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Why Forget? On the Adaptive Value of Memory Loss

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Abstract

Is forgetting mostly a positive force in human life? On the surface, this seems to not be the case, and people often associate memory loss with frustration in their everyday lives. Yet, forgetting does not have exclusively negative consequences; it also serves valuable, indeed vital, functions. In this article, I review and reflect on evidence from various areas of research, and I argue that forgetting serves at least three broad purposes. First, it is part of emotion regulation, and it promotes subjective well-being by limiting access to negative memories and by reducing unpleasant affect. Forgetting thereby allows for positivity and painlessness. Second, it is involved in knowledge acquisition, and it provides a basis for obtaining semantic and procedural knowledge by allowing for abstraction and automatization. Third, forgetting is part of context attunement, and it orients information processing for the present and the future by facilitating environmental sensitivity and by ensuring that knowledge is current, which enables timeliness and updating. Overall, I suggest that forgetting helps people to be happy, well-structured, and context sensitive, and thereby that it serves fundamentally adaptive functions.

Keywords

memory, forgetting, functions, adaptation, emotion, learning, context

What are the positive functions of normal forgetting? This question may baffle and even offend those who consider forgetting a nuisance or a serious problem. It is certainly easy to see forgetting as counterproductive and negative because it is the loss of information over time or the inability to recover once retrievable information. Moreover, forgetting can be annoying and embarrassing because it entails being unable to remember a fact, an event, or a skill. Nevertheless, forgetting also has adaptive consequences, and one may be better off forgetting some things than none at all. In this article, I attempt a functional analysis, and I consider which demands (e.g., needs and objectives) forgetting serves in natural contexts (see Bruce, 1991). This approach is inspired by the suggestion that the use and utility of memory are important considerations (e.g., Anderson & Milson, 1989; Baddeley, 1988; Nairne & Pandeirada, 2010), and it is related to the idea that information processing often benefits from being appropriately ignorant and limited in scope (e.g., Hertwig & Todd, 2003; Hess, 2014; Payne & Sekuler, 2014).

In attempting to systematically review and reflect on the beneficial nature of forgetting, I seriously consider William James's (1890) claim that "In the practical use of our intellect, forgetting is as important a function as recollecting" (p. 679). Not only James but also Nietzsche (1873–1876/1998), Ribot (1882), and Breuer and Freud (1893–1895/1955) proposed that forgetting serves positive functions. Yet, only limited numbers of researchers in recent works have considered in detail the benefits of forgetting, and they have done so in relation to specific domains such as memory updating (Anderson & Milson, 1989; R. A. Bjork, 1989; Schacter, 2001; Schooler & Hertwig, 2005; Storm, 2011a; detailed portrayals of these works are discussed later). The positive functions of forgetting seem to have been somewhat neglected for several reasons. First, people perceive mostly the negative consequences of forgetting in their daily lives. Owing to its nature, successful forgetting typically goes unnoticed. A second reason may be the traditional focus on learning as the retention of information. This focus can be equated with the view that loss of information is the opposite of learning. Finally, the historical prevalence of

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the "storehouse" metaphor, which suggests that memories are accurately and orderly stored and retrieved, may have led to a descriptive conceptualization of forgetting and may have hindered a more functional approach. Yet, it is important to examine not only the "how" but also the "why" of forgetting. For example, a functional analysis can be informative as to which features of forgetting are important and can help establish criteria for measuring progress (see Nairne & Pandeirada, 2010).

Superior Memory: On Remembering Too Much

If forgetting is mostly helpful, then it is to be expected that a superior memory might sometimes have detrimental effects on information processing. Indeed, Jill Price (also known as "AJ") is a middle-aged woman who is dominated by her memory (see Parker, Cahill, & McGaugh, 2006). AJ is a relatively well-functioning individual with an IQ within the normal range. What makes her extraordinary is her ability to remember an immense amount of autobiographical information without attempting to do so. For example, when unexpectedly given a specific date from the previous 20 years as a cue, she immediately recalls accurate and detailed memories of where she was, what she was doing, and what events took place on that day. Furthermore, whenever AJ recollects a personal memory, it cues the retrieval of another related memory in an unstoppable cascade. This quote demonstrates how AJ suffers from her unusual abilities; according to her, recall "is non-stop, uncontrollable and totally exhausting. . . . Most have called it a gift but I call it a burden. I run my entire life through my head every day and it drives me crazy" (Parker et al., 2006, p. 35). AJ is one among several individuals with highly superior autobiographical memory (HSAM; Ally, Hussey, & Donahue, 2012; LePort et al., 2012). All such individuals remember personally significant information exceptionally well but typically perform on average on standard laboratory tests of memory. Moreover, individuals with HSAM exhibit an atypical high level of obsessive behavior that seems tied to their mnemonic abilities (LePort et al., 2012). For example, they often organize their memories chronologically or feel an urge to write them down. Yet, not all individuals with HSAM view their special ability in a negative light like AJ (LePort et al., 2012).

The case of AJ is intriguing, because it demonstrates how remembering too much may be problematic and also how a superior memory is not necessarily associated with excelling in other areas of life. In fact, AJ reports that her performance in school was average and that she has held ordinary jobs (e.g., as an executive assistant; Parker et al., 2006). Similarly, in other investigations of individuals with HSAM, researchers have made no mention of above-average performances in the educational system or the work domain (Ally et al., 2012; LePort et al., 2012). The case of AJ and, to a certain extent, other cases of HSAM matches the classic case of Solomon Shereshevsky (also known as "S") as reported by Luria (1968). S was able to remember vast amounts of information but was also overwhelmed by overly comprehensive memories that comprised irrelevant details that he had to learn to intentionally forget, and he was described as "disorganized, changing jobs dozens of times" (Luria, 1968, p. 158). Also, it is interesting to note that the savant syndrome, which involves highly superior abilities in a limited domain, always draws on a massive memory (Treffert, 2009) but also is associated with serious mental disabilities and pervasive deficits in social functioning (see Boucher & Bowler, 2008). Said differently, having an exceptionally good memory is no guarantee that one is a well-functioning individual. However, a superior memory is sometimes desired, and the mentioned cases should be distinguished from instances of exceptional memory capabilities caused by the use of mnemonic techniques (see Worthen & Hunt, 2011). Such techniques are deliberately used, and the memories they uphold are by definition not unwanted.

Conceptual Considerations: On the Nature and Functions of Forgetting

As the individual stories depicted earlier illustrate, too perfect a memory can be a burden, and some forgetting is useful. Another indication that forgetting may be beneficial comes from a consideration of its nature.

Graded and context-dependent forgetting

Whereas forgetting may be seen as destructive by a casual observer who associates it with memory deletion, it may be viewed more favorably when one recognizes that it is a graded and context-dependent phenomenon. Forgetting is not (or at least very seldom is) part of an all-or-nothing phenomenon in which a memory is either completely absent (erased) or entirely present (exists). This fact is captured by the view that memory inaccessibility does not necessarily imply memory unavailability (Tulving & Pearlstone, 1966)—a view that is adhered to by most theories of forgetting. For example, theories in which forgetting is considered to result from memory inhibition typically suggest that some factor causes performance on a memory task to fall below a neutral baseline condition, and that inhibition is associated with decreased representational activation rather than an absolute loss of memory (e.g., Anderson, 2003; Depue, 2012; Storm & Levy, 2012). Also, forgetting does not seem to be part of an all-

or-nothing phenomenon because something can be forgotten under some circumstances, for example, in a test of free recall, but not others, such as in a test of recognition (e.g., Basden, Basden, & Gargano, 1993; Green, Sedikides, & Gregg, 2008). Furthermore, forgetting may occur with respect to some, but not other, parts of a certain memory—for example, nondeclarative emotions associated with a particular event can be forgotten, although declarative (conscious and explicit) memory for that event is retained (e.g., Schiller et al., 2010). Finally, even if forgetting might hypothetically be a part of an all-or-nothing phenomenon, it is impossible to know whether something has been completely forgotten. The fact that a memory is not recalled at one point in time does not mean that it will not eventually come to mind in the future (Erdelyi, 2010; Tulving, 1974).

When forgetting is understood as graded and context dependent, it can be considered beneficial because it does not eliminate memories from the brain. Rather, it hinders their expression. Should the memories later be needed, they may become accessible again—for example, owing to a change in context or a directed search effort.

Motivated forgetting

Forgetting is not only graded and context dependent but it is also motivated by personal values and goals, such as self-protection (Skowronski, 2011), self-consistency (Conway, 2005), and self-enhancement (Sedikides & Gregg, 2008), in at least two ways. First, some memories are unwanted and can be intentionally forgotten (Anderson & Levy, 2009; MacLeod, 1998). For example, continuously suppressing certain memories makes them less likely to be recalled later on (Anderson & Green 2001). Second, forgetting creates an "empty space" in which positive memory construction may take place. Much research has shown that retrieval is a constructive process that can be strongly influenced by postevent information or gist-based rationalization, for example. Although most researchers have stressed that memory construction is problematic, and that memories can become distorted or fabricated (e.g., Loftus, 2004; Wells & Olson, 2003; Yapko, 1997), other researchers have suggested that malleability is not a flaw and that it reflects the operation of adaptive processes (e.g., Boyer, 2009; E. J. Newman & Lindsay, 2009; Schacter, Guerin, & St. Jacques, 2011). Indeed, the construction of inaccurate memories may be one way that humans deal with an uninformative or unacceptable past. Such distorted (or even false) memories may be adaptive if they form the basis for desired narratives that do not conflict with objective and factual aspects of the world. For instance, a memory of an only moderately positive meeting with a person that one wants to get to know better may be reconstructed when negative impressions are replaced with positive interpretations. Forgetting seems to be quite necessary for such a process because it allows one to escape unwanted aspects of the past. Moreover, simulation of future episodes, which is important for planning in everyday life, requires a flexible extraction and recombination of details from various past events (Hassabis & Maguire, 2007). Such simulation does not involve literal reproduction of stored memories and has been suggested as being a highly constructive process (Schacter & Addis, 2007). If memories were not forgotten, such construction could not take place.

The nature of forgetting hints at why it often is a positive phenomenon. Yet, forgetting can also be considered a positive phenomenon because it serves particular adaptive purposes. On a general level, I suggest that forgetting functions as a sorting device that helps people discard unneeded information. On a more specific level, I suggest that forgetting serves important functions in relation to at least three domains in human life—namely, emotion, cognition, and behavior. Specifically, forgetting may regulate emotion, structure cognition, and make behavior context sensitive and thereby serve the three functions of emotion regulation, knowledge acquisition, and context attunement. This idea is illustrated in Table 1 and is described in detail in the following pages.

