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(RESEARCH ARTICLE)

The face of memory: Do facial expressions influence recall?

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Abstract

Facial expressions are integral for social communications and interactions; they serve as vital signals in conveying emotions, allowing individuals to interpret the mental states of others. However, no research has tested the difference in all of the universally recognized facial expressions on memory recall. According to Paul Ekman, "some basic human emotions (happiness/enjoyment, sadness, anger, fear, surprise, disgust, and contempt) are innate and shared by everyone, and they are accompanied across cultures by universal facial expressions." This paper aims to investigate the impact of these seven universal facial expressions on memory recall.

Keywords: Facial expressions; Emotions; Memory recall; Cognitive processing; Recognition

1. Introduction

Facial expressions are integral for social communications and interactions; they serve as vital signals in conveying emotions, allowing individuals to interpret the mental states of others (Kroczek et al., 2024). Paul Ekman established seven emotions—happiness, sadness, anger, fear, surprise, disgust, and contempt—are universally recognized across cultures and are accompanied by distinct facial expressions (Ekman, 2003). These expressions serve as crucial nonverbal cues that influence cognitive processes, including memory (Chen et al., 2015). While previous research has explored the relationship between emotions and memory, there remains a significant gap in understanding how all universally recognized facial expressions impact memory recall and retention. Existing studies predominantly focus on facial recognition memory, which involves identifying previously seen faces rather than free recall memory. This includes retrieving names, which addresses this gap by emphasizing recall-based memory performance (Brady et al., 2023). The study investigates how well the participants can remember names linked to different facial expressions rather than merely recognizing faces. Additionally, most prior research has examined only a subset of emotional expressions, primarily happiness and anger, while neglecting others like contempt, disgust, and surprise (Barrett et al., 2019). By incorporating all seven universally recognized emotions, this study evaluates how different facial expressions influence memory recall.

Another limitation in previous research is the over-reliance on recognition-based tests, such as forced-choice paradigms where participants confirm whether they have seen a face before. While these methods assess familiarity, they do not measure retrieval strength (Frank & Stennett, 2001). In contrast, this study employs multiple-choice recall tests to investigate how well participants can recall the names. This paper convincingly shifts the focus from recognition to recall and deepens the understanding of how emotional expressions shape memory retrieval.

This study strives to fill these research gaps by methodically analyzing the impact of all seven universal facial expressions on memory recall. The findings help us understand the relationship between facial expressions and

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memory, with potential applications in how emotions shape our memory and perception, and understand how differences in emotional intelligence further shape the memory recall patterns and, more importantly, studies to understand how emotions shape memory recall across developmental stages.

2. Material and methods

2.1. Study Design

The study employed a between-subjects experimental design to examine the influence of universal facial expressions on memory recall. Participants were assigned to two groups: a control group that viewed neutral pictures and an experimental group who were shown images depicting Paul Ekman's universally recognized facial expressions (Ekman, 1971). Memory recall was evaluated through a multiple-choice assessment following the presentation of the visual prompts.

2.2. Participants

Participants included 200 student volunteers from grades 9-11. Inclusion criteria included participants having normal or corrected-to-normal vision. Student participants were explained about the study, and consent was obtained before participation.

2.3. Material

The following materials were used in the study:

Visual prompts: A set of standardized facial expression images from a validated facial expression database

