

EMOTIONAL CONGRUITY AT ENCODING AND RETRIEVAL AS INTERNAL  
CONTEXTUAL CUES FOR LONG-TERM MEMORY

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## ABSTRACT

This study investigated whether emotional congruence between encoding and retrieval enhances long-term memory performance. Grounded in context-dependent memory theory and encoding variability theory, we tested whether discrete emotions—specifically fear and joy—serve as internal contextual cues that influence memory retrieval. Participants (N = 131) completed a Swahili-English paired associates task while listening to emotion-inducing audio clips during both encoding and retrieval phases. Physiological data (GSR, plethysmograph, respiration) were recorded but not yet analyzed; emotional arousal was assessed via the Self-Assessment Manikin. Three hypotheses were tested: (1) congruent emotional states will improve memory performance, (2) memory will follow an inverted-U pattern across arousal levels, and (3) congruence benefits will be greater in fear-based than joy-based conditions. Bayesian ANOVAs provided weak-to-moderate evidence for the null across all tests. Exploratory analyses of retention scores showed no credible benefit for congruence, and fear and joy yielded descriptively similar patterns. These results suggest that under the specific conditions of this study—including moderate arousal levels and concurrent task demands—discrete emotional congruence did not reliably enhance long-term memory. However, limitations in emotion induction intensity and task timing may have obscured potential effects. This line of research has implications for models of emotional memory and applications in education, clinical psychology, and eyewitness contexts

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## Introduction

Emotions are integral to human cognition, influencing memory encoding, attention, perception, reasoning, and problem-solving (Buchanan, 2007; Dolcos et al., 2005; Kensinger & Schacter, 2006). These effects span both conscious and unconscious processing and are particularly impactful when it comes to memory formation and retrieval. While the emotional enhancement of memory is well-documented, less is known about how specific emotions affect both the encoding and retrieval phases—especially when the same emotion is maintained across both. This concept, known as emotional congruence, may offer insight into how internal emotional context guides long-term memory.

Traditional theories such as Encoding Variability Theory and context-dependent memory have focused largely on external contextual cues—for instance, environmental factors like location or background sounds (Godden & Baddeley, 1975; Smith & Vela, 2001). We extend these theories by examining internal contextual cues, namely emotions, and clarify their distinction: Encoding Variability Theory focuses on how multiple distinct encoding contexts create flexible retrieval pathways, while context-dependent memory emphasizes the benefit of matching conditions between encoding and retrieval. Our study deviated from both by isolating emotional congruence as a unique form of internal contextual overlap to determine whether emotional congruence across encoding and retrieval phases can improve memory performance.

In our view, external cues set the stage for understanding context dependency, but internal cues may offer an even more intimate window into how memory is formed and later recalled. Previous studies have typically investigated the influence of emotions during a single phase of memory processing—either during encoding or retrieval. In contrast, our study considered

emotional congruence across both stages. We hypothesized that participants would demonstrate better long-term memory performance when the emotional state at encoding matched the emotional state at retrieval—that is, under conditions of emotional congruence—compared to emotionally incongruent conditions, in which the emotional state at retrieval differed from that at encoding on a paired-associates test. This approach acknowledged the dynamic and integrated nature of memory functions and provided a more comprehensive view of how emotions impact memory consolidation. Although emotional arousal has been widely studied in relation to short-term memory and immediate recognition (e.g., Kensinger, 2009; Talmi, 2013), fewer studies have investigated the influence of consistent emotional contexts on the consolidation and subsequent retrieval of long-term memories.

### **Historical Background on Emotions and Memory**

The interplay between emotions and memory has been a focal point of psychological research for decades, with significant theoretical and empirical advancements shaping our understanding of this dynamic relationship. Early studies on memory tended to focus on neutral stimuli and general cognitive processes, but the emergence of research on flashbulb memories in the 1970s marked a pivotal turning point in highlighting the profound role of emotions in memory. Coined by Brown and Kulik (1977), *flashbulb memories* are vivid, emotionally charged recollections of significant events—such as remembering where one was during the 2001 World Trade Center attacks. This formative work demonstrated that emotionally significant experiences are often remembered with greater clarity and persistence than neutral ones, sparking widespread interest in the mechanisms underlying emotion-enhanced memory.

Building on this early work, researchers in the 1980s and 1990s began exploring the neurobiological underpinnings of emotional memory. LeDoux (1996) and McGaugh (2000)

highlighted the amygdala's role in tagging emotionally salient memories through neuromodulatory signals, which interact with the hippocampus to strengthen long-term consolidation.

In parallel, cognitive psychologists investigated how emotions influence different stages of memory. Bower's (1981) network theory of affect conceptualized emotions as nodes in a semantic network, activating linked memories through mood-congruent associations. This explains why individuals tend to recall memories consistent with their current mood (Eich & Metcalfe, 1989). Furthermore, research by Kensinger and Schacter (2006) and Tyng et al. (2017) emphasized that emotional arousal enhances memory specificity by focusing attention on emotionally charged stimuli. When individuals experience emotionally significant events, physiological responses—such as increased heart rate and heightened amygdala activation—prioritize the processing of critical details while filtering out extraneous information, leading to deeper encoding and more robust long-term storage (Vuilleumier, 2005).

More recently, advances in context-dependent memory have expanded our understanding of how contextual cues influence retrieval processes. Encoding Variability Theory (Glenberg, 1979) highlights that memory recall is strengthened when there is an overlap between contextual information at encoding and retrieval, typically focusing on external cues such as physical surroundings or sensory inputs (Ostendorf et al., 2020). While these studies underscore the importance of context congruence, they have largely focused on external cues. This body of work provides a foundation for contemporary research exploring emotional congruence—specifically, whether maintaining the same emotional state at both encoding and retrieval enhances long-term memory consolidation. Although research has shown that emotions influence encoding and retrieval independently, few studies have tested whether *emotional*

*congruence*—the same emotion present at both stages—can act as a retrieval cue, similar to traditional external contexts by reinforcing shared retrieval cues or whether variability in emotions disrupts recall. By building on findings from mood-congruence and context-dependent memory research, studies in this area can help clarify whether internal affective states function similarly to external environmental cues in guiding retrieval.

Together, these developments have shaped an interdisciplinary field that integrates cognitive, affective, and neurobiological perspectives on how emotions influence memory formation and retrieval. Cognitive research has explored how emotional attention and encoding mechanisms impact memory specificity (Kensinger & Schacter, 2006), while affective neuroscience has demonstrated that amygdala-hippocampal interactions modulate the consolidation of emotionally salient events (McGaugh, 2000). These advancements not only refine theoretical models of how emotions shape memory processes but also open new avenues for applied research. For example, understanding emotional congruence effects could inform clinical interventions for trauma-related memory biases, improve educational strategies for optimizing emotional conditions during learning, and enhance forensic settings by evaluating how discrete emotions at the time of recall impact eyewitness testimony accuracy.

### **Memory: Encoding and Retrieval**

Encoding and retrieval are fundamental stages of memory processing. Encoding involves converting sensory input into a stable memory trace, while retrieval refers to accessing that stored information ( Craik & Lockhart, 1972). These processes determine both the strength and accessibility of memories, influencing performance across real-world and experimental settings. Understanding the distinctions between encoding and retrieval is particularly important for advancing memory research, as different cognitive and neural mechanisms govern these

processes, and their interaction shapes the accuracy and longevity of stored information (Squire et al., 2015).

Encoding can be enhanced by a number of well-researched techniques. Some of these include elaborative encoding, spaced repetition, and the use of contextual cues to create richer memory traces. Emotional arousal enhances encoding by increasing attention and facilitating stronger neural connections in memory-related brain regions. The amygdala plays a key role here, modulating hippocampal activity via stress-related neuromodulators like norepinephrine and cortisol (McGaugh, 2000). This process facilitates synaptic plasticity and promotes long-term potentiation, ultimately enhancing memory consolidation (Kensinger, 2009). The prefrontal cortex further regulates these processes by integrating emotional and cognitive information during encoding, ensuring that salient details are effectively captured (Dolcos et al., 2005). During retrieval, emotional arousal can either facilitate or disrupt recall depending on context. This process again engages the amygdala and hippocampus, but places greater emphasis on the prefrontal cortex, which supports controlled search and reconstruction of memory (Ranganath et al., 2003).

Studying the interaction between emotional arousal, encoding, and retrieval is critical for refining current memory models and guiding future research directions. Memory theories, such as context-dependent memory and encoding variability theory, have primarily examined external contextual influences—like environmental or sensory cues—but have largely overlooked the role of discrete emotions as retrieval cues. Discrete emotions may act as internal retrieval cues by reactivating neural patterns formed during encoding. Testing this possibility—whether emotional congruence facilitates long-term recall—offers a key contribution of our study. Investigating whether emotional congruence or variability affects long-term memory may provide critical

insights into how these specific emotions shape memory distortions, influence trauma-related recall, and impact cognitive flexibility. Moreover, understanding these mechanisms holds significant practical implications: in educational contexts, aligning emotions during study and testing may enhance academic performance by improving memory retrieval, while in forensic settings, clarifying how emotions serve as internal retrieval cues could improve the accuracy of witness statements.

## **Theoretical Framework**

### ***Mood-Congruent Memory***

The Mood-Congruent Memory (MCM) Theory posits that individuals are more likely to recall memories that align with their current mood or emotional state (Bower, 1981). This theory emerged from broader research on affect and cognition, focusing on how mood states influence memory retrieval. Bower's work introduced the network theory of affect, which conceptualizes emotions as nodes within an extensive associative network. In this model, each emotion is represented as a distinct node that is interconnected with other nodes representing related memories and concepts. When an individual experiences a particular mood, the corresponding node becomes activated, and through a process known as spreading activation, this activation propagates to adjacent nodes. As a result, memories that are linked to that specific emotional node are primed and become more accessible. This mechanism explains why individuals in a sad mood may be more likely to recall similarly negative experiences, as the activation of the 'sadness' node facilitates the retrieval of associated information.

