Available online at:
https://cc.arcabc.ca/islandora/object/cc%3Apsycjournal

J Camosun Psyc Res. (2019). Vol. 1, pp. 20-30.
Submitted April 2019; accepted 3 May 2019.

The effect of fear on brain activity.

Author: Miranda Kohuch*

Supervising Instructor: Michael Pollock, Psyc 215 ("Biological Psychology")

Department of Psychology, Camosun College, 3100 Foul Bay Road, Victoria, BC, Canada V8P 5J2

*Corresponding author email: mirandakohuch97@gmail.com

ABSTRACT

Generalized Anxiety Disorder (GAD) is a severe pathology that has been known to affect the functionality of individuals in their everyday lives even when the presence of a non-fearful stimuli is introduced, however, the effect of anxiety on individuals with GAD is thought to increase and therefore, effect the functionality more in the presence of fear-provoking stimuli. The present study first investigated under longitudinal baseline conditions how fear was related to the brain activity of a Camosun College Psychology student by measuring their prefrontal (frontal EEG and reinforcement-based decision making), hippocampal (free recall performance), and amygdala (heart rate) activity while being non-experimentally exposed to different levels of anxiety-causing stimuli. Correlational analyses revealed that fear was most strongly related to levels of amygdala (r = 0.36) and hippocampal (r = -0.21) activity. In a second study, in order to examine if fear plays a casual role upon hippocampal activity, this relationship was experimentally tested by randomly assigning the participant across days to a high-fear conditioning (horror movies) versus a low-fear condition (non-horror movies). The results showed no statistically significant effect of fearful stimuli upon hippocampal activity. Implication of the study suggest that the experimental level of fear induced within the study was not great enough to produce an effect upon free recall that was able to be reliably detected.

1. Introduction

Generalized Anxiety Disorder (GAD) is a severe mental disorder that produces a global lifetime prevalence of about 2-3% (Diwadkar et al., 2017) and a lifetime prevalence in young people of between 6% to 30% (Mash & Wolfe, 2019). This pathology is commonly categorized through a long-term disruption in daily activities due to the presence of excessive and uncontrollable worry over many activities or events (Mash & Wolfe, 2019). Common symptoms that are seen within individuals with the disorder are irritability, concentration difficulties, difficulty sleeping, and a lack of energy (Mash & Wolfe, 2019) which can be detrimental to the daily functioning of individuals with the disorder to the point where they feel that they are trapped within the realms of their anxiety. It has been shown in past research that individuals with GAD tend to have a greater difficulty with suppression than retrieval in memory tasks (Diwadkar et al., 2017) as well as having to make decisions based on either receiving a reward or punishment following the decision made (White et al., 2017).

Previous studies conducted have shown a reduced amount of activity in brain structures such as the thalamus, cerebellum, hippocampus, and amygdala in individuals with GAD when compared to their healthy counterparts (Diwadkar et al., 2017).

The studies that focus on the cognitive deficits in individuals with GAD, such as suppression and retrieval, as well as the ability to make decisions based on the presence of a reward or punishment (White et al., 2017) have found decreased activity in brain areas that are vital for normal brain function. With regards to suppression and retrieval tasks, Diwadkar and colleagues (2017) proved in their research that, "…GAD participants were characterized by more Suppression-than Retrieval-related hypo-activation…these effects suggested that GAD confers susceptibility for processes of memory control…" (p. 46). Whereas, White and colleagues (2017) showed in their research that, "…individuals with generalized anxiety disorder showed impaired reinforcement-based decision making…during feedback, they showed a reduced correlation between PE and BOLD responses within the ventromedial prefrontal cortex… [and the] dorsomedial prefrontal cortex… relative to healthy comparison subjects." (p113-114) suggesting that GAD does have an effect on the ability to make decisions as well as with suppression and retrieval of memories.

