Gaze patterns of anatomy students through classroom learning and familiarization

Ghebremichael, Abenet

http://hdl.handle.net/2144/15090

Boston University
GAZE PATTERNS OF ANATOMY STUDENTS THROUGH CLASSROOM LEARNING AND FAMILIARIZATION

by

ABENET GHEBREMICHAEL

B.S., Boston College, 2012

Submitted in partial fulfillment of the requirements for the Degree of

Master of Science

2014
GAZE PATTERNS OF ANATOMY STUDENTS THROUGH CLASSROOM LEARNING AND FAMILIARIZATION

ABENET GHEBREMICHAEL

Abstract

This study aims to identify the gaze patterns of medical students as they correlate with learning and familiarization through the length of a course. The gaze patterns of medical gross anatomy students (n=31) were documented as they identified anatomical structures on a computer screen. Each student took the test before the start of the Human Gross Anatomy course, and was randomly assigned to a group (A, B, or C) that would take it after one of three course section exams, Back and Limbs, Thorax Abdomen Pelvis, and Head and Neck, respectively. Their gaze patterns were expected to change as they become more familiar with the course material, particularly with respect to cognitively salient Areas of Interest (cAOIs) that are relevant to identifying the tagged structure. We predict that unfamiliar students will demonstrate more saccadic movements, shorter fixation times on cognitively salient AOIs, and longer fixation times on visually salient AOIs when compared to experienced students. Predictions that saccade frequency would decrease with familiarity and that fixation time in visually salient AOIs would decrease were not upheld. There appears to be a decrease in fixation time on the area surrounding the AOIs (White Space) for groups of subjects familiar with the material. This is found to be a statistically significant decrease in Group B’s Back and Limbs (p = 0.038) and Thorax Abdomen Pelvis (p = 0.000) sections as well as Group C’s Back and Limbs
section (p = 0.013). This decrease in fixation time on the White Space is due to an increase in fixation time on cognitively salient AOIs with the only statistically significant increase occurring in Group C’s Thorax Abdomen Pelvis section.
Table of Contents

Title Page………………………………………………………………………………….i

Copyright Page……………………………………………………………………………ii

Approval Page……………………………………………………………………………iii

Abstract…………………………………………………………………………………iv

Table of Contents……………………………………………………………………vii

List of Tables……………………………………………………………………………viii

List of Figures……………………………………………………………………………ix

List of Abbreviations…………………………………………………………………xii

Introduction……………………………………………………………………………1

Methods…………………………………………………………………………………6

Results…………………………………………………………………………………15

Discussion …………………………………………………………………………………46

Appendices………………………………………………………………………………55

References……………………………………………………………………………….59
Vita........................................................................................................................................61
LIST OF TABLES

Table 1: Group A Fixation Time on White Space for Individual Stimuli………………………..55

Table 2: Group B Fixation Time on White Space for Individual Stimuli………………………56

Table 3: Group C Fixation Time on White Space for Individual Stimuli………………………57

Table 4: High MRT Scorer Fixation Time in White Space for Individual Stimuli………58
LIST OF FIGURES

Figure 1: Test Images.................................................................10

Figure 2: Three practice questions taken from the Vandenburg Mental Rotation Test (MRT).................................................................13

Figure 3: Baseline and Revisit Questionnaire Scores.................................................16

Figure 4: MRT Score vs Practical Score.................................................................16

Figure 5: Revisit Questionnaire vs MRT.................................................................17

Figure 6: Practical Score vs Questionnaire.............................................................18

Figure 7: Fixation Time on White Space.................................................................19

Figure 8: Fixation Time on White Space with Pooled Baseline.........................20

Figure 9: Fixation Time on White Space for High MRT scorers......................21

Figure 10: Fixation Time on White Space for High MRT Revisit and Pooled Baseline...22

Figure 11: Fixation Time on White Space with Correctly Identified Revisit..........23

Figure 12: Fixation Time on White Space with High Exam Scorers...............24

Figure 13: Revisit Fixation Time on White Space of High and Low MRT Scorers...25

Figure 14: Revisit Fixation Time in White Space for Correctly and Incorrectly Identified Structures .................................................................26
Figure 15: Revisit Fixation Time on White Space for High and Low Exam Scorers…27

Figure 16: Fixation Time on Cognitively Salient AOIs …………………………………28

Figure 17: Fixation Time on Visually Salient AOIs…………………………………………29

Figure 18: Fixation Time on Cognitively Salient AOIs for Baseline and Correctly Identified Stimuli in Revisit …………………………………………………………………………………30

Figure 19: Fixation Time on Visually Salient AOIs for Baseline and Correctly Identified Stimuli in Revisit …………………………………………………………………………………31

Figure 20: Fixation Time on Cognitively Salient AOIs for only High MRT Scorers …32

Figure 21: Fixation Time on Visually Salient AOIs for High MRT Scorers ……………33

Figure 22: Group A Fixation Time on Cognitively Salient AOIs in BL …………………34

Figure 23: Group A Fixation Time on Cognitively Salient AOIs in TAP………………35

Figure 24: Group A Fixation Time on Cognitively Salient AOIs in HN …………………35

Figure 25: Group B Fixation Time on Cognitively Salient AOIs in BL…………………36

Figure 26: Group B Fixation Time on Cognitively Salient AOIs in TAP…………………37

Figure 27: Group B Fixation Time on Cognitively Salient AOIs in HN…………………38

Figure 28: Group C Fixation Time on Cognitively Salient AOIs in BL …………………38

Figure 29: Group C Fixation Time on Cognitively Salient AOIs in TAP …………………39
Figure 30: Group C Fixation Time on Cognitively Salient AOIs in HN ..........................40

Figure 31: Group A Fixation Time on Visually Salient AOIs in BL .............................41

Figure 32: Group A Fixation Time on Visually Salient AOIs in TAP ............................41

Figure 33: Group A Fixation Time on Visually Salient AOIs in HN ......................... 42

Figure 34: Group B Fixation Time on Visually Salient AOIs in BL ......................... 42

Figure 35: Group B Fixation Time on Visually Salient AOIs in TAP ......................... 43

Figure 36: Group B Fixation Time on Visually Salient AOIs in HN ......................... 43

Figure 37: Group C Fixation Time on Visually Salient AOIs in BL ......................... 44

Figure 38: Group C Fixation Time on Visually Salient AOIs in TAP ......................... 44

Figure 39: Group C Fixation Time on Visually Salient AOIs in HN ......................... 45

Figure 40: Saccade Frequency .................................................................................. 46
LIST OF ABBREVIATIONS

AOI: Area of Interest

AOIs: Areas of Interest

BL: Back and Limbs

CogAOI: Cognitively Salient Area of Interest

HN: Head and Neck

TAP: Thorax Abdomen and Pelvis

VisAOI: Visually Salient Area of Interest
Introduction

Human beings are a highly visual species. Even though peripheral vision can cover a large area, gaze focuses to concentrate vision on areas of attraction. Yarbus notes that “when examining an object, determining its proportions, counting the elements of an object, and so on, we usually use eye movements and voluntarily change the points of fixation” (Yarbus, 1967). Research in gaze tracking has shown it to be a process occurring “in two states: in a state of fixation or in a state of changing the points of fixation” (Yarbus, 1967). Saccades are defined as an identical and simultaneous very rapid rotation of the eyes that occur between fixations (Yarbus, 1967). A fixation is a point where high resolution foveal vision is momentarily stopped to acquire visual information (Krupinski, 2013). In actuality, smaller involuntary movements of the eye, of which the viewer is unaware, accompany this process (Yarbus, 1967). Thus a fixation is technically defined by a maximum gaze dispersion over a minimum amount of time. It is with these two components, fixation and saccade, that a “gaze pattern” can be formed.

Gaze patterns are studied because of what they suggest. Yarbus noted that “eye movements reflect the human thought processes; the observer’s thought may be followed to some extent from records of the eye movement”. “Analysis of the eye-movement records shows that the elements attracting attention contain, in the observer’s opinion, may contain, information useful and essential for perception. Elements on which the eye does not fixate, either in fact or in the observer’s opinion, do not contain such information. (Yarbus 1967)” When subjects were given pictures to view he noted that it
was certain elements of the picture that most drew their attention. In general these areas are called Areas of Interest (AOI). In a picture of the forest he found that focus was directed more toward the outline of a bear rather than the complexity of forest trees. He found in other pictures that it wasn’t necessarily directed toward color. Yarbus “noted that the study of these elements shows that they give information, allowing the meaning of the picture to be obtained.” These elements are now referred to as cognitively salient Areas of Interest (cAOI), which attract gaze due to an informed significance of the element. Visually salient Areas of Interest (vAOIs) attract gaze due to a relatively striking visual feature of the element. Fixations occur are more likely to occur at areas of higher local contrast (Parkhurst and Nieburs, 2003).

An aspect of cognitive control in perception is the influence of a viewing task. Task was first found to have an effect when it was noted that subjects freely examined an image of a tower differently when they were asked to look at the image with the task of finding a person in the tower window (Buswell, 1935). Task influences a number of measures of eye movement including number of fixations and gaze duration on specific elements of photographs (Castelhano, 2009). Giving different tasks will create different gaze patterns and cognitively salient AOIs for an image. Changes in measures of saccades have been researched too. It was found that saccade amplitude (the measure of the distance between fixations) doesn’t change with viewing task (Castelhano, 2009).

Yarbus noted that the viewers of his paintings who had a similar background examined them differently from those who were seeing it for the first time and those
unfamiliar with the epoch represented by the painting (Yarbus 1967). This finding that prior knowledge affects the pattern with which one views an image is supported by multiple sources. It was found that novice, intermediate, and expert laproscopic surgeons exhibit different gaze-patterns during surgery (Kocak et al., 2005). When comparing experts to non-experts it was found that gaze patterns are different when looking at images of brain CTs. It was found that neurologists looked at the clinically relevant areas of both high and low visual salience, while non-experts only looked at the ones with high visual salience (Matsumoto et al, 2011). VisAOIs attract gaze from all kinds of viewers, but less experienced viewers tend to focus on them more. The same experiment found that while experts fixated most on clinically relevant areas, non-experts fixated most on high contrast areas (Matsumoto et al, 2011). A better understanding of what experts look at is important, because it can help train non-experts in the given field. It was found that a greater Adenoma Detection Rate is correlated with a centrally focused Visual Gaze Pattern, and this may lead to implementing better detection strategies (Almansa et al., 2011).

