Autobiographical Memory

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In Press

Oxford Handbook of Human Memory

2022

Abstract

Autobiographical memory—memory for our personal past—is a multifaceted mnemonic activity that evolves throughout the lifespan and interacts with numerous other cognitive functions. Retrieving personal past events engages processes of cue specification, search, and elaboration of details within the specified event. The retrieved content varies from specific episodes unique in time and place to more general representations of autobiographical facts (personal semantics). As expected given this complexity, autobiographical memory is mediated by distributed brain networks, with key regions in the medial temporal lobes and their connections to both anterior and posterior cortical regions supporting different levels of specificity in memory retrieval. These patterns only partially overlap with those evoked by laboratory-based episodic memory paradigms. While most empirical work on autobiographical memory focuses on the recall of particular past events, more recent research concerns individual differences in the way that people tend to remember their past. The formal study of autobiographical memory dates to the 19th century, but research in this field is burgeoning, particularly in relation to brain network connectivity. New paradigms that bridge the gap between traditional laboratory memory tasks and rich, naturalistic autobiographical memories will enhance the understanding of memory as it operates in everyday life.

Keywords: autobiographical memory, episodic memory, medial temporal lobe, prefrontal cortex, parietal lobe, amnesia, individual differences

The origins of the formal study of autobiographical memory date to the 19th century with Galton and Freud (Robinson, 1986). Freud took the approach of a psychiatrist delving into a patient's life history in order to explain and treat neuroses, and Galton the approach of a botanist trying to create a taxonomy of personal recollections. In both cases, their influence is evident in the present day: psychotherapy techniques often involve interpretation of memory for personal past events (albeit not necessarily through a psychodynamic approach; e.g., Neshat-Doost et al., 2013; Resick & Schnicke, 1992; Romano et al., 2020), and researchers still use Galton's method of using words to cue the retrieval of personal memories.

With the dominance of cognitive psychology beginning in latter half of the 20th century, the introspective methods of Freud, Galton and others gave way to laboratory stimuli—such as word lists—as facsimiles for real-life events that could be manipulated for the purposes of hypothesis testing, much the same way fruit flies are used to study heredity (Tulving, 1983). Yet laboratory stimuli lack the personal significance, emotionality, physical enactment, spatial complexity, self-initiation, and extended delay periods typical of real-life events. Therefore, researchers seeking to improve generalization of their findings have increasingly incorporated naturalistic methods, particularly autobiographical memory paradigms, over the past 20 years (Diamond, Abdi, et al., 2020; see Figure S1).

Research groups employing naturalistic versus laboratory methods had quietly tolerated each other over the years (although tensions have erupted; see Banaji & Crowder, 1989; Neisser, 1978). Under the assumption that evolution would not create separate memory systems for laboratory versus naturalistic stimuli, the foundational principles accepted by memory researchers would be reflected in a common lexicon regardless of the research platforms, yet in some cases “autobiographical memory” is treated as a distinct form of memory (e.g., Greenberg

& Rubin, 2003). While the terms “laboratory”, “naturalistic”, and “autobiographical” are convenient labels for classifying methodologies, the boundaries between these categories can be blurred by tuning parameters such as emotion, delay, and narrative structure, as described in detail below. Considering autobiographical memory research as a subculture or set of practices within the domain of memory and cognition promotes the comparison and contrast of findings as a technical rather than a theoretical matter.

In the vast majority of autobiographical memory paradigms, the examiner requests the participant to access and elaborate upon events from their past in response to cues of varying specificity, such as a cue word (e.g., “flag”), a lifetime period (e.g., teenage years), or a specific event (e.g., high school graduation). For the purposes of this chapter, we focus on the distinctions between the processes of generation/access and elaboration in response to such cues, and between two domains of evoked autobiographical content: event-specific (episodic) and general (non-episodic or semantic). While these distinctions are imperfect, they provide a useful framework for interpreting the literature.

With respect to processes, *generation* or *access* refers to active search and retrieval processes engaged to isolate specific events in response to a cue, including navigation through life periods, habitual or repeated events (e.g., holiday dinners), or other semantic or gist-like knowledge structures (Conway & Pleydell-Pearce, 2000). In the presence of a specific retrieval cue (either generated as a result of the above-described process or provided by the examiner), *elaboration* processes are engaged to populate the accessed memory with details.

Autobiographical content encompasses both specific details about past experiences as well as world- and self-related knowledge in which those experiences are embedded. These content domains align with the distinction between episodic (event-specific) and semantic

(factual) memory as delineated by Tulving (1972, 1983), although as noted below caution is warranted when inferring theoretical psychological/brain systems based solely on content analysis. Tulving coined the term *autonoetic awareness* to describe the subjective state of mental time travel that marks a recollected event as part of one's personal past, a hallmark of episodic autobiographical memory (Tulving, 2002; Wheeler et al., 1997; see Chapter 2.1. Episodic Memory). The *subjective re-experiencing* of retrieved episodes is evoked to different degrees depending on both the retrieved event and the individual doing the retrieval (Rubin, 2021; see Chapter 5.5. Recognition Memory: The Role of Recollection and Familiarity).

We begin by surveying measurement tools and issues in autobiographical memory research, including methodological advancements and limitations. We then summarize research on the neural correlates and cognitive functions of autobiographical memory, including individual differences. Next, we review research concerning autobiographical memory in childhood and in aging. Finally, we suggest some of the key questions remaining in autobiographical memory research and suggest fruitful areas for further investigation.

Measuring Autobiographical Memory

Many techniques and principles considered standard in laboratory assessment of memory do not apply for autobiographical memory (see Chapter 1.5. Methods to Study Human Memory). Memory experiments generally seek to control encoding and recall conditions that can confound interpretation of performance at test, but such control is unattainable in autobiographical memory studies concerned with the recall of events over the lifespan. Events that are freely recalled or generated in response to cues such as words or lifetime periods are—by definition—self-selected, whereas laboratory materials are selected by the experimenter. The accessibility of autobiographical events is dependent upon rehearsal, emotional salience, personal significance,

and other factors that are intentionally eliminated by traditional laboratory assessment methods. Whereas the temporal resolution of episodic memory as assessed in the laboratory is at the level of seconds, minutes, and hours, the temporal resolution of autobiographical memory ranges from days to years. Autobiographical memory recall is further affected by individual differences in verbal behaviour and social factors associated with the disclosure of personal information— influences that do not play as large a role in laboratory episodic memory tasks. Finally, relative to typical laboratory studies, studies of autobiographical memory are more concerned with qualities of richness and subjective recollection, whereas laboratory studies are typically concerned with accuracy relative to the information presented at encoding. Indeed, for most lifespan events, the ground truth of what happened is unverifiable. Given this complexity, it should not be surprising that there is no single accepted technique for measuring autobiographical memory. Below we describe the dominant techniques for assessment of autobiographical memory as well as some newer methods designed to more closely align autobiographical memory assessment with standard experimental techniques (see also Sheldon et al., 2018).

Cueing Technique

The cueing technique, in which words are presented to evoke autobiographical memories, dates back to the 19th century as one of the earliest and best-known methods of studying memory (Galton, 1879). In contemporary research, this technique has been used to assess generation or access to events across the lifespan. In general, the temporal distribution of these events is distributed as a power function whereby recent events (i.e., days or weeks old) are accessed with the greatest frequency relative to remote events (Rubin & Schulkind, 1997). Two exceptions to this distribution in healthy adults are enhanced access to events from the late-teen and early-adult

years, known as the reminiscence bump (Rubin & Schulkind, 1997), and an absence of access to early childhood events, known as childhood amnesia (Usher & Neisser, 1993).

The cueing method has been widely used to assess the effects of depression and other psychological disorders on access to autobiographical memories. In the Autobiographical Memory Test (AMT; Williams & Broadbent, 1986), participants recall specific events in response to cue words of varying emotional valence (e.g., “happy,” “guilty,” “fashion”). As the cues are non-specific, they are presumed to evoke generalized or categorical event representations (encompassing numerous events) prior to the specific ones that are explicitly requested by the experimenter (Conway, 2001). That is, a word such as “guilty” will not directly evoke a specific event, but rather a higher-level category such as “things I feel guilty about,” followed by a self-guided search through memory for a specific event (Gruenewald & Lockhead, 1980). A key finding from research with the Autobiographical Memory Test is that individuals with depression produce over-general descriptions (“I feel guilty all the time”) rather than specific events, as their event descriptions terminate at the categorical level prior to a finer-grained specific event (Williams et al., 2007; see also Sheldon et al., 2018).

Cueing techniques have employed a variety of visual, auditory, and other sensory cues in addition to words (e.g., Cady et al., 2008; Chu & Downes, 2002; El Haj et al., 2020), and since these methods are primarily concerned with generation and access, higher-order executive search and retrieval strategies are engaged to navigate through life periods to select and verify specific events. Moreover, as expected given the encoding specificity principle, cue characteristics such as imageability (Anderson et al., 2012; Rasmussen & Berntsen, 2011; Williams et al., 1999), emotional intensity (Simpson & Sheldon, 2019), and presentation (e.g., visually vs. orally; van Vreeswijk & de Wilde, 2004) have been shown to bias memory retrieval. Cueing methods are

optimized for the efficient collection of large and diverse autobiographical event sets, but different methods are required to isolate the elaboration or experiential qualities of accessed events (e.g., Devitt et al., 2016; Luchetti & Sutin, 2016; Rubin et al., 2003).

Interview Methods

In most interview methods, event generation and access occur outside of the test, with specific event titles provided by the examiner or selected by the participant prior to testing. These methods focus therefore on elaboration processes engaged upon event access—including the integration of perceptually, spatially, and emotionally rich details—to form a coherent narrative. The Autobiographical Memory Interview (AMI; Kopelman et al., 1989) assesses specific events across childhood, early adult life, and recent events and, through a separate interview, personal semantic information (e.g., the location of one's secondary school). The Test Episodique de Mémoire du Passé autobiographique (TEMPau; Piolino et al., 2003) takes a similar approach to assessing episodic autobiographical memory, with a finer grain of life period (Piolino et al., 2003). In both cases, the examiner rates each memory according to its specificity.

Rather than rely on experimenter ratings, the Autobiographical Interview (Levine et al., 2002) deconstructs transcribed autobiographical memory narratives using an objective and manual-based scoring protocol that classifies details into internal (event-specific) or external (non-specific) categories. Internal subcategories comprise event, perceptual, time, place, and thought/emotion details characteristic of episodic memory, whereas external subcategories comprise semantic information, as well as details about events unrelated to the identified main event, repetitions, and metacognitive or editorial statements. This method objectively quantifies dissociable autobiographical memory elements as they occur naturally within a freely recalled

narrative, without any need for artificially separating autobiographical memory elements at the time of testing.

This technique has been influential in assessing autobiographical memory in over 300 studies, especially neuropsychological studies of patients with damage to hub medial temporal lobe regions classically involved in detail recovery, including in medial temporal lobe amnesia (e.g., Miller et al., 2020) and neurodegenerative diseases (e.g., Irish et al., 2014), as well as in imaging studies of medial temporal lobe structure and function (e.g., Bonnici et al., 2018; Palombo, Bacopulos, et al., 2018; Thakral, Madore, et al., 2017). This measure of detail recovery has been extended to numerous other populations, including children (e.g., Sekeres, Riggs, et al., 2018) and psychiatric patients (e.g., McKinnon et al., 2015). Although the Autobiographical Interview originally assessed autobiographical memory across 5 life periods (Levine et al., 2002), the cueing method is flexible and often adapted to the needs of the study. Moreover, the scoring technique has been applied to analysis of narratives concerning future, imagined, or other types of events (Addis et al., 2008; Madore & Schacter, 2014; Thakral, Benoit, et al., 2017).

As these techniques use cues selected prior to testing, they may produce divergent findings from measures concerned with spontaneous generation of events (Clark et al., 2019; Palombo et al., 2015). Accordingly, the cueing techniques described in the previous section have had greater application in psychiatric disorders that have characteristic event-generation/access deficits, whereas interview techniques have been more focused on neuropsychological populations with impaired detail recovery capacities, particularly those involving the medial temporal lobes.

For the sake of inter-rater reliability, internal details in the Autobiographical Interview are defined in relation to event specificity and not inferred conscious experience. A highly

accessible remote event may be recounted in great detail but without subjective re-experiencing relative to a more recent and unique event. For example, Cermak and O'Connor (1983) described an amnesic patient who recounted past events “with a clarity bewildering to those cognizant of his memory deficiencies” (p. 230) that were determined to be non-episodic “personal folklore” (see also Brewer, 1988). Similarly, external details (and more specifically semantic details) are produced *in opposition* to the standard Autobiographical Interview instructions to recall an event specific in time and place and therefore are not expected to track with semantic abilities.

Elevated external details may reflect reduced executive control over retrieval or compensatory processes in the presence of reduced specificity (Levine et al., 2002; McKinnon et al., 2015; Renoult et al., 2020; Spreng et al., 2018).

As noted above, caution is warranted when attempting to map verbal behaviour (e.g., narrative production) to psychological constructs (e.g., episodic and semantic memory), especially when effects are subtle. This is particularly relevant when analyzing individual differences, as opposed to group effects. When effects could be attributable to superficial aspects of a given measure (i.e., method variance), the use of multiple measures is recommended to seek convergence. Given that detail counts may not reflect subjective re-experiencing, collecting subjective vividness ratings would be informative. When using cueing methods, it is recommended that event cues be optimized to the research questions. For instance, those studying individual differences in episodic autobiographical memory should cue for specific, unique, and unrehearsed events (e.g., staged events, Armson et al., 2021; see below) rather than highly accessible events (e.g., the first event that comes to mind in response to a lifetime period cue; Clark & Maguire, 2020) that are more likely to be rehearsed and schematized.

Verifiable and Staged Events

The lack of experimental control over encoding limits the range and rigour of questions one can ask, not the least of which is whether or not the recovered content is accurate. To overcome these limitations, researchers have devised methods to either verify or directly control the to-be-remembered events while retaining the ecological validity of real-life episodes.

Earlier work focused on publicly shared events, such as “flashbulb memory”—memory for public and extraordinary events (Brown & Kulik, 1977)—and showed that accuracy is lower than expected given subjective reports of vividness (Neisser & Harsch, 1992; Talarico & Rubin, 2003). While this research provided insights into emotionally-charged events with societal significance, it was less informative concerning memory for everyday events. Diary records provide time-stamped and detail-rich event descriptions that can be used later to cue and verify everyday episodic autobiographical memories (Linton, 1975; Wagenaar, 1986). Following in this tradition, experimenters have used prospectively collected audio diaries (Fuentemilla et al., 2014; Levine et al., 2004), or photos taken by subjects (St. Jacques et al., 2008), as potent retrieval cues to investigate neural correlates of vivid memory reactivation. However, diary-recorded events are typically self-selected for their significance (but see Brewer, 1988), and the act of diary recording or intentional photo-taking alters memory (Antony et al., 2017; Henkel, 2014).

Recent studies using wearable camera technology overcome both of these limitations (Chow & Rissman, 2017; Milton et al., 2011; St. Jacques et al., 2013). Wearable cameras can be worn over long periods while automatically capturing high volumes of time- and geo-tagged photographic memory cues, enabling researchers to map structure in memory and neural activity across spatial, temporal, and semantic/content distances that would be difficult to capture in a laboratory experiments (e.g., Nielson et al., 2015; Sreekumar et al., 2018). As with the methods

mentioned above, wearable camera methods must tolerate high degrees of heterogeneity in types of events that are retrieved within and across subjects (Hodges et al., 2006).

One way to pair the experimental control of laboratory encoding paradigms with the richness and ecological validity of autobiographical memory assessment is to design or control real-world events for subsequent memory testing. These staged-event methods allow researchers to map fine-grained details and dynamics in retrieval back to the ground truth of the encoded event. Staged events are particularly useful for group comparisons in controlling event content and retention interval across groups (e.g., younger and older adults; Diamond, Abdi, et al., 2020; Mair et al., 2019; St. Jacques et al., 2015) that are often confounded with memory performance in retrospective autobiographical memory paradigms (Aizpurua & Koutstaal, 2015). Moreover, such events can overcome a major limitation of most other autobiographical memory elicitation methods, which is that accuracy can be assessed—as is the case with laboratory materials—but over longer timescales than available through the use of laboratory materials.