In the current study, based on the previously reported decrease in hippocampal and amygdala activity seen in GAD patients, it was hypothesized that as fear/anxiety levels increase, then hippocampal, prefrontal and amygdala activity would decrease. The final hypothesis stated that as fear/anxiety levels increased, reward system activity would decrease as well. The hypotheses for the study were based on the previous research that individuals with GAD experience under-engagement in brain regions such as the hippocampus and amygdala when asked to retrieve information following a suppression task. This rationale led to the interest to further investigate the effect that anxiety/fear has on the reward system since it had been proven to cause an effect in the ventromedial and dorsomedial prefrontal cortices.

2. Methods

2.1 Participants

An individual Psychology student from Camosun College was recruited to participate within the current study. The students current age was 21, and the student identified as female in terms of their gender. The participant at the time of these studies had been diagnosed with General Anxiety Disorder and was currently taking a selective serotonin reuptake inhibitor (SSRI), citalopram at a dosage of 40 mg.

2.2 Materials and Apparatus

The materials used in this experiment were a 13-inch MacBook Air laptop and the software PEBL: Psychology Experiment Building Language, in order for the participant to complete free recall tests. The "Non-Horror" films (e.g., Aladdin) and "Horror" films (e.g., Silent Hill, see Table 3 for full list) were watched on the streaming service, Netflix, or rented from the iTunes Store, and watched on an Apple TV on an approximate screen length of 30-inches. On plain, white standard printer paper cut into pieces approximately 1.00cm by 6.00cm, the names of specific horror movies were written onto the slips or the term "Non-Horror" which indicated the type of film that was expected to be watched that day. The pieces of paper were all placed in a small,

yellow bucket and each slip of paper was folded in half.

2.3 Procedure

2.3.1 Baseline Study

Each of the four different hypotheses were tested for a maximum of 12 days, and the correlations between the independent variable (fear/anxiety) and the dependent variables (hippocampal, prefrontal, amygdalae, and reward system activity) were recorded in order to find the hypothesis with the largest negative correlation. The level of anxiety/fear was determined through the use of the Pollock Modified-POMS Scale (Appendix A) and the level of anxiety was rated on a scale from 0 to 100, where 0 being "Not at all" and 100 being "Extremely". The level of fear/anxiety determined through the use of this scale was used for all four hypotheses' daily fear/anxiety level that would correspond with the different dependent variables measured each day. The level of significance set in this experiment was .05.

The participant was subjected to four different procedures for the baseline portion of the study in order to test each of the four dependent variables. Since the participants brain activity in the hippocampus, prefrontal cortex, and amygdala was unable to be recorded directly from the structure itself, a series of tasks were performed in order to gain an indirect measurement of the level of brain activity within each of the areas. To test for hippocampal activity, a free recall test was administered for three trial runs. The free recall test was used through the program PEBL (The Psychology Experiment Building Language) and was administered in three different trials where the participant was momentarily shown ten different words (e.g., SERVE, COSTUME, BLANKET) that they were expected to recall once the final word had been presented on the screen. The values that the participant recalled correctly were tabulated up and divided by the total number of words (thirty) that were presented to the participant in order to receive an overall percentage that represented the level of activity that may be present alongside a certain level of fear/anxiety. This variable was measured two-times daily over the span of the 12 days at different times of the day in hopes to account for differing anxiety levels, and the average score from the trials at two different times of the day were averaged out in order to find the average recollection rate corresponding to the daily anxiety level.

When testing the prefrontal and the amygdalae activity, the participants underwent different testing methods twice-daily for the 12 days in order to indirectly measure the activity in these structures. To determine the activity within the prefrontal cortex, a MUSE headband was placed along the participants forehead for one minute of recording. Under each of the sections, Alpha_AF7 and Alpha_AF8, the activity reading at each 10 second mark for one minute was written down to produce a total of 6 readings per column. The six values in each column were then averaged out by adding them all together and dividing the value by six, and then the singular values produced within each column were averaged together in order to provide a single value corresponding to prefrontal activity at different anxiety levels. To test for amygdalae activity, the heartrate of the participant was recorded for one minute. The participant measured their own heartrate by placing their pointer and middle fingers along the carotid artery located within the cervical region. The number that the participant counted was doubled in order to account for the second pulse that is not so easily felt as the dominant one. The heartrate

values of the two daily trials were averaged out in order to provide a singular value which represents the arousal level of the participant at the daily anxiety level.

