FEAR AND ANGER AT RETRIEVAL IMPACT MEMORY PERFORMANCE

by

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Negative emotions have been shown to affect memory formation, but research on how emotion affects memory retrieval is limited. The current study attempts to answer how fear or anger at retrieval affects how well neutral information is remembered. Participants read a neutral story and then completed a 2-minute distractor task. To induce the intended emotion, the participants watched a 2-minute emotion inducing video that put them in one of three conditions, fear, anger, or no emotion; this video was followed by two memory tests measuring the retrieval of the neutral story using a free recall and multiple-choice memory test. Finally, they self-reported on the emotions they felt from watching the video. A total of 261 participants were recruited from the UO Human Subjects Pool. Of those participants, 87 did not effectively complete the distractor task or the memory tests and were excluded from the data. Analysis of every participant regardless of how well the video created the intended emotion showed no significant results. However, within the 72 participants who felt the intended emotion from their video condition, there was a significant main effect of emotion on the participant's ability to recall exact words from the neutral story. The neutral condition performed the best, then fear, then anger. A third exploratory analysis sorted participants by which emotion they reported as feeling the strongest, and this analysis showed that those who felt sadness recreated the neutral story better than those who felt anger. This study has implications for real world situations, such as eyewitnesses in court who are put in emotionally charged situations and asked to remember an event.

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Introduction

Negative emotions are part of being human. Although some encourage controlling and suppressing negative emotions (Mamat & Anderson, 2023) and others encourage leaning into negative emotions (Ford et al., 2018), they are an undeniable part of being alive. Negative emotions can sometimes disrupt quality of life (Apter et al., 1988), and perhaps negative emotions can also disrupt episodic memory.

Episodic memory is the recollection of an experience, like remembering a favorite movie or a story from childhood. Episodic memory is crucial to a person's everyday functioning. Without episodic memory, it would be challenging to understand the context of an event or even form a coherent sense of self. Episodic memory is also important because it is used in instances like an eyewitness testimony in court or remembering a morning routine to wonder where a set of keys might be.

To understand how episodic memory functions, it is important to understand encoding and retrieval. Encoding is the act of putting a memory into long term memory. When a memory is stored in long term memory, it is encoded. Retrieval is the act of bringing a memory back into conscious thought. When a memory is brought back to mind, whether prompted or unprompted, it is retrieved. Memory is always subject to change. Long term memory does not function like an art museum, where memories can be viewed without being altered. Instead, each time a long-term memory is retrieved, it is re-encoded a little bit differently.

In cognitive psychology, negative emotions affect episodic memory (Bisby et al., 2017). Past scientific research has looked at how emotional experiences can affect the accuracy of a memory. Flashbulb memories are memories of learning about a significant and emotion inducing public event. Research on flashbulb memories shows that participants report remembering these

flashbulb memories with great confidence but are often very inaccurate about the details of the actual event (Hirst & Phelps, 2016).

The literature on the intersection between emotion and memory includes several previous studies that have shown that negative emotions can significantly impact memory performance. Simpson & Sheldon (2020) found that negative autobiographical memories were remembered with greater accuracy than positive or neutral episodic memories. Similarly, Sharot (2006), found that emotion enhances the accuracy of episodic memories. Finally Minor & Herzmann (2019) found that memories with negative emotional valence led to increased performance in item and source memory compared to memories with neutral emotional valence. All these studies concluded that negative memories are recalled better than neutral memories.

However, these studies, and most of the research in this field, have looked at the influence of negative emotions during the formation of a memory (memory encoding). Whether the memory itself is inherently emotional or the environment where it was encoded induced emotions, the scope of the literature addressed in this review only encompasses the encoding part of long-term memory. There is limited literature exploring the effect of negative emotional state during memory retrieval on the recall of neutral memories. The current study aims to fill this gap in the literature by investigating the impact of fear and anger during memory retrieval on the recall accuracy of neutral information.

The objective of this thesis is to further the exploration of how these two concepts are interlinked by investigating how emotions, specifically negative emotions, can affect a person's memory accuracy. The primary research question is, "How do anger and fear at retrieval affect memory of neutral information?" The answer to this question will contribute to the literature on emotion's role in episodic memory.

To methodology to answer this question was a behavioral experiment on a computer that had participants memorize a neutral story, induced them with either fear, anger, or no emotion, and had them recall the story in a free response and multiple choice test.

