



CHAPTER

42

Current Perspectives on Directed Forgetting

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Abstract

This chapter reviews updated Directed Forgetting (DF) research, reflecting significant changes in the field. It is divided into four sections, beginning with methodologies of item-method and list-method DF and their measurement challenges. The next section addresses how people respond to directed forgetting cues by implementing forgetting strategies, suggesting a shift towards controlled processes. Subsequent sections summarize empirical and theoretical developments, indicating a paradigm shift that has taken place in DF theorizing—namely, list-method DF, once attributed to retrieval inhibition is now considered by some to reflect a context-change phenomenon, whereas item-method DF, previously explained by selective rehearsal processes is now being reevaluated for encoding inhibition and contextual unbinding processes. Such views provide a radical departure from the ways that DF has been interpreted previously, and they highlight how conceptualizing about DF has evolved in light of newer research methodologies and findings.

Key Words: directed forgetting, motivated forgetting, intentional forgetting, context-change, inhibition

Introduction

Everyday forgetting is an inevitable process that occurs largely outside of our intentions, usually causing annoyance when it becomes apparent. Forgotten bills, misplaced keys, and missed birthdays uncomfortably remind us about how frustrating it is to forget things. However, it is not always the case that remembering is the virtue and forgetting is the flaw or the sin of our cognitive system. Sometimes remembering is the undesired outcome, and forgetting is precisely what we need to do. When checking out of a hotel, we do not want to retain the number of the room where we stayed; purging that information out of mind helps declutter it. Sometimes instead of inputting the new password, we mistakenly enter the old password, which we wish was less accessible at that moment. In extreme cases, such as when memories are traumatic, it may be dysfunctional to ruminate on them, and one may wish to reduce their accessibility. Thus, forgetting can be an adaptive process for navigating a complex world, and to the extent that we can control it, we would benefit from it.





Memory control has been a topic of active investigation in cognitive research, and directed forgetting (DF) is a long-standing and widely used laboratory procedure for examining memory control (e.g., Muther, 1965; R. Bjork et al., 1968). In DF studies, participants are presented items to learn for a memory test, which are subsequently cued to either be remembered (R) or forgotten (F). At test, however, all items are evaluated regardless of memory instruction. Decades of research confirm that people have poorer memory for items followed by an F cue than items followed by an R cue, suggesting that we can control our memory voluntarily to impair access to unwanted information. The critical question is how people do it.

This chapter is organized into four main sections. The first section outlines the basic methodology for different DF designs and discusses measurement issues. The next section reviews the strategies that people report in DF studies, directly addressing the question of how people do it. The third section reviews the major empirical findings and the theoretical debate regarding both DF methods. It aims to highlight the sea change that has taken place in DF theorizing—namely what used to be widely attributed to inhibition (i.e., list-method DF) has been argued by some to not necessarily involve inhibition, whereas what used to be explained through noninhibitory mechanisms (i.e., item-method DF) is gaining momentum in terms of inhibitory explanations. Furthermore, although the context-shift account is well established as the mechanism behind the list-method DF, its role in item-method DF is also receiving renewed attention. In summary, such views provide a radical departure from the ways that DF paradigms have been interpreted previously, and they highlight how conceptualizing about DF has evolved in light of newer research methods and findings. The final section provides concluding comments.

Directed Forgetting Paradigms and Their Typical Outcomes

There are two established DF methodologies, and the way forgetting is accomplished appears to differ between DF paradigms. The procedures and their basic outcomes are summarized in Figure 42.1.

List-Method Paradigm

In list-method DF, participants typically study two lists of items, which can include words or other stimuli. After presentation of List 1, some participants receive an F instruction, whereas others receive an R instruction. Participants in the F condition may be told that the list was presented in error, and they should attempt to forget it in order to do better on the “real” list. Note that participants could be warned to expect an F cue (i.e., the F cue need not involve surprise or deception). The R cue provides a control group against which to assess the effects of the forget instruction, and it typically involves telling participants to keep remembering List 1 because it was only the first half of the study material. Then all participants study List 2 and are subsequently tested on all items, including the ones they were told to forget. Two outcomes are associated with list-method DF: List 1 is impaired in F condition compared to R condition, whereas List 2 is enhanced in F condition compared to R condition, collectively referred to as *list-method DF effects* (for reviews, see E. Bjork et al., 1998; MacLeod, 1998, 2012; Sahakyan et al., 2013; Sahakyan & Foster, 2016). Note that although F/R cues are usually implemented between-subjects, they can also be implemented in within-subjects multilist designs. In this procedure, two lists are typically assigned to the first block, and two lists are assigned to the second block. The F cue occurs either during the first block (e.g., after presentation of List 1) or during the second block (e.g., after presentation of List 3). Two lists are typically assigned to the first block (L1 and L2), and two lists are assigned to the second



