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Happy Learning
How Different Emotions Affect Semantic Memory

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ABSTRACT
Emotions are ubiquitous in learning activities and are considered closely linked to school climate and classroom climate. However, the question of how these emotions may affect memory encoding and retrieval has not gained sufficient attention. Previous empirical studies focused more on emotional effects on episodic memory rather than semantic memory. Therefore, this research aimed to investigate the effect of induced different emotions on the encoding and retrieval of semantic memory. Fifty-seven participants who were still in the learning stages were randomly assigned to a positive group (attended to positive emotional video), a negative group (attended to negative emotional video), and a neutral group (attended to neutral pictures). They needed to encode and retrieve words under different emotions. Compared to the neutral group, positive and negative emotions can enhance the encoding and retrieval of semantic memory. The possible implications of this research can be used in school climate and classroom climate design.

Keywords: *Emotion induction, Positive emotion, Negative emotion, Semantic memory, Learning.*

1. INTRODUCTION

Emotions are ubiquitous in learning activities and are considered closely linked to school climate and classroom climate. However, the standard for effective climate educational settings varies for administrators, principals, teachers, students, and parents. Researchers in the psychological field [1, 2] and World Economic Forum [3] have urged scientists, leaders, and policymakers to share interdisciplinary perspectives on emotion manipulation in educational settings to enhance student's academic performances and build adequate emotional competencies.

Multiple fields of scholars have done an extensive research to scrutinise the sciences behind emotions in learning. For example, Pekrun and Linnenbrink-Garcia have shown that emotions profoundly impact engagement, academic performance, and human development on both students and teachers [4]. Pekrun (2006) also maintained that positive emotions could stimulate stronger motivation, but negative emotions may disturb learning [5]. This aligned with Huang's alert that students who had experiences in school anxiety, harassment, bullying, and issues regulating or controlling their emotions have poorer academic performance [6].

However, the question of how these emotions may affect memory encoding and retrieval has not gained sufficient attention. Moreover, a tremendous amount of literature investigated only the effects of emotions on episodic memory. Students' academic performances are assessed based on high-stakes tests, which heavily rely on students' memory recall abilities. Since memory is the glue and fundamental element of learning that holds learning together, no individual can keep what has been learned if excluding the role of memory from learning processes. Hence, memory is the key process in the modern education system that creates the foundation for linking new knowledge by association.

Previous literature showed that negative and positive emotions might have diverse effects on memory through distinctive neural pathways. For instance, positive emotion tended to upgrade encoding a memory event's conceptual and relevant viewpoints [7, 8]. This behavioural effect would be associated with increased activities in the dorsolateral prefrontal cortex [9] and the left temporal region [10]. Both regions have been impacted in the processing of semantic information. Negative emotions, on the contrary, may accelerate memory encoding for details [11], and the underlying mechanism would be usually accompanied by the activation of the amygdala [12].

According to Elibol-Pekaslan and Sahin-Acar (2018), many researchers have examined which types of long-term memory were frequently used in the classroom setting. They conveyed that both episodic and semantic memory systems helped assess recently learned knowledge in the exam context. Compared to this area, the relationship between emotions and semantic memory remains unclear [13].

Existing studies suggested that individuals with induced positive moods tended to activate a broader semantic field, a lexical set grouped by meanings referring to a specific subject to facilitate semantic processing [14]. Meanwhile, people with negative moods were likely to limit the spread of activation to close associates and primary word meanings in semantic memory [14]. Moreover, other researchers concluded that, compared to induced negative moods, induced positive moods accelerated the facilitation of semantic memory better [15]. However, these studies mainly focused on mood rather than emotion when encoding and retrieving semantic memory. Mood and emotion are differentiated concepts. Moods can last for hours or days, whereas emotions only last from seconds to minutes.

Additionally, previous empirical studies focused more on emotional effects on episodic memory rather than semantic memory. Moreover, the answers to these questions remain unclear: 1) to what extent can emotions affect academic performances and semantic memory encoding and retrieval, and 2) the effectiveness of using multimedia to manipulate emotion to impact learning results.