Forgetting and Happiness: On Emotion Regulation

Forgetting may influence emotion and may promote happiness. People thrive when they often experience positive affect, and the rate of positive to negative emotions experienced over a given time period predicts ratings of subjective well-being (Kahneman, 1999; also see Fredrickson, 2013). Because memories are known to elicit emotions, it seems more important to retain positive, rather than negative, memories if one wishes to often experience positive affect. Indeed, adults overall do remember twice as many positive, rather than negative, autobiographical memories (Berntsen & Rubin, 2002; Sanitioso, Kunda, & Fong, 1990; Walker, Skowronski, & Thomson, 2003). Furthermore, compared with younger adults, older adults especially remember more positive, rather than negative, memories (Mather & Carstensen, 2005). One reason for this prevalence of positive memories seems to be that positive events are more frequent than negative events (Walker, Skowronski, & Thomson, 2003). Another reason may be the existence of a reminiscence "bump" with respect to positive, but not negative, memories from young adulthood (Berntsen & Rubin, 2002; Rubin & Berntsen, 2003; Rubin, Wetzler, & Nebes, 1986). I focus on a third possible reason—namely, that people seem to selectively forget negative experiences.

Table 1. Proposed Functions and Goals Served by the Different Sorts of Forgetting, and the Positive Effects Enabled by These Kinds of Forgetting

Function of forgetting	Goal of forgetting	What is forgotten	What forgetting enables
Emotion regulation	Remembering more positive than negative experiences	Negative declarative memories	Positivity
	Not feeling bad about negative experiences	Negative emotions	Painlessness
Knowledge acquisition	Learning facts and general knowledge	Redundant and false information	Abstraction
	Learning how to efficiently carry out actions	Unnecessary steps and conscious knowledge	Automatization
Context attunement	Relating to the present and the future	Distant and inappropriate information	Timeliness
	Renewal of information that is no longer correct	Outdated information	Updating

The thesis that forgetting helps people cope with negative experiences was famously suggested by Breuer and Freud (1893–1895/1955). Their conceptualization remains highly controversial, but the basic idea that it often is adaptive to forget negative memories and to retain positive memories seems much less contentious. In general, people may prefer to forget negative experiences and to cherish positive experiences because the former are unpleasant, and often inconvenient, whereas the latter are associated with joy and confidence. Selective forgetting of negative, declarative memories may then help to obtain a healthy ratio of positive to negative affect and may leave room for a focus on positive emotions and optimistic thinking—that is, what has recently been termed *positivity* (Fredrickson, 2009). Also, when it is not possible to completely disregard declarative memories of negative experiences, it might still be possible to dampen the unpleasant emotions associated with recalling those experiences. The goal of this kind of forgetting would be to not feel bad about negative experiences, and such forgetting may enable what can be called *painlessness*.

The idea that selective forgetting of negative memories is often helpful does not imply that all negative memories should be forgotten. Some such memories allow a person to avoid future negative events, and they serve a purpose. However, if otherwise healthy people were preoccupied with negative memories most of the time, they would feel miserable. Also, fixation on negative memories is associated with psychopathology—for example, depression (Dalgleish & Werner-Seidler, 2014; Hertel, 2004) and posttraumatic stress disorder (Brewin & Holmes, 2003; McNally, 2006). Indeed, selective forgetting of negative memories may facilitate mental health and may be a part of emotion regulation—that is, people's attempts to control which emotions they experience, when they experience them, and how they experience and express them (Gross, 1998; Koole, 2009). Forgetting as part of emotion regulation may target either declarative or nondeclarative (implicit) memory, as will be elaborated on in the following section.

Positivity

Forgetting as part of emotion regulation may target declarative memory in the encoding or retrieval phase. The notion that forgetting may take place during memory encoding is somewhat unconventional (see Roediger, Weinstein, & Agarwal, 2010), but it is in accordance with recent suggestions that a focus on what happens during the early stages of memory processing can inform the understanding of forgetting (e.g., Anderson & Hanslmayr, 2014; Cubelli, 2010; Wixted, 2005). However, the notion that forgetting may target retrieval is of course quite conventional.

Expressive suppression. There is evidence that some emotion regulation strategies deployed during encoding influence subsequent memory performance. One such strategy is expressive suppression, which involves attempts to conceal behavioral signs of emotion (e.g., facial expressions) and which makes people appear less emotional (e.g., calmer). When such suppression demands effort, it follows that it might be cognitively costly. Specifically, self-monitoring and corrective processes involved in suppression may divert resources from other cognitive activities (Franchow & Suchy, 2015; Richards, 2004). In fact, expressive suppression has been found to degrade memory. For example, in one study, participants watched a short film known to elicit negative emotion, and they were told to suppress emotional responses (Richards & Gross, 2000, Experiment 1). When unexpectedly given a cued-recognition test, these participants remembered the auditory and visual details of the

film more poorly than participants in a control group who had been instructed to just watch the film. In additional studies, researchers have used other kinds of stimuli, procedures, and tests, and they have confirmed that expressive suppression degrades memory (Bonanno, Papa, Lalande, Westphal, & Coifman, 2004; Dillon, Ritchey, Johnson, & LaBar, 2007; Richards, Butler, & Gross, 2003; Richards & Gross, 1999, 2006). Furthermore, such degradation occurs exclusively because of expressive suppression. For example, reappraisal, which is another emotion regulation strategy, does not lead to degraded memory (Richards et al., 2003; Richards & Gross, 2000, Experiment 3) and can actually improve free recall (Dillon et al., 2007) as well as recognition (Richards & Gross, 2000). In sum, people may not intend for expressive suppression to influence subsequent memory, but it does so nonetheless. From an emotion regulation perspective, this is a favorable consequence because it means that people are not very likely to remember experiences that they initially did not like much.

Mnemic neglect. Research on memory for self-threatening information also suggests that emotion regulation at the encoding stage can affect subsequent memory performance. According to the mnemic neglect model (Sedikides & Green, 2009), people avoid or shallowly process self-threatening information because they strive for a positive self-concept. Moreover, the model posits that threatening information gets separated from stored self-knowledge, whereas nonthreatening information is integrated with that knowledge (Pinter, Green, Sedikides, & Gregg, 2011). Accordingly, people recall self-threatening information poorly, relative to that which is self-affirming; forgetting unpleasant, personally relevant information thereby functions as a self-protective mechanism.

The mnemic neglect model is based on studies in which participants are provided with self-descriptive statements and then take a memory test. In one study (Sedikides & Green, 2000, Experiment 1), participants were assigned to either a self- or other-referential condition, and they took a personality test that was apparently unique in providing feedback regarding which behaviors the participants (or an unknown other person) were likely to perform. A surprise test of free recall revealed that participants recalled negative trait-central, self-referential behaviors poorly (e.g., "I would be unfaithful when in an intimate relationship") relative to positive trait-central, self-referential behaviors (e.g., "I would follow through on a promise made to friends") and other-referential behaviors. In later studies, researchers have confirmed this result (Green, Pinter, & Sedikides, 2005; Green & Sedikides, 2004; Green et al., 2008; Green, Sedikides, Pinter, & Van Tongeren, 2009; Sedikides & Green, 2004; but also see L. S. Newman, Sapolsky, Tang, & Bakina, 2014, who have shown that the result depends on the test procedure used). Also, evidence suggests that forgetting negative material is strategic because there are some interesting instances in which mnemic neglect is absent. When information is not perceived as highly diagnostic of negative traits (Green & Sedikides, 2004), when it refers to behaviors that are regarded as malleable (Green et al., 2005), and when a self-improvement motive has been subtly activated (Green et al., 2009), people do remember threatening information. Furthermore, people do remember information that may help them avoid a future threat, as when they process information for its survival relevance (Nairne, 2010). In sum, people exclusively forget important, negative self-referential information about which they believe they can do nothing.

Memory suppression. Expressive suppression and mnemic neglect affect memory encoding, as just described. Emotion regulation may also involve engaging executive control processes during memory retrieval. Experiments with the think/no-think (TNT) paradigm demonstrate that people can forget unwanted memories when instructed to continuously suppress them (for reviews, see Anderson & Hanslmayr, 2014; Anderson & Levy, 2009; but see Wegner, 2009, for a review of related research on thought suppression, which generally suggests that such suppression is often difficult). In the TNT paradigm, participants are asked to learn unrelated cue–target pairs (e.g., words or pictures). Then, in the critical phase, participants are told to intentionally suppress (avoid thinking about) a subgroup of the targets when they are shown the related cues. With regard to the remaining cues, they are told to recall (think about) the target. A finding that has been reported several times is that fewer of the targets subjected to suppression are recallable compared with a group of baseline targets not involved in the critical phase of the experiment (e.g., Anderson & Green, 2001; Benoit & Anderson, 2012; Depue, Banich, & Curran, 2006; Küpper, Benoit, Dalgleish, & Anderson, 2014; Nørby, Lange, & Larsen, 2010). However, in some studies, researchers have also failed to replicate this effect (e.g., Bergström, Velmans, de Fockert, & Richardson-Klavehn, 2007; Bulevich, Roediger, Balota, & Butler, 2006; Mecklinger, Parra, & Waldhauser, 2009), leading some to consider below-baseline forgetting as an elusive phenomenon (e.g., Raaijmakers & Jakab, 2013). Overall, below-baseline forgetting can be produced with the TNT paradigm, but further research is warranted to clarify why such forgetting is sometimes present and sometimes not.

There is evidence that negative memories can be suppressed in the TNT paradigm. In one study, Depue et al. (2006) used the TNT paradigm with face–word pairs (Experiment 1) and face–picture pairs (Experiment 2),

and they found that negative items showed a larger suppression effect than neutral items. Also, using the TNT paradigm in a functional magnetic resonance imaging study with face–picture pairs, Depue, Curran, and Banich (2007) found that memories of negative pictures could be suppressed (no neutral condition was used). Furthermore, in an attempt to obtain a higher ecological validity, Küpper et al. (2014) used pictorial stimuli in another TNT study and presented participants with naturalistic reminders to highly aversive scenes; they found that suppression reduced recall probability of scenes as well as the number of details recalled from the scenes (no neutral condition was used). Finally, in three TNT studies, researchers extended these results by showing that neutral and negative words were suppressible to a similar degree (Van Schie, Geraerts, & Anderson, 2013) and that details from both positive and negative autobiographical or episodic (spatiotemporally contextualized) memories can be suppressed (Noreen & MacLeod, 2013, 2014). Yet, a few studies with the TNT paradigm (Chen et al., 2012; Marx, Marshall, & Castro, 2008; Nørby et al., 2010) show that negative memories may also resist being forgotten, under some circumstances, when such memories are especially salient or when control of suppression slips, for example. Overall, the former studies demonstrate that it is possible to intentionally forget unwanted negative memories, but the latter studies suggest that there are boundary conditions determining when this happens.