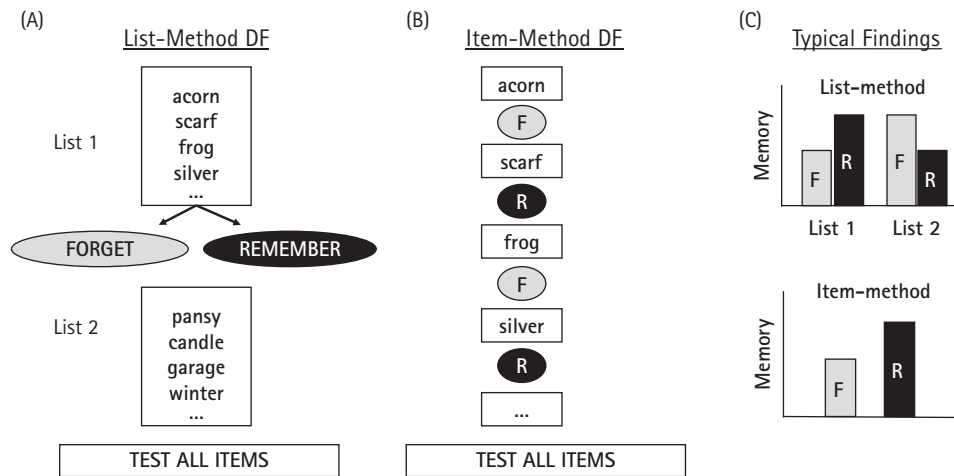


Figure 42.1 The list-method and item-method DF paradigms and their typical findings. (A) In list-method DF study, an entire list of items is studied, followed by a forget (F) or remember (R) instruction. A second list is then studied, usually followed by an R instruction. Afterwards, memory for all items is tested. The typical findings are illustrated in panel C (top), demonstrating the twofold effect of the F instruction on the recall test, with impaired List 1 recall and enhanced List 2 recall. (B) In item-method DF study, each item is followed by an F or R instruction, and subsequently memory for all items is tested. The typical findings are shown in panel C (bottom), with impaired memory of F items compared to R items. In both paradigms, participants are unaware that they should maintain or forget the respective item, and therefore the control processes responsible for these effects act on the memory representations rather than on the initial perception of an item/event.

block (L3 and L4). Participants complete the F condition for the first block and complete the R condition for the second block (or vice versa). Memory for both lists is tested after each block. This procedure produces findings similar to those of the traditional between-subjects two-list design (e.g., Zellner & Bäuml, 2006). Finally, multilist, within-subjects designs have also been used, with two lists presented in each block, and F or R instruction in between the lists. Thus, the F cue can be presented more than once. Testing takes place after each block, without violating the F cue (e.g., only List 2 is tested in the F condition, whereas either list can be tested in the R condition). On the last block, the F cue can be violated, and List 1 can be tested once (E. Bjork et al., 1998; Hanslmayr et al., 2012; Manning et al., 2016). Such within-subjects designs are especially suited for neural studies that require multiple measures from the same participants.

Item-Method Paradigm

In item-method DF, F/R cues are delivered after each item has been presented. Participants are told that F items will not be tested, and they should attempt to forget them. At test, participants are evaluated on all items regardless of memory instruction. Typically, F items show a memory impairment compared to R items, known as the *item-method DF effect*. Although many studies in the past did not include any baseline for assessing DF impairment and enhancement in item-method paradigm, more recent studies started including some form of a baseline condition into the design of the experiment. For example, some studies include a Remember-all condition, and F and R items are compared to dummy coded items in Remember-all condition to infer about the impairment of F items and the enhancement of R items, respectively (e.g., Sahakyan & Foster, 2009; Taylor et al., 2018; Taylor & Fawcett, 2012). Other studies



have assigned positive, negative, and zero value points in lieu of R, F, and baseline trials (e.g., Foster & Sahakyan, 2012) or used uncued trials intermixed with R/F cues (e.g., Fawcett & Taylor, 2008; Zwissler et al., 2015). In general, inclusion of some form of baseline is particularly useful for assessing magnitude differences in item-method DF among special populations or between different stimuli that are subjected to DF manipulation.