Therefore, this research aimed to investigate the effect of induced different emotions on the encoding and retrieval of semantic memory. More precisely, it examined whether induced emotion and induced mood shared a similar effect on semantic memory. To examine to what extent the induced different emotions can impact learning.

The current study speculated that individuals with induced positive emotions could outperform participants in a neutral state on a semantic memory recognition task. Furthermore, the induction of positive and negative emotions may enhance semantic memory retrieval more significantly than the condition where negative emotions were induced.

2. METHOD

2.1.Participants

Fifty-seven participants (44 females and 13 males without geography majors) took part in the study. Eight additional participants took part in this experiment but were not included in data analysis, since they failed in emotion induction. The average age of participants' age was 22.53 (SD = 4.61). Participants were randomly divided into 3 groups which were positive (n = 18, M_{age} = 20.94, SD = 3.56), negative (n = 20, M_{age} = 23, SD = 4.58) and neutral (n = 19, M_{age} = 23.53, SD = 5.31) groups.

All participants were normal and had correct-to-normal vision and audition without a history of mental and dysthymic disorders. All of the participants had sound English proficiency levels to understand the experiment. The local ethics committee approved the study, and all participants agreed to the consent form.

2.2.Material

Emotion induction media: video and background music. Positive, negative, and neutral emotion videos and music were carefully selected and designed. The positive emotional video (happiness, 2min 33s) was designed to collect children's adorable and playful behaviours video clips. This design has been supported by Dan-Glauser et al.'s assertion that infants are positive emotional stimuli. The negative emotional video (sadness, 3min 26s) contained a series of stories and interviews of Syrian children living in wars. This negative emotion stimuli design is aligned with Dan-Glauser et al.'s supposition that contents that violated human rights could be regarded as negative emotional stimuli [16]. Furthermore, the neutral video (1min 50s) was to edit 22 neutral pictures together, displaying 5 seconds each with no sound response to people but did not arouse boredom.

For supplemental materials for videos and music, see appendix.

Geographical names and familiarity. Forty geographical names were randomly selected from Africa and South America on Google maps (e.g., Dodoma, Darkar). Geographical names were the rational neutral words for participants to remember. Considering participants' academic background and life experiences, the premise was set as they were not familiar with African and South American geographical names.

2.3.Procedure

The experiment was designed by PsychoPy. The experiment included three main sections: emotion induction, encoding, and recognition (Figure 1). The experiment started with a domain familiarity check to confirm with participants whether they were familiar with the geographical name of Africa and South America. Participants would be asked to rate their present emotion level on a five-point self-rating scale of the emotion check questionnaire with 1 for solid negative and 5 for solid positive. This step was named the emotion check in this experiment (Figure 1). The emotion check 1 and 2 were used to check if the emotion induction succeeded, and the emotion check 3 and 4 were used to check whether the induced emotion lasted throughout the whole experiment or not.

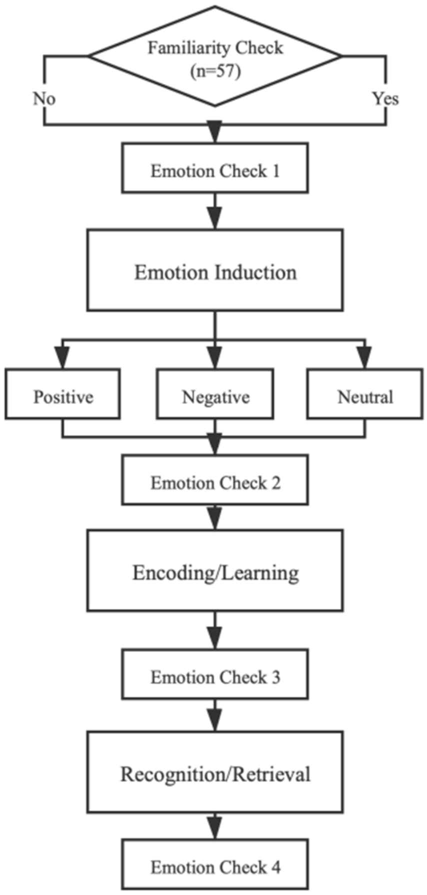

Figure 1. The flow chart of the experiment.

The first emotion check was conducted before the emotion induction section. Emotion videos would be played during emotion induction. After emotion induction, participants were to rate their second emotion check.

