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**Review Research Article**

# The Malleable Past: Investigating the Mechanisms and Benefits of Adaptive Memory Reconstructions

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ARTICLE INFORMATION	ABSTRACT
<p><b>Corresponding Author:</b> Ragini Bahadur</p> <p><b>Article history:</b> Received: 01-12-2020 Revised: 10-12-2020 Accepted: 21-12-2020 Published: 23-12-2020</p> <p><b>Key words:</b> Memory distortions, imagination inflation, gist- based abstraction, associative errors, misinformation integration</p>	<p>Current research suggests that several forms of memory distortion, despite their potential for disrupting everyday life, may represent adaptive cognitive processes that prioritize efficient knowledge utilization over verbatim accuracy. This perspective necessitates examining how imagination inflation, gist-based abstraction, associative errors, and post-event misinformation integration potentially contribute to optimized memory function. Recent cognitive and neuroimaging studies provide evidence for linking these distortions to adaptive processes like future simulation, semantic encoding, creative problem-solving, and dynamic memory updating. This framework further emphasizes the influence of factors like sleep and retrieval conditions on the manifestation of distortions, while also acknowledging conceptual challenges associated with an adaptive perspective on memory.</p>

Human memory, once conceptualized as a pristine archive of past experiences, has been thoroughly debunked as an inevitably reconstructive and distortion-prone process. This recognition, while long acknowledged within the theoretical and applied domains of cognitive psychology, has experienced a recent resurgence in prominence. Catalysts for this renewed research fervor include the sobering realization that memory errors play a significant role in the tragic misidentification of innocent individuals, culminating in wrongful convictions, and the ongoing debate surrounding the validity of recovered memories of childhood sexual abuse. Concurrently, cognitive neuroscience has emerged as a powerful tool for elucidating the neural underpinnings of memory distortion, striving to delineate the neurophysiological signatures of veridical versus false memories. Observations of memory distortions – both in the rigorously controlled environment of the laboratory and the messy tapestry of everyday life – have propelled inquiries into the very essence and function of memory. This pervasive phenomenon begs the question: why are our memories so susceptible to inaccuracies? Bernstein and Loftus, reflecting a widely held viewpoint within the domain of memory distortion theories, posit that memory is inherently a reconstructive process. Drawing upon fragments of experience, we actively assemble the past, weaving a coherent narrative that becomes the foundation of our autobiographical landscape.

The pervasiveness of memory distortions raises a pivotal question: does the very architecture of memory possess inherent flaws that facilitate the emergence of false recollections? This perception of memory as a fallible and unreliable system resonates with Anderson and Milson's (1999) observation of artificial intelligence researchers' skepticism towards utilizing human memory as a model, often accompanied by remarks like "We certainly wouldn't want our system to be burdened with something as unreliable as human memory". This notion of memory distortions reflecting deficient or dysfunctional cognitive processing finds further support in empirical evidence demonstrating heightened susceptibility to such distortions among individuals with lower intelligence, frontal lobe damage, temporal lobe pathology, post-traumatic stress disorder symptoms, and dissociative experiences. While intuitively linking memory distortions to inherent flaws in its architecture remains tempting, a burgeoning counter-narrative emphasizes their potential role as adaptive cognitive processes. These processes, while contributing to efficient memory function, may by nature introduce distortions as trade-offs. This perspective finds its roots in Bartlett's classic schema theory (Bartlett, 1932) where schemas facilitate knowledge organization and interpretation, impacting recall accuracy. Recently, cognitive and neuro-scientific advancements have further bolstered this adaptive view (Brainerd, Reyna, 2005. Schacter, 2001, Boyer, 2009)

signifying its growing traction. This momentum underscores the necessity for a comprehensive synthesis of emerging evidence and insights to consolidate and further propel this nascent framework.

'*Remembering: A Study in Experimental and Social Psychology*', published by Sir Frederic Bartlett in 1932, used evidence of memory distortions to refute the idea that remembering is a literal or exact reproduction of the past. Instead, Bartlett (1932) argued that remembering "is an imaginative reconstruction or construction (p. 213)" that is heavily reliant on the operation of a schema, a concept he borrowed from British neurologist Henry Head. A schema is, according to Bartlett, "an active organization of past reactions, or of past experiences, which must always be supposed to be operating in any well-adapted organic response (1932, p. 201)". Bartlett's "turning round" on schemata illuminates a crucial truth about human memory: our very tools for adapting and responding efficiently can also generate errors. This article introduces adaptive constructive processes, defined as cognitive functions that benefit memory and cognition while creating potential distortions, illusions, or outright mistakes. This concept extends beyond memory, as seen in judgment heuristics (Tversky & Kahneman, 1974) and visual illusions (Gregory & Gombrich, 1973; Roediger, 1996), both instances where efficiency can coexist with occasional inaccuracies.

