

The Relationship between Emotion and Working Memory Performance

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Abstract: Working memory is modelled as multi-sectional, making possible reference to its need of updating and the limited capacity. Emotion is the intrinsic cognitive process divided into pleasure or displeasure outcomes, and can both be a factor to the memory or a result of memory. The manipulation of emotional stimuli in working memory can somehow increase one's abilities of updating and expanding the capacity. Anxiety is the negative result of emotion regulation, which contributes to a poor performance on working memory tasks. A negative association was found between these two aspects. On the contrary, the emotion regulation ability can be improved through training of the working memory. It was concluded that there is a possible correlation between working memory and emotion, whilst the direction may be unclear to some extent. Future research should examine the specific directions of this relationship more comprehensively. This review can provide some guidance to future intervention studies and practices regarding emotion and working memory in children at schools.

Keywords: Working Memory Capacity, Working Memory Updating, Emotion Regulation

1. Introduction

Cognitive psychology can be either studied by observing the change of behaviour or through analysis of the brain image via technologies [1]. Memory is one of the major cognitive processes that psychologists aim to study. Memory is defined as a mental process includes steps of encoding, storage, and retrieval [2]. Working memory is referred to both inputting and storing information in short-term memory while manipulating it to complete a goal [2]. Working memory can organize multiple pieces of information at the same time, with each typical component of the store responsible for each type of stimulus, including the verbal and acoustic (i.e., phonological loop), the visual and spatial (i.e., the visuo-spatial sketchpad), as well as the general processor which contributes to the strategical control and govern the sub-components (i.e., the central executive) [1]. In addition to this model, an extra component was suggested by Baddeley to be added to the existing model, namely the episodic buffer, which is capable of combining each separate information together forming the whole image. As the model has displayed, it is predicted that stimuli of the same codes contradict with each other, whereas the interference does not exist between two different types of stimuli. For instance, one phonological and one visual information can be processed simultaneously. Working memory capacity (WMC) describes the maximum capacity of the amount of information that can be manipulated when being distracted, in which all

the information beyond the maximum capacity will neither be stored nor processed successfully [3]. A typical experiment, known as the Peterson and Peterson-type procedure (i.e., counting backwards of a list), can be used to test one's limit of the WMC. The extreme to the WMC limit can also be used to explain the behaviour of forgetting, as the new information keeps replacing the older counterparts through attention shifting, which can be concluded by a term called refresh. By integrating the idea of attentional refresh with Baddeley's Working Memory Model (WMM), the incoming information will be either stored or decay during the competing for space inside each independent component [4].

Emotion, as a conscious cognitive process, is defined as a mental representation revealing either a pleasure or displeasure state of mind [1]. As the emotion is highly dependent on personal feeling, a common method of measuring one's level of pleasure is through filling out the self-reporting form by participants themselves. Emotion is a summation of internal perceptions of the outside world, which further indicates people's responses, often a judgement, toward what people are aware of [1]. Factors stimulating emotions can vary based on specific circumstance and differences of each individual but are mainly contributed by any of the three senses, including the sight, sound, and smell, additionally, the imagery and memory. Responses to the stimulus are often classified into either of the five following categories: the feeling of sadness, disgust, anger, fear, and joyfulness, together forming the summation of an activation map of the emotion. Furthermore, the activation of different emotion contents is measurable through brain scanning technology and is matched to specific brain areas to map the brain structure and its corresponding function. In this case, emotions are more inclined to be defined as a type of neural nerve impulse aroused by a cognitive activity [1]. Emotion as mental representations are not universal among all people and circumstances but are highly determined by the relative content, relational or situational. For example, it can be two aspects affecting one's emotional response to the same situation. The relational content is referring to the closeness of the object to a person, while the situational is focusing on the importance of an event to the person [1].

The main theory of working memory proposed by the previous research particularly focused on the multi-sectional specified model, assuming the limit of memory capacity exists, and somehow relates to the refresh or the update of the new incoming memories [4]. Emotions is highly dependent on one's personal experience of the sensing, perceiving, and describing stages. The core of emotion in a psychological situation can be seen as the sum of many single percepts and eventually merged or integrated into a whole image, with a neural reference as the evidence to an intrinsic cognitive network [1]. While the working memory and emotion seemed to be separated cognitive scales, in fact, there are some deep relations between the two psychological aspects. Working memory, as mentioned, is largely dependent on the individual's past experiences, making the emotion a potential factor influencing its level and extent. Moreover, memory was also listed as one of the five initiates of the emotion, representing there may be a possible deeper connection between the two aspects, both psychologically and neurologically. In addition to the direct relation, both working memory and emotion have some common factors (e.g., the requiring of attention, the common brain area, i.e., amygdala, being activated when functioning). Although there are numerous research findings indicating the possible relation between working memory and emotion, yet there were not much research investigating how emotion affects one's working memory directly. Overall, this review aims to discuss and evaluate the extent of which emotion has an impact on the working memory capacity and refreshing ability. It also demonstrated the effectiveness of working memory training on emotional regulation. This review can provide some suggestions to the design of emotional development related interventions for children and adolescents at schools, as well as relevant research.

