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Embodied Effect on Memory Performance

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Abstract: The relevant theories of psychology have made great progress since the 1980s, among which the emergence and development of embodied cognition theory have played a crucial role in the transformation of the psychological research paradigm. The theory of embodied cognition emerged from the critical reflection of the original mind-body dualism. Through the continuous exploration and research of the theory by scholars at home and abroad, its outline is becoming clearer, and the relevant theories and evidence are constantly emerging. The core of the embodied cognitive theory, which opposes the traditional cognitive psychology of mind-matter duality, is to integrate mind and body and the environment with them into the cognitive process system and to emphasize the interaction between the three. The related effects in embodied cognition are reflected in the processing of human memory. The research on embodied effects in memory performance plays a vital role in consolidating and developing the construction of embodied cognition theory. More and more studies have shown that the process of memory is embodied, and its encoding and retrieval processes are embodied. It is a process of encoding and simulating events and their associated environments, which bases on the perception of the body. This paper summarized the progress of the research on embodied effects in memory performance, analyzed the related mechanisms of embodied effects in memory performance, and make suggestions for future research paths.

Keywords: embodied effect, memory, sensorimotor simulation, encoding, retrieval

1. Introduction

The emergence and development of embodied cognition theory is undoubtedly a new milestone in the recent history of cognitive psychology, and its theories and research have caused a paradigm shift in thinking and research at many levels of cognitive psychology, changing more fundamentally the behaviorist theories and mind-body dualism that had dominates American and world psychology in the past. “A specter hovers over the cognitive science laboratory, and that specter is embodied cognition ”[1]. Embodied cognition theory has shifted the trend of thinking that separates the body and environment from the mind and heart, and only studied behavior at the expense of consciousness, towards thinking that the environment influences bodily sensations and bodily sensations shape cognition, emphasizing the interactions and influences between the environment, body, and brain, and shifting the direction of cognitive psychology research to an inquiry into the origins of the mind in bodily experience. Cognition is the cognition of the body. When the movement of the body or the

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experience or simulation of the body state affects cognition, attitude, social perception, emotion, etc., this effect is referred to as the embodied effect [2].

The study of embodied cognition involves a combination of multiple perspectives and approaches. The theoretical features of embodied cognition include embodiment, contextuality, generativity, dynamism, etc. [3]. The research dimensions include theoretical features, cognitive processes, neurological research, and applied research. Memory, as an important component of the cognitive process, has become the focus of relevant research. Memory is the basis of cognitive realization and the source of recognition. It includes the acquisition of the real environment and its evoked feelings, as well as the reproduction of past feelings and cognition, which has a wide range of cognitive science and neurological research significance.

The study on memory can be traced back to Ebbinghaus‘ use of the quantitative research method of the savings curve, which essentially described the ability of cognition to retain information. Later, Richard Atkinson and Richard Shiffrin proposed the modal model of memory, describing the relationship and role of sensory memory, short-term memory, and long-term memory, as well as the control processes, providing an explanation for how memory is encoded from sensory memory into long-term memory and the retrieval of specific memories in long-term memory. To understand complex cognitive processes, Baddeley and Hitch proposed working memory and its model, showing that memory can operate independently and can be simultaneous in dynamic comprehension and perception of auditory and visual information. To study long-term memory, Endel Tulving proposed episodic memory and semantic memory, and subsequent research found that the two often interact with each other, with the long-term memories losing their contextual character and being converted into semantic memories. Neuropsychological researchers have also investigated the neural mechanisms of memory in the context of neurological damage caused by accidents and in animal studies, showing the importance of the prefrontal lobe for attention and memory [4], and proposing that memory function may be achieved through continuous neuronal firing or temporary changes in neural networks, and the hippocampus plays an important role in the formation of new memories and long-term memory [5]. The measurement methods of memory studies mainly include the measurement of completeness and accuracy of short-term presentation, delayed-response task, measurement of memory duration and its span, and methods of change detection, free recall, cued recall, and other methods.

Research on embodied effect in the process of memory can provide support for relevant theories of embodied cognition in high-level cognitive activities, and also provide a new direction for the development of embodied cognition theory and the understanding of memory mechanism [6]. This thesis aims to provide a brief overview and analysis of the current research on embodied effects in memory performance, outline the problems and mechanisms involved in the research, and provide insights and suggestions for the development of future research.

