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Memory Sins in Applied Settings: What Kind of Progress?

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Abstract

Over two decades ago, I proposed that memory errors could be classified into seven basic categories or sins (Schacter, 1999, 2001), comprising three sins of omission (transience, absentmindedness, and blocking) and four sins of commission (misattribution, suggestibility, bias, and persistence). In the past two decades, much has been learned about the nature and basis of the memory sins. Here, I assess the extent of progress that has been made during that time regarding applied implications of five of the sins: transience, absentmindedness, misattribution, suggestibility, and persistence. The manifestations of these sins have been examined in a variety of applied settings, including educational, clinical, legal, and technological domains. I argue that considerable progress has been made in characterizing the impact of memory sins in each domain, identify gaps in and limitations of our current knowledge, and briefly consider how these developments bear on broad questions regarding the reliability of human memory.

Keywords

Memory; Forgetting; Absentmindedness; False Memories; Intrusive Memories; Applied Cognition

General Audience Summary

We rely on our memories to perform countless tasks in our everyday lives. But our memories are not perfect: much psychological research has revealed that memory does not operate like a videorecorder, and is subject to errors that can cause problems in everyday life. These errors range from relatively harmless incidents where we forget the name of an acquaintance, or where we put our keys or glasses, to more serious cases in which an eyewitness to a crime mistakenly identifies an innocent person as the perpetrator. In 2001, I wrote a book, *The Seven Sins of Memory*, in which I classified memory errors into seven categories or “sins”. Three “sins of omission” refer to different kinds of forgetting: *transience* (forgetting information over time), *absentmindedness* (when a failure to pay attention leads to forgetting), and *blocking* (temporary inaccessibility of information that is present in memory, even in the presence of strong retrieval cues). Four “sins of commission” refer to cases in which memory is present, but either wrong or unwanted: *misattribution* (misremembering the source of a memory, such as mistaking fantasy for reality), *suggestibility* (memories that are implanted by a suggestion), *bias* (when our current knowledge or beliefs distort our recollections of the past), and *persistence* (intrusive recall

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of disturbing or traumatic events). Here, I discuss research conducted during the past two decades that has examined several of the memory sins in everyday settings, ranging from the classroom and the courtroom to clinical contexts and real-world impacts of technology, such as smartphones and fake news. I conclude that we have made impressive progress in understanding how memory sins impact our function in everyday settings, and generating steps to counter them, identify gaps in our knowledge and future research directions, and discuss implications for our understanding of the reliability of human memory.

The study of memory errors can be an invaluable source of information regarding the fundamental nature of memory. This insight was articulated forcefully in the classic work of Bartlett (1932) and elaborated on by many others since (e.g., Bjork & Bjork, 1988; Brainerd & Reyna, 2005; Fawcett & Hulbert, 2020; Loftus, 2005; Roediger & McDermott, 2000; Schacter, 1996). Equally important, however, memory errors are of great significance in many applied contexts, ranging from the classroom to the courtroom to clinical settings, among others (e.g., Baddeley et al., 2002; Dunlosky et al., 2013; Loftus, 1979).

Over two decades ago, I classified memory's transgressions into seven basic categories, which, by analogy to the ancient seven deadly sins, I called the seven sins of memory (Schacter, 1999, 2001). Three "sins of omission" describe different kinds of forgetting: *transience* (decreasing accessibility of information over time), *absentmindedness* (breakdown at the interface of attention and memory that results in poor encoding or failure to initiate retrieval), and *blocking* (temporary inaccessibility of information stored in memory, even in the presence of strong retrieval cues). Four "sins of commission" refer to situations in which memory is present, but either wrong or unwanted: *misattribution* (attributing a memory or idea to the wrong source), *suggestibility* (implanted memories that result from suggestion or misinformation), *bias* (retrospective distortions produced by current knowledge, beliefs, and feelings), and *persistence* (intrusive remembering of disturbing experiences). My initial discussions considered the cognitive and neural mechanisms responsible for each sin, as well as how they impact memory functions in everyday life. Moreover, I also argued for an adaptive perspective on the seven sins: even though they can have serious negative consequences, the seven sins do not reflect fundamental defects or shortcomings of memory, but rather are byproducts of adaptive memory processes that serve important cognitive functions (Schacter, 2001).

During the ensuing two decades, much research has appeared concerning the nature and consequences of each sin, and considerable new evidence has emerged to support the aforementioned adaptive perspective. I discussed some of this research in an updated edition of the 2001 book (Schacter, 2021) and a brief article (Schacter, 2022b). Here, I focus on five memory sins that have been the target of research with important applied implications during the past two decades: transience, absentmindedness, misattribution, suggestibility, and persistence (I do not focus on blocking and bias because the word limit for this article required some selectivity; see Schacter 2021, 2022b for discussion of recent developments). We now know considerably more about the nature and consequences of these memory sins in applied contexts than we did two decades ago. Although gaps remain, this newly acquired knowledge is helping to develop approaches to mitigating the negative everyday consequences of several memory sins.

This paper is organized into sections corresponding to individual sins, but not all phenomena considered here neatly reflect the operation of a single sin. For example, as discussed in the next section, memory phenomena related to GPS use likely reflect the operation of both transience and absentmindedness; in subsequent sections, I note where bias contributes to phenomena discussed under the rubric of misattribution and suggestibility. Thus, it is important to acknowledge that some memory phenomena reflect the influence of more than one memory sin.

Transience

Transience might be characterized as the “original sin” of memory because it featured prominently in the pioneering work of Ebbinghaus (1885/1964) and his famous depiction of the forgetting curve. Attempts to characterize the nature of forgetting over time have a long history in both psychology and neuroscience (cf., Sadeh & Pertzov, 2020; Wixted, 2004). With respect to applied concerns, I discuss here advances during the past two decades regarding the conditions in which transience is selectively decreased or increased, and also consider research concerning how technology impacts retention.

Anti-Transience

One of the most striking phenomena bearing on retention over time to emerge during the past two decades concerns individuals who have been identified as possessing Highly Superior Autobiographical Memory (HSAM; LePort et al., 2012). Individuals with HSAM exhibit an extraordinary ability to recall their everyday personal experiences despite performing unremarkably on standard laboratory tests of memory. LePort et al. (2016) probed memory for everyday events in HSAM and control participants across retention intervals of 1 week, 1 month, 1 year, and 10 years. They found no differences between the two groups at the 1-week retention interval. By contrast, HSAM individuals remembered significantly more details about their personal experiences at each of the longer retention intervals, suggesting that individuals with HSAM do not encode more information about their personal experiences than controls. Instead, they show a selective reduction in transience, which I refer to as *anti-transience*.

LePort et al. (2016) also reported that individuals with HSAM scored significantly higher than controls on a measure of obsessive-compulsive tendencies, including tendencies for rumination, and that scores on this measure were related to greater preservation of detail in autobiographical events across a 1-month delay. These findings led LePort et al. (2016, p. 8) to argue that exceptional retention of detailed memories over time in HSAM “may well be the result of the more efficient consolidation and retrieval of these detailed memories, perhaps rooted in obsessively driven, habitual rehearsal of autobiographical material.”