While a flicker of recognition for adaptive processes influencing memory distortions can be traced back to Bartlett's seminal work in 1932, and further echoes have resonated through the research landscape (e.g., Brainerd & Reyna, 2005; Howe, 2011; Howe et al., 2011; Neisser, 1967; Newman & Lindsay, 2009; Schacter, 1999, 2001), the prevailing lens through which memory distortions have been scrutinized is that of deficiencies or imperfections within the memory system itself. This dominant perspective finds fertile ground in the observed association between elevated rates of memory distortions and various indicators of suboptimal cognitive processing. For instance, individuals with a heightened vulnerability to disruptions in consciousness or dissociative experiences demonstrably exhibit a greater susceptibility to diverse types of memory distortions (Clancy et al., 2000). Further complicating the picture, recent research has linked memory distortions to both low intelligence (Zhu et al., 2010) and the distressing symptomatology of post-traumatic stress disorder (Goodman et al., 2011). Such findings may seem, at first glance, to cast considerable doubt on the viability of the adaptive perspective. However, a recent compelling argument, marshaled by Schacter, Guerin, and St. Jacques (2011), leverages burgeoning evidence to advocate for the notion that specific memory distortions can indeed be attributed to the operation of adaptive constructive processes (McKay & Dennett, 2009; Schacter, 2001). Delving into three prevalent domains – imagination inflation, gist-based/associative errors, and post-event misinformation – this article seeks to illuminate the intriguing link between memory distortions and corresponding adaptive processes. Drawing evidence from both cognitive and neuroimaging/neuropsychological studies, it is argued that these distortions, while arising from adaptive functions like future event simulation, planning, and coping, can paradoxically introduce errors and illusions. By weaving together insights from psychology, neuroscience, and diverse research areas like prospective memory and the default network, this work aims to provide a comprehensive framework for understanding the multifaceted nature of memory distortions and pave the way for future exploration of their adaptive potential and pitfalls.

Memory distortion through imagination inflation, where vividly imagining events can lead to false memories of their occurrence (Garry et al., 1996; Loftus, 2003), has traditionally been attributed to source monitoring failures (Johnson et al., 1993). While acknowledging this crucial role, a recent adaptive perspective proposed by Schacter, Guerin, and St. Jacques (2011) posits that imagination inflation also stems from the constructive nature of memory during future event simulation. This adaptive future simulation allows individuals to mentally rehearse potential scenarios, potentially enhancing preparedness and decision-making (Buckner & Carroll, 2007; Gilbert & Wilson, 2007; Schacter & Addis, 2007). Notably, converging evidence from various research areas reveals striking similarities between past and future recollection. Neuroimaging studies pinpoint extensive overlap in brain regions activated during past and future recall (Addis et al., 2007, 2009; Hassabis et al., 2007; Okuda et al., 2003; Spreng & Grady, 2010; Szpunar et al., 2007). Similarly, behavioral studies demonstrate comparable cognitive processes engaged in both domains (D'Argembeau & Van der Linden, 2006; D'Argembeau & Mathy, 2011; Szpunar & McDermott, 2008). Furthermore, individuals exhibiting memory deficits often display parallel impairments in future simulation – observed in amnesiac patients (Addis & Schacter, 2012), older adults and Alzheimer's patients (Schacter et al., 2011), and individuals with depression (Williams et al., 1996) or schizophrenia (D'Argembeau et al., 2008). These shared neural and cognitive underpinnings (Johnson et al., 1993) explain the susceptibility of past and future memories to confusion, leading to imagination inflation. This highlights the complex interplay between adaptive functions like future simulation and potential memory distortions.

Gist-based and associative memory errors, comprising two subcategories of false memories, present an intriguing paradox: while reflecting distortions in recollection, they may also serve underlying adaptive functions. Gist-based errors occur when individuals recognize novel items resembling previously encountered ones, relying on the overall essence of the experience (Brainerd & Reyna, 2005; Koutstaal & Schacter, 1997). Associative errors, exemplified by the Deese/Roediger-McDermott (DRM) paradigm, involve falsely recalling or recognizing non-presented "critical lure" words associated with presented word lists (Deese, 1959; Roediger & McDermott, 1995; Gallo, 2010). While readily classified as memory distortions due to the inclusion of non-experienced items, these errors also reveal retention of valuable information. In gist-based errors, individuals retain the general theme or meaning of encountered experiences, facilitating generalization and abstraction (Brainerd & Reyna, 2005; McClelland, 1995; Schacter, 1999, 2001). This ability possesses adaptive value, allowing for flexible application of knowledge beyond specific instances. Similarly, associative errors have been linked to enhanced creativity in studies demonstrating a positive correlation between DRM false recognition and performance on a remote associates task, a measure of convergent thinking (Dewhurst et al., 2011; Howe et al., 2011). This suggests that the associative network underlying false memories can also contribute to the generation of diverse and novel connections, a hallmark of creative thought. Further support for an adaptive interpretation emerges from neuroimaging studies. Brain regions activated during both associative/gist-based false and true recognition overlap significantly (Schacter et al., 2011; Schacter & Slotnick, 2004). Additionally, areas engaged in semantic elaboration during encoding, a process promoting long-term memory retention, show activation during both subsequent true and false recognition

(Schacter et al., 2011). This neural overlap suggests that the cognitive processes underlying both accurate and distorted memories share common features, highlighting the potential adaptive underpinnings of even seemingly erroneous recollections.