Painlessness

Emotions may be regulated when negative declarative memories are forgotten, as described earlier. Yet, emotion regulation may also take place when negative nondeclarative memories are selectively forgotten. Two facts make such forgetting possible. First, because several declarative and nondeclarative memory systems exist (Squire, 2004), forgetting may occur in relation to a nondeclarative emotional system, but not other systems, that store a specific memory. Second, under certain circumstances, retrieval can create a time window in which a memory trace is labile, and a part of it can be restored with different contents (Hardt, Einarsson, & Nader, 2010).

Fear extinction. Research on fear extinction suggests that the nondeclarative emotional part of a negative memory may be selectively forgotten (for reviews, see Agren, 2014; Haaker, Golkar, Hermans, & Lonsdorf, 2014). In one placebo-controlled study, healthy participants were administered a beta-adrenergic receptor blocker, Propranolol, before reactivating laboratory-induced fear memories (Kindt, Soeter, & Vervliet, 2009). This procedure completely removed nondeclarative fearful responses 1 day later (when no Propranolol was administered) without affecting the declarative memory of the fear inducing event. Moreover, attempts to reinstate the fearful response failed (also see Sevenster, Beckers, & Kindt, 2013; Soeter & Kindt, 2010, 2012). Other studies have demonstrated that administering Propranolol shortly after exposure to a traumatic stressor may decrease subsequent posttraumatic stress reactions (Famularo, Kinscherff, & Fenton, 1988; Pitman et al., 2002; Vaiva et al., 2003; also see Brunet et al., 2011), possibly because the drug affects memory restorage. Furthermore, some studies have shown that the use of pharmacological agents is not required for blocking restorage if using extinction training in a certain time window (e.g., Agren et al., 2012; Schiller et al., 2010; Steinfurth et al., 2014; but for critical assessments of the effectiveness of such extinction training, see Agren, 2014; Kindt & Soeter, 2013). In one study, healthy participants were engaged in extinction training of a laboratory-induced fear memory (Schiller et al., 2010). In two groups of participants, the fear memory was reinstated by a single presentation of the conditioned stimulus, either 10 min or 6 hr before extinction training, but a third group was not reminded of the fear memory before extinction training. When participants were again presented with the conditioned stimuli without the unconditioned stimulus, there was no spontaneous recovery of the fear response among participants who received extinction training 10 min after reinstatement (within the restorage window), although this was not the case among participants who received this training 6 hr after reinstatement (outside the restorage window) or among participants who did not receive reinstatement. In sum, the nondeclarative part of an aversive memory may be selectively forgotten during retrieval and restorage of that memory.

The fading affect bias (FAB). Work on the FAB (Skowronski, 2011) similarly reveals that the nondeclarative emotional part of a negative memory can selectively change. The intensity of both negative and positive emotions associated with event recall dampens as the time from the original event increases. However, the FAB means that the decrease is not equal for negative and positive emotions. The intensity of the emotions felt at event recall (compared with the emotions felt at event occurrence) tends to fade more quickly for negative episodes rather than for positive episodes, possibly because negative events tend to be less rehearsed than positive events (Walker & Skowronski, 2009). This tendency has been found in several studies with time spans from weeks to years. In some of these studies, researchers have used a retrospective methodology (e.g., Ritchie, Skowronski, Hartnett, Wells, & Walker, 2009) and their results may have been influenced by backward-looking biases in memory. However, other researchers have used prospective diary designs in which participants rated the valence

and intensity of events when they occurred, and then they later tested participants' memories (e.g., Ferguson, 2003; Holmes, 1970; Ritchie & Skowronski, 2008; Walker, Vogl, & Thompson, 1997; also see Bohn & Berntsen, 2007, for a finding consistent with the FAB). For example, in one study, participants handed in diaries of unique events and ratings of pleasantness associated with these events each week for long periods of time (Walker et al., 1997). After a retention interval of either 3 months (Experiment 1), 1 year (Experiment 2), or 4.5 years (Experiment 3), participants retrospectively rated the pleasantness of the events recorded in the diaries. An FAB was found in all three experiments. Also, the FAB has been documented in several different cultures (Ritchie et al., 2015). Overall, the FAB may help people to be optimistic and hopeful because they are not weighed down by overly intense negative memories and may use the relatively more intense positive memories to form positive identities and expectations for the future (Walker & Skowronski, 2009).

Discussion

Healthy people remember fewer negative memories than positive memories. I suggest that one important reason is that people engage in emotion regulation by selectively forgetting negative memories. Such selective forgetting may take place at the encoding or the retrieval phase and in relation to declarative or nondeclarative negative memories. At encoding, expressive suppression of a negative emotion can degrade a subsequent memory of an unpleasant experience. Also, people generally avoid self-threatening information that they believe they cannot act on, and such information is forgotten to a greater extent than self-affirming information. At retrieval, an unwanted, negative, long-term memory can be suppressed, and this may result in forgetting that memory. In these three instances, people selectively forget negative declarative memories. Yet, not only are negative declarative memories forgotten but the emotions associated with negative events are forgotten as well. An aversive memory can be recoded as less emotionally intense if it is retrieved and restored in a certain sensitive time window. Moreover, the intensity of both the unpleasant and the pleasant emotions associated with negative and positive events, respectively, fades over time, but the intensity of the former emotions fades more quickly than the intensity associated with the latter emotions. In these two instances, people do not forget conscious knowledge of the negative events, but over time, they feel less anxious about their unpleasant experiences.

Boundary conditions. Selectively forgetting negative memories may be a reasonable form of emotion regulation. However, people might not benefit from indiscriminate forgetting of negative experiences for several reasons. First, forgetting only mild to moderate intensity experiences may be adaptive. As noted earlier, negative experiences can be important to remember because they can signal future dangers that should be avoided. This might particularly be the case when experiences are associated with intense negative emotions, such as when an assault evokes strong fear. Second, it may be difficult to forget intense negative experiences, regardless of how much one wants to. It is debatable whether traumatic experiences (e.g., an assault) can be forgotten (Gleaves, Smith, Butler, & Spiegel, 2004; McNally, 2004). Also, witnessing spectacular public events (e.g., the 9/11 attack) can result in so-called flashbulb memories that are vivid and durable (but not necessarily entirely accurate; Luminet & Curci, 2009; Talarico & Rubin, 2009). Furthermore, some research shows that people respond with less arousal to neutral or slightly negative events than to positive events of similar strength (the positivity offset), but they respond with more arousal to highly negative events compared with highly positive events (the negativity bias; Cacioppo, Gardner, & Berntson, 1997; Norris, Gollan, Berntson, & Cacioppo, 2010). This asymmetry may be associated with poorer encoding of slightly negative events than slightly positive events, but it may be associated with better encoding of highly negative events than highly positive events because arousal is known to help memory encoding (Kensinger & Schacter, 2008; LaBar & Cabeza, 2006). Consequently, it may be easier to forget slightly negative events than slightly positive events, but it may be more difficult to forget highly negative events than highly positive events. Third, it only seems to be adaptive to forget a minor portion of one's negative memories if one wishes to learn from failures and to maintain sensitivity to the negative events that are an inevitable part of reality. Actually, results from most studies show that only minor portions (typically 10%–15%) of negative memories are selectively forgotten (e.g., Depue et al., 2007; Green & Sedikides, 2004; Ritchie et al., 2009). Yet, even if a person forgets only a few more negative memories than positive memories, this may still be a large enough effect to form a mnemonic basis for a slightly positive mind-set.

Main points. Notwithstanding these caveats, the main message is that forgetting serves an adaptive function in relation to emotion as part of emotion regulation. An individual who remembers negative experiences too well may find it difficult to maintain an optimistic outlook. For example, individuals with HSAM might remember negative and positive events equally well and therefore have trouble seeing the world in a positive light. Fairly little is known about the prevalence of negative to positive memories among individuals with HSAM, but some evidence suggests that such individuals are not overly optimistic but are rather neutral or even slightly pessimistic.

For example, AJ has a history of anxiety and depression (Parker et al., 2006). Moreover, the group of individuals with HSAM investigated in one study scored higher, albeit not significantly higher, than control participants on a common measure of depression (LePort et al., 2012). Thus, superior memory is not necessarily associated with a focus on the positive.

I propose that selective forgetting of negative declarative memories helps to uphold a healthy ratio of positive to negative affect and helps to form a foundation on which positivity can flourish among people in general. Moreover, forgetting negative nondeclarative memories may make it possible for people to not be too upset by bad memories and to allow for painlessness. Overall, forgetting negative memories may help people experience more positive affect than negative affect during their daily lives. When people are not too bound by memories of past failures and sorrows, they may be able to construct a likeable self-image and a hopeful worldview. Moreover, a surplus of positive emotions may lead individuals to be active and explorative most of the time because positive emotions signal safety and that things are going well (Clore & Storbeck, 2006; Norris, Larsen, Crawford, & Cacioppo, 2011; Shiota, 2014). Such approach behavior may lead to a buildup of physical (e.g., bodily strength), mental (e.g., navigational skills), and social (e.g., relations to more capable others) resources, which may be associated with increased vigor (see Fredrickson, 2004).

Forgetting and Cognitive Economy: On Knowledge Acquisition

Forgetting may not only have an effect on emotion but may also influence cognition. Specifically, forgetting may regulate cognitive economy and may help people to cost-efficiently structure their knowledge and to process information with little effort. Complex information processing, such as reasoning and decision making, is efficient only when a restricted amount of appropriate long-term memory is activated and considered (Gaissmaier, Schooler, & Mata, 2008; Gigerenzer, Hertwig, & Pachur, 2011; Hertwig & Todd, 2003). Unrestricted access to vast quantities of information would make it difficult to maintain focus and to make choices. Indeed, people process only a limited number of items or chunks of information at any given time in their daily lives (Cowan, 2010; Galotti, 2007; Miller, 1956). One reason may be that people intentionally focus on certain information (see Johnston & Dark, 1986). Another reason may be limitations in working memory capacity (see Cowan, 2010). A third obvious possibility is that people have access to only a restricted number of memories in long-term memory, owing to forgetting.

The idea that forgetting helps to structure cognition is hinted at by the earlier description of the case histories involving superior memory. This also seems to be what James (1890) had in mind when he wrote that selection on the basis of forgetting "is the very keel on which our mental ship is built" (p. 680). Surprisingly, this idea does not seem to have been pursued to any extent (but see Schacter, 2001, who briefly touched on the topic), despite the fact that at least three sorts of information that people encounter are not worth remembering and would give rise to mnemonic clutter if retained. First, information can be false. For example, if one comes across the notion that birds are mammals, it would make no sense to remember this information because it is incorrect. Second, information can be irrelevant. For example, the particular set of clothes that a lecturer wears when giving a talk on birds is unimportant. Third, information can be redundant. For example, it would be trivial to remember every particular instance when one has encountered a bird with two wings.