Medical Gross Anatomy is a course based on naming and identifying the structures of the human body and understanding their relations with one another. The analysis of gaze-patterns when identifying structures may be helpful in that it can guide an understanding of the relative importance of AOIs in the learning of anatomy. This study will run tests on medical students of an anatomy course prior to its start (baseline test) and at time points during the course (revisit tests) to see if changes in gaze pattern occur with an increased familiarity. These three time points occur soon after the exams
concluding the three section of the course: the Back and Limbs (BL) section, the Thorax, Abdomen, and Pelvis (TAP) section, and the Head and Neck (HN) section, in chronological order. The test being given to the students is a 2-dimensional analog of the course practical examinations, in which the task is to identify an indicated structure in a cadaver.

It is predicted that upon familiarization of anatomical images, subjects will view the image more discriminately by spending a larger proportion of time on cognitively salient AOIs than they do in the baseline and images they haven’t been familiarized with. This focus on cogAOIs should be accompanied by a decrease of time spent looking at areas of the image useless to the task of identifying the structure. This variable will be recorded as fixation time in an AOI. This experiment tests the hypothesis that when compared to baseline or unfamiliar anatomical images (1) subjects familiar with images will have an increased fixation time on cogAOIs, (2) a decreased fixation time on visAOIs and (3) a decreased saccade frequency. Subjects will be determined as familiar or unfamiliar with a section as a whole by how they performed on the course’s practical exams. Subjects will also be determined as familiar or unfamiliar with an individual image if they correctly identified the indicated structure. These two assessments of proficiency allow the correlation of subject familiarity with gaze pattern on a section-level as well as the level of individual stimuli.

There are subjects that will vary in their ability to visually analyze images when given a task. This is important to the human anatomy course because it consists of a very
visual component in the practical exam as well as the cognitively-oriented written exam. Those with a visuospatial aptitude perceive objects and the spatial relationship around them with greater efficacy. The Vandenberg Mental Rotation Test (MRT) is one that very robustly assigns a score to visuospatial ability. This study’s pool of subjects is expected to have a mix of visuospatial abilities. Assuming they are familiar with the material to the same degree, we predict that subjects with greater visuospatial ability will generate a more consistent gaze-pattern than is different from those with a lower visuospatial ability. It is also expected that subjects who received a low MRT score prior to the start of the course, will have a gaze pattern that will match the high MRT scorers toward the end of the course, because learning manifests itself in not only in the acquisition of new information, but also the development of perception (Lai et al., 2013) (Nodine et al, 1999).

Literature shows the there is a change in gaze patterns with learning and increased experience with the material (Matsumoto et el, 2009) (Kundel, 2008) (Nodine, 1999) (Harvey et al, 2014) (Kocak et al., 2005). With each successive year of training pathology residents were found to look at breast biopsies with shorter, more efficient gaze patterns and different strategies (Krupinski, 2012). It should be noted that this is a study of change in gaze pattern with learning and familiarity and that these students progress from completely uninformed to familiar with the subject-matter. This is a difference from most of the literature, which studies the difference between subjects who are familiar with the material and those who are experts.
Methods

The protocol for this study was approved by the Boston University Medical Campus Institutional Review Board (protocol #H-32308).

Subjects

The entire Fall 2013 Gross Anatomy class was contacted about this study by email before matriculating at BUSM. Thirty-one subjects volunteered to participate in the experiment, which involves three gaze-tracking tests that were scheduled to occur before, during, and after their Medical Gross Anatomy course. Subjects who have taken any type of anatomy course were excluded from the pool of applicants. Participants had to have normal or corrected-to-normal vision, be right-handed, and be native English speakers. Subjects were randomly assigned an anonymous subject identification number that enabled the researchers to connect the student to their performance in the experiment as well as their course performance without linking the subjects’ name to the study. The subject to ID number sheet was only accessible to a specified member of the IRB protocol who was not connected to the Gross Anatomy course. Subjects were compensated $30 for each of the three tests and an additional $10 if all three were attended.

Gaze-Tracking Technology and Testing Conditions

Tests were administered in a closed room in the Spivack Center. Subjects were advised to wear contact lenses instead of glasses, if possible, as glasses occasionally
obscure the eye from the gaze tracking camera. Subjects were asked to remove any jewelery in or around the head and neck area to prevent reflections from such objects. Subjects were seated in a chair adjusted to their own comfort level and were offered eye drops to relieve dryness that may cause excessive blinking. Subjects’ heads were positioned on a pre-adjusted chinrest which was sanitized with alcohol wipes prior to each use. The headrest was fixed 60 cm in front of the monitor that displayed the test.

A 22 inch LCD monitor was used to provide a larger viewing area than a standard monitor. The Red-m camera, supplied by SensoMotoric Instruments (SMI; www.smivision.com), recorded gaze by tracking pupillary movements. The contrast in infrared radiation between the pupil and iris is used to identify the location of the pupil within the eye. This camera recorded at a resolution of 1280x720 and at a speed of 120 Hz. The camera sat at the base of the monitor and was angled upward at a 20 degree angle. The parameters of a fixation are set for minimum duration of 80 milliseconds and a maximum dispersion of 100 pixels. The software interprets movement beyond these parameters as a saccade.

Subjects had a keyboard and mouse in front of them for changing slides and answering questions. The area around the stimulus monitor was cleared of any unnecessary visual distractions. The examiner’s laptop was positioned away from the subject’s view. The examiner remained in the room during the testing process to oversee any complications. The lights were turned off during testing to minimize the potential for glare interfering with the camera. The door was closed to minimize audible distractions.
Experimental Design

The experiment involved three successive tests. The baseline test occurred prior to the start of the Human Gross Anatomy course. This test serves to function as a control, as subjects have not had significant exposure to material from the course and would not have been familiar with the images and questions of the test. Next, subjects are administered the revisit test during the course. The revisit test is the same test administered at three separate times. The subjects were randomly separated into three groups (11 in group A, and 10 each in B and C) to take the revisit test at one of the three time points. The three revisit tests occur at the end of the three regionally organized sections of the anatomy course: Back and Limbs (BL), Thorax Abdomen Pelvis (TAP), and Head and Neck (HN), in that respective order. Each section concludes with an exam and the subjects of the corresponding group were administered the revisit test within 10 days after the section exams. Each section of the course lasts approximately one month. Subjects of Group A took the revisit with immediate exposure to only the first section of the course material. Group B took the revisit test with exposure to the first two sections of the course, with the earlier section having a month gap since the last exposure to the material. Subjects in Group C took the revisit with exposure to all three sections of the course material with a one and two month gap since exposure to the second and first section, respectively. Six months after the end of the course all subjects will return to take the third, follow up, test. This final test will examine how gaze patterns change with an extended period of time since exposure to course material.
The Test

SMI Experiment Center was the software used to create and run the gaze-tracking test, which consisted of a series of images of cadaveric dissections. Arrows were placed on the images indicating the structures to be identified. Images that were chosen were comparable to the material students were exposed to in the laboratory portion of the course and the associated practical exams. Images were chosen that contain as few visually salient distractions as possible (Figure 1). Images were generated either by taking pictures of cadaver dissections or by finding appropriate images online. The test included 22 images: 7 Back and Limbs images, 8 Thorax Abdomen Pelvis images (2 of these were cross-sections), and 7 Head and Neck images. During the experiment, images were randomized within each section. Images were in color and not distorted to fit the screen.

The revisit test and the follow up test were different from the baseline test in that they also included a fourth section of images unrelated to any section of the anatomy course. This section had a set of seven “obscure” anatomical images that displayed anatomical dissections of animals. These images were tagged in the same way the human dissections were and subjects were instructed to identify the structure. The baseline test was also carried out concurrently with an EEG recording in which a 128-lead electrode cap was fitted to the subject’s head. These data are not described in this thesis.
The test began with an instructions page. The subsequent slides were two practice stimulus-response slide sets to familiarize subjects with the flow of the test. The next step was a five-point calibration and validation procedure that ensures an accurate spatial representation of the subject’s gaze relative to the stimulus screen. A calibration test with a maximum dispersion value of less than or equal to 1.0 degree was considered sufficiently accurate to proceed. Then the subjects viewed the 22 stimuli. Preceding each stimulus image was a three-second inter-stimulus interval consisting of a cross-hair at the center of the screen on which the subjects were instructed to focus. This standardized the location at which all subjects’ gaze started for all images. After the interstimulus slide, subjects viewed the image. Subjects were allowed no more than 60 seconds per image, but were instructed on how to advance the slide if they wanted to do so. Each stimulus image was followed by an answer screen on which the subject identified the structure on the previous screen by typing in their answer. If they were not able to identify the structure they were instructed to describe the indicated structure as precisely as possible or type “Do not know”.

Figure 1: Test Images. A) One of the images given in the Back and Limbs section of the test. B) One of the images given in the Thorax Abdomen Pelvis section of the test.
Areas of Interest

Areas of Interest were delineated *a priori* using SMI’s gaze-tracking analysis software, BeGaze. Cognitively salient AOIs were identified for each of the 22 stimuli by identifying and delineating features on the images that are useful or essential for identifying the indicated structure. Three experimenters familiar with the Medical Gross Anatomy course, including that course’s Course Director, identified the boundaries of these AOIs. These judgments were further confirmed by running trial experiments on subjects that are proficient in anatomy to see if their gaze patterns suggested a salience of those structures. Visually Salient AOIs are regions of an image that attract gaze through some sort of visual characteristic of the region rather than an intellectually informed characteristic of the region. Visually salient AOIs were also generated for some of the images, based on high contrast in color or, rarely, other visually striking features of the image. All of the structures that were indicated by an arrow were included as visAOIs, because their attention was directed there by the arrows.

Gaze Variables

The BeGaze software automatically generates the gaze variables used in the study. The two tests analyzed in this study, the baseline test and revisit test, are analyzed separately by BeGaze. BeGaze automatically compiles the questionnaire data for the subjects. It is compiled in the form of the response associated with each of the images. This data is exported into Microsoft Excel format and the identification responses are given a score of 0, 1, and 2 for incorrect, descriptively correct, and correctly named,
respectively. For the purposes of this study, descriptively correct answers were considered incorrect. Therefore the correct answers in this study were equivalent to the answers that would have been graded as correct on an actual exam.