[INSERT FIGURE 1 HERE].

Our lab has recently devised a variety of controlled real-world encoding paradigms to investigate accuracy and forgetting (Armson et al., 2017; Diamond, Abdi, et al., 2020; Diamond, Armson, et al., 2020; Diamond & Levine, 2020), eye movements and imagery (Armson et al., 2021), and spatiotemporal structure (Diamond et al., 2018; Diamond & Levine, 2020) in real-world memories over delays of days to years. One such paradigm involves an audio-guided, museum-like tour of the artwork around Baycrest hospital, which elicits enhanced recognition accuracy and subjective recollection in comparison to a version of this same event as experienced seated in front of a computer (Diamond, Abdi, et al., 2020). In one such study, we demonstrated that—contrary to widely-held skepticism about real-life memory accuracy—free

recall of typical daily life events is highly accurate, even though the quantity of recalled details declines with time and age (Diamond, Armson, et al., 2020; see also Wixted et al., 2016).

Controlled real-world events have also been applied in assessment of memory for spatial and temporal relations, allowing researchers to extend phenomena identified in laboratory recall and recognition paradigms to memory for travelled routes through large-scale environments (see also Dede et al., 2016; Diamond et al., 2018; Diamond & Levine, 2020; Griffiths et al., 2016; Jeunehomme & D'Argembeau, 2019; St. Jacques et al., 2008; see Figure 1). While some may ask what these paradigms offer over virtual reality, limited evidence from rodents (Aghajan et al., 2015), monkeys (Thome et al., 2017), and humans (Diamond, Abdi, et al., 2020) suggests that real-world and virtualized events elicit different patterns of neural activity and episodic memory. On the other hand, virtual platforms are more applicable when studying the neural correlates of encoding and for manipulations that cannot readily be executed in a real-life context (e.g., Bréchet et al., 2019; Vass et al., 2016).

The Cognitive Neuroscience of Autobiographical Memory

The amnesic patient Henry Molaison, known throughout his lifetime as HM, was seminal in demonstrating the key role of the medial temporal lobes and hippocampus in memory, including autobiographical memory. In Mr. Molaison's case, removal of tissue from his medial temporal lobes bilaterally for the treatment of intractable epilepsy resulted in a dense anterograde amnesia (Scoville & Milner, 1957). Critical work with a series of brain-injured patients, including Mr. Molaison, over the remainder of the 20th century further solidified the importance of the medial temporal lobes in both retrieving and forming autobiographical memories (Cermak & O'Connor, 1983; Rosenbaum et al., 2005; Vargha-Khadem, 1997; Zola-Morgan et al., 1983). With the advent of functional neuroimaging techniques, researchers identified an extended left-

lateralized prefrontal, medial temporal, and parietal network supporting autobiographical memory, with the medial temporal lobes as a hub (Cabeza & St. Jacques, 2007; Maguire, 2001; Svoboda et al., 2006). These regions appear to coordinate different stages of remembering corresponding to the above-described generative and elaborative processes. Generation is mediated by the left lateral prefrontal cortex, which interacts with the medial prefrontal cortex in activating self-referential processes, and the temporoparietal junction in retrieving the spatial context of the event (Burgess et al., 2001). Elaboration is associated with the hippocampus and retrosplenial cortex, enhanced by the amygdala and visual regions (Anderson et al., 2017; McCormick et al., 2015).

More recent studies focusing on functional specialization along the long axis of the hippocampus have found that posterior hippocampal regions are preferentially involved with elaboration, whereas anterior regions are involved with generation and linkage to existing knowledge (Bonnici & Maguire, 2018; Brunec et al., 2018; Reagh & Ranganath, 2018; Sheldon et al., 2019). These findings correspond to differential connectivity of these hippocampal regions, with the posterior sectors preferentially connected to cortical regions engaged in sensory (particularly visual) processing and the anterior sectors connected to prefrontal regions involved in memory selection and monitoring (Brunec et al., 2018; Ranganath & Ritchey, 2012). The contents of retrieved autobiographical memories are monitored or evaluated in ventromedial prefrontal cortex (Cabeza & St. Jacques, 2007), and the prefrontal cortex is more broadly implicated in maintaining, retrieving, manipulating, and otherwise coordinating information encoded in the medial temporal lobes and posterior cortical regions (Diamond & Levine, 2018).

The advent of finer-grained imaging techniques has allowed researchers to focus on the role of hippocampus and medial temporal lobe subfields in episodic and autobiographical

memory. While hippocampal ablation causes dense amnesia, there is no corresponding relationship between whole hippocampal volume or activation on (non-autobiographical) episodic memory performance in healthy adults (Poppenk & Moscovitch, 2011; Van Petten, 2004). Hippocampal subfields are implicated in the formation of distinct neural representations of similar events (pattern separation) and retrieving previously stored memory representations based on incomplete cues (pattern completion; Grande et al., 2019; Knierim & Neunuebel, 2016). Palombo, Bacopulos, et al. (2018) found that the dentate gyrus and cornu ammonis (CA) regions 2/3 were related to episodic autobiographical memory, and selective damage to CA3 in patients with encephalitis has been linked to both anterograde and retrograde episodic autobiographical amnesia using the Autobiographical Interview (Miller et al., 2017, 2020).

While many of these neuroanatomical findings apply to both laboratory episodic memory and episodic autobiographical memory, the aforementioned differences across these two platforms are evident in neuroimaging data. Episodic memory for lists and autobiographical memory map onto different brain activation patterns, particularly with lateral frontoparietal cortex associated with laboratory episodic memory and medial frontal and temporal regions associated with autobiographical memory (Gilboa, 2004; McDermott et al., 2009). A key difference between laboratory-based versus autobiographical episodic memory is that autobiographical memory involves episodic memory representations that span days, weeks, months, and years, typical of many everyday human episodic memory activities, and such temporal gradients are also central to theories of information storage and processing in relation to memory networks in the brain. Standard consolidation theory is driven by classic observations of temporally graded retrograde amnesia in amnesic patients (including HM; Corkin, 1984; Ribot, 1881; Zola-Morgan et al., 1983) and holds that the medial temporal lobes are needed only for

recent memories before they are consolidated in the neocortex (e.g., Squire, 1992). By contrast, multiple trace theory (Nadel & Moscovitch, 1997) holds that the hippocampus is always needed to reconstruct episodic memories at retrieval.

As discussed above, comparisons across recent and remote memories are confounded by retrieval accessibility and prior rehearsal. For example, when retrieving a decades-old memory, one is likely to draw upon well-rehearsed salient episodes (e.g., high school graduation), whereas numerous less salient events from the past days or weeks are more readily accessible to consciousness due to the recency effect. Therefore, when retrieving remote memories, one is more likely to draw upon semantic knowledge (e.g., facts about high school) than recollection of temporally-spatially specific episodic details. The Autobiographical Interview (Levine et al., 2002; see above) partially circumvents this problem by separating episodic from non-episodic details in transcribed autobiographical protocols (although, as noted above, it is possible for details classified as episodic to be semanticized). While findings with this technique have been mixed (e.g., Dede et al., 2016; Heyworth & Squire, 2019), most studies of medial temporal lobe amnesics have found that episodic autobiographical details are reduced for remote as well as recent events, including in Mr. Molaison and other patients with very focal hippocampus damage (e.g., Kurczek et al., 2015; Miller et al., 2020; Race et al., 2011; Rosenbaum et al., 2008; Steinvorth et al., 2005). Similarly, neuroimaging studies have shown that factors such as personal significance, vividness, and emotionality modulate hippocampus involvement in remote memory retrieval independently from memory age (Addis et al., 2004; Ryan et al., 2001; Sheldon & Levine, 2013; but see Squire et al., 2010), with likely changes in the laterality of hippocampus activation and its pattern along the anterior–posterior axis (Bonnici et al., 2012; Svoboda et al., 2006).

Trace transformation theory addresses the issue of hippocampus involvement in remote memories by proposing that the hippocampus supports an episodic and context-bound memory for as long as the memory is available, and over time it also supports the development of a more gist-like, schematic version of the memory in the neocortex (Moscovitch et al., 2016; Winocur et al., 2010; see Chapter 6.7. Systems Consolidation, Transformation, and Reorganization: Multiple Trace Theory, Trace Transformation Theory, and Their Competitors). There is then a dynamic interplay between these two forms of memory, such that one or the other may be dominant depending on the circumstances at retrieval. In accord with the above-described findings concerning the long axis of the hippocampus, the most recent version of this theory holds that posterior hippocampus interacting with posterior neocortex represents perceptually rich details (i.e., supporting elaboration), whereas anterior hippocampus interacting with anterior neocortex represents schemas (i.e., supporting generation; Sekeres, Winocur, et al., 2018; see also Gilboa & Moscovitch, 2021; Ranganath & Ritchey, 2012; Sheldon & Levine, 2016).

Parietal and temporoparietal brain regions have also been linked to autobiographical memory (see Chapter 5.9. Frontoparietal Contributions to Retrieval). The angular gyrus is involved in integrating memory features within an egocentric framework, facilitating the subjective experience of recollection (Bonnici et al., 2018; Thakral, Madore, et al., 2017). Similarly, precuneus volume is associated with egocentric autobiographical memory in both healthy individuals and in patients (Ahmed et al., 2018; Hebscher et al., 2018). These posterior cortical regions are involved in visual imagery and processing necessary for retrieving and subjectively re-experiencing vivid memories (Ahmed et al., 2018; Rubin & Greenberg, 1998).

The Autobiographical Memory Network

Autobiographical memory is a multifaceted cognitive process that is expected to be mediated by large-scale network interactivity. As such, a network approach to studying autobiographical memory has become dominant over the past decade and contributed to our understanding of how memory functions in the brain and relates to other cognitive processes. This research has manifested in studies of both structural (i.e., white matter tracts) and functional (i.e., the correlation of activity between different areas) connectivity between brain regions.

With respect to structural connectivity, the fornix (the main pathway from the hippocampus) relates to the amount of episodic detail in autobiographical memories (Hodgetts et al., 2017; Memel et al., 2020; see also Rudebeck et al., 2009). The uncinate fasciculus, which connects the rostral (including medial temporal) lobes and the ventral, medial, and orbital prefrontal cortex (Schmahmann et al., 2007), is involved in self-referential processing of autobiographical information, along with a sense of phenomenological re-experiencing of autobiographical memories (Levine et al., 1998, 2009; see also Memel et al., 2020). The structural integrity of the inferior longitudinal fasciculus, connecting the anterior temporal lobe and the occipitotemporal fusiform gyrus, correlates with semantic autobiographical memories (Hodgetts et al., 2017; but see Memel et al., 2020).

Fibre density between the medial temporal lobes and ventromedial prefrontal cortex is associated with individual differences in laboratory episodic memory performance (Schott et al., 2011), and although this finding has yet to be extended to more naturalistic autobiographical memory retrieval, it aligns with functional patterns of prefrontal cortex–medial temporal lobe connectivity in autobiographical memory (Svoboda et al., 2006). Sheldon et al. (2016) used resting-state fMRI to show that medial temporal lobe functional connectivity to posterior brain regions supporting visual/perceptual processing, such as parietal and occipital cortices, was

associated with a tendency towards episodic autobiographical remembering, whereas medial temporal lobe functional connectivity to inferior and middle prefrontal cortex related to more semantic or fact-based autobiographical remembering. This accords well with the above-outlined studies on the structural connectivity of the autobiographical memory network.

Functional connectivity within the autobiographical memory network has also been assessed using electrophysiological methods, with particular attention paid to brain oscillatory activity at the theta (~4–8 Hz) and gamma (>25 Hz) frequency ranges (Düzel et al., 2010). Theta phase synchrony and theta–gamma coupling provide a substrate for temporal lobe–neocortical engagement, as demonstrated in studies of laboratory materials (Colgin, 2015; Köster et al., 2014; Nyhus & Curran, 2010; see Chapter 4.5. Oscillatory Brain Mechanisms for Memory Formation—Online and Offline Processes). Given the multimodal and distributed nature of autobiographical recollection, autobiographical memory paradigms should optimally engage these oscillatory dynamics (e.g., Steinvorth et al., 2010). Accordingly, the presentation of potent episodic autobiographical retrieval cues (participants’ prospectively-collected audio recordings of events during recording with magnetoencephalography; MEG) was associated with phase-synchronized theta oscillations between the hippocampus and the precuneus/medial prefrontal cortex (Fuentemilla et al., 2014) and large-scale gamma synchrony across frontal, temporal, and parietal regions (Fuentemilla et al., 2018). These findings were robust in comparison to superficially similar recordings of semantic information. Moreover, gamma-synchrony emerged with accumulated recollection late in retrieval epochs, and both theta–phase coupling and gamma synchrony were absent in a case of Severely Deficient Autobiographical Memory (SDAM; see below; Fuentemilla et al., 2018). Disruption of theta phase coupling and theta–gamma phase–amplitude coupling between the medial temporal lobes and posterior cortical areas using

continuous theta-burst stimulation altered oscillatory dynamics and vividness (Hebscher et al., 2019), pointing to a causal role for these oscillatory dynamics for the subjective richness of autobiographical recollection, particularly in relation to visual processes.

Autobiographical Memory and Related Cognitive Functions

While the network of brain regions supporting autobiographical memory has been referred to as the core recollection network (Rugg & Vilberg, 2013), it is associated with putatively non-mnemonic tasks that similarly involve the projection of oneself into another time, place, or perspective, such as future thinking, navigation, and theory of mind (Buckner & Carroll, 2007). These tasks share an internally-directed perspective, rather than externally-directed attention, setting the stage for self-projection or memory construction (Spreng et al., 2008; see chapter 7.3. Prospective Cognition and its Links with Memory.) According to the constructive episodic simulation hypothesis, episodic memory is constructive (rather than reproductive) to enable individuals to flexibly extract and recombine elements of past experiences to simulate future ones (Schacter & Addis, 2007). In support of this view, the ability to remember details from past experiences corresponds to the ability to imagine details in future experiences (e.g., Mullally & Maguire, 2014; Schacter et al., 2012), and amnesic patients with medial temporal lobe damage are unable to imagine specific future events (Lechowicz et al., 2016; Schacter et al., 2017).

Inducing participants to specifically engage episodic memory processes by instructing them to focus on specific contextual details (as opposed to the overarching gist) when remembering events activates the autobiographical memory network (Madore et al., 2016) and enhances recall of episodic details in autobiographical memory retrieval (Madore et al., 2019). Such episodic memory induction influences performance on a range of tasks—such as creative

divergent thinking (Madore et al., 2015), open-ended problem solving (Madore & Schacter, 2014), and future imagination (Madore & Schacter, 2016)—that draw upon event construction, or the assembly and maintenance of a detailed mental scenario (Madore et al., 2019). Details from this scenario can be drawn from personal past experiences, and then flexibly applied to new situations—for example, in planning the steps needed to solve a complicated social problem (Sheldon et al., 2011).

One particularly influential branch of research that generally aligns with the self-projection view, but which has largely stemmed from rodent research, examines the correspondence between episodic memory processes and spatial navigation (or the projection of the self through physical space; see Chapter 3.3. Memory for Space). Cognitive map theory was first put forth by Tolman (1948) to describe the behaviour of rats in mazes and was solidified by the discovery of place cells in the rodent hippocampus, which fire whenever the animal revisits a particular location (O’Keefe et al., 1998). Broadly, this theory proposes that the same processes that are used to map the spatial environment are also used to represent past experiences and guide future actions (Epstein et al., 2017). The hippocampus is the focal brain substrate in these processes, and given its key role in autobiographical memory, there has been considerable interest in linking spatial and memory abilities (e.g., Buzsáki & Tingley, 2018; Ekstrom & Ranganath, 2018; Vikbladh et al., 2019). Researchers have worked to integrate the hippocampus’s function in episodic and spatial memory by proposing that cognitive maps are used to represent and organized knowledge across all domains (Behrens et al., 2018).

