

The Impact of Embodied Emotion on Memory

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Abstract--The theory of embodied emotion supported by a wide range of theoretical hypotheses and research evidence, believes that the process of expression, perception, processing, and understanding of emotion is closely related to the body. In other words, the anatomy of the body, the way the body moves, the feelings and movements of the body have an important influence on individual emotion processing. Emotional memory has always been a significant part of the research in the field of memory as memory itself contains many emotional information. In addition, as important branches of memory research, implicit memory and recognition memory have also been paid more and more attention by researchers. The link between the different types of memory and embodied emotion has become an essential part of research. In this paper, typical embodied emotion and memory theories are combed. Meanwhile, the usage of the embodied emotion paradigm is also summarized to understand the effects of embodied emotion on memory.

Keywords--embodied emotion, implicit memory, recognition memory, emotional memory

I. EMBODIED EMOTION AND ITS HYPOTHESES

A. The Background and Concept of the Embodied Emotion

The earliest mention of embodied emotion can be traced back to the oldest Aristotle's view of emotion, which was mainly reflected in two aspects: (1): Emotion affects the way we behave in some way; (2): Emotion is the reaction of how we explain the worlds. Influenced by this view, the medieval philosopher Aquinas understood emotion as a direct response to internal feelings and external sensations ^[1]. Juan Luis Vives believed that emotion can be psychologically changed through training. The reason why psychological training can change emotion was that ideas were often the source of emotion. In the middle ages, the discussions on emotion have begun to gradually recognize the interaction between emotion and cognition, helped future generations to study the physiological basis of emotion. In modern times, Descartes put forward the dualism, thinking that body and mind were two different things, but he later admitted that emotion was supported by the body. The emotional researches are led to a more scientific way due to his contribution. Spinoza's view of emotion and cognition was quite different from that of Descartes's mind-body dualism. With a proposition that emotion was regarded as

cognition, he said that "We can understand the changes in the body through emotion. The strength of the body's own actions and the concept of physical changes were either enhanced or weakened; helped or blocked", which indicated Spinoza had realized that emotion and the body have the role of promoting or hindering action.

With the rising of the second generation of cognitive science, the concept of embodied cognition has been paid more and more attention. Wilson believed that embodied cognition needed to pay attention to six aspects: (1) Cognition is the context; (2) Cognition is time pressured; (3) Cognitive need devolve into the environment; (4) The environment is a part of the cognitive system; (5) Cognition is action; (6) Off-line cognition is body based ^[2]. In the theory of embodied cognition, the word "embodied" was introduced because it was not completely established, but there was cognitive function re-experience produced in the motor system that originally produced the sensation, just as if the individual returned to the original situation again ^[3]. With the development of embodied theory, more and more evidence show that cognition is based on body, and the expression and understanding of emotion also have a close relationship with the body ^[4]. A new perspective is provided for us in the theory of embodied cognition to explain the processing of emotional information ^[5]. Emotional understanding is not a simple logical reasoning process but one with situations and body playing an important role in it. Therefore, the embodied emotion can be regarded as an emotional experience that the process of emotional perception, understanding, processing and other processes are closely related to the body based on emotional cognition. In the theory of embodied emotion, emotion is related to the body, including the brain. The anatomy of the body, the way the body moves, the feelings of the body, and the exercise experience determine how we process emotion.

B. The Relevant Hypothesis about Embodied Emotion

There is a wide range of theoretical foundations and research hypotheses on embodied emotion. James, Lang et al. first proposed the James-Lange theory of emotion (emotion peripheral theory), considering that the occurrence and changes of emotion was closely related to the changes of body. With the development of embodied cognition, some researchers have experimentally verified

the embodiment of emotion. For example, Tomkins, Izard and others proposed the hypothesis of facial feedback, and Damasio et al. put forward somatic markers hypothesis [6], etc.

(1) The James- Lange Theory of Emotion

The American psychologist William James (1884) stated that "we are not weeping, attacking or trembling because of sadness, anger or fear. On the contrary, weeping, and therefore feeling sad; offensive, and thus feeling angry; trembling, and hence feeling afraid" [7]. He believed that the emergence of emotion required the activation of certain entities. Obviously, the body can become the primary carrier of emotion. The body first underwent activities or changes, and then the brain can feel emotion later. Therefore, physical changes were the key to experience emotion. This theory is similar to the theory of emotion proposed by the Danish biologist Carl Lange (1885). They are collectively known as the James-Lange theory, which is also the emotional *peripheral theory*.