The saccade frequency in a stimulus and percent fixation time on an AOI were both generated by BeGaze and exported to Excel format for subsequent parsing of the data. The percent fixation time on an AOI is calculated as the amount of time (milliseconds) the subject fixated within that AOI, divided by the total time the image was on screen (in milliseconds). However, not all subjects’ gaze were tracked for the entirety of the image being up, resulting in loss of data fixation. In order to account for the variations, the percent fixation times per an AOI were adjusted by dividing by the percent fixation time of all AOIs of the image. This adjusts the AOI fixation time data so that they are all out of 100%, making comparisons among AOIs accurate. BeGaze automatically generates the AOI, “White Space”, which gathers data on the image outside of the created AOIs.

Errors in gaze tracking due to either poor tracking by the camera or excessive blinking on the part of the subject were assessed. Tracking ratio is the percentage of time a subject’s gaze was tracked divided by the total time an image was on the screen. It is generated by BeGaze as the dwell time on the image. If a subject viewed an image with a tracking ratio of less than 80%, it was discarded from subsequent analyses of gaze variables. This ensures that only data with a minimal amount of data loss is used.
Non Gaze Variables

Three weeks after the Baseline Test the subjects took the Mental Rotation Test (MRT), a test of visuospatial abilities (Vandenberg, Oct. 1978). The Mental Rotation Test consists of a collection of 20 questions split equally into two timed sections of three minutes each. Each question involves comparing an indicated structure to a list of four other structures and identifying which of those four are the same as the original structure, but rotated (Figure 2). Subjects were instructed to identify which two of the four structures were only different in that they were rotated about its axis. Scoring accounted for previously documented visuospatial differences between male and female subjects.

Figure 2. Three practice questions taken from the Vandenburg Mental Rotation Test (MRT)
Subjects’ performances in the Medical Gross Anatomy course are included in this study to determine how learning (as determined by grades) correlates with gaze patterns. After the course was over, the Course Director provided all subjects’ grades on each of the three written exams, three practical exams, and final course grade. One pre-approved individual who was neither associated with the Gross Anatomy course nor a primary member of the research team received the grades and connected them to the anonymous Subject ID numbers.

Finally, subjects’ answers on the experiment test itself were included as an assessment of knowledge of the material presented in the experiment. These answers were scored as correct if the subject identified the structure using the correct term. Close misspellings were deemed acceptable as a correct score. Descriptive answers were scored as incorrect.

Analysis

Comparative statistical analyses were performed using IBM SPSS Statistics Software. Comparisons were made between the saccade frequency and fixation time of the baseline to the revisit using a Paired T-test. The non-parametric Wilcoxon Signed-Rank test was used for comparisons in which at least one sample was less than 30 subjects. Comparisons between different sets of data within the revisit group were made using the Mann-Whitney U test. A bivariate Pearson Correlation test was used to compare two different variables. All differences were deemed statistically significant if they had a p-value of 0.05 or less.
Results

Subject performance

Subject performance on the experiment questionnaire task is used as a proxy to determine whether subjects are familiar with the material they have been exposed to in the Gross Anatomy course, and only that material. Subjects in Group A should be familiar with only BL material, Group B should be familiar with BL and TAP, and Group C should be familiar with all three sections. All three groups performed as expected to uphold that prediction (Figure 3). When comparing the baseline questionnaire scores to the revisit, all three groups had statistically different scores in the BL section with $p = 0.003$, 0.007, and 0.007, respectively. In the TAP section, the familiar groups, Groups B and C, scored statistically higher with $p = 0.005$ and 0.007, respectively, while Group A, the naïve group, didn’t score differently on the revisit when compared to the baseline. In the HN section only group C, the only familiar group, scored statistically higher than baseline ($p = 0.007$). The revisit test groups that were not familiar with the material of the section did not score more than the baseline with statistical significance.

Additionally, subjects performed most strongly on the questions related to the section they had just completed (BL for Group A, TAP for group B, HN for group C). With familiar subjects, the more time since covering a section’s material the weaker the performance on the revisit questionnaire, while still statistically greater than the baseline.
Figure 3: Baseline and Revisit Questionnaire Scores. All averaged questionnaire scores within a section show the baseline and revisit amounts. P-values are derived by Wilcoxon Signed Rank Test comparing the Revisit to the Baseline. Asterisks (*) indicate significant differences between the indicated column and the baseline measure.

Figure 4: MRT Score vs Practical Score. The y-axis indicates subject performance on the Gross Anatomy course practical exam. The practical exams scores that were used were from the section exam most recently prior to the revisit test (i.e. group A subjects BL, Group B subjects TAP, Group C subjects HN). The x-axis indicates subject performance on the visuospatial exam. Mann-Whitney U Tests were used to compare high scorers and low scorers of both visuospatial test and
practical exam to one another. Asterisks (*) indicate significant differences between the indicated column and the baseline measure.

Visuospatial ability, indicated by an MRT score, is plotted with practical exam scores in Figure 4, in order to determine whether there is a correlation between the two. A Pearson Test shows that there is no significant correlation between the two \( (p = 0.075) \). Practical scores of individuals with MRT scores above 60\% are not statistically different from those of individuals with MRT scores below 40\% \( (p = 0.064 \text{ Mann Whitney U Test}) \).

![Figure 5: Revisit Questionnaire vs MRT. The y-axis indicates subject performance on the gaze-test questionnaire. Percentage of correctly identified structures is limited to the section of the test corresponding to the most recently familiarized section material (e.g. group A subjects questionnaire percentage from only the BL section of the gaze test questionnaire). The x-axis indicates subject performance on the Mental Rotation Test. Asterisks (*) indicate significant differences between the indicated column and the baseline measure.](image)

Subjects’ revisit questionnaire scores are plotted along against their MRT scores in Figure 5. A Pearson Test shows that there is no significant correlation of the two \( (p = 0.915) \). Therefore the revisit questionnaire scores are on average the same irrespective of MRT.
score. When comparing individuals scoring above 60% with individuals below 40% the questionnaire scores are not statistically different (Mann Whitney U test p= 0.184).

Figure 6: Practical Score vs Questionnaire. The y-axis indicates subject performance on the gaze-test questionnaire. Percentage of correctly identified structures is limited to the section of the test corresponding to the most recently familiarized section material (e.g. group A subjects questionnaire percentage from only the Back and Limbs section of the gaze test questionnaire). The x-axis indicates practical exam performance. The practical exam scores are from the section exam most recently prior to the revisit test, which corresponds with the material tested in the questionnaire score. Asterisks (*) indicate significant differences between the indicated column and the baseline measure.

Revisit questionnaire scores are plotted with practical exam score in Figure 6 to see if there is a correlation with performance. The correlation is statistically significant using a Pearson Correlation giving an approximated significance of 0.000. Mann Whitney U test shows that when comparing subjects, who scored above 80% on the practical to below 80% there is a statistical difference between MRT score (Mann Whitney U test p=0.032)

*Gaze Data*
In this study we predict that subjects who are familiar with image content will spend more time focusing on cognitively salient regions of the image. Therefore they should ignore the non-salient parts of the image (white space) as well as the visually salient (but cognitively useless) areas (visAOIs), and focus their gaze instead on the cognitively salient AOIs (cogAOIs).

**Gaze Data on White Space**

Figure 7: Fixation Time on White Space. The y-axis indicates fixation time on white space as a percentage of the total fixations as an average of all subjects within the group. The x-axis indicates the three subject groups in chronological order of administration of gaze-test and the sections in chronological order of the introduction of material in the Gross Anatomy course. Comparisons between the fixation time of the baseline and revisit test were done using a paired t-test. Asterisks (*) indicate significant differences between the indicated column and the baseline measure.

A baseline and revisit bar graph of fixation time on the White Space is displayed in Figure 7 to see if there is a difference between the two. The Revisit group spent less time fixating on the White Space in all comparisons, except for the Head and Neck sections of Group B and C. The five sections with the largest reduction of fixation time on the revisit
test are Group A BL (9.92%); Group B BL (10.2%) and TAP (14.5%); and Group C BL (12.9%) and TAP (4.86%). Group B looked at the white space for significantly less time for both BL images (p=0.038) and TAP images (p=0.000).

There is a lot of variation within the groups, so the White Space comparison of Figure 7 is graphed with the baseline averages pooled from all three groups. This is displayed in Figure 8. Most sections also have lower fixation time on the white space with revisit groups than with the baseline. The exceptions are also HN of Group B and C. The five sections with the largest reductions in fixation time on white space when comparing baseline and revisit are Group A BL (10.6%), Group B BL (12.9%) and TAP (13.2%),

Figure 8: Fixation Time on White Space with Pooled Baseline. The y-axis indicates fixation time on white space as a percentage of the total fixations as an average of all subjects within the group. The x-axis indicates the three subject groups in chronological order of administration of gaze-test and the sections in chronological order of the introduction of material in the Gross Anatomy course. The baseline data is a pooled average of all three groups. Comparisons between the fixation time of the baseline and revisit test were done using a paired t-test. Asterisks (*) indicate significant differences between the indicated column and the baseline measure.
and Group C BL (9.90%) and TAP (5.60%). Group B looked at the white space for significantly less time for both BL images (p=0.015) and TAP images (p=0.000). N values range between 39 and 185 subjects (variation is due to exclusion of gaze data with poor tracking ratio).

Figure 9: Fixation Time on White Space for High MRT scorers. The y-axis indicates fixation time on white space as a percentage of the total fixations as an average of all subjects within the group. The x-axis indicates the three subject groups in chronological order of administration of gaze-test and the sections in chronological order of the introduction of material in the Gross Anatomy course. Subjects that were used scored at least a 60% on the Mental Rotation test. Comparisons between the fixation time of the baseline and revisit test were done using a Wilcoxon Signed-Rank test. Asterisks (*) indicate significant differences between the indicated column and the baseline measure.

In figure 9 only subjects with high visuospatial ability are compared to one another to see if there is a difference between their baseline and revisit fixation times on White Space. Most revisit groups decreased their fixation time on the White Space except for Group B and C HN as well as Group A TAP, which remains approximately the same. The sections with the largest decreases in fixation time are Group A BL (4.55%) and HN (5.70%),
Group B BL (16.0%) and TAP (18.3%), and Group C BL (8.78%). The only group in which this decrease was a significant difference was for Group B TAP section (p = 0.01). N values range between 12 and 28 subjects.