2. The Impact of Emotion Processing on Working Memory Performance

2.1. The Effects of Working Memory Capacity

It was hypothesized that emotion, as one of the factors affecting the working memory, would enlarge the working memory capacity when emotions are involved. The strengthening of working memory capacity can be explained by the involvement of the brain part amygdala. Garrison and Brandon investigated the effect of emotion have on working memory capacity by designing an operation span task (OSPAN) with emotion engaged [2]. The samples of the study were around 3 hundreds in total (with 80% females and an average age of 19). The OSPAN task is composed of both a simple math question and a word, either emotional or neutral, to be remembered [5]. The measurement of performance is known as the all-or-nothing, which answers with correct math, word, and exact order were count as correctly recalled; in addition, a simple count of the correct answers was also recorded in spite of the order of the words. The difference between emotion and neutral groups are most significant in the emotion involved condition, especially for the all-or-nothing measure. The most salient result in the emotion-involved condition can be explained as it goes through a more automatic and faster cognitive processing course. The automatic thinking and decision pathway is also known as the “intuitive thinking”, and one explanation of it is descended from ancestors by evolutionary development, which enables them to be alert to the danger, also initiating people’s emotion and promoting automatic thinking.

Another research finding is also in-line with the previous study. Ahu Gokce et al. proposed an experiment by replicating Philip’s positive and negative emotion paradigm [6]. The researcher conducted the test on 40 participants who were psychology undergraduates, and then randomly assigned them to either the positive or the negative emotion conditions. The two conditions differ from each other by the given picture that participants were asked to memorize, with one related to the positive and another related to the negative emotions. The rest steps for both groups are the same, including fixation and recall. Participants’ performance and working memory capacity is inferred by a K value, calculated as multiplying the size of the size with difference between correct and incorrect answers, then divided by the number of wrong answers. It shows that the positive image results in longest working memory maintenance and largest capacity, while the neutral stimulus following, and negative stimulus least. The reduction and increase of working memory capacity affected by negative and positive content correspondingly, also reveals the overall association between emotion and working memory capacity. The least capacity in negative emotion condition might be due to the pressure of the living environment, for which humans evolved to be alert and therefore shifts attention to the stimuli. On the other hand, positive stimuli connect the separated components of brain when processing and representing the memory, thus lowers the burden of working memory capacity and allows for more in coming information.

2.2. The Influences of Working Memory Updating

The frequency of updating the memory can be linked to one’s healthiness of the sentimental states, such that an example of whom with negative mood, the depression patients, are known to be impaired with the updating of emotional related memories. In the quasi experiment by Zahra Khayyer et al., the result is in line with the previous research, which stress does have an influence on auditory working memory (AWM) [7]. The sample of the study were composed of university students, and were controlled for possible extraneous variables by completing questionnaires prior to the study (such as background of drug taking and hormone control). Participants were asked to complete a N-back task with auditory stimuli, which two stimuli were presented in order and participants should press either 0 or 1 as no or yes to respond to the question. The two conditions

differed by having an induction of stress or not, which the participants in the experimental condition placed their hand into the ice-cold water for 3 minutes before completing the N-back task. The result shows that the stress may lead to influence on performance of the AWM. Specifically, positive stimuli promote more accurate response and less reaction time, while it is the opposite for the negative counterparts. The result that the decrease of accuracy in the AWM caused by stress and anxiety might be due to attention shifting and limited capacity. The positive stimuli, in contrast, goes through a different mechanism by serving as a buffer to the next stimuli, relieving stress and enhanced cognitive function. Besides areas involving abnormality and the therapy to mental disorders, the updating of working memory can also be linked to language studies. There is a number of studies claiming that the bilinguals, or even people speaking more than two languages, can perform better on the working memory tasks due to the fact that they have trained the working memory capacity to be larger than those who speak only one language.