There is, however, further clarity needed in understanding what it is about “spatial” memory that contributes to episodic and autobiographical memory. A stream of research that has been conducted largely independently from the studies of cognitive map theory also investigates

and links the hippocampus's function in both spatial and episodic processing, but focuses on spatial memory for scenes and contexts rather than maps and navigation. Scene construction theory posits that in order to retrieve a past event, a mental image of a scene or spatial location must first be called to mind, and it can then serve as a scaffold for further event details to be built upon (Hassabis & Maguire, 2007). This is similar to the view that the key function of the autobiographical memory network is in constructing events, but it focuses on detailed spatial scenes as the critical aspect. Events have to happen *somewhere*, so it is logical that autobiographical episodic memories would be anchored by spatial context. Accordingly, scenes have a privileged role in autobiographical memory retrieval: individuals are quicker to retrieve autobiographical memories based on scene rather than object cues, and these scene-based memories are more detailed and vivid (Hebscher et al., 2018; Robin & Moscovitch, 2014). Episodic autobiographical memory, measured both at the trait and task performance level, corresponds more closely to the visualization of details in scenes than to navigational abilities (Clark et al., 2019; Fan, Abdi, et al., 2020). Further evidence in support of the involvement of scene processing in autobiographical episodic memory is derived from oculomotor measures, including eye movements that recapitulate visuospatial context (Lenoble et al., 2019; Wynn et al., 2019) and relate to episodic richness of free recall, especially in individuals with self-reported high episodic autobiographical memory traits (Armson et al., 2021).

A related point of view defines an event memory as a mental construction of a scene recalled as a single occurrence (Rubin & Umanath, 2015). This theoretical framework still asserts the importance of scenes in retrieving memories but deemphasizes the importance of “reliving” or re-experiencing that was highlighted by Tulving (1972) in his initial conceptualization of episodic autobiographical memory. The proponents of this theory

emphasize the role of the hippocampus and ventral visual stream in scene construction. They propose that event memory provides a cleaner contrast to semantic memory than does the construct of episodic memory because it does not conflate the independent dimensions of whether or not a memory is relived, is about the self, is recalled voluntarily, or is based on a single encoding.

While the scene construction and event memory accounts differ in some aspects, such as their emphasis on the importance of re-experiencing in defining an episode, they are both centered on the formation of visual images that are more generally implicated in vividly remembering past experiences (Barry et al., 2019; Rubin & Greenberg, 1998; Rubin & Umanath, 2015). Accordingly, individuals with aphantasia—a congenital lack of mental imagery but otherwise normal cognition (Zeman et al., 2015)—report deficient autobiographical memory (Dawes et al., 2020; Greenberg & Knowlton, 2014; Watkins, 2018; see studies on Severely Deficient Autobiographical Memory or SDAM below). While this field of study is at an early stage, it points to new avenues of research for better understanding the role of visual processing in autobiographical memory retrieval.

Individual Differences in Autobiographical Memory

Individuals differ in how they tend to recall autobiographical information (Palombo, Sheldon, et al., 2018; see Chapter 8.1. Individual Differences in Working and Long-Term Memory). People with Highly Superior Autobiographical Memory (HSAM, LePort et al., 2012) have extraordinary recall of remote events, even mundane ones, whereas those with Severely Deficient Autobiographical Memory (SDAM; Palombo et al., 2015) report being unable to re-experience any specific details from past memories, despite normal learning and memory for facts. While most individuals likely fall on a spectrum of autobiographical memory capacities (as

is the case with traits such as personality or intelligence), examination of the extreme ends of this spectrum can help inform models of autobiographical memory.

While the neural and cognitive substrates of these extreme autobiographical memory abilities remain under investigation, some evidence indicates that consolidation may be the key underlying process. HSAM individuals recall the same amount of episodic detail as controls do one week after an event has occurred, but HSAM recall performance is superior after one month and at more remote delays (LePort et al., 2016). Individuals with HSAM also score higher than controls do on measures of obsessive–compulsive disorder (OCD), indicating that they may repeatedly retrieve and review autobiographical memories and thus retain them better over time (LePort et al., 2016). This suggests that individual differences in autobiographical memory may be driven by the ability to retrieve, rather than encode, information. However, HSAM individuals are also susceptible to false recognition of lures in an associative word-list task and show higher false memory than controls do for details in a photographic slide show, indicating that they use the same reconstructive memory mechanisms as do people with typical memory abilities (Patihis et al., 2013). With regards to SDAM, these individuals report no subjective sense of reliving when remembering past experiences and lack the corresponding fMRI, event-related potential (ERP), and neural synchrony effects associated with conscious recollection, even when recognition is intact (Fuentemilla et al., 2014, 2018; Palombo et al., 2015).

HSAM and SDAM appear to be specific to episodic autobiographical memory; these individuals have broadly normal neuropsychological test performance (including on clinical tests of memory; LePort et al., 2012; Palombo et al., 2015). As reviewed above, episodic recollection plays a role in numerous other cognitive functions such as problem solving, decision making, and future planning, and an inability to retrieve details in such a manner should thus have a host

of negative consequences in daily life. On the other hand, forgetting is also adaptive and crucial for normal memory function (Richards & Frankland, 2017), and holding onto vast amounts of episodic detail should also be detrimental.

In spite of these predictions, substantial functional impairment in HSAM and SDAM individuals has yet to be revealed. Indeed, there is evidence for enhanced non-episodic abilities in SDAM (Watkins, 2018). Similarly, individuals with aphantasia (or a lack of visual mental imagery; many of whom also report having impaired autobiographical memory), are more likely to have scientific occupations (Zeman et al., 2020). These findings suggest that the relationship between autobiographical memory abilities and everyday functioning may change according to how function is defined. For instance, event construction abilities may relate to performance on abstract tasks of problem solving, but real-life problem solving (as is done in scientific occupations as well as in daily life tasks) may relate to one's ability to extract commonalities across episodes rather than the ability to recollect details of individual episodes.

Examining individuals along the spectrum of autobiographical memory abilities between the extremes of HSAM and SDAM can inform current theoretical models of autobiographical memory, in particular domain-specific component processes that may mediate individual differences in autobiographical memory (Palombo, Sheldon, et al., 2018). For example, visual imagery is largely accepted to play a crucial role in episodic autobiographical memory (Greenberg & Knowlton, 2014; Rubin & Umanath, 2015), and individual differences in visual imagery (e.g., strong imagery for objects and contextual details versus strong imagery for schematics and spatial transformations) moderate episodic memory retrieval (Sheldon et al., 2017; see also Rubin, 2020). Differences in emotional processing could also contribute to differences in autobiographical memory—emotional intensity enhances autobiographical

memory recall (Holland & Kensinger, 2010; Talarico et al., 2004), and trait levels of anxiety, neuroticism, and extraversion are associated with differences in autobiographical memory (Holland & Kensinger, 2010; Walker et al., 2014). As noted above, performance-based measures of autobiographical recall have been augmented by survey-based measures assessing stable individual differences in autobiographical memory (Berntsen et al., 2019; Palombo et al., 2013). Individual differences in autobiographical memory abilities correspond to different patterns of resting-state medial temporal lobe functional connectivity (Sheldon et al., 2016; see above), and when applied to a separate sample, these patterns related to individual differences in cognition, such that lower episodic autobiographical memory corresponded to enhancements in brain networks supporting semantic or gist-based processing (Petrican et al., 2020; see also Milton et al., 2021). Together, these studies provide support to the notion that individual differences in autobiographical memory exist in the context of a broader profile of cognitive strengths and weakness, including semantic or non-episodic processing enhancements in people who self-report a lack of subjective re-experiencing.

The Development of Autobiographical Memory

Given that aphantasia, SDAM, and HSAM appear to reflect congenital abilities, they have been proposed to be developmental syndromes akin to prosopagnosia (the inability to recognize faces; Kress & Daum, 2003), developmental topographical disorientation (the inability to navigate familiar environments; Iaria & Burles, 2016), and developmental anomia (the inability to name objects; Gvion & Friedmann, 2016). While there has been relatively little work examining stable individual differences in autobiographical memory abilities, we have a better understanding about how autobiographical memory performance tends to develop and change across the lifespan across individuals.

Autobiographical Memory in Childhood

Although infants and young children can recall complex sequences and routines (Meltzoff, 1988; Reese, 2009) the development of episodic autobiographical memory (i.e., spatiotemporally specific recall of prior episodes, accompanied by autonoetic awareness) is protracted (see Chapter 8.2. Memory in Infancy and Childhood and Chapter 8.3. Memory Development in Middle Childhood and Adolescence). Childhood amnesia, originally identified over 100 years ago (Freud, 1924; Miles, 1895), has been further classified into two distinct periods: infantile amnesia and childhood amnesia (Newcombe et al., 2007). *Infantile amnesia* refers to the developmental period during the first two years of life from which adults cannot recall any autobiographical memories (Usher & Neisser, 1993). *Childhood amnesia* refers to a subsequent developmental period lasting approximately 3 to 5 years where the amnesia is lifting, but from which only a limited subset of autobiographical memories can be recalled (Newcombe et al., 2007; Perner & Ruffman, 1995).

Studying the (lack of) autobiographical memory in infants and very young children is challenging because these developmental populations have undeveloped linguistic abilities (Fivush & Nelson, 2004); consequently, most early investigations of autobiographical memory emergence have relied on retrospective designs in which adults are asked to provide their earliest autobiographical memories (Bruce et al., 2000; Fiske & Pillemer, 2006; Grabner et al., 2009; Rubin, 2000). Adults can recall some memories from as early as age 2 when directly asked about specific events that are known to have happened in their past, such as the birth of a sibling or a hospitalization, but empirical evaluations of the distributions of frequencies of memories at particular ages (Bruce et al., 2000; Rubin, 2000) indicate that adults spontaneously recall practically no autobiographical memories from before 2 years of age. The number of

autobiographical memories recalled by adults increases steeply after the age of 3 and begins to level off around the age of 5, and adult-like autobiographical memory recall seems to be present by 7 years of age. Most of the earliest autobiographical memories that adults can recall are from between the ages of 3 to 4 (Bruce et al., 2000; Rubin, 2000; Usher & Neisser, 1993).

Despite a historically heavy reliance on retrospective memory paradigms, children over the age of 2 have strong enough linguistic abilities to be directly asked about events in their past (Fivush & Nelson, 2004), and a more recent body of work has examined the development of autobiographical memory by asking children to recall events from different points in the past (Bauer & Larkina, 2014; Cleveland & Reese, 2008; Peterson et al., 2011). While children between the ages of 2 and 6 are reliably able to recall some autobiographical events even after 1 year, such as a birthday party or a field trip (Hudson & Fivush, 1991), cueing is required and the resulting accounts are fragmented and semanticized (Newcombe et al., 2007; Perner & Ruffman, 1995). Moreover, children who were younger at the time of an event exhibit faster rates of forgetting, as compared to children who were older (Morris et al., 2009; Perner & Ruffman, 1995). Based on these findings, it is widely accepted that the emergence of autobiographical memory is not a consequence of a qualitative developmental shift, but rather a continuously developing ability across childhood (Bauer, 2006; Courage & Howe, 2004). In other words, infantile amnesia does not simply lift when a child reaches a particular age—children experience an elongated developmental period during which they acquire autobiographical memory.

Why is there such a prolonged delay in humans' ability to form lasting autobiographical memories? Early theories suggested that the "cognitive self" (Howe & Courage, 1993, 1997), which emerges around 24 months of age (Povinelli et al., 1996, 1999) is required to encode experiences with reference to oneself. Adult-like self-projection capacities, including

autobiographical memory but also theory of mind and navigation, emerge together at approximately 4 years of age (Bluestein & Acredolo, 1979; Perner & Ruffman, 1995). Social Interaction Theory proposes that environmental influences relating to parent-child interactions, language development, and the emergence of narrative abilities contribute to the emergence of both autobiographical memory capacities and an understanding of the self (K. Nelson & Fivush, 2004). Yet the fact that non-human animals exhibit infantile amnesia suggests that biological accounts are required to fully explain infantile and childhood amnesia (Josselyn & Frankland, 2012; Newcombe et al., 2007).

Biological accounts hold that immature hippocampal systems preclude the storage and retrieval of episodic details early in life (Bauer, 2006; Li et al., 2014; C. A. Nelson, 2000; Newcombe et al., 2007; Pillemer & White, 1989). Infantile maturational processes interfere with the storage or consolidation of acquired episodic information (Josselyn & Frankland, 2012), and the maturation of these systems depends heavily on environmental experiences (Alberini & Travaglia, 2017). Hippocampal neurogenesis is thought to drive continuous remodelling of hippocampal circuits in early development, changing previously-established synaptic connections that support existing memories and ultimately rendering these memories nearly inaccessible (Campbell & Spear, 1972; Frankland et al., 2013; Richards & Frankland, 2017), providing a mechanistic explanation for infantile and childhood amnesia. Accordingly, experimental enhancement of hippocampal neurogenesis in mice induces forgetting of recently formed memories, whereas suppression of hippocampal neurogenesis in infant mice (i.e., during the developmental window when hippocampal neurogenesis levels are high) mitigates forgetting (Akers et al., 2014).

While the foregoing evidence is restricted to rodent models, the hippocampal neurogenesis hypothesis was recently tested in children previously treated for malignant brain tumors (medulloblastoma) with cranial radiotherapy that suppresses hippocampal neurogenesis and reduces hippocampal volume (Sekerer, Riggs, et al., 2018). As expected with significant hippocampal pathology, anterograde (i.e., post-radiation treatment) episodic (but not semantic) autobiographical memory was reduced in the tumour group relative to non-treated children. However, retrograde (pre-radiation treatment) episodic autobiographical memory was spared, which is contrary to expectation in the presence of hippocampal pathology, suggesting that the suppression of neurogenesis rescued retrograde memories from forgetting.

How might a mechanism that promotes forgetting be adaptive in early development? Infants are born into a noisy, complicated environment from which they must extract patterns and regularities in order to form knowledge structures that are necessary for survival and for encoding future episodes. It may therefore be maladaptive to devote neural resources to attempting to encode specific episodes until such knowledge structures are established (Richards & Frankland, 2017). More generally, to the extent that memory is meant to optimize decision making, forgetting details of specific episodes may be as important as remembering them (see Chapter 2.2. Generalization & Abstraction: Human Memory as a Magic Library); forgetting enables more flexible behaviour and less overfitting of previous knowledge to new and unpredictable situations (Richards & Frankland, 2017).

Age-related gains in autobiographical memory abilities are thought to be linked to general changes in the neural networks that support autobiographical memory retrieval in adults, including grey matter volume and myelination within the hippocampus (Benes et al., 1994; DeMaster et al., 2014; Gogtay et al., 2004) and prefrontal cortex (Huttenlocher, 1979; Schneider

et al., 2004), as well as in connectivity between the hippocampus and other key regions in the autobiographical memory network (Qin et al., 2014). Evidence in support of such a link is emerging in fMRI, where the canonical autobiographical memory brain network (see above) is more readily observed in adults relative to children (Bauer et al., 2017). This protracted development of the neural substrates supporting autobiographical memory has also been demonstrated in studies using laboratory measures of episodic memory (DeMaster et al., 2014; DeMaster & Ghetti, 2013; Ghetti et al., 2010; Ofen et al., 2007; Paz-Alonso et al., 2008).