Several key studies have provided empirical support for MCM. For example, Eich and Metcalfe (1989) demonstrated that individuals who encoded information while in a specific mood (e.g., happy or sad) were better able to recall that information when their mood was later

reinstated. This finding supports the concept of mood-dependent memory, which refers to the improved recall of information when the mood at encoding matches the mood at retrieval. Closely related is the concept of mood-congruent memory, which suggests that the content of what is recalled is biased toward memories that match one's current mood; that is, people tend to retrieve mood-consistent information (Bower, 1981). In practice, these phenomena mean that if a person is in a positive mood, they are more likely to recall positive experiences, whereas a negative mood increases the likelihood of retrieving negative memories. For instance, individuals with depression often exhibit mood-congruent memory biases, recalling predominantly negative events, which may contribute to a cycle of persistent distress (Gotlib & Joormann, 2010).

While MCM has been widely supported, critiques of the theory focus on its applicability across different memory tasks and contexts. For instance, research indicates that the effects of mood on memory are more pronounced in free-recall tasks than in recognition tasks (Blaney, 1986). One reason for this disparity is that free recall requires participants to generate retrieval cues internally, making them more reliant on their current mood to access stored information. In contrast, recognition tasks provide external cues that can override or mask the influence of an individual's mood on memory retrieval. Furthermore, this difference suggests that the influence of mood on retrieval is contingent on task demands—when individuals must actively retrieve information without external prompts, their internal affective state plays a larger role. Additionally, researchers have debated whether these effects are specific to mood or generalize to broader emotions, leading to calls for more precise operational definitions of mood and emotion.

In our study, we build on Mood-Congruent Memory (MCM) theory by focusing

specifically on emotional congruence rather than mood congruence. While MCM examines the alignment between mood at retrieval and memory content, our research explores how discrete emotions during encoding and retrieval influence memory performance. For example, broader mood states such as a prolonged period of depression or sustained elation can persist for hours or days and broadly affect an individual's cognitive functioning, whereas discrete emotions like fear or joy are short-lived responses to specific events. By isolating discrete emotions rather than generalized mood states, our study extends the MCM framework by testing whether emotional congruence effects hold at the level of specific emotions rather than broad affective states.

While MCM is supported by extensive research, our study addresses two key limitations. First, MCM typically examines valence-based congruence—whether positive moods facilitate retrieval of positive memories and negative moods enhance the retrieval of negative memories (Bower, 1981). This broad affective approach does not account for how specific discrete emotions—which may share valence but differ in arousal or motivational direction—impact memory retrieval. For instance, fear and anger are both high-arousal negative emotions but may influence memory differently due to their distinct physiological and cognitive effects. By testing specific emotions rather than broad affective states, our study provides a more precise evaluation of emotional congruence effects. Additionally, MCM research has primarily investigated mood effects on retrieval rather than encoding. Most studies examine how an individual's mood at the time of recall biases memory content but do not address whether maintaining the same emotion at both encoding and retrieval enhances memory performance. Our study expands MCM by testing emotional congruence across both encoding and retrieval phases, investigating whether experiencing the same emotion at both stages (e.g., fear-fear or joy-joy) strengthens memory recall compared to mismatched conditions (e.g., fear-joy, joy-fear). Furthermore, while MCM

suggests that mood-congruent retrieval occurs due to spreading activation within affective memory networks (Bower, 1981), it does not fully account for the role of physiological arousal in memory processes. Our study addresses this by examining how emotions with distinct arousal levels (high-arousal fear and joy) influence memory retrieval in congruent and incongruent conditions. This allows us to test whether emotional congruence effects are purely affective (based on valence and mood networks) or also depend on physiological arousal as a retrieval cue. By addressing these limitations, our study refines MCM theory and provides a more detailed understanding of how specific emotions impact long-term memory performance.

### ***Context-Dependent Memory Theory***

Context-Dependent Memory (CDM) refers to the phenomenon in which memory recall is enhanced when the conditions present at encoding match those present at retrieval. For example, Godden and Baddeley's (1975) classic study demonstrated that divers recalled word lists more accurately when tested in the same underwater or land environment in which they had originally learned them. Subsequent work by Smith and Vela (2001) further established that stable environmental contexts—such as background sounds, lighting, or spatial layout—can serve as powerful retrieval cues. While most studies of CDM have focused on external or physical environments, there is growing interest in how internal contexts, such as mood or emotional state, may play a similar role. It is important to distinguish this theory from Encoding Variability Theory, which focuses on the benefits of varied encoding conditions to create flexible retrieval pathways. In contrast, Context-Dependent Memory emphasizes the role of consistent contextual overlap between encoding and retrieval in enhancing memory performance.

Our study builds on this framework by testing whether emotional congruence—experiencing the same discrete emotion during encoding and retrieval—can serve

as an internal context cue to facilitate memory. While traditional CDM studies have used environmental or sensory stimuli, we extend the theory to examine whether matching emotional states function analogously to external contexts in supporting memory performance. This represents a novel application of CDM, as relatively little work has examined discrete emotional states (as opposed to mood or valence) as context-dependent cues.

### ***Encoding Variability Theory***

Encoding variability theory (EVT), proposed by Glenberg (1979), focuses on how variability during encoding influences memory by creating multiple, flexible retrieval pathways. This theory differs from Context-Dependent Memory (CDM), which emphasizes that memory performance improves when the encoding and retrieval contexts are similar or matched. While CDM highlights the benefits of contextual stability—suggesting that cue reinstatement strengthens recall—EVT posits that encoding information in multiple, distinct contexts enhances generalizability, allowing retrieval to succeed even when specific cues from the original learning environment are absent.

Traditionally, both EVT and CDM have focused on external contextual cues, such as location, sensory input, or environmental features. Our study extends these frameworks by exploring whether internal cues—specifically discrete emotional states—can serve a similar function. By comparing memory performance across emotionally congruent and incongruent encoding–retrieval conditions, we investigate whether discrete emotions act as internal contextual cues that either benefit from consistency (as CDM predicts) or from variability (as EVT suggests). This comparison allows us to test which theoretical mechanism—contextual stability or encoding diversity—better supports long-term memory consolidation when applied to internal emotional context.

It is important to distinguish between the benefits of contextual variability and the effects of retrieval cue congruence. Research has shown that contextual congruence—when the same cues are present during both encoding and retrieval—can improve memory by reactivating the original neural pathways formed during encoding (Herz, 1997; Godden & Baddeley, 1975; Sorokowska, 2022). These cues may be external (e.g., location, scent, background noise) or internal, such as mood or emotion (Eich & Metcalfe, 1989). However, when encoding involves multiple, diverse cues, memory generalization improves: retrieval is more successful across a wider variety of contexts, even if the exact original cues are not reinstated (Glenberg, 1979; Lohnas, Polyn, & Kahana, 2011). This aligns with the spacing effect, in which learning the same material in different settings improves retention (Bjork & Bjork, 1992).

Importantly, EVT is often misattributed as a form of retrieval practice. Retrieval practice refers to actively recalling information during the learning phase, which strengthens memory traces through use (Roediger & Karpicke, 2006). In contrast, EVT does not require repeated retrieval; instead, it posits that passive encoding under varied contextual conditions alone can enhance recall through the creation of multiple associations.

However, EVT also acknowledges limits to variability: excessive variability during encoding may dilute the distinctiveness of individual memory traces, making them harder to retrieve when the test context closely matches only one of many encountered cues (Smith & Handy, 2014). Thus, whether congruence or variability improves recall depends on both the structure of the task (e.g., free recall vs. recognition; see Mulligan, 2004) and the type of contextual information involved (e.g., external vs. internal cues).

Most research on EVT has focused on external context, such as changes in physical environment (Godden & Baddeley, 1975), background sounds (Smith, 1982), or olfactory stimuli

(Herz, 1997). In contrast, the role of internal states, such as emotions, remains underexplored. Our study extends EVT by treating emotion as an internal contextual cue, and testing whether emotional congruence between encoding and retrieval enhances recall in the same way that environmental cue overlap does.

We hypothesize that if emotions function as internal retrieval cues, then maintaining the same emotional state at encoding and retrieval should facilitate memory performance. This parallels prior findings with environmental congruence and offers a novel application of EVT to the domain of emotion and memory. We test this principle using discrete emotions (fear and joy). In doing so, we address a gap in the literature regarding how discrete emotional experiences may influence context-based memory. Together, these theories highlight the need to consider emotional congruence as a distinct form of internal contextual continuity—a gap this study seeks to address.

## **Emotions and Memory**

### ***The Role of Emotions in Memory***

Emotions play a pivotal role in information processing and retention by enhancing attention, directing cognitive resources, and strengthening the consolidation of emotionally significant events. In this study, emotions are defined as distinct, event-specific psychological and physiological responses to stimuli, distinct from longer-lasting emotional states or moods (hours-days) (Ekman, 1992). Emotionally arousing events are often better remembered than neutral ones, primarily because arousal activates the amygdala, enhancing memory consolidation. This activation occurs through the release of neuromodulators such as norepinephrine, which increase amygdala activity and facilitate communication with the hippocampus to promote synaptic plasticity and long-term potentiation (McGaugh, 2000;

Kensinger, 2009). Emotions also guide attention by prioritizing emotionally salient information. When an emotionally charged event occurs, brain regions involved in attentional control—such as the prefrontal and parietal cortices—allocate more processing resources to the most critical details while filtering out less relevant background information (Tyng et al., 2017; Vuilleumier, 2005). This selective focus not only deepens encoding but also creates stronger, more detailed memory traces.

Furthermore, emotions influence decision-making by modulating activity in regions responsible for evaluating risks and rewards, including the orbitofrontal cortex and anterior cingulate cortex. In emotionally charged situations, these regions integrate affective signals with cognitive assessments, biasing judgments and choices toward options that align with the individual's current emotional state (Bechara et al., 2000). For example, heightened fear may prompt more cautious, risk-averse decisions, while elevated joy can encourage more optimistic and risk-seeking behavior. Together, these processes illustrate how emotions not only shape memory formation but also impact the broader spectrum of cognitive functions.

### ***Neurobiological Mechanisms of Emotional Memory***

Key brain regions, including the amygdala, hippocampus, and prefrontal cortex, are integral to emotional memory. The amygdala modulates hippocampal activity during emotional arousal, strengthening the encoding and consolidation of emotionally salient memories (McGaugh, 2000). This amygdala–hippocampus interaction, established in prior sections, helps prioritize emotionally relevant details for long-term storage (Kensinger & Schacter, 2006). The prefrontal cortex integrates emotional signals with cognitive processes, contributing to the regulation of emotional responses and the retrieval of emotionally salient memories (Kensinger & Schacter, 2006).

