Embodied Memory and Its Intrinsic Mechanisms

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Embodied memory research primarily investigates the role of the body and its sensorimotor processes in memory. Manipulating or constraining the physical state, embodied characteristics, or availability of the body can affect the efficiency, valence, and content of memory. The underlying mechanisms can be explained through the encoding specificity principle, priming effects, metaphorical representation theory, and reactivation hypothesis, yet no unified model has been established. Based on the commonalities across existing research and theories, we propose a sensorimotor simulation model of embodied memory that emphasizes the role of reactivation in embodied memory, aiming to explicate the process through which the body influences memory within a single framework and further specify the conditions for reactivation. Future research urgently requires multi-dimensional basic and applied investigations into the stability of embodied memory and its deeper mechanisms.

Full Text

Embodied Memory and Its Intrinsic Mechanism

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Abstract

Embodied memory research primarily investigates the role of the body and its sensorimotor processes in memory. Manipulating or restricting the physical state, embodied characteristics, or availability of the body can influence the efficiency, valence, and content of memory. The underlying mechanisms can be explained by the encoding specificity principle, priming effects, metaphor representation theory, and the reactivation hypothesis, yet no unified model has emerged. Based on commonalities across existing research and theories, we propose a sensorimotor simulation model of embodied memory that emphasizes the role of reactivation, aiming to explain how the body influences memory

within a single framework and to specify the conditions for reactivation. Future research urgently requires multi-dimensional basic and applied investigations into the stability and deeper mechanisms of embodied memory.

Keywords: memory, body, embodied cognition, the sensorimotor simulation model, the encoding specificity principle

Since Ebbinghaus employed empirical methods to study memory, scholars have continuously transformed our understanding of memory, from multiple-store memory models (Atkinson & Shiffrin, 1968) to semantic network models (Collins & Loftus, 1975). Memory evolved from abstract symbols stored discretely in the brain to interconnected nodes within the brain. However, even then, memory traces remained merely combinations of abstract symbols manipulated according to syntactic rules, unrelated to the body. After Harnad (1990) pointed out that abstract symbol manipulation models could not explain how symbolic systems connect to the world, the embodied perspective—which holds that the body and its modes of activity shape cognition—developed into an influential current in cognitive science. Since then, the view that "cognition is based on and originates from the body" has gradually become consensus, with researchers recognizing that the body may be crucial in shaping higher cognitive functions such as memory (Cook & Goldin-Meadow, 2006; Dutriaux et al., 2019; Glenberg, 1997; Harmon-Jones et al., 2015; Mille et al., 2021; Marre et al., 2021; Wilson, 2002).

Embodied memory research primarily explores how the body and its sensorimotor processes affect memory. Glenberg (1997) emphasized the importance of the motor system in memory, arguing that the world is encoded according to affordances that depend on an organism' s capacity for action. Additionally, Damasio (1989) and Ianì et al. (2018) found that brain activity during information recognition and recall predominantly occurs near sensory and motor regions, with the premotor cortex being critical for encoding episodic memory. Subsequent theoretical and empirical studies have shown that memory shares processing resources with the sensorimotor system and, to some extent, supports action (Dutriaux & Gyselinck, 2016; Dutriaux et al., 2019; Tucker & Ellis, 2004; Wilson, 2002). These results strongly demonstrate that memory is not simply an abstract entity stored in our brains but derives from proximal sensory projections that include sensorimotor elements—in other words, symbols only acquire meaning through sensorimotor experience (Harnad, 1990). From this new perspective, memory processes are no longer higher cognitive activities completely divorced from ordinary sensory processing but rather multi-modal components integrating vision, audition, action, space, emotion, and language through interaction with the environment. These multi-modal components are activated, shaped, and strengthened during initial processing and stored in corresponding sensorimotor channels. During retrieval, memory traces partially reactivate the perceptual and motor neural systems consistent with those engaged during encoding (Dutriaux et al., 2019; Glenberg, 1997; Ianì & Bucciarelli, 2018; Ianì, 2019; Matheson & Barsalou, 2018). In daily life, the influence of the body and sensorimotor processes on memory is readily observable: when attempting to recall an experience, simply adopting a posture or action related to the original experience can enhance recall effectiveness (Rand & Wapner, 1967; Slowikowski & Motion, 2021).