Autobiographical Memory in Older Adults

There is also a wealth of research studying autobiographical memory on the opposite end of the lifespan (see Chapter 8.4. Memory and Aging) that documents normal age-related deficits in episodic, spatiotemporally specific autobiographical memories, with a relative sparing of general semantic knowledge (e.g., Levine et al., 2002; Tromp et al., 2015). One explanation for this pattern of performance is that, relative to younger adults, older adults remember past events through a more integrative lens which stresses social roles, rather than recollecting specific details without the corresponding general contextual information (Hess, 2005). Accordingly, older adults tend to perform better than younger adults when their autobiographical memory narratives are rated in terms of underlying meanings, personal thoughts or feelings, and gist information (Adams et al., 1997). An alternative explanation, in line with Conway & Pleydell-Pearce's (2000) model, is that episodic details may become more difficult to retrieve with age because they are represented lower than semantic knowledge is on the hierarchy of autobiographical information organization. As such, age-related changes to the prefrontal cortex may cause memory retrieval to terminate at the level of non-specific semantic representations (Craik & Grady, 2002).

The behavioural pattern of reduced episodic autobiographical memory specificity in normal aging corresponds with structural and functional neuroanatomical changes, including reduced medial temporal lobe volumes (Dickerson et al., 2009; Head et al., 2008; Wolk et al., 2011), particularly in the hippocampus (Allen et al., 2005). The perforant path, which connects the entorhinal cortex to the hippocampus and is essential for normal hippocampal function (Hyman et al., 1986), is specifically affected in aging (Witter, 2007; Yassa et al., 2010), and human and animal studies suggest that this structural connectivity is a neural substrate for age-related memory decline due to a shift in hippocampus network dynamics away from pattern separation and toward pattern completion (Wilson et al., 2006).

Considering larger-scale networks, resting-state activity in the default mode network decreases with age (Damoiseaux et al., 2008). On the other hand, older adults show reduced ability to suppress the default network when faced with tasks requiring greater cognitive effort, suggesting a slower reallocation of attention or resources (Persson et al., 2007). A proposed mechanism for the selective impairment of episodic memory with age is the Default–Executive Coupling Hypothesis of Aging, which posits that greater connectivity between the default network and executive control regions in the brain may underlie an age-related shift towards relying on accumulated knowledge to support goal-directed behaviour (Grady, 2012; Maillard et al., 2012; Spreng & Schacter, 2012; Turner & Spreng, 2015). In support of this hypothesis, the strength of default–executive coupling was related to the preponderance of semantic autobiographical memory details in older adults (Spreng et al., 2018).

Behaviourally, older adults show reduced monitoring of their objective performance in recognition memory for a real-life event, endorsing similar subjective richness in spite of reduced recognition fidelity as demonstrated by sensitivity to lures (Diamond, Abdi, et al., 2020).

Such reduced monitoring is associated with executive and frontal lobe function (Diamond & Levine, 2018). By contrast—and as expected from laboratory tasks—their subjective recollection of a laboratory event aligned with their objective performance (Diamond, Abdi, et al., 2020).

As might be expected considering healthy older adults' subjective recollection ratings of real-life (but not laboratory) events, endorsement of trait autobiographical memory abilities is stable with age (Fan, Romero, et al., 2020; Setton et al., 2021) and related to everyday function such that high trait episodic memory is associated with increased everyday memory slips with age (Fan, Romero, et al., 2020). While counterintuitive, this relationship suggests that lifetime reliance on efficient and rich detail recovery in everyday life confers vulnerability to age-related medial temporal lobe decline, whereas those with congenitally low episodic autobiographical memory abilities may rely on lifelong experience with compensatory practices that bypass these systems to accomplish everyday tasks.

Conclusion

In 1978, Ulric Neisser, regarded as the father of cognitive psychology, claimed that experimental psychology had done nothing to advance understanding of real-life memory (Neisser, 1978). Neisser's critique was matched by a response with the provocative title "The Bankruptcy of Everyday Memory", which held that findings from studies of autobiographical or other real-life memory tasks fail to generalize as they are contaminated and heterogeneous (Banaji & Crowder, 1989). Extreme and dismissive positions make useful targets but do little to advance theory. In reality, both viewpoints have merit. While Neisser's claim was overstated, it is still the case that laboratory methods lack the richness and temporal scales of real-life memories. Judging by the increase in autobiographical memory research in the past 2 decades, this body of research has held researchers' interest and grown in vitality in spite of the

methodological challenges. Conversely, it is also the case that many naturalistic methods produce noisy data that are hard to replicate.

The gap between laboratory and naturalistic autobiographical methods is evident at the behavioural and neural level, even though both claim to explore the same basic phenomena. This is a serious problem for a science that seeks to explain behaviour across contexts. New paradigms that bridge traditional laboratory methods with the study of rich, naturalistic memory function, such as staged events, enable control over the encoding of memories that better match how real autobiographical memories are formed, as well as more refined assessment and verification of the contents of the retrieved memory. Such paradigms emphasize autobiographical memory's multifaceted nature and will undoubtedly play a key role moving forward in helping us better understand how and why we remember.

Considering neuroimaging findings, a network approach, emphasizing the relationship of autobiographical memory to other cognitive functions, has advanced the field beyond analysis of specific brain regions and isolating putatively mnemonic processes. The latter approach stemmed from research in patients with brain lesions and jumpstarted our understanding of how the brain supports memory, but modern neuroimaging techniques can now guide researchers toward a more holistic understanding of autobiographical memory function in healthy adults that better represents its multimodal, multifactorial nature. This will be critical for further investigating how autobiographical memory overlaps with and is distinct from episodic memory as measured in the laboratory.

A promising and relatively unexplored area is the development of the autobiographical memory network across the lifespan, and by extension how healthy individuals differ in their congenital autobiographical memory abilities. It is possible that the development of extreme

memory syndromes such as HSAM and SDAM parallels other neurodevelopmental syndromes such as prosopagnosia or topographical disorientation. As is the case with a network approach to neuroimaging, investigating inter-individual differences in autobiographical memory development in relation to these other cognitive abilities can help to define the inter-relationships among putatively different cognitive abilities.

For example, researchers are investigating how visual perspective (i.e., first- versus third-person) shapes autobiographical memory (St. Jacques, 2019) and the role visual imagery plays in remembering (Dawes et al., 2020). Another well-established stream of work investigates the overlap between spatial navigation and episodic memory, and this relationship is being assessed in the framework of autobiographical memory (Fan, Abdi, et al., 2020). Autobiographical memory has also been studied in the context of psychiatric disorders such as major depression, which can help answer questions about the role that over-general memory or excessive rumination may play in these disorders (Liu et al., 2017), and conversely how psychopathology may influence or manifest in autobiographical memory changes. Given that autobiographical memory is so interwoven in daily life, its study will continue to address basic questions about memory processes and its relationship to real-life outcomes and everyday function.

References

- Adams, C., Smith, M. C., Nyquist, L., & Perlmutter, M. (1997). Adult Age-Group Differences in Recall for the Literal and Interpretive Meanings of Narrative Text. *The Journals of Gerontology: Series B*, 52B(4), P187–P195. <https://doi.org/10.1093/geronb/52B.4.P187>
- Addis, D. R., Moscovitch, M., Crawley, A. P., & McAndrews, M. P. (2004). Recollective qualities modulate hippocampal activation during autobiographical memory retrieval. *Hippocampus*, 14(6), 752–762. <https://doi.org/10.1002/hipo.10215>
- Addis, D. R., Wong, A. T., & Schacter, D. L. (2008). Age-Related Changes in the Episodic Simulation of Future Events. *Psychological Science*, 19(1), 33–41. <https://doi.org/10.1111/j.1467-9280.2008.02043.x>
- Aghajan, Z. M., Acharya, L., Moore, J. J., Cushman, J. D., Vuong, C., & Mehta, M. R. (2015). Impaired spatial selectivity and intact phase precession in two-dimensional virtual reality. *Nature Neuroscience*, 18(1), 121–128. <https://doi.org/10.1038/nn.3884>
- Ahmed, S., Irish, M., Loane, C., Baker, I., Husain, M., Thompson, S., Blanco-Duque, C., Mackay, C., Zamboni, G., Foxe, D., Hodges, J. R., Piguet, O., & Butler, C. (2018). Association between precuneus volume and autobiographical memory impairment in posterior cortical atrophy: Beyond the visual syndrome. *NeuroImage: Clinical*, 18, 822–834. <https://doi.org/10.1016/j.nicl.2018.03.008>
- Aizpurua, A., & Koutstaal, W. (2015). A matter of focus: Detailed memory in the intentional autobiographical recall of older and younger adults. *Consciousness and Cognition*, 33, 145–155. <https://doi.org/10.1016/j.concog.2014.12.006>
- Akers, K. G., Martinez-Canabal, A., Restivo, L., Yiu, A. P., Cristofaro, A. D., Hsiang, H.-L. (Liz), Wheeler, A. L., Guskjolen, A., Niibori, Y., Shoji, H., Ohira, K., Richards, B. A.,

- Miyakawa, T., Josselyn, S. A., & Frankland, P. W. (2014). Hippocampal Neurogenesis Regulates Forgetting During Adulthood and Infancy. *Science*, 344(6184), 598–602.
<https://doi.org/10.1126/science.1248903>
- Alberini, C. M., & Travaglia, A. (2017). Infantile Amnesia: A Critical Period of Learning to Learn and Remember. *Journal of Neuroscience*, 37(24), 5783–5795.
<https://doi.org/10.1523/JNEUROSCI.0324-17.2017>
- Allen, J. S., Bruss, J., Brown, C. K., & Damasio, H. (2005). Normal neuroanatomical variation due to age: The major lobes and a parcellation of the temporal region. *Neurobiology of Aging*, 26(9), 1245–1260. <https://doi.org/10.1016/j.neurobiolaging.2005.05.023>
- Anderson, R. J., Dewhurst, S. A., & Dean, G. M. (2017). Direct and generative retrieval of autobiographical memories: The roles of visual imagery and executive processes. *Consciousness and Cognition*, 49, 163–171. <https://doi.org/10.1016/j.concog.2017.02.010>
- Anderson, R. J., Dewhurst, S. A., & Nash, R. A. (2012). Shared cognitive processes underlying past and future thinking: The impact of imagery and concurrent task demands on event specificity. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 38(2), 356–365. <https://doi.org/10.1037/a0025451>
- Antony, J. W., Ferreira, C. S., Norman, K. A., & Wimber, M. (2017). Retrieval as a Fast Route to Memory Consolidation. *Trends in Cognitive Sciences*, 21(8), 573–576.
<https://doi.org/10.1016/j.tics.2017.05.001>
- Armson, M. J., Abdi, H., & Levine, B. (2017). Bridging naturalistic and laboratory assessment of memory: The Baycrest mask fit test. *Memory*, 25(8), 999–1008.
<https://doi.org/10.1080/09658211.2016.1241281>

- Armson, M. J., Diamond, N. B., Levesque, L., Ryan, J. D., & Levine, B. (2021). Vividness of recollection is supported by eye movements in individuals with high, but not low trait autobiographical memory. *Cognition*, 206, 104487.
<https://doi.org/10.1016/j.cognition.2020.104487>
- Banaji, M. R., & Crowder, R. G. (1989). The Bankruptcy of Everyday Memory. *American Psychologist*, 9.
- Barry, D. N., Barnes, G. R., Clark, I. A., & Maguire, E. A. (2019). The Neural Dynamics of Novel Scene Imagery. *Journal of Neuroscience*, 39(22), 4375–4386.
<https://doi.org/10.1523/JNEUROSCI.2497-18.2019>
- Bauer, P. J. (2006). Constructing a past in infancy: A neuro-developmental account. *Trends in Cognitive Sciences*, 10(4), 175–181. <https://doi.org/10.1016/j.tics.2006.02.009>
- Bauer, P. J., & Larkina, M. (2014). The onset of childhood amnesia in childhood: A prospective investigation of the course and determinants of forgetting of early-life events. *Memory*, 22(8), 907–924. <https://doi.org/10.1080/09658211.2013.854806>
- Bauer, P. J., Pathman, T., Inman, C., Campanella, C., & Hamann, S. (2017). Neural correlates of autobiographical memory retrieval in children and adults. *Memory*, 25(4), 450–466.
<https://doi.org/10.1080/09658211.2016.1186699>
- Behrens, T. E. J., Muller, T. H., Whittington, J. C. R., Mark, S., Baram, A. B., Stachenfeld, K. L., & Kurth-Nelson, Z. (2018). What Is a Cognitive Map? Organizing Knowledge for Flexible Behavior. *Neuron*, 100(2), 490–509.
<https://doi.org/10.1016/j.neuron.2018.10.002>
- Benes, F. M., Turtle, M., Khan, Y., & Farol, P. (1994). Myelination of a Key Relay Zone in the Hippocampal Formation Occurs in the Human Brain During Childhood, Adolescence,

and Adulthood. *Archives of General Psychiatry*, 51(6), 477–484.

<https://doi.org/10.1001/archpsyc.1994.03950060041004>

Berntsen, D., Hoyle, R. H., & Rubin, D. C. (2019). The Autobiographical Recollection Test (ART): A Measure of Individual Differences in Autobiographical Memory. *Journal of Applied Research in Memory and Cognition*, 8(3), 305–318.

<https://doi.org/10.1016/j.jarmac.2019.06.005>

Bluestein, N., & Acredolo, L. (1979). Developmental Changes in Map-Reading Skills. *Child Development*, 50(3), 691–697. JSTOR. <https://doi.org/10.2307/1128934>

Bonnici, H. M., Chadwick, M. J., Lutti, A., Hassabis, D., Weiskopf, N., & Maguire, E. A. (2012). Detecting Representations of Recent and Remote Autobiographical Memories in vmPFC and Hippocampus. *Journal of Neuroscience*, 32(47), 16982–16991.

<https://doi.org/10.1523/JNEUROSCI.2475-12.2012>

Bonnici, H. M., Cheke, L. G., Green, D. A. E., FitzGerald, T. H. M. B., & Simons, J. S. (2018). Specifying a Causal Role for Angular Gyrus in Autobiographical Memory. *Journal of Neuroscience*, 38(49), 10438–10443. <https://doi.org/10.1523/JNEUROSCI.1239-18.2018>

Bonnici, H. M., & Maguire, E. A. (2018). Two years later – Revisiting autobiographical memory representations in vmPFC and hippocampus. *Neuropsychologia*, 110, 159–169.

<https://doi.org/10.1016/j.neuropsychologia.2017.05.014>

Bréchet, L., Mange, R., Herbelin, B., Theillaud, Q., Gauthier, B., Serino, A., & Blanke, O. (2019). First-person view of one’s body in immersive virtual reality: Influence on episodic memory. *PLOS ONE*, 14(3), e0197763.