While these interactions are central to the formation of declarative memories, it is important to note that long-term memory encompasses multiple systems. For example, procedural memory—which involves the acquisition of skills and habits—relies more on the basal ganglia and cerebellum, and although it is less directly modulated by the amygdala, emotional arousal can still influence the learning of motor and implicit behaviors indirectly. Similarly, aspects of implicit memory and priming, which are governed by different neural circuits, may also be affected by emotional arousal. Future research should explore these broader effects to provide a more comprehensive understanding of how emotion impacts various long-term memory systems.

### ***Distinction Between Emotions, Moods, and Emotional States***

To accurately investigate the role of emotional congruence in memory, it is necessary to differentiate discrete emotions, moods, and emotional states, as each plays a distinct role in cognitive processing. Emotions are brief, intense responses to specific stimuli that trigger physiological and psychological changes (Ekman, 1992). They are typically short-lived, lasting from seconds to minutes, and are associated with discrete events (e.g., fear in response to a threat or joy after receiving good news).

In contrast, moods are longer-lasting, diffuse affective states that do not have a clear or immediate cause (Eich & Metcalfe, 1989). Unlike emotions, which arise rapidly and dissipate quickly (typically lasting a few seconds to a few minutes), moods persist over a longer period of time (hours, days, or longer) and influence cognition more broadly, affecting thought patterns and general outlook rather than immediate reactions (Russel, 2003; Barrett, 2006). This distinction is critical because Mood-Congruent Memory (MCM) theory suggests that congruency of moods bias memory retrieval, making it more likely for individuals to recall memories that

match their current state (Bower, 1981).

While emotions and moods are well-established constructs, emotional states bridge the two concepts. Emotional states can be understood as temporary affective conditions that emerge from both environmental factors and internal cognitive processes. They are more sustained than emotions but less stable and pervasive than moods. Emotional states are particularly relevant in the context of memory consolidation, as they persist long enough to shape how information is encoded and retrieved but do not exert the same broad, long-term influence on memory recall as moods do (Kensinger, 2009).

This study specifically examines how emotions function as internal contextual cues during memory encoding and retrieval. By isolating transient emotions triggered by specific events, we can better understand how emotional congruence influences long-term memory consolidation. This distinction ensures that the study's findings contribute to emotion-memory theories, rather than general mood-based memory biases, clarifying the unique impact of discrete emotions—rather than mood states—on memory encoding and retrieval, which is central to the present study.

### **Evolutionary Perspective on Emotions and Memory**

The strong link between stress-related emotions and memory underscores their adaptive significance from an evolutionary standpoint. Emotions like fear and anger evolved as survival mechanisms; fear, for instance, facilitates rapid encoding of life-threatening events, ensuring that organisms remember dangerous situations to avoid similar threats in the future (Öhman & Mineka, 2001). This adaptive advantage is reflected in neurobiological mechanisms that prioritize the processing of threats via the amygdala and related structures. Similarly, anger may have evolved to aid in navigating social conflicts and asserting dominance in competitive

environments, thereby ensuring that critical social interactions are remembered for adaptive responses in future confrontations (Carver & Harmon-Jones, 2009).

Although they are not directly tied to immediate survival threats, these emotions enhance memory for affiliative and cooperative interactions, which are vital for establishing social bonds, group cohesion, and ultimately, reproductive success. The ability to recall positive social experiences likely contributed to the evolution of prosocial behavior, as strong social networks can offer protection and resource sharing, further increasing an individual's fitness (Silk, 2007).

Collectively, these findings suggest that the encoding of emotionally salient events—whether through negative or positive emotional responses—provides an adaptive advantage by creating robust memory traces that guide future behavior. This evolutionary lens not only explains the vividness and persistence of emotional memories but also highlights their relevance to modern challenges—such as treating trauma, enhancing learning, or guiding affect-based interventions.

## **Stress and Its Effects on Memory**

### ***Acute and Chronic Stress***

Stress, defined as the physiological and psychological response to perceived threats or challenges, has both facilitating and impairing effects on memory, depending on its duration and intensity (Schneiderman et al., 2008). Acute stress is characterized by a short-term activation of the hypothalamic-pituitary-adrenal (HPA) axis—a complex system in which the hypothalamus releases corticotropin-releasing hormone (CRH), prompting the pituitary to secrete adrenocorticotrophic hormone (ACTH), which in turn stimulates the adrenal cortex to release stress hormones such as cortisol and adrenaline. These hormones influence key brain

regions—particularly the amygdala and hippocampus—to enhance memory encoding and consolidation (McGaugh, 2000; Cahill & McGaugh, 1998).

In contrast, chronic stress results from prolonged exposure to stressors—typically defined as stress lasting for weeks, months, or longer—and has detrimental effects on memory. Sustained high levels of cortisol can damage hippocampal neurons, reduce dendritic branching, and impair synaptic plasticity, leading to deficits in both encoding and retrieval (Sapolsky, 1996). Moreover, chronic cortisol exposure disrupts the regulatory functions of the prefrontal cortex by causing dendritic atrophy and reducing connectivity, which in turn undermines executive functions such as working memory, decision-making, and emotional regulation (Arnsten, 2009).

To ensure that our data reflect the effects of acute stress rather than confounds from chronic stress, we administered the Perceived Stress Scale (PSS) to assess participants' stress levels over the past month. Although the PSS provides an indication of recent stress, it does not fully capture the long-term, chronic stress exposure that may have more profound neurobiological impacts. In future research, we plan to incorporate additional measures specifically designed to assess chronic stress over extended periods, thereby providing a more comprehensive understanding of how different stress durations influence memory processes. It is important to note that while chronic stress can have profound effects on memory, our study does not directly test these long-term impacts. The PSS was included to screen for chronic stress exposure, but future studies should employ longitudinal designs to fully investigate its role in emotional memory.

### ***Stress-Related Emotions***

Our study initially focused on stress-related emotions, specifically fear and anger, which activate the amygdala, enhancing memory encoding under acute stress conditions (LeDoux,

1996). Fear triggers a fight-or-flight response, heightening arousal and improving encoding of survival-relevant information (LeDoux, 1996). Anger mobilizes resources to confront challenges, ensuring that information about stressors is retained for adaptive responses in future situations (Carver & Harmon-Jones, 2009). These evolutionary mechanisms explain why stress-related emotions often enhance memory performance compared to neutral or positive emotions. Upon piloting the data, we found that inducing anger was biased to the individual's life experiences, so we were unable to consistently elicit this emotion to a high enough arousal level for every participant. We therefore pivoted our initial study to include emotions that we were able to elicit enough to affect memory processes.

### ***Non-Stress-Related Emotions***

To provide a comparative framework, we intended to include joy and tenderness as positive, non-stressful emotions. Based on pilot testing, we excluded anger and tenderness from the final experiment. The arousal threshold of 5/10 on the Self-Assessment Manikin was selected to reflect a moderate level of physiological and subjective arousal, consistent with research showing that moderate arousal is most conducive to memory enhancement (Yerkes & Dodson, 1908; Tyng et al., 2017). This level is high enough to differentiate emotional from neutral states, but not so intense that it introduces noise due to excessive stress or cognitive overload. Furthermore, the midpoint threshold aligns with previous studies using the SAM scale to differentiate emotionally relevant vs. non-relevant conditions (Bradley & Lang, 1994). Anger elicited highly variable responses across participants, and tenderness consistently failed to reach our predefined arousal threshold (5/10), making them unsuitable for consistent induction and analysis. While these emotions may be less arousing than stress-related emotions like fear or anger, research indicates that positive emotions promote attentional engagement and cognitive

flexibility, which can facilitate memory retention in meaningful contexts (Tyng et al., 2017). By examining both stress-related and non-stress-related emotions, we aimed to explore how emotional valence and arousal interact to shape memory processes. Due to time constraints, we removed measures of valence and have chosen to focus solely on one positive emotion—joy—since it reliably induces higher arousal levels than tenderness, allowing for clearer comparisons with stress-related emotions. In our study, we assess emotional congruence by considering arousal only if the elicited emotion reaches our set threshold of 5/10 on the Self-Assessment Manikin, accompanied by corresponding physiological changes. This 5/10 threshold represents a moderate level of arousal that is likely sufficient to produce measurable cognitive and physiological effects, ensuring that the emotion is robust enough to influence memory consolidation processes (Tyng et al., 2017). Moreover, it is important to note that excessively high levels of arousal can impair memory consolidation—a phenomenon consistent with the inverted-U relationship described by the Yerkes-Dodson law (Yerkes & Dodson, 1908) and with research demonstrating that extreme stress or prolonged high arousal can lead to memory impairments (Lupien et al., 2009; McEwen, 1998).

The selected emotions met three criteria: physiological measurability (detectable by our equipment), subjective recognizability (reportable by participants), and experimental inducibility (elicitable at a consistent arousal level). Stress-related emotions like fear and sadness elicit measurable responses, such as increased heart rate and skin conductance, making them suitable for physiological monitoring (Juslin & Laukka, 2010). Positive emotions like joy and tenderness are reliably recognized and reported by participants, ensuring consistency in self-assessments. The use of pre-validated (through a validated schema shown in the Methods section as well as our own preliminary audio testing), wordless audio clips allows for consistent emotion induction

without introducing verbal interference, aligning with guidelines for emotion-inducing stimuli (Juslin & Laukka, 2010). This selection process ensures that our emotional conditions are both theoretically grounded and experimentally reliable, aligning with the study's aim to isolate the effects of discrete emotions on memory performance.

### **Preliminary Work: Refining Emotion Induction Methods**

We piloted our study using 3-minute video clips designed to elicit the emotions of joy, sadness, fear, and anger, as well as neutral states. However, the video clips did not elicit the desired emotional responses, with participants reporting emotional arousal levels averaging below 5/10 on the Self-Assessment Manikin, indicating insufficient emotional intensity to support physiological differentiation. This level of emotional intensity was insufficient to observe clear physiological effects, which are crucial for understanding how emotions influence memory. Wordless audio/music clips were used to maintain emotional induction during encoding and retrieval, by continuously playing in the background during learning phases, thereby maintaining the elicited emotion for a longer period than a video clip would.