I suggest that forgetting functions to help knowledge acquisition when useless memories are lost. Knowledge acquisition requires that information be perceived and stored in the brain, but discarding useless information is also necessary if a sound cognitive economy is to be maintained. Indeed, people quickly forget most events that they experience, and with a retention interval of 1 week or more, very few episodic memories are recallable (Conway, 2009; Linton, 1986; Williams, Conway, & Baddeley, 2008). However, in the process of forgetting episodic memories, important knowledge may be extracted. Forgetting episodic memories may help form semantic memories, which are factual and comprise general knowledge about the world. This may happen when memories of particular situational circumstances are lost in a process of abstraction. Consistent with this idea, it has been suggested that semantic learning is based on an initial acquisition of concrete, context-bound information and a qualitative transformation of this information to more abstract forms (Bransford & Franks, 1976; Hardt, Nader, & Nadel, 2013; Semb & Ellis, 1994). Forgetting episodic memories may also help form procedural memories, which are memories for how to do things and how to perform skilled actions. This may happen when there is decreased conscious involvement and when the steps needed for carrying out an action are reduced, thereby leading to automatization. I deal with these possibilities in the following sections.

Abstraction

Several results indicate that episodic memories are forgotten in the process of acquiring semantic knowledge. In the retention of textual information in laboratory settings, specific details are quickly forgotten, and mainly high-level abstract knowledge is retained over time (Kintsch,

Welsch, Schmalhofer, & Zimny, 1990; also see Reyna & Brainerd, 1995, who suggested that verbatim memories are forgotten more quickly than gist memories). Studies of memory for knowledge obtained in educational settings show the same tendency (Conway, Gardiner, Perfect, Anderson, & Cohen, 1997; Herbert & Burt, 2001, 2003, 2004). On immediate tests, students are typically able to recall specific details about the internal and external learning contexts—that is, thoughts and feelings experienced as well as situational information about the teacher, other students, and the classroom, for example. However, over time, knowledge about the learning context mostly disappears, and primarily abstract, decontextualized knowledge remains. For example, in one study, Conway et al. (1997) tested psychology students' memory for material taught in a university setting. Memory awareness was measured by multiple-choice examinations taken at the end of an introductory course and 6 months later. Initially, correct responses were associated with *remember awareness*—that is, students knew when, where, and how they acquired their knowledge—but after the half-year delay, correct responses were mainly coupled to *know awareness*—that is, students just knew the answers without remembering the circumstances of learning. This remember-to-know shift was confirmed by two other studies, which also demonstrated that students who had a high degree of know awareness tended to have a high degree of semantic organization (Herbert & Burt, 2001, 2003; also see Dewhurst, Conway, & Brandt, 2009). Overall, these studies show that learning often changes from being episodic and literal to being semantic and abstract.

Acquiring concepts and schemata. Exactly how episodic memories transform into semantic memories is unclear, but there are indications. Some theories suggest that concept learning involves the storage of all individual exemplars or instances (so-called exemplar theories; e.g., Hintzman, 1986; Medin & Schaffer, 1978), whereas others posit that it involves the storage of summary representations that are abstracted across exemplars (so-called prototype theories; e.g., Posner & Keele, 1968; J. D. Smith & Minda, 2000). Storage of all individual exemplars provides detailed information but obviously lacks cognitive economy. Accordingly, it may be argued that some complexity minimization and abstraction in concept learning is likely and that people form at least some prototypes (see Burgoon, Henderson, & Markman, 2013; Feldman, 2003; Rouder & Ratcliff, 2006). Forgetting episodic details originally tied to specific exemplars seems to play a role in the latter process, as indicated by the studies in which researchers investigated the remember-to-know shift mentioned earlier. Also, recent research on category induction indicates that forgetting may help form concepts. In several studies, researchers have found that spacing and interleaving versus massing and blocking the presentation of exemplars of different categories during study are associated with both a high rate of forgetting and efficient inductive learning, as measured by the ability to classify new exemplars as belonging to a conceptual category (e.g., Kang & Pashler, 2012; Kornell & Bjork, 2008; Kornell, Castel, Eich, & Bjork, 2010; Vlach, Sandhofer, & Kornell, 2008; Wahlheim, Dunlosky, & Jacoby, 2011). For example, after participants studied multiple paintings by different artists, they were better at identifying new paintings by previously studied artists when different artists' paintings had been presented spaced (interleaved) versus when each artist's paintings had been presented massed (consecutively; Kornell & Bjork, 2008). One reason may be that spaced but not massed presentation allows participants to forget nonrepresentative surface details while accumulating knowledge about central features of the conceptual category (Vlach, Sandhofer, & Kornell, 2008; also see R. A. Bjork, 2015). Said differently, if core characteristics of a developing concept are to be isolated and learned, it may help to forget irrelevant surface details.

People not only learn individual concepts but also form *schemata*—that is, high-level semantic memory structures that represent accumulated general knowledge of particular domains (Bartlett, 1932/1964), for example, about typical (fixed) structural information (e.g., a chair; Minsky, 1975) or frequent events (e.g., a visit to a restaurant; Schank & Abelson, 1977). Schemata are abstract, consist of several interlinked concepts, and provide a context for interpreting new knowledge. They often originate in similarity-based learning (for an alternative possibility, see Ahn, Brewer, & Mooney, 1992). Specifically, similarities among situations that resemble one another may be considered constants and generalized (Rumelhart & Norman, 1978; Schank & Abelson, 1977; Van Dijk & Kintsch, 1983). Forgetting seems to be involved in this form of learning when redundant information is ignored. This is indicated by studies in which participants were presented with instances from one or more categories—for example, insects (in which members of a given category shared a large proportion of features, such as antennas and wings, while differing in several others, such as legs and tails)—and were asked to list distinct features that would enable them to identify specific instances while omitting redundant features (Clapper & Bower, 1991, 1994; also see Clapper, 2007; Daniel, 1972). Learning was indicated by a decreased listing of consistent values (e.g., antennas), as these were uninformative. At the same time, listing of variable dimensions increased (e.g., legs) because these were useful for distinguishing among different instances within a category. As indicated by these results, episodic information that matches constant core features of an evolving schema can be forgotten, thereby avoiding

redundancy in memory representation. Also, differences among related situations can be ignored and forgotten if they seem unimportant. Alternatively, they may be incorporated into the schema as optional variables.

Relearning. Forgetting of irrelevant episodic information may help form concepts and schemata, as just described. Yet, forgetting may also contribute to knowledge acquisition by providing a foundation for efficient relearning. This counterintuitive prediction follows from the important new theory of disuse developed by R. A. Bjork and Bjork (1992). This theory suggests that forgetting is a failure of retrieval (accessibility) and not of storage (availability), and it distinguishes between retrieval strength (i.e., how activated and easy a memory is to get to) and storage strength (i.e., how well-learned and interassociated a memory is with other memories). One important assumption in this theory is that increments in storage strength are a decreasing function of current retrieval strength. In other words, when retrieval strength (performance) is low, more is gained in storage strength (learning) because of further study or practice, possibly because low retrieval strength leads a learner to engage in learning enhancing processing activities that would be bypassed if retrieval strength was high and a memory was easily accessible (for other possible reasons, see R. A. Bjork, 2011). The proposed reverse relationship between retrieval and storage strength implies that forgetting (low retrieval strength) may foster learning (an increase in storage strength), and this is indeed what several experiments have shown (e.g., R. A. Bjork & Allen, 1970; Jacoby, 1978; Storm, Bjork, & Bjork, 2008). These findings have led R. A. Bjork and others (e.g., E. L. Bjork & Bjork, 2011; R. A. Bjork, 1994, 2015) to suggest that conditions, which a learner associates with forgetting and obstacles, can enable long-term retention and should be considered so-called "desirable difficulties." One such condition was mentioned earlier—namely, spacing or interleaving practice or study. Examples of other such conditions are varying the conditions of practice or study (e.g., by changing the context) or having learners actively retrieve memories (e.g., by taking memory tests). Such conditions will often be considered frustrating and difficult by learners but are desirable conditions because they engage encoding and retrieval processes that support long-term retention.

Automatization

Forgetting may not only help acquire semantic knowledge, it may also assist the development of procedural knowledge (skills) through a process of automatization, when explicit knowledge is lost and needless subprocedures are discarded.

Loss of explicit knowledge. Several theories posit that skill development involves actions becoming less dependant on explicit (declarative) knowledge and conscious oversight and that skills end up relying on procedural memory (e.g., Anderson, 1992, 1996; Tzelgov, Yehene, & Naveh-Benjamin, 1997). One proposition is that the development of skills through consistent practice involves a gradual reduction of the need for attention and that automaticity is equivalent to independence from attentional resources (Hasher & Zacks, 1979; Posner & Snyder, 1975; Shiffrin & Schneider, 1977). For example, in the adaptive control of thought (ACT) theory of cognitive architecture (e.g., Anderson, 1996; Anderson et al., 2004), skill acquisition involves refining strategies (so-called productions) for solving particular (e.g., algebraic) problems. One process in skill acquisition is proceduralization, which involves forming implicit, domain-specific productions through the interpretation of explicit knowledge. According to the theory, knowledge is initially represented in explicit form. This knowledge is interpreted by general productions—that is, problem-solving methods that are weak because they are domain general (e.g., analogy and means-end analysis). For example, an inexperienced individual can refer back to a teacher's step-by-step instructions when attempting to solve an algebraic problem. However, with experience, he or she may eliminate references to the explicit knowledge by building the effect of the reference into productions—that is, by just knowing the answer. In accordance with this, the verbal rehearsal of problem-solving steps that characterizes early performance may be dropped (e.g., Anderson, 1983).

To the extent that the same plan is chosen, or the same behavior is enacted on several occasions, conscious consideration becomes superfluous. For example, studies have shown that skilled typists have poor explicit knowledge of what their hands and fingers are doing (Logan & Crump, 2009) and where the keys are positioned (Liu, Crump, & Logan, 2010; Snyder, Ashitaka, Shimada, Ulrich, & Logan, 2014) despite the fact that they are experts in typing. Moreover, it seems best not to remember conscious information regarding an acquired skill because attending to or reflecting on automatic actions may disrupt their performance (a fact that is known as Humphrey's law or "the centipede effect"). The deteriorative effects of attending to skills can be illustrated by a simple observation: Anyone who has experienced eagerness and nervousness related to making a good impression in a social situation knows how difficult it can be to control otherwise fluent motor behavior. The deteriorative effect of paying attention to skilled action has also been formally investigated (Beilock, Carr, MacMahon, & Starkes, 2002; Logan & Crump, 2009; Snyder & Logan, 2013). For example, telling experienced typists to pay attention to their hands disrupts their performance (Logan & Crump, 2009).