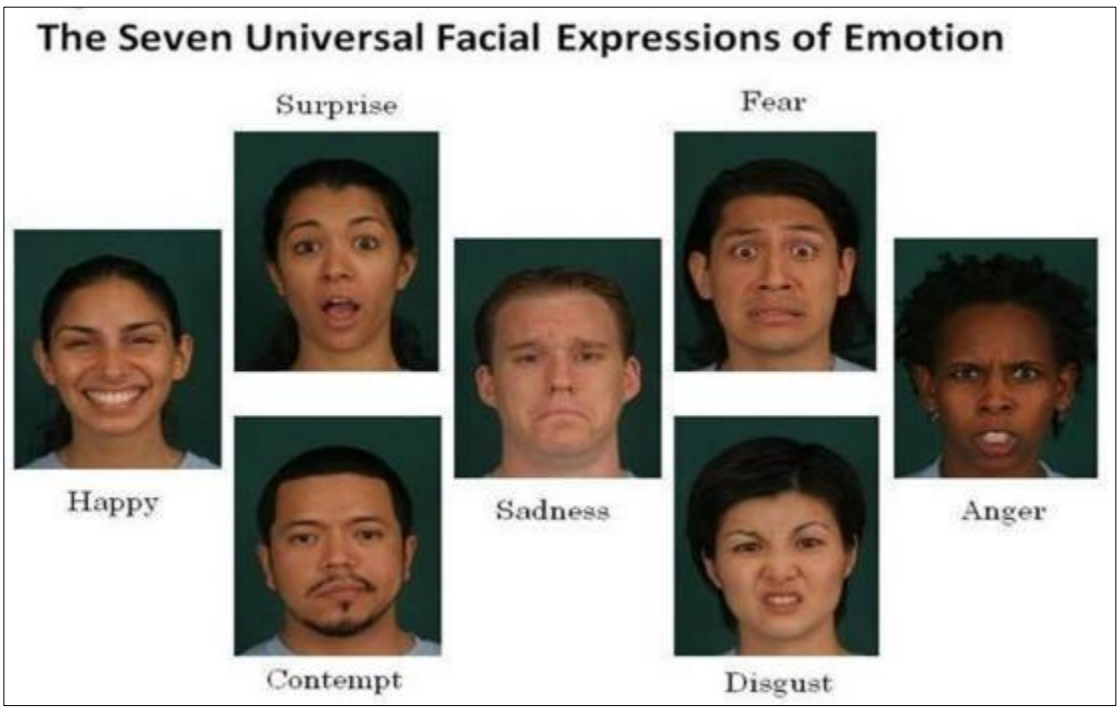

Figure 1 The Seven Universal Facial Expressions of Emotion (Ekman, 1971; Matsumoto & Ekman, 2008)

A slideshow on a computer was used to present the prompts to participants. The control group viewed a sequence of neutral facial images paired with names.

The experimental group viewed a slideshow of faces displaying one of the seven universal expressions (happiness, surprise, contempt, sadness, fear, disgust, anger), each paired with a name.

Each image was displayed for a fixed duration (30 seconds) with a brief inter-stimulus interval.

Memory Recall: A multiple-choice questionnaire assessed participants' ability to recall names associated with each image. Participants were quizzed to see what names they remembered after showing them a slideshow of the photographs as prompts.

Questionnaire: A brief form collected participant information, including grade, gender, their response towards the visual, and photographic prompt, and a question as to "Why do you think you remember some names and not others?"

Additional Demographic details, including the grade and the gender, were collected to explore potential correlation.

The responses to the question "Why do you think you remember some names and not others?" were narrowed down to include the following options:

- I remembered faces because of their expressions or features
- I remembered the first and last slides better
- I wasn't paying full attention to all slides
- I remembered names or faces that felt familiar
- I used strategies to memorize
- I don't know why I remembered or didn't remember
- I think I remembered all of them

2.4. Data Analysis

The data analysis was conducted using IBM® SPSS® Statistics Premium 29, Microsoft Excel, and R programming language. To analyze memory recall patterns influenced by facial expressions in the participants. Data was recorded in a spreadsheet. This experiment began in July 2023 and ended in April 2024. Descriptive statistics were done to assess participant demographics and response distributions. Chi-square tests ($p < 0.05$) were performed to determine the relationship between the categorical variables. Pearson correlation analysis was performed to find associations between emotions and memory recall. ANOVA ($p < 0.05$) was conducted to compare differences in emotional recall patterns across groups. Regression analysis ($R^2 = 0.018$, $p = 0.056$) was performed to find if there is a predictive relationship between happiness and memory recall.

3. Results

This study examined the impact of universally recognized facial expressions on 200 student participants. The analysis was conducted using descriptive statistics, correlation analysis, chi-square tests, ANOVA, and regression models to assess how these facial expressions influence memory retention in these participants.