Figure 10: Fixation Time on White Space for High MRT Revisit and Pooled Baseline. The y-axis indicates fixation time on white space as a percentage of the total fixations as an average of all subjects within the group. The x-axis indicates the three subject groups in chronological order of administration of gaze-test and the sections in chronological order of the introduction of material in the Gross Anatomy course. The baseline data is a pooled average of all three groups. Subjects that were used scored at least a 60% on the Mental Rotation test. Comparisons between the fixation time of the baseline and revisit test were done using a Wilcoxon Signed-Rank test. Asterisks (*) indicate significant differences between the indicated column and the baseline measure.

Again, there is variation within the groups, so the White Space comparison of Figure 9 is graphed with the baseline averages pooled from all three groups and displayed in figure 10. Similarly, most of the revisit tests show less fixation time spent on the White Space than they did in the baseline test except for Group A BL, Group B HN, and Group C HN. The groups with the largest decreases in fixation time are Group A BL (4.55%) and HN (6.20%), Group B BL (15.0%) and TAP (16.7%), and Group C BL (9.63%) and TAP (6.17%). Group B had a significant reduction of fixation time in TAP section (p = 0.002).
Figure 11: Fixation Time on White Space with Correctly Identified Revisit. The y-axis indicates fixation time on white space as a percentage of the total fixations as an average of the subjects. The x-axis indicates the three subject groups in chronological order of administration of gaze-test and the sections in chronological order of the introduction of material in the Gross Anatomy course. Revisit fixation times on a stimulus-image in which the subject did not correctly identify the indicated structure were excluded from the analysis. All baseline fixation times were included based on the premise that subjects were unfamiliar with the images. There is no data for the TAP and HN section of group A because subjects did not correctly answer those stimuli. Comparisons between the fixation time of the baseline and revisit test were done using a Paired t-test. Asterisks (*) indicate significant differences between the indicated column and the baseline measure.

Comparing the baseline fixation time on White Space to the Revisit may include subjects in the revisit who are in the course but are not becoming familiarized with the material. In Figure 11, only fixation times are included in the revisit if the subject correctly identified the structure indicated in the stimulus-image. Group A did not have any subjects who responded correctly to questionnaires in either the TAP or HN sections so a comparison is not depicted in the graph. Subjects who identified the structure correctly tended to look at the White Space less than the baseline in all sections except for the Group C HN.
section. The decreases that are statistically significant are Group B TAP ($p = 0.000$) and Group C BL ($p = 0.013$).

![Figure 12: Fixation Time on White Space with High Exam Scorers.](image)

The revisit fixation time on White Space may be skewed by subjects who do not have good grasp on the material. In figure 12, revisit fixation time on White Space only includes subjects who had high performance on the exam. The baseline to revisit comparisons that are displayed only include sections of the material that have been covered by the group, so it is predicted that the revisits in each comparisons would exhibit a decrease in fixation time on White Space. This was as expected except for the
Group C TAP section. The two sections, BL and TAP, for group B are statistically significant with $p = .021$ and $p = 0.010$, respectively.

Figure 13: Revisit Fixation Time on White Space of High and Low MRT Scorers. The y-axis indicates fixation time on white space as a percentage of the total fixations as an average of all subjects within the group. The x-axis indicates the three subject groups in chronological order of administration of gaze-test and the sections in chronological order of the introduction of material in the Gross Anatomy course. The data are further subdivided into high MRT scorers, greater than 60% (red), and low MRT scorers, less than 40% (blue). Comparisons between the fixation time of high and low scorers were done using a Mann-Whitney U test.

It would be expected that there should be a trend when comparing the revisit fixation on White Space of the subjects with a high visuospatial ability to those who with a low ability. It is predicted that when encountering knowledgeable material students with high MRT scores would fixate less on the White Space. However, there are no significant differences in white space fixation time between revisiting subjects who scored high on the visuospatial test and revisiting subjects who scored low on the visuospatial test (Figure 13).
Figure 14: Revisit Fixation Time in White Space for Correctly and Incorrectly Identified Structures. The y-axis indicates fixation time on white space as a percentage of the total fixations as an average of all subjects within the group. The x-axis indicates the three subject groups in chronological order of administration of gaze-test and the sections in chronological order of the introduction of material in the Gross Anatomy course. The data are further subdivided into stimulus-image in which the subject did not correctly identify the indicated structure (blue) and those that were correctly identified (red). Group A TAP and HN are not depicted because there were no subjects who scored correctly in these categories. Comparisons between the fixation time of correct and incorrectly scored stimuli were done using a Mann-Whitney U test.

It is expected that revisit fixation times on the White Space for stimulus images in which the structure was correctly identified would be less than the fixation times in which the structure was incorrectly identified. There were no significant differences in fixation times between correct and incorrect individuals (Figure 14).
Figure 15: Revisit Fixation Time on White Space for High and Low Exam Scorers. The y-axis indicates fixation time on white space as a percentage of the total fixations as an average of all subjects within the group. The x-axis indicates the three subject groups in chronological order of administration of gaze-test and the sections in chronological order of the introduction of material in the Gross Anatomy course. The data is further subdivided into subjects who scored above a 90% on the practical exam (Red) and those who scored below an 80% (Blue). Comparisons between the fixation time of high and low scorers were done using a Mann-Whitney U test. Asterisks (*) indicate significant differences between the indicated column and the baseline measure.

It is expected that higher performers will spend less time fixating on the white space at revisit than will low performers (Figure 15). The Group A BL and Group C TAP both fixated more on the white space in the revisit test than in the baseline. In the other four comparisons they fixated more on the white space in the baseline than in the revisit test. The Group C HN comparison has a drop in the fixation time on White Space in the revisit test that is statistically significant (p = 0.045) using a Mann-Whitney U test.

Gaze Data on cognitively salient AOIs and visually salient AOIs

Results show that fixation time on the White Space is reducing with familiarity, indicating that gaze patterns are shifting to a different area of the stimulus-image. There
must be a resulting increase in fixation time on cogAOIs, visAOIs, or both. It is predicted that an increase is found in the cogAOIs and a decrease in the visAOIs, when viewing familiar images. A trend is expected among the familiar sections: BL for Group A; BL and TAP for Group B; and BL, TAP, and HN for Group C.

Figure 16: Fixation Time on Cognitively Salient AOIs. The y-axis indicates fixation time on cogAOIs as a percentage of the total fixations. The x-axis indicates the three subject groups in chronological order of administration of gaze-test and the sections in chronological order of the introduction of material in the Gross Anatomy course. Each bar is an average of subjects’ baseline or revisit fixation time within the group and section. Comparisons between the fixation times of the baseline and revisit were done using a Paired t-test. Asterisks (*) indicate significant differences between the indicated column and the baseline measure.

In Figure 16, fixation times on cognitively salient regions of the images at baseline are compared to the same variable in the revisit. For groups familiar with the section being viewed, there were consistent increases in the percentage of time spent on these AOIs. However, this increase was only significant for one group (Group C, TAP images; p = 0.039).
Figure 17: Fixation Time on Visually Salient AOIs. The y-axis indicates fixation time on visAOIs as a percentage of the total fixations. The x-axis indicates the three subject groups in chronological order of administration of gaze-test and the sections in chronological order of the introduction of material in the Gross Anatomy course. Each bar is an average of subjects’ baseline or revisit fixation time within the group and section. Comparisons between the fixation times of the baseline and revisit were done using a Paired t-test. Asterisks (*) indicate significant differences between the indicated column and the baseline measure.

Figure 17 displays the groups’ fixation time on visAOIs in the baseline compared to the revisit. There doesn’t seem to be a trend among the groups’ familiar sections. In the BL section, all groups increased in fixation on visAOIs. In the TAP section they fixated on visAOIs more in the revisit than in the baseline with Group B having a statistically significant increase (p = 0.010) using a paired t-test. In the HN section, Group A increased its fixation on visAOIs in the revisit with statistical significance (p = 0.047). For group B and C the revisits looked at the HN visAOIs slightly less in the revisit. Those two comparisons were the only ones with a decrease.
Figure 18: Fixation Time on Cognitively Salient AOIs for Baseline and Correctly Identified Stimuli in Revisit. The y-axis indicates fixation time on cogAOIs as a percentage of the total fixations. The x-axis indicates the three subject groups in chronological order of administration of gaze-test and the sections in chronological order of the introduction of material in the Gross Anatomy course. Each bar is an average of subjects’ baseline or revisit fixation time within the group and section. The revisit fixation time only accounts for stimulus images in which subjects correctly identified the structure. Fixation times aren’t shown for TAP in Group A and HN in Groups A and B, because they didn’t have sufficient stimuli in which subjects scored correctly. All baseline fixation times are included based on the premise that all subjects were unfamiliar with the material at the time. Comparisons between the fixation times of the baseline and revisit were done using a Paired t-test.

It is expected that excluding stimuli in which subjects did not correctly identify that structure would remove data with which students weren’t familiar. This is shown in Figure 18 and 19 for cogAOIs and visAOIs, respectively. The comparisons that are shown are all comparisons with a revisit that is familiar with the material. In the Figure 18, the graph shows that all subjects fixated more on cogAOIs in the revisit than in the baseline, but none of them with statistical significance.
Figure 19: Fixation Time on Visually Salient AOIs for Baseline and Correctly Identified Stimuli in Revisit. The y-axis indicates fixation time on visAOIs as a percentage of the total fixations. The x-axis indicates the three subject groups in chronological order of administration of gaze-test and the sections in chronological order of the introduction of material in the Gross Anatomy course. Each bar is an average of subjects’ baseline or revisit fixation time within the group and section. The revisit fixation time only accounts for stimulus images in which subjects correctly identified the structure. Comparisons between the fixation times of the baseline and revisit were done using a Paired t-test. Asterisks (*) indicate significant differences between the indicated column and the baseline measure.

In figure 19, all comparisons except for Group C’s Head and Neck section show that the revisits fixated more on visAOIs than the baseline. Group B has a significant increase with TAP images (p = 0.000).
Figure 20: Fixation Time on Cognitively Salient AOIs for only High MRT Scorers. The y-axis indicates fixation time on cogAOIs as a percentage of the total fixations. The x-axis indicates the three subject groups in chronological order of administration of gaze-test and the sections in chronological order of the introduction of material in the Gross Anatomy course. Each bar is an average of subjects’ baseline or revisit fixation time within the group and section. These fixation times only include those of subjects who scored at least 60% on the MRT. Comparisons between the fixation times of the baseline and revisit were done using a Wilcoxon Signed-Rank test.