Additionally, we observed significant variability in participants' responses to anger, indicating that anger may be more difficult to reliably induce through music or generalized stimuli, as it is often shaped by personal experiences and context (Scherer & Zentner, 2001). Based on this result and supporting literature, we revised the emotion set—replacing anger with tenderness—for a second round of piloting to improve consistency and arousal level balance. Our selection of fear, sadness, joy, and tenderness (a positive but subtle emotion) as target emotions is supported by an established framework for identifying emotion-eliciting audio clips, as discussed in the Methods section.

Empirical evidence suggests that tenderness tends to elicit lower arousal levels compared

to high-arousal emotions like fear. For example, studies by Vuoskoski and Eerola (2012) have shown that musical passages designed to evoke tenderness are typically characterized by slower tempos and softer dynamics, which produce lower physiological arousal ratings. This empirical pattern aligns with our preliminary findings for the audio clips, where tenderness was consistently rated below 5/10 on self-reported arousal scales.

The second round of piloting confirmed that our audio clips reliably elicited the intended emotions at a significant arousal level for fear and joy at the target arousal threshold ( $>5/10$ ), while tenderness and sadness remained below that range. As a result, the final experiment focused solely on fear and joy—emotions that are both theoretically relevant and experimentally robust. These adjustments underscore the importance of grounding methodological decisions in both empirical data and established research frameworks, ensuring the reliability of our study's design.

## **Current Study**

Our research aimed to explore the impact of emotional congruity on memory retrieval, focusing on both the encoding and retrieval phases of memory. Specifically, we aimed to determine whether memory performance is influenced by the congruence of emotions experienced during encoding and retrieval, as compared to emotional incongruence.

The independent variables consisted of the emotional condition at encoding and at retrieval, each with two levels: fear, joy (emotionally congruent vs. incongruent). The dependent variables consisted of long-term memory performance, operationalized as accuracy on a Swahili-English paired-associates recall task.

### **Study Objectives and Hypotheses**

Testing whether emotional context congruence affects memory consolidation represents a significant theoretical contribution, as this area has received limited empirical attention. The present study focuses on whether maintaining consistent emotional states between encoding and retrieval enhances long-term memory performance. Specifically, we investigate whether discrete emotion congruence—such as experiencing fear at both encoding and retrieval—improves recall accuracy compared to mismatched emotional states.

Originally, we also intended to examine whether emotions at encoding might have a stronger influence on memory than the same emotions experienced during retrieval. This prediction is grounded in theories of emotional arousal and attentional focus, particularly the well-established idea that heightened emotional states during encoding direct cognitive resources more effectively toward the material being learned (Tyng et al., 2017). However, due to time constraints, we dropped these experimental conditions from testing.

The theoretical foundation for this hypothesis relies on several interrelated mechanisms.

Emotional states during encoding activate neural systems such as the amygdala and hippocampus, which are critical areas for memory consolidation (Kensinger & Schacter, 2006). If retrieval occurs in a neutral emotional context, those same systems may not be sufficiently re-engaged, making recall more difficult. Moreover, discrete emotions may serve as internal contextual cues; when the retrieval context does not match the encoding emotion, these cues become less accessible, weakening memory accuracy (Glenberg, 1979; Ostendorf et al., 2020). Inconsistent emotions between encoding and retrieval may thus reduce retrieval efficiency by increasing context variability and reducing arousal-related reactivation (LaLumiere et al., 2017).

These mechanisms highlight why congruent emotional states may facilitate better recall—especially if high-arousal emotions are intentionally engaged during encoding. Although we were unable to test this prediction in the current project, the theoretical basis is strong, and it suggests promising avenues for future research.

### ***Objectives***

Our study aimed to:

1. Assess the effect of emotional congruence on long-term memory accuracy, specifically whether matched emotional states at encoding and retrieval improve recall compared to mismatched states.
2. Examine whether the effect of emotional congruence on memory is moderated by emotion type (e.g., fear vs. joy).
3. Apply and evaluate predictions drawn from encoding variability theory, context-dependent memory, and mood-congruent memory theories.

### ***Primary Hypothesis***

***H1:*** Emotions function as internal contextual cues in memory, such that participants will

demonstrate higher memory accuracy when the emotional state at encoding matches the emotional state at retrieval—that is, under emotionally congruent conditions—compared to emotionally incongruent conditions (Eich & Metcalfe, 1989; Godden & Baddeley, 1975).

This hypothesis is grounded in context-dependent memory research, which has shown that matching external contextual cues (e.g., scent or environment) during encoding and retrieval improves recall (Godden & Baddeley, 1975; Herz, 1997). We propose that discrete emotions may serve a similar function internally.

*Example:* Participants in the fear-encoding/fear-retrieval condition are expected to perform better than those in the fear-encoding/joy-retrieval condition.

### ***Secondary Hypotheses***

***H2 (Inverted-U Arousal Hypothesis):*** Memory performance will follow a non-linear pattern consistent with the Yerkes-Dodson law (1908), such that performance is highest at moderate arousal levels (around 5–6/10 on the Self-Assessment Manikin) and declines at both low and high extremes. This hypothesis aligns with evidence that moderate emotional arousal enhances consolidation and attention, while excessive arousal may disrupt cognitive processing (Tyng et al., 2017; McEwen, 1998). Although only self-report arousal measures are available at present, physiological data will be analyzed in a future stage to more robustly evaluate this curvilinear relationship.

***H3 (Fear-Based Congruence Should Produce Stronger Effects Than Joy-Based):*** The positive effect of emotional congruence on memory will be stronger in fear-based conditions than in joy-based conditions. This prediction is based on findings that fear is associated with increased sympathetic arousal, attentional narrowing, and deeper encoding—especially when congruent at both stages (McGaugh, 2000; Kensinger & Schacter, 2006). Joy, while also high-arousal, may

promote broader attention and less memory selectivity, possibly reducing the congruence benefit.

*Example:* Participants in fear-fear congruent conditions are expected to recall more word pairs than participants in joy-joy congruent conditions.

***Predicted Outcomes: Emotional Congruence vs. Variability Effects on Memory Recall***

If findings show better recall in emotionally congruent conditions, this would suggest that emotions function as internal contextual cues, enhancing retrieval when the emotional state at recall matches that during encoding. This aligns with context-dependent memory research, which has shown that matching contextual information—whether external (e.g., scents or environments; Godden & Baddeley, 1975; Herz, 1997) or internal (e.g., mood; Eich & Metcalfe, 1989)—can facilitate memory retrieval by reinstating the neural and cognitive state present during encoding.

In contrast, if recall is better in emotionally incongruent conditions, it may suggest that a mismatch between emotions activates distinct processing pathways that reduce interference or promote novelty-based encoding benefits. However, our study design does not include repeated exposures or distributed learning, so it cannot directly test the encoding variability hypothesis as traditionally defined, so any benefit observed in incongruent conditions would more likely reflect retrieval-based effects—such as novelty, arousal mismatch, or reduced interference—rather than encoding variability per se, which depends on multiple encoding events across varied contexts (Bjork & Bjork, 1992). Since our paired-associates task involves a single learning phase and a single test, any improved recall in incongruent conditions would likely reflect differences in retrieval processing or arousal mismatch effects, rather than generalized retrieval flexibility.

Finally, if no difference is found between congruent and incongruent conditions, this may suggest that emotional context does not serve as a strong retrieval cue in this task, or that other

factors—such as arousal level, task difficulty, or individual variability in emotion regulation—play a more dominant role.

## Methods

### Transparency and Openness

We report how we determined our sample size, all data exclusions, all manipulations, and all measures in the study, and the study follows JARS (Applebaum et al., 2018). Data were analyzed using JASP (Version 0.19.3; JASP Team, 2024). This study's design and its analysis were not pre-registered.

### Participants

Our participant population was from York University's Undergraduate Research Participant Pool (URPP). We used an open-ended Sequential Bayes Factor approach, with a maximum sample size of 450 participants, for recruitment (Schönbrodt & Wagenmakers, 2018). Our expectation was that a sample size of  $n = 50$  per condition would be adequate to show moderate support for the null or experimental hypothesis, so we used that number as a starting point for data collection goals. Due to time constraints and availability, data collection was completed with a final sample of 150 participants across four experimental conditions. Due to our choice to use Bayesian analyses, we are able to increase the sample size at a later date to ensure we reach our desired moderate evidence threshold for either the null or experimental hypothesis, for each hypothesis of interest.

As part of the study, we collected demographic information, including age, gender, ethnicity, bilingualism status, and handedness. Descriptive statistics and contingency analyses were conducted to examine demographic distribution. Where relevant, demographic variables were evaluated for potential inclusion as covariates in exploratory models. To determine whether any demographic variables systematically differed across experimental conditions, we conducted chi-square tests of independence (or multinomial tests, where appropriate) for categorical

variables such as gender, language background, or ethnicity. For continuous variables such as age, one-way ANOVAs or non-parametric equivalents were used to assess group differences.

## **Materials**

### ***Physiological Instruments***

Our research utilized various physiological instruments to capture real-time changes in emotional arousal. Specifically, we used BioSemi hardware, including a plethysmograph sensor to measure blood volume and heart rate, a respiration belt to assess breathing patterns, and galvanic skin response (GSR) electrodes to monitor skin conductance. The resulting physiological data will be analyzed using EEGLAB. These instruments have been reliably used in empirical research to measure emotional changes: for example, plethysmography has been validated as a tool for detecting fluctuations in heart rate associated with emotional arousal (Naqvi et al., 2004), respiration belts have been shown to effectively capture variations in breathing that correlate with emotions (Eiríksson, 2024), and GSR is widely recognized as a sensitive measure of autonomic nervous system activity during emotional responses (Goshvarpour & Goshvarpour, 2019). Importantly, these physiological measures were continuously recorded throughout the experiment to detect any deviations from baseline conditions, providing valuable insights into the dynamic interplay between emotion and memory consolidation.

