGES"

Michelangelo permissions (educational permissions from webmaster@uisoftware.com)

www.uisoftware.com

Image obtained from link:

<http://www.metasynth.com/BRYCEART/Brycers/pieta.jpg>

Bellini's permissions (permissions for educational purposes):

initaly@initaly.com

Image obtained from link:

<http://www.initaly.com/regions/veneto/pix/bellini/pieta.jpg>

Van Gogh permissions (obtained from):

www.mystudios.com

Image obtained from link:

<http://www.mystudios.com/art/post/van-gogh/van-gogh-pieta.jpg>

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