Social, Motivational, and Emotional Influences on Memory: Recent advances and emerging themes

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Not all memories are created equal. Decades of research show that memory is enhanced for events that are either intrinsically emotional or motivationally-relevant. Early models suggested that affective contexts increase attention and arousal, which in turn facilitates information processing during encoding, memory stabilization during consolidation, and memory accessibility during retrieval (Kensinger & Corkin, 2004; McGaugh, 2004; LaBar & Cabeza, 2006). These models have provided the foundation for emotional memory research. However, they are insufficient to explain the nuanced influences of different affective states on the breadth of memory processes identified in recent years. This special issue integrates advances in research on these topics, illustrating how social, motivational, and emotional factors shape the structure and form of memory. Specifically, these studies highlight how affect influences memory to incorporate an individual's internal mental state as well as their surrounding context. Below, we highlight three major themes that emerge from this special issue. First, we discuss how affective influences on memory are better characterized as a transformation in the structure of memories rather than simple enhancements. Second, we discuss how affective and social contexts influence memory encoding and retrieval strategies. Finally, we discuss how affective influences on memory are shaped by how individuals interpret environmental cues.

Influence of Affect on the Organizational Structure of Memory

While emotion is known to reliably enhance memory, open questions remain regarding how it influences the organizational structure of memory. Here, we operationalize structure to refer to both the type of information stored in memory (e.g., semantic versus episodic details), and organization of features and events in memory (e.g., how information is clustered together). Early emotional memory research began to address this question by demonstrating trade-offs between enhanced memory for salient features of an event (e.g., a snake) and impaired memory for their background (e.g., a hiking path; Kensinger et al., 2007; Loftus, Loftus, & Messo, 1987). These emotional memory trade-offs show that affect can prioritize certain features and change the relationship amongst features of events in long-term memory. Multiple studies in this

issue build upon these ideas, detailing how affective states related to reward, emotional cueing, and social elaboration restructure memory.

Similar to memory for emotional items, memory is also enhanced for neutral items encoded in motivationally-relevant contexts. For example, reward incentives enhance hippocampal-dependent memory for the targets of goal pursuit, a process mediated by both anticipation of reward receipt and feedback (Madan, 2013; Shohamy & Adcock, 2010). Rouhani and colleagues (this issue) and Murty and colleagues (this issue) build upon this prior work to show that motivation also changes the structure of memory. Rouhani and colleagues (this issue) show that during a gambling task, individuals use feedback as an event boundary. In this way, in response to surprising feedback, individuals will separate information prior to and after feedback into separate events in memory. Thus, feedback not only enhances memory for specific items but also creates “mental distance” between subsequent events. While Rouhani and colleagues (this issue) demonstrate how feedback can discretize elements during memory encoding, Murty and colleagues (this issue) show how feedback may bind discrete elements of an event into an associative representation consisting of different phases a social exchange. The authors tested children between 4-6, who typically show dramatic increases in associative memory across this range. Children played a game where they selected a cake for target characters, and received positive or negative feedback on their selections. The authors showed age-related invariance in memory between specific characters and the decisions they made. Leveraging prior work showing consistent improvements in associative binding across 4-to-6 years of age, the authors were able to interpret the age-invariance in associative binding to infer that decision elements become more tightly bound to each other in the context of social feedback. Together these findings show that affective mechanisms not only enhance memory, but restructure individual elements of features in memory.

While these first two studies focused on influences on the organization of memory, studies in this special issue also characterized how affect influences the types of information stored in memory. Often studies of social and affective influences on memory use simple list learning paradigms, which assay whether specific information is represented in memory. However, these paradigms do not explicitly probe the *qualities* of information stored in memory and their relationship to broader semantic knowledge. Sheldon and colleagues (this issue) addressed this question by investigating how affective-laden cues influence memory, and showed that emotional-arousal increased the amount of episodic details but not semantic details during autobiographical recall. Relatedly, Rajaram and colleagues (this issue) characterized how social collaboration influenced representations of episodic and semantic details in memory. The authors showed that when groups of individuals work together to retrieve memories (i.e., collaborative memory), individuals tend to increase memory for episodic details and, importantly, increase their rejection of semantically-related lures. Together, these

findings suggest that emotional and social contexts foster the incorporation of greater episodic rather than semantic details in memory. Wilson and colleagues (this issue) provided support that restructuring information around a social context facilitates episodic details by testing individuals with the behavioral variant of fronto-temporal dementia (bvFTD) that have severe impairments in socio-affective processing. Specifically, bvFTD individuals showed impairments in providing episodic-like details when imagining future scenarios—which recruits overlapping mechanisms to memory retrieval (Hassabis, Kumaran, & Maguire, 2007)—that were specific to social versus non-social contexts.