In addition, our instrumentation was placed following best-practice guidelines to ensure reliable signal acquisition and participant comfort. The plethysmograph sensor was attached to the non-dominant hand's annular finger (i.e., the fourth digit) to avoid interfering with the participant's ability to use a computer mouse and keyboard, as recommended by previous studies on cardiovascular measures (Naqvi et al., 2004). The respiration belt was positioned around the

chest, where it could accurately capture the expansion and contraction associated with breathing (Eiríksson, 2024). For the GSR, electrodes were affixed to the palmar surfaces of the non-dominant hand's middle and index fingers, specifically on the central section of these digits, which typically exhibit a high density of sweat glands, ensuring a sensitive measure of skin conductance (Goshvarpour & Goshvarpour, 2019). To optimize the signals further, stabilizing nodes—essentially grounding pads or securing electrodes as recommended by the equipment manufacturer—were attached to the palm. These nodes helped reduce motion artifacts, thereby enhancing the fidelity of the recorded data (Critchley, 2002).

This careful placement and continuous recording of physiological measures allow us to precisely capture the distinct arousal patterns associated with discrete emotions, such as fear and joy, ensuring that our study can accurately assess the impact of these specific emotional responses on memory processes.

### ***Memory Test***

We administered a memory test consisting of a long-term memory test (long-term memory paired associate test). The Long-Term Memory Paired Associate Test (LTM-PAT) assessed a person's capacity for longer-term memory of associations between things. A paired-associates test is a measure of declarative memory, specifically assessing associative memory within the long-term memory system. In this task, participants were required to learn pairs of stimuli (such as words or images) and later recall one item when presented with its paired associate. This process taps into explicit memory formation and retrieval mechanisms, which are heavily reliant on the hippocampus (Squire et al., 2015). Previous research has also used paired-associates tasks to investigate the neural underpinnings of associative memory, further supporting its role in assessing declarative memory (Buck et al., 2021).

Our specific test focused on Swahili-English word translations. Participants were presented with 10 Swahili-English word pairs during encoding, followed by three practice learning trials in which they were shown the Swahili word and asked to recall the English translation, with feedback provided. For the retrieval phase, participants were presented with Swahili words and recalled their English translations as the final test. The participants' ability to encode, store, and retrieve information from long-term memory was evaluated by this final test. Notably, our preliminary testing showed that two of our selected Swahili words (Rangi-Paint, Gari-Car) were very similar or the same as words in Urdu and Farsi, leading us to replace these with Shajara-Diary and Kioo-Mirror.

### ***Stress Tests***

The Perceived Stress Scale (PSS) is a widely used self-report instrument designed to assess the degree to which individuals perceive their lives as stressful (Cohen, Kamarck, & Mermelstein, 1983). It evaluates how unpredictable, uncontrollable, and overloaded respondents have found their lives over the past month. In our study, the PSS was administered at the end of the experimental session to avoid unintentionally priming stress-related thoughts or emotions during the main tasks. This strategic placement allowed us to assess baseline perceived stress levels without contaminating the emotional manipulations or memory outcomes.

The original 10-item version of the PSS has demonstrated strong psychometric properties, with Cronbach's alpha values ranging from .78 to .91 in prior research (Cohen & Williamson, 1988; Lee, 2012). While reliability for our current sample has not yet been computed, we anticipate similar internal consistency given the consistency of findings across populations in past studies. Including the PSS aligns with best practices in emotion and memory research, where controlling for individual variability in stress is important for interpreting how

emotional arousal influences cognitive performance.

### ***Emotion-Inducing Audio Stimuli***

Audio stimuli, specifically music and soundscapes, have been shown to evoke strong emotional responses due to their ability to modulate emotions through various acoustic criteria (Juslin & Laukka, 2010). In particular, elements such as loudness, tonality, timbre, and rhythm have been demonstrated to directly impact emotional experiences (Vuoskoski et al., 2022). For example, fast tempos combined with major modes tend to evoke feelings of joy, whereas fast tempos paired with minor modes are often associated with anger. Table 1 (adapted from Juslin & Laukka, 2010) outlines the specific acoustic criteria used for each audio clip, ensuring that the stimuli reliably elicit the target emotions.

Audio clips play a central role in our study by providing a consistent emotional backdrop that integrates seamlessly into the cognitive tasks. A key advantage of audio stimuli is their ability to sustain emotional engagement throughout the task without introducing distraction. To ensure that the audio enhances emotional engagement without interfering with memory performance, we exclusively use wordless audio clips, played on BOSE noise cancelling headphones. The decision to use wordless audio stems from the design of the LTM-PAT, which requires participants to encode and retrieve word pairs. Including lyrics or spoken words in the audio could create verbal interference, competing with the cognitive resources needed to process and memorize the word pairs (Baddeley, 1992). Research in auditory processing shows that background speech or lyrics can disrupt verbal working memory and encoding processes, leading to reduced performance on language-based tasks (Salamé & Baddeley, 1989). By using wordless audio, we mitigate this risk and ensure that the emotional content of the audio does not conflict with the linguistic demands of the LTM-PAT. Additionally, wordless audio clips allow for more

consistent emotional induction, as they rely on non-verbal acoustic features such as melody, rhythm, tempo, and harmony to evoke specific emotions (Juslin & Laukka, 2010). These features have been shown to reliably elicit emotions without introducing semantic content that could distract participants or bias their memory performance. For example, slow tempos and minor keys are associated with sadness, while faster tempos and major keys are linked to joy (Vuoskoski & Eerola, 2012). This ensures that the emotions elicited by the audio are distinct and measurable, aligning with the goals of the study. Emotional arousal was considered experimentally valid if the SAM arousal rating reached or exceeded 5/10, in line with thresholds established during preliminary testing. To control for unintended auditory differences, all emotion-inducing audio clips were manually adjusted to similar volume levels and durations using Audacity. Efforts were made to maintain perceptual consistency in loudness and length across all stimuli.

By carefully selecting wordless audio clips tailored to evoke the target emotions of fear and joy we ensure that the emotional induction process is both effective and unobtrusive. This approach supports the integrity of the paired associates task while allowing us to examine the impact of emotional congruence on memory encoding and retrieval.

Table 1. *Acoustic Criteria for Eliciting Musical Emotions*

Emotion	Musical features
Happiness	Fast tempo, small tempo variability, major mode, simple and consonant harmony, medium-high sound level, small sound level variability, high pitch, much pitch variability, wide pitch range, ascending pitch, perfect 4th and 5th intervals, rising micro intonation, raised singer's formant, staccato articulation, large articulation variability, smooth and fluent rhythm, bright timbre, fast tone attacks, small timing variability, sharp contrasts between "long" and "short" notes, medium-fast vibrato rate, medium vibrato extent, micro-structural regularity
Sadness	Slow tempo, minor mode, dissonance, low sound level, moderate sound level variability, low pitch, narrow pitch range, descending pitch, "flat" (or falling) intonation, small intervals (e.g., minor 2nd), lowered singer's formant, legato articulation, small articulation variability, dull timbre, slow tone attacks, large timing variability (e.g., rubato), soft contrasts between "long" and "short" notes, pauses, slow vibrato, small vibrato extent, ritardando, micro-structural irregularity
Anger	Fast tempo, small tempo variability, minor mode, atonality, dissonance, high sound level, small loudness variability, high pitch, small pitch variability, ascending pitch, major 7th and augmented 4th intervals, raised singer's formant, staccato articulation, moderate articulation variability, complex rhythm, sudden rhythmic changes (e.g., syncopations), sharp timbre, spectral noise, fast tone attacks/decays, small timing variability, accents on tonally unstable notes, sharp contrasts between "long" and "short" notes, accelerando, medium-fast vibrato rate, large vibrato extent, micro-structural irregularity
Fear	Fast tempo, large tempo variability, minor mode, dissonance, low sound level, large sound level variability, rapid changes in sound level, high pitch, ascending pitch, wide pitch range, large pitch contrasts, staccato articulation, large articulation variability, jerky rhythms, soft timbre, very large timing variability, pauses, soft tone attacks, fast vibrato rate, small vibrato extent, micro-structural irregularity
Tenderness	Slow tempo, major mode, consonance, medium-low sound level, small sound level variability, low pitch, fairly narrow pitch range, lowered singer's formant, legato articulation, small articulation variability, slow tone attacks, soft timbre, moderate timing variability, soft contrasts between long and short notes, accents on tonally stable notes, medium fast vibrato, small vibrato extent, micro-structural regularity

*Note: Adapted from "Expression, Perception, and Induction of Musical Emotions: A Review and a Questionnaire Study of Everyday Listening" by P.N. Juslin and P. Laukka (2010), Journal of New Music Research, 33(3), p. 221*

### **Demographics**

We have also collected background measures, including demographic information and socioeconomic status (SES), to better contextualize our findings and control for potential confounding factors. The demographic questionnaire was administered at the very beginning of the experiment, prior to any learning trials. This questionnaire gathered data on participants' age, gender, ethnicity, educational level, and employment status, providing a comprehensive profile of the sample. SES was assessed through questions related to income, education, and occupation, as these factors are known to influence cognitive performance and emotional processing. These background measures enabled us to examine whether individual differences moderate the relationship between emotional congruence and memory performance, thereby enriching the interpretation of our results.

### **Self-Assessment Manikin (SAM)**

We employed the Self-Assessment Manikin (SAM) scale to measure emotional responses. The assessment utilized a visual rating scale to measure emotional responses consisting of three elements: valence (positive to negative feeling), arousal (high to low intensity), and dominance (high to low control over the emotion). Participants selected images that best represented their emotion. For the purposes of our study, we only used the arousal measure as the other two were not relevant.

**Figure 1.**

*Self-Assessment Manikin (SAM): Arousal Scale*

Rank the following emotions based on how strongly you are **currently** experiencing it:

0 1 2 3 4 5 6 7 8 9

Sadness

Joy

Tenderness

Fear

*Note. Adapted from “Affective Auditory Stimuli: Adaptation of the International Affective Digitized Sounds (IADS-2) for European Portuguese” by A.P Soares et al., (2013), Behavior Research Methods, 45(4)*

**Cognitive Distraction Task**

During the post-encoding delay period, participants engaged in a cognitive distraction task designed specifically to prevent rehearsal of the learned material during memory consolidation. To fill this interval, participants played a modified version of the puzzle game

2048, which involves merging numbered tiles to reach increasingly higher values. This game was selected because it provides moderate cognitive engagement without inducing significant emotional arousal or stress that could interfere with the experimental manipulation.