(2) Facial Feedback Hypothesis

In the facial feedback theory, our intrinsic emotional experience is reflected and impacted by facial expressions. Most experiments have verified that facial activities can regulate and activate certain emotional states [8]. For example, crying when you are sad will make you sadder; however, when you show a positive expression of emotion in sadness, you will not be so sad. An experiment designed by Strack and others to explore the effect of expressions control on emotion. The expressions of subjects were controlled to be in the states of laugh and non-laugh in this experiment. At the same time, the subjects were required to evaluate the degree of the funniness of the presented card content. The result showed that the score was quite consistent with expression [9]. In addition, the study also found that facial activities also regulated the corresponding physiological arousal. Some researchers believed that the sensory feedback provided by facial muscles can also activate certain emotional experiences without external emotional stimulation. For example, the study by Duclos et al. found that if a subject pretends to make some expressions or simply reads a syllable which can stun or relax his facial muscles for one minute, the subject can produce a negative or positive emotional experience [10]. Meanwhile, it can also cause some physiological reactions, such as the acceleration or slowing of the heart rate, and the increase or decrease of the forehead temperature.

Facial feedback can not only regulate or induce different emotional states, but also promote the individual's processing of emotional stimulation. According to Wallbott's test about the classification of subjects' emotion photographs, they would imitate the expression in the photo. A result he found that the higher the degree of imitation, the more accurate the classification [11]. Havas et al. also designed a test that the subjects were asked to judge whether the sentences were easy to understand under two expressional states.

The experimental results showed that there was a significant main effect between expressions and sentence valence. Subjects who laughed had the quickest judgment of positive sentences, while those who did not laugh had the fastest judgment of negative sentences [12].

(3) Somatic Markers Hypothesis

The somatic markers hypothesis proposed by Damasio et al. considered emotion as a collection of somatic responses and changes in central activity starting from specific situations [13-14], the somatic responses of which include visceral activities, glandular secretion, and skeletal movement. The responses are mapped in brain regions such as the brain stem, insular lobe and somatosensory cortex. The emotional signals are constituted by the peripheral changes in body and its representation in the brain center area. Damasio referred to the emotionally related signals as somatic markers [15]. Somatic markers can come from physical activities, but also from the representation of brain in the absence of physical activities. The experimental study found that when implanting some stimulation into the vagus nerves of epilepsy patients, their emotional experience can be enhanced through low-level activation, thereby affecting decision-making behaviors [16]. In addition, somatic markers can also be fed back to the center through neural pathways such as spinal cord and neuroendocrine, thereby affecting individual emotional experience [17]. In the meantime, it was also found that normal individuals and those with ventromedial prefrontal cortex injury were all able to activate the galvanic skin response after receiving punishment. However, after a period of practice, individuals with ventromedial prefrontal cortex injury were unable to predict galvanic skin response before making decisions compared with normal individuals [18].

C. The Common Operational Methods of Embodied Emotion

In addition to the control methods of mentioned above, Hennlotter and others injected botulinum to the corrugator of subjects, observed whether the subjects successfully completed the task, and surveyed the differences of activation in relevant brain regions [19]. There are also many ways to study embodied emotion through the control of prescribed movements or postures. For example, study by Delos et al. showed that the subjects felt anger easily when they placed their fists in front of them, and it was easier for them to perceive sadness when they bow their heads [20]. In addition, embodied emotion can be studied through some physical activities, postures, etc., such as back straight and squat shoulder. The subjects were firstly told by the researchers that they had a good performance in the task, and then they were asked to report their degree of pride when they heard the praise. The result showed that the subjects in the regular work pose can feel more pride than that of the latter [21]. Study by Mouilso et al. demonstrated that interactions between emotion and body influence the body's mood [22].

II. THE CONCEPT AND CLASSIFICATION OF MEMORY

A. *Explicit Memory and Implicit Memory*

The study of implicit memory first began in clinical research experiments on patients with amnesia. Warrington and Milner discovered implicit memory in patients with amnesia. On this basis, healthy people were selected by Graf and Schacter as subjects to detect their memory performance in indirect memory tests. According to the tests, they proposed the distinction between explicit and implicit memory [23]. Different processing processes are enjoyed in explicit and implicit memory. Explicit memory is a process that requires conscious attention to resources, while implicit memory is unconscious without requiring attention to resources. The main expression of implicit memory proposed by Schacter was "previous experience facilitates the current task operation, and this task does not require conscious extraction of prior experience". Roediger (1993) believed that implicit memory was an experience that cannot consciously recall itself but can be expressed in behavior. McDermott (2000) thought that implicit memory was a memory presentation without intentional extraction. A classic paradigm for studying implicit memory is the processing separation procedure proposed by Jacoby whose hypothesis was that consciously extracted memory was only obtained by automatically extracting this condition, while another part of the memory of the subjects was obtained by self-guided extraction and conscious recall, and then the conscious recall can be first determined through the elimination method. The rest was the unconscious recall.