The final hypothesis was tested through the use of a self-made questionnaire (Appendix B) that was created with the purpose to evaluate the severity of difficulty for making a certain decision. Each time a decision was made that was of significance (e.g., which route to drive to school), the participant would write down what the decision was, what time the decision was made at, as well as rate the difficulty of the decision on a 5-point scale, in which 5 being "Very Difficult" and 1 being "Very Easy". Before the participant was to go to bed, the difficulty levels were all added together, and an average value was recorded based on the number of decisions that day. The value that represented the average difficulty level of decisions that day was compared with the daily fear/anxiety level from the Pollock Modified-POMS scale.

2.3.2 Experimental Study

The participant was tested through random assignment to either an experimental or controlled condition in which they were instructed to watch a film based on which slip of paper they drew from the yellow bucket. Based on either pulling a strip with the name of a specific horror movie, or a slip that simply read "Non-Horror", the participant was expected to watch the assigned film, or a film of choice that was not considered a horror film. Once the film was finished for the non-horror film, the participant completed three trials of the free recall test using PEBL Testing and took the average percentage of correctly recalled words. If the participant was assigned to watch a horror film then, at the point in the film when the participant believed they were at the height of their anxiety/fear, they completed three trials of the free recall test using PEBL Testing in which the average of correctly recalled words was recorded. The participant ensured that they were able to watch a maximum of 6 horror movies in order to ensure that no harm came to the participant or others and the participant was not forced to finish the film if they did not wish to do so once the free recall tests had been completed.

3. Results

3.1 Baseline Study

Levels of anxiety/fear were measured through the use of the Pollock Modified-POMS scale and were compared alongside four different dependent variables (see Figures 1, 2, 3, and 4). Each of the four dependent variables produced different values based on their correlations with anxiety/fear levels (see Table 1). When measuring the hippocampal (r = - 0.21, p = 0.522), prefrontal (r = -0.05, p = 0.874), and reward system activity (r = -0.14, p = 0.668) a negative correlation was observed between the variables meaning that as one variable increased, the other variable decreased. Pertaining to how amygdalae activity related to the different daily anxiety/fear levels, a positive correlation resulted (r = 0.36, p = 0.263) which showed the largest correlation out of all four of the dependent variables on their independent variable. Although the correlation between amygdalae activity and anxiety level was the largest, the effect of fear on hippocampal activity provided a negative correlation (r = - 0.21, p = 0.522) with the largest of the three negative correlations, and was therefore used to test for the Experimental portion of the study in order to investigate further whether increasing anxiety/fear levels will decrease the activity of the hippocampus.