Literature Review

There were two hypotheses in this study. The first hypothesis is that anger at retrieval would lead to worse recall of a neutral story, compared to no emotion. The second hypothesis is that fear at retrieval would lead to worse recall of a neutral story, compared to no emotion. The rationale behind the hypotheses was derived from the current literature on emotion, episodic memory, and attention. Attention plays a crucial role in determining which memories are stored in long-term memory. A study done by Öhman et al. (2001) found that negative memories draw much more attention compared to neutral or positive memories, leading to better memory of the negative memories. In the present study it was assumed that the participant's attention will be drawn to their current emotional state (because of the emotion inducing video) rather than their memory of the neutral information. Therefore, in the fear and anger condition, the negative emotional state will divert participants' attention away from the neutral story, leading to less accurate recall of the story compared to those with a neutral emotional state.

Another study researched the effect of stressful situations in a classroom. When students were under stressful situations while encoding new memories, they were less likely to recall details compared to learning in non-stressful environments (Vogel & Schwabe, 2016). This study is different from the current study because it examined semantic memory instead of episodic memory and stress instead of fear and anger. However, it is likely that the results of the current study will be similar to the classroom study because both episodic memory and semantic memory are types of declarative long-term memory (Lum & Conti-Ramsden, 2013), and stress is represented in the brain in a similar manner to fear and anger. This is because (to estimate) emotions are represented in the brain in three major areas, the amygdala, the insular cortex, and the periaqueductal grey. Of these structures, the amygdala is most closely associated with fear

and anger, the emotions investigated in the current study, and anxiety, closely related to stress (Lindquist et al., 2012). It is therefore plausible that fear and anger create the same results with episodic memory that stress does with semantic memory.

In contrast to these findings, an additional study showed that a memory with negative emotional valence improves the accuracy of that memory compared to a neutral memory (Cahill et. al.,1998). To find these results, the study investigated the impact of stress hormones, such as epinephrine and cortisol, on memory consolidation. It found that these stress hormones, which are released when a participant is feeling negative emotions, lead to better consolidation of memory. Since fear and anger release stress hormones (Merz & Wolf, 2022), the results of this study could mean that in the current study the fear and anger conditions could release stress hormones in the body that would lead to better recall of the neutral information. Despite this possibility, the more likely scenario is that the stress hormones will only enhance the recall of the emotion inducing video (which is not measured in the current study) but decrease the likelihood that they would remember the neutral information.

This literature indicates that negative emotions at retrieval would decrease memory performance. This leads to the two main hypotheses for this research study. The first hypothesis was that feeling anger at retrieval would lead to worse recall of a neutral story, compared to no emotion. The second hypothesis was that feeling fear at retrieval would lead to worse recall of a neutral story, compared to no emotion.

Fear and anger were chosen as the emotions for this research study because they are distinct emotions according to Paul Ekman's theory of emotions. Ekman’s theory suggests that there are six core emotions: anger, disgust, joy, fear, sadness, and surprise (Ekman & Davidson, 1994). Surprise is not included in this thesis because at the time of the experimental design,

further research suggested that surprise is not actually a basic emotion (Ortony, 2022). However, research published after the data collection of this thesis challenges that view and reinstates surprise as a basic emotion (Neta & Kim, 2023). Regardless, this work uses anger, disgust, fear, joy, and sadness as the five basic emotions. Fear and anger were the only two emotions that were induced, but the other three emotions were included when the participant self-reported on their emotions. Fear and anger were also ideal because they are likely easier to induce consistently in participants than sadness or positive emotions.