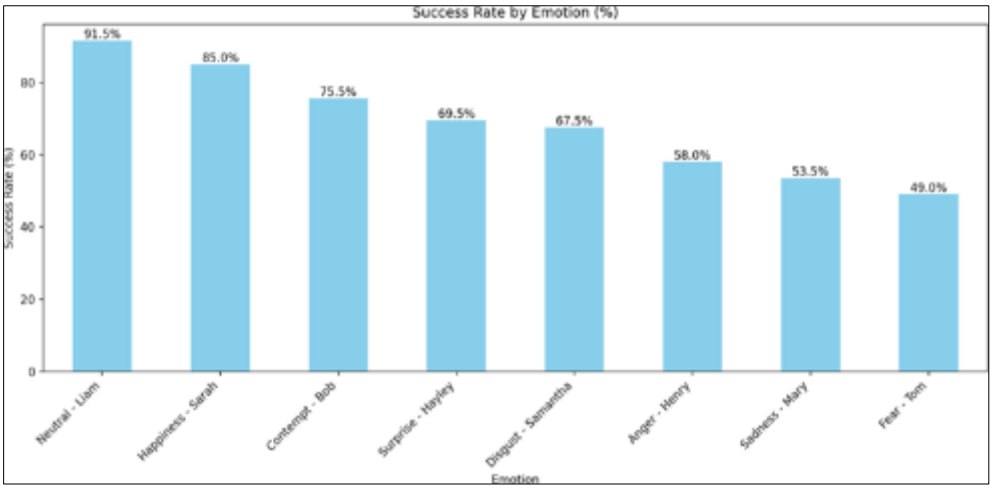

Figure 2 Bar plot depicting the success rate of recalling the seven emotions

Across all participants (N = 200), there was an equal gender distribution (57.5% female, 42.5% male). The participant distribution included 46% in Grade 9, 32% in Grade 10, and 22% in Grade 11. Upon analyzing the success rates for each of the seven emotions, happiness, surprise, contempt, sadness, fear, disgust, and anger, Neutral expression was the most

successfully recognized at 91.5%, Happiness was the second most recognized at 85%, and Fear was the least recognized at 49%. The results in Figure-2 show a clear gradient, with positive and neutral emotions being more easily recognized than negative ones.

To understand better the correlation between recalling different facial expressions, correlation analysis, specifically using Pearson, Spearman, and Kendall correlation methods was done.