Converging with this interpretation of anti-transience in HSAM, research concerned with the effects of testing or retrieval practice on retention has shown that compared to restudying target information, retrieval practice via testing reduces the amount of forgetting over time (for detailed review and discussion, see McDermott, 2021; Roediger & Karpicke, 2018). This pattern has been documented for stories (Roediger & Karpicke, 2006), word lists (e.g., Congleton & Rajaram, 2012; Wheeler et al., 2003) and paired associates (Toppino & Cohen,

2009). In these studies, additional study opportunities typically produce a small advantage over intermittent testing at a short delay (e.g., 5 minutes), but this advantage is eliminated or even reversed after longer delays (e.g., 48 hours, 1 week). This pattern is robust and has been confirmed in a formal meta-analysis (Rowland, 2014).

Importantly, these benefits of retrieval practice reach beyond the laboratory to the classroom. For example, McDermott et al. (2014) reported that compared with a restudy condition, providing intermittent quizzes in seventh-grade science and high school history classes produced improved performance on both within-semester tests and on final exams given one or two months after the within-semester tests. Extending these findings, Heitman et al. (2021) provided evidence from a university lecture setting for mnemonic benefits attributable to giving quizzes that are adapted to students' level of knowledge after a two-week delay but not after a one-week delay, and also found that both adaptive and non-adaptive quizzing produced memory benefits at both delays compared to a note-taking condition (for a review of retrieval practice in the classroom, see Agarwal et al., 2021). Benefits of testing on long-term retention extending over delays of several months have been extended to other applied domains, including suturing skills in dental students (Sennhenn-Kirchner et al., 2018) and knowledge of cardiovascular anatomy in medical students (Kleiman et al., 2019). Thus, although it is widely acknowledged that research on retrieval practice has a long history in cognitive psychology (Roediger & Karpicke, 2006), the finding that it can slow down forgetting over time, and the extension of this work to applied settings, can be attributed mainly to research that has emerged during the past two decades.

Hyper-Transience

These findings on anti-transience associated with HSAM and retrieval practice contrast with, and also have practical implications for, a clinical phenomenon that has received increasing attention during the past two decades: *accelerated long-term forgetting* (ALF), which has been documented most extensively in studies of epileptic patients (for detailed reviews, see Elliott et al., 2014; Mameniškiene et al., 2020). Patients characterized by ALF typically show intact memory performance across retention intervals of 30–60 minutes, together with impaired performance over retention intervals of days and weeks across a range of tasks and materials. Thus, in contrast to individuals with HSAM who exhibit anti-transience, ALF patients exhibit what we might think of as *hyper-transience*.

ALF has been linked with significant problems in everyday life. For example, patients with ALF have autobiographical memory impairments that may include difficulties in remembering significant life events (Manes et al., 2005; Ricci et al., 2015). In a study of epileptic children with ALF, Gascoigne et al. (2019) found that lower levels of recall on a list memory test after a 7-day delay were associated with increased behavioral and social problems as well as mood disruptions in the epileptic group, but not in healthy controls. Moreover, ALF may also be a sensitive early indicator for subsequent cognitive decline in elderly populations (Wearn et al., 2020; Weston et al., 2018).

Given the nature and impact of memory loss over time in ALF, and the findings reviewed earlier that retrieval practice can reduce forgetting over time, a key question concerns whether retrieval practice can reduce forgetting in ALF patients. Ricci et al. (2019) studied

story recall in three ALF patients and a matched control group. In a control condition where there was no retrieval practice, ALF patients showed normal recall after a 30-minute retention interval and impaired recall after retention intervals of 24 hours, 1 week, and 4 weeks. However, retrieval practice shortly after initial study eliminated group differences at the 24-hour delay, and a “booster” retrieval practice session given two weeks after study further improved retention in ALF patients at the 4-week delay. These findings indicate that an anti-transience manipulation can be used to combat hyper-transience as expressed in ALF. However, the implications of these findings for everyday function remain to be determined; as Ricci et al. (2019, p. 45) note, “exploring ways these strategies can be operationalized in everyday life are crucial next steps.”

Impact of Technology: Evidence from GPS

One of the emerging issues relevant to applied implications of the seven sins during the past decade concerns the possibly negative impact of technology use, including smartphones, the Internet, and GPS on memory. I discussed this issue with respect to transience in the updated edition of *The Seven Sins of Memory* (Schacter, 2021b) and in a recent article (Schacter, 2022a; for broader reviews of the impact of technology on memory, see Clinch et al., 2021; Finley et al., 2018; Marsh & Rajaram, 2019; see also the special issue of *Memory* edited by Wang (2022)). Here I focus on evidence from GPS, summarizing some key points I made in earlier discussions and updating them in light of new evidence.

Media accounts of the potential impact of technology are typically phrased in dramatic terms, as exemplified by the title of a recent article in *The Guardian*, “Is your smartphone ruining your memory? A special report on the rise of ‘digital amnesia’” (Seal, 2022). This characterization applies most directly to transience, because the main idea is that people suffering from digital amnesia have developed an impaired ability to form and retain new memories over time. However, absentmindedness is also relevant, because technology-related memory failures can also reflect distraction and consequent poor encoding resulting from technology use.

Directly relevant to this point, Gardony et al. (2015) examined spatial memory after navigation with or without GPS, which was crossed with full or divided attention during navigation. They reported that GPS use during navigation impaired subsequent spatial memory in the full attention condition. Spatial memory was also impaired in the divided attention condition compared with the full attention condition, but it was no worse when participants used GPS than when they did not. These findings led Gardony et al. (2015) to suggest that using GPS divides attention, which in turn produces impaired subsequent memory for navigated routes. More recently, Sugimoto et al. (2022) compared navigation of everyday routes (residential areas in Kyoto City) when participants navigated the route with a smartphone app (Google Maps) versus when they used a paper map. When attempting to retrace the route, participants who had navigated with Google Maps performed more poorly when they were tested without this aid than when they were allowed to use it, whereas participants who had navigated with a paper map performed similarly with or without an aid during route retracing. By contrast, a study by Kelly et al. (2022) compared route retracing on a virtual navigation task following learning conditions in which a) participants

followed turn-by-turn directions on the same route either three or four times, or b) followed turn-by-turn directions once or twice and were then tested twice. They failed to find an effect of learning condition on final retracing performance (i.e., lack of a testing effect). However, in contrast to other studies, GPS-like guidance was provided in both learning conditions.

A neuroimaging study by Javadi et al. (2017) provides evidence for differences between GPS- and memory-based navigation. Before fMRI scanning, participants learned about the spatial layout of London's Soho via a walking tour. The next day, they performed two types of spatial navigation tasks in the scanner while viewing a filmed simulation of SoHo. In one task, participants relied on their memories of the tour to navigate, and in the other task, they navigated via GPS-like instructions from the experimenters. The former but not the latter condition produced increased activity in the right hippocampus, which plays an important role in memory and spatial navigation, and also in a part of the prefrontal cortex implicated previously in spatial planning. Moreover, when participants entered new streets during memory-based navigation, right posterior hippocampal responses tracked the number of paths in the street network available for future travel, whereas activity in the right anterior hippocampus reflected global properties of the street that a participant entered; these effects were not observed when participants navigated using GPS.