The development of procedural knowledge is clearly beneficial because it removes the burden of intentionally considering every action and thereby reduces the load on working memory. Also, the use of automatically activated procedural knowledge frees capacity for other activities and therefore may be considered adaptive (Bargh & Chartrand, 1999; Bargh & Morsella, 2008). In sum, forgetting may help the development of skills by eliminating conscious event memories.

Discarding needless subprocedures. Another circumstance in which forgetting may be helpful for skill learning is when practice involves discarding needless cognitive or motoric subprocedures. For example, in ACT, forming efficient productions involves collapsing a sequence of (sub-)productions into a single production that has the effect of the sequence (McKendree & Anderson, 1987). This process, which is termed *composition*, creates a new, single production that does the same work as the sequence but with fewer steps. Composition is not considered an absolutely necessary component of skill acquisition in more recent versions of ACT (Anderson, 1993), but it is evident that learning sometimes involves limiting the number of steps needed to carry out an action. For example, an expert in algebra does not need to consider intermediate steps when solving a mathematical problem but can instantly produce the correct solution. The instance theory developed by Logan (1988, 1990) also posits that one mechanism in skill development is the reduction of the number of steps needed to carry out an action. According to this theory, initial, nonautomatic performance relies on algorithm computation—that is, on relating a number of internal (and possibly external) representations to each other—to produce an output. Yet, each time an algorithm is executed, a separate memory representation is stored (an instance), so that future processing may avoid algorithm computation and rely entirely on memory retrieval. In other words, skills develop via a transition from algorithm computation (which may be characterized as multistep memory retrieval) to single-step, direct-access retrieval of past solutions from memory. Specifically, with experience, the number of instances (solutions) stored in memory increases, and these will compete with algorithm processing in a race during later retrieval. When many instances have been stored, a person is more likely to rely on these than to engage in algorithm processing. For example, when children learn to add pairs of digits, they initially count the units in both digits to produce the sum. After some practice, an association is formed in memory between a pair of digits and their sum, and the latter may be instantly retrieved from memory.

When practiced but extraneous or wrong subprocedures are discarded during a procedural learning process, actions can be carried out faster and more fluently. Forgetting may facilitate this process, although it is important to acknowledge that this hypothesis has not been empirically investigated. An alternative possibility may be that people do not forget subprocedures, but instead they pay less attention to them when a skill is learned. With regard to the previously mentioned example of children who learn to add pairs of digits, this would mean that they do not forget to count the units in both digits but that they simply do not use this procedure anymore.

Discussion

People are typically able to retrieve a limited amount of applicable knowledge when faced with abstract or practical tasks in their day-to-day lives. I suggest that one reason is that forgetting helps discard useless information during the acquisition of knowledge. The remember-to-know shift observed in learning is not only associated with forgetting episodic memories but also with the development of semantic knowledge, including concepts and schemata. Forgetting of episodic surface details originally tied to specific exemplars may help form concepts, whereas forgetting redundant and nondiagnostic information may help form schemata. When high-level knowledge is generated in the process of forgetting of episodic memories, it allows a person to rely on abstract knowledge, such as pattern recognition, instead of needing to consider several particular instances when reasoning and making decisions. Forgetting may not only help abstraction—it may also assist the development of procedural knowledge. With practice, actions are automatized—that is, they are executed efficiently and quickly. Forgetting seems to facilitate skill development when procedures become independent of explicit knowledge. Indeed, attention to a trained skill can obstruct performance. Also, skills develop through a reduction of the steps needed to carry out actions, and forgetting may be implicated in this process.

Boundary conditions. Forgetting useless, episodic information may help people uphold a sound cognitive economy and avoid information overload. However, this does not mean that all episodic memories are or should eventually be forgotten, for at least three reasons. First, episodic memory comprises a system in itself (Tulving, 2002) and holds personally relevant memories that help people form an identity and maintain a connection to their history (Conway, 2009). Second, although forgetting episodic memories may be adaptive when acquiring abstract or practical knowledge, the significance of such forgetting depends on the relative importance of prototypes versus exemplars in learning and categorization. It seems to be fairly uncontroversial to argue that people form prototypes (and that forgetting may help this

process), but it has been a matter of debate how important such abstractions are compared with representations of specific instances (e.g., see Rouder & Ratcliff, 2006; J. D. Smith, 2014; Tunney & Fernie, 2012), and only future research will clarify this issue. Third, forgetting must be flexible if it is to be helpful in the process of acquiring knowledge. Consider the idea that forgetting of episodic details is involved in conceptual learning. Overall, such learning can profit from a more lasting forgetting of details because most of them are irrelevant. However, sometimes a forgotten detail turns out to be worth remembering. For example, a child who attempts to learn the concept "bird" may have observed several birds fly but only one bird walk, and he or she may have discarded the latter feature as an episodic peculiarity. Yet, birds not only fly but also walk, so the feature "walking" should not be forgotten in a definitive sense. Fortunately, forgetting (low retrieval strength) can foster relearning (e.g., when observing a second walking bird) according to the new theory of disuse (R. A. Bjork & Bjork, 1992) and empirical evidence (Storm et al., 2008).

Main points. Some episodic memories are, and should be, retained. However, most such memories are not, and I propose that forgetting has a beneficial effect on cognition because it helps the economy of cognition. Without forgetting, a person would be overwhelmed by details. This is eloquently described in the fictional story "Funes the Memorious" by the Argentinian writer Jorge L. Borges. Ireneo Funes, the protagonist in this story, remembers everything:

> He was, let us not forget, almost incapable of general, platonic ideas. It was not only difficult for him to understand that the generic term dog embraced so many unlike specimens of differing sizes and different forms; he was disturbed by the fact that a dog at three-fourteen (seen in profile) should have the same name as the dog at three-fifteen (seen from the front). . . . To think is to forget a difference, to generalize, to abstract. In the overly replete world of Funes there was nothing but details, almost contiguous details. (Borges, 1944/1962, pp. 114–115)

Moreover, some of the real-world individuals described earlier suffer from similar problems. The famous patient S remarked "I can only understand what I can visualize," and he struggled to grasp abstract ideas (Luria, 1968, p. 130). Furthermore, executive functioning and abstract reasoning is markedly impaired in AJ (Parker et al., 2006). For example, she scores very low on the Halstead Category Test (Halstead & Settlage, 1943) of abstraction and concept formation (no such tests are administered in Ally et al., 2012; LePort et al., 2012).

Overall, I suggest that forgetting plays a basic role in fine-tuning learning—it assists semantic and procedural knowledge acquisition by tempering access to unnecessary information and by reducing cognitive complexity, thereby allowing for abstraction and automatization. Forgetting may ensure that people are not overwhelmed by the retrieval of very detailed and extensive records of experience. Moreover, when conscious deliberation needs to reflect only on a limited number of memories, and when access to memories that do not serve skilled action well is restricted, information processing may be efficient (see Gaissmaier et al., 2008; Gigerenzer & Goldstein, 1996; Hertwig & Todd, 2003). It is hard to imagine how memory would support effective thinking and action if memories that were unusable or would hinder performance had not been discarded and made less accessible. For example, to make a quick judgment in a social interaction (e.g., to categorize a particular individual's behavior as kind, honest, or cruel) or to respond promptly in a potentially threatening situation (e.g., to decide whether to fight or to flee), one needs to avoid mnemonic overload or excessive processing and instead rely on easily accessible knowledge (see Klein, Cosmides, Tooby, & Chance, 2002).

Forgetting and Context Sensitivity: On Context Attunement

Forgetting helps regulate emotion and structure cognition, but it may also help to make people context sensitive. Humans have the potential for bringing to mind a huge number of memories that would be inappropriate or irrelevant in a particular context. Yet, at any given point in time, only limited numbers of memories are activated, and those memories are typically relevant to the given circumstances. One reason that mostly relevant memories are retrieved may be that people intentionally focus on memories that are usable in a particular context (see Johnston & Dark, 1986). Another reason seems to be that external stimuli function as reminders that activate corresponding memories (Tulving, 1983). A third reason may be that forgetting limits the accessibility of memories that do not help people adapt to present and future contexts. This function of forgetting is important because memories ultimately matter only to the extent that they inform current and prospective thinking and behavior and help people adapt to "the now and the next" (Klein, 2013, p. 222). For example, an individual remembers the route to his or her office because it helps to achieve the goal of getting to work now and in the future. Yet, that individual may forget other memories that are not related to any goals and may thereby avoid being distracted by irrelevant information.

Evidence supports the idea that memories of the past serve present and future goals. Remembered past and

imagined future events show a similar effect of temporal distance. The retention of the former fits the reverse of the power function of the latter (Spreng & Levine, 2006). Also, with increasing distance in both temporal directions, ratings of detail and sensory vividness decline, and reliance on schematic descriptions increases (Berntsen & Bohn, 2010). Furthermore, neuroimaging evidence suggests that remembering the past and imagining the future are based on a common and distinct neural network (Addis, Wong, & Schacter, 2007). This finding has given rise to the idea that a primary function of the brain is to simulate and anticipate upcoming activities, as captured by the concept of "the prospective brain" (Schacter, Addis, & Buckner, 2007). Finally, the idea that memories are closely related to goals is in accordance with the notion that memory and context are intimately related. The importance of context in relation to memory (Thompson & Tulving, 1973)—and, specifically, forgetting (Tulving, 1974)—was stressed early on and is highlighted in newer ecological or evolutionary approaches (e.g., Anderson & Schooler, 2000; Barnier, Sutton, Harris, & Wilson, 2008; Klein et al., 2002).

I suggest that forgetting helps people to be sensitive to the context and supports behavioral adaptation through context attunement. Context attunement may be understood as the process through which people relate to, and synchronize with, their surroundings in a time-sensitive manner. Specifically, I propose that forgetting helps people to focus on relevant goals, enabling timeliness (when distant memories that are irrelevant to current objectives are forgotten) and enabling updating (when outdated memories are revised). These possibilities are addressed next.

Timeliness

Everyday life is typically more informed by the recent past than by distant history. For example, to be able to follow a developing news story, one has to retrieve newly learned information about the event and integrate it with facts about the world. Accordingly, memory works as an ecologically optimizing retrieval system when information that is recent and has occurred frequently is primed and easily accessible and when information that has not been used for a long period of time or not very often is less accessible. This idea has been advocated by Anderson and his colleagues, who have suggested that the memory system extracts statistics from past experience and history of use, calculates a "need probability," and is able to anticipate which memories are likely to be required soon (Anderson, 2007; Anderson & Milson, 1989; Schooler & Anderson, 1997).