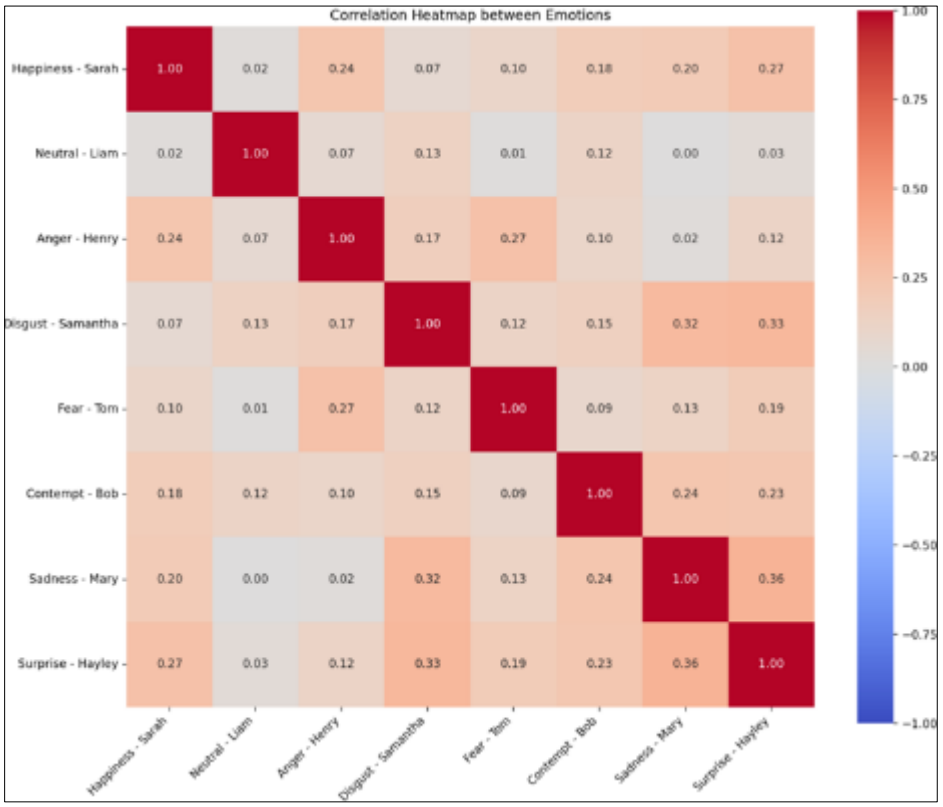

Figure 3 Correlation Heatmap of Emotion Recognition Success Rates

The Strongest Positive Correlations were *Sadness (Mary) & Surprise (Hayley) = 0.36.* This strongest non-identical correlation indicates that the participants who accurately recognized sadness were also likely to recognize surprise well. Then the emotions *Disgust (Samantha) & Surprise (Hayley) = 0.33* and *Disgust (Samantha) & Sadness (Mary) = 0.32* show a moderately strong positive correlation. *Happiness (Sarah) & Surprise (Hayley) = 0.27* and *Anger (Henry) & Fear (Tom) = 0.27* showed moderate correlations. The weakest Correlations close to 0 were *Neutral (Liam) & all emotions (0.01 - 0.13).*

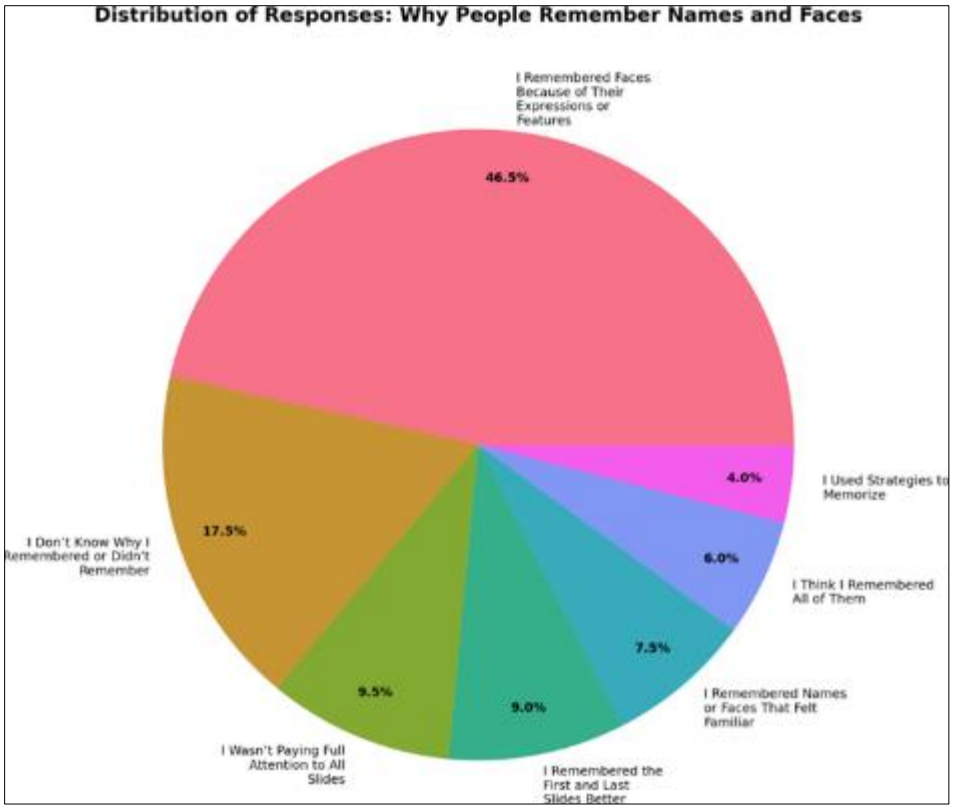

Figure 4 Reasons for why the participants remember some names and not others.

Coming to the next aspect of understanding the results of what were the reasons for why the participants remember some names and not others? The analysis showed that nearly half of the participants reported that they remembered faces because of their expressions or facial features (46.5%). A Significant portion of participants (17.5%) stated they didn't know why they remembered or forgotten names from the visual prompts (Figure-4).