<https://doi.org/10.1371/journal.pone.0197763>

- Brewer, W. F. (1988). Memory for randomly sampled autobiographical events. In U. Neisser & E. Winograd (Eds.), *Remembering Reconsidered* (1st ed., pp. 21–90). Cambridge University Press. <https://doi.org/10.1017/CBO9780511664014.004>
- Brown, R., & Kulik, J. (1977). Flashbulb memories. *Cognition*, 5(1), 73–99. [https://doi.org/10.1016/0010-0277\(77\)90018-X](https://doi.org/10.1016/0010-0277(77)90018-X)
- Bruce, D., Dolan, A., & Phillips-Grant, K. (2000). On the Transition from Childhood Amnesia to the Recall of Personal Memories. *Psychological Science*, 11(5), 360–364. <https://doi.org/10.1111/1467-9280.00271>
- Brunec, I. K., Bellana, B., Ozubko, J. D., Man, V., Robin, J., Liu, Z.-X., Grady, C. L., Rosenbaum, R. S., Winocur, G., Barense, M. D., & Moscovitch, M. (2018). Multiple Scales of Representation along the Hippocampal Anteroposterior Axis in Humans. *Current Biology*, 28(13), 2129–2135.e6. <https://doi.org/10.1016/j.cub.2018.05.016>
- Buckner, R. L., & Carroll, D. C. (2007). Self-projection and the brain. *Trends in Cognitive Sciences*, 11(2), 49–57. <https://doi.org/10.1016/j.tics.2006.11.004>
- Burgess, N., Maguire, E. A., Spiers, H. J., & O’Keefe, J. (2001). A Temporoparietal and Prefrontal Network for Retrieving the Spatial Context of Lifelike Events. *NeuroImage*, 14(2), 439–453. <https://doi.org/10.1006/nimg.2001.0806>
- Buzsáki, G., & Tingley, D. (2018). Space and Time: The Hippocampus as a Sequence Generator. *Trends in Cognitive Sciences*, 22(10), 853–869. <https://doi.org/10.1016/j.tics.2018.07.006>
- Cabeza, R., & St. Jacques, P. L. (2007). Functional neuroimaging of autobiographical memory. *Trends in Cognitive Sciences*, 11(5), 219–227. <https://doi.org/10.1016/j.tics.2007.02.005>

- Cady, E. T., Harris, R. J., & Knappenberger, J. B. (2008). Using music to cue autobiographical memories of different lifetime periods. *Psychology of Music*, 36(2), 157–177.
<https://doi.org/10.1177/0305735607085010>
- Campbell, B. A., & Spear, N. E. (1972). Ontogeny of memory. *Psychological Review*, 79(3), 215–236. <https://doi.org/10.1037/h0032690>
- Cermak, L. S., & O'Connor, M. (1983). The anterograde and retrograde retrieval ability of a patient with amnesia due to encephalitis. *Neuropsychologia*, 21(3), 213–234.
[https://doi.org/10.1016/0028-3932\(83\)90039-8](https://doi.org/10.1016/0028-3932(83)90039-8)
- Chow, T. E., & Rissman, J. (2017). Neurocognitive mechanisms of real-world autobiographical memory retrieval: Insights from studies using wearable camera technology: Wearable cameras and autobiographical memory. *Annals of the New York Academy of Sciences*, 1396(1), 202–221. <https://doi.org/10.1111/nyas.13353>
- Chu, S., & Downes, J. J. (2002). Proust nose best: Odors are better cues of autobiographical memory. *Memory & Cognition*, 30(4), 511–518. <https://doi.org/10.3758/BF03194952>
- Clark, I. A., Hotchin, V., Monk, A., Pizzamiglio, G., Liefgreen, A., & Maguire, E. A. (2019). Identifying the cognitive processes underpinning hippocampal-dependent tasks. *Journal of Experimental Psychology: General*. <https://doi.org/10.1037/xge0000582>
- Clark, I. A., & Maguire, E. A. (2020). Do questionnaires reflect their purported cognitive functions? *Cognition*, 195, 104114. <https://doi.org/10.1016/j.cognition.2019.104114>
- Cleveland, E. S., & Reese, E. (2008). Children remember early childhood: Long-term recall across the offset of childhood amnesia. *Applied Cognitive Psychology*, 22(1), 127–142.
<https://doi.org/10.1002/acp.1359>

- Colgin, L. L. (2015). Theta–gamma coupling in the entorhinal–hippocampal system. *Current Opinion in Neurobiology*, 31, 45–50. <https://doi.org/10.1016/j.conb.2014.08.001>
- Conway, M. A. (2001). Sensory–perceptual episodic memory and its context: Autobiographical memory. *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences*, 356(1413), 1375–1384. <https://doi.org/10.1098/rstb.2001.0940>
- Conway, M. A., & Pleydell-Pearce, C. W. (2000). The construction of autobiographical memories in the self-memory system. *Psychological Review*, 107(2), 261–288. <https://doi.org/10.1037/0033-295X.107.2.261>
- Corkin, S. (1984). Lasting Consequences of Bilateral Medial Temporal Lobectomy: Clinical Course and Experimental Findings in H.M. *Seminars in Neurology*, 4(02), 249–259. <https://doi.org/10.1055/s-2008-1041556>
- Courage, M. L., & Howe, M. L. (2004). Advances in early memory development research: Insights about the dark side of the moon. *Developmental Review*, 24(1), 6–32. <https://doi.org/10.1016/j.dr.2003.09.005>
- Craik, F. I. M., & Grady, C. L. (2002). Aging, Memory, and Frontal Lobe Functioning. In D. T. Stuss & R. T. Knight (Eds.), *Principles of Frontal Lobe Function* (pp. 528–540). Oxford University Press. <https://doi.org/10.1093/acprof:oso/9780195134971.003.0031>
- Damoiseaux, J. S., Beckmann, C. F., Arigita, E. J. S., Barkhof, F., Scheltens, P., Stam, C. J., Smith, S. M., & Rombouts, S. a. R. B. (2008). Reduced resting-state brain activity in the “default network” in normal aging. *Cerebral Cortex*, 18(8), 1856–1864. <https://doi.org/10.1093/cercor/bhm207>

- Dawes, A. J., Keogh, R., Andrillon, T., & Pearson, J. (2020). A cognitive profile of multi-sensory imagery, memory and dreaming in aphantasia. *Scientific Reports*, 10(1), 10022. <https://doi.org/10.1038/s41598-020-65705-7>
- Dede, A. J. O., Frascino, J. C., Wixted, J. T., & Squire, L. R. (2016). Learning and remembering real-world events after medial temporal lobe damage. *Proceedings of the National Academy of Sciences*, 113(47), 13480–13485. <https://doi.org/10.1073/pnas.1617025113>
- DeMaster, D. M., & Ghetti, S. (2013). Developmental differences in hippocampal and cortical contributions to episodic retrieval. *Cortex*, 49(6), 1482–1493. <https://doi.org/10.1016/j.cortex.2012.08.004>
- DeMaster, D. M., Pathman, T., Lee, J. K., & Ghetti, S. (2014). Structural Development of the Hippocampus and Episodic Memory: Developmental Differences Along the Anterior/Posterior Axis. *Cerebral Cortex*, 24(11), 3036–3045. <https://doi.org/10.1093/cercor/bht160>
- Devitt, A. L., Monk-Fromont, E., Schacter, D. L., & Addis, D. R. (2016). Factors that influence the generation of autobiographical memory conjunction errors. *Memory*, 24(2), 204–222. <https://doi.org/10.1080/09658211.2014.998680>
- Diamond, N. B., Abdi, H., & Levine, B. (2020). Different patterns of recollection for matched real-world and laboratory-based episodes in younger and older adults. *Cognition*, 202, 104309. <https://doi.org/10.1016/j.cognition.2020.104309>
- Diamond, N. B., Armson, M. J., & Levine, B. (2020). The Truth Is Out There: Accuracy in Recall of Verifiable Real-World Events. *Psychological Science*, 0956797620954812. <https://doi.org/10.1177/0956797620954812>

- Diamond, N. B., & Levine, B. (2018). The Prefrontal Cortex and Human Memory. In B. L. Miller & J. L. Cummings (Eds.), *The Human Frontal Lobes: Functions and Disorders* (Third Edition, pp. 137–157). The Guilford Press.
- Diamond, N. B., & Levine, B. (2020). Linking Detail to Temporal Structure in Naturalistic-Event Recall. *Psychological Science*, 0956797620958651.
<https://doi.org/10.1177/0956797620958651>
- Diamond, N. B., Romero, K., Jeyakumar, N., & Levine, B. (2018). Age-Related Decline in Item But Not Spatiotemporal Associative Memory for a Real-World Event. *Psychology and Aging*, 33(7), 1079–1092. <https://doi.org/10.1037/pag0000303>
- Dickerson, B. C., Feczko, E., Augustinack, J. C., Pacheco, J., Morris, J. C., Fischl, B., & Buckner, R. L. (2009). Differential effects of aging and Alzheimer’s disease on medial temporal lobe cortical thickness and surface area. *Neurobiology of Aging*, 30(3), 432–440. <https://doi.org/10.1016/j.neurobiolaging.2007.07.022>
- Düzel, E., Penny, W. D., & Burgess, N. (2010). Brain oscillations and memory. *Current Opinion in Neurobiology*, 20(2), 143–149. <https://doi.org/10.1016/j.conb.2010.01.004>
- Ekstrom, A. D., & Ranganath, C. (2018). Space, time, and episodic memory: The hippocampus is all over the cognitive map. *Hippocampus*, 28(9), 680–687.
<https://doi.org/10.1002/hipo.22750>
- El Haj, M., Kapogiannis, D., & Antoine, P. (2020). The picture of the past: Pictures to cue autobiographical memory in Alzheimer’s disease. *Journal of Clinical and Experimental Neuropsychology*, 42(9), 914–923. <https://doi.org/10.1080/13803395.2020.1825636>

- Epstein, R. A., Patai, E. Z., Julian, J. B., & Spiers, H. J. (2017). The cognitive map in humans: Spatial navigation and beyond. *Nature Neuroscience*, 20(11), 1504–1513.
<https://doi.org/10.1038/nn.4656>
- Fan, C. L., Abdi, H., & Levine, B. (2020). On the relationship between trait autobiographical episodic memory and spatial navigation. *Memory & Cognition*.
<https://doi.org/10.3758/s13421-020-01093-7>
- Fan, C. L., Romero, K., & Levine, B. (2020). Older adults with lower autobiographical memory abilities report less age-related decline in everyday cognitive function. *BMC Geriatrics*, 20(1), 308. <https://doi.org/10.1186/s12877-020-01720-7>
- Fiske, K., & Pillemer, D. (2006). Adult recollections of earliest childhood dreams: A cross-cultural study. *Memory*, 14(1), 57–67. <https://doi.org/10.1080/09658210444000511>
- Fivush, R., & Nelson, K. (2004). Culture and Language in the Emergence of Autobiographical Memory. *Psychological Science*, 15(9), 573–577. <https://doi.org/10.1111/j.0956-7976.2004.00722.x>
- Frankland, P. W., Köhler, S., & Josselyn, S. A. (2013). Hippocampal neurogenesis and forgetting. *Trends in Neurosciences*, 36(9), 497–503.
<https://doi.org/10.1016/j.tins.2013.05.002>
- Freud, S. (1924). *A general introduction to psychoanalysis* (Pocket Books).
- Fuentemilla, L., Barnes, G. R., Düzel, E., & Levine, B. (2014). Theta oscillations orchestrate medial temporal lobe and neocortex in remembering autobiographical memories. *NeuroImage*, 85, 730–737. <https://doi.org/10.1016/j.neuroimage.2013.08.029>
- Fuentemilla, L., Palombo, D. J., & Levine, B. (2018). Gamma phase-synchrony in autobiographical memory: Evidence from magnetoencephalography and severely

deficient autobiographical memory. *Neuropsychologia*, 110, 7–13.

<https://doi.org/10.1016/j.neuropsychologia.2017.08.020>

Galton, F. (1879). Psychometric Experiments. *Brain*, 2, 149–162.

Ghetti, S., DeMaster, D. M., Yonelinas, A. P., & Bunge, S. A. (2010). Developmental

Differences in Medial Temporal Lobe Function during Memory Encoding. *Journal of*

Neuroscience, 30(28), 9548–9556. <https://doi.org/10.1523/JNEUROSCI.3500-09.2010>

Gilboa, A. (2004). Autobiographical and episodic memory—One and the same?

Neuropsychologia, 42(10), 1336–1349.

<https://doi.org/10.1016/j.neuropsychologia.2004.02.014>

Gilboa, A., & Moscovitch, M. (2021). No consolidation without representation: Correspondence

between neural and psychological representations in recent and remote memory. *Neuron*,

109(14), 2239–2255. <https://doi.org/10.1016/j.neuron.2021.04.025>

Gogtay, N., Giedd, J. N., Lusk, L., Hayashi, K. M., Greenstein, D., Vaituzis, A. C., Nugent, T.

F., Herman, D. H., Clasen, L. S., Toga, A. W., Rapoport, J. L., & Thompson, P. M.

(2004). Dynamic mapping of human cortical development during childhood through

early adulthood. *Proceedings of the National Academy of Sciences*, 101(21), 8174–8179.

<https://doi.org/10.1073/pnas.0402680101>

Grabner, R. H., Ansari, D., Koschutnig, K., Reishofer, G., Ebner, F., & Neuper, C. (2009). To

retrieve or to calculate? Left angular gyrus mediates the retrieval of arithmetic facts

during problem solving. *Neuropsychologia*, 47(2), 604–608.

<https://doi.org/10.1016/j.neuropsychologia.2008.10.013>

Grady, C. L. (2012). The cognitive neuroscience of ageing. *Nature Reviews Neuroscience*, 13(7),

491–505. <https://doi.org/10.1038/nrn3256>

- Grande, X., Berron, D., Horner, A. J., Bisby, J. A., Düzel, E., & Burgess, N. (2019). Holistic Recollection via Pattern Completion Involves Hippocampal Subfield CA3. *Journal of Neuroscience*, 39(41), 8100–8111. <https://doi.org/10.1523/JNEUROSCI.0722-19.2019>
- Greenberg, D. L., & Knowlton, B. J. (2014). The role of visual imagery in autobiographical memory. *Memory & Cognition*, 42(6), 922–934. <https://doi.org/10.3758/s13421-014-0402-5>
- Greenberg, D. L., & Rubin, D. C. (2003). The Neuropsychology of Autobiographical Memory. *Cortex*, 39(4), 687–728. [https://doi.org/10.1016/S0010-9452\(08\)70860-8](https://doi.org/10.1016/S0010-9452(08)70860-8)
- Griffiths, B., Mazaheri, A., Debener, S., & Hanslmayr, S. (2016). Brain oscillations track the formation of episodic memories in the real world. *NeuroImage*, 143, 256–266. <https://doi.org/10.1016/j.neuroimage.2016.09.021>
- Gruenewald, P. J., & Lockhead, G. R. (1980). The free recall of category examples. *Journal of Experimental Psychology: Human Learning and Memory*, 6(3), 225–240. <https://doi.org/10.1037/0278-7393.6.3.225>
- Gvion, A., & Friedmann, N. (2016). A Principled Relation between Reading and Naming in Acquired and Developmental Anomia: Surface Dyslexia Following Impairment in the Phonological Output Lexicon. *Frontiers in Psychology*, 7. <https://doi.org/10.3389/fpsyg.2016.00340>
- Hassabis, D., & Maguire, E. A. (2007). Deconstructing episodic memory with construction. *Trends in Cognitive Sciences*, 11(7), 299–306. <https://doi.org/10.1016/j.tics.2007.05.001>
- Head, D., Rodrigue, K. M., Kennedy, K. M., & Raz, N. (2008). Neuroanatomical and cognitive mediators of age-related differences in episodic memory. *Neuropsychology*, 22(4), 491–507. <https://doi.org/10.1037/0894-4105.22.4.491>

- Hebscher, M., Levine, B., & Gilboa, A. (2018). The precuneus and hippocampus contribute to individual differences in the unfolding of spatial representations during episodic autobiographical memory. *Neuropsychologia*, 110, 123–133.
<https://doi.org/10.1016/j.neuropsychologia.2017.03.029>
- Hebscher, M., Meltzer, J. A., & Gilboa, A. (2019). A causal role for the precuneus in network-wide theta and gamma oscillatory activity during complex memory retrieval. *ELife*, 8, e43114. <https://doi.org/10.7554/eLife.43114>
- Henkel, L. A. (2014). Point-and-Shoot Memories: The Influence of Taking Photos on Memory for a Museum Tour. *Psychological Science*, 25(2), 396–402.
<https://doi.org/10.1177/0956797613504438>
- Hess, T. M. (2005). Memory and Aging in Context. *Psychological Bulletin*, 131(3), 383–406.
<https://doi.org/10.1037/0033-2909.131.3.383>
- Heyworth, N. C., & Squire, L. R. (2019). The nature of recollection across months and years and after medial temporal lobe damage. *Proceedings of the National Academy of Sciences*, 116(10), 4619–4624. <https://doi.org/10.1073/pnas.1820765116>
- Hodges, S., Williams, L., Berry, E., Izadi, S., Srinivasan, J., Butler, A., Smyth, G., Kapur, N., & Wood, K. (2006). SenseCam: A Retrospective Memory Aid. In P. Dourish & A. Friday (Eds.), *UbiComp 2006: Ubiquitous Computing* (pp. 177–193). Springer.
https://doi.org/10.1007/11853565_11
- Hodgetts, C. J., Postans, M., Warne, N., Varnava, A., Lawrence, A. D., & Graham, K. S. (2017). Distinct contributions of the fornix and inferior longitudinal fasciculus to episodic and semantic autobiographical memory. *Cortex*, 94, 1–14.
<https://doi.org/10.1016/j.cortex.2017.05.010>