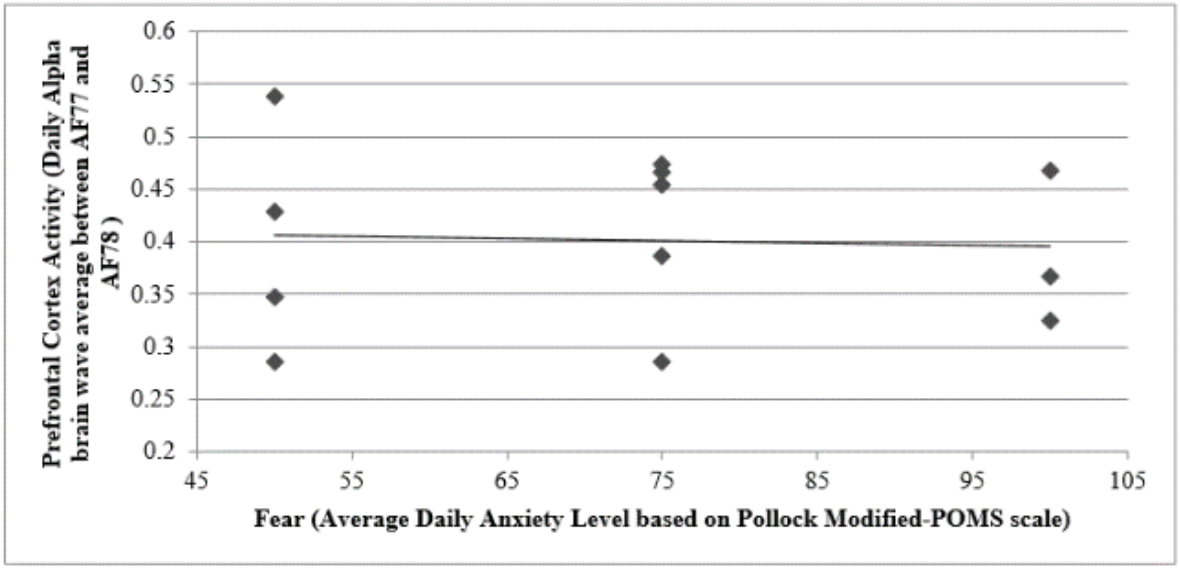

Figure 1. Average of daily prefrontal brain waves between AF7 and AF8 at an average of daily anxiety level.

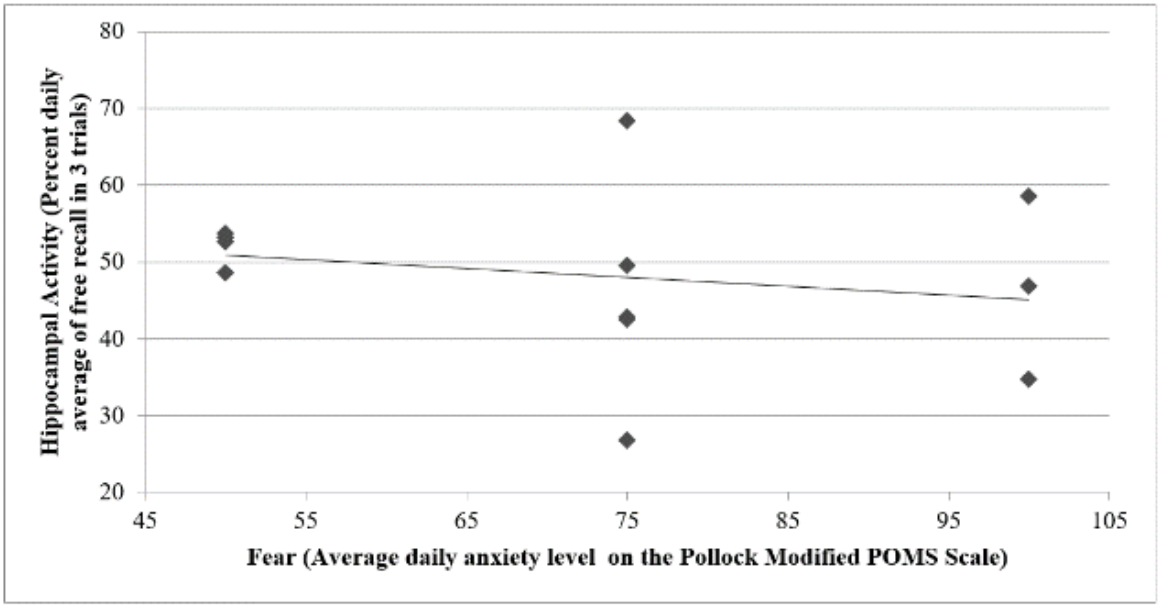

Figure 2. The average of daily, correctly recalled words using a free recall test at an average daily level of anxiety