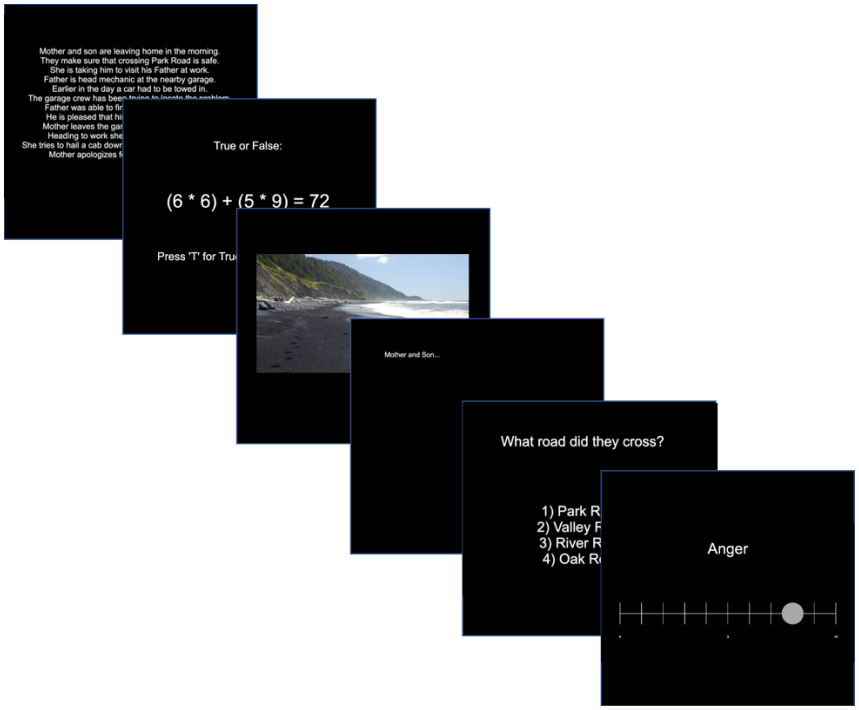
Methods

Participants

This study concerns the effect of negative emotional state at retrieval on the performance of episodic memory. For 80% power with an alpha level of 0.05 and a moderate effect size of 0.33, 90 participants were needed for the study, 30 in each condition. In the end, 261 participants were recruited from the UO Human Subjects Pool and of those, 87 participants did not effectively complete the study and were excluded from the data. They were excluded because they scored below-chance (below 50%) on the true or false math questions (with the assumption that they were not paying attention to this aspect of the study and therefore might not have been paying attention to other aspects of the study), or they did not recreate the neutral story for the free response memory test. More participants were recruited than initially intended because many participants did not report feeling the emotion they were intended to feel from their emotion induction video condition. Eventually data collection was stopped, due to time constraints, although the intended number of thirty participants that felt the intended emotion in each condition was never met.

Experimental Design

Figure 1: Experimental Design



This figure shows the steps the participants completed to progress through the study. First they memorized the neutral story, then they completed a math task to avoid continuous rehearsal of the story, then they watched a video designed to induce either fear, anger, or no emotion, then they recreated the story in a free response format to assess unprompted recall abilities, then they answered multiple choice questions to assess prompted recall abilities, and finally they self-reported on their emotions to check that they felt the emotion that they were supposed to feel from the video.

The study was a 30-minute computer task conducted in an isolated room to minimize distractions. To begin the study, each participant read a neutral story on a computer that was 12 sentences long, formatted so that each sentence was on its own line. The story was neutral because none of the words have strong negative or positive connotations. The story is about a son visiting his father, a mechanic, at work. This story had been used in multiple previous studies as a neutral story to be memorized by participants, which is the same function to how it is used in the current study (Heuer & Reisberg, 1990).

Mother and son are leaving home in the morning.
They make sure that crossing Park Road is safe.
She is taking him to visit his Dad at work.
Father is head mechanic at the nearby garage.
Earlier in the day a car had to be towed in.
The garage crew has been trying to locate the problem.
Father was able to find the broken connection.
He is pleased that his son watched the repair.
Mother leaves the garage being late for her job.
Heading to call work she passes a police station.
Mother apologizes for her delay to her boss.
She tries to hail a cab downtown at the number 3 bus stop.

The participants were instructed to read the story twice and attempt to commit it to memory. They had as much time as they needed but must try to memorize it for at least two minutes. This meant that they could spend more, but not less, than two minutes on this section of the study.

When they were done reading the story, they completed a math task, evaluating two-step math equations (e.g., (1*10) + (4*3) = 17) as true or false. This distraction task forced their attention away from the story and stopped them from repeating the story to themselves or using other techniques to keep the story in their working memory. The math distractor task took about two minutes to complete.