- Holland, A. C., & Kensinger, E. A. (2010). Emotion and autobiographical memory. *Physics of Life Reviews*, 7(1), 88–131. <https://doi.org/10.1016/j.plrev.2010.01.006>
- Howe, M. L., & Courage, M. L. (1993). On resolving the enigma of infantile amnesia. *Psychological Bulletin*, 113(2), 305–326. <https://doi.org/10.1037/0033-2909.113.2.305>
- Howe, M. L., & Courage, M. L. (1997). The emergence and early development of autobiographical memory. *Psychological Review*, 104(3), 499–523. <https://doi.org/10.1037/0033-295X.104.3.499>
- Hudson, J. A., & Fivush, R. (1991). As time goes by: Sixth graders remember a kindergarten experience. *Applied Cognitive Psychology*, 5(4), 347–360. <https://doi.org/10.1002/acp.2350050405>
- Huttenlocher, P. R. (1979). Synaptic density in human frontal cortex—Developmental changes and effects of aging. *Brain Research*, 163(2), 195–205. [https://doi.org/10.1016/0006-8993\(79\)90349-4](https://doi.org/10.1016/0006-8993(79)90349-4)
- Hyman, B. T., Hoesen, G. W. V., Kromer, L. J., & Damasio, A. R. (1986). Perforant pathway changes and the memory impairment of Alzheimer’s disease. *Annals of Neurology*, 20(4), 472–481. <https://doi.org/10.1002/ana.410200406>
- Iaria, G., & Burles, F. (2016). Developmental Topographical Disorientation. *Trends in Cognitive Sciences*, 20(10), 720–722. <https://doi.org/10.1016/j.tics.2016.07.004>
- Irish, M., Hornberger, M., Wahsh, S. E., Lam, B. Y. K., Lah, S., Miller, L., Hsieh, S., Hodges, J. R., & Piguet, O. (2014). Grey and White Matter Correlates of Recent and Remote Autobiographical Memory Retrieval – Insights from the Dementias. *PLOS ONE*, 9(11), e113081. <https://doi.org/10.1371/journal.pone.0113081>

- Jeunehomme, O., & D'Argembeau, A. (2019). The time to remember: Temporal compression and duration judgements in memory for real-life events. *Quarterly Journal of Experimental Psychology*, 72(4), 930–942. <https://doi.org/10.1177/1747021818773082>
- Josselyn, S. A., & Frankland, P. W. (2012). Infantile amnesia: A neurogenic hypothesis. *Learning & Memory*, 19(9), 423–433. <https://doi.org/10.1101/lm.021311.110>
- Knierim, J. J., & Neunuebel, J. P. (2016). Tracking the flow of hippocampal computation: Pattern separation, pattern completion, and attractor dynamics. *Neurobiology of Learning and Memory*, 129, 38–49. <https://doi.org/10.1016/j.nlm.2015.10.008>
- Kopelman, M. D., Wilson, B. A., & Baddeley, A. D. (1989). The autobiographical memory interview: A new assessment of autobiographical and personal semantic memory in amnesic patients. *Journal of Clinical and Experimental Neuropsychology*, 11(5), 724–744. <https://doi.org/10.1080/01688638908400928>
- Köster, M., Frieze, U., Schöne, B., Trujillo-Barreto, N., & Gruber, T. (2014). Theta–gamma coupling during episodic retrieval in the human EEG. *Brain Research*, 1577, 57–68. <https://doi.org/10.1016/j.brainres.2014.06.028>
- Kress, T., & Daum, I. (2003). Developmental Prosopagnosia: A Review. *Behavioural Neurology*, 14(3–4), 109–121. <https://doi.org/10.1155/2003/520476>
- Kurczek, J., Wechsler, E., Ahuja, S., Jensen, U., Cohen, N. J., Tranel, D., & Duff, M. (2015). Differential contributions of hippocampus and medial prefrontal cortex to self-projection and self-referential processing. *Neuropsychologia*, 73, 116–126. <https://doi.org/10.1016/j.neuropsychologia.2015.05.002>

- Lechowicz, M., Miller, L., Irish, M., Addis, D. R., Mohamed, A., & Lah, S. (2016). Imagining future events in patients with unilateral temporal lobe epilepsy. *British Journal of Clinical Psychology*, 55(2), 187–205. <https://doi.org/10.1111/bjc.12107>
- Lenoble, Q., Janssen, S. M. J., & Haj, M. E. (2019). Don't stare, unless you don't want to remember: Maintaining fixation compromises autobiographical memory retrieval. *Memory*, 27(2), 231–238. <https://doi.org/10.1080/09658211.2018.1501068>
- LePort, A. K. R., Mattfeld, A. T., Dickinson-Anson, H., Fallon, J. H., Stark, C. E. L., Kruggel, F., Cahill, L., & McGaugh, J. L. (2012). Behavioral and neuroanatomical investigation of Highly Superior Autobiographical Memory (HSAM). *Neurobiology of Learning and Memory*, 98(1), 78–92. <https://doi.org/10.1016/j.nlm.2012.05.002>
- LePort, A. K. R., Stark, S. M., McGaugh, J. L., & Stark, C. E. L. (2016). Highly Superior Autobiographical Memory: Quality and Quantity of Retention Over Time. *Frontiers in Psychology*, 6. <https://doi.org/10.3389/fpsyg.2015.02017>
- Levine, B., Black, S. E., Cabeza, R., Sinden, M., McIntosh, A. R., Toth, J. P., Tulving, E., & Stuss, D. T. (1998). Episodic memory and the self in a case of isolated retrograde amnesia. *Brain*, 121(10), 1951–1973. <https://doi.org/10.1093/brain/121.10.1951>
- Levine, B., Svoboda, E., Hay, J. F., Winocur, G., & Moscovitch, M. (2002). Aging and autobiographical memory: Dissociating episodic from semantic retrieval. *Psychology and Aging*, 17(4), 677–689. <https://doi.org/10.1037/0882-7974.17.4.677>
- Levine, B., Svoboda, E., Turner, G. R., Mandic, M., & Mackey, A. (2009). Behavioral and functional neuroanatomical correlates of anterograde autobiographical memory in isolated retrograde amnesic patient M.L. *Neuropsychologia*, 47(11), 2188–2196. <https://doi.org/10.1016/j.neuropsychologia.2008.12.026>

Levine, B., Turner, G. R., Tisserand, D., Hevenor, S. J., Graham, S. J., & McIntosh, A. R.

(2004). The Functional Neuroanatomy of Episodic and Semantic Autobiographical Remembering: A Prospective Functional MRI Study. *Journal of Cognitive Neuroscience*, 16(9), 1633–1646. <https://doi.org/10.1162/0898929042568587>

Li, S., Callaghan, B. L., & Richardson, R. (2014). Infantile amnesia: Forgotten but not gone.

Learning & Memory, 21(3), 135–139. <https://doi.org/10.1101/lm.031096.113>

Linton, M. (1975). Memory for real-world events. In D. A. Norman & D. E. Rumelhart (Eds.),

Explorations in cognition (pp. 376–404). Freeman & Company.

Liu, Y., Yu, X., Yang, B., Zhang, F., Zou, W., Na, A., Zhao, X., & Yin, G. (2017). Rumination mediates the relationship between overgeneral autobiographical memory and depression in patients with major depressive disorder. *BMC Psychiatry*, 17(1), 103.

<https://doi.org/10.1186/s12888-017-1264-8>

Luchetti, M., & Sutin, A. R. (2016). Measuring the phenomenology of autobiographical

memory: A short form of the Memory Experiences Questionnaire. *Memory*, 24(5), 592–602. <https://doi.org/10.1080/09658211.2015.1031679>

Madore, K. P., Addis, D. R., & Schacter, D. L. (2015). Creativity and Memory: Effects of an

Episodic-Specificity Induction on Divergent Thinking. *Psychological Science*, 26(9), 1461–1468. <https://doi.org/10.1177/0956797615591863>

Madore, K. P., Jing, H. G., & Schacter, D. L. (2019). Selective effects of specificity inductions

on episodic details: Evidence for an event construction account. *Memory*, 27(2), 250–260. <https://doi.org/10.1080/09658211.2018.1502322>

Madore, K. P., & Schacter, D. L. (2014). An episodic specificity induction enhances means-end problem solving in young and older adults. *Psychology and Aging*, 29(4), 913–924.

<https://doi.org/10.1037/a0038209>

Madore, K. P., & Schacter, D. L. (2016). Remembering the past and imagining the future: Selective effects of an episodic specificity induction on detail generation. *Quarterly Journal of Experimental Psychology*, 69(2), 285–298.

<https://doi.org/10.1080/17470218.2014.999097>

Madore, K. P., Szpunar, K. K., Addis, D. R., & Schacter, D. L. (2016). Episodic specificity induction impacts activity in a core brain network during construction of imagined future experiences. *Proceedings of the National Academy of Sciences*, 113(38), 10696–10701.

<https://doi.org/10.1073/pnas.1612278113>

Maguire, E. A. (2001). Neuroimaging studies of autobiographical event memory. *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences*, 356(1413), 1441–1451. <https://doi.org/10.1098/rstb.2001.0944>

Maillard, P., Carmichael, O., Fletcher, E., Reed, B., Mungas, D., & DeCarli, C. (2012).

Coevolution of white matter hyperintensities and cognition in the elderly. *Neurology*, 79(5), 442–448. <https://doi.org/10.1212/WNL.0b013e3182617136>

Mair, A., Poirier, M., & Conway, M. A. (2019). Memory for staged events: Supporting older and younger adults' memory with SenseCam. *Quarterly Journal of Experimental Psychology*, 72(4), 717–728. <https://doi.org/10.1177/1747021818765038>

McCormick, C., St-Laurent, M., Ty, A., Valiante, T. A., & McAndrews, M. P. (2015).

Functional and Effective Hippocampal–Neocortical Connectivity During Construction

- and Elaboration of Autobiographical Memory Retrieval. *Cerebral Cortex*, 25(5), 1297–1305. <https://doi.org/10.1093/cercor/bht324>
- McDermott, K. B., Szpunar, K. K., & Christ, S. E. (2009). Laboratory-based and autobiographical retrieval tasks differ substantially in their neural substrates. *Neuropsychologia*, 47(11), 2290–2298. <https://doi.org/10.1016/j.neuropsychologia.2008.12.025>
- McKinnon, M. C., Palombo, D. J., Nazarov, A., Kumar, N., Khuu, W., & Levine, B. (2015). Threat of Death and Autobiographical Memory: A Study of Passengers From Flight AT236. *Clinical Psychological Science*, 3(4), 487–502. <https://doi.org/10.1177/2167702614542280>
- Meltzoff, A. N. (1988). Infant imitation after a 1-week delay: Long-term memory for novel acts and multiple stimuli. *Developmental Psychology*, 24(4), 470–476. <https://doi.org/10.1037/0012-1649.24.4.470>
- Memel, M., Wank, A. A., Ryan, L., & Grilli, M. D. (2020). The relationship between episodic detail generation and anterotemporal, posteromedial, and hippocampal white matter tracts. *Cortex*, 123, 124–140. <https://doi.org/10.1016/j.cortex.2019.10.010>
- Miles, C. (1895). A Study of Individual Psychology. *The American Journal of Psychology*, 6(4), 534. <https://doi.org/10.2307/1411191>
- Miller, T. D., Chong, T. T.-J., Aimola Davies, A. M., Johnson, M. R., Irani, S. R., Husain, M., Ng, T. W., Jacob, S., Maddison, P., Kennard, C., Gowland, P. A., & Rosenthal, C. R. (2020). Human hippocampal CA3 damage disrupts both recent and remote episodic memories. *ELife*, 9, e41836. <https://doi.org/10.7554/eLife.41836>

- Miller, T. D., Chong, T. T.-J., Aimola Davies, A. M., Ng, T. W. C., Johnson, M. R., Irani, S. R., Vincent, A., Husain, M., Jacob, S., Maddison, P., Kennard, C., Gowland, P. A., & Rosenthal, C. R. (2017). Focal CA3 hippocampal subfield atrophy following LGI1 VGKC-complex antibody limbic encephalitis. *Brain*, *140*(5), 1212–1219.
<https://doi.org/10.1093/brain/awx070>
- Milton, F., Fulford, J., Dance, C., Gaddum, J., Heuerman-Williamson, B., Jones, K., Knight, K. F., MacKisack, M., Winlove, C., & Zeman, A. (2021). Behavioral and Neural Signatures of Visual Imagery Vividness Extremes: Aphantasia versus Hyperphantasia. *Cerebral Cortex Communications*, *2*(2). <https://doi.org/10.1093/texcom/tgab035>
- Milton, F., Muhlert, N., Butler, C. R., Smith, A., Benattayallah, A., & Zeman, A. Z. (2011). An fMRI study of long-term everyday memory using SenseCam. *Memory*, *19*(7), 733–744.
<https://doi.org/10.1080/09658211.2011.552185>
- Morris, G., Baker-Ward, L., & Bauer, P. J. (2009). What remains of that day: The survival of children’s autobiographical memories across time. *Applied Cognitive Psychology*, n/a–n/a. <https://doi.org/10.1002/acp.1567>
- Moscovitch, M., Cabeza, R., Winocur, G., & Nadel, L. (2016). Episodic Memory and Beyond: The Hippocampus and Neocortex in Transformation. *Annual Review of Psychology*, *67*(1), 105–134. <https://doi.org/10.1146/annurev-psych-113011-143733>
- Mullally, S. L., & Maguire, E. A. (2014). Memory, Imagination, and Predicting the Future: A Common Brain Mechanism? *The Neuroscientist*, *20*(3), 220–234.
<https://doi.org/10.1177/1073858413495091>

- Nadel, L., & Moscovitch, M. (1997). Memory consolidation, retrograde amnesia and the hippocampal complex. *Current Opinion in Neurobiology*, 7(2), 217–227.
[https://doi.org/10.1016/S0959-4388\(97\)80010-4](https://doi.org/10.1016/S0959-4388(97)80010-4)
- Neisser, U. (1978). Memory: What are the important questions? In M. M. Gruneberg, P. E. Morris, & R. N. Sykes (Eds.), *Practical aspects of memory* (pp. 3–24). Academic Press.
- Neisser, U., & Harsch, N. (1992). Phantom flashbulbs: False recollections of hearing the news about Challenger. In E. Winograd & U. Neisser (Eds.), *Affect and Accuracy in Recall* (1st ed., pp. 9–31). Cambridge University Press.
<https://doi.org/10.1017/CBO9780511664069.003>
- Nelson, C. A. (2000). Neural plasticity and human development: The role of early experience in sculpting memory systems. *Developmental Science*, 3(2), 115–136.
<https://doi.org/10.1111/1467-7687.00104>
- Nelson, K., & Fivush, R. (2004). The Emergence of Autobiographical Memory: A Social Cultural Developmental Theory. *Psychological Review*, 111(2), 486–511.
<https://doi.org/10.1037/0033-295X.111.2.486>
- Neshat-Doost, H. T., Dalgleish, T., Yule, W., Kalantari, M., Ahmadi, S. J., Dyregrov, A., & Jobson, L. (2013). Enhancing Autobiographical Memory Specificity Through Cognitive Training: An Intervention for Depression Translated From Basic Science. *Clinical Psychological Science*, 1(1), 84–92. <https://doi.org/10.1177/2167702612454613>
- Newcombe, N. S., Lloyd, M. E., & Ratliff, K. R. (2007). Development of episodic and autobiographical memory: A cognitive neuroscience perspective. In R. V. Kail (Ed.), *Advances in child development and behavior* (Vol. 55, pp. 37–85). Elsevier.