Effects of Affective and Social Contexts Influences on Memory

The second theme that emerged in this special issue is the influence of affective and social contexts on memory. Recently, the importance of these contextual influences on memory have been increasingly addressed in the literature (see Stark et al., 2018, for an overview), and previous work has demonstrated how affective and social contexts can influence memory and provided additional support for the perspective of commonalities between different motivational factors' influences on memory (e.g., Madan, 2017). Gaesser (this issue) took a broad view and provided a novel perspective for understanding others by integrating the theoretical advances associated with episodic representations and scene construction with those of social cognition. This is a new approach for considering how the episodic system can underlie our understanding of other people and the contents of the mind. Turning to empirical studies, Frankenstein and colleagues (this issue) provided information about individual's social traits in different phases of the experiment and found better recognition memory for additional traits that were consistent with the initially provided information. This study examined how people develop schemas and priors about others. Using an experimental procedure that involved real social interactions, Abel and Baüml (this issue) found both benefits and drawbacks of collective remembering. In the experiment, sets of three participants initially studied lists of words individually and later engaged in a collaborative recognition test. Participants were not told, however, that some of the studied words were unique to different participants. Findings indicated that collaboration enhanced memory for shared information, but also allowed for distortion due to social contagion--particularly when both other participants had studied the word. Including an individual retrieval task prior to collaboration helped protect against this distortion, without attenuating the enhancements provided by collaborative remembering of shared information (also see Rajaram et al., this issue, for other recent work on collaborative memory).

Bowen and colleagues (this issue) examined reward and memory, asking participants to remember indoor and outdoor scenes, with higher reward rates

associated with one of the image categories. Memory was later tested using a recognition procedure and it was found that high-reward images had both higher hit rates and higher false alarm rates. Furthermore, participants were more likely to respond “old” to images from the high-reward category, even after adjustments were made to the false alarm penalty. The reward manipulation in this study is novel in that reward values were associated with categories of stimuli, while prior studies assign reward values item-wise. The results demonstrate that reward motivation does not ‘simply’ improve memory discriminability and that more work is needed to understand how motivation influences biases in memory and decision-making. Moreover, these findings show that motivational contexts at retrieval can shift response biases.

Two studies in the special issue investigated how the context surrounding choice behavior relates to subsequent memory. Katzman and Hartley (this issue) examined the role of agency in learning in children, adolescents, and young adults (i.e., across ages 8 to 25). Given a cover story involving space travel and a search for treasure, participants were sometimes given a choice of which planet to search for treasure and other times told that the “autopilot” would choose--removing agency. Here different galaxies served as contextual cues and separated experimental conditions, with planets having varied reward probabilities based on the associated condition. Along with the reward feedback, participants also saw trial-unique object images. Results indicated that participants had better memory for the images (after a two-day delay) when they made the choices themselves, rather than the ‘autopilot’ system, and when the difference in reward probabilities was meaningful--i.e., the consequential choices; that is, it was not simply that making a choice impacted subsequent memory, but more specifically that the context of the choices mattered to the reward outcome. Decker and colleagues (this issue) also studied the relationship between choices and memory, but specifically investigated the influence of errors. In two experiments with slightly different methods, participants had to categorize presented images as living or nonliving. In Experiment 1, the probability of the living and non-living categories was manipulated (90:10), whereas in Experiment 2, the congruency between spatial presentation and response mapping was manipulated by presenting images on the left or right side of the screen and varying the congruency between spatial presentation and response mapping. In either instance, memory was subsequently tested in an immediate, surprise recognition test. Categorization errors in the initial tasks were associated with poorer memory--as was the case for images shown immediately after the errors. Eye-tracking was used in the second experiment, with pupil size shown to relatively increase on error trials, suggesting that error-related changes in physiological arousal may underlie this transient memory impairment.