Afterwards, the participants were shown one of three videos, a fear inducing, anger inducing, or neutral video. Emotion inducing videos can reliably create fear and anger in participants (Uhrig et.al., 2016). The fear inducing and neutral videos were from the Database of Affective Videos (Israel et al.,2021). This database has 188 emotionally valent videos intended to create a specific emotion in the viewer. The videos in this library were curated by 422 people viewing them and rating them on various emotions. The neutral video chosen from this database was rated highly on indifference, satisfaction, and no emotion, and rated low on all other emotions. It featured a camera moving slowly across a beach scene as if the person watching the

video was walking on a beach. The fear video was rated highly on anxiety and fear, and low on all other emotions. This video showed feet on a bed and strange creatures darting in and out of the screen as if the viewer was lying in bed with unnerving creatures crawling around them. The anger video was taken from a previous study which used this video to create anger in participants (Devilly, & O'Donohue, 2021). This video was a report of animals being abused, first it showed a dog starved by its owner, then cats kept in squalor conditions, and then a dog being kicked. Participants who watched the fear inducing (lying on the bed) video were part of the fear condition, those who watched the anger inducing (animal abuse) video were part of the anger condition, and those who watched the neutral (beach) video were part of the neutral condition. ⅓ of the participants were in each condition.

Figure 2: The Three Videos Used in this Study

This figure shows a screen capture of each of the videos used in this study.

After watching whichever video was part of their condition, the participants were asked to recreate the neutral story about the mechanic as best as they could from memory. They were instructed to recreate it with the exact words and format of the original. They had to take at least two minutes to write, but there was no time limit for this part of the experiment. When the participants finished recreating the story, they were given a multiple choice quiz with 12

questions, one from each line of the story. The questions asked about specific details from the story and the participant selected the correct choice from four possible options.

What road did they cross?

1.Park Road

2.Valley Road

3.River Road

4.Oak Road

Finally, the participants self-reported their emotions on a 20-point 0-10 slider scale (.5 scores were available). This occurred after the memory tests to ensure that the emotions from the induction video were still present. The self-report acted as a manipulation check to see if the video was effective in producing the intended emotion in the participant.

Data Analysis

For this project, three methods of analyzing the data were used. In each one there are three different measures of memory accuracy. Two measures came from the free response test and one from the multiple choice test.

Exact Word Recall Measure

To score the free response test, the story that the participants created was compared to the original text by counting the number of overlapping words between them. Filler words, such as "and" or "the", were removed from the original text which left 55 words from the story. The free response from each participant got a score of how many of the 55 words were included in their text. This measurement assessed how well participants could recall exact words from the story, which is a feature of an accurate memory of the story. A higher number of overlapping words between the participant's response and the original text leads to a higher exact word recall score. Here are the words that made up the list:

> Mother, Son, Leaving, Home, Morning, Make, Sure, Crossing, Park, Road, Safe, Taking, Visit, Dad, Work, Father, Head, Mechanic, Nearby, Garage, Earlier, Day, Car, Towed, Crew, Trying, Locate, Problem, Father, Find, Broken, Connection, Pleased, Son, Watched, Repair, Leaves, Late, Job, Heading, Work, Passes, Police, Station, Apologizes, Delay, Boss, Tries, Hail, Cab, Downtown, Number, 3, Bus, Stop

The exact word recall measure was a measure of verbatim memory. This means that if a participant remembered the gist of a story but did not write the exact same words (such as using "bus station" instead of "bus stop"), they would not receive points for those words, even though they remembered that moment in the story. Also, if a participant wrote a word from a different point in the story somewhere else, they would get a point for that word even though they did not accurately remember it (such as incorrectly writing "stop at Park Road" at the beginning but getting the point for "stop" from "bus stop", even though they forgot that section).

Semantic Similarity Measure

Another measure of the free response test looked at the overall recall of the story regardless of whether the exact words were used. An AI (Artificial Intelligence) tool called the Universal Sentence Encoder that compares language was used to compare the participant's response to the original story. Each participant's free response was entered into the AI code and was compared to the original neutral story. The Universal Sentence Encoder works by creating a sentence level embedding of a 512-dimensional vector that can be combined with other sentence vectors to create one vector for a multiple sentence block of text. This vector is compared to the vector of a different block of text, and the Universal Sentence Encoder then generates a correlation score from 0-1.0 that signifies the semantic similarity between the two vectors (Cer et al., 2018). In the current study, that correlation score represented how similar the participant's response was to the original story. The higher the correlation, the more similar the response. This

semantic similarity measure investigates a different aspect of the free response test than the exact word recall measure.