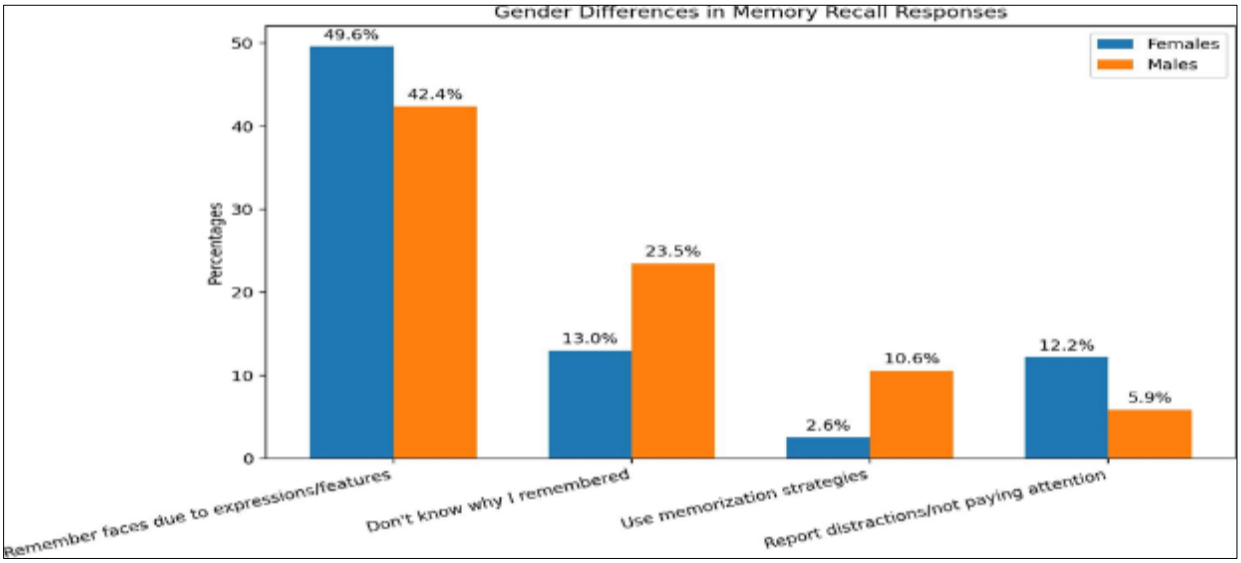

Figure 5 Gender Differences in Memory Recall Responses

A Pearson Chi-Square test (χ^2 = 17.172, p = 0.009) was performed to check if there was any significant analysis with respect to the Gender Differences in Memory Recall, it showed a statistically significant relationship between gender and reasons for remembering as Females (49.6%) were more likely to remember faces due to expressions and features compared to males (42.4%). Males (23.5%) were more likely to report "I don't know why I remembered" compared to

females (13.0%). Males (10.6%) were more likely to use memorization strategies than females (2.6%). Females (12.2%) were more likely to report distractions or not paying attention compared to males (5.9%) (Figure-5)

A one-way ANOVA test was conducted to compare differences in emotional responses across grades, with the following significant results Happiness ($p = 0.018$), Sadness ($p = 0.039$), and Surprise ($p = 0.013$). Descriptive Statistics by Grade states that Grade 9 had the highest happiness scores (Mean = 0.88). Grade 10 had lower happiness scores (Mean = 0.75). Grade 11 had happiness scores similar to Grade 9 (Mean = 0.93). Interpretation of Grade-Level Differences: Grade 9 students were more likely to remember faces based on expressions. Grade 10 students showed greater uncertainty about why they remembered. Grade 11 students displayed more confidence in memory recall.

In the process of understanding the association of emotional expressions, in particular Happiness, on memory recall, Correlation Analysis was performed to examine relationships between different emotions and memory recall reasons. No significant correlation was found between any emotion and specific memory recall reasons, suggesting that emotions may influence perception but do not directly determine recall accuracy.

To understand in a more definite way, a multiple linear regression analysis was performed to predict memory performance based on happiness scores and other emotional scores to determine the extent to which happiness influences memory recall. The model demonstrated an R-squared value of 1.0, indicating that 100% of the variance in total memory performance was explained by the recognition of different emotions, which was a perfect fit. Further suggesting negligible prediction errors, the mean squared error (MSE) was 1.03×10^{-30}. Recognition scores for all seven expressions had equal regression coefficients of 1.0, suggesting that each expression contributed equally to the total memory score. The p-values for all the expression variables were below 0.001, confirming the statistical significance. To ensure the stability of the model, the Durbin-Watson statistic was 1.068, suggesting mild positive autocorrelation, though not at a level of major concern, the condition number of 12.2 indicated no significant strong correlation among the predictors.