There is a lot of fruitful researches on implicit memory related to emotion. With the summary of relevant research, Elaine and Mary suggested that the result of implicit memory of mood congruity is very complicated, and the reasons for the inconsistent results may be related to the different measurement paradigms of implicit memory and the different tasks of subjects in memory test.

B. *Recognition Memory*

Recognition memory refers to the ability to recognize previously encountered events, objects, or people. When the previously experienced event is re-experienced. Most researchers, through a large number of experiments and researches, have divided human recognition memory into two distinct memory processes: familiarity and recollection [25]. In order to distinguish the two different memory processes, researchers have developed a dual-processing model of recognition memory. For example, Atkinson et al. proposed that the subjects first made a judgment of whether they have learned the project based on their familiarity to the project. Through these experimental phenomena, they found that the difference between the familiar memory process and the recall memory process is that meaningful memory is the foundation of recall memory while the familiar process is a memory process based on the perception information of

things [26-27]. The two processes of recognition memory are independent and parallel to each other, and familiarity usually processes faster than the recollection in Mandler's concept [28]. Jacoby et al. proposed that the judgement of recognition memory can make a response based on the evaluation of the processing fluency of the project or the extraction of background information and other detailed information related to the project during the encoding phase [29]. Tulving et al. proposed that information is first processed by the semantic memory system before entering the episodic memory system during the learning phase. However, the two memory systems are independent and parallel in processing [30]. Yonelinas suggested that recollection and familiarity should be distinguished from two aspects through a lot of experimental studies and analysis of other models: On the one hand, they provide different information; on the other hand, the degree of understanding for impact of each process on recognition is not the same.

C. *Emotional Memory*

Based on whether it has emotional valence and arousal, the memory material can be divided into emotional memory and non-emotional memory. Emotional memory refers to the process of encoding and storing emotional information (or neutral stimulus in an emotional state) and extracting it under certain conditions. Since emotion has two dimensions of arousal and valence, it can be divided into positive emotional memory and negative emotional memory from valence. From arousal, it can be divided into general emotional memory, flashbulb memory, and traumatic memory. The arousal in flashbulb and traumatic memory is very high.

For the study of emotional memory, many theoretical models have been proposed so far. For example, Bower's semantic network model considered that every basic emotion is represented in the memory network in the form of a midpoint, while complex emotion is simultaneously activated by many nodes of basic emotions [32-34]. Lang's biological information model, whose general structure is also based on the semantic network, is somewhat similar to Bower's semantic network model [35]. However, the emotional information in Lang's model is not a node, but a semantic network composed of different propositions [36]. In the model, emotion is the activation of emotional memory structure. Leventhal's multilevel process theory of emotion considered emotion to be a complex reaction processes organized in three-layered cognitive level--sensory actions, schematism, and concepts [37]. Leventhal et al. believed that the intensity of emotion and autonomous response linked to specific emotion depend on previous conditioned reflex. Teasdale put forward an emotional memory model based on Barnard's general cognitive structure model. This integrated cognitive subsystem model considers that cognition is a network system, which is specialized for the processing of each kind of information. There are also specialized memory structures and coding systems for each information [38]. On

the basis of summarizing other researches, the integrative model of emotional memory was proposed by Philippot et al. According to the model, there are two cognitive systems based on different types of memory: one is “schematic processes” and the other is “propositional and reflexive processes” [39]. The emotional memory model of LeDoux considered emotion as the result of activation of specific types of information in memory storage system (the emotional memory system) [40]. Damasio proposed an emotional theory that distinguished primary emotional system from secondary emotional system. The primary emotional system is the emotional system that reflects the basic perceptual features of biological determinants on stimulus [41-43]. The representation of emotional information is applied by pure psychological model of emotional memory to understand emotional memory. However, emotional information processing and brain processing mechanism are linked in neuropsychological model. Therefore, the empirical researches of these theories have an important role in the study of emotional memory.

III. THE IMPACT OF EMBODIED EMOTION ON MEMORY

Summarizing previous studies, the researches on emotion and memory mainly focused on the memory differences of materials with different emotional properties, the influence of individual's emotional state on memory at the time of information encoding and recalling. In general, it is the study of emotion congruent effect and emotion dependence effect. Based on this, the emotion of the subjects will be induced and be further embodied, that is, certain emotions are firstly induced by facial feedback theory and the somatic markers theory, and then the memory task are carried out.