Prompted Recall Measure

The final measure of memory accuracy examined whether a participant would remember a detail of the story when prompted. To achieve this, each participant took a twelve question multiple choice quiz. Each question of the quiz asked about a detail from one line starting with line 1 and continuing until line 12, the final line of the story. Each question had four possible answers labeled A, B, C, or D, and the participant had to choose the correct one. Participants took this test after the free response test so that the questions would not jog their memory before they tried to recreate the story. Most participants did perfectly or almost perfectly on the test, which made the results close to the ceiling. This made it harder to decipher whether a trend existed in the data, because the trend might be muted by the ceiling effect.

All comparisons between conditions were performed using one way between-subject ANOVAs.

Results

Emotion Induction Manipulation Check

At the end of the study the participants rated their emotions on the five emotions from Paul Ekman's theory of emotions; anger, disgust, fear, joy, and sadness. The rating scales were Likert scales from 0-10. This self-report measure was used as a manipulation check to ensure that the participants felt the emotion that they were supposed to feel according to the video condition that they were a part of. However, the emotion inducing videos were not always effective in inducing the intended emotion, according to this self-report measure. To account for this, the results were analyzed in three ways, an All Participant Analysis, an Intended Emotion Analysis, and a Strongest Emotion Analysis.

All Participant Analysis

The All Participant Analysis of the data did not consider the participants' scores on the self-report of emotions. This analysis included everyone who effectively completed the study, regardless of whether they felt the intended emotion, and compared the results between the fear, anger, and neutral conditions on semantic similarity, exact word recall, and prompted recall. This analysis examined whether memory accuracy was affected just from watching an emotion-inducing video, even if the self-report showed that it did not induce the intended emotion.

Table 1: Participants in All Participant Analysis

Video Condition	# of Participants
Anger	59
Fear	58
Neutral	62

Induced Emotion Analysis

The Induced Emotion Analysis of the data only included those who reported feeling the emotion that aligned with their condition. For those who watched the fear video, they were only included in this analysis if they rated fear as high or higher than the next highest emotion. If the participant was in the anger condition, then they were only included if they reported feeling anger as much or more than any other emotion. For the neutral video, participants were included if they did not report feeling fear or anger most strongly.

Table 2: Participants in the Induced Emotion Analysis

Video Condition	# of Participants
Anger	13
Fear	24
Neutral	40

Strongest Emotion Analysis

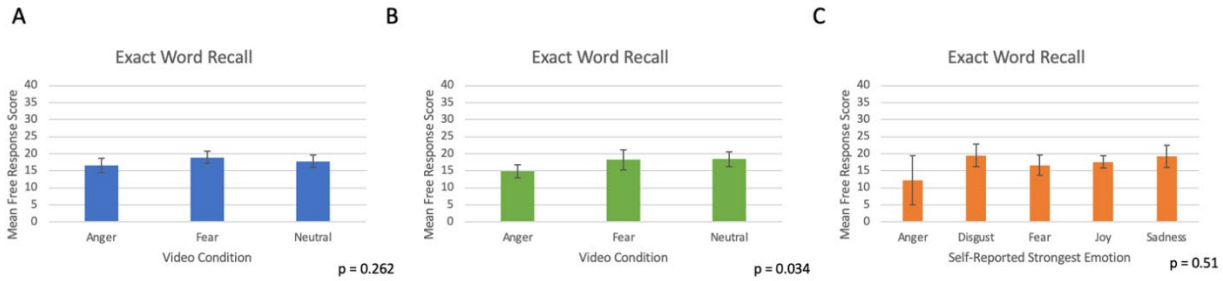
The Strongest Emotion analysis is an exploratory analysis that ignored the videos the participants watched and grouped them by the emotion they ranked the highest. This excluded the participants who rated multiple emotions as the highest score and sorted the rest into anger, disgust, fear, joy, and sadness.