Idiosyncrasies in Motivation and Memory

Several papers in the special issue explored how environmental cues and individual traits shape the ways in which they form and retrieve memories. This is a theme that connects to previous work illustrating that information is prioritized in memory based on what is valued or important to an individual or what is motivationally relevant in the moment. These goals can be idiosyncratic based on traits of the individual. For example, people with high levels of affective empathy exhibit a greater memory advantage for social compared to nonsocial information (Wagner, Handle, & Walter, 2015), and people may better remember information about others who are similar to themselves (Leshikar & Gutchess, 2015).

As illustrated by the papers in this collection, the impact of goals and motivations can emerge broadly across individuals or can be idiosyncratic, varying across individuals or task contexts. The work of Lin, Cabrera, and Reuter-Lorenz (this issue) illustrates a pervasive tendency for people to preferentially learn win-associations better than loss-associations in a probabilistic learning task. This learning asymmetry occurs when each type of outcome is equally weighted, for points or money, and even when participants are explicitly instructed about the outcome contingencies. Furthermore, Elliott and colleagues (this issue) identify individual differences that can critically shape the impact of reward. Their study of individual differences finds that episodic memory, but not working memory, capacity contributes to the ability to prioritize remembering high-value information. Griffin and Schnyer's (this issue) results encompass both perspectives, illustrating persistent effects as well as some individual differences. Consistent with prior work (e.g., Kensinger, 2007), emotionally negative information exerted different effects on memory than neutral information, but task context mattered. More memory errors occur for negative than neutral information when semantic aspects of the input were emphasized but there are fewer memory errors for negative than neutral information when orthographic aspects of the input were emphasized. Furthermore, individual differences in depressive symptoms and negative mood affected the magnitude of EEG markers of memory.

The idiosyncratic effects of motivation on memory also can be defined on the basis of shared group membership. Two of the papers in the special issue focus on the importance of age as an aspect of identity that helps to determine what information is motivationally relevant. One of the most prominent theories of adult development and motivation is socioemotional selectivity theory, which purports that as individuals become more aware of the limited time remaining in their lives, their goals shift so that they prioritize emotionally meaningful experiences rather than seeking out new experiences and knowledge (Carstensen, Isaacowitz, & Charles, 1999). This theory is thought to explain shifts in preferences to spend more time with loved ones and to prioritize more positive emotional information with age, in contrast to young adults' emphasis on information seeking and prioritization of negative information. Across three cognitive tasks, Barber and colleagues (this issue) replicated findings of age differences

in the prioritization of emotional information, with effects driven by changes in response to negative rather than positive information. However, measures of future time perspective did not directly account for age differences; neither did individual differences in cognitive ability, another potential explanation offered for age differences in positivity effects. Own-age effects represent another way of thinking about the motivational relevance of information with age. These effects reflect young adults' tendency to preferentially attend to and remember faces or other information about members of their young adult in-group, compared to out-group members such as older adults. Strickland-Hughes and colleagues (this issue) extended research on own-age effects to associative memory for faces and names, finding that both younger and older adults showed own-age biases. These biases in memory, however, were not reflected in measures of visual attention. Taken together, these papers converge with prior work in finding age differences in what types of information is prioritized in cognition, yet highlight the difficulty of identifying the precise mechanisms that underlie these age differences.

The final paper in the special issue considers the contribution of both individual differences in motivational content as well as group differences. Mok and colleagues (this issue) cued participants to imagine a specific future episode and found that this reduced the discounting of delayed rewards for younger adults, though less so for older adults. Imagining personally relevant events did not affect probability discounting without a delay in either group, revealing the importance of a temporal component when using personal episodic information to support judgments.

Summary

The collection of papers in this special issue show the ways in which thinking about social, motivational, and emotional influences on memory has advanced dramatically in recent years, bringing the topic into the mainstream of memory research. In developing this special issue, we were struck by the growth of interest in this topic and the many excellent studies that could have contributed to this special issue beyond those we ultimately were able to publish. We hope that this special issue helps to catalyze additional research and theory on these topics, integrating topics historically considered outside of the realm of the core study of "cognition" to understand how these social, motivational, and emotional processes can critically impact memory.

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