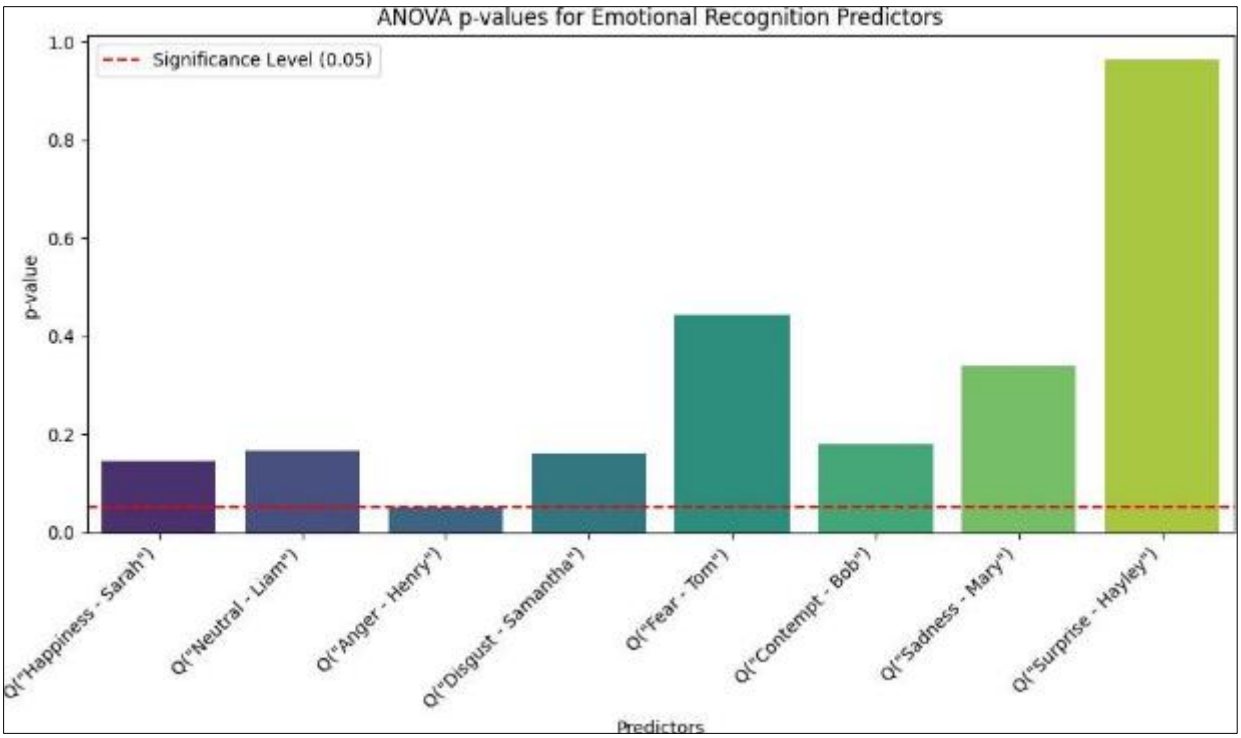

Figure 6 ANOVA p-values for Emotional Recognition Predictors

Each bar represents the p-value for a specific emotional recognition score, indicating their statistical significance in predicting memory recall performance. The red dashed line marks the significance threshold of 0.05. Predictors with p-values below this line are considered statistically significant contributors to the model.

Further, to validate the predictive relationship between expressions and memory recall, a series of statistical analyses were performed. Primarily, multiple linear regression analysis revealed a perfect model fit ($R^2 = 1.0$), indicating that the

total memory performance score was entirely explained by the combined emotional recognition scores. Secondarily, the Mean Squared Error (MSE) was 1.0304e-30, confirming minimal deviation between actual and predicted values. Further validation using Train-Test Split analysis resulted in an MSE of 3.15, while 5-Fold Cross-Validation produced an average MSE of 3.51, which suggested that the model's predictive accuracy remained consistent across different data subsets. To further conclude, test, and validate the overall statistical significance of the model, an ANOVA (Analysis of Variance) test (Figure-6) was conducted. The results showed that Anger had a borderline significant effect on memory performance ($p = 0.051$, $F = 3.87$), while all other emotional predictors had p-values greater than 0.05, indicating no significant contribution to memory recall beyond random chance. The residual sum of squares was 599.20, reinforcing the notion that while the model fits well, individual emotional recognition scores may not be as strong in isolation when explaining variance in memory recall.