Figure 20 compares the revisit fixation time on cogAOIs of only subjects who scored high on the visuospatial exam to their fixation time in the baseline. There does not seem to be a clear trend within the sections. Group A and C fixated on cogAOIs more in the revisit than in the baseline for all sections. Conversely, Group B fixated on cogAOIs more in the baseline than in the revisit in all sections. No differences were statistically significant.
Figure 21: Fixation Time on Visually Salient AOIs for High MRT Scorers. The y-axis indicates fixation time on visAOIs as a percentage of the total fixations. The x-axis indicates the three subject groups in chronological order of administration of gaze-test and the sections in chronological order of the introduction of material in the Gross Anatomy course. Each bar is an average of subjects’ baseline or revisit fixation time within the group and section. These fixation times only include those of subjects who scored at least 60% on the MRT. Comparisons between the fixation times of the baseline and revisit were done using a Wilcoxon Signed-Rank test. Asterisks (*) indicate significant differences between the indicated column and the baseline measure.

Figure 21 compares the revisit fixation time on visAOIs of only subjects who scored high on the visuospatial exam to their fixation time in the baseline. It is expected that subjects with high visuospatial ability fixate on visAOIs less in the revisit sections they are familiar with than in the baseline. Among high MRT scorers there doesn’t seem to be a trend within a section. Group B’s section TAP significantly increased in fixation on visAOIs (p = 0.014).
Figure 22: Group A Fixation Time on Cognitively Salient AOIs in BL. The y-axis indicates fixation time on cogAOIs as a percentage of the total fixations for Group A. The x-axis indicates the cogAOIs and the stimulus-image that it is in for the BL section. Each bar is an average of subjects’ baseline or revisit fixation time for each cogAOI. Comparisons between the fixation times of the baseline and revisit were done using a Wilcoxon Signed-Rank test.

It is expected that when looking at the individual cogAOIs of a section reveal, at least one per a stimulus-image would have an increase in fixation time in the revisit. Figure 22 displays the individual cogAOI graph for Group A in the BL section. Group A fixated more on cogAOIs in the revisit for all AOIs except for the BL5 musculocutaneous nerve and BL7 extensor digitorum muscle. None of the changes were statistically significant.
Figure 23: Group A Fixation Time on Cognitively Salient AOs in TAP. The y-axis indicates fixation time on cogAOs as a percentage of the total fixations for Group A. The x-axis indicates the cogAOs and the stimulus-image that it is in for the TAP section. Each bar is an average of subjects’ baseline or revisit fixation time for each cogAOI. Comparisons between the fixation times of the baseline and revisit were done using a Wilcoxon Signed-Rank test. Asterisks (*) indicate significant differences between the indicated column and the baseline measure.

Figure 23 displays the individual cogAOI graph for Group A in the TAP section. There doesn’t seem to be any clear trend in the comparisons of Group A’s TAP section. Revisit fixation time did increase with the recurrent laryngeal nerve though (p = 0.043).
Figure 24: Group A Fixation Time on Cognitively Salient AOIs in HN. The y-axis indicates fixation time on cogAOIs as a percentage of the total fixations for Group A. The x-axis indicates the cogAOIs and the stimulus-image that it is in for the HN section. Each bar is an average of subjects’ baseline or revisit fixation time for each cogAOI. Comparisons between the fixation times of the baseline and revisit were done using a Wilcoxon Signed-Rank test. Asterisks (*) indicate significant differences between the indicated column and the baseline measure.

Figure 24 displays the individual cogAOI graph for Group A in the HN section. Comparisons in this graph did not either show a clear trend. The baseline looked at the mastoid process statistically more than the revisit with a \( p = 0.027 \).

![Graph](image)

Figure 25: Group B Fixation Time on Cognitively Salient AOIs in BL. The y-axis indicates fixation time on cogAOIs as a percentage of the total fixations for Group B. The x-axis indicates the cogAOIs and the stimulus-image that it is in for the BL section. Each bar is an average of subjects’ baseline or revisit fixation time for each cogAOI. Comparisons between the fixation times of the baseline and revisit were done using a Wilcoxon Signed-Rank test. Asterisks (*) indicate significant differences between the indicated column and the baseline measure.

Figure 25 displays the individual cogAOI graph for Group B in the BL section. Aside from the piriformis AOI of BL2 and 3 and BL4 ulnar artery, subjects viewed all cogAOIs more in the revisit than in the baseline. The ulnar artery was fixated on less in the revisit.
with a p = 0.028 and the brachial plexus was fixated on more in the revisit with a p = 0.046.

Figure 26 displays the individual cogAOI graph for Group B in the TAP section. There did not seem to be any clear trend in the change in fixation time for Group B on the TAP section.
Figure 27: Group B Fixation Time on Cognitively Salient AOIs in HN. The y-axis indicates fixation time on cogAOIs as a percentage of the total fixations for Group B. The x-axis indicates the cogAOIs and the stimulus-image that it is in for the HN section. Each bar is an average of subjects’ baseline or revisit fixation time for each cogAOI. Comparisons between the fixation times of the baseline and revisit were done using a Wilcoxon Signed-Rank test.

Figure 27 displays the individual cogAOI graph for Group B in the HN section. This graph shows no clear trends in the fixation time spent on cogAOIs for the HN section.

Figure 28: Group C Fixation Time on Cognitively Salient AOIs in BL. The y-axis indicates fixation time on cogAOIs as a percentage of the total fixations for Group C. The x-axis indicates the cogAOIs and the stimulus-image that it is in for the BL section. Each bar is an average of...
subjects’ baseline or revisit fixation time for each cogAOI. Comparisons between the fixation times of the baseline and revisit were done using a Wilcoxon Signed-Rank test. Asterisks (*) indicate significant differences between the indicated column and the baseline measure.

Figure 28 displays the individual cogAOI graph for Group C in the BL section. Group C looked at the gluteus maximus and piriformis statistically significant more in the revisit than in the baseline with $p = 0.043$ for both.

![Figure 28: Group C Fixation Time on Cognitively Salient AOIs in BL](image)

Figure 29: Group C Fixation Time on Cognitively Salient AOIs in TAP. The y-axis indicates fixation time on cogAOIs as a percentage of the total fixations for Group C. The x-axis indicates the cogAOIs and the stimulus-image that it is in for the TAP section. Each bar is an average of subjects’ baseline or revisit fixation time for each cogAOI. Comparisons between the fixation times of the baseline and revisit were done using a Wilcoxon Signed-Rank test. Asterisks (*) indicate significant differences between the indicated column and the baseline measure.

Figure 29 displays the individual cogAOI graph for Group C in the TAP section. Subjects looked at the recurrent laryngeal nerve more in the revisit than in the baseline with a statistical significance of $p = 0.028$. 
Figure 30: Group C Fixation Time on Cognitively Salient AOIs in HN. The y-axis indicates fixation time on cogAOIs as a percentage of the total fixations for Group C. The x-axis indicates the cogAOIs and the stimulus-image that it is in for the HN section. Each bar is an average of subjects’ baseline or revisit fixation time for each cogAOI. Comparisons between the fixation times of the baseline and revisit were done using a Wilcoxon Signed-Rank test. Asterisks (*) indicate significant differences between the indicated column and the baseline measure.

Figure 30 displays the individual cogAOI graph for Group C in the HN section. Subjects in this graph looked more at the carotid/vagus AOI more in the revisit and the foramen Magnum less in the revisit with statistical significance of $p = 0.043$ for both.
Figure 31: Group A Fixation Time on Visually Salient AOs in BL. The y-axis indicates fixation time on visAOIs as a percentage of the total fixations for Group A. The x-axis indicates the cogAOIs and the stimulus-image that it is in for the BL section. Each bar is an average of subjects’ baseline or revisit fixation time for each cogAOI. Comparisons between the fixation times of the baseline and revisit were done using a Wilcoxon Signed-Rank test. Asterisks (*) indicate significant differences between the indicated column and the baseline measure.

Figure 32: Group A Fixation Time on Visually Salient AOs in TAP. The y-axis indicates fixation time on visAOIs as a percentage of the total fixations for Group A. The x-axis indicates the cogAOIs and the stimulus-image that it is in for the TAP section. Each bar is an average of subjects’ baseline or revisit fixation time for each cogAOI. Comparisons between the fixation times of the baseline and revisit were done using a Wilcoxon Signed-Rank test.
Figure 33: Group A Fixation Time on Visually Salient AOIs in HN. The y-axis indicates fixation time on visAOIs as a percentage of the total fixations for Group A. The x-axis indicates the cogAOIs and the stimulus-image that it is in for the HN section. Each bar is an average of subjects’ baseline or revisit fixation time for each cogAOI. Comparisons between the fixation times of the baseline and revisit were done using a Wilcoxon Signed-Rank test.

Figure 34: Group B Fixation Time on Visually Salient AOIs in BL. The y-axis indicates fixation time on visAOIs as a percentage of the total fixations for Group B. The x-axis indicates the cogAOIs and the stimulus-image that it is in for the BL section. Each bar is an average of subjects’ baseline or revisit fixation time for each cogAOI. Comparisons between the fixation times of the baseline and revisit were done using a Wilcoxon Signed-Rank test.
Figure 35: Group B Fixation Time on Visually Salient AOIs in TAP. The y-axis indicates fixation time on visAOIs as a percentage of the total fixations for Group B. The x-axis indicates the cogAOIs and the stimulus-image that it is in for the TAP section. Each bar is an average of subjects’ baseline or revisit fixation time for each cogAOI. Comparisons between the fixation times of the baseline and revisit were done using a Wilcoxon Signed-Rank test. Asterisks (*) indicate significant differences between the indicated column and the baseline measure.

Figure 36: Group B Fixation Time on Visually Salient AOIs in HN. The y-axis indicates fixation time on visAOIs as a percentage of the total fixations for Group B. The x-axis indicates the cogAOIs and the stimulus-image that it is in for the HN section. Each bar is an average of subjects’ baseline or revisit fixation time for each cogAOI. Comparisons between the fixation times of the baseline and revisit were done using a Wilcoxon Signed-Rank test. Asterisks (*) indicate significant differences between the indicated column and the baseline measure.
Figure 37: Group C Fixation Time on Visually Salient AOIs in BL. The y-axis indicates fixation time on visAOIs as a percentage of the total fixations for Group C. The x-axis indicates the cogAOIs and the stimulus-image that it is in for the BL section. Each bar is an average of subjects’ baseline or revisit fixation time for each cogAOI. Comparisons between the fixation times of the baseline and revisit were done using a Wilcoxon Signed-Rank test.