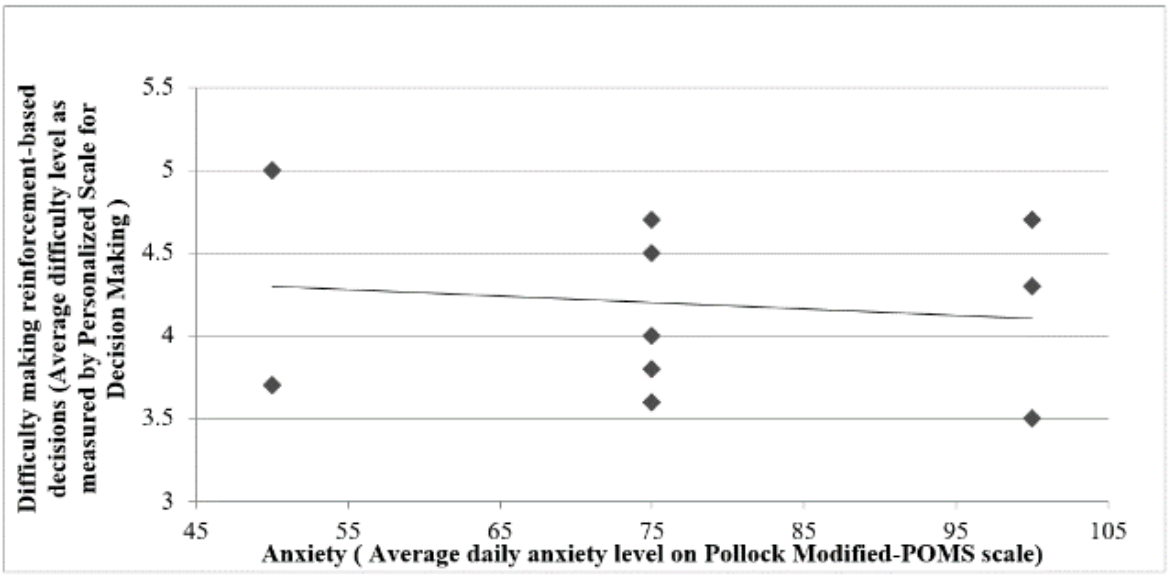

Figure 3. Average daily heartrate from a collection throughout the day with the corresponding average of daily anxiety levels.