2. Research on Embodied Effects in Memory Performance Studies

In contrast to the original abstract symbol theory, the research paradigm of embodied effects in memory is based on the perceptual symbol System (PSS). Perceptual symbols correspond to the brain’s memory encoding of different perceptions and are reactivated in the process of retrieval. A growing number of studies have shown that the human body is the key to the formation of high-level cognitive functions such as memory [7], and the theory that the brain regions to be activated for recall are mostly near the motor nervous system areas shows the connection between memory and body movement [8]. Movements in different forms (gestures, eye movements, etc.) contribute to the encoding and retrieval of memories. Thus, memory is to some extent embodied and its encoding process is based on the body’s experience and perception of the facts of the event, thus shaping the neural pathways associated with sensory perception. The resulting memory traces are dynamic to

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adapt to the understanding and memory of different information. Research on mental simulation has also demonstrated the importance of body movements for memory. Recall-related mental simulation is analogous to recreating memories in the brain. This process activates the same stimuli that initially generated the sensorimotor neural circuits, causing activation in the cerebral cortex that encoded the associated sensations and events. Some scholars believe that mental Simulation relies heavily on the brain's sensorimotor system, referring to it as Sensorimotor Simulation [9], through which the relationship between motor perception and memory can be explained: while the body moves, the neural circuit responsible for processing movement and perception will store the perceptual information related to the movement. When we recall it, the mental simulation will activate the relevant neural network, to reproduce the previous perception in the brain.

Current research on the embodied effect in memory performance is diverse and can be broadly divided into two categories in terms of manipulation of the memory process: those that alter the physical state, environmental conditions, and experimental content during encoding to study memory effects, and those that alter the previously remembered environment or body gestures during memory retrieval to study changes in the effects of memory retrieval. The results of the studies were expressed in terms of the accuracy of the subjects' recall of the experimental content, the amount of information, the relevance of the content, and the length of recall. Studies altering associated factors of the encoding process include reverse proof of the effect of sensorimotor simulation, for example, altering the occupancy of the audience's motor effector during the encoding phase to study the influence on the audience's memory effects on memorizing action phrases accompanying the speaker's gestures [10,11]. Among the studies that altered the previous experimental setting during memory retrieval, Godden and Baddeley's diving experiment' better explained the principle of encoding specificity. The experiment was a 2×2 between-subjects experiment in which participants were divided into two groups, one on land to learn the words and one underwater in scuba gear to perform the same word-learning task. The two groups were then divided into two groups each. The two groups separated from the group that had studied on land were given a land-based and an underwater memory test individually and in the same way, the two groups separated from the group that had studied underwater were given land-based and underwater memory tests. It was found that the groups that were in the same environment (both on land and both underwater) scored higher than the groups that were not in the same environment. This type of study is also seen in eye movement studies, for example, where manipulations of the subject's eyes are altered during the memory retrieval phase to study the effect of gaze on memory [12].

Based on the cues in the encoding and retrieval process of memory, the current research can be divided into congruent cue study and metaphor study. Congruent cues, i.e. consistent clues in the activation of memory pathways during encoding and retrieval, involve the application of the sensorimotor simulation model as well as the reactivation hypothesis. The studies of congruent cues test the facilitation of congruent cues to memory by verifying the promotion of the same memory components to recall during encoding and retrieval. For example, the effect of the listener's consistency of hand and arm movements during the encoding and retrieval phase on memory for content related to the speaker's gestures during a speech [13]. Metaphor study is a research paradigm that correlates body movement perception with abstract meaning, which facilitates the retrieval of information with higher social meaning by activating body movement perception. For example, upward motion perception facilitates one's recall of events with a positive meaning.

Although there is currently no clear research model for related research and conflicting conclusions drawn from experiments, several interrelated theories and hypotheses have been validated as the research process has progressed. Current theoretical hypotheses that have been experimentally demonstrated include 1. Triggering cues related to the original memory speeds up the memory retrieval process [14]. This conclusion is based on studies into the memory encoding process:

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memories are encoded in groups, including people's experiential knowledge, emotions, and somatic movements, and such an encoding method is conducive to memory retrieval. For example, when returning to a place they lived many years ago, people are more likely to recall events and details associated with it. 2. Sensations, movements, or states that are consistent with the original encoding process facilitate the retrieval process, while incongruent sensations and physical movements hinder the retrieval process [10,11,15]. For example, people are more likely to recall pleasant experiences when they smile and hold a stretched posture; in contrast, sad expressions and curled-up body postures facilitate the recall of unpleasant experiences [16]. 3. Parallel tasks that occupy the same neural resources as recall hinder retrieval [9]. This conclusion is a reverse proof of the sensorimotor simulation model and its related theories, that is, to contrast the role of embodied effects in the memory process by hindering the sensorimotor simulation of subjects. Related phenomena also occur in the process of tool recognition. For example, people may have a certain delay in identifying tools with handles oriented in the same direction that the occupied hand orients to [17]. 4. Metaphor-related perceptual experiences can be used as retrieval cues to trigger and speed up the retrieval of memories that have relevance to sensorimotor simulations.