In line with Anderson and his colleagues' proposition, there is evidence that human memory reflects environmental regularities. In two studies, Anderson and Schooler (1991, 2000) analyzed real-world data (occurrences of certain words in *The New York Times*, parental speech, and e-mail) and found that the most accessible memories were those that reflected information that had occurred recently and frequently in the past, and that the least accessible memories were those that reflected information that had occurred a long time ago and not very often. These results indicate that the memory system is influenced by the distribution and occurrence of information in the environment and that forgetting may be an adaptive phenomenon that ensures that untimely and infrequent information is not easily brought to mind because it is not contextually appropriate (see Anderson & Milson, 1989). Moreover, this information-limiting process helps people focus on the most recent information. This is beneficial insofar as this information is typically most relevant for adapting to the present and for the future.

Heuristics based on forgetting. The context attunement effect of forgetting, which has just been described, may lay the groundwork for some heuristics or "rules of thumb" that humans use in everyday information processing. According to the theory of fast and frugal heuristics (Gigerenzer & Selten, 2001; Gigerenzer, Todd, & the ABC Research Group, 1999; Goldstein et al., 2001), humans possess a repertoire of heuristics that help them make cost-effective, everyday decisions. Two heuristics that have been found to benefit from forgetting are the recognition and fluency heuristics. The recognition heuristic uses information about whether an object is recognized to make inferences about that object, with respect to some criterion (Goldstein & Gigerenzer, 2002). For example, if one of two German cities is recognized (e.g., Berlin) and the other is not (e.g., Munich), then it is inferred that the recognized object has the highest value with respect to the criterion (e.g., has the largest population). To be successful in discriminating among objects, people are required by the heuristic to not recognize too many or too few, because it only works when exactly one of the alternatives is recognized. Without forgetting, a person would eventually recognize all objects, but with too much forgetting, a person would not recognize any objects; in both cases, recognition would no longer be a useful heuristic. Whereas the recognition heuristic is based on binary judgments, the fluency heuristic exploits the fact that the ease or speed at which something is retrieved from memory can be informative. Specifically, the fluency heuristic indicates that if two options are considered, the one that is recognized more easily has the highest value with respect to the criterion. For example, if Berlin is recognized faster than Munich, it may be inferred that the former is more important and houses more people.

The recognition and fluency heuristics have been modeled in a computer model of ACT (Schooler & Hertwig, 2005). When this model was tested on pairs of German cities, and when the computer model was asked to determine which was the largest, its decisions closely matched those made by humans (see Goldstein & Gigerenzer, 2002). More interesting, when the forgetting rates of the model were varied, it was found that performance and accuracy peaked at intermediate decay rates with respect to both heuristics. These results show that forgetting can help decision making.

Retrieval-induced forgetting (RIF). Another phenomenon that demonstrates that forgetting may help keep focus on recently practiced information and may facilitate complex information processing is RIF. RIF refers to the phenomenon that continuously recalling certain memories impairs the recall of related memories (Anderson, Bjork, & Bjork, 1994). In the typical paradigm used to study RIF, participants study category labels and exemplars (e.g., fruit–orange; country–Denmark; fruit–banana) and then continuously rehearse (i.e., practice retrieving) half the members of half the categories (e.g., fruit–o_____). A later test typically shows that recall of nonrehearsed exemplars from categories in which some items are rehearsed is poorer than recall of items from categories in which no items are rehearsed (i.e., recall for "banana" is less than for "Denmark"; for reviews, see E. L. Bjork, Bjork, & MacLeod, 2006; Levy & Anderson, 2002; Murayama, Miyatsu, Buchli, & Storm, 2014). RIF is a robust phenomenon that has been demonstrated with many different kinds of memories—for example, semantic (e.g., Johnson & Anderson, 2004) and episodic (e.g., Barnier, Hung, & Conway, 2004) memories—although it is also subject to some moderating factors (see Anderson, 2003)—for example, semantic integration (when the study material is well-integrated, RIF may disappear [Anderson & McCulloch, 1999] or one may observe retrieval-induced facilitation—i.e., enhanced recall of nonpracticed information that is related to the practiced information [Chan, McDermott, & Roediger, 2006]). Moreover, RIF primarily occurs with information that clearly competes with the recall of target memories (for reviews, see Murayama et al., 2014; Storm, 2011b). For example, practicing retrieving "orange" can impair a strong high taxonomic frequency associate, such as "banana," more than a weak associate, such as "guava." This indicates that RIF may help resolve interference during retrieval and that it is a fundamentally adaptive form of forgetting that may help maintain a focus on recently practiced memories by degrading access to associated competing memories.

RIF may also facilitate problem solving. Specifically, RIF may help people avoid mental fixation so that they are not stuck with an inappropriate strategy that interferes with the selection of an appropriate strategy. One study demonstrated that people who show the most forgetting are also the best at overcoming interference in a creative problem-solving task (Storm & Angello, 2010). Half the participants (experimental condition) read words intended to fixate them on incorrect solutions in a subsequent creative problem-solving task, whereas the other half (baseline condition) did not. Participants in the fixation condition reached significantly fewer solutions in the problem-solving task than participants in the baseline condition. More interesting, individual differences in RIF predicted the extent to which participants suffered fixation: Participants who exhibited the most forgetting solved more problems than participants who showed less forgetting, thereby illustrating another positive function of forgetting (also see Koppel & Storm, 2014; Storm, Angello, & Bjork, 2011; Storm & Pate, 2014).

Cue-dependent forgetting. Forgetting helps people to use their recent past in the service of present objectives, as described earlier. Yet, forgetting is also directly tied to context in a helpful way. According to the principle of encoding specificity (Thompson & Tulving, 1973; Tulving, 1984), memory functions most efficiently when encoding and retrieval circumstances are alike with regard to the internal (e.g., mood-state) and the external (e.g., physical) contexts (also see Morris, Bransford, & Franks, 1977; Roediger & Guynn, 1996). It follows from the encoding specificity principle that recall may fail when the context does not provide suitable cues. This requirement is captured by the concept of cue-dependent forgetting, according to which, forgetting results from a lack of appropriate retrieval information (Tulving, 1974). Stated differently, the probability of recalling a memory does not solely depend on the strength of the memory trace but on the presence or absence of proper retrieval cues. This is why people sometimes have difficulty remembering extracontextual information.

Cue-dependent forgetting has been demonstrated in several studies. One may distinguish among studies in which the effects of incidental global contexts (the entirety of a particular environment; for a review, see S. M. Smith & Vela, 2001), nonglobal contexts (a part of the environment, such as background color; e.g., Murnane & Phelps, 1995), nonincidental contexts (when participants expect to be tested; e.g., Tulving & Thomson, 1973), and internal (mental or physiological) states (e.g., Eich, 1995) have been examined. These contexts may also interact. For example, context effects from the physical environment (e.g., a room) are reliable (S. M. Smith & Vela, 2001) but are influenced by a person's potential attempts to suppress the influence of external stimuli (e.g., because he or she is introspecting). To reframe the concept of cue-dependent forgetting, people often do not remember what does not match the current context. This lack of

retrieval is beneficial, insofar as information that is unrelated to the present context is typically irrelevant. Moreover, this phenomenon makes long-term memory automatically in tune with the context. Information is often most relevant in a context that is similar to that in which the information was learned. If appropriate retrieval information is not provided by the environment, or internally generated on the basis of some kind of motivation, there is often no need for memories that do not come to mind.

Updating

Another aspect of context sensitivity is being perceptive to the current state of the world. Accordingly, forgetting can be beneficial when it helps to discard out-of-date information. Forgetting owing to memory updating may occur in relation to both short- and long-term memory. Short-term memory is in constant flux, and information must be discarded continuously if short-term memory is to flexibly serve goals under changing circumstances (Altmann & Gray, 2002; Hasher, 2007). For example, Hasher and her colleagues (e.g., Hasher, Zacks, & May, 1999; Zacks & Hasher, 1994) have proposed that one way that the contents of short-term memory is constrained is by the deletion of no longer relevant information. Moreover, if a long-term memory is out of date and no longer useful, it can be adaptive to forget it (E. L. Bjork & Bjork, 1996; E. L. Bjork et al., 2006; R. A. Bjork, 1989). For example, one would want to recall the current password to one's e-mail account and not the old one. In the following sections, I focus on long-term memory updating.

Directed forgetting. Long-term memory updating is demonstrated in listwise, directed-forgetting paradigms. In the typical instance of such a paradigm, participants in the experimental condition read or hear a list of items to learn (List 1). Then, they are unexpectedly told that the list just learned was for practice, or was presented by mistake, and that they have to learn another "correct" list (List 2), thereby creating an incentive to forget the items in List 1. At least two results are usually reported (for reviews, see E. L. Bjork et al., 2006; Depue, 2012; MacLeod, 1998). When asked to recall all items later on, participants in the experimental condition remember more List 2 items than List 1 items compared with participants in the control condition, who are instructed to remember both lists of words—that is, the instruction to forget List 1 improves memory for List 2. Second, when participants are instructed to forget List 1 halfway through the experiment, their ability to remember List 1 items is impaired, relative to participants in the control group who are told to remember both lists (the directed-forgetting effect). The directed-forgetting effect is beneficial because the forgotten items from List 1 do not cause proactive interference (conflict with subsequent learning) in relation to the to-be-remembered items that are to replace them—that is, the effect allows for efficient memory updating.

Reconsolidation. The idea that forgetting helps long-term memory updating is also qualified by recent research, which shows that well-stored memories can sometimes be changed. Conventionally, long-term memories were believed to be rather stable when fully consolidated on the basis of psychological processes (e.g., rehearsal) and neurobiological processes (e.g., cellular consolidation; Hardt et al., 2010; Wixted, 2010)—that is, memories were thought to become progressively resistant to being forgotten. However, new findings suggest that memories may be reconsolidated under certain circumstances. Specifically, retrieval may put a memory into a state of transient plasticity in which it can be modified—for example, weakened, strengthened, or given different content (Agren, 2014; Hardt et al., 2010; Schiller & Phelps, 2011).