The effects of GPS use on retention considered so far provide some evidence for what I have called a *task-specific* effect (Schacter, 2022a): relying on technology impacts memory for aspects of the specific task performed (e.g., remembering details of a route navigated using GPS) or reduces hippocampal activity during task performance. However, discussions of an emerging digital amnesia typically depict a broader negative impact on memory that goes beyond the specific task being performed while using GPS or another technological aid. I have referred to this broader impact as a *domain-specific* effect (e.g., extensive use of GPS produces a negative impact on spatial memory even when not relying on GPS) or an even more wide-ranging *domain-general* effect (e.g., relying on GPS produces a negative impact on both spatial and non-spatial memory; see Schacter, 2022a, for further elaboration). Therefore, addressing the question of whether technology is producing a widespread digital amnesia requires assessing the strength of evidence for domain-specific and domain-general effects.

There is yet little evidence against which to assess these possibilities, but a study by Dahmani and Bohbot (2020) revealed that greater self-reported lifetime GPS experience in 50 drivers was associated with worse spatial learning and memory performance on two virtual maze tasks. Because these findings are correlational, they could reflect either a negative impact of GPS experience on spatial learning and memory, or that individuals who have poor spatial navigation skills prior to using GPS rely more on GPS as a compensatory response. Dahmani and Bohbot provide suggestive though still correlational evidence for the former perspective, which would implicate what I have termed a domain-specific effect of GPS use on spatial learning and memory, but additional studies with larger samples will be needed to evaluate this possibility (for additional discussion, see Schacter, 2022a, and for related evidence, see Ruginski et al., 2019). Note also that the results of this study do not speak to the question of whether GPS use produces a domain-general effect that extends to

non-spatial forms of memory. There is currently no evidence for such a far-reaching claim, which remains to be assessed in future studies.

Absentmindedness

Absentminded memory errors occur as a consequence of attentional failures during either encoding or retrieval. During the past two decades, manifestations of absentminded memory failures have emerged in several domains with important applied implications. Here I focus on mind wandering, media multitasking, hot car deaths, and missing person alerts.

Mind Wandering

Absentminded forgetting has emerged as an issue in research on *mind wandering* (i.e., task-unrelated thoughts; for discussion of definitional issues, see Seli et al., 2018). This line of research began in earnest during the early 2000s following the publication of an influential review by Smallwood & Schooler (2006). Although not initially focused on consequences of mind wandering for memory, studies soon began to examine the impact of mind wandering on memory and learning in educational settings. Memory failures associated with mind wandering can be viewed as absentminded errors because forgetting is thought to reflect a lack of, or reduction in, attention to target material during encoding.

In a study by Lindquist and McLean (2011), undergraduates attending three 50-minute psychology lectures heard five auditory attention probes spaced at roughly equal intervals and were asked to report when they experienced task-unrelated thoughts. Overall, students reported task-unrelated thoughts in response to approximately one-third of the auditory probes, and the frequency of such thoughts was negatively correlated with retention of lecture content. Related studies reported similar findings regarding mind wandering and subsequent memory during video-recorded lectures (Risko et al., 2012; Szpunar et al., 2013). Wammes et al. (2016) also documented a negative correlation between the occurrence of mind wandering and retention of lecture content on quizzes during a 12-week undergraduate course, although poor quiz performance was more strongly linked to the occurrence of intentional mind wandering (i.e., deliberately turning attention to task-unrelated thoughts) than unintentional mind wandering (which occurs despite an individual's desire to focus on task-related thoughts; for discussion of the distinction between intentional and unintentional mind wandering, see Seli et al., 2016).

These observations have led to investigations examining ways to mitigate the occurrence of mind wandering and thereby enhance attention to and memory for lecture content. Several experiments from my laboratory revealed that interpolated testing, where participants are given periodic quizzes during a lecture regarding specific contents, can reduce mind wandering and boost memory for lecture content compared with restudying the same information (Jing et al., 2016; Szpunar et al., 2013). Using slightly different materials and procedures, Welhaf et al. (2022) also observed that interpolated testing reduced mind wandering during a video-recorded lecture (albeit with a relatively small effect size), but failed to observe a significant benefit of interpolated testing on memory for lecture content. As noted by Welhaf et al., one potentially important difference between their methods and those used by Jing et al. (2016) and Szpunar et al. (2013) is that in the latter

studies, participants were allowed to take notes during the lecture, whereas in Welhaf et al., participants were not allowed to take notes. Interpolated testing was associated with increased note taking in two experiments by Szpunar et al. (2013) and in Experiment 1 but not Experiment 2 by Jing et al. (2016). It is thus possible that note taking plays a role in the beneficial effect of interpolated testing on subsequent retention of lecture content, but more research is needed to assess the issue.

Media Multitasking

Wammes and colleagues (2019) have distinguished mind wandering during classroom lectures from a related kind of disengagement: media multitasking, which involves multitasking by simultaneously engaging smartphone, laptop, or similar screen-based media. Media multitasking is, not surprisingly, quite common among students in educational settings, and a growing number of studies have examined various effects of using smartphones or other devices for activity that is unrelated to a lecture (e.g., Sunday et al., 2021; Zhou & Deng, 2022).

Wammes et al. (2019) conducted an initial study during a half-semester in which they occasionally probed students regarding whether they were media multitasking. Wammes et al. found that students responded affirmatively on approximately one-third of probe trials, and that the occurrence of media multitasking was negatively associated with retention of lecture content. In a second study conducted across an entire semester, they asked about both media multitasking and mind wandering, and found that media multitasking was more detrimental for retention of lecture content than was mind wandering. Wammes et al. suggested that the lesser impact of mind wandering on retention of lecture content might have occurred because students can more easily allocate “partial resources” to internal thoughts (i.e., mind wandering) while still maintaining attention to an external task (i.e., the lecture) than they can allocate attention to two external tasks (i.e., smartphones/laptops vs. the lecture).

Other studies have also documented negative effects of media multitasking on attention and subsequent memory in educational settings (Graben et al., 2022; Gupta & Irwin, 2016; Ravizza et al., 2014; Rosen et al., 2013; Sana et al., 2013; Wood et al., 2012). Related to the distinctions among task-specific, domain-specific, and domain-general effects discussed earlier, these findings establish that media multitasking has detrimental task-specific effects on memory, which is not surprising given numerous prior demonstrations that divided attention during study/encoding negatively impacts memory in many situations. The more interesting question concerns whether chronic media multitasking also produces broader, perhaps domain-general memory deficits. As discussed by Uncapher and Wagner (2018), extensive or chronic media multitasking has been linked to poor task-related retention even when individuals are not engaging in media multitasking on the task in question (for particularly strong evidence on this point, see Madore et al., 2020). Such findings raise the possibility that chronic media multitasking can cause a kind of persisting absentmindedness that results in impaired memory performance across various domains in everyday life. Importantly, however, because the relevant data are correlational, it is also possible that individuals who are prone to absentmindedness and related kinds of attention failures

become, as a consequence, especially likely to engage in media multitasking (for discussion, see Madore et al., 2020; Schacter, 2022a; Uncapher & Wagner, 2018). Sorting out the direction of causality is a critical task for future research.