Additionally, bilinguals tend to have better performance on the updating of new information. A piece of research conducted by Ma and his fellows aimed to investigate whether bilinguals can perform better on working memory tasks, including the condition with emotion involved, on Chinese students from Yunnan Normal University [8]. Participants were then classified into groups by their second language level (determined by passing different levels of English tests). The first experiment is about recalling numbers, and the participants presses different keys to respond whether the number presented for the first and second trials are the same. The second experiment is the classic paradigm “N-back”, in this case, participants experienced 1-back and 2-back repeated, which is to press key responding whether the current letter have appeared in 1/2 letter(s) before. Both experiment results indicates that individuals who are bilinguals performed better on working memory tasks, since bilingual required an ability of free-switching between languages, that is a common outcome to the cognitive foundation of working memory ability.

3. Bidirectional Relationship between Emotional Regulation and Working Memory Performance

Emotion regulation is the key part for an individual to maintain a healthy and mindful mental states. A deficiency in emotion regulation ability may lead to various psychological disorders. One example of the failed regulation of emotion can be anxiety, which is the negative outcome to the lack of self-control over emotion. Similarly, a failure of emotion regulation (anxiety) may negatively affect the working memory ability. Karolina and colleagues assessed the relationship between anxiety and working memory abilities by creating a questionnaire to determine the level of anxiety and replicate four paradigms to measure the working memory ability [9]. The stress and anxiety questionnaire used the self-report form (PSS-4). Participants will report to the forms by the likert-scale ranging from 1 to 5, representing never to very often. The working memory ability is measured by 4 tests in total, including the simple and complex span task, running memory task, and N-back recall task. In the four tasks, participants were asked to memorize and recall a list of words in serial order, or to recall the last appeared random number of items/characters. The overall result shows that anxiety does affect participants’ working memory performance in a negative way, in specific, participants who are old and less-educated make worse performance on the working memory task and scored lower. Although this study indicates there is an association between the emotion regulation and working memory, but the correlation is bidirectional and not specified.

Furthermore, another study states a clear directional correlation between the two variables. In the study by Yoon et al., researchers examine the working memory capacity affected by the level of emotion regulation (operationalized by either the negative or neutral stimulus) in the generalized anxiety disorder (GAD) population [10]. Participants in this study were all recruited by volunteered sampling method and were mostly young adults. A number of participants were diagnosed to have

GAD by using the DSM IV through a clinical interview with the psychiatrist. Each participant then completed a set of operation span task, a stress-inducing task, and a self-report questionnaire about the stress level before and after they had completed the tasks. The study result indicates the decrease of working memory capacity is most significant in the condition with stress induced and in GAD population. Moreover, it also suggested that negative information acts as the distractors to individuals making retentional cognitive process, especially for the GAD individuals.

In addition to the studies regarding to the pre-existing stress or anxiety, another research manipulated the level of anxiety of a group of participants and compares their performance to the controlled group. Therefore, it further supports the potential relationship between emotion regulation and working memory. Xiu et al. hypothesized that training working memory capacity of one person may enhance the attention control, and further improve one's ability of emotion regulation [11]. The study sample were random allocated in to either of the two groups, tested to have no significant difference on their prior anxiety level. The working memory test used pictures, including neutral and negative emotions, as the stimuli, then compared the number of correctly recalled responses of the two groups. Participants' attention control was measured by a test (ANT-S), then a cue was pointed to either the congruent or incongruent to the direction of the target, and the reaction time identified the target was recorded down. The emotion regulation task was done twice, both before and after the working memory task. Participants' reaction time is an indication for their attention shifting, and both the self-report and the electroencephalograph (EEG) results both contribute to the level of emotion arousal. The study result indicates that the average attention control ability of participants improved significantly after a 20 days period of training the working memory, and there is a correlational relationship found between emotion regulation and attention control. Furthermore, one indication of emotion regulation, the Late Positive Potential (LPP), appears to be decrease apparently, supporting the argument of improving the overall emotion regulation ability.

4. Conclusion

In conclusion, the relationship between emotion and working memory performance is bidirectional. Emotion can be a stimulus strengthening one's working memory capacity and increasing the frequency of updating new information or can be a result of failed emotion regulation and worsening the performance on working memory tasks. It even can be reversely improved through training of working memory. However, many of the studies in this area only points out the association between the working memory and emotions but are not able to infer a clear directional relationship between the two variables. Future research should investigate this relationship in a more systematical way. This review can provide some insights for future intervention studies and practices regarding working memory and emotional development in children and adolescents.

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