The task served two key purposes: (1) to provide a neutral, low-arousal buffer between encoding and retrieval, minimizing the likelihood that participants would mentally rehearse the paired-associate word pairs; and (2) to introduce a sufficient delay (approximately five minutes) between learning and testing to ensure that the final test assessed long-term memory, rather than immediate or short-term recall. Including a structured distraction task during this window allows for a clearer interpretation of memory performance based on early consolidation, without contamination from continued encoding or emotional interference. This practice is grounded in the theory of memory consolidation, which posits that uninterrupted encoding followed by a low-arousal interval supports the transition of memory traces from short- to long-term storage (Wixted, 2004).

### **Procedure**

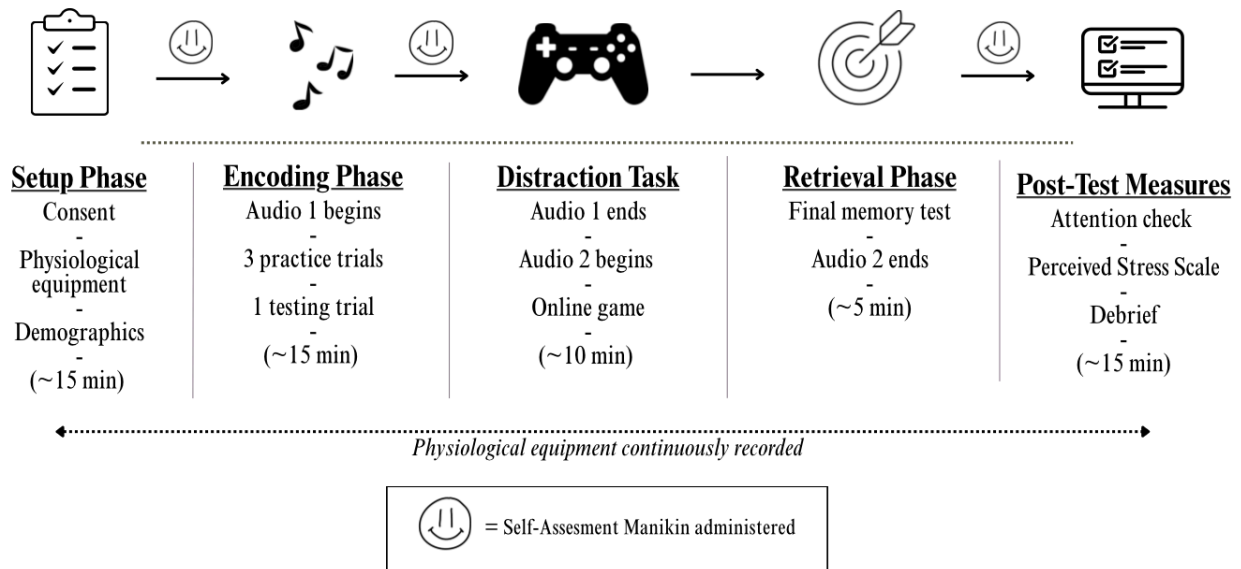
The research procedure consisted of several distinct phases and spanned approximately 45 minutes. First, verbal consent was obtained and physiological instruments were applied—including a plethysmograph sensor (attached to the non-dominant hand's annular finger), a respiration belt (secured around the chest), and galvanic skin response (GSR) electrodes applied to the palmar surface of the index and middle fingers. This setup phase lasted approximately 15 minutes. During this time, participants read and signed the written consent form and provided their URPP identification number for course credit. Next, baseline physiological measures were recorded while participants completed an initial Self-Assessment Manikin (SAM) self-report of their emotional state (approximately 1–4 minutes). Following this,

participants filled out a demographic questionnaire before receiving a prompt that an audio clip, designed to elicit the target emotion, would begin playing.

During the encoding phase, the audio clip was played continuously as participants studied paired-associate test materials, with each word pair presented for 5 seconds before automatically advancing to the next word-pair. Participants then completed three practice tests with provided answers over 5–15 minutes, with continuous physiological monitoring throughout. At the conclusion of the encoding phase, participants completed the SAM again, and the audio clip was turned off. A subsequent audio prompt, beginning right before the distraction task signaled the beginning of the retrieval phase.

Before the final memory test, participants completed a 5-minute distraction task by playing a number-based computer game, which was intended to allow the encoded information to consolidate into long-term memory. The second emotion-inducing audio clip began immediately before this game and continued playing throughout the distraction task and into the retrieval phase, which lasted approximately five minutes. Following retrieval, participants completed a SAM self-report to rate their emotional arousal during the final test. They were then asked to describe the two audio clips they heard (attention check), followed by the Perceived Stress Scale (PSS), a written feedback section, and a 2-minute debriefing session.

**Figure 2.**  
*Study Protocol Overview*



### Randomization and Condition Assignment

To reduce experimenter bias, participants were randomly assigned to one of four conditions (fear–fear, joy–joy, fear–joy, joy–fear) using Python’s `random.shuffle()` function. Each condition determined both the emotion induced during encoding and the emotion during retrieval. The order of stimulus presentation (Swahili–English word pairs) was independently randomized per participant. Emotion-inducing audio clips were standardized across conditions and not randomized. No blinding procedures were implemented. Participants and experimenters were aware of which emotion was being played, though the purpose of the study was masked until debriefing.

## Results

To assess the strength of evidence for our hypotheses, we employed Bayesian analysis, a statistical measure that compares the likelihood of observing the data under one hypothesis against another. Bayesian methods offer several advantages over traditional null hypothesis significance testing, including the ability to quantify evidence for both the null and alternative hypotheses, reduced dependence on sample size, and more intuitive interpretations of model comparisons. Specifically, it enabled us to quantify the support for our alternative hypothesis (the influence of emotions on memory) in relation to the null hypothesis (emotions having no impact on memory). We interpreted Bayes Factors ( $BF_{10}$ ) following the loose classification proposed by Wagenmakers et al. (2018). Specifically, values between 1 and 3 were considered weak evidence for the alternative hypothesis, values between 3 and 10 indicated moderate evidence, and values greater than 10 represented strong to very strong evidence for the alternative hypothesis. Conversely,  $BF_{10}$  values between  $1/3$  and 1 were interpreted as anecdotal to weak evidence for the null, and values less than  $1/3$  were taken as moderate to strong evidence in favor of the null model.

Our research aimed to shed light on the intricate relationship between emotions and memory consolidation. By examining the impact of congruent and incongruent emotions at encoding and retrieval, we aim to provide valuable insights into memory processes and contribute to the existing body of knowledge in this field.

### Primary Hypothesis Analysis

To test whether emotional congruence enhances long-term memory performance, a Bayesian ANOVA was conducted with final test performance as the dependent variable and emotional congruence (congruent vs. incongruent) as a fixed factor. Only participants who

achieved at least >4/10 correct on the third learning trial were included (N = 72), ensuring that final scores reflected retained knowledge beyond chance. Of these, 38 participants were in the congruent condition (M = 6.90, SD = 2.05), and 34 were in the incongruent condition (M = 6.65, SD = 1.63),  $d = 0.14$ .

Results provided moderate evidence in favor of the null model ( $BF_{10} = 0.279$ ), suggesting that emotional congruence did not reliably influence final test performance. The model-averaged posterior distribution showed overlapping 95% credible intervals between conditions (Congruent: [6.22, 7.57]; Incongruent: [6.08, 7.22]), and the effect of Congruency itself was not credibly different from zero ( $Mean = 0.106$ , 95%  $CI = [-0.310, 0.516]$ ). Model-averaged  $R^2$  was low ( $R^2 = 0.002$ ), indicating minimal variance explained. Bayes Factors were computed in JASP using a default Cauchy prior on effect size ( $r = 0.707$ ), as recommended by Wagenmakers et al. (2018).

These findings do not support the hypothesis that emotional congruence between encoding and retrieval enhances memory performance. While the observed means numerically favored the congruent condition, the Bayes factor and credible intervals suggest this difference is not meaningful. Future research should further investigate the boundary conditions under which emotion functions as an internal retrieval cue, potentially using more intense induction procedures or extended retention intervals.

## **Secondary Hypotheses Analyses**

### ***H2: Inverted-U Relationship Between Arousal and Memory***

The second hypothesis proposed that memory performance would follow an inverted-U pattern based on arousal levels, such that moderate arousal (around 5–6/10 on the Self-Assessment Manikin) would yield the highest performance, with lower performance at both

low and high arousal extremes (Yerkes & Dodson, 1908). However, arousal was only measured via self-reported SAM scores, and physiological data (e.g., GSR, plethysmograph, respiration) are not yet analyzed.

A preliminary exploration of SAM arousal ratings showed that most participants clustered around moderate levels, limiting the range of arousal scores and constraining our ability to test the inverted-U prediction. Due to the restricted variance in self-reported arousal, we did not conduct a formal analysis for this hypothesis at this time. Once physiological data are processed, a curvilinear regression model or segmented Bayesian regression may be used to evaluate this hypothesis.

### ***H3: Greater Congruence Benefit in Fear-Based Conditions***

To evaluate whether emotional congruence produces stronger memory performance in fear-based conditions compared to joy-based ones, a Bayesian independent samples t-test was conducted on final test scores, restricted to participants in congruent conditions who met the encoding accuracy threshold of  $\geq 4/10$ . The analysis compared participants in the fear-fear ( $n = 21$ ) and joy-joy ( $n = 17$ ) conditions.

The results provided moderate evidence in favor of the null hypothesis,  $BF_{10} = 0.318$ , indicating that the data were approximately 3.14 times more likely under the null model than the alternative. Final test scores were similar between the fear ( $M = 6.86$ ,  $SD = 2.20$ ) and joy ( $M = 6.94$ ,  $SD = 1.92$ ) groups,  $d = -0.04$ , suggesting no meaningful difference in performance between emotional conditions. These findings do not support the hypothesis that congruent fear-based emotional states lead to stronger memory outcomes than joy-based ones.