Currently, numerous studies on embodied memory have emerged internationally. The earliest body-oriented research predates the formalization of embodied cognition theory, with researchers approaching embodiment from the perspective of context-dependent memory, treating body posture as an internal context that could be manipulated between learning and recall to investigate how bodily postures constitute relevant processing contexts that influence memory (Díez-Álamo et al., 2019). With the advent of embodied cognition theory, researchers further transformed facial and bodily postures related to emotional states into spatial movements independent of emotional encoding, explaining the influence of embodied manipulation on memory retrieval from a metaphorical perspective (Casasanto & Dijkstra, 2010; Casasanto & de Bruin, 2019). Moreover, researchers have demonstrated the importance of embodied manipulation in memory by restricting or altering motor effectors to interfere with the availability of the motor system (Dutriaux & Gyselinck, 2016; Dutriaux et al., 2019; Ianì & Bucciarelli, 2017, 2018). In summary, the body plays a significant role in memory processes. However, the psychological processes underlying embodied memory and the key variables through which the body influences memory remain unclear, requiring further theoretical and empirical investigation.

Exploring this topic can, on one hand, provide support for elevating the importance of embodied cognition in higher cognitive activities and, on the other hand, offer a new functional approach to understanding memory mechanisms (李荆广, 郭秀艳, 2009; Caravà, 2021; Hutto & Myin, 2017; Hutto & Peeters, 2018). Additionally, embodied memory research holds substantial applied value: through simple adjustments to body posture and movement, people can autonomously influence the valence of recalled content, enhance memory quality, regulate emotional states, and promote social adaptation.

This study reviews empirical research and theories on embodied memory, synthesizing them to propose a sensorimotor simulation model of embodied memory that reveals the underlying logic and provides theoretical reference for its theoretical development and practical application.

2. Advances in Embodied Memory Research

The shift from disembodied to embodied cognition represents a major paradigm transformation in cognitive science (张博, 葛鲁嘉, 2017). Body-oriented researchers have gradually moved from formalized, symbolic computational paradigms toward concrete, experiential, and situated embodied paradigms. This section presents diverse embodied memory research from a paradigmatic perspective to provide templates for future investigations. Current experimental manipulations in embodied memory research can be summarized into three categories: (1) manipulating participants' physical states, specifically the consistency of body posture between encoding and retrieval, primarily applied to posture-dependent memory effects; (2) manipulating embodied characteristics, specifically the match between the conceptual representation metaphorically signaled by body posture or movement during retrieval and the content being retrieved, primarily applied to congruency memory effects; and (3) interfering with embodied activation by restricting or altering motor effectors to demonstrate the reverse effect of embodiment on memory. These manipulations can be further subdivided into four experimental paradigms: (1) adopting body postures consistent with the encoding phase to influence memory retrieval by simulating the initial state (the simulation paradigm); (2) employing bodily postures or facial expressions with social meaning (e.g., "upright" and "smiling" associated with positive meanings like happiness, pride, and energy; "hunched" and "frowning" associated with negative meanings like sadness, discouragement, and dejection) to influence memory retrieval by priming the social meaning of body posture (the priming paradigm); (3) employing spatial movement representations that have metaphorical mappings with emotional valence, such as upward and downward vertical movements, to influence retrieval by activating emotional valence through vertical spatial movement from a metaphorical perspective (the metaphor paradigm); and (4) employing dual tasks to perform interfering postures during encoding or retrieval to hinder mental simulation and eliminate embodied effects (the reverse validation paradigm).