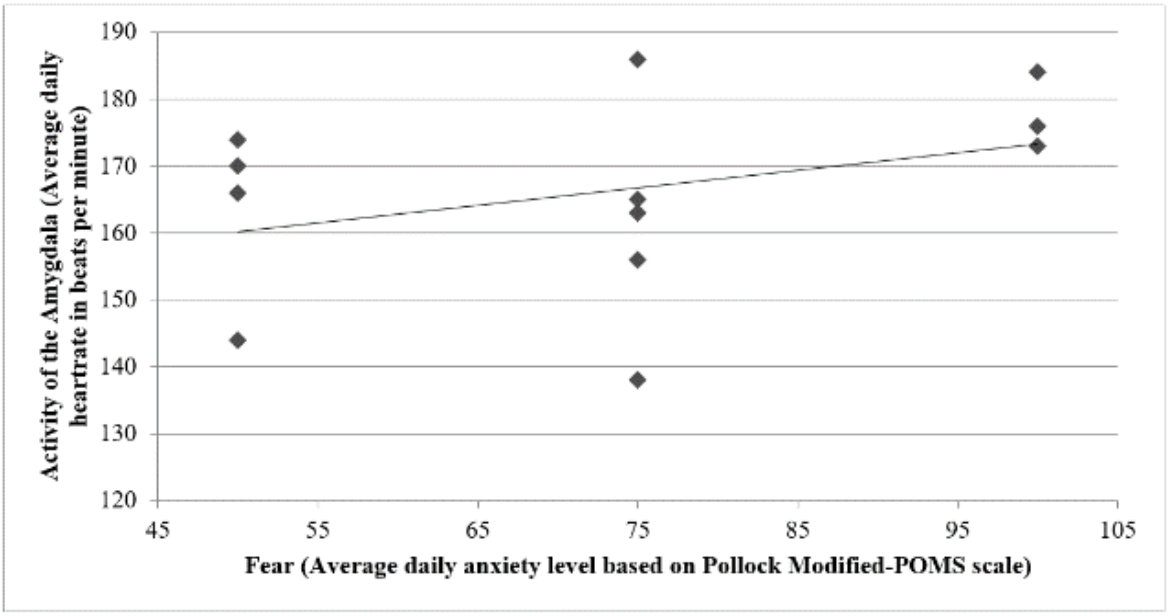

Figure 4. Average daily difficulty with reinforcement-based decision making based on a daily, average anxiety level.

Table 1

Baseline correlation coefficient (r) values.

Hypothesis examined	*r*
Level of Fear and Prefrontal Cortex Activity	- 0.05
Level of Fear and Hippocampal Activity	- 0.21
Level of Fear and Amygdala Activity	0.36
Level of Anxiety on Reinforcement-Based Decision Making	- 0.14

Table 2

Experiment descriptive statistics.

Condition name	Statistic	Value
Watching a Horror Movie	Mean	36.51666667
	S.D.	7.624806008
	N.	6
Watching a Non-Horror Movie	Mean	46.86666667
	S.D.	9.865833298
	N.	6

Table 3

List of the specific Horror Movies

Horror Movies Assigned	**Non-Horror Category**
The Grudge	**Non-Horror**
Silent Hill	**Non-Horror**
The Conjuring	**Non-Horror**
The Orphanage/ El Orfanato	**Non-Horror**
White Noise	**Non-Horror**
Darkness Falls	**Non-Horror**

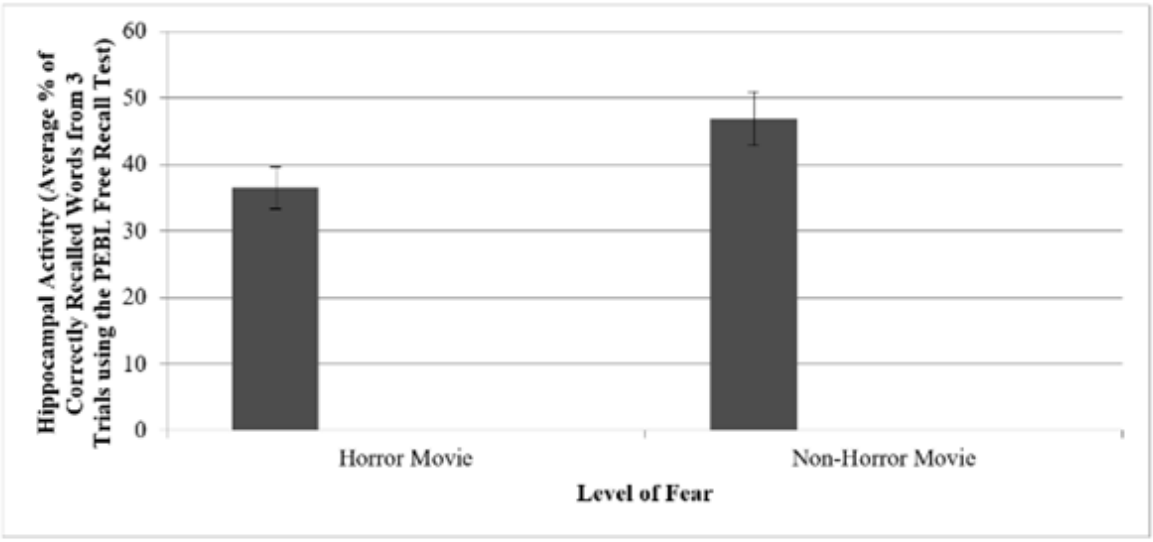

Figure 5. Average percent of correctly recalled words after watching a film either labelled as a horror movie or a non-horror film.