Figure 38: Group C Fixation Time on Visually Salient AOIs in TAP. The y-axis indicates fixation time on visAOIs as a percentage of the total fixations for Group C. The x-axis indicates the cogAOIs and the stimulus-image that it is in for the TAP section. Each bar is an average of subjects’ baseline or revisit fixation time for each cogAOI. Comparisons between the fixation times of the baseline and revisit were done using a Wilcoxon Signed-Rank test.
Figure 39: Group C Fixation Time on Visually Salient AOIs in HN. The y-axis indicates fixation time on visAOIs as a percentage of the total fixations for Group C. The x-axis indicates the cogAOIs and the stimulus-image that it is in for the HN section. Each bar is an average of subjects’ baseline or revisit fixation time for each cogAOI. Comparisons between the fixation times of the baseline and revisit were done using a Wilcoxon Signed-Rank test. Asterisks (*) indicate significant differences between the indicated column and the baseline measure.

It is expected that a comparison between the baseline and revisit fixation time on individual visAOIs would show that in their familiar sections, revisit subject fixation time would decrease. Group A didn’t fixate on the visAOIs with any sort of trend for any of its sections, shown in Figures 31, 32, and 33. In Figure 31, the familiar, BL Section is displayed for Group A. The subjects looked at the Inferior Gluteal nerve statistically significantly less in the revisit with a $p = 0.043$. In Figure 37 showing the TAP section, Group B fixated on 3 visAOIs, the colon, vagus, and phrenic, statistically significantly more in the revisit than in the baseline ($p = 0.043, 0.036,$ and $0.018$ respectively). In Figure 39 showing the HN section, Group C looked at the Face stimulus-image 5 statistically significantly less in the revisit than in the baseline with a $p = 0.043$. 

* $p = 0.05$
Figure 40: Saccade Frequency. The y-axis indicates saccade frequency within a stimulus-image. The x-axis indicates the three subject groups in chronological order of administration of gaze-test and the sections in chronological order of the introduction of material in the Gross Anatomy course. Comparisons between the baseline and revisit saccade frequencies were performed using a Wilcoxon Signed-Rank test.

Saccade frequency variable is the relative amount of saccades occurring in a stimulus-image. Figure 40 displays the saccade frequencies for each group. The variation between saccades is marginal and observes no real pattern between naïve and experienced groups. Non-parametric testing shows that none of the changes between the revisit and baseline groups are statistically significant.

Discussion

The purpose of this study seeks to observe changes in the gaze-pattern of students as they start off unfamiliar with images of anatomy to become learned students of the course. The ability to identify the indicated structure in the gaze tracking tests is a measure of their familiarity with anatomical structures. Figure 1 displays this familiarization with the material as the course progresses with statistical significance,
proving that subjects are learning the material as they are exposed to it. It also shows that groups that have not been exposed to the material in the course are not correctly identifying structures of that section.

It was expected that the non-gaze variables (questionnaire score, practical exam score, and MRT score) would correlate with one another. Of the three, the only correlation that was statistically significant is the one between questionnaire score and the practical exam score (Figure 6). Subjects took the practical exam after studying for an entire section and within 10 days took the revisit test, on which they performed similarly. This further shows that the revisit test is an accurate reflection of the practical exam given by the course. It was also expected that subjects with high visuospatial ability would perform better on the practical exam and structure-identification on the revisit test. However, the MRT score was not found to correlate with either of these other assessments (Figures 4 and 5).

We hypothesized that once familiarized with the material subjects’ gaze patterns would (1) decrease in the amount of saccades, (2) increase in fixation on cogAOIs, and (3) decrease in fixation on visAOIs and other irrelevant areas of the image, including White Space. Results show that the shift of fixation time away from the White Space and toward cogAOIs correlates with familiarity. As they became more familiar with the course, students of anatomy did not exhibit a decrease in saccade frequency nor did they exhibit a decrease in fixation on visAOIs.

*Saccades*
It was expected that unfamiliar subjects would exhibit a greater saccade frequency than familiar ones, because of the need to gain familiarity by scanning it more extensively. However, our study found no statistically significant difference in saccade frequency between groups familiar and unfamiliar with the material (Fig 40). The results don’t exhibit any sort of trend as groups become familiar with the material. It appears that saccade frequency is a feature of gaze that remains constant irrespective of familiarity at this level of learning. Other measurements of saccade were found vary along with familiarity. An examination of the saccades revealed that pathologists had longer average lengths (seconds), shorter distances (degrees of visual angle), and faster velocities than residents and medical students (Krupinski, 2013). Saccade frequency may be linked to fixation duration: the less time a fixation is occurring, the more often saccades are occurring between them. It was also shown that fixation durations remain constant irrespective of task (Castelhano et al., 2009). It is not well understood what governs the amount of saccades a viewer will make.

*Locations of visual attention*

Results show a correlation between familiarity of anatomy images and a shift of the gaze pattern toward cogAOIs. This conclusion is first suggested in Tables 1-3 (Appendix) by a decrease of the average percent fixation time on the White Space, indicating that subjects are focusing their gaze on either the cogAOIs or visAOIs. Even though there is still a decrease in the fixation time for Group Cs TAP and HN section, it is not as great of a decrease as the other familiar sections, which each exhibit a change of at least 10%. The comparisons of these fixation times on individual stimuli are based on
averages of samples ranging from 4-11 subjects in either the baseline or revisit. When comparing individual stimuli, samples of these sizes may have too much variation to produce results of statistical significance.

To counter a lack of sample size the stimuli were pooled into the anatomical sections and analyzed. Comparisons of fixation time on White Space in figures 7 and 8 show that groups who are familiarized with the revisit section have a decreased fixation time in the White Space, except for the HN section of Group C. Furthermore, the Group B BL and TAP section have a decrease that is statistically significant. These results uphold our prediction that subjects will shift their attention away from the nonsalient aspects of the image to those that aid identification of the tagged structure.

In an examination of fixation time on White Space by only the high MRT scorers, the only significant difference was in Group B, which examined the White Space on the TAP images for significantly less time than they did at baseline. In both, the high MRT and the all-subjects comparisons, the pooled-baseline results (Figures 8 and 10) varied only slightly and didn’t change any statistical significance. The analysis of only high MRT scorers suggests that visuospatial ability has little impact on the subjects’ disinclination to examine the white space in the revisit, when compared to baseline.

We also postulated that those who correctly identified the structure in the revisit test would be more likely to exhibit a decrease of fixation time on white space. This trend is generally indicated (Figure 11), though most of the differences are not significant. Group B’s TAP section and Group C’s BL section had statistically significant reductions
in fixation time on white space in the revisit. A similar comparison was made in Figure 12 excluding subjects who performed poorly on the practical exam. The familiar groups exhibited the general trend in which they reduced the proportion of time they spent examining white space, although most of these differences are nonsignificant. Group B is the only group in which the shift away from White Space is a significant reduction on familiar images.

From these analyses it appears that there is a trend occurring. Groups that are familiar with the sections are fixating less on the white space than they did in the baseline test. Since in most of the images the white space encompasses a majority of the image surrounding the AOIs, it can be deduced that their gaze patterns have become less scattered throughout the image and more focused on AOIs. The exception to this trend is in Group C, who does not follow this prediction with respect to TAP or HN images (Figures 8-12). This is also suggested in Tables 1-4 (Appendix) as a smaller decrease in fixation time on White Space with familiarity. This may be due to the inclusion of cross-sectional images in the TAP section, which don’t follow the expected trend in Group C (Table 3). This may also be due to the classification of AOIs in the HN section of the test. Some of these images included the face as a visAOI, when it would have been more consistent with the other images if it had been left as White Space.

The non-gaze variables, questionnaire score, practical exam score, and MRT score were analyzed within the revisit tests to see if a trend emerges. With the expected trend of fixation time decreasing in the white space, it is thought that subjects who did
not perform well in the course or the experiment task (Figures 14 and 15) or who have low visuospatial ability (Figure 13) would not show the predicted shift away from baseline. However Figures 13, 14, and 15 show that there is no discernable trend when comparing low to high scorers. The only statistically significant result is that the high practical exam scorers in Group C fixated less on the white space than low scorers. The lack of a strong trend, may indicate that knowing the material well enough to perform well on the practical exam and the revisit structure-identification does not appreciably shift the gaze away from the white space. It may be that being visually familiar is all that is necessary to stimulate a more informed gaze-pattern, rather than needing to also recall anatomical nomenclature.

If subjects are looking less at the white space then it is predicted that they would be looking more at the cogAOIs. Figure 18 shows that fixation time tends to increase on cogAOIs with familiarity in the section. The only statistically significant increase is in Group C’s TAP section. This was reflected by a decrease of fixation time in the White Space, but it was not statistically significant. When comparing the baseline to correctly identified images in the revisit, the trend is sustained, yet none of the comparisons are statistically significant (Figure 18). When comparing the baseline to high MRT scorers in the revisit, the trend does not exist.

When looking at the statistically significant differences between the baseline and revisit fixation time on individual cogAOIs, there is no discernable trend. The “brachial plexus trunks” from Group B’s BL section (Figure 25), the “gluteus maximus” and the
“piriformis/superior gluteal artery” from Group C’s BL section (Figure 18), “the recurrent laryngeal nerve” from Group C’s TAP section (Figure 29), and the “vagus/carotid” from Group C’s HN section (Figure 30) follow the prediction that fixation increases with familiarity. On the other hand, the “ulnar art” from Group B’s BL section (Figure 25) and the “foramen magnum” from Group C’s HN section (Figure 30) do not. There are also statistically significant differences in Group A’s TAP and HN section, which are sections with which they are not familiar (Figures 23 and 24). The unexpected results when comparing individual AOIs rather than whole sections may be due to the fact that the sample sizes only range from 5-11 subjects.

It was also predicted that with familiarity a shift of gaze would occur out of visAOIs. However, it can’t be proven that this is happening. There doesn’t seem to be a trend with regard to visually salient AOIs when groups are familiar with a section. Non-parametric tests show that familiar sections have statistically significant increases and decreases in some of their visAOIs. The “inferior gluteal nerve” from group A’s BL section and the “face” from Group C’s HN section decreased, while the “colon”, “phrenic”, and “vagus” visAOIs from Group B’s TAP section increased in fixation time with familiarization (Figures 31, 35, and 39). Again these trends may simply be a result of the effect of making comparisons with small sample sizes (5-11 subjects).