- Nielson, D. M., Smith, T. A., Sreekumar, V., Dennis, S., & Sederberg, P. B. (2015). Human hippocampus represents space and time during retrieval of real-world memories. *Proceedings of the National Academy of Sciences*, 112(35), 11078–11083.
<https://doi.org/10.1073/pnas.1507104112>
- Nyhus, E., & Curran, T. (2010). Functional role of gamma and theta oscillations in episodic memory. *Neuroscience & Biobehavioral Reviews*, 34(7), 1023–1035.
<https://doi.org/10.1016/j.neubiorev.2009.12.014>
- Ofen, N., Kao, Y.-C., Sokol-Hessner, P., Kim, H., Whitfield-Gabrieli, S., & Gabrieli, J. D. E. (2007). Development of the declarative memory system in the human brain. *Nature Neuroscience*, 10(9), 1198–1205. <https://doi.org/10.1038/nn1950>
- O’Keefe, J., Burgess, N., Donnett, J. G., Jeffery, K. J., & Maguire, E. A. (1998). Place cells, navigational accuracy, and the human hippocampus. *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences*, 353(1373), 1333–1340.
<https://doi.org/10.1098/rstb.1998.0287>
- Palombo, D. J., Alain, C., Söderlund, H., Khuu, W., & Levine, B. (2015). Severely deficient autobiographical memory (SDAM) in healthy adults: A new mnemonic syndrome. *Neuropsychologia*, 72, 105–118. <https://doi.org/10.1016/j.neuropsychologia.2015.04.012>
- Palombo, D. J., Bacopulos, A., Amaral, R. S. C., Olsen, R. K., Todd, R. M., Anderson, A. K., & Levine, B. (2018). Episodic autobiographical memory is associated with variation in the size of hippocampal subregions. *Hippocampus*, 28(2), 69–75.
<https://doi.org/10.1002/hipo.22818>

- Palombo, D. J., Sheldon, S., & Levine, B. (2018). Individual Differences in Autobiographical Memory. *Trends in Cognitive Sciences*, 22(7), 583–597.
<https://doi.org/10.1016/j.tics.2018.04.007>
- Palombo, D. J., Williams, L. J., Abdi, H., & Levine, B. (2013). The survey of autobiographical memory (SAM): A novel measure of trait mnemonics in everyday life. *Cortex*, 49(6), 1526–1540. <https://doi.org/10.1016/j.cortex.2012.08.023>
- Patihis, L., Frenda, S. J., LePort, A. K. R., Petersen, N., Nichols, R. M., Stark, C. E. L., McGaugh, J. L., & Loftus, E. F. (2013). False memories in highly superior autobiographical memory individuals. *Proceedings of the National Academy of Sciences*, 110(52), 20947–20952. <https://doi.org/10.1073/pnas.1314373110>
- Paz-Alonso, P. M., Ghetti, S., Donohue, S. E., Goodman, G. S., & Bunge, S. A. (2008). Neurodevelopmental Correlates of True and False Recognition. *Cerebral Cortex*, 18(9), 2208–2216. <https://doi.org/10.1093/cercor/bhm246>
- Perner, J., & Ruffman, T. (1995). Episodic Memory and Autonoetic Consciousness: Developmental Evidence and a Theory of Childhood Amnesia. *Journal of Experimental Child Psychology*, 59(3), 516–548. <https://doi.org/10.1006/jecp.1995.1024>
- Persson, J., Lustig, C., Nelson, J. K., & Reuter-Lorenz, P. A. (2007). Age Differences in Deactivation: A Link to Cognitive Control? *Journal of Cognitive Neuroscience*, 19(6), 1021–1032. <https://doi.org/10.1162/jocn.2007.19.6.1021>
- Peterson, C., Warren, K. L., & Short, M. M. (2011). Infantile Amnesia Across the Years: A 2-Year Follow-up of Children’s Earliest Memories: Infantile Amnesia. *Child Development*, 82(4), 1092–1105. <https://doi.org/10.1111/j.1467-8624.2011.01597.x>

- Petrican, R., Palombo, D. J., Sheldon, S., & Levine, B. (2020). The Neural Dynamics of Individual Differences in Episodic Autobiographical Memory. *ENeuro*.
<https://doi.org/10.1523/ENEURO.0531-19.2020>
- Pillemer, D. B., & White, S. H. (1989). Childhood Events Recalled by Children and Adults. In *Advances in Child Development and Behavior* (Vol. 21, pp. 297–340). Elsevier.
[https://doi.org/10.1016/S0065-2407\(08\)60291-8](https://doi.org/10.1016/S0065-2407(08)60291-8)
- Piolino, P., Belliard, S., Desgranges, B., Perron, M., & Eustache, F. (2003). Autobiographical Memory and Autoneotic Consciousness in a case of Semantic Dementia. *Cognitive Neuropsychology*, 20(7), 619–639. <https://doi.org/10.1080/02643290242000899>
- Poppenk, J., & Moscovitch, M. (2011). A Hippocampal Marker of Recollection Memory Ability among Healthy Young Adults: Contributions of Posterior and Anterior Segments. *Neuron*, 72(6), 931–937. <https://doi.org/10.1016/j.neuron.2011.10.014>
- Povinelli, D. J., Landau, K. R., & Perilloux, H. K. (1996). Self-Recognition in Young Children Using Delayed versus Live Feedback: Evidence of a Developmental Asynchrony. *Child Development*, 67(4), 1540. <https://doi.org/10.2307/1131717>
- Povinelli, D. J., Landry, A. M., Theall, L. A., Clark, B. R., & Castille, C. M. (1999). Development of young children’s understanding that the recent past is causally bound to the present. *Developmental Psychology*, 35(6), 1426–1439. <https://doi.org/10.1037/0012-1649.35.6.1426>
- Qin, S., Cho, S., Chen, T., Rosenberg-Lee, M., Geary, D. C., & Menon, V. (2014). Hippocampal-neocortical functional reorganization underlies children’s cognitive development. *Nature Neuroscience*, 17(9), 1263–1269. <https://doi.org/10.1038/nn.3788>

- Race, E., Keane, M. M., & Verfaellie, M. (2011). Medial Temporal Lobe Damage Causes Deficits in Episodic Memory and Episodic Future Thinking Not Attributable to Deficits in Narrative Construction. *Journal of Neuroscience*, 31(28), 10262–10269.
<https://doi.org/10.1523/JNEUROSCI.1145-11.2011>
- Ranganath, C., & Ritchey, M. (2012). Two cortical systems for memory-guided behaviour. *Nature Reviews Neuroscience*, 13(10), 713–726. <https://doi.org/10.1038/nrn3338>
- Rasmussen, A. S., & Berntsen, D. (2011). The unpredictable past: Spontaneous autobiographical memories outnumber autobiographical memories retrieved strategically. *Consciousness and Cognition*, 20(4), 1842–1846. <https://doi.org/10.1016/j.concog.2011.07.010>
- Reagh, Z. M., & Ranganath, C. (2018). What does the functional organization of cortico-hippocampal networks tell us about the functional organization of memory? *Neuroscience Letters*, 680, 69–76. <https://doi.org/10.1016/j.neulet.2018.04.050>
- Reese, E. (2009). The development of autobiographical memory: Origins and consequences. In *Advances in Child Development and Behavior* (Vol. 37, pp. 145–200). Elsevier.
[https://doi.org/10.1016/S0065-2407\(09\)03704-5](https://doi.org/10.1016/S0065-2407(09)03704-5)
- Renoult, L., Armson, M. J., Diamond, N. B., Fan, C. L., Jeyakumar, N., Levesque, L., Oliva, L., McKinnon, M., Papadopoulos, A., Selarka, D., St Jacques, P. L., & Levine, B. (2020). Classification of general and personal semantic details in the Autobiographical Interview. *Neuropsychologia*, 144, 107501. <https://doi.org/10.1016/j.neuropsychologia.2020.107501>
- Resick, P. A., & Schnicke, M. K. (1992). Cognitive Processing Therapy for Sexual Assault Victims. *Journal of Consulting and Clinical Psychology*, 60(5), 748–756.
<https://doi.org/10.1037/0022-006X.60.5.748>
- Ribot, T. (1881). *Les maladies de la memoire*. Germe Baillare.

- Richards, B. A., & Frankland, P. W. (2017). The Persistence and Transience of Memory. *Neuron*, 94(6), 1071–1084. <https://doi.org/10.1016/j.neuron.2017.04.037>
- Robin, J., & Moscovitch, M. (2014). The effects of spatial contextual familiarity on remembered scenes, episodic memories, and imagined future events. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 40(2), 459–475. <https://doi.org/10.1037/a0034886>
- Robinson, J. A. (1986). Autobiographical memory: A historical prologue. In D. C. Rubin (Ed.), *Autobiographical memory* (pp. 19–24). Cambridge University Press.
- Romano, M., Ma, R., Moscovitch, M., & Moscovitch, D. A. (2020). Autobiographical memory bias. In *Clinical handbook of fear and anxiety: Maintenance processes and treatment mechanisms* (pp. 183–202). American Psychological Association. <https://doi.org/10.1037/0000150-011>
- Rosenbaum, R. S., Köhler, S., Schacter, D. L., Moscovitch, M., Westmacott, R., Black, S. E., Gao, F., & Tulving, E. (2005). The case of K.C.: Contributions of a memory-impaired person to memory theory. *Neuropsychologia*, 43(7), 989–1021. <https://doi.org/10.1016/j.neuropsychologia.2004.10.007>
- Rosenbaum, R. S., Moscovitch, M., Foster, J. K., Schnyer, D. M., Gao, F., Kovacevic, N., Verfaellie, M., Black, S. E., & Levine, B. (2008). Patterns of Autobiographical Memory Loss in Medial-Temporal Lobe Amnesic Patients. *Journal of Cognitive Neuroscience*, 20(8), 1490–1506. <https://doi.org/10.1162/jocn.2008.20105>
- Rubin, D. C. (2000). The distribution of early childhood memories. *Memory*, 8(4), 265–269. <https://doi.org/10.1080/096582100406810>

- Rubin, D. C. (2020). The ability to recall scenes is a stable individual difference: Evidence from autobiographical remembering. *Cognition*, 197, 104164.
<https://doi.org/10.1016/j.cognition.2019.104164>
- Rubin, D. C. (2021). Properties of autobiographical memories are reliable and stable individual differences. *Cognition*, 210, 104583. <https://doi.org/10.1016/j.cognition.2021.104583>
- Rubin, D. C., Burt, C. D. B., & Fifield, S. J. (2003). Experimental manipulations of the phenomenology of memory. *Memory & Cognition*, 31(6), 877–886.
<https://doi.org/10.3758/BF03196442>
- Rubin, D. C., & Greenberg, D. L. (1998). Visual memory-deficit amnesia: A distinct amnesic presentation and etiology. *Proceedings of the National Academy of Sciences*, 95(9), 5413–5416. <https://doi.org/10.1073/pnas.95.9.5413>
- Rubin, D. C., & Schulkind, M. D. (1997). The distribution of autobiographical memories across the lifespan. *Memory & Cognition*, 25(6), 859–866. <https://doi.org/10.3758/BF03211330>
- Rubin, D. C., & Umanath, S. (2015). Event memory: A theory of memory for laboratory, autobiographical, and fictional events. *Psychological Review*, 122(1), 1–23.
<https://doi.org/10.1037/a0037907>
- Rudebeck, S. R., Scholz, J., Millington, R., Rohenkohl, G., Johansen-Berg, H., & Lee, A. C. H. (2009). Fornix Microstructure Correlates with Recollection But Not Familiarity Memory. *Journal of Neuroscience*, 29(47), 14987–14992.
<https://doi.org/10.1523/JNEUROSCI.4707-09.2009>
- Rugg, M. D., & Vilberg, K. L. (2013). Brain networks underlying episodic memory retrieval. *Current Opinion in Neurobiology*, 23(2), 255–260.
<https://doi.org/10.1016/j.conb.2012.11.005>

- Ryan, L., Nadel, L., Keil, K., Putnam, K., Schnyer, D., Trouard, T., & Moscovitch, M. (2001). Hippocampal complex and retrieval of recent and very remote autobiographical memories: Evidence from functional magnetic resonance imaging in neurologically intact people. *Hippocampus*, 11(6), 707–714. <https://doi.org/10.1002/hipo.1086>
- Schacter, D. L., & Addis, D. R. (2007). The cognitive neuroscience of constructive memory: Remembering the past and imagining the future. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 362(1481), 773–786. <https://doi.org/10.1098/rstb.2007.2087>
- Schacter, D. L., Addis, D. R., Hassabis, D., Martin, V. C., Spreng, R. N., & Szpunar, K. K. (2012). The Future of Memory: Remembering, Imagining, and the Brain. *Neuron*, 76(4), 677–694. <https://doi.org/10.1016/j.neuron.2012.11.001>
- Schacter, D. L., Benoit, R. G., & Szpunar, K. K. (2017). Episodic future thinking: Mechanisms and functions. *Current Opinion in Behavioral Sciences*, 17, 41–50. <https://doi.org/10.1016/j.cobeha.2017.06.002>
- Schmahmann, J. D., Pandya, D. N., Wang, R., Dai, G., D’Arceuil, H. E., de Crespigny, A. J., & Wedeen, V. J. (2007). Association fibre pathways of the brain: Parallel observations from diffusion spectrum imaging and autoradiography. *Brain*, 130(3), 630–653. <https://doi.org/10.1093/brain/awl359>
- Schneider, J. F. L., Il’yasov, K. A., Hennig, J., & Martin, E. (2004). Fast quantitative diffusion-tensor imaging of cerebral white matter from the neonatal period to adolescence. *Neuroradiology*, 46(4), 258–266. <https://doi.org/10.1007/s00234-003-1154-2>
- Schott, B. H., Niklas, C., Kaufmann, J., Bodammer, N. C., Machts, J., Schütze, H., & Düzel, E. (2011). Fiber density between rhinal cortex and activated ventrolateral prefrontal regions

- predicts episodic memory performance in humans. *Proceedings of the National Academy of Sciences*, 108(13), 5408–5413. <https://doi.org/10.1073/pnas.1013287108>
- Scoville, W. B., & Milner, B. (1957). Loss of recent memory after bilateral hippocampal lesions. *Journal of Neurology, Neurosurgery & Psychiatry*, 20(1), 11–21. <https://doi.org/10.1136/jnnp.20.1.11>
- Sekeres, M. J., Riggs, L., Decker, A., Medeiros, C. B. de, Bacopulos, A., Skocic, J., Szulc-Lerch, K., Bouffet, E., Levine, B., Grady, C. L., Mabbott, D. J., Josselyn, S. A., & Frankland, P. W. (2018). Impaired Recent, but Preserved Remote, Autobiographical Memory in Pediatric Brain Tumor Patients. *Journal of Neuroscience*, 38(38), 8251–8261. <https://doi.org/10.1523/JNEUROSCI.1056-18.2018>
- Sekeres, M. J., Winocur, G., & Moscovitch, M. (2018). The hippocampus and related neocortical structures in memory transformation. *Neuroscience Letters*, 680, 39–53. <https://doi.org/10.1016/j.neulet.2018.05.006>
- Setton, R., Lockrow, A. W., Turner, G. R., & Spreng, R. N. (2021). Troubled past: A critical psychometric assessment of the self-report Survey of Autobiographical Memory (SAM). *Behavior Research Methods*. <https://doi.org/10.3758/s13428-021-01604-7>
- Sheldon, S., Amaral, R., & Levine, B. (2017). Individual differences in visual imagery determine how event information is remembered. *Memory*, 25(3), 360–369. <https://doi.org/10.1080/09658211.2016.1178777>
- Sheldon, S., Diamond, N. B., Armson, M. J., Palombo, D. J., Selarka, D., Romero, K., Bacopulos, A., & Levine, B. (2018). Assessing Autobiographical Memory: Implications for Understanding the Underlying Neurocognitive Mechanisms. In J. T. Wixted (Ed.),

- Stevens' Handbook of Experimental Psychology and Cognitive Neuroscience* (pp. 1–34).
John Wiley & Sons, Inc. <https://doi.org/10.1002/9781119170174.epcn111>
- Sheldon, S., Farb, N., Palombo, D. J., & Levine, B. (2016). Intrinsic medial temporal lobe connectivity relates to individual differences in episodic autobiographical remembering. *Cortex*, 74, 206–216. <https://doi.org/10.1016/j.cortex.2015.11.005>
- Sheldon, S., Fenerci, C., & Gurguryan, L. (2019). A Neurocognitive Perspective on the Forms and Functions of Autobiographical Memory Retrieval. *Frontiers in Systems Neuroscience*, 13. <https://doi.org/10.3389/fnsys.2019.00004>
- Sheldon, S., & Levine, B. (2013). Same as it ever was: Vividness modulates the similarities and differences between the neural networks that support retrieving remote and recent autobiographical memories. *NeuroImage*, 83, 880–891.
<https://doi.org/10.1016/j.neuroimage.2013.06.082>
- Sheldon, S., & Levine, B. (2016). The role of the hippocampus in memory and mental construction: Memory and mental construction. *Annals of the New York Academy of Sciences*, 1369(1), 76–92. <https://doi.org/10.1111/nyas.13006>
- Sheldon, S., McAndrews, M. P., & Moscovitch, M. (2011). Episodic memory processes mediated by the medial temporal lobes contribute to open-ended problem solving. *Neuropsychologia*, 49(9), 2439–2447.
<https://doi.org/10.1016/j.neuropsychologia.2011.04.021>
- Simpson, S., & Sheldon, S. (2019). Testing the impact of emotional mood and cue characteristics on detailed autobiographical memory retrieval. *Emotion*.
<https://doi.org/10.1037/emo0000603>

Spreng, R. N., Lockrow, A. W., DuPre, E., Setton, R., Spreng, K. A. P., & Turner, G. R. (2018).