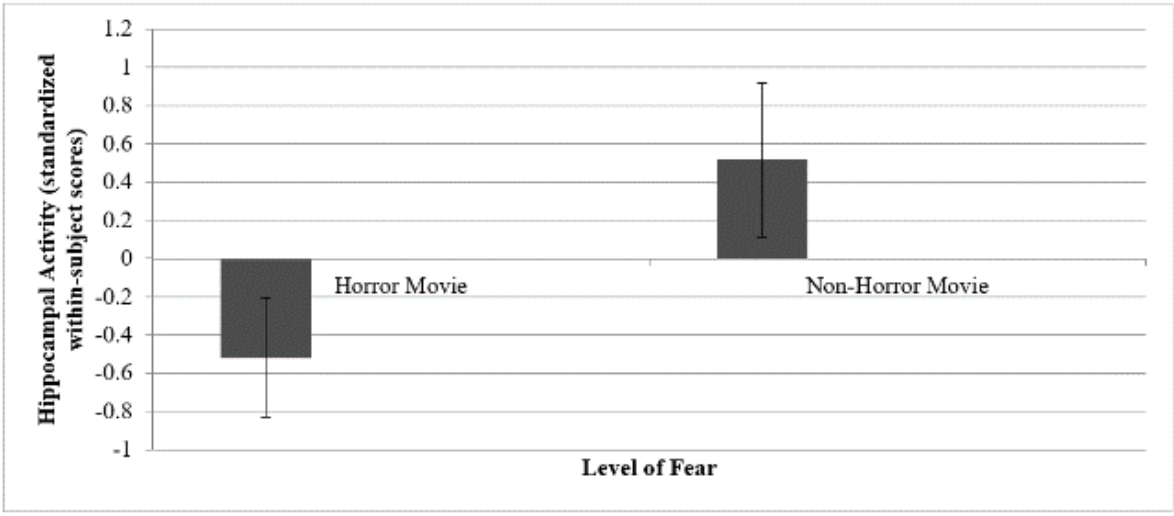

Figure 6. Paired Samples t-test regarding the mean difference between the level of fear and hippocampal activity as tested using a free recall test.

3.2 Experimental Study

The mean of correctly recalled words under controlled conditions of watching a "Non-Horror" film was 46.8 (*SD* = 7.62) and the mean of correctly recalled words under experimental conditions, watching a "Horror" film was 36.5 (*SD* = 9.86) (see Figures 5 and 6). These data results were analyzed using a *t*-test and the results were not statistically significant, t (10.0) = 2.03, p = .07 (see Table 2).

4. Discussion

The present study was first carried out under longitudinal baseline conditions in order to determine how the effects of anxiety/fear affect an individual with Generalized Anxiety Disorder (GAD) who was a Psychology student at Camosun College. The hypotheses predicting that an increase in anxiety/fear levels will cause a decrease in activity within two different brain regions, the hippocampus and the prefrontal cortex, proved to be expressed through the negative correlations shown in the results. Another negative correlation to note that approved the original hypothesis above, but with a decrease in reward system activity instead of a brain structure. There was also a negative correlation between the two variables which proved that as one increased, the other would decrease. The hypothesis that did not conclude to be accurate was that as anxiety/fear levels increased, there would be a decrease within amygdalae activity. The hypothesis was proven as untrue due to a positive correlation being present following the Baseline Study.