3. Problems and Mechanisms of Embodied Cognition Research In-memory Performance

From the existing research, the following problems may exist in the research of embodied cognition in memory performance: 1. Whether the measurement for memory effectiveness is reasonable, and whether the evaluation criteria for memory quality and control experiment Settings are appropriate. For example, in how to evaluate the degree of memory retrieval of a subject during the experiments, some experiments should appropriately set the control group. 2. Attention should be paid to the effects of variables in the experiment that are unrelated to the purpose of the experiment. For example, in the eye movement study, subjects were asked to fix a central cross to limit the eye movement in the process of memory retrieval, to study the influence of this restriction on the retrieval process [18]. In this experiment, attention should be paid to the possible occupation of control and memory on cognitive resources while subjects were fixating on the central cross. 3. Whether the experiment reflected the embodied effect. Relevant questions include whether the requirements of experimental variables on the subjects reflect the effect of body perception on memory performance, or whether the experimental results are affected simply by improving the participants' attention level.

Current studies have shown that the body plays an important role in the formation and retrieval of memory, but the specific mechanism, physiological basis, and long-term effects inside the processes need to be explored. In the current research background, the following mechanisms are proposed for research: 1. The mechanism of triggering emotion by behavior strengthens the encoding of memory. Previous studies have shown that emotion plays a role in memory consolidation, and its physiological response is manifested in the high level of amygdala activation and cortisol release caused by emotion. People often experience different emotions with corresponding body movements and expressions, which are expressed as perceptual symbols present in neural pathways that are linked to pre-existing individual experiences and which have the effect of reinforcing the expression of emotions, thus facilitating the encoding process. 2. Behaviors contribute to the generation of group memory, and the representation of memory components can promote and speed up memory retrieval. For example, when recalling an event, the details of its environment, body movements, and bodily sensations can be used as retrieval cues to facilitate recall. 3. Behavior contributes to the generation of episodic memory, which is more conducive to the encoding and retrieval of memory than semantic memory, thus promoting the generation of memory details in short-term memory and the generation of long-term memory. 4. Physical actions stimulate brain areas related to memory, thus strengthening memory. This mechanism can be used to construct a brain structure network to study the relationship between related brain regions by magnetic resonance technology and to verify its long-term effect on memory.

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5. Changing body movements and sensory experiences improve the plasticity of memory pathways, so that memory can constantly process and complete new encoding according to the changes in situations and events, and form changeable memory traces. From the perspective of human development, human evolution depends on constant contact with the actual world, and the formation of complex neural pathways in the brain is based on the experience and reinforcement of physical perception in the real world. The adaptation of humans to the changeable natural environment and situation eventually contributes to the formation of complex neural pathways. The avoidance of danger and the repeated verification of survival experience enable people to realize high-level thinking processes such as thinking leaps and association and to quickly convert and integrate memories.

4. Conclusion

Research on the embodied effect in memory performance has involved a variety of paradigms and theoretical foundations, but all are based on the activation of neural networks associated with motor perception and the reproduction of bodily perception at the time of encoding. Most of the existing experimental studies do not have a fixed research pattern, they have focused on short-term studies of fixed paradigms, and their findings may be contradictory due to the failure to identify key factors, and some studies have encountered the problem that the results of the experiment cannot be examined by repeating the test. Therefore, the current research may be constrained by the inherent paradigms and may not reflect the value of the embodied effect. Future research should pay more attention to the combination of the original meaning of embodied cognition and the purpose of the research, so that the relationship between embodied effect and memory can be studied in a more stereoscopic way, closer to the real environment, and in a long-term multidimensional way. Based on the consideration of the relationship between embodied cognition and memory, the body-cognition-memory model is put forward, in which the body's perception of the external environment can shape the brain's cognitive network, and will correspondingly produce explicit and implicit memories that will influence the structure and pattern of cognition, and long-term memory has a sustained effect on cognition. Cognition in this model changes through physical exposure to the outside world, which affects the understanding of memory. The model distinguishes between perception and memory to emphasize their interaction to explain the long-term role of cognition and memory but does not suggest a complete separation of their physiological structures. The model contributes to the understanding of the long-term role of memory concerning the embodied effect and guides research on the neurological basis of the role of memory about the embodied effect. In the future, the long-term role of the embodied effect on memory can be investigated, supplemented by the study of the accumulation of memories on personality traits from multiple perspectives, thus gradually approaching the study of practical applications.

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