In the encoding section, 20 geographical names were presented on a computer screen for 5 seconds each, and participants were instructed to memorise each name for a later memory test. The emotional music, which was the same background music of emotional videos, played in the background to uphold its reduced emotions while participants were encoding geographical names. After the encoding phase, participants were asked to respond to their third emotion check.

The word test bank for the recognition phase contains a mixture of 20 previously presented geographical names and 20 new geographical names. Participants were required to respond with a "left" key for recognising the geographical name, a "right" key if they did not see the name during the encoding section, or an "up" key if they were not sure.

Moreover, all three groups were using the same word list, and the order of geographical names was randomly organised. As the same as the encoding section, the emotional music played in the background to retain their induced emotions while participants recognised the geographical names. After the recognition section, participants were to complete their last emotion check.

2.4.Data analysis

The threshold for statistical significance was set at $p<0.05$ for all analyses.

Data was collected from PsychoPy experiments and analysed in Excel and ANOVA.

We calculated the number of 'right' (succeed in recognizing encoded and new geographical names), 'not sure' (cannot distinguish encoded and new geographical names), and 'wrong' (fail to recognize encoded and new geographical names) of three groups. By analysing the data from the neutral group and taking its pattern as the benchmark, the other two groups' data on "right", "not sure" and "wrong" will be scrutinized. Higher accuracy of 'right' indicated that this group of emotions had a positive effect on memory, and lower accuracy of 'right' indicated that this group of emotions had a negative effect on memory. Refer to the Discussion section for more details.

3. RESULTS

3.1.Emotion check

The emotion check 1 tested at the start of the experiment was deemed as the emotional benchmark of each participant. It was used for comparison with subsequent emotion checks to check the impact of emotion induction. As seen in Figure 2, after positive emotion induction, the values of emotion check 2 (M = 4.23, SE = 0.55) were rated as significantly more positive than emotion check 1 (M = 3.50, SE = 0.92), and, identically, the values of emotion check 2 (M = 1.75, SE = 0.55) after negative emotion induction, were rated to be more negative than emotion check 2 (M = 3.10, SE = 0.91). In addition, the values of neutral emotion check 2 (M=2.74, SE=0.45) were similar to emotion check 1 (M=2.84, SE=0.69), and both values were close to 3 after the neutral emotion check.

Moreover, this is schematically shown in Figure 2. For all three groups, the values of emotion check 3 were tested closer to 3 after encoding (positive: M = 3.17, SE = 1.04; negative: M = 2.30, SE = 0.80; neutral: M = 2.63, SE = 0.50). Both positive and negative emotion groups demonstrated decay in induced emotions after the encoding, where the positive emotion group showed less positive in emotion and the negative appeared to be less negative (Figure 3). Furthermore, the recognition values of emotion check 4 were more positive for all three groups (positive: M = 3.39, SE = 1.03. negative: M = 2.4, SE = 0.88. neutral: M = 2.95, SE = 0.62).

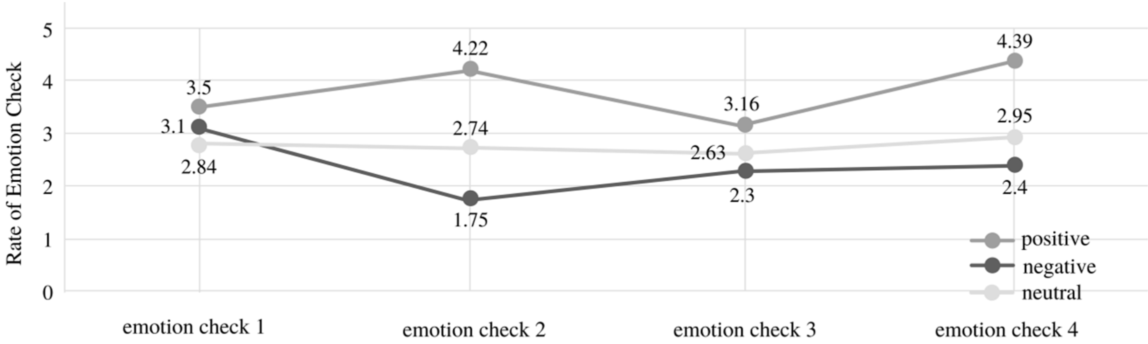

Figure 2. Emotion check during the experiment. (1 = negative, 2 = somewhat negative, 3 = neutral, 4 = somewhat positive, and 5 = positive)