2.1 Simulation Paradigm

In the simulation paradigm, participants are randomly assigned to groups based on learning posture (e.g., sitting vs. standing) and learn memory materials. During the test phase, half of each group recalls in the same posture while the other half recalls in the opposite posture. If recall performance is significantly better when learning and testing postures match than when they mismatch, body posture is considered to influence memory processing and retrieval. Reed (1931) first introduced body posture as an organismic variable in what was considered an analysis of context-dependent memory, but this initial attempt yielded null results. In contrast, Rand and Wapner (1967) evaluated the effectiveness of posture status as a contextual factor in memory for nonsense syllables and found that time saved in relearning increased substantially when body posture during a 15-minute delayed relearning phase matched the initial learning posture. In more complex motor activities, Miles and Hardman (1998) conducted a study under two physiological states—rest and aerobic exercise on a stationary bike—while monitoring participants' heart rates in real time. Results showed that memory performance was superior when heart rate was consistent across encoding and retrieval (same state) compared to when it changed (different state). Huff et al. (2018) used the presence or absence of gestures as an action context in a procedural task (learning to tie knots) and found a context consistency effect, indicating that consistency in motor information availability between learning and testing is crucial for successful procedural learning.

In summary, the memory trace of an experience includes the body posture adopted when acquiring that experience. Humans can better recover their memories by simulating their initial encoding state.

2.2 Priming Paradigm

The priming paradigm focuses on executing embodied operations with social meaning or emotional representation during retrieval to influence retrieved content. Riskind (1983) pioneered research on the effects of facial and body posture on memory retrieval, finding that smiling and upright posture facilitated recall of pleasant experiences, whereas sad facial expressions and hunched posture facilitated recall of unpleasant experiences. Veenstra et al. (2016) also found that hunched posture more readily triggered negative recall than upright posture when examining how posture affects recovery from existing negative emotions. Subsequently, Dijkstra et al. (2007) extended Riskind' s research in three ways: first, they examined posture effects for specific activities rather than general organismic variables; second, they added a delayed recall task (retesting after two weeks) to investigate the long-term effects of congruency on autobiographical memory for the first time; and third, they included elderly participants to assess developmental consistency of the effect. Results showed that in both young and older adults, past personal life events were more accessible when body posture matched the original experience. In another study, Michalak et al. (2014) found that when depressed patients sat in a slumped posture, they recalled more negative words from a set containing both positive (e.g., beautiful) and negative (e.g., tired) experimental materials, whereas depressed patients in upright postures showed more balanced memory for positive and negative words. Similarly, Michalak et al. (2015) found that manipulating students' walking patterns to mimic either depressed or happy gaits biased their recall of emotional words. These results demonstrate that bodily behaviors associated with positive and negative emotional valence can influence the retrieval of emotional memories.

Compared to the one-to-one replication of encoding states in the simulation method, the priming method employs partial or similar replication, expanding the ways embodied operations affect memory and making research more flexible and ecologically valid.

2.3 Metaphor Paradigm

The metaphor paradigm extends priming research from socially meaningful postures and expressions to more concise spatial movement representations—vertical movement. Casasanto and Dijkstra (2010) first used metaphor to explain the congruency effect between body action and emotional valence. Participants were randomly assigned to move marbles upward or downward between boxes while retrieving positive or negative autobiographical memories. Results showed faster retrieval when movement direction matched memory valence (upward for positive, downward for negative). Moreover, in Experiment 2, participants moved marbles upward or downward while retrieving and recounting autobiographical memories based on neutral cues (e.g., "Tell me what happened yesterday"). Results showed participants recalled more positive memories when moving upward and more negative memories when moving downward. These findings indicate that vertical spatial movement behavior not only influences memory retrieval efficiency but also partially determines the emotional content of retrieved memories. Seno et al. (2013) extended these findings, suggesting that the key to emotional valence modulation of memory is self-motion perception rather than visual motion itself. By viewing upward and downward moving grating stimuli, participants experienced vection illusions (perceiving self-motion opposite to the observed stimulus motion). Results showed participants recalled positive events more frequently when perceiving upward self-motion (with downward stimulus motion). Additionally, when grating motion was reduced to a level that produced no vection illusion, no emotional valence modulation was detected. This suggests self-motion perception can modulate memory retrieval by influencing emotion. Väljamäe and Seno (2016) further validated this possibility by testing memory recognition for positive, negative, and neutral emotional images under high and low arousal levels. In a recent study, Casasanto and de Bruin (2019) first demonstrated that mental metaphors could be strategically activated to improve word learning ability, terming this phenomenon the strategic use of mental metaphor (SUMM effect).