Hot Car Deaths

Everyday absentminded errors are often associated with failures of prospective memory—i.e., remembering to carry out planned actions in the future (e.g., Brandimonte et al., 1996). As is well known, prospective memory functions can be broadly divided into *time-based* prospective memory (i.e., remembering to carry out an action at a specific time in the future) and *event-based* prospective memory (i.e., remembering to carry out an action in the future action when a specific event or cue is encountered; Einstein & McDaniel, 1990).

During the early 2000s, perhaps the most devastating manifestation of absentminded forgetting attributable to what we can think of as a time-based prospective memory failure came to wide attention: hot car deaths of infants whose parents forgot that they left their infant in the car, trapping them in a rear car seat. In these cases, parents are unaware that they have left their child in a hot car, in contrast to other cases in which a parent makes an ill-considered conscious decision to leave a child in a hot car while carrying out a task (e.g., shopping) and returns to find out that the child has died.

At least four key factors have turned up repeatedly in these tragic cases of absentminded forgetting (for discussions of individual cases, see Otterman, 2019; Schacter, 2021; Weingarten, 2009). First, these parents are often accomplished, caring, and responsible, and should not be characterized as chronically “absentminded” because they experienced a consequential incident of absentminded forgetting. Second, such cases typically involve a change of routine, where the parent unknowingly engages in automatic processing and executes the steps of their normal routine, not realizing that they need to override such automatic processing and engage in a behavior at a future time that is not part of their normal routine (e.g., dropping off a child). Third, the parent is often focused on a pressing matter unrelated to the child that requires extensive conscious processing (e.g., work-related matters, a significant personal problem). Fourth, no retrieval cue is available to remind the parent to carry out the key non-routine action when that cue is critically needed (i.e., at the moment the child should be taken out of the car); thus in contrast to mind wandering, this manifestation of absentminded forgetting occurs primarily at retrieval. This latter point is likely related to the fact that these kinds of cases only began to appear after recommendations were instituted in the 1990s mandating that child car seats be moved to the rear to protect young children from the possibly fatal consequences of front-seat airbags, thus removing the child from a parent’s immediate visual field. It is perhaps not surprising that absentminded forgetting emerged as an unintended and likely never-considered consequence of this change given the intuitively low likelihood that a parent would ever forget that their child was in the car with them. However, the absence of this retrieval cue is highly relevant in view of studies of prospective memory that have highlighted that the successful execution of a delayed intention depends critically on the presence of a retrieval cue at the moment the intended action needs to be executed (e.g., Dismukes, 2012; Loft, 2014; Vortac et al., 1995).

Legal consequences for affected parents have varied widely (Otterman, 2019), and researchers have just begun to study the factors that impact assignment of blame in these cases (Hanson et al., 2015). Despite the drastic consequences of this form of absentminded forgetting, the fact that a missing retrieval cue is critical to its occurrence also means that forgetting can be overcome in a straightforward manner: by providing an inescapable reminder that a child is in the rear car seat, thereby converting the task from time-based to event-based prospective memory. These cues can range from homemade visual reminders, such as a doll or a toy in the front seat, to devices such as the Elepho eClip, which can be attached to a car seat and sends both visual and auditory alert to drivers' smartphones that remind them that a child is in the car (Baldwin, 2019), to electronic rear seat reminders systems now available as optional features from some manufacturers, as well as a reminder feature on the traffic app Waze (Messer, 2017; Miller, 2019).

However, a paradoxical aspect of this form of absentminded forgetting constitutes a barrier to eliminating it: parents need to be aware that such extreme forgetting can occur in order to overcome it, yet many never consider the possibility or flatly reject the idea that it could happen to them (Weingarten, 2009). An important and as yet unexplored issue for applied research would be to investigate beliefs related to the perceived limits of absentminded forgetting, and how such beliefs could be modified to allow for the kind of extreme forgetting that occurs in hot car deaths of young children like those discussed here.

Missing Person Alerts

Another high-stakes domain that may sometimes involve absentminded forgetting concerns missing person alerts (e.g., AMBER alerts), which have been subject to criticism because they frequently do not yield useful identifications (Griffin et al., 2007). As Lampinen and Moore (2016b, p. 145) note, "A common strategy when children or adults go missing is to release photographs of the missing person to the general public in hopes that someone will notice the missing person and alert authorities." Although there are many possible reasons why missing persons alerts often fail, Lampinen and Moore (2016b) contend that one contributing factor is a failure of a specific type of event-based prospective memory referred to by as *prospective person memory*: remembering to carry out a specific action when one encounters a designated person. Various lines of evidence indicate that prospective person memory is highly vulnerable to forgetting. For example, after participants in laboratory and classroom experiments have been instructed to look out for a particular person who they initially see in a photo or video, they later frequently fail to identify the individual in various settings, such as in a classroom or a location in a campus dining hall where students have to pass to enter. This failure occurs even under conditions where the target individual is present in the participant's visual field and where the participant is given monetary incentives to report seeing the individual (for review, see Lampinen & Moore, 2016b).

With respect to the above noted ineffectiveness of missing persons alerts, researchers have examined the extent to which it may be attributable to breakdowns in specific aspects of prospective person memory, including attending to the alert, remembering to try to identify the target person, and recognizing the target individual when that individual is encountered (Lampinen & Moore, 2016a; Moore & Lampinen, 2019). While each of these factors likely

plays a role, recent evidence has highlighted the importance of what Moore and Lampinen (2019) have referred to as *strategic monitoring*, that is, drawing on attentional resources to maintain the goal of searching for the missing individual. Participants in a simulated missing person search task who engaged in strategic monitoring made more sightings of the target individual than those who did not, suggesting that a form of absentmindedness contributed to memory failure. As noted by Moore and Lampinen (2019), an important task to improve the effectiveness of missing persons alerts would be to develop procedures for increasing strategic monitoring in real-world cases.

Misattribution and Suggestibility

Misattribution refers to attributing a memory or idea to the wrong source, and suggestibility refers to misinformation or misleading suggestions that result in implanted memories. Misattribution errors can occur without misleading suggestions, but memory errors resulting from suggestibility always involve misattribution. Because the two are closely related, and are often relevant to the same applied settings—most prominently, eyewitness testimony and forensic interviewing—I consider them together here. I begin by discussing studies documenting false recall and recognition in clinical decision making, which mainly concerns misattribution errors. Next, I consider recent research regarding misattribution and suggestibility related to the Internet and social media, and then discuss developments related to their role in legal settings.