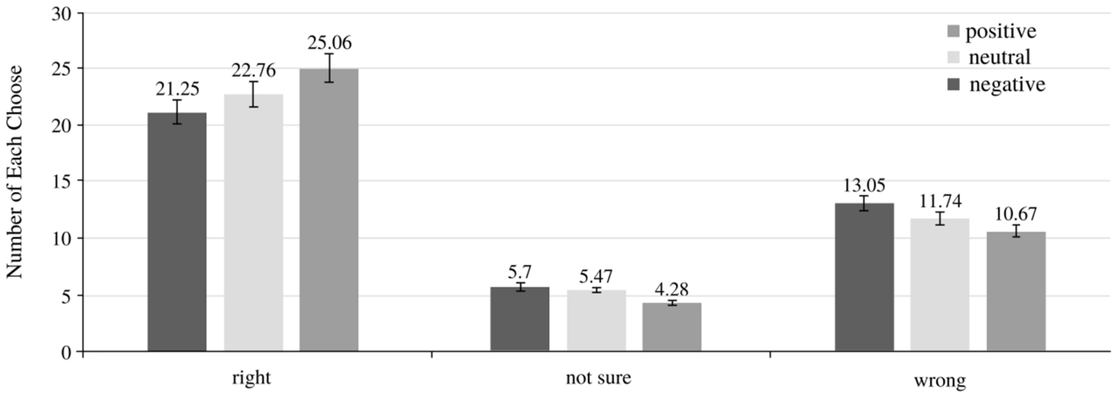

Figure 3. The average accuracy of three groups (positive, negative, and neutral). (min=0 and max=40)

3.2.Emotion and semantic recognition task accuracy rate

Figure 3 presented the average performance for positive, negative, and neutral groups. The positive emotion group had the highest right answers and the lowest number of wrong answers. Conversely, participants who were in the negative emotion group ranked as the lowest for having correct answers and ranked as the top for wrong responses. Meanwhile, participants who were in the neutral group performed better than those in the negative group but worse than those in the positive group. Nevertheless, it is worth noticing that there was only a marginal difference in the wrong answer category, while when comparing the time participants pressed “not sure”, the difference was even more tenuous.

The recognition accuracy rate and “not sure” rate were subjected to several one-way analysis of Variance (ANOVA) having three levels of induced emotions (positive, negative, and neutral). All effects were statistically significant at the .05 significance level. The effect of the induced emotions on the accuracy rate was statistically significant, $F(2, 54) = 3.40$, $p = .04$, $\eta^2 = .112$, indicating that induced emotions did have influences on the percentage of corrected answers that participants performed, with a median effect size. However, the effect of induced emotion on “not sure” answers was not significant, $F(2, 54) = 0.54$, $p = .59$, $\eta^2 = .020$, which means the time participants clicked “not sure” was not dependent on whether emotions were successfully induced. Similarly, the effect on wrong answers was non-significant, $F(2, 54) = 2.15$, $p = .13$, $\eta^2 = .074$(See Figure 3).

4. DISCUSSION

The result gathered above indicated that individuals in the positive group scored higher in accuracy rate than individuals that were allocated in the control and negative group. Namely, induced positive emotions can improve semantic memory retrieval. Consequently, induced positive emotions are likely to stimulate the effectiveness of individuals in learning settings. However, the relationship between the induced emotion and an individual's sense of uncertainty, which was indicated by the “not sure” rate, was not evident enough in the current study. We tended to neglect the effect of overloaded cognitive capacity on emotion while learning. Based on a task that participants needed to recall 6 letters, researchers found that memory trials that were cognitively overloading tended to dampen down the activation of the amygdala, which is mainly responsible for processing the induced negative emotions [17]. Recognition of a whole word list required much more workload than recall of letters. Hence, we can speculate that the negative emotional effects in the current study were overridden by the high workload trials so that the induction of the emotion could be unsuccessful. Furthermore, according to Pekrun‘s control-value theory of achievement emotions [5], enjoyment, as one type of positive activating emotion, can promote motivation as a precondition for effort investment, hence positively impacting learning achievement or the semantic memory retrieval results. Whereas satisfaction, as a type of positive deactivating emotion, can have a different impact on learning achievement. This variation aligned with Plass's valence x activation classification of learning-relevant emotions that classify emotions as positive activating, positive deactivating, negative activating and negative deactivating [18]. Different classifications of positive emotions have different impacts on learning. The current study failed to distinguish the various types, that are valence and activation dimensions, of positive and negative emotions.