The previously mentioned studies on restorage of fear memories show how forgetting may be implicated in reconsolidation. In those studies, the nondeclarative emotional, but not the declarative, part of a memory was forgotten. Other researchers have investigated whether declarative memories can be reconsolidated (e.g., Chan & LaPaglia, 2013; Forcato, Rodríguez, Pedreira, & Maldonado, 2010; Hupbach, Gomez, & Nadel, 2009; Schwabe & Wolf, 2009; Strange, Kroes, Fan, & Dolan, 2010). For example, in one of these studies, Chan and LaPaglia (2013) used a misinformation paradigm in six experiments, and they showed that declarative memories may be updated with new information on the basis of forgetting. In the learning phase, participants watched an episode from a television show. In the reactivation phase, participants completed a cued recall test of 24 details from the movie without feedback. In the relearning phase, participants listened to an audio narrative that purportedly recapped the movie. Among the 24 details queried during the reactivation phase, 8 were presented incorrectly (misinformed items), 8 were not mentioned (neutral items), and 8 were presented correctly (represented items) in this narrative. A final test revealed a markedly impaired recognition accuracy of misinformed relative to neutral items—that is, misinformation resulted in participants forgetting details of the television episode, and these details were updated with the misinformed items (which participants believed to be true), but this did not occur among participants in the control group who did not have their memories reactivated.

Reconsolidation has not only been demonstrated with respect to declarative memory (e.g., Chan & LaPaglia, 2013) but also with respect to conditioned memory (e.g.,

Galluccio, 2005) and procedural memory (e.g., Walker, Brakefield, Hobson, & Stickgold, 2003); therefore, it seems as though reconsolidation is a general property of memory. The concept of reconsolidation bears a similarity to the fundamental idea in research that memories are often malleable and may be affected by postevent information. As noted earlier, malleability has often been considered problematic and has been associated with the distortion and fabrication of memories. However, it would be difficult to consider a memory system to be flexible if it did not allow itself to be updated in light of new information that was believed to be correct. In that sense, reconsolidation may be an important foundation for memory plasticity and may be a mechanism that allows an understanding of how individuals build on past experience while incorporating new information. In accordance with this view, reconsolidation has been proposed to be a fundamentally adaptive process (Hardt et al., 2010; Lee, 2009; Schacter, Guerin, & St. Jacques, 2011). To the extent that forgetting (of outdated memories) is part of the reconsolidation process, forgetting has an adaptive function.

Discussion

People are usually able to relate easily to present and future contexts. An important reason for this seems to be that events that do not relate to current or prospective goals are forgotten quickly and at a high rate. People primarily retain information that has occurred recently or that tends to recur frequently in their environment, and they use the accessibility of their memories to make rule-of-thumb decisions—for example, by applying the recognition and fluency heuristics. Such heuristics are effective decision-making tools thanks to a moderate amount of forgetting, and they seem to have an ecological basis because they exploit a combination of basic capacities of the human mind (such as recognition and recall) and environmental regularities. People's memories are affected not only by environmental regularities but also directly by the contexts in which they find themselves. The concept of cue-dependent forgetting captures the fact that recall may fail because the context does not provide appropriate cues. When no cues are present, there is often no need for a memory to be retrieved. Memories also need to be updated. If outdated information was not forgotten, the memory system would not be able to renew itself. Updating is illustrated by research on directed forgetting. Also, research on reconsolidation makes the case for the importance of updating in memory. The latter line of research highlights the importance of timing. Reconsolidation only occurs during specific time intervals following reactivation.

Boundary conditions. In general, context attunement through forgetting of distant memories and updating of old memories may be helpful. However, there seems to be at least three exceptions to this rule. First, although distant memories are typically irrelevant to the present and the future, and therefore have a reduced state of accessibility, it is surely the case that old memories can sometimes be important. For example, consider a person who remembers how much he enjoyed himself when he was engaged in a particular sport many years ago. Such a reminiscence may lead him to be more physically active and possibly healthier as well as more satisfied with his life. The retrieval of such old memories may often happen involuntary and may prompt people to not live exclusively within a narrow timeframe but to draw on lessons from the remote past (see Berntsen, 2010). Second, cue-dependent forgetting is basically adaptive because it helps people to be in tune with their surroundings; however, there may be exceptions to this rule. For example, a repressive political regime can put great effort into not mentioning, and removing reminders of, an incident that reveals its oppressive policies (Connerton, 2008). Yet, if such an incident is forgotten, it may hinder a democratic transformation of that society, and this can be considered a negative effect of cue-dependent forgetting. Third, there may be occasions when a memory is updated, and it then becomes necessary to change it back to its old form through reversal learning. For example, a memory of a friend who is single is updated when he or she enters a relationship, but if the relationship ends, the memory must be brought back to its old state.

Main points. Despite such exceptions, I propose that forgetting is generally a positive force that helps people focus on the now and the next. Indeed, without forgetting, a person might be stuck in the past. For example, individuals with HSAM spend a great deal of time remembering the past. AJ reports that she thinks "about the past all the time" and that she has problems stopping retrieving episodic memories (Parker et al., 2006, p. 35). The individual known as "HK" estimates that he spends 30% of his time thinking about memories but that it used to be even more (Ally et al., 2012), and several other individuals with HSAM report that they habitually and sometimes obsessively recall their memories—for example, before bed (LePort et al., 2012). Such cases indicate that a superior memory may be associated with a preoccupation with a past time perspective (see Zimbardo & Boyd, 1999) that can be problematic when there is a need to attend to the present and the future (although it is interesting and somewhat puzzling that the individuals investigated by LePort et al., 2012, mostly do not believe that

their memories distract them from current tasks or hinder planning for the future).

In sum, I propose that forgetting allows for timeliness and updating and helps people with ordinary memory functions orient themselves flexibly toward the now and the next in a changing world. Distant memories often refer to events that are not very likely to occur in the present or the future, and forgetting such memories may allow people to focus on recent memories that have more relevance to current circumstances and that have higher predictive value with regard to anticipating and planning for the future (Anderson & Schooler, 1991, 2000; Nairne & Pandeirada, 2008). Accordingly, forgetting may help individuals adapt to the informational demands of the environment and make them sensitive to the probability that different favorable or threatening events will occur. Moreover, forgetting information that is outdated because it turned out to be incorrect (e.g., there was no water to be found at a particular location) or no longer valid (e.g., a former foe is now a friend) can limit the potentially interfering effects of such information. Such forgetting may help keep memory updated and relevant for guiding future behavior (see Lee, 2009).

General Discussion

As presented here, forgetting serves rather different and separable functions in relation to emotion, cognition, and behavior. However, this does not mean that forgetting in one domain has no effect in other domains. When forgetting, as part of emotion regulation, helps to create a slightly positive mind-set and encourages emotional health, this may lead people to engage in learning (knowledge acquisition; see Fredrickson, 2004) and to be open to their environment (context attunement; see Hermes, Hagemann, Naumann, & Walter, 2011; Norris et al., 2011). When forgetting, as part of knowledge acquisition, helps to organize knowledge and ensure a good cognitive economy, this may help people to understand and control their emotions (emotion regulation; see Ochsner & Gross, 2005) and to perceive their surroundings in a structured and meaningful way (context attunement; see Clapper, 2007; Feldman, 2003). Finally, when memory is kept current by forgetting distant and outdated information, this may help people avoid being stuck with unpleasant memories (emotion regulation; see Steinfurth et al., 2014) and to discard cognitive information that is obsolete (knowledge acquisition; see R. A. Bjork, 1989). Furthermore, forgetting seems to share some similarities in relation to emotion, cognition, and behavior. First, memory inhibition is probably an important (but possibly not the only) mechanism underlying adaptive forgetting in all three domains. Second, the characteristics of a to-be-forgotten memory and the informational structure of the environment are important internal and external factors that moderate forgetting related to emotion, cognition, and behavior. I discuss these themes next.

The mechanism of forgetting

There are several theoretical accounts of forgetting. In two theories, forgetting is explained with reference to the context of a memory. According to interference theory, a memory is difficult to retrieve because other information competes with that memory (e.g., McGeoch, 1932; Tomlinson, Huber, Rieth, & Davelaar, 2009; Underwood, 1957). According to cue-dependency theory, forgetting results from the absence of proper retrieval information (e.g., S. M. Smith & Vela, 2001; Tulving, 1974). In three other theories, forgetting is explained with reference to the state of a memory itself. The unsuccessful encoding or consolidation account suggests that a newly formed memory is fragile and is forgotten if not stored properly (e.g., Müller & Pilzecker, 1900; Wixted, 2004, 2005). The decay account posits that a memory trace will fade and lose strength if it is not used (e.g., Altmann & Gray, 2002; R. A. Bjork & Bjork, 1992; Thorndike, 1914). Finally, inhibition theory posits that a factor may lower the state of activation of a memory, making it difficult to retrieve. In the following, I focus on inhibition as a cause of adaptive forgetting, although it should be noted that the inhibitory account of forgetting is subject to debate, with some questioning it (e.g., MacLeod, Dodd, Sheard, Wilson, & Bibi, 2003; Raaijmakers & Jakab, 2013; Verde, 2012), and others advocating it (e.g., Anderson, 2003; Depue, 2012; Schilling, Storm, & Anderson, 2014). This focus should not be taken to mean that all virtues of forgetting are necessarily based on inhibition. Yet, I do think inhibition may explain many instances of adaptive forgetting related to emotion, cognition, and behavior.

Inhibition. Inhibition involves restraining or overriding a response (see MacLeod, 2007), and it can be tied to benefits whenever a response is inappropriate and should be withheld. A reminder may cue an unwanted memory, and that memory may be directly suppressed (Anderson & Green, 2001; for a recent review, see Anderson & Hanslmayr, 2014). Moreover, a cue may be associated with several memories, and if the target memory is to be retrieved, it may be necessary to suppress competing and interfering nontarget memories (Anderson et al., 1994; for a recent review, see Murayama et al., 2014).

Inhibition is a typical explanation for effects obtained in most of the experimental paradigms mentioned earlier—that is, mnemic neglect (Sedikides & Green, 2009); the TNT and the RIF (Anderson & Levy, 2009); as well as the listwise, directed-forgetting (E. L. Bjork et al., 2006)

paradigm (although alternative noninhibitory explanations have been proposed; Raaijmakers & Jakab, 2013; Tomlinson et al., 2009; Verde, 2012). Inhibition may also work during both encoding (e.g., mnemic neglect) and retrieval (e.g., memory stopping). As a theory about forgetting, inhibition has at least three advantages. First, inhibition is a flexible phenomenon that reflects memory inaccessibility. Even though a memory is not recallable at one point in time, it still may be present in the memory system, as indicated by studies on recognition memory (e.g., Geiselman, Bjork, & Fishman, 1983) and on implicit memory tasks such as priming (e.g., Basden et al., 1993) and relearning (e.g., Geiselman & Bagheri, 1985). This means that such a memory may become accessible again should it be needed. Second, classic theories, for example, of unsuccessful encoding or consolidation, decay, and interference, principally posit forgetting as failed information processing and as a passive process. Inhibition is the only explanation that ties forgetting to a dedicated mental mechanism that actively acts on memories (Anderson, 2003). Thus, it is relatively easy to associate with a functional view of forgetting. Third, forgetting is motivated—that is, driven by values and goals. The inhibitory account fits nicely with this facet of forgetting because inhibition is tied to executive functions on both psychological (Levy & Anderson, 2008) and neurobiological (Munakata et al., 2011) levels.