2.4 Reverse Validation Paradigm

Mahon and Caramazza (2008) proposed an alternative approach to validating the relationship between memory and embodiment: inhibition or damage to the motor system would impair memory performance. In other words, sensorimotor simulation may be inhibited or disrupted by concurrent tasks that involve the same sensorimotor resources. Dutriaux and Gyselinck (2016) found that adopting an interfering posture (hands behind back) reduced memory for pictures and words representing manipulable objects compared to a control group (hands in front). This result was replicated in older adults (Dutriaux et al., 2021). Dutriaux et al. (2019) further modulated motor simulation through posture and linguistic action contexts to manipulate conceptual memory for manipulable objects. They found that memory for words representing manipulable objects was impaired by interfering postures when associated with action verbs but not when associated with attention verbs. Beyond restricting posture, concurrent tasks using the same sensorimotor resources also hinder embodiment' s facilitative effects on memory. Ianì and Bucciarelli (2017, 2018) investigated whether speakers' gestures could improve listeners' memory by utilizing the listeners' motor system. They found that listeners recalled action phrases accompanied by speakers' gestures better when not engaged in additional activity. However, this advantage was blocked when listeners moved the same motor effectors (their arms and hands) as the speaker during encoding or retrieval, while the advantage remained when listeners moved different effectors (their legs and feet). Because Ianì and Bucciarelli (2017, 2018) only manipulated listeners' motor system availability during encoding or retrieval separately using irrelevant motor tasks, their results could be alternatively explained by action context matching being the key factor. Halvorson et al. (2019) addressed this by adding motor tasks during both encoding and retrieval, finding that gesture' s memory-enhancing effect depended on contextual matching between encoding and retrieval. Additionally, Ianì et al. (2018) investigated the neural basis of speakers' gesture facilitation by applying transcranial magnetic stimulation to inhibit primary motor cortex and premotor cortex separately, finding that the facilitative effect disappeared only with premotor cortex inhibition. These studies provide behavioral and physiological evidence for the importance of embodied operations in memory processing by restricting motor system availability.

3. Intrinsic Mechanisms of Embodied Memory

While investigating how embodied operations affect memory, researchers have also examined the processing mechanisms of embodied memory, proposing four main theoretical explanations.

3.1 Encoding Specificity Principle

The encoding specificity principle posits that retrieval is more effective when conditions at retrieval resemble those during initial encoding (Tulving & Thomson, 1973). Replicating body posture facilitates memory access for at least two reasons. First, for complete replication, stored representations created when a stimulus is encoded into memory include both stimulus features and accompanying contextual cues. Body posture becomes bound with the stimulus during encoding, thereby facilitating retrieval when replicated. This explains posture-dependent memory effects and reverse validation paradigm results. Second, for partial replication, recreating specific aspects of the bodily environment facilitates retrieval of positive and negative memories because positive and negative life events were originally experienced and encoded within those contexts—for example, facial expressions or body postures associated with emotional valence (smiling vs. frowning, upright vs. hunched). This explains posture-congruent memory effects. The emergence of embodied cognition theory provides support for the encoding specificity principle. Kent and Lamberts (2008) suggest that the sensorimotor simulation model (SMM) may reveal the mechanism underlying encoding specificity: SMM posits that recalling perceptual information reactivates the neural networks responsible for processing that information during encoding. Therefore, from a memory structure perspective, information available during encoding can also be utilized during retrieval (Martin, 2007).

3.2 Priming Effect

Current research suggests three possible priming effects underlying embodied memory, primarily explaining embodied memory phenomena in emotional autobiographical recall. First, **congruency priming** posits that people tend to retrieve memory content consistent with the nature of expressed behavior.