Semanticized autobiographical memory and the default – executive coupling hypothesis of aging. *Neuropsychologia*, 110, 37–43.

<https://doi.org/10.1016/j.neuropsychologia.2017.06.009>

Spreng, R. N., Mar, R. A., & Kim, A. S. N. (2008). The Common Neural Basis of

Autobiographical Memory, Prospection, Navigation, Theory of Mind, and the Default Mode: A Quantitative Meta-analysis. *Journal of Cognitive Neuroscience*, 21(3), 489–510. <https://doi.org/10.1162/jocn.2008.21029>

Spreng, R. N., & Schacter, D. L. (2012). Default Network Modulation and Large-Scale Network

Interactivity in Healthy Young and Old Adults. *Cerebral Cortex*, 22(11), 2610–2621.

<https://doi.org/10.1093/cercor/bhr339>

Squire, L. R. (1992). Memory and the hippocampus: A synthesis from findings with rats,

monkeys, and humans. *Psychological Review*, 99(2), 195–231.

<https://doi.org/10.1037/0033-295X.99.2.195>

Squire, L. R., Horst, A. S. van der, McDuff, S. G. R., Frascino, J. C., Hopkins, R. O., & Mauldin,

K. N. (2010). Role of the hippocampus in remembering the past and imagining the future. *Proceedings of the National Academy of Sciences*, 107(44), 19044–19048.

<https://doi.org/10.1073/pnas.1014391107>

Sreekumar, V., Nielson, D. M., Smith, T. A., Dennis, S. J., & Sederberg, P. B. (2018). The

experience of vivid autobiographical reminiscence is supported by subjective content representations in the precuneus. *Scientific Reports*, 8(1), 14899.

<https://doi.org/10.1038/s41598-018-32879-0>

- St. Jacques, P. L. (2019). A New Perspective on Visual Perspective in Memory. *Current Directions in Psychological Science*, 28(5), 450–455.
<https://doi.org/10.1177/0963721419850158>
- St. Jacques, P. L., Montgomery, D., & Schacter, D. L. (2015). Modifying memory for a museum tour in older adults: Reactivation-related updating that enhances and distorts memory is reduced in ageing. *Memory*, 23(6), 876–887.
<https://doi.org/10.1080/09658211.2014.933241>
- St. Jacques, P. L., Olm, C., & Schacter, D. L. (2013). Neural mechanisms of reactivation-induced updating that enhance and distort memory. *Proceedings of the National Academy of Sciences*, 110(49), 19671–19678. <https://doi.org/10.1073/pnas.1319630110>
- St. Jacques, P. L., Rubin, D. C., LaBar, K. S., & Cabeza, R. (2008). The Short and Long of It: Neural Correlates of Temporal-order Memory for Autobiographical Events. *Journal of Cognitive Neuroscience*, 20(7), 1327–1341. <https://doi.org/10.1162/jocn.2008.20091>
- Steinvorth, S., Levine, B., & Corkin, S. (2005). Medial temporal lobe structures are needed to re-experience remote autobiographical memories: Evidence from H.M. and W.R. *Neuropsychologia*, 43(4), 479–496.
<https://doi.org/10.1016/j.neuropsychologia.2005.01.001>
- Steinvorth, S., Wang, C., Ulbert, I., Schomer, D., & Halgren, E. (2010). Human entorhinal gamma and theta oscillations selective for remote autobiographical memory. *Hippocampus*, 20(1), 166–173. <https://doi.org/10.1002/hipo.20597>
- Svoboda, E., McKinnon, M. C., & Levine, B. (2006). The functional neuroanatomy of autobiographical memory: A meta-analysis. *Neuropsychologia*, 44(12), 2189–2208.
<https://doi.org/10.1016/j.neuropsychologia.2006.05.023>

- Talarico, J. M., LaBar, K. S., & Rubin, D. C. (2004). Emotional intensity predicts autobiographical memory experience. *Memory & Cognition*, 32(7), 1118–1132.
<https://doi.org/10.3758/BF03196886>
- Talarico, J. M., & Rubin, D. C. (2003). Confidence, Not Consistency, Characterizes Flashbulb Memories. *Psychological Science*, 14(5), 455–461. <https://doi.org/10.1111/1467-9280.02453>
- Thakral, P. P., Benoit, R. G., & Schacter, D. L. (2017). Imagining the future: The core episodic simulation network dissociates as a function of timecourse and the amount of simulated information. *Cortex*, 90, 12–30. <https://doi.org/10.1016/j.cortex.2017.02.005>
- Thakral, P. P., Madore, K. P., & Schacter, D. L. (2017). A Role for the Left Angular Gyrus in Episodic Simulation and Memory. *The Journal of Neuroscience*, 37(34), 8142–8149.
<https://doi.org/10.1523/JNEUROSCI.1319-17.2017>
- Thome, A., Marrone, D. F., Ellmore, T. M., Chawla, M. K., Lipa, P., Ramirez-Amaya, V., Lisanby, S. H., McNaughton, B. L., & Barnes, C. A. (2017). Evidence for an Evolutionarily Conserved Memory Coding Scheme in the Mammalian Hippocampus. *The Journal of Neuroscience*, 37(10), 2795–2801. <https://doi.org/10.1523/JNEUROSCI.3057-16.2017>
- Tolman, E. C. (1948). Cognitive maps in rats and men. *Psychological Review*, 55(4), 189–208.
<https://doi.org/10.1037/h0061626>
- Tromp, D., Dufour, A., Lithfous, S., Pebayle, T., & Després, O. (2015). Episodic memory in normal aging and Alzheimer disease: Insights from imaging and behavioral studies. *Ageing Research Reviews*, 24, 232–262. <https://doi.org/10.1016/j.arr.2015.08.006>

- Tulving, E. (1972). Episodic and Semantic Memory. In E. Tulving & W. Donaldson (Eds.), *Organization of memory* (pp. 381–402). Academic Press.
- Tulving, E. (1983). *Elements of Episodic Memory*. Oxford University Press.
- Tulving, E. (2002). Episodic Memory: From Mind to Brain. *Annual Review of Psychology*, 53(1), 1–25. <https://doi.org/10.1146/annurev.psych.53.100901.135114>
- Turner, G. R., & Spreng, R. N. (2015). Prefrontal Engagement and Reduced Default Network Suppression Co-occur and Are Dynamically Coupled in Older Adults: The Default–Executive Coupling Hypothesis of Aging. *Journal of Cognitive Neuroscience*, 27(12), 2462–2476. https://doi.org/10.1162/jocn_a_00869
- Usher, J. A., & Neisser, U. (1993). Childhood amnesia and the beginnings of memory for four early life events. *Journal of Experimental Psychology: General*, 122(2), 155–165. <https://doi.org/10.1037/0096-3445.122.2.155>
- Van Petten, C. (2004). Relationship between hippocampal volume and memory ability in healthy individuals across the lifespan: Review and meta-analysis. *Neuropsychologia*, 42(10), 1394–1413. <https://doi.org/10.1016/j.neuropsychologia.2004.04.006>
- van Vreeswijk, M. F., & de Wilde, E. J. (2004). Autobiographical memory specificity, psychopathology, depressed mood and the use of the Autobiographical Memory Test: A meta-analysis. *Behaviour Research and Therapy*, 42(6), 731–743. [https://doi.org/10.1016/S0005-7967\(03\)00194-3](https://doi.org/10.1016/S0005-7967(03)00194-3)
- Vargha-Khadem, F. (1997). Differential Effects of Early Hippocampal Pathology on Episodic and Semantic Memory. *Science*, 277(5324), 376–380. <https://doi.org/10.1126/science.277.5324.376>

- Vass, L. K., Copara, M. S., Seyal, M., Shahlaie, K., Farias, S. T., Shen, P. Y., & Ekstrom, A. D. (2016). Oscillations Go the Distance: Low-Frequency Human Hippocampal Oscillations Code Spatial Distance in the Absence of Sensory Cues during Teleportation. *Neuron*, 89(6), 1180–1186. <https://doi.org/10.1016/j.neuron.2016.01.045>
- Vikbladh, O. M., Meager, M. R., King, J., Blackmon, K., Devinsky, O., Shohamy, D., Burgess, N., & Daw, N. D. (2019). Hippocampal Contributions to Model-Based Planning and Spatial Memory. *Neuron*, 102(3), 683-693.e4. <https://doi.org/10.1016/j.neuron.2019.02.014>
- Wagenaar, W. A. (1986). My memory: A study of autobiographical memory over six years. *Cognitive Psychology*, 18(2), 225–252. [https://doi.org/10.1016/0010-0285\(86\)90013-7](https://doi.org/10.1016/0010-0285(86)90013-7)
- Walker, W. R., Yancu, C. N., & Skowronski, J. J. (2014). Trait anxiety reduces affective fading for both positive and negative autobiographical memories. *Advances in Cognitive Psychology*, 10(3), 81–89. <https://doi.org/10.5709/acp-0159-0>
- Watkins, N. W. (2018). (A)phantasia and severely deficient autobiographical memory: Scientific and personal perspectives. *Cortex*, 105, 41–52. <https://doi.org/10.1016/j.cortex.2017.10.010>
- Wheeler, M. A., Stuss, D. T., & Tulving, E. (1997). Toward a theory of episodic memory: The frontal lobes and autonoetic consciousness. *Psychological Bulletin*, 121(3), 331–354. <https://doi.org/10.1037/0033-2909.121.3.331>
- Williams, J. M. G., Barnhofer, T., Crane, C., Herman, D., Raes, F., Watkins, E., & Dalgleish, T. (2007). Autobiographical memory specificity and emotional disorder. *Psychological Bulletin*, 133(1), 122–148. <https://doi.org/10.1037/0033-2909.133.1.122>

Williams, J. M. G., & Broadbent, K. (1986). Autobiographical memory in suicide attempters.

Journal of Abnormal Psychology, 95(2), 144–149. <https://doi.org/10.1037/0021-843X.95.2.144>

Williams, J. M. G., Healy, H. G., & Ellis, N. C. (1999). The Effect of Imageability and

Predicability of Cues in Autobiographical Memory. *The Quarterly Journal of Experimental Psychology Section A*, 52(3), 555–579. <https://doi.org/10.1080/713755828>

Wilson, I. A., Gallagher, M., Eichenbaum, H., & Tanila, H. (2006). Neurocognitive aging: Prior memories hinder new hippocampal encoding. *Trends in Neurosciences*, 29(12), 662–670.

<https://doi.org/10.1016/j.tins.2006.10.002>

Winocur, G., Moscovitch, M., & Bontempi, B. (2010). Memory formation and long-term

retention in humans and animals: Convergence towards a transformation account of hippocampal–neocortical interactions. *Neuropsychologia*, 48(8), 2339–2356.

<https://doi.org/10.1016/j.neuropsychologia.2010.04.016>

Witter, M. P. (2007). The perforant path: Projections from the entorhinal cortex to the dentate gyrus. In H. E. Scharfman (Ed.), *Progress in Brain Research* (Vol. 163, pp. 43–61).

Elsevier. [https://doi.org/10.1016/S0079-6123\(07\)63003-9](https://doi.org/10.1016/S0079-6123(07)63003-9)

Wixted, J. T., Mickes, L., Dunn, J. C., Clark, S. E., & Wells, W. (2016). Estimating the

reliability of eyewitness identifications from police lineups. *Proceedings of the National Academy of Sciences*, 113(2), 304–309. <https://doi.org/10.1073/pnas.1516814112>

Wolk, D. A., Dunfee, K. L., Dickerson, B. C., Aizenstein, H. J., & DeKosky, S. T. (2011). A medial temporal lobe division of labor: Insights from memory in aging and early

Alzheimer disease. *Hippocampus*, 21(5), 461–466. <https://doi.org/10.1002/hipo.20779>

- Wynn, J. S., Shen, K., & Ryan, J. D. (2019). Eye Movements Actively Reinstatement Spatiotemporal Mnemonic Content. *Vision*, 3(2), 21. <https://doi.org/10.3390/vision3020021>
- Yassa, M. A., Muftuler, L. T., & Stark, C. E. L. (2010). Ultrahigh-resolution microstructural diffusion tensor imaging reveals perforant path degradation in aged humans in vivo. *Proceedings of the National Academy of Sciences*, 107(28), 12687–12691. <https://doi.org/10.1073/pnas.1002113107>
- Zeman, A., Dewar, M., & Della Sala, S. (2015). Lives without imagery – Congenital aphantasia. *Cortex*, 73, 378–380. <https://doi.org/10.1016/j.cortex.2015.05.019>
- Zeman, A., Milton, F., Della Sala, S., Dewar, M., Frayling, T., Gaddum, J., Hattersley, A., Heuerman-Williamson, B., Jones, K., MacKisack, M., & Winlove, C. (2020). Phantasia—The psychological significance of lifelong visual imagery vividness extremes. *Cortex*. <https://doi.org/10.1016/j.cortex.2020.04.003>
- Zola-Morgan, S., Cohen, N. J., & Squire, L. R. (1983). Recall of remote episodic memory in amnesia. *Neuropsychologia*, 21(5), 487–500. [https://doi.org/10.1016/0028-3932\(83\)90005-2](https://doi.org/10.1016/0028-3932(83)90005-2)

Figures

Figure 1. Examples of using a controlled or staged real-world events to measure naturalistic memory, including maps of the environment and sample stimuli.

A) Visitors to museum exhibit explored items in a controlled sequence as dictated by a scavenger-hunt-style pamphlet. At test, participants rated pairs of photographs from the exhibit relative to their original temporal order (i.e., intact vs. reordered; requiring retrieval of spatiotemporal context) or—in the case of lure photographs from a conceptually and perceptually related exhibit—as old/new, enabling dissociation of item vs. associative memory (Diamond et al., 2018). Temporal order items were classified as “near” or “far” according to the number of intervening items in the original exhibit, with “near” items deemed to be more difficult. Whereas the museum exhibit presented in (A) was incidental (i.e., not experimentally manipulated, using members of the public who happened to attend the exhibit), the audio-guided Baycrest Tour (B) enabled experimental control akin to a laboratory study, with the capacity to test free recall,

recognition, and hypothesis-driven manipulations and contrasts (Armson et al., 2021; Diamond, Abdi, & Levine, 2020; Diamond, Armson, & Levine, 2020; Diamond & Levine, 2020).