Individual differences. If inhibition is adaptive, it follows that individual differences in the ability to forget may be associated with either certain deficits or advantages in the domains of emotion regulation, knowledge acquisition, and context attunement. The previously mentioned case stories depicting individuals with HSAM suggested that it is not always helpful to have a superior memory and that forgetting can sometimes be helpful. Other evidence comes from experimental investigations of individual differences in forgetting among people with ordinary memories, which I describe in the next section.

Inhibitory deficits may be a cause of emotional dysregulation in disorders such as depression and anxiety. Some studies have shown that depression is associated with a diminished ability to suppress negative memories (Hertel & Gerstle, 2003; Joormann, Hertel, LeMoult, & Gotlib, 2009; Joormann & Tran, 2009; but see Harris, Sharman, Barnier, & Moulds, 2010). Also, an absence of a self-protective mnemic neglect and an enhanced access to negative self-relevant memories have been found in individuals who are dysphoric (Saunders, 2011; also see Saunders, Worth, & Fernandes, 2012) or high in trait anxiety (Saunders, 2013; also see Marzi, Regina, & Righi, 2014); in addition, some researchers have found that posttraumatic stress disorder is associated with inadequate memory inhibition abilities (Amir, Badour, & Freese, 2009; Cottencin et al., 2006; but see Kenny & Bryant, 2013). Furthermore, some research suggests that forgetting can prevent the retrieval of negative memories among healthy individuals. Individuals who exhibit higher levels of laboratory-induced forgetting tend to recall fewer negative (but more positive) autobiographical memories than those who exhibit lower levels of such forgetting (Storm & Jobe, 2012), and individuals with higher self-perceived control over intrusive thoughts show more forgetting of aversive laboratory stimuli than those with lower self-perceived control (Küpper et al., 2014).

Inhibitory deficits may also cause deficiencies in knowledge acquisition. For example, attention-deficit/hyperactivity disorder is associated with learning difficulties, and in two studies, researchers have found this condition to be associated with a reduced ability to forget (Storm & White, 2010; White & Marks, 2004). Also, individuals who exhibit low levels of forgetting tend to have low working memory capacity (Aslan & Bauml, 2011; Aslan, Zellner, & Bäuml, 2010). Such results indicate that forgetting may be involved in efficient knowledge acquisition, but more research is needed. For example, are individuals who are good at acquiring abstract knowledge also good at forgetting redundant information?

Finally, inhibitory deficits may be tied to a reduced ability to let go of the past and to update memory. This possibility is in accordance with time perspective theory, which posits that individuals differ with respect to their overall temporal orientation and that a preoccupation with either the past, the present, or the future is associated with distinct forms of reasoning and decision making (Zimbardo & Boyd, 1999). For example, excessive preoccupation with a past negative time perspective has been associated with psychopathology (e.g., Beek, Berghuis, Kerkhof, & Beekman, 2010; Boyd & Zimbardo, 2005; Lyubomirsky & Nolen-Hoeksema, 1995). Yet, almost nothing is known about individual variability in the ability to use forgetting to adapt to the present and the future (for an exception, see Storm & Angello, 2010).

Factors moderating forgetting

Studies of both individuals suffering from mental disorders and healthy individuals suggest that forgetting owing to inhibition can be beneficial. Yet, whether inhibition succeeds in a specific instance may depend on both memory and environmental factors.

The characteristics of the to-be-forgotten memory. The strength of a memory is one characteristic that may influence whether it can be forgotten. When using theories of inhibition, researchers typically do not consider the strength of a memory despite the possibility that

inhibition may influence a robust memory less than a fragile memory. A notable exception is the previously mentioned new theory of disuse (R. A. Bjork & Bjork, 1992), which posits that storage strength counteracts loss of retrieval strength during a retention interval. One interpretation of this proposition is that it may take the most effort to forget well-learned memories that have high storage strength. Also, neuroscientific research shows that a memory takes time to stabilize (consolidate), and even when stabilized, a memory can be brought into a state of transient plasticity under certain circumstances in which it can be modified (reconsolidated). Such knowledge should be considered in behavioral experiments on forgetting. For example, investigating the effects of varying the interval between learning and forgetting instructions when studying the effects of consolidation seems important (see Wixted, 2004, 2005). Furthermore, it seems important to investigate whether a memory is especially susceptible to inhibition if it is reactivated in a reconsolidation paradigm.

The type of memory is another characteristic that may influence whether it can be forgotten. Traditionally, forgetting has been conceptualized in relation to declarative memory. However, as described earlier, forgetting may also target nondeclarative memory systems—for example, conditioned and procedural memory (see Cubelli, 2010; Wixted, 2010). Very little is known about the extent to which inhibition underlies forgetting related to such types of memory. For example, extinction training may be used to forget the emotional part of an aversive memory; however, could inhibition also play a role in such a process? Moreover, there is a long tradition of studying behavioral inhibition in the motor domain (see Gallistel, 1980); however, can it be empirically demonstrated that such motor inhibition has effects on procedural memory, as suggested here? One recent study, in which Dreisbach and Bäuml (2014) found that newly acquired motor habits could be forgotten in a directed-forgetting paradigm, indicates an affirmative answer, but more research is clearly needed.

The informational structure of the environment. The characteristics of a to-be-forgotten memory is an intrinsic factor that affects whether inhibition will succeed. The informational structure of the environment is an extrinsic factor that may influence inhibition in at least two ways. First, if an individual is exposed to information that matches an inhibited memory, that memory may be released from inhibition (Little, Storm, & Bjork, 2011; Storm et al., 2008). Consequently, if some information has appeared recently and frequently in the environment, it will be hard to forget. In addition, it follows from the new theory of disuse that the combined forces of forgetting and reexposure (at least, when reexposure involves practice or restudy) can in fact increase the accessibility of a memory more than had the memory not been forgotten (E. L. Bjork & Bjork, 2011; R. A. Bjork, 1994, 2015). Second, a memory may not be activated because of reexposure, but it can be activated because of a cue in the environment. In such cases, reactivation may be followed by the suppression of that memory, either because the memory is unwanted in and of itself or because it interferes with a target memory. If such inhibition persists for some duration, it might help an individual adapt to the informational regularities of the environment. Specifically, if a memory is inhibited on one occasion, it may make sense for it to also be inhibited on future occasions if the memory is unwanted or generally interfering. For example, it can be beneficial to persistently inhibit one's old password because there is no use for it now, and most likely there will be no use for it in the future. In some studies on RIF, researchers have shown that inhibition can persist for at least a week (e.g., Garcia-Bajos, Migueles, & Anderson, 2009; Storm, Bjork, & Bjork, 2012); however, other researchers have failed to find such long-term effects (e.g., Carroll, Campbell-Ratcliffe, Murnane, & Perfect, 2007; MacLeod & Macrae, 2001; for examples of researchers who used TNT and listwise, directed-forgetting paradigms, see Noreen & MacLeod, 2014; Nørby et al., 2010; Wheeler, 1995). Clearly, more research is needed to determine why inhibition sometimes persists and sometimes does not.

Final thoughts

It is a common belief that having a good memory equals remembering as much as possible. The basic tenet of this article has been that this is not true. A good memory is one that retrieves the right memories at the right time and does not retrieve memories that are burdensome or irrelevant to current tasks. This should of course not be taken to mean that forgetting is always functional. Clearly, normal forgetting can be frustrating, and pathological forgetting—as in memory disorders such as dementia—can be disabling and ultimately catastrophic. Accordingly, a complete understanding of forgetting would entail delineating both when forgetting is helpful and when it is harmful. Forgetting redundant information, for instance, may help knowledge acquisition, but when people fail to recall facts they want to remember, forgetting is not helpful, and ideally, both situations should be accounted for. Moreover, although forgetting may in general be helpful in the domains of emotion, cognition, and behavior, it might not be so in all particular instances because functionality depends on a fit between a trait and the characteristics of the environment (see Nairne, 2010). Though it can be adaptive to forget more negative than positive experiences in a safe environment, for example, the same

may not be true in a threatening environment, in which a focus on negative information can help an individual avoid dangers. Finally, functional analyses have sometimes been criticized for being post hoc rationalizations and so-called "just-so" stories—that is, narratives or explanations that are difficult to verify or falsify (Gould & Lewontin, 1979; also see Andrews & Gangestad, 2002). However, when researchers can use such analyses to plausibly integrate evidence from different areas and to suggest new ideas, these analyses may nevertheless have important heuristic value and will ideally lead to research into new areas.

Overall, the argument presented here should be considered suggestive rather than definitive. Having said that, I do think a fairly strong case can be made that forgetting serves positive functions for several reasons. First, individuals who unintentionally have extraordinary memories are often overwhelmed by their special abilities, and they do not typically excel in other areas of life. Second, in experimental studies, researchers have identified many specific instances in which forgetting helps information processing, and these can be considered parts of the broader categories of emotion regulation, knowledge acquisition, and context attunement. Third, individual differences in the ability to forget correlate with measures of relevant traits among people with ordinary memories. All these facts suggest that forgetting may function as a helpful mnemonic sorting device and that an ability to remember vast amounts of information is not necessarily very helpful or associated with a high level of functioning in everyday life.

I have argued that a good memory requires forgetting for effective functioning in the domains of emotion, cognition, and behavior. Forgetting, I have suggested, is involved in emotion regulation, and it frees people from some of their unpleasant past. Pushing away negative memories and dampening unpleasant emotions may sustain a positive mind-set and allow for productive thought and action. Also, forgetting is part of knowledge acquisition, and it helps people to discard detailed event information that is false or unimportant. When such information is lost, it may help structure cognition and provide it with a focus. Furthermore, forgetting is involved in context attunement, and it helps people limit the influence of the distant past and information that is no longer valid. Thus, forgetting may ensure that knowledge is relevant and current, and it may allow for a focus on the now and the next. I have also argued that many forms of adaptive forgetting related to emotion, cognition, and behavior are mediated by a common mechanism—namely, memory inhibition. Individuals vary in their ability to inhibit memory, and inhibition is constrained by the characteristics of the to-be-forgotten memory and by the informational regularities of the environment. In sum, forgetting driven by inhibition helps to limit the influence of the past, and it frees up mental capacity, which allows people to engage in and effectively adapt to a changing world. For these reasons, normal forgetting is mostly a positive force in human life.

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