Dependent Measures

Directed forgetting has been primarily assessed in terms of the number of correctly recalled or recognized items. However, as new methods and tools continue to be developed, researchers strive to include a wider array of behavioral measures, including serial position functions (Geiselman et al., 1983; Lehman & Malmberg, 2009; Pastötter & Bäuml, 2010, 2012; Sahakyan & Foster, 2009; Sheard & MacLeod, 2005), intrusion errors (Lehman & Malmberg, 2009; Sahakyan & Delaney, 2010; Spillers & Unsworth, 2011), decomposing retrieval dynamics measures into response initiation and response transition measures (Lehman & Malmberg, 2009; Spillers & Unsworth, 2011; Unsworth et al., 2012), using time estimates (Sahakyan & Smith, 2014), and response latencies (Fawcett & Taylor, 2008, 2012; Spillers & Unsworth, 2011; Taylor, 2005; Unsworth et al., 2012). This list of behavioral measures is augmented by the growing list of neural methods that are being deployed to study DF, from brain oscillations and event-related potentials (ERPs) to functional imaging and pattern classifications (for a review, see Anderson & Hanslmayr, 2014). Throughout the years, the repertoire of tools has grown both in scope and in sophistication, promoting a deeper understanding of the mechanisms of DF and helping clarify interpretations.

Neither the item-method nor the list-method DF arises because of demand characteristics, with participants actively withholding the F items during the test. Additional incentives to recall or recognize the F items do not produce improved performance (MacLeod, 1999).

Directed Forgetting Is a Controlled Process

What do we know about what people do in response to the F cue? My lab and others have conducted multiple studies using list-method DF, and we have examined many strategy reports provided by participants (for reviews, see Sahakyan et al., 2013; Sahakyan & Foster, 2016). In list-method DF studies, people report a variety of behaviors in response to the F cue that range from “*I did nothing*” to “*I stopped thinking about the items*,” “*I thought about other things unrelated to experiment*,” all the way to “*I prayed to forget*.” These strategies vary in the effectiveness that they produce DF, and they also demonstrate the complexity of DF phenomenon. However, it is clear that participants have to engage in controlled behaviors in order to observe list-method DF. Doing “nothing” in response to the F cue does not produce DF, and neither does believing the F cue in case it was staged or presented as a surprise (Foster & Sahakyan, 2011). What matters for list-method DF is what people do in response to the F cue akin to research demonstrating that what people do to learn matters more than merely having an intention to learn (e.g., Hyde & Jenkins, 1973; Mandler, 1967; Postman, 1964). These results are important not only for demonstrating that forgetting is a controlled process but also for explaining individual differences in the ability to forget unwanted information. People may think that they have already forgotten and therefore fail to deploy any controlled behaviors—this was the case in a DF study with older adults, who believed they had already forgotten (Sahakyan, Delaney, & Goodmon, 2008). Also, participants may not know what kind of strategy to deploy in order to forget, and therefore do nothing in response to the F cue. Thus, researchers should be vigilant about what their participants do in response to the F cue, especially when examining population differences.



I am not aware of any published item-method DF study that examined strategy reports. However, my lab recently collected such data, and I describe it briefly because it provides interesting insights (Sahakyan & Whitlock, 2023). We tested 100 participants in an item-method DF study, which involved studying words, half followed by an R cue and the other half by an F cue. Testing involved a yes/no recognition test, which intermixed studied words with new words, where participants were told to endorse any previously studied item, regardless of the cue that followed it (i.e., the forget instruction was canceled at test). Discrimination accuracy (d') between the R and F conditions confirmed a robust DF effect, with worse memory for F than R items. At the end of the test, participants were asked to indicate what they did in response to the F cue, and they had an option to select *as many* of the provided strategies that applied to them. The choices included “*I did nothing*” (9% selected this response), “*I thought of other things unrelated to experiment*” (12% endorsement), “*I stopped thinking about the Forget words*” (33% endorsement), “*I rehearsed previous words that were followed by Remember instruction*” (40% endorsement), “*I actively suppressed Forget words*” (12% endorsement), and “*Other*” (4% endorsement). Note that very few participants reported multiple strategies, even though they were told to select as many options that applied to them ($n = 8$).

These reports confirm the complexity of behaviors that participants employ in item-method DF, and they also provide several interesting observations. First, the reports of “doing nothing” are much lower in an item-method DF study than in the previous list-method DF studies, in which more than one-third of participants reported “doing nothing” (see Foster & Sahakyan, 2011; Sahakyan et al., 2013). Also, participants who reported “doing nothing” never selected any other strategy, whereas participants reporting active strategies occasionally selected more than one strategy.

Figure 42.2 summarizes the DF effect among those who reported “doing nothing” against all those who reported at least one active strategy. The results confirm the same finding as what is typically found in the list-method DF study—namely there is no item-method DF effect among participants who report “doing nothing,” whereas all remaining strategies produce a robust DF effect, with effect sizes ranging from Cohen