Clinical Decision Making

A growing body of research has used concepts and findings from cognitive psychology to analyze how clinicians in psychological and medical settings use their knowledge and experience to make decisions and generate diagnoses about various kinds of patients. Two related frameworks that have important implications for memory are fuzzy trace theory, which makes a key distinction between verbatim and gist representations (e.g., Reyna et al., 2016), and schema theory, which focuses on the role of organized knowledge in encoding and retrieval of new memories (e.g., Alba & Hasher, 1983). Both perspectives have been applied to the analysis of clinical decision making, where there is evidence that expert clinicians, compared with novices, tend to rely on abstract, gist-based representations and schematic knowledge structures that result from their experience and accumulated expertise (Blalock & Reyna, 2016; Weine & Kim, 2019). Relying on gist-based and schematic knowledge can have beneficial effects on clinicians' ability to remember abstract or gist-like diagnostic information that is relevant to clinical decision making, but it can also result in poorer memory for specific diagnostic details (e.g., Brailey et al., 2001; Marsh & Ahn, 2012; Witteman & Tollenaar, 2012). Most relevant to the present concerns, recent studies indicate that experienced clinicians can be especially susceptible to false recall and recognition of diagnostically relevant information, reflecting the operation of misattribution and also the memory sin of bias, where an expert clinician's current knowledge can contribute to erroneous memory.

Webb et al. (2016) compared memory for hypothetical case vignettes in expert clinicians with that of lay judges: undergraduates in an introductory psychology course who had not

yet received instruction in psychological disorders. All participants were given three case vignettes of patients with psychological disorders that included a simple case, a complex-coherent case involving a likely set of symptoms, and a complex-incoherent case involving an unlikely set of symptoms. On a recall test administered after a brief delay, experts recalled more details that had been presented in the vignettes than did nonexperts, but they also produced more false recalls of symptoms that had not been presented. Lay judges produced similar numbers of false recalls for all three types of vignettes, whereas experts produced the fewest false recalls for the complex-coherent vignettes and the most false recalls for the complex-incoherent vignette. Webb et al. suggested that increased false recall among experts for the complex-incoherent vignette reflected the influence of schematic knowledge (i.e., in attempting to make sense of the complex-incoherent case, experts “were forcing information together that logically does not relate into a relatable theme or existing schema”; 2016, p. 395). One limitation of this study, however, is that the two groups differed substantially in age.

Foster et al. (2017) reported broadly similar findings in a study that examined schema formation during clinical training among an entirely undergraduate population. Students in a general psychology course were randomly divided into two groups; the training group received training in recognizing diagnostic features of generalized anxiety disorder (GAD) by studying vignettes containing critical features of GAD, whereas the control group was exposed to vignettes that did not contain any information about GAD. Both groups were then exposed to a new vignette describing a case of GAD in which two common diagnostic features of GAD—uncontrollable worry and restlessness—were not included. On subsequent recall and recognition tests, the trained participants falsely recalled “uncontrollable worry” and falsely recognized “restlessness” at a significantly higher rate than did participants in the control group, which Foster et al. attributed to the formation of a schema (i.e., organized knowledge regarding GAD) in the trained group. Weine and Kim (2019) reported a related type of misattribution error in a study of how practicing clinicians and clinical trainees remember realistic case vignettes for which they were initially asked to provide a diagnosis. The vignettes consisted of events that were either traumatic or nontraumatic, reactions of patients to those events that were either intense or mild, and subsequent behaviors that were either severe or mild. On a recognition test, participants were shown brief descriptions of events, reactions, and behaviors that had appeared in the vignettes along with related events, reactions, and behaviors that had not appeared previously. Expert clinicians had greater difficulty distinguishing the true and false items than did clinical trainees, and years of clinical experience, but not age, was negatively correlated with recognition accuracy.

Both experts and trainees, however, were more likely to misremember what Weine and Kim (2019) called causally incoherent cases, where the severity of the patient’s reaction was disproportionate to the event or behavior, as coherent than to misremember causally coherent cases as incoherent (e.g., they tended to falsely remember reactions that aligned with the strength of behaviors). Thus, while this study provides some evidence that schemas associated with expertise resulted in memory distortion, it also reveals a common tendency for both experts and trainees to produce misattribution errors that reflect more causal coherence in their memories for case vignettes than was actually present.

Although more research is needed to examine the nature and prevalence of misattribution errors in clinical decision making, the findings of the aforementioned studies are broadly consistent with perspectives such as fuzzy trace theory and schema theory, and also have potentially significant implications for clinical practice because they highlight that experienced clinicians may be especially susceptible to schema-based misattribution errors.

Internet, Social Media, and Fake News

With the emergence of the Internet age, smartphones, and social media, interest in and concern about misattributed and suggested memories has increased, especially regarding the potential for manipulated or fake news items to serve as a source of misinformation (for reviews, see Brashier & Marsh, 2020; Brashier & Schacter, 2020; Pennycook & Rand, 2021). Several findings have emerged with implications for the operation of misattribution and suggestibility in applied settings.

First, recent research has extended to fake news one of the best-known findings in the domain of misattribution, the *illusory truth effect*, which occurs when repetition of a statement, even a false statement, increases the likelihood that people will judge that statement to be true—a misattribution based on enhanced fluency or familiarity (Begg et al., 1992; Hasher et al., 1977). Pennycook et al. (2018) showed that the illusory truth effect holds for repeated fake news stories that had actually been posted on Facebook, including implausible stories and those that were flagged as contested by factcheckers (see also Fazio et al., 2019). Cavillo and Harris (2022) reported an illusory truth effect for repeated true and false news headlines when they were presented as statements (e.g., “Mark Zuckerberg Posts About Orgies on Little St. James Island”) but not when they were presented as questions (e.g., “Did Mark Zuckerberg Post About Orgies on Little St. James Island?”), addressing concerns that fact-checkers’ practice of posting questions about fake headlines might backfire by increasing illusory truth (for related evidence, see Brashier et al., 2020, and for a comprehensive analysis of work on illusory truth, see Henderson et al., 2022).

Second, fake news can serve as a source of misinformation that creates false memories. Murphy et al. (2019) found that almost half of the participants in their study of memories for events related to a 2018 referendum that resulted in the repeal of the eighth amendment to the constitution of Ireland, which is responsible for restrictive abortion laws, claimed to remember an event depicted in a fake news headline and photo. Further, providing evidence that the sin of bias also influenced responding, they reported some evidence that a higher percentage of participants who voted “yes” to repeal the amendment reported false memory for fake news that made the “no” side look bad (compared to fake news that made the “yes” side look bad), whereas the opposite was observed for participants who had voted “no” (for discussion of related evidence, see Clinch et al., 2021; Schacter, 2022a).

Third, evidence is emerging concerning factors that can impact false memories for fake news stories. Murphy and Flynn (2022) examined whether such false memories might be especially prevalent following exposure to deepfake videos, which use artificial intelligence algorithms to create extremely realistic and convincing audio-visual recordings in which individuals are depicted engaging in actions and behaviors that they never actually performed. In an initial experiment, Murphy and Flynn exposed participants to two fake

news stories (one regarding former President Barack Obama, the other a remake of the movie *The Shining*) in the form of a deepfake video, text alone, or text with photos. False memories occurred when participants claimed in response to a series of questions that they recalled seeing or hearing about the fake news event, remembered that it actually happened, or recalled seeing the remake of the movie in a specific setting or hearing about it. Some participants reported false memories of the fake news events conveyed in each format. The deepfake video of *The Shining*, but not Obama, elicited a significantly higher false memory rate than the other formats. In their second experiment, they carried out a similar comparison using a higher quality deepfake video to present a fake news story about the socialite Kim Kardashian. There was no difference in false memory rates across formats, even though participants rated the deepfake video as extremely realistic and likely to be convincing to others. Given these mixed results, further studies will be required to assess whether the increased false memory rate for *The Shining* deepfake is specific to that video or extends to other kinds of deepfakes, and if so, what factors contribute to elevated false memories for deepfakes.