That is, when nonverbal expression is positive (e.g., smiling or upright posture), participants are more likely to retrieve pleasant memories from their life experiences; when nonverbal expression is negative (e.g., frowning or hunched posture), retrieved memories become more negative (Riskind, 1983). Second, **cognitive priming** suggests that mental representations of expressive behaviors are stored alongside life experiences. Later cognitive evaluation or mental representation of nonverbal expression can serve as a retrieval cue to guide memory (Riskind, 1983). This process may be somewhat independent of whether individuals have corresponding emotional reactions to the nonverbal expression. For instance, the cognitive evaluation "I am smiling" may guide recall of previous smile-related memories or broader categories of memories implied by smiling' s positive connotation (Bower, 1981; Isen et al., 1978). Third, **emotional priming** suggests that when emotional material is stored in memory, it may generate an emotion (e.g., pleasant material produces positive emotion), making the material more retrievable when in a similar emotional state by priming the encoding emotion (Bower, 1981; Isen et al., 1978; Ross & Atkinson, 2020).

Most current research has validated the congruency priming hypothesis. Although emotional and cognitive priming may produce similar effects, few studies have tested these alternative explanations. Future research should clarify whether nonverbal expressions influence memory through the emotions they generate or through their mental representations and evaluations, and should articulate the relationships and distinctions among these explanations.

3.3 Metaphor Representation Theory

Metaphor representation theory (Lakoff & Johnson, 1980, 1999) emphasizes the crucial role of metaphor in understanding the world, mapping concrete sensorimotor information schemas onto non-sensorimotor information to express and comprehend abstract concepts. This indirect representation is deeply influenced by language and culture. When discussing emotions, people frequently use expressions linking positive emotions to upward movement or position in space (e.g., "cheer up") and negative emotions to downward movement or position (e.g., "feeling down") (Lautenbach et al., 2019). According to metaphor representation theory, these linguistic metaphors correspond to "mental metaphors" (Casasanto, 2009). Laboratory manipulations of emotional responses through body posture often involve upward or downward trajectories, as do emotional facial expressions: smiling raises the corners of the mouth, eyes, cheeks, and eyebrows, while frowning lowers the corners of the mouth and eyebrows. According to metaphor theory, smiling and holding one' s head high facilitate positive memories and encourage positive evaluation partly because these actions activate upward schema representations, which constitute components of positive emotion. Thus, emotional memory interacts not only with specific bodily actions co-occurring with positive and negative states (e.g., smiling vs. frowning, upright vs. hunched) but also with more systematic upward and downward vertical spatial movements.

3.4 Reactivation Hypothesis

The reactivation hypothesis posits that brain regions active during perception and encoding of sensory information are reactivated when retrieving the same information (Damasio, 1989). Because stored information is enriched with sensory and motor information during both encoding and retrieval, motor information stored in the motor system may become part of the memory trace. According to this hypothesis, motor processes occurring during encoding should be reactivated during retrieval (Nyberg et al., 2001). Evidence indicates that posture modulates the use of motor information, particularly in motor imagery performance (Lorey et al., 2009; Sirigu & Duhamel, 2001). Sirigu and Duhamel (2001) demonstrated that motor imagery response times were slower when hands were behind the back versus on a table. Moreover, transcranial magnetic stimulation studies show that postures inconsistent with imagined actions reduce motor cortex excitability (Vargas et al., 2004), while action-related concepts involve automatic activation of motor cortex (de Vega, 2012). Therefore, recall performance significantly declines under interfering postures: restrictive postures hinder embodied activation by inhibiting brain regions responsible for motor simulation, thereby reducing memory traces (Villatte et al., 2021), while interfering postures using the same effectors occupy the same motor system, preventing memory from being awakened through reactivation of encoded information (Davis et al., 2020). Recent literature suggests that the reactivation of sensorimotor activity during encoding in the reactivation hypothesis aligns with sensorimotor simulation in embodied cognition theory: retrieving memory activates not only concepts in long-term memory but also the sensorimotor patterns associated with those concepts (Dutriaux et al., 2019).