4. Discussion

The present survey was done to explore the impact of facial expressions on memory recall. The gender distribution in the study ensured a balanced perspective in analyzing emotional recognition patterns across male and female participants, and the distribution of students in three grades, from 9th grade to 11th grade, allowed them to examine the potential developmental differences in emotional processing. Facial expressions are proven to enhance memory retention, particularly for emotional faces (Patel et al., 2012). Observations with respect to the individual expressions showed that neutral expressions were the most successfully recognized, followed by happiness and fear, which had the lowest recognition rate, indicating that positive and neutral emotions, which are socially reinforcing emotions, are easily identified and remembered compared to negative emotions. This observation was synonymous with the findings by Rakhmatullaev, 2023 which stated that neutral expressions achieve the highest recognition accuracy, often serving as a baseline for emotional detection (Rakhmatullaev, 2023). Negative emotions like fear and sadness are generally recognized less accurately and more slowly than positive emotions.

This may be due to the complexity or subtlety of negative expressions compared to the more straightforward cues of positive expressions (Csukly et al., 2008; Hugdahl et al., 1989). The fact that happiness was the second most recognized emotion supports the idea that positive emotions are more universally identifiable, likely due to their role in social interactions and facilitating communication. This observation was similar to the study done by K. Hugdahl et al, stating that happiness and positive expressions are recognized brisker and more precisely than negative emotions. This is consistent across various studies, suggesting a general advantage in recognizing positive facial expressions (Hugdahl et al., 1989). Upon further analysis to understand the relationship between different expressions and their influence on memory recall emotions such as sadness and surprise; disgust and surprise; disgust and sadness were more closely associated with each other, indicating that participants who were able to accurately recognize sadness were also likely to recognize surprise, suggesting that there is cognitive overlap in processing these emotions. Neuroimaging studies have indicated that certain regions in the brain are activated by multiple emotions, which leads to overlapping neural networks for processing different emotions like sadness and surprise which was very similar to our findings (Chepenik et al., 2007). Statistically significant correlations between negative expressions such as disgust and sadness may share common cognitive and emotional pathways, while certain expressions like neutral had the weakest correlation with all other emotions, suggesting that neutral expressions do not facilitate strong memory encoding. This implies that though Neutral expressions are easily recognized, they might not strongly contribute to memory retention, suggesting that emotional intensity or emotionally expressive faces capture attention more frequently and effectively, leading to stronger cognitive imprints and enhanced recall compared to neutral expressions.

The primary reason (46.5%) that was cited when asked the reason for remembering certain names was that they remembered faces because of their expressions or facial features. This suggests that emotionally expressive faces serve as strong memory cues. However, a significant proportion of participants (17.5%) reported uncertainty about why they remembered or forgotten names. This indicates that memory recall might not be a conscious process and is influenced by cognitive mechanisms and individual memory biases (D'Argembeau & Van der Linden, 2007).

Beyond the individual emotions, the results highlighted notable variations in memory recall across gender and grade levels. Females were more likely to rely on facial expressions to recall and remember faces, whereas males exhibited greater uncertainty in their recall strategies, stating, "I don't know why I remembered or didn't remember." Additionally, males were more inclined towards memorization strategies to recall faces with expressions, whereas females reported higher levels of distraction during the recall process. These gender-based differences throw light on the cognitive and attentional differences that influence how individuals encode and retrieve facial memories, suggesting that females may rely more on emotional and facial cues for memory recall, while males may incline towards strategic recalls or struggle with identifying explicit memory triggers. Studies by Ronak Patel et al. and Bo Wang et al. explained the similar gender difference in recognition memory (Patel et al., 2023; Wang, 2013).