Table 3: Participants in the Strongest Emotion Analysis

Self-Reported Strongest Emotion	# of Participants
Anger	6
Disgust	10
Fear	19
Joy	61
Sadness	29

Exact Word Recall Results

Figure 3: Exact Word Recall Results



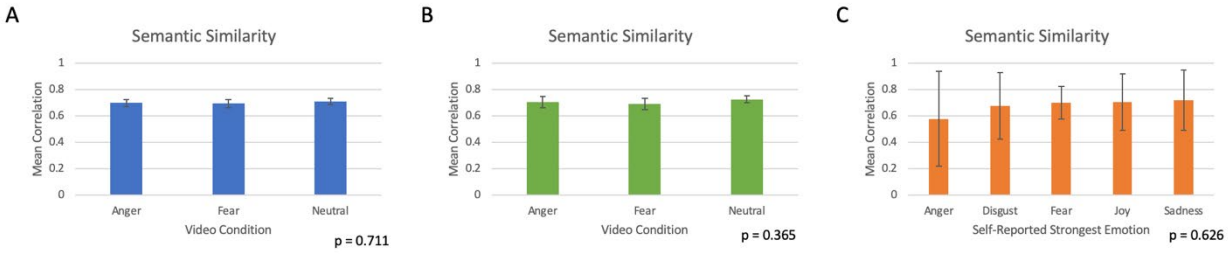
This Figure shows the data from the Exact Word Recall measure within the three measures of memory accuracy. (A) shows the data from the All Participant Analysis. There are no significant results. (B) shows the data from the Induced Emotion Analysis. The main effect that the neutral condition performed the best, then fear, then anger was significant with a p-value of 0.034. (C) shows the data from the Strongest Emotion Analysis (exploratory). There are no significant results.

Figure 3 shows the results from the Exact Word Recall measure. In part A, the results of the All Participant analysis are presented. The graph seems to show a slight trend that the fear condition did the best, then neutral, then anger, but the data was not significant and had a p-value of 0.262. In part B, the data shows the results of the Induced Emotion analysis. This finding was

significant. Those in the neutral condition recalled the most words, followed by fear, then anger. The p-value was 0.034. In part C, the results of the exploratory Strongest Emotion analysis are shown. The graph shows disgust as the highest score, then sadness, joy, fear, and anger as the lowest, but the main effect is not significant, with a p-value of 0.510.

Semantic Similarity Results

Figure 4: Semantic Similarity Results



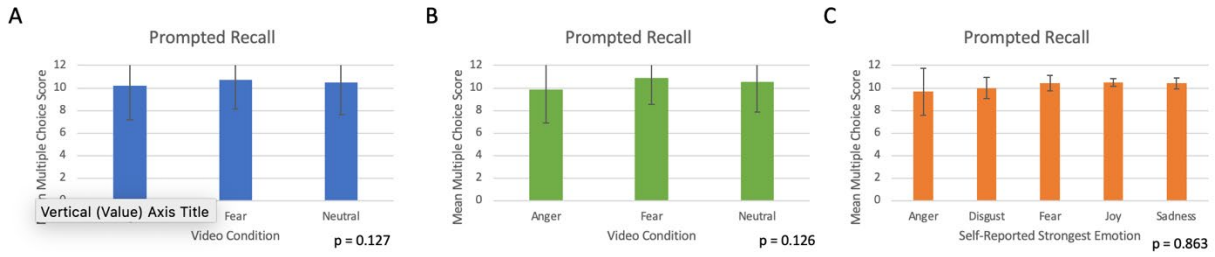
This figure shows the data from the Semantic Similarity Results within the three measures of memory accuracy. (A) shows the data from the All Participant Analysis. There are no significant results. (B) shows the data from the Induced Emotion Analysis. There are no significant results. (C) shows the data from the Strongest Emotion Analysis (exploratory). The main effect is not significant, but an exploratory follow-up test showed those in the sadness condition recreated the original story more accurately than those in the anger condition.

The results of the Semantic Similarity measure produced by the Universal Sentence Encoder are shown in Figure 4. In part A, the data shows the results of the All Participant analysis. Although the graph seems to show that people in the neutral category had a slightly higher correlation score, then next anger, then fear, the main effect was not significant and had a p-value of 0.711. In part B, the data shows the results of the Induced Emotion analysis. Although the graph shows a trend that those in the neutral condition did the best, then anger, then fear, and this trend was slightly stronger than in Figure 1, this pattern was also not significant and had a p-value of 0.365. In part C, the exploratory Strongest Emotion analysis is shown, and the main

effect of the analysis (first sadness, then joy, fear, disgust, and finally anger with the lowest score) is not significant with a p-value of 0.626. A follow up test of this analysis showed a significant result between the average correlation score of the sadness condition and the anger condition with a p-value of 0.043.