Table 2. *Summary of Bayesian Results for Hypotheses*

Hypothesis	Test Description	Group Means (SD)	$BF_{10}$	Interpretation
H1	Emotional congruence (congruent vs. incongruent)	Congruent: $M = 6.90, SD = 1.34$ Incongruent: $M = 6.65, SD = 1.25$	0.297	Moderate evidence in favour of the null model; emotional congruence did not influence recall
H2	Emotion at encoding vs. emotion at retrieval	Not reported (see note)	Not conducted	No direct analysis comparing encoding-only vs. retrieval-only emotion was conducted for this hypothesis
H3	Fear-Fear vs. Joy-Joy (both congruent)	Fear-Fear: $M = 6.86, SD = 1.33$ Joy-Joy: $M = 6.94, SD = 1.26$	0.318	Moderate evidence in favour of the null model; no difference in recall based on discrete emotion type

Note.  $BF_{10}$  = Bayes Factor for the alternative model over the null.  $M$  = mean;  $SD$  = standard deviation. No specific contrast was conducted comparing emotion present only at encoding vs. only at retrieval for H2.

### Exploratory Analyses

To examine whether emotional congruence influenced memory retention rather than overall performance, a new variable—Retention Score—was computed for each participant. This score was defined as the difference between final test performance and the participant’s accuracy on the third encoding trial:

$$RetentionScore = FinalTest_{score} - Learning3_{score}$$

A score of zero indicates perfect retention (i.e., all learned word pairs were recalled at test). Negative scores reflect forgetting, with lower values indicating greater memory loss. Positive scores—while rare—may indicate guessing, noise, or unusual performance variability, as no additional learning occurred between encoding and retrieval. All exploratory retention analyses were conducted on the full sample ( $N = 131$ ), regardless of encoding performance, in order to assess natural variability in memory decay across emotional conditions.

### *Retention as a Function of Emotional Congruence*

A Bayesian ANOVA was conducted to compare Retention Scores between the congruent ( $n = 62$ ) and incongruent ( $n = 69$ ) conditions. Results provided weak evidence in favor of the null model,  $BF_{10} = 0.458$ , suggesting that emotional congruence did not reliably influence memory retention. Descriptive statistics indicated that participants in the congruent condition showed slightly greater forgetting ( $M = -0.32$ ,  $SD = 0.83$ ) compared to those in the incongruent condition ( $M = -0.16$ ,  $SD = 0.47$ ), but the groups' 95% credible intervals overlapped substantially. These results do not support the hypothesis that emotional congruence facilitates memory stabilization over time.

### ***Retention as a Function of Emotion Type (Congruent Only)***

To investigate whether retention scores differed by emotion within congruent conditions, a Bayesian ANOVA was conducted comparing fear-fear and joy-joy participants on their retention score. The analysis was run on the full sample ( $N = 31$ ), with no minimum encoding performance threshold.

Results yielded weak evidence for the null hypothesis ( $BF_{10} = 0.482$ ), indicating that the data were approximately 2.1 times more likely under the null model than under the alternative. This analysis suggests no difference in retention between congruent fear and congruent joy conditions.

### ***Demographic Analyses***

To assess whether demographic variables differed systematically across emotional condition groups, Bayesian contingency analyses were conducted for categorical variables (e.g., gender, language background, ethnicity, occupation, and self-reported social class), and a one-way ANOVA was used for age. These analyses were used to determine whether any variables should be considered as covariates in exploratory models.

There was moderate to strong evidence in favor of the null hypothesis for gender, age, ethnicity, occupation, and self-reported social class, indicating these variables were evenly distributed across conditions and unlikely to bias results.

However, language background showed evidence of imbalance across experimental conditions. Eighteen participants (14%) reported a non-English native language, and several of these individuals also reported low confidence in English as a second language. Some experimental groups contained a higher proportion of these participants than others, raising the possibility that limited English proficiency may have influenced performance on the verbal paired-associates task.

### ***Self-Reported Arousal Scores***

Self-reported arousal scores were collected at three time points—baseline, post-encoding, and post-retrieval—using the Self-Assessment Manikin (SAM) scale. Ratings were provided on a 9-point scale, with higher values indicating greater arousal. Baseline arousal was low and consistent across groups (Fear:  $M = 2.50$ ,  $SD = 0.71$ ; Joy:  $M = 2.50$ ,  $SD = 0.71$ ), confirming emotionally neutral starting states. Arousal increased during the encoding phase, with higher ratings in the fear condition ( $M = 6.50$ ,  $SD = 0.71$ ) than the joy condition ( $M = 4.50$ ,  $SD = 0.71$ ). Arousal remained elevated during the retrieval phase, particularly in the fear group ( $M = 7.50$ ,  $SD = 2.12$ ) compared to the joy group ( $M = 5.50$ ,  $SD = 0.71$ ), suggesting that emotion was successfully re-induced or sustained throughout the task.

Table 3. *Summary of Bayesian Results for Exploratory Analyses*

<b>Analysis</b>	<b>Group Comparison</b>	<b>Retention Means (SD)</b>	$BF_{10}$	<b>Interpretation</b>
Retention by Congruence	Congruent vs. Incongruent	Congruent: $M = -0.32$ , $SD = 0.83$ Incongruent: $M = -0.16$ , $SD = 0.47$	0.485	Weak evidence in favour of the null model; emotional congruence did not improve retention
Retention by Emotion (congruent only)	Fear-Fear vs. Joy-Joy	Fear-Fear: $M = -0.31$ , $SD = 0.93$ Joy-Joy: $M = -0.34$ , $SD = 0.69$	0.482	Weak evidence in favour of the null model; retention did not differ by discrete emotion type

*Note.* Retention Score = Final Test Score – Encoding Trial 3 Score. Positive values reflect improved performance; negative values indicate forgetting.  $BF_{10}$  = Bayes Factor in favor of the alternative over the null.  $M$  = mean;  $SD$  = standard deviation.

## Discussion

The current study aimed to investigate whether discrete emotional congruence between encoding and retrieval facilitates long-term memory performance. We specifically examined whether matching the emotions fear and joy across encoding and retrieval would improve memory accuracy on a paired-associates task compared to mismatched or incongruent emotions by drawing on context-dependent memory theory, encoding variability theory, and mood congruent theory.

### Interpretation and Implications

The findings of this research have several meaningful theoretical and applied implications, even in the absence of strong statistical support for the primary hypothesis. First, the study contributes to the refinement of memory models involving internal emotional cues. While traditional Context-Dependent Memory and Mood-Congruent Memory theories have focused largely on external cues or broad affective states, our study tested whether discrete emotions—specifically fear and joy—could function as internal context markers that facilitate memory retrieval. Our findings suggest that this effect may not hold under all conditions, particularly when emotion induction is moderate and not highly immersive.

This outcome raises broader questions about emotional congruence, such as whether discrete emotions must be strongly felt or tightly integrated with task content to influence retrieval. While we explore this timing issue more fully in the Future Directions section, this observation highlights the need for careful temporal design in emotion-memory research. For example, emotional congruence may require strongly felt and task-relevant emotions to influence memory, consistent with predictions from models of emotional salience and depth of encoding.

Our results also inform and nuance encoding variability theory (Glenberg, 1979). While

EVT posits that encoding information in varied contexts can strengthen retrieval by forming multiple associations, our findings suggest that internal variability, such as shifts in discrete emotional state, may not provide the same benefit—especially when emotional salience is low. This helps differentiate between the effects of external contextual variation (e.g., location, sensory input) and internal affective variation, highlighting a theoretical boundary in EVT’s applicability. Prior studies have examined internal context effects such as mood (Eich & Metcalfe, 1989), drug state (Eich, 1980), physical exertion (Miles & Hardman, 1998), and fatigue (Kelemen & Creeley, 2003), suggesting that internal states can serve as powerful retrieval cues under certain conditions. However, discrete emotional states remain relatively underexplored in this context, particularly in relation to encoding variability frameworks.

These insights have direct educational implications. If future studies demonstrate stronger effects under higher arousal or more immersive emotion conditions, it may be possible to design learning environments that intentionally align emotional context between studying and test-taking—particularly in high-stakes scenarios. For example, instructors might use emotionally evocative study materials, audio environments, or mild stress-inducing elements during review sessions to simulate test-like emotional conditions.

Stress modulation also plays a critical role. Prior research suggests that acute stress during encoding may enhance memory, while chronic stress impairs it (McGaugh, 2000; Sapolsky, 1996). Our study focused on acute, discrete emotional states, but low arousal intensity, as indicated by SAM self-reports, may have limited the magnitude of this effect. Techniques such as brief aerobic exercise, personalized imagery, or immersive storytelling may better induce reliable high-arousal states in future research or classroom applications.

A notable extension of this work lies in forensic psychology, where eyewitness testimony

often involves emotional incongruity between the original event and later recall settings (e.g., recalling a traumatic event in the relative calm of a police station). While emotional congruence has been proposed as a mechanism to enhance memory, the present study did not test conditions comparable in intensity to those experienced during real-world, high-arousal events such as witnessing a crime. Instead, the emotional inductions used here were moderate in nature and may not generalize to extreme stress or life-threatening contexts. Therefore, further research is needed to examine whether strong emotional congruence effects emerge under higher arousal conditions, and how these compare to more neutral retrieval settings commonly found in forensic procedures such as lineup identifications.

### **Limitations**

This study presents several limitations that should be considered when interpreting the results. First, although the design focused on discrete emotions (fear and joy), real-world experiences often involve mixed or conflicting emotions, which may interact in non-additive ways to influence memory (Larsen, 2000; Schwarz, 2012). By isolating single emotions, the study enhances internal validity but may limit ecological validity, as emotional experiences are often complex and dynamic during both encoding and retrieval.

Another limitation concerns the difficulty in isolating valence effects from emotion-specific mechanisms. Although fear and joy differ in valence (negative vs. positive), they also vary in arousal and motivational direction. As a result, we cannot determine whether observed effects (or lack thereof) stem from valence, arousal, or the unique characteristics of each emotion. This issue is compounded by the absence of neutral conditions in the final experimental design due to time constraints, preventing a direct comparison to a baseline state.