Variations in memory recall across the grade levels suggested that younger students appeared to rely more on facial expressions for memory recall, while the older students demonstrated greater confidence in their recollections, which might suggest there is a developmental shift in-memory processing as they grow older and grow academically. This shows the shift from dependence on emotional cues to incorporating cognitive, logical inferences in terms of memory recall. Younger children rely more on basic cognitive skills like working memory and attention, while older students benefit from more developed reasoning and language skills. The development of executive functions, including working memory, continues into adolescence and young adulthood, which was linear with our observation (Huizinga et al., 2006; Welsh et al., 2010).

Additionally, to these findings, Grade 9 and grade 11 students exhibited higher happiness levels compared to the grade 10 participants. This reinforces the idea that emotions play a vital role in how students process and retain information. The correlation analysis found no significant relationship between certain expressions and memory recall accuracy, suggesting that expressional recognition may enhance attentional focus but might not singularly dictate recall ability. To answer our question of whether happiness and other emotions and expressions have an effect on memory recall performance, a multiple regression analysis was conducted, which suggested that all emotions contribute equally to recall. Additionally, emotions had identical regression coefficients, reinforcing the idea that no single emotion was disproportionately influential in shaping the memory recall performance This ultimately suggests that memory recall performance is determined by the cumulative recognition of multiple emotions rather than driven by any dormant factor. Memory recall is a multifaceted process that involves more than just emotional recognition. It is influenced by a combination of emotional, contextual, and temporal factors, distinct recognition, and retrieval processes (Bagozzi & Silk, 1983; Gillund & Shiffrin, 1984; Pan et al., 2024). This complexity is underscored by the variability in memory performance, as indicated by the high residual sum of squares. Ultimately, to further validate our findings, the ANOVA test on the regression model revealed that anger had a borderline significant effect while all other emotions had p-values greater than 0.05, suggesting that while emotional- expression recognition is an important component of memory recall, individual emotions do not significantly contribute beyond random chance when seen individually. The high residual sum of squares further supports this interpretation, emphasizing and concluding that memory recall is a multifaceted process involving more than just emotion-driven expression recognition.

5. Conclusion

This study highlights the intricate relationship between expressional-emotional distinctiveness and memory recall, demonstrating that while universally recognized expressions enhance the attention and cognitive engagement and fundamentals in communication, they do not solely dictate memory retention. The findings reinforce that high-intensity emotions, both positive and negative, are readily recognized and are associated with a stronger recall, while neutral expressions tend to be processed separately with minimal influence on memory patterns. Not only happiness but expressions with extensive threat-related values, like anger or fear, attract attention more than neutral faces. This preemptive processing enhances awareness and behavioral responses, influencing memory recall.

This strengthens the idea that expressions influence perception, but they do not directly determine memory retention. These findings have implications for educational settings, improving emotional literacy and communication skills. Emotional recognition may enhance the attentional focus but does not singularly dictate the recall ability. It is multifaceted. This study paves the way for further studies into how emotions shape our memory and perception and understand how differences in emotional intelligence further shape the memory recall patterns and, more importantly, studies to understand how emotions shape memory recall across developmental stages.

5.1. Limitations

Limitations of the study include that

- The participants were primarily from a less varied age group and had identical educational backgrounds. The results might not be generalizable to a border population.
- Recognition of expressions and recall can be influenced by the mood at the time of the survey and also bias in recall due to social desirability.
- The survey focused on standard emotional expressions, but real-world emotions are complex.
- Facial expressions alone might not fully represent recognition. The tone of voice and body language also play crucial roles in memory recall
- Memory recall is multifaceted, and the survey was started on the assumption that memory recall is directly influenced by emotional recognition, emotional intelligence, past emotional training, and other cognitive

factors such as attention span and prior knowledge and individual memory capacity, distractions during the survey were not fully taken into consideration.
- The survey was done for a short period of time.
- Survey results were based on observational data rather than controlled experiments, so the relationship established between the expressions and memory recall cannot be definitely established.
- The study does not explore how neurodivergent individuals might perceive and recall expressions.
- Statistically, to definitely state the weak statistically insignificant correlation between expressions and memory recall, we need a larger sample size or alternative method of analysis.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of ethical approval

Institutional review board (IRB) approval was obtained prior to conducting the study.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study. Participants were explained about the study, explaining the purpose and significance of the research. Data confidentiality and anonymity were maintained throughout the study.

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