Like any other experiment, this experiment is not accessible without limitations. For the experiment design, this experiment only studied the impact of one positive emotion (enjoyment) and one negative emotion (sadness) on memory. Regardless, future research could continue to explore the effect of other positive and negative emotions on memory that can be tested, and the results might be the opposite. Secondly, the simple emotion check questions are too hasty to check emotion induction, and there is no adequate device to detect participants' cognitive responses and the effectiveness of emotional manipulation. In future research, portable EEG devices can be used to check the brain activities of participants. More researchers can also try other emotion manipulation techniques and emotional transmission strategies more carefully, such as entertainment, emotional contagion and empathy [18]. Examples include in-person interactive activities (win or lose the games) or mimic real-life classroom scenarios (praise & engaging or criticism & bullying).

Moreover, due to COVID-19, our participants were doing this experiment at different times, energy levels, and environments with different moods. Furthermore, the number of males and females in this experiment is out of balance. Hence, further works are needed to arrange for participants to do the experiments simultaneously for a day in the same environment. More males and more sample sizes are also needed in future studies to test the generalizability. The neutral emotion induction is also suggested to play before the experiment to ensure all participants have the same mood when doing the experiments.

Emotions affect the efficiency and effectiveness of students' adhesives in learning, that is, memory. Not to mention, the emotions can also affect students' and teachers' engagement, achievement, personality development, and well-being [4]. Hence, the conclusion is that emotions are of primary practical importance in education. Failing to control the emotions of students during learning activities may lead to depreciated learning results than expected.

The possible implications of this research can be used in school climate and classroom climate design. Recent advances in social-emotional learning programs [19, 20], these psychological intervention studies suggests that it is possible to design educational environments to promote students' and teachers' positive academic emotions, reduce their negative emotions at school, such as confusion, in ways that enhance learning results.

Constructing academic tasks, assessments, and environments in emotionally beneficial ways will not be an easy task. The best of researchers' efforts will be required to successfully design and implement interventions targeting students' and teachers' emotions, such that educational research on emotions can inform educational practitioners, administrators, and policy-makers how they might be able to shape classroom instruction and educational institutions in effectively productive ways [4].

5. CONCLUSION

This research provides initial evidence that positive and negative emotions can enhance the encoding and retrieval of semantic memory compared to neutral emotions.

This research has important theoretical as well as practical implications. The possible implications of this research can be used in school climate and classroom climate design.

The next series of research interests may include the proposed strategies to embed emotion manipulation into learning activities and environments so that it makes the instruction "emotionally sound" and the design criteria for the educational climate in our communities so that the emotions of students, teachers can benefit not only individually but also as communities and the society as a whole.

These questions call for interdisciplinary collaboration of scholars from education, psychology, neuroscience, computer engineering, sociology, economics, cultural anthropology, and architecture fields. This future series of research aims to implement emotion manipulation strategies to create learning environments that support students' adaptive emotions, hence achieving better learning results.

APPENDIX

Supplemental materials for videos and music:

https://www.bilibili.com/video/BV1HK4y1L76P.

https://www.bilibili.com/video/BV1VW411j7AT.

https://www.unige.ch/cisa/research/materials-and-online-research/research-material/

Positive music: 'Tritsch-Tratsch-Polka, Op. 214' Vienna Philharmonic played, Willi Boskovsky and Johann Strauss (Willi et al.,1966, track 10).

Negative music: 'Theme (From' Schindler's List')' played by Itzhak Perlman and John Williams(Itzhak, P. & John, W. , 1999, disc 2 track 3)

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