In conclusion, both cognitive and neuroimaging evidence suggest that gist-based and associative memory errors, while undeniably reflecting distortions in recollection, may also serve important adaptive functions. Their contributions to generalization, abstraction, and even creative thinking offer a compelling perspective on the multifaceted nature of memory and its potential trade-offs between accuracy and flexibility.

Post-event misinformation, the introduction of erroneous information after initial event encoding, has been extensively studied as a potent source of false memories. Cognitive research over the past four decades has established various factors affecting misinformation susceptibility (Loftus, 2005). Recent neuroimaging work delves deeper, revealing intriguing parallels between the neural bases of true and false memory formation in this paradigm.

Studies demonstrate that brain regions supporting true memory encoding also facilitate the encoding and integration of misleading information, ultimately leading to false memories (Baym & Gonsalves, 2010, Okado & Stark., 2005). Furthermore, sensory reactivation patterns during memory retrieval – brain activity associated with recalling perceptual details – align with the modality of original event and subsequent misinformation exposure, respectively Stark, et al. 2010). These findings echo those on gist-based and associative memory errors, suggesting a close neural relationship between true and false memory encoding in the misinformation paradigm. Edelson et al (2011) introduced a social conformity twist to this paradigm, investigating its influence on transient and persistent memory errors. Participants viewed a movie with others, underwent individual memory tests, and later, during fMRI scanning, answered movie-related questions alone or paired with fabricated answers supposedly from their co-observers. Increased errors associated with fabricated answers confirmed conformity's influence, even persisting through later memory tests despite warnings about the answer source's unreliability.

The fMRI results further illuminate this persistence: heightened bilateral medial temporal lobe activity was observed solely for persistent false memories compared to control conditions or cases where participants corrected their answers later. This suggests that only misinformation leading to enduring false memories triggers additional encoding mechanisms via medial temporal lobe engagement, highlighting a distinct neural signature for the formation of persistent false memories. Edelson et al.'s findings align with an adaptive approach to misinformation effects. False memories arising from misinformation might reflect a dynamic memory system's flexibility in incorporating relevant new information for memory updates, supporting their observations.

Studies by Ross and Wilson show people often remember their pasts in overly positive or negative ways to boost their current self-evaluation, potentially benefiting well-being (see also (Newman, 2009, McKay & Dennett, 2009, Conway, 2005). Additionally, studies by Porter et al. propose adapting to incorporate information from others about negative events enhances preparedness for future encounters (Porter S, et al., 2010). However, this hypothesis is debatable, as other studies like (Bohn & Berntsen, 2007, Kensinger & Schacter, 2007) find positive events more susceptible to distortion than negative ones.

Defining "adaptive" precisely is crucial. Schacter (2001) points out that psychologists use the term differently. In evolutionary theory, it has a specific technical meaning: a feature resulting from natural selection and heritable variation. More loosely, it can refer to any beneficial feature, regardless of its origins. Further terms like "exaptation" and "spandrel" describe beneficial features arising as byproducts, not direct selections. McKay and Dennett (2009) offer insightful analysis of mistaken beliefs, distinguishing those caused by breakdowns (delusions) from those reflecting normal functioning. Within the latter, they further differentiate byproducts of limitations from "design features" – true adaptations. They conclude that, only positive illusions, unrealistically optimistic self-views, meet their criteria for strict evolutionary adaptations. While the distortions discussed here clearly stem from a normal memory system, unlike confabulations caused by brain damage, the available data doesn't allow us to definitively distinguish among the different meanings of "adaptive" mentioned above. Nonetheless, it was argued that claims for an adaptive perspective on memory distortions don't require strict evolutionary justifications. They're valuable theoretically if they help us examine the nature and consequences of adaptive processes like future simulation, gist encoding and retrieval, or memory updating. Only recently has earnest research into the adaptive aspects of memory distortions emerged. Several recent ideas and findings like the need for a flexible memory system for future simulation (see Newman & Lindsay, 2009, Schacter & Addis, 2007, Suddendorf & Corballis, 2007), the link between creativity and associative false memories (Howe, et al., 2011, Dewhurst, et al., 2011), and the observation that misinformation leading to persistent false memories relates to memory updating (Hardt, et al. 2010, Edelson, et al. 2011) – are novel and potentially impactful. One key implication is the need for greater theoretical focus on understanding the functions memory serves and how those functions shape cognitive and neural mechanisms. Further investigation into how and why adaptive processes can produce memory distortions remains an exciting and relatively unexplored avenue for both cognitive psychology and cognitive neuroscience.

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- International Journal of Social Sciences Arts & Humanities*

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