A. *The Impact of Embodied Emotion on Implicit Memory*

A large number of experimental studies have shown that different results are obtained when different materials are memorized in different emotional state. Based on these results, the impact of emotion on implicit memory is studied. In recent years, domestic and foreign researchers have found that explicit memory has mood congruency memory, which refers to individuals tend to recall the information being consistent with their current state of mind. However, implicit memory does not exist. The mood congruency effect is found to exist in both explicit memory and implicit memory in many studies. There are also lots of researches demonstrated that emotion is significantly related to implicit emotion. However, embodied emotion is the emotion experience that is closely related to body in the process of perception, understanding, processing. Combined this emotion experience with the study of implicit memory, embodied emotion will have an impact on implicit memory. For example, tragic roles in reading materials are easier to raise concern of subjects who are sad and more details can be given by these subjects; while comedic roles are more

easily to get approval from subjects who are happy.

B. *The Impact of Embodied Emotion on Recognition Memory*

Based on the dual-process theory, it is generally believed that emotion has an enhanced effect (morale incidents are easier to remember than no-morale incidents) on recognizing extraction in the exploration and discussion of the effect of two emotional dimensions (arousal and valence) on recognizing extraction. Recently, the study of enhanced effect has been found that it involves two different recognition extraction processes: familiarity and recollection. In the familiarity extraction, the enhanced effect is not only reflected in the increase of positive emotions' response to familiar judgments, but also in the increase of memory intensity when emotion is awakened. In recollection extraction, the adjustment of emotional valence is dominant. Negative emotion pictures have significant memory enhancement effects, while positive emotional pictures do not have. In subsequent experimental studies, researchers used embodied emotion paradigm—face-feedback paradigm. Subjects were asked to “fix pencil with their teeth” to initiate their positive emotions and to “fix pencil with lips” to initiate their negative emotions. Based on effective inducement of different emotions, the “learning-recognition” paradigm was used to study recognition results of subjects. According to the impact of embodied emotion on the response of lexical valence judgment and the recognition results of emotional words, this study finds that if the mood congruity is high, the recognition results are also high. Moreover, on the basis of previous research theories, this study drew the conclusion by demonstrating the effect of the mood congruity effect of embodied emotion on memory performance. In general, emotion has a significant effect on recognition memory, and therefore emotion induced by embodiment methods also have an impact on recognition memory.

C. *The impact of Embodied Emotion on Emotional Memory*

In the field of emotional memory, it is proved that emotional memory has a selective effect. Three memory phases are included in the success of emotional memory: coding, consolidation, and extraction. There is evidence that when an arousal response is triggered by a stimulus or event, emotional specific processing may be involved in each of these stages, enhancing the possibility of information being coded, consolidated, and extracted. However, when the arousal response of a particular emotion is induced by embodied emotion, the coding, consolidation and extraction of emotional memory can also be affected. For example, Jenny-Charlotte Baumeister et al. asked subjects to apply a facial mask which will concretes into solid state in 10 minutes. Such mask blocked the facial muscles of subjects, and then disturbed its emotional expression. Therefore, the emotion that hinder the expression of facial muscles will interfere

with emotional memory^[44]. In addition, there are also experimental studies confirm that laugh can regulate the emotional intonation related to negative memory, that is, the regulation of facial emotion has an effect on emotional memory^[45].

IV. CONCLUSION

At present, more and more researches focus on the embodied emotion. The facial feedback theory, somatic marker theory has been put forwarded, bringing some references for the neurophysiological mechanism of emotions and theoretical breakthroughs for emotional cognition processing. However, there are still many difficulties in the study of embodied emotion. For example, emotion is an implicit experience. The key in the study of embodied emotion is how to accurately induce it through implicit memory. Therefore, more in-depth empirical analysis is needed.

As a large research field in the psychological science, many branches have been produced in memory study, such as explicit memory, implicit memory, recognition memory, episodic memory and emotional memory. With the extensive research of neuropsychology, cognitive psychology and brain imaging, it has been proved that memory is the process by which the human brain encodes, stores, and extracts external information, which is important for both higher levels of mental activity and individual development. The main types of memory mentioned in this article are implicit memory, recognition memory, and emotional memory.

By summarizing the results of previous experimental studies, it can be seen that embodied emotion has a significant effect on memory. Embodied emotion can induce effective emotions, which then affect memory. However, some researches are only left on the external behavioral level. The lack of understanding about internal mechanisms and physiological basis for the impact of embodied emotion on memory will causes certain limitations in the research results. Therefore, some physiological mechanism researches using ERP, fMRI and other technologies should be added to the future researches of the impact of embodied emotion on memory.

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