4. Summary of Existing Theories and Research on Embodied Memory

The encoding specificity principle and priming effects adequately explain the role of embodied operations with experiential connections in memory, with the former emphasizing simulation and the latter emphasizing cognitive factors. However, both struggle to explain memory effect differences caused by embodied operations without obvious meaningful connections, a gap that metaphor representation theory fills. The reactivation hypothesis provides physiological-level explanation but has only been investigated with manipulable objects, words, pictures, or action phrases. These four explanations show some progression and have each received partial empirical support, yet no unified model exists to explain embodied memory mechanisms within a single framework. Therefore, this study attempts to synthesize existing research and theories to propose a psychological process model of embodied memory, explaining how the body acts upon memory.

Information processing theory conceptualizes memory as the encoding, storage, and retrieval of input information. Current embodied operations affecting memory and their theoretical explanations can be summarized into three categories: (1) overlap of embodied operations between encoding and retrieval phases; (2) overlap between the representational meaning of embodied operations during retrieval and the retrieved content; and (3) controlling embodied operations to hinder memory encoding and retrieval. All three essentially influence the reactivation of initial encoding, differing only in activation degree (complete, partial, or none). Given this, the sensorimotor simulation model—one of embodied cognition' s primary mechanisms—can effectively integrate existing research and theories. This model includes four components: first, mental representation is essentially reactivation of prior experience; second, simulation can be disrupted by parallel tasks involving the same sensory channels; third, simulation can work offline; and fourth, simulation depends on prior experience and skills (Dijkstra & Post, 2015; Körner et al., 2015). According to this theory, embodied memory can be conceptualized as mental simulation created in brain-specific modality regions, comprising reactivation of sensorimotor patterns originally associated with encoded events, with the body serving as the medium for reactivation.

Neuroimaging and behavioral studies have demonstrated shared modality-specific activation between encoding and recall, indicating that sensorimotor reactivation is a specific component enabling our cognitive system to retrieve memory traces (Dijkstra & Post, 2015; Ianì, 2019). Clark et al. (1983) and Schramke and Bauer (1997) provided strong evidence that reactivated arousal may be the root of embodied memory effects. In these experiments, participants exercised or rested before learning word lists, then performed matching or mismatching activities before recall tests. Memory improved significantly when activities matched—that is, when physiological arousal was consistent. Furthermore, Wheeler et al. (2000) found that retrieving visual and auditory information reactivated sensory regions initially activated during perception: the precuneus and left fusiform cortex. Similar activation was detected in the inferior parietal cortex during encoding and retrieval of spatial information (Persson & Nyberg, 2000). This indicates that brain regions share similar activation patterns during encoding and retrieval events. Therefore, memory is a sensorimotor simulation process—information retrieval occurs by simulating the original event and reactivating the sensorimotor regions initially engaged during encoding.

Based on this, we propose the sensorimotor simulation model of embodied memory (Figure 1), emphasizing reactivation' s role to provide a unified explanation of embodied memory mechanisms. Specifically, manipulating body availability and physical state affects encoding and retrieval phases, or manipulating embodied characteristics during retrieval alone, achieves reactivation of perceptual and motor information recorded during initial encoding, thereby facilitating information retrieval. Existing theories can explain individual pathways: the encoding specificity principle and reactivation hypothesis represent direct online embodied triggers, while priming effects and metaphor representation theory represent indirect offline embodied triggers. However, all share the core mechanism of reactivating sensorimotor regions involved in initial encoding. Thus, the sensorimotor simulation model can comprehensively integrate current research and theoretical explanations, clarifying the psychological processes through which embodied operations affect memory.