Results from the present study support the findings from past studies in which hippocampal and amygdalae activity had decreased in individuals with GAD compared to their healthy counterparts when being asked to perform multiple suppression-retrieval tasks (Diwadkar et al., 2017). Past research has also found that there has been hypo-engagement within multiple regions of the brain within the medial lobe, containing the hippocampus and amygdala (Diwadkar et al., 2017) which showed a negative correlation for fears impact on hippocampal activity, yet a positive correlation between fear levels and amygdalae activity. The present findings also supported the results of a study that compared healthy controls with individuals who were diagnosed with GAD to see how well they performed while making decisions based on the context of a reward or punishment being present at their moment of choosing (White et al., 2017).

A major limitation in the study was that there was only one participant. This one participant only represented the age of 21, female, with GAD and taking a SSRI medication. The study may have been better executed if there was a diversity of participants who participated within the study, including but not limited to: gender, age, culture, and level of anxiety they experience. Over the span of the 12 days in which the Baseline Studies occurred, a wide range of anxiety levels had been present based on the Pollock Modified-POMS scale. The fluctuating anxiety/fear levels could have affected the results by affecting the significance that the anxiety/fear levels have in conjunction with each of the dependent variables which would have affected the correlation values within the Baseline Study period by giving an unreliable correlation value to test in the Experimental portion of the study. Based on participant comments, they had been anticipating having to watch horror movies at some point during the 12-day span of the experimental procedure, which may have affected the results on the

days under controlled conditions, possibly producing a higher anxiety level.

Since the results of the Experimental portion of the experiment were not statistically significant, this implies that while non-significantly associated in baseline conditions, the level of fear experimentally induced within the study did not produce an effect upon free recall that was great enough to be reliably detected. Since the current study was unable to determine whether anxiety/fear does cause a decrease in hippocampal activity, future studies should focus on studying which structures undergo hypo engagement when anxiety increases, in order to reduce the negative effects that anxiety can have on individuals in their daily lives. Future studies need to prioritize this to ensure that individuals with GAD are able to reduce daily distress by providing them with some effective strategies for reducing the feeling that they are living their life within the boundaries of their anxiety disorder.

References

Diwadkar, V.A., Re, M., Cecchetto, F., Garitto, M., Piccin, S., Bonivento, C., … Brambilla, P. (2017). Attempts at memory control induce dysfunctional brain activation profiles in generalized anxiety disorder: An exploratory fMRI study. *Psychiatry Research. Neuroimaging, 266*, 42-52. https://doi.org/10.1016/j.psychresns.2017.05.010

Mash, E. J., & Wolfe, D. A. (2019). *Abnormal child psychology* (7th ed., pp. 376). Boston, MA, Cengage Learning, Inc.

Pinel, P.J.J, & Barnes, J.S. (2018). *Biopsychology* (10th ed., pp. 491). Hoboken, NJ, Pearson Higher Education, Inc.

White, S.F., Geraci, M., Lewis, E., Leshin, J., Teng, C., Averbeck, B., … Blair, K.S. (2017). Prediction error representation in individuals with generalized anxiety disorder during passive avoidance. *The American Journal of Psychiatry, 174*(2), 110-117. https://doi.org/10.1176/appi.ajp.2016.15111410

Appendix A

The Shortened Unidirectional but Multifaceted version of the Profile of Mood States (SUM-POMS) Scale

by Dr. Michael Pollock, Camosun Psychology

Part A. – Individual Negative & Positive Moods

Using the 0 to 100 range scale shown below, for each of the following moods indicate HOW MUCH YOU ARE FEELING THEM RIGHT NOW.

0	25	50	75	100
Not at all	A Little	Moderately	Quite a lot	Extremely

Negative Moods

MOOD SCORE

Anxiety _____

Adjectives: *Tense, On Edge, Uneasy, Restless, Nervous, and Anxious*

Appendix B

Personalized Scale for Decision-Making

Time of Decision Made: _____

Date of Decision Made: _____

What was the decision you had to make?

_____

_____

_____

Please indicate by circling a box of how difficult/easy it was to make the above decision:

Very Difficult	Somewhat Difficult	Neutral	Somewhat Easy	Very Easy
5	4	3	2	1