Prompted Recall Results

Figure 5: Prompted Recall Results



This figure shows the data from the Prompted Recall measure within the three measures of memory accuracy. (A) shows the data from the All Participant Analysis. There are no significant results. (B) shows the data from the Induced Emotion Analysis. There are no significant results. (C) shows the data from the Strongest Emotion Analysis (exploratory). There are no significant results.

The results from the Prompted Recall Analysis are shown in Figure 5. Part A shows the data from All Participant analysis. This data was not significant and had a p-value of 0.127. It showed a slight trend that those in the fear condition scored highest, then neutral, then anger. In part B, the graph showed the results from the Induced Emotion analysis. Although the graph indicates that fear scored the highest, then neutral, then anger, this data was not significant, and the p-value was 0.126. In part C, the graph shows the results of the exploratory Strongest Emotion analysis. Although the graph shows joy with the highest score, then fear, sadness, disgust, and finally anger. The results are not significant with a p-value of 0.863.

Discussion

This thesis sought to expand on the literature of negative emotions and episodic memory by asking whether feeling a negative emotion at retrieval would impact memory of a neutral story. It was hypothesized that fear and anger at retrieval would decrease accuracy of neutral information. The results largely did not support the hypothesis that fear or anger would decrease memory accuracy. There were two significant results, one was a main effect of the exact word recall measure within the induced emotion analysis, where participants reported feeling the intended emotion for their condition. This significant result supports the hypothesis because it showed the neutral condition as scoring the highest, and the negative emotions as scoring lower. The other significant result was an exploratory analysis between sadness and anger in the semantic similarity measure of the third analysis, which grouped participants based on which emotion they ranked the highest. This significant result did not support or oppose the hypothesis because it was a comparison between two negative emotions.

Despite two significant results throughout the three analyses, the general trend of the results showed that negative emotions do not affect accuracy of neutral episodic memory. These findings suggest that people feeling fear and anger in the real world still have unbridled accuracy when reporting on episodic memories.

The largest limitation to this study was the sample size of participants that reported feeling the intended emotion from the video. Neither the anger nor the fear condition reached the 30 participant threshold that was put forth at the beginning of this study. This shortcoming greatly modifies the conclusions that can be drawn from the results. Another limitation was the challenge of inducing specific negative emotions using videos and having accurate measures of

those emotions. It was this shortcoming that led to the small sample size in certain analysis groups.

Further research in this area would be beneficial. The current literature concerning negative emotions at the retrieval of a memory is minimal and future studies could delve further into this aspect of memory research. More specifically, if a method was found that could more consistently induce a specific emotion into a participant, then this study could be reproduced with more conclusive results. Similarly, there could be a more precise measure of memory accuracy that could further improve this study. Beyond this study, further research could expand this area of research. A direction for future investigation could be the effect of positive emotions on episodic memory. Although this would pose methodological challenges because positive emotions are difficult to consistently induce in a participant, the results of such a study would be greatly consequential.

The results of the current study indicate that the accuracy of recall is not strongly affected by emotion at retrieval. This finding has broader implications in moments where memory accuracy is crucial. One such instance is eyewitness testimonies. A court environment could be a stressful place and could produce negative emotions like fear and anger that were examined in this study. If the eyewitness is recalling something neutral, then the results of this study indicate that their recollection accuracy will be largely unscathed. Another implication of these results is classroom testing environments. If students were able to learn the material in a neutral environment, then even if something goes awry and they enter the testing environment feeling angry or scared, it is indicated that they will still be able to accurately recall the material. Other moments in life, such as grieving a loved one, create negative emotions in a person for a long

period of time. It might be comfort to someone in that position that their episodic memories, which would include memories that they have with that person, would still be accurate.

Beyond the real-world applications, this study's results have significance in cognitive psychology. In the research on emotionality at episodic memory encoding, it is shown that emotionality can affect the accuracy of episodic memory. In contrast, this study shows that emotionality at retrieval does not have the same effect. The results of this study are therefore an important contribution to the academic field.

This study adds to the existing literature on the intersection of negative emotions and memory. It provides evidence that negative emotions, specifically fear and anger, do not strongly affect recall accuracy of neutral information. With continued research into this subject, important issues like grief management, classroom testing environments, and eyewitness testimonies will be understood more completely.

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