Figure 1. Sensorimotor Simulation Model of Embodied Memory

However, reactivation is conditional. Although embodied memory effects have been demonstrated extensively, they remain controversial. Recently, Díez-Álamo et al. (2019) replicated Reed (1931) and Rand and Wapner (1967) to explain their contradictory results in posture-dependent memory research, while controlling for emotional variables to test posture-congruent memory effects. Neither experiment demonstrated effects of embodied manipulation on memory for action-related verbal materials. Additionally, Hammond et al. (2019) attempted to replicate Miles and Hardman (1998) to determine whether physical activity could serve as a contextual cue for object location memory but found no such effect. These non-replications raise a key question: To what extent does memory depend on these sensorimotor processes? Based on prior research, we propose that the likelihood of embodied manipulation affecting participants in specific tasks or contexts depends on activation level, which is determined by the relationship between the processing task and the chosen sensorimotor modality (Chen et al., 2018; Philipp et al., 2020). Accordingly, we identify three main constraints: (1) **Memory task**: Task specificity influences the degree to which embodied operations activate memory —the more specific the task, the weaker the embodied activation effect (e.g., object location memory < conceptual memory tasks); (2) **Embodied operation**: Compared to simple, automatic, routine, and low cognitive-demand operations, complex, intentional, unfamiliar, and high-demand operations have weaker effects on memory (e.g., space walking machine < stationary bike); and (3) **Recall method**: Compared to free recall, more specific recall tasks show weaker embodied activation effects (e.g., object location recall < free recall). These constraints align with findings in embodied cognition research that "uncertainty" produces stronger embodied effects (Plonsky & Erev, 2021; Slepian et al., 2011).

In summary, this study proposes a sensorimotor simulation model of embodied memory from an embodied cognition perspective, integrating existing theories and research to specify the processes, essence, and conditions of embodied memory. Future research may manipulate body sensorimotor patterns to simulate and reproduce the somatosensory components of memory events, thereby controlling memory retrieval and opening new research directions.

5. Limitations and Future Directions of Embodied Memory Research

5.1 Stability of Embodied Memory Effects

Embodied memory effects are remarkably subtle. Numerous detail variables—including experimental material selection (Marre et al., 2021), embodied priming method (Casasanto & de Bruin, 2019; Quettier et al., 2021), encoding duration control (Rand & Wapner, 1967), individual differences (Lomoriello et al., 2021), and presence of emotional variables (Díez-Álamo et al., 2019)—can cause effects to disappear or reverse. This may result from replication studies focusing on formal similarity (assuming that adding body variables suffices to investigate embodiment-memory relationships) while neglecting conceptual similarity (adding body variables should activate specific modalities from initial encoding to influence memory outcomes). Therefore, future work must identify and validate reactivation conditions. Given the unclear boundaries of embodied memory research, replication studies remain necessary but should attend to conceptual rather than merely formal similarity with original experiments to enhance persuasiveness (Berg, 2019).

5.2 Deep Mechanisms of Embodied Memory Effects

Current embodied memory research concentrates primarily on phenomenology, while investigations of intrinsic mechanisms lack direct behavioral and physiological confirmation. This limitation may stem from constraints of body posture, absence of core moderating variables, non-operationalizable theories, and mismatches between research paradigms and neurophysiological tools. However, understanding that embodiment affects memory through reactivation may enable researchers to transcend current limitations. Since mirror neurons make it possible for individuals to automatically activate similar simulation processes when observing others' actions (Sinigaglia & Rizzolatti, 2011), future research might transform direct activation from three-dimensional self-embodied operations to indirect activation from two-dimensional observation of others' actions. This shift from action to observation would overcome limitations of body posture in research tools, broaden the body' s conceptualization, and flexibilize research perspectives and methods.

5.3 Applications of Embodied Memory Effects

Embodied memory research currently holds more theoretical than practical value. Despite the effect' s intimate connection to the body, practical applications remain scarce, with only a few studies demonstrating direct positive impacts on vocabulary memory (Casasanto & de Bruin, 2019; Mehta et al., 2015). How to effectively harness embodied memory effects' positive potential warrants future attention. Based on our proposed model, we speculate that manipulating different body sensorimotor patterns could control memory valence and content, thereby indirectly adjusting cognition and emotion to ultimately influence behavior. Future applied research might explore: (1) how embodied manipulation in interpersonal contexts can regulate individuals' memories of others, affecting evaluations and interaction patterns; and (2) whether embodied manipulation in psychological interventions can induce clients to access positive memory content, adjusting emotional states and promoting healing. These directions could open new pathways for social research and psychotherapy.

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Note: Figure translations are in progress. See original paper for figures.