Additionally, a majority of these anatomical structures are considered visAOIs, because of a black arrow contrasting with anatomical images is pointing directly at the structure. Because it is necessary to view the indicated structure for the task, it may be that they should also be considered cogAOIs to some extent. If this is the case then it makes sense
that they would attract the attention of both familiar and unfamiliar subjects in much the same way that neurologists and controls both gazed at clinically relevant areas that were visually salient in CT scans (Matsumoto et al., 2011).

A more robust analysis of the data could have been performed with a larger N. Loss of gaze data due to issues with the gaze tracking technology significantly reduced the amount of reliable data. Failure in tracking may have been exacerbated by subjects who wear glasses, subjects with brightly-colored iris pigmentation, and subjects with epicanthal folds. In addition, there may be an inevitable degree of variation in gaze patterns between individuals. Yarbus “concluded that individual observers differ in the way they think and, therefore, differ also to some extent in the way they look at things” (Yarbus, 1967). If this is the case, the only way to increase robustness of the study would be to increase the number of subjects.

Percent fixation time functions as an accurate gaze measurement in determining relative importance. It allows for an analysis of importance of an AOI without the interfering aspect of a varying gaze strategy within a subject’s gaze pattern as well as among subjects. Like much of the literature, this experiment is showing that increasing familiarity with the material produces a more efficient search strategy. The next step in the research in the education of anatomy would be to follow up this study with one that can assess the development of a precise visual strategy that accompanies identification. Expert and non-expert viewing of brain CTs found them to be associated with “top-down instruction” and “bottom-up salience” strategies, respectively (Matsumoto et al., 2011).
The literature describes the initial global, Gestalt-like patterns, which are characteristic of expertise in the viewing of breast biopsies (Krupinski et al, 2012). A similar pattern is also found in the detection of cancers on mammograms (Kundel et al, 2008). In expertise that involves a physical component there is an established “quiet eye” pattern found in surgeons and the increased fixation duration pattern found around the approaching football contact in soccer (Savelsberg et al, 2002) (Harvey et al, 2014). An accurate association of a pattern to successful learning in anatomy can bring insight into shaping the methodology of the course and to learning in general.
Appendices

Table 1: Group A Fixation Time on White Space for Individual Stimuli. The Average of group A subjects’ fixation time on white space are displayed for each stimulus-image in baseline and revisit columns. In the difference column, the average baseline of a given stimulus-image is subtracted from the revisit (revisit – baseline = difference). The Difference column that is highlighted yellow indicates the section that the group of subjects are familiar with.

<table>
<thead>
<tr>
<th>Fixation Time on White Space</th>
<th>Group A</th>
<th>Baseline</th>
<th>Revisit</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>BL1</td>
<td>45.915</td>
<td>38.424</td>
<td>-7.4909</td>
<td></td>
</tr>
<tr>
<td>BL2</td>
<td>58.503</td>
<td>62.346</td>
<td>-3.8428</td>
<td></td>
</tr>
<tr>
<td>BL3</td>
<td>46.819</td>
<td>54.709</td>
<td>7.88989</td>
<td></td>
</tr>
<tr>
<td>BL4</td>
<td>37.906</td>
<td>26.177</td>
<td>-11.73</td>
<td></td>
</tr>
<tr>
<td>BL5</td>
<td>59.89</td>
<td>28.211</td>
<td>-31.679</td>
<td></td>
</tr>
<tr>
<td>BL6</td>
<td>71.749</td>
<td>64.817</td>
<td>-7.2325</td>
<td></td>
</tr>
<tr>
<td>BL7</td>
<td>89.015</td>
<td>57.56</td>
<td>-31.455</td>
<td></td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td></td>
<td></td>
<td>-11.122</td>
<td></td>
</tr>
<tr>
<td>TAP1</td>
<td>55.9</td>
<td>54.671</td>
<td>-1.2288</td>
<td></td>
</tr>
<tr>
<td>TAP2</td>
<td>52.935</td>
<td>62.02</td>
<td>9.08549</td>
<td></td>
</tr>
<tr>
<td>TAP3</td>
<td>79.561</td>
<td>63.624</td>
<td>-15.937</td>
<td></td>
</tr>
<tr>
<td>TAP4</td>
<td>58.3</td>
<td>65.847</td>
<td>7.54646</td>
<td></td>
</tr>
<tr>
<td>TAP5</td>
<td>62.705</td>
<td>57.874</td>
<td>-4.8303</td>
<td></td>
</tr>
<tr>
<td>TAP6</td>
<td>62.154</td>
<td>69.471</td>
<td>7.31688</td>
<td></td>
</tr>
<tr>
<td>TAP7</td>
<td>79.031</td>
<td>68.327</td>
<td>-10.704</td>
<td></td>
</tr>
<tr>
<td>TAP8</td>
<td>53.537</td>
<td>67.003</td>
<td>13.4667</td>
<td></td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td></td>
<td></td>
<td>0.58945</td>
<td></td>
</tr>
<tr>
<td>HN1</td>
<td>43.413</td>
<td>28.219</td>
<td>-15.193</td>
<td></td>
</tr>
<tr>
<td>HN2</td>
<td>20.374</td>
<td>8.0876</td>
<td>-12.286</td>
<td></td>
</tr>
<tr>
<td>HN3</td>
<td>34.472</td>
<td>32.066</td>
<td>-2.4053</td>
<td></td>
</tr>
<tr>
<td>HN4</td>
<td>41.223</td>
<td>40.012</td>
<td>-1.2108</td>
<td></td>
</tr>
<tr>
<td>HN5</td>
<td>37.179</td>
<td>32.316</td>
<td>-4.8623</td>
<td></td>
</tr>
<tr>
<td>HN6</td>
<td>74.24</td>
<td>72.948</td>
<td>-1.2923</td>
<td></td>
</tr>
<tr>
<td>HN8</td>
<td>60.226</td>
<td>60.29</td>
<td>0.06428</td>
<td></td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td></td>
<td></td>
<td>-5.3123</td>
<td></td>
</tr>
</tbody>
</table>

Table 1 is a chart that breaks down the fixation times of individual images within a section for Group A. Negative values in the difference column indicate that a smaller amount of time was spent fixating in the White Space in the revisit than in the baseline. A positive value in the difference column indicates the opposite. The highlighted section, BL, has more negative difference values for its corresponding stimuli than the other sections. The TAP section has an average difference close to 0. The HN section has an average difference that is negative but not as negative as the BL section indicating that it also had more fixation time on the White Space.
Table 2: Group B Fixation Time on White Space for Individual Stimuli. The Average of group B subjects’ fixation time on white space are displayed for each stimulus-image in baseline and revisit columns. In the difference column, the average baseline of a given stimulus-image is subtracted from the revisit (revisit – baseline = difference). The Difference column that is highlighted yellow indicates the section that the group has been exposed to in the course.

<table>
<thead>
<tr>
<th>Group B</th>
<th>BL1</th>
<th>BL2</th>
<th>BL3</th>
<th>BL4</th>
<th>BL5</th>
<th>BL6</th>
<th>BL7</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>45.46111</td>
<td>57.90897</td>
<td>60.94555</td>
<td>24.40051</td>
<td>59.87634</td>
<td>68.81075</td>
<td>80.27661</td>
<td>-12.1789</td>
</tr>
<tr>
<td></td>
<td>33.28221</td>
<td>50.27506</td>
<td>59.40496</td>
<td>27.82348</td>
<td>32.13538</td>
<td>67.83869</td>
<td>50.99827</td>
<td>-7.6339</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-1.54059</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3.422976</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-27.741</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-0.97206</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-29.2783</td>
</tr>
<tr>
<td></td>
<td>TAP1</td>
<td>TAP2</td>
<td>TAP3</td>
<td>TAP4</td>
<td>TAP5</td>
<td>TAP6</td>
<td>TAP7</td>
<td>Average</td>
</tr>
<tr>
<td></td>
<td>50.40122</td>
<td>66.27411</td>
<td>72.35244</td>
<td>65.92591</td>
<td>58.9955</td>
<td>70.99957</td>
<td>67.14252</td>
<td>-22.1189</td>
</tr>
<tr>
<td></td>
<td>28.2823</td>
<td>55.95165</td>
<td>48.36055</td>
<td>65.63983</td>
<td>41.29167</td>
<td>59.67516</td>
<td>48.66793</td>
<td>-10.3225</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-23.9919</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-0.28609</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-17.7038</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-11.3244</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-18.4746</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-11.1127</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-14.4169</td>
</tr>
<tr>
<td></td>
<td>HN1</td>
<td>HN2</td>
<td>HN3</td>
<td>HN4</td>
<td>HN5</td>
<td>HN6</td>
<td>HN7</td>
<td>Average</td>
</tr>
<tr>
<td></td>
<td>31.70857</td>
<td>12.36818</td>
<td>36.93755</td>
<td>36.66278</td>
<td>35.21286</td>
<td>75.22804</td>
<td>55.53277</td>
<td>-0.68475</td>
</tr>
<tr>
<td></td>
<td>31.02382</td>
<td>6.063232</td>
<td>40.33746</td>
<td>30.17108</td>
<td>35.95432</td>
<td>83.99321</td>
<td>64.57237</td>
<td>-6.30495</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3.39914</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-6.49171</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.741466</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8.765169</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>9.039599</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.200249</td>
</tr>
</tbody>
</table>

Table 2 is a break down of the individual stimuli for each section for Group B. The subjects of Group B are familiar with material from BL and TAP. The difference values of those first two sections are negative for each of the individual images except for BL image 4. The averages for the whole sections are large negative values. The HN section has an average difference that is slightly positive.
Table 3: Group C Fixation Time on White Space for Individual Stimuli. The Average of group C subjects’ fixation time on white space are displayed for each stimulus-image in baseline and revisit columns. In the difference column, the average baseline of a given stimulus-image is subtracted from the revisit (revisit – baseline = difference). The Difference column that is highlighted yellow indicates the section that the group has been exposed to in the course.