Murphy et al. (2021) examined whether exposure to push polls increases the incidence of false memories for fake news stories. Push polls refer to polling questions that are intended to influence a respondent's vote by planting implied misinformation (e.g., "Would you be more or less likely to vote for John McCain if you knew he had fathered an illegitimate black child?"; Murphy et al., 2021, p. 693). Murphy and colleagues conducted four experiments in which they asked push poll and other questions about both well-known public figures and fictitious people; they found consistent evidence that exposure to the push poll questions increased the incidence of false memories for related fake news stories involving these individuals. The effect was larger after a delay of a week than a few minutes, suggesting that it is at least partly attributable to poor source memory.

A study from Xiong et al. (2022) suggests that the process of associative inference impacts recognition of fake news items. Associative inference is an adaptive process that allows people to combine information from distinct episodes (A-B, B-C) to make novel connections that have not been directly experienced (A-C; e.g., Zeithamova & Preston, 2010). However, making such associative inferences can increase source misattributions regarding the original episodes, such that details actually present in, for example, a previously studied B-C episode are mistakenly remembered as part of the related A-B episode (Carpenter & Schacter, 2017; Carpenter et al., 2021). In Xiong et al.'s experiments, during Phase 1, participants were shown real news items in the form of A-B and B-C Tweets (e.g., an A-B Tweet linked Mitch McConnell with a ship named Ping May, and the related B-C Tweet linked the Ping May with cocaine hidden in the ship). During Phase 2, participants took a recognition test that included some new fake news items. In two experiments, Xiong et al. found that in Phase 2, participants were more likely to falsely recognize having seen during Phase 1 a fake news Tweet (e.g., cocaine found on a cargo ship owned by Mitch McConnell) when it was an A-C item formed by combining elements of the preceding A-B, B-C associative inference items than when a fake news Tweet was not preceded by related A-B, B-C items. However, the perceived accuracy of the fake news items was rated as slightly lower when preceded by associative inference. Thus, while these results suggest that associative inference could

operate to increase false recognition of fake news in real-world settings, they do show that associative inference would also contribute to accepting fake news as real.

Eyewitness Identification

There is perhaps no applied context in which misattribution and suggestibility have received more attention than in legal settings, where the consequences of such memory errors can be severe, as reflected in the ever-mounting tally of wrongful convictions overturned by DNA evidence in which eyewitness misidentification played a role (69% of the first 375 exonerations; see innocenceproject.org and Garrett, 2011). There is also perhaps no applied domain of memory research where our understanding of some key issues has changed as much during the past two decades as in the study of eyewitness identification. Though beyond the scope of this article to discuss in detail, two key developments should be highlighted.

The first development concerns our understanding of the consequences of using simultaneous lineups (where an eyewitness views all suspects at once) vs. sequential lineups (where an eyewitness views suspects one at a time, and makes a ‘thumbs-up or “thumbs-down” identification). Research initiated during the 1980s and 1990s supported the position that sequential lineups, compared with simultaneous lineups, reduce false identifications without a corresponding reduction in hits (see Steblay et al., 2011; Wells et al., 1998). However, studies using signal detection procedures (i.e., ROC curves) fail to show an advantage for sequential lineups, indicating instead that sequential lineups induce more conservative responding – which is desirable because it reduces the chances of false identifications that could arise as a result of misattribution or suggestibility – rather than an increased ability to discriminate between the culprit and innocent suspects (Gronlund et al., 2014; Gronlund & Benjamin, 2018). This signal detection perspective raises important policy issues about the advantages and disadvantages of using a lineup procedure that induces a more conservative decision criterion (for excellent discussion of this issue, see Wells, 2014; Wixted et al., 2014).

The second key development is that our understanding of the relation between confidence and accuracy in eyewitness identification has changed. As discussed by Wixted and Wells (2017), the idea that eyewitness confidence is largely unrelated to eyewitness accuracy had become increasingly accepted in the legal system based on psychological studies. However, Wixted and Wells make a strong case that psychological studies increasingly favor the idea that confidence is closely related to accuracy under some conditions and poorly related under others. Specifically, mounting experimental evidence shows that under conditions in which fair lineups are used and suggestive influences are absent, confidence and accuracy are strongly related, but under conditions that involve unfair line-ups, feedback, or misleading suggestions, confidence can become decoupled from accuracy (see also, Wixted et al., 2015). Indeed, as Wixted and Wells highlight, in a dramatic and well-known eyewitness misidentification case in which Jennifer Thompson confidently but incorrectly identified Ronald Cotton as the man who raped her (Thompson-Cannino et al., 2010), Thompson’s initial identification was indecisive and expressed with low confidence; it was only after receiving confirmatory feedback from police that Thompson expressed her

identification with high confidence (see also, Wells, 2020). To avoid the corrupting effect on memory of influences such as confirmatory feedback and misleading suggestions, Wixted and colleagues (2021) have recommended that a witness's memory should be tested only once. Given the possibly widespread impact of this recommendation on real-world cases, the progress made in this line of research is likely to be among the most consequential recent developments in research on memory sins in applied settings.

Implanted False Memories and Forensic Interviews

By highlighting the corrupting effects of post-event suggestion on memory, the foregoing studies also dovetail with research extending work on implanted "rich false memories" (Loftus, 2003), which demonstrates the damaging effects of suggestion on recall of autobiographical events. This line of research was inspired by the well-known controversy that began in the 1990s concerning whether recovered memories of childhood sexual abuse could be explained as false memories implanted by suggestive procedures used in psychotherapy (for a recent assessment, see Otgaar et al., 2022). Following Loftus and Pickrell's (1995) seminal "lost in the mall" false memory study, numerous subsequent studies showed that a significant minority of participants, typically in the vicinity of 20%–30% of a young adult sample, developed false memories of suggested events that never happened (for review of early studies, see Loftus & Bernstein, 2005). In contrast to those studies, Shaw and Porter (2015) reported that by using a potent suggestive procedure combining visual imagination and social pressure, after three interviews, 70% of their undergraduate sample falsely remembered having committed a crime involving police contact when they were adolescents. Although this proportion far exceeded false memory rates in previous rich false memory studies, Wade et al. (2018) raised concerns about the criteria that Shaw and Porter used to classify participants' reports as false memories. They pointed to previous research (e.g., Lindsay et al., 2004; Scoboria et al., 2017) that distinguished between false *beliefs*, where people accept a suggestion as true and speculate about details of what might have happened, and false *memories*, where people report a subjective experience of remembering the event and recall details of what happened. Wade et al. re-scored Shaw and Porter's results using criteria from previous studies that distinguished between false memories and false beliefs, and they concluded that only about 25–30% of Shaw and Porter's participants met these criteria for false memories, similar to earlier studies; the remaining reports met criteria for false beliefs.