While the study originally included low-arousal emotions (e.g., sadness, tenderness) in its

pilot phase, these were excluded from the final design due to insufficient arousal levels as indicated by Self-Assessment Manikin (SAM) scores. However, the final stimuli used in the experiment still produced only moderate arousal on average, based on post-task SAM ratings. As a result, the current findings reflect memory performance under moderate-arousal emotional conditions and cannot speak to how emotional congruence may operate under high-arousal states—such as those encountered in forensic or trauma-related contexts. Future research should include validated high-arousal emotion stimuli to determine whether emotional congruence effects become more pronounced when participants experience more intense emotional states.

A key limitation of the current study involves the timing of emotional induction during the retrieval phase. Specifically, the retrieval audio clip began immediately before the 5-minute distraction task, meaning that the new emotion may have started consolidating alongside the encoded material. This creates a potential confound, as it becomes unclear whether memory retrieval occurred in the presence of a truly distinct retrieval emotion or whether the new emotion had already begun influencing the memory trace. As a result, any null effects observed may reflect interference between emotional states across phases rather than a lack of congruence effects. The absence of a dedicated retrieval-phase induction period may have weakened the manipulation's potency and limited the interpretability of congruence-related findings.

The emotion induction method itself presents a limitation. Although wordless audio clips are supported by past research for inducing affective states (Juslin & Laukka, 2010), our participants' self-reported arousal scores on the SAM scale were modest, suggesting only moderate levels of experienced arousal. However, this interpretation is tentative, as the current analysis does not include physiological data (e.g., GSR, plethysmograph, respiration), which were collected but have not yet been analyzed. Prior studies often rely on physiological markers

rather than—or in addition to—self-report to assess emotional arousal (e.g., Bradley & Lang, 2007), raising the possibility that our audio stimuli may have induced higher physiological arousal than participants reported. Thus, a key limitation is the current absence of objective arousal validation, which may have underestimated the effectiveness of our induction method. The ongoing physiological analysis will help clarify whether arousal levels were sufficient to meaningfully influence memory performance.

In addition, SAM ratings were used as the sole measure of emotional arousal in this analysis. Although physiological data (e.g., GSR, plethysmograph, respiration) were collected and are planned for future analyses, the present study relied on subjective ratings, which may not reflect true physiological arousal or engagement. This limits our ability to confirm that arousal levels reached the threshold required to meaningfully influence memory.

Moreover, there was a procedural difference in timing between the emotion induction and memory engagement phases: during encoding, the audio clip began simultaneously with the learning task, whereas during retrieval, the audio played for five minutes before the memory test began. Although total exposure time to the emotion was matched across phases, the temporal proximity between audio onset and memory engagement differed, which may have influenced the emotional salience or peak arousal at the critical moment of encoding versus retrieval. However, this concern is complex: because the learning phase spanned several minutes, encoding likely occurred continuously throughout the induction period, not just at the start. As such, emotional effects may have been distributed across time rather than tied to a single moment. Resolving this issue would require future studies to test memory performance at multiple time points within the retrieval induction period—e.g., immediately after audio onset, midway through, and near the end—to assess how emotional salience evolves and whether peak

alignment with retrieval matters. While this timing inconsistency remains a possible confound, it reflects a broader challenge in emotion-memory research: balancing ecological validity with precise temporal control.

Another limitation lies in the absence of a performance threshold during the encoding phase. Although all participants completed the same number of learning trials, variability in initial encoding success likely introduced noise into the final memory outcomes. As a partial mitigation, we conducted a conditional analysis by calculating retrieval accuracy for participants who reached a minimum number of correct responses during the encoding phase. While this approach does not pair individual items across phases, it provides an approximate estimate of memory performance for adequately learned material. A more precise method would involve item-level tracking, pairing each learned item with its corresponding retrieval score—a refinement that could be implemented in future replications.

### ***Design Modifications***

If this study were to be conducted again, several key design revisions would be implemented to address both methodological limitations and theoretical ambiguities. First and foremost, the emotion induction procedures would be modified to ensure stronger, more immersive emotional experiences. Importantly, the stimuli used in this study—wordless audio clips—reflect emotionally evocative materials that could realistically be integrated into learning environments, such as classrooms or study sessions. Unlike more immersive or visually intense stimuli, which may disrupt cognitive processing, subtle affective cues like music allow researchers to test emotional congruence without introducing significant task interference. While SAM ratings indicated only moderate arousal, this aligns with typical real-world settings, where students are unlikely to experience extreme emotional states during learning. The lack of a strong

emotional congruence effect under these realistic conditions suggests that such effects may not be easily leveraged in everyday educational contexts. However, this makes the finding itself informative, and it reinforces the value of studying emotional context using materials that balance ecological validity with experimental control.

A second major revision would involve temporal separation of emotional phases. In the current study, the retrieval-phase audio clip began just before the distraction task, allowing the retrieval emotion to begin consolidating alongside the encoding material. This introduces a confound, blurring the lines between the encoding and retrieval contexts. To isolate retrieval-phase effects more cleanly, future studies should insert a brief neutral buffer period between the distraction task and retrieval, followed by a dedicated and controlled retrieval-phase emotion induction. This would ensure that the retrieval emotion is not influencing post-encoding consolidation and would enhance interpretability of congruence effects.

Additionally, participant performance during encoding would be more tightly controlled. In the present design, no performance threshold was required before proceeding to the memory test, leading to high variability in encoding strength. Some participants may have had weak initial memory traces, making it difficult to interpret null results at retrieval. A revised design would incorporate an adaptive learning phase, where participants must meet a minimum accuracy criterion (e.g., 80%) before proceeding. This ensures that all participants have sufficiently encoded the material, allowing retrieval effects to be interpreted with greater confidence and reducing noise in the final data.

Future testing on this topic should incorporate an adaptive learning procedure, in which participants are required to reach a minimum performance threshold (e.g., 80% correct) before advancing to the retrieval phase. This would ensure that memory comparisons are based on

well-established memory traces and reduce noise related to weak or failed encoding.

Additionally, implementing an item-level conditional analysis—where individual word-pair encoding is directly matched with retrieval outcomes—would offer more accurate insight into the influence of emotional congruence, particularly in cases where initial learning strength varies across participants.

### **Future Directions**

Future research should also examine whether potential emotional congruence effects are driven by affective valence (positive vs. negative) or by the unique characteristics of specific discrete emotions (e.g., fear vs. joy). The current design included only one positive and one negative emotion, making it impossible to determine whether any future effects would reflect a broader valence-based mechanism or emotion-specific processes. Importantly, before exploring this distinction, it is necessary to establish a robust emotional congruence effect. If such an effect is reliably observed, follow-up studies could vary both valence and arousal by including additional positive (e.g., pride, tenderness) and negative (e.g., anger, sadness) emotions. This would allow for a clearer dissociation between valence-based and identity-specific contributions to memory performance, and help clarify the extent to which emotional congruence operates through affective matching versus deeper emotion-specific mechanisms.

Another key direction involves disentangling the relative influence of emotion at encoding versus retrieval, even when emotional states differ across phases. While the present study focused on emotional congruence, future research should isolate these phases by comparing memory outcomes in two critical conditions: (1) emotion-neutral, where an emotional state is induced during encoding and followed by a neutral state at retrieval, and (2) neutral-emotion, where encoding occurs in a neutral state and retrieval is paired with an

emotional induction. By contrasting these conditions, researchers can determine whether emotion primarily facilitates memory consolidation during encoding, or whether it serves more as a retrieval cue. This targeted manipulation would allow for a more precise test of whether emotional modulation exerts its effects through enhanced encoding, cue-based retrieval, or both.

In future designs, researchers should also aim to improve emotion induction techniques. Although audio clips are widely used to elicit emotions in laboratory settings, our results suggest that wordless music may not reliably generate or sustain discrete emotional states at sufficient arousal levels. Despite strong literature support, many participants reported low or moderate SAM ratings, and the emotional state may not have been held long enough to affect retrieval. Additionally, the timing of the audio clips varied slightly: encoding began immediately after the first audio clip, while retrieval began approximately five minutes after the second. Although the total audio duration was similar, future studies should equalize timing and consider using multi-modal induction strategies—such as virtual reality, guided imagery, or visual-auditory combinations—to enhance emotional consistency and potency.

Although the present study did not find strong evidence that emotional congruence between encoding and retrieval enhances long-term memory performance under moderate-arousal conditions, it provides a valuable foundation for theory-driven research on internal context effects. By applying the frameworks of context-dependent memory, mood-congruent memory, and encoding variability theory to discrete emotional states, this study tests a novel extension of existing models beyond external or mood-based cues. The findings suggest that the role of discrete emotional congruence in memory is likely nuanced, potentially moderated by arousal intensity, emotion type, or task demands.

This line of research remains theoretically and practically important. In educational

settings, understanding how emotional context influences memory may help design study environments that align more closely with testing conditions, potentially improving retention and performance. In forensic contexts, emotional congruence between real-world events and interview conditions may impact the accuracy of eyewitness recall, particularly in high-stakes or emotionally charged situations. Continued work in this area—especially using higher-arousal stimuli and more immersive induction methods—can clarify the mechanisms by which emotion shapes memory and inform both scientific models and applied practices.

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## APPENDICES

### Appendix A: Swahili-English LTM Paired Associates Test

Swahili	English
Kioo	Mirror
Ubati	Wing
Shajara	Diary
Jani	Grass
Athari	Spot
Lingana	Equal
Sailiwa	Examine
Meneja	Director
Nuka	Stink
Nyuki	Bee

*Note: Adapted from “Long-term memory, sleep, and the spacing effect” by Bell et al., (2014), Memory, 22(3)*

**Appendix B: Exclusion Criteria Summary Table**

<b>Analysis</b>	<b>Exclusion Criteria Applied</b>
H1: Congruence Effect on Recall	Participants excluded if they scored below 7/10 on the third encoding trial or failed attention checks.
H2: Encoding Emotion Effect	Same as H1: Excluded if encoding accuracy < 7/10 or failed attention checks.
H3: Fear-Fear vs. Joy-Joy	Included only participants in the congruent conditions; excluded if encoding accuracy < 7/10.
Exploratory: Retention by Congruence	Full sample included (N = 131); no exclusions based on encoding accuracy
Exploratory: Retention by Emotion	Included only Fear-Fear and Joy-Joy participants (N = 31); no exclusions.