<table>
<thead>
<tr>
<th>Group</th>
<th>BL1</th>
<th>BL2</th>
<th>BL3</th>
<th>BL4</th>
<th>BL5</th>
<th>BL6</th>
<th>BL7</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>41.36954</td>
<td>67.62597</td>
<td>68.07612</td>
<td>31.7594</td>
<td>62.81573</td>
<td>66.56969</td>
<td>93.79795</td>
<td>-12.8607</td>
</tr>
<tr>
<td></td>
<td>30.42262</td>
<td>48.77303</td>
<td>62.42168</td>
<td>26.32272</td>
<td>47.58214</td>
<td>66.28569</td>
<td>60.18153</td>
<td>-10.9469</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-18.8529</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-5.65444</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-5.43668</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-15.2336</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-6.28399</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-3.6164</td>
</tr>
<tr>
<td>BL5</td>
<td>62.81573</td>
<td>47.58214</td>
<td>60.18153</td>
<td>50.47959</td>
<td>73.05196</td>
<td>62.50082</td>
<td>61.4865</td>
<td>-8.78163</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-19.4555</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5.075068</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-8.55314</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3.058659</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-3.57685</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>7.663455</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-4.8541</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group</th>
<th>TAP1</th>
<th>TAP2</th>
<th>TAP3</th>
<th>TAP4</th>
<th>TAP5</th>
<th>TAP6</th>
<th>TAP7</th>
<th>TAP8</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>50.95944</td>
<td>70.495</td>
<td>80.13316</td>
<td>55.32253</td>
<td>59.03274</td>
<td>69.9933</td>
<td>66.07768</td>
<td>53.82304</td>
<td>-3.41659</td>
</tr>
<tr>
<td></td>
<td>42.17781</td>
<td>56.23217</td>
<td>60.67761</td>
<td>60.3976</td>
<td>50.47959</td>
<td>73.05196</td>
<td>62.50082</td>
<td>61.4865</td>
<td>-12.8607</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-8.78163</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-14.2628</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-19.4555</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5.075068</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-8.55314</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3.058659</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-3.57685</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>7.663455</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-4.8541</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group</th>
<th>HN1</th>
<th>HN2</th>
<th>HN3</th>
<th>HN4</th>
<th>HN5</th>
<th>HN6</th>
<th>HN7</th>
<th>HN8</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>35.72224</td>
<td>22.44011</td>
<td>33.22835</td>
<td>40.05065</td>
<td>27.4496</td>
<td>80.70125</td>
<td>53.70813</td>
<td>31.86312</td>
<td>-3.85912</td>
</tr>
<tr>
<td></td>
<td>31.86312</td>
<td>4.643296</td>
<td>27.90469</td>
<td>16.12486</td>
<td>36.15276</td>
<td>96.26665</td>
<td>56.42885</td>
<td>31.86312</td>
<td>-17.7968</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-5.32366</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-23.9258</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8.703163</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>15.5654</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2.720716</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-3.41659</td>
</tr>
</tbody>
</table>

Table 3 is a breakdown of the individual stimuli for each section for Group C. Group C is familiar with the material of all three sections. The averages of all three sections are negative, but the BL section has a large negative value.
Table 4: High MRT Scorer Fixation Time in White Space for Individual Stimuli. The average of each groups’ high MRT scorers’ fixation time on white space are displayed for each stimulus-image in baseline and revisit columns. In the difference column, the average baseline of a given stimulus-image is subtracted from the revisit (revisit – baseline = difference). The Difference column that is highlighted yellow indicates the section that the group has been exposed to in the course.

<table>
<thead>
<tr>
<th>Group</th>
<th>Baseline</th>
<th>Revisit</th>
<th>Difference</th>
<th>Baseline</th>
<th>Revisit</th>
<th>Difference</th>
<th>Baseline</th>
<th>Revisit</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>BL1</td>
<td>71.34</td>
<td>49.159</td>
<td>-22.18</td>
<td>31.781</td>
<td>26.73469</td>
<td>-5.0464</td>
<td>50.4396</td>
<td>58.861</td>
<td>8.42159</td>
</tr>
<tr>
<td>BL2</td>
<td>60.483</td>
<td>55.529</td>
<td>-4.954</td>
<td>65.2899</td>
<td>48.65958</td>
<td>-16.630</td>
<td>70.2439</td>
<td>51.015</td>
<td>-19.2286</td>
</tr>
<tr>
<td>BL3</td>
<td>34.657</td>
<td>48.471</td>
<td>13.81</td>
<td>59.4688</td>
<td>65.78128</td>
<td>6.3124</td>
<td>59.3929</td>
<td>57.866</td>
<td>-1.52652</td>
</tr>
<tr>
<td>BL4</td>
<td>34.730</td>
<td>32.225</td>
<td>-2.505</td>
<td>29.2094</td>
<td>8.523909</td>
<td>-20.685</td>
<td>22.1279</td>
<td>30.078</td>
<td>7.9034</td>
</tr>
<tr>
<td>BL5</td>
<td>75.080</td>
<td>12.182</td>
<td>-62.89</td>
<td>69.5627</td>
<td>21.50535</td>
<td>-48.057</td>
<td>60.6758</td>
<td>44.772</td>
<td>-15.9036</td>
</tr>
<tr>
<td>BL6</td>
<td>82.377</td>
<td>56.514</td>
<td>-25.86</td>
<td>68.6631</td>
<td>52.24192</td>
<td>-16.421</td>
<td>49.4641</td>
<td>65.318</td>
<td>15.8544</td>
</tr>
<tr>
<td>BL7</td>
<td>83.440</td>
<td>74.540</td>
<td>-8.900</td>
<td>87.4089</td>
<td>49.98228</td>
<td>-37.426</td>
<td>92.1329</td>
<td>61.593</td>
<td>-30.5394</td>
</tr>
</tbody>
</table>

The chart in Table 4 shows average fixation time on White Space for individual images for each section and each group. It is expected that the highlighted, familiar, sections would have negative values and the unfamiliar sections would not. This is mostly accurate except for the Group A HN section, which has an average difference of approximately -4.31 and the Group C TAP section that has an average difference of approximately 3.82.
REFERENCES


VITA:
Abenet Ghebremichael
Born 1988

abenet.michael@gmail.com

Address: 124 sheridan Ave. Medford, MA 02155
Cell: (617) 820-4566

Education:
Boston University Class of 2014 – GPA: 3.67
M.A. Anatomy and Neuroscience (Vesalius Program)
Boston College Class of 2011
Pre-Med, B.S. Biology
Boston Latin High School Class of 2006

Relevant Coursework:
Undergraduate - Genetics, Cell Biology, Molecular Evolution, Biological Chemistry,
Biochemistry, Vertebrate Cell biology, Intro to Neuroscience, Cell Biology of the Nervous
System, Cell Physiology and Exercise, Molecular Biology, Research in Biochemistry, Medicinal
Biochemistry and Metabolism, Health and Holistic Living (not including Pre-Med courses and
labs)

Graduate – Medical Gross Anatomy, Biostatistics, Medical Neuroscience, Medical Histology,
Teaching in the Biomedical Sciences, Professional Skills, Journal Club

Lab and Research:

• Gaze tracking Study (current) – Under head investigator Dr Ann Zumwalt. Gaze tracking
software and EEG will be used to analyze whether there is a difference in gaze tracking patterns
between subjects familiar and unfamiliar with given stimuli and whether they correlate with EEG
recognition patterns. Subjects will be drawn from a Medical Gross Anatomy course and tests will
be conducted prior to and after familiarization with course material.
• Boston University Renal Lab – Under head investigator Dr Tamar Aprahamian elucidating the pathophysiology of induced models of murine SLE. Results suggest the connection a specific adiponectin receptor in the pathogenesis of this model. A publication is expected. Laboratory techniques include: tissue harvesting and histological staining. Data was collected with microscopic photography and analysis through Adobe Photoshop.

• Research in Biochemistry – an undergraduate course project to engineer yeast strains that are deficient in specific enzymes linked to yeast anti-oxidative pathways in order to further elucidate the extent of their roles. These enzymes, methionine sulfoxide reductases, have human homologs and are integral in protecting the most easily oxidized amino acid, Methionine. Lab technologies used include: spectrophotometry, DNA/RNA/protein purification, immunoblots, ELISA, gel electrophoresis, SDS-PAGE, 2D PAGE, chromatography.

• Biotechnology Research - I developed a research proposal for the potential alleviating effects of the knockdown of myostatin, a negative regulator of myocyte growth and differentiation, in mouse models of diabetes and metabolic syndrome.

• Molecular Evolution – I used MUSCLE, CLUSTEL and PUBMED as well as other sequence alignment algorithms to investigate evolutionary relationships of genes across species

• Vertebrate Cell Biology - I researched the effects of mutated FGF-23, a transcription factor, and put forth a theory as to how it may be implicated in rickets/osteomalacia and hypocalcemia

**Computer Skills:** proficient in Microsoft Word, Excel, Powerpoint; experience with pharmaceutical software (NexGen); proficient programming ability in Java, Adobe Photoshop

**Employment:**

02/12 – present: Cataldo EMS (EMT) Somerville, MA

• Respond to 911 calls with medical assistance and transport to hospitals

7/08 – present: Northshore ARC (PCA) Boston, MA

• prepare meals, watch over patient and provide homecare/health

1/07 – 04/10: YMCA (lifeguard) Boston, MA
• minor and major medical and rescue emergencies
• surveillance of the pools, enforcing rules and testing and managing pool chemicals
  02/09 – 06/09: Rite Aid (pharmacy tech) Somerville, MA

• filling prescriptions and assisting customers with their orders
• maintaining cleanliness and order and keeping files up to date and stock items accounted for

Volunteer Experience:

8/08 – present: Eritrean-YPFDJ (mentor/active member) Somerville, MA

• organize events, parties, concerts, public awareness functions
• mentor Eritrean youths in the community about cultural history and current events
  06/11 – 9/11: WTC Medical Monitoring/Treatment (intern) Mt Sinai Hospital, NYC

• Preparing outreach material and attending events to educate applicants of medical benefits funded
  by the federal bill, the Zadroga Act
• Shadowing patients and occupational physicians in the health monitoring department
  09/10 – 12/11: Eagle EMS (EMT/first responder) Boston College, MA

• Respond to emergency medical situations and provide scope-limiting care at campus events
  06/11 – 9/11: Lenox Hill Hospital (transporter) Manhattan, NY

• Providing doctors and nurses with equipment, medication and medical supplies

Certs: (Red Cross & YMCA) Life-guard, CPR, First Aid and AED certified, EMT-basic