The distinction between false memories and false beliefs is important from a theoretical perspective, but from an applied perspective, Shaw and Porter's finding that their suggestive procedure produced a false belief of having committed a crime in 70% of their participants is still noteworthy because of its possible implications for false confessions, specifically what Kassin and colleagues (e.g., Kassin, 2017; Kassin et al., 2010) call *internalized false confessions*: when people mistakenly come to believe that they have committed a crime, often in response to suggestion and social pressure during forensic interviews. The kind of procedure used by Shaw and Porter could be a useful tool for better understanding how suggestive procedures in forensic interviews can lead to false beliefs of the kind that are involved in real-life cases of false confessions.

These considerations highlight the need for effective procedures to counter the occurrence of rich false memories and false beliefs. Developing non-suggestive forensic interviewing techniques that elicit accurate information has long been of concern to the field, as illustrated by the development of the widely used Cognitive Interview (CI; Fisher & Geiselman, 1992; for a review, see Memon et al., 2010). The CI, which includes several retrieval techniques designed to increase accurate recall of event details in a non-suggestive manner, such as contextual reinstatement and recalling an event from different perspectives, has proven useful not only in forensic settings, but also recently in a public health context as an aid to contact tracing (Evans et al., 2022; cf., Garry et al., 2021). Minhas et al. (2022) developed a version of the CI that they call AICI, which uses a chatbox (rather than a person) to administer the CI and artificial intelligence tools to analyze an individual's report as a basis for developing appropriate follow-up questions. Minhas et al. found that after participants viewed a sexual harassment video, AICI yielded more correct recall and fewer errors than did the standard CI or other control conditions. Future research should examine whether the AICI helps to avoid the emergence of suggested false memories in real-world interviews.

Findings from Oeberst et al. (2021) highlight that even after they have been formed, rich false memories can, to some extent, be reversed. After implanting false memories of plausible autobiographical events in undergraduates during three suggestive interviews in which participants also recalled true events, the researchers found that false memories—but not true memories—could be reduced through the use of two techniques: 1) *source sensitization*, where participants were reminded that memories can arise from sources other than one's personal experience, such as a photo or family narrative; and 2) *false memory sensitization*, where participants were told that repeated cueing could produce false memories and were instructed to report if this consideration might apply to one of their memories. Oeberst et al. noted that some degree of acceptance of the false events occurred even after implementation of their two reversal strategies, which they attributed to persisting false beliefs. While it remains to be determined how broadly these reversal strategies apply, the findings of Oeberst et al. further highlight the potential importance of the distinction between false memories and false beliefs in applied settings.

Persistence

Persistence is characterized by the presence of unwanted and emotionally-arousing intrusive memories, typically resulting from disturbing or traumatic events, that produce negative effects on psychological well-being and are sometimes associated with clinical psychopathology, such as post-traumatic stress disorder (PTSD; for review, see Brewin et al., 2010). Recent years have witnessed considerable progress in understanding the nature and basis of such intrusive memories (e.g., Cohen & Kahana, 2022; Iyadurai et al., 2018). Most relevant to the present concerns, there has also been impressive progress in applying insights from basic research to the treatment of intrusive memories in clinical settings (Iyadurai et al., 2019; Phelps & Hoffman, 2019). Here I consider two such examples involving research focused on memory reconsolidation and memory suppression, respectively.

Persistence and Memory Reconsolidation

One line of treatment-oriented research has emerged from basic research regarding the phenomenon of *reconsolidation*, which was discovered in studies of laboratory rats showing that retrieval of an experimentally-induced and already consolidated fear memory placed it into an unstable or labile state in which the memory was vulnerable to disruption by a protein synthesis inhibitor known to block the initial consolidation of fear memories (e.g., Nader et al., 2000; for review, see Lee et al., 2017). Applied to intrusive memories in clinical populations, several studies have investigated whether administering propranolol, a beta-receptor blocker and protein synthesis inhibitor that impacts emotional memories (Lonergan et al., 2013), either before or after reactivation of an emotional or traumatic memory, modifies or reduces the impact of that memory. Case studies have been reported in which such an approach is effective in PTSD patients plagued by specific intrusive memories (Kindt & van Emmerik, 2016), and a growing number of randomized clinical trials have recently investigated the effectiveness of this approach in reducing intrusive memories and related symptoms in PTSD patients or recall of aversive material in non-clinical samples. Results have been mixed, as have the conclusions from recent meta-analyses. A meta-analysis by Pigeon et al. (2022) revealed some evidence for the effectiveness of the propranolol/reactivation approach for reducing intrusive memories and related phenomena in both PTSD patients and non-clinical samples. By contrast, in a broader meta-analysis that included both pharmacological and non-pharmacological manipulations, Astill Wright et al. (2021, p. 10) concluded: “We found no overall effect of pharmacological/ECT reconsolidation agents plus MR (memory reminder) procedures on PTSD symptoms, nor any specific effect of propranolol plus MR in subgroup analysis.” Similarly, a meta-analysis by Raut et al. (2022) failed to reveal evidence of a significant effect of propranolol on PTSD symptoms in seven studies in which researchers attempted to block reconsolidation, although there was evidence for a reduction in heart rate after recalling a traumatic memory under the influence of propranolol.

Further research will be required to sort out the reasons for these differing conclusions, but consistently positive results have come from a series of behavioral studies by Holmes and colleagues, who have attempted to interfere with the initial consolidation or the reconsolidation of traumatic memories by having participants play the computer video game *Tetris* shortly after memory reactivation (for an early study, see Holmes et al., 2009; for review, see Monfils & Holmes, 2018). Given that intrusive traumatic memories typically contain vivid visual and spatial imagery, and *Tetris* involves visuo-spatial processing (i.e., manipulation of colored geometric forms to create horizontal blocks of those forms), the researchers hypothesized that playing *Tetris* after memory reactivation would interfere with the visuo-spatial components of an intrusive memory. In two experiments involving healthy participants in which memory reactivation was conducted 24 hours after participants watched a film depicting violent death and serious injury, James et al. (2015) reported evidence that intrusive memories of the film, as assessed by diary entries the following week, were significantly lower in the group that played *Tetris* after memory reactivation compared with various control groups.

In a later field study of patients who had experienced real-world trauma, Iyadurai et al. (2018) examined the effectiveness of the reactivation plus *Tetris* treatment for mitigating intrusive memories in people who went to a hospital emergency room following a motor vehicle accident; memory reactivation occurred within hours of the traumatic event. They cued these individuals to recall the most disturbing parts of the accident, and then had them play *Tetris*. A control group, also involved in a motor vehicle accident, subsequently completed an activity log of what they did in the emergency room instead of playing *Tetris*. All participants kept a daily diary for the next week in which they recorded intrusive memories. Participants in the reactivation plus *Tetris* treatment recorded fewer intrusive memories of the accident in their diaries than did participants in the control group.

In a follow-up study, Kanstrup et al. (2021) noted some limitations of the Iyadurai et al. (2018) study (possibly important differences in the administration of experimental and control tasks, no long-term follow-up, only a single type of trauma investigated) and attempted to remedy them. They studied 41 individuals brought to an emergency room within 72 hours of having experienced one of several different kinds of traumatic events (motor vehicle accident, industrial accident, assault). The experimental group received the reactivation-*Tetris* treatment while in the emergency room via an app delivered to their smartphones, whereas the control group listened to a radio podcast, also via an app delivered to their smartphones. Both groups recorded intrusive memories in a diary for the first week after the trauma and then again for a week during the fifth week after trauma. Replicating and extending the previous findings of Iyadurai et al. (2018), Kanstrup et al. (2021) reported a reduction in intrusive memories for the *Tetris* group compared with the control group both one week and five weeks after trauma.

Whereas the foregoing studies targeted traumatic memories of very recent experiences, Kessler et al. (2018) successfully applied the same approach to reducing the incidence of approximately two-decades old intrusive memories in individuals with PTSD, and Thorainsdottir et al. (2022) reported similar findings in three women with traumatic intrusive memories dating to childhood. It remains to be determined whether the positive results from the *Tetris* studies specifically reflect the operation of the same kinds of reconsolidation mechanisms identified in neurobiological research. Most important for applied concerns, the data provide an empirical basis to support the usefulness of this approach in real-world settings in which intrusive memories result from traumatic experiences.

Persistence and Memory Suppression

A related emerging area of research with applied implications comes from well-known studies that investigated the nature of memory suppression processes using the “think-no think” paradigm first reported by Anderson and Green (2001). In these studies, participants first study lists of unrelated paired-associates (e.g., ordeal-roach), and are later presented with the cue word (e.g., ordeal) together with instructions either to recall the associated item (“think”) or to suppress it from conscious awareness (“no think”; I discuss findings from this paradigm as illustrating the sin of blocking in Schacter, 2021, 2022b). Anderson and Green (2001) initially reported that recall in the “no think” condition was significantly lower than recall in the “think” condition, and that it was also lower than recall for non-tested pairs

that constituted a baseline control. Although some subsequent studies have failed to replicate this effect (e.g., Bulevich et al., 2006; Wessel et al., 2020), meta-analyses have revealed the existence of a modest but significant suppression effect (Anderson & Huddleston, 2012; Stramaccia et al., 2020; for a broad review, see Anderson & Hulbert, 2021).

Most relevant to the present concerns, individuals with PTSD, which is characterized by a heightened occurrence of intrusive memories, exhibit impaired abilities to suppress memories in the think-no think paradigm (Catarino et al., 2015; see also, Streb et al., 2016). In a study using a variant of the standard think-no think paradigm in which words were paired with pictures of common objects combined with fMRI, Mary et al. (2020) studied cognitive and neural aspects of memory suppression in 102 individuals who had been exposed to the 2015 terrorist attacks in Paris, 55 of whom developed PTSD symptoms after the attack (PTSD+) and 47 of whom did not (PTSD-), as well as 73 individuals who did not experience the attacks (non-exposed). Following study of word-object pairs, participants attempted to repeatedly suppress recall of target objects, and were then given a perceptual identification test in which studied and non-studied objects were presented in visual noise and response times were recorded as participants attempted to identify them. All groups showed reduction of intrusive memories with repeated suppression attempts. On the perceptual identification test, participants identified previously studied objects more quickly than non-studied objects, and this priming effect was reduced for previously suppressed objects in the PTSD- and nonexposed groups, but not in the PTSD+ group, thus extending the domain of impaired suppression in individuals with PTSD to implicit memory. FMRI analyses revealed differences in the functional connectivity of regions involved cognitive control (i.e., dorsolateral prefrontal cortex) and memory (i.e., hippocampus and precuneus) in the PTSD+ group compared with the other two groups: PTSD- and non-exposed groups showed decreased coupling between these regions during suppression attempts whereas the PTSD+ group did not. The authors concluded that their results point toward disrupted memory control in PTSD and suggested that developing treatments geared to addressing control deficits represents a potentially fruitful direction for clinical interventions (for related observations from this same sample concerning predictive and reactive control of intrusive memories, see Leone et al., 2022).

Despite the modest size of the think-no think suppression effect, the data from patients with PTSD suggest that it can be useful in identifying clinically relevant suppression deficits, and therefore merits further study in individuals with impaired memory suppression abilities.

Concluding Comments

Based on the research reviewed in this article, it is clear that significant progress has been made during the past two decades in documenting and understanding the impact of memory sins in applied settings. New phenomena have been uncovered, and perhaps even more important, evidence has emerged concerning novel methods and interventions for reducing the negative impact of transience, absentmindedness, misattribution, suggestibility, and persistence. This research is still in its early stages, and more work needs to be done to link findings from the laboratory with applied everyday settings, but compared with the

research landscape when I first discussed the seven sins of memory two decades ago, the progress is impressive.

By focusing on the negative everyday impacts of the memory sins, it is easy to conclude that human memory is fundamentally flawed and unreliable: What kind of memory system would allow a parent to forget a baby in a hot car, make erroneous identifications that result in wrongful imprisonment, generate compelling beliefs about events that never happened, or produce uncontrollable images of past experiences that damage psychological well-being? However, I do not share this view. Although the negative consequences of the memory sins can be severe, these extreme effects constitute just a small part of the overall landscape of memory function and occur only under relatively restricted sets of conditions. Absent those conditions, memory can be highly accurate (e.g., Diamond et al., 2020), contribute to psychological well-being (e.g., Walker & Skowronski, 2009) and support everyday functioning in a way that is essential for survival (e.g., Nairne & Pandeirada, 2016).

Moreover, as noted earlier, a key component of my initial conceptualization of the seven sins (Schacter, 1999, 2001) is that far from reflecting the operation of a flawed system, the sins are better conceived as costs we pay for adaptive aspects of memory that largely serve us well. Although beyond the scope of this article to discuss, evidence favoring this adaptive perspective has increased substantially during the past two decades, both with respect to various forms of forgetting (e.g., Bjork & Bjork, 2019; Fawcett & Hulbert, 2020; Nørby, 2015) and distortion (e.g., Howe, 2011; Schacter et al., 2011, in press). This adaptive perspective has led my colleagues and I to propose that some memory errors are products of a system that is tuned to use the past to simulate future experiences, and both cognitive and neuroimaging evidence support this view (e.g., Schacter, 2012, 2021; Schacter & Addis, 2020). An important task will be to explore the applied implications of an adaptive perspective.

In a thoughtful essay, Baddeley (2022) asked whether the study of memory has become unduly preoccupied with its sins. To the extent that a focus on the memory sins blinds us to the numerous strengths of memory, Baddeley's concern is justified. But that need not be the case if one takes an adaptive perspective on the memory sins. Moreover, given the important—sometimes lifechanging—effects of these sins in applied settings, continuing to explore their nature and consequences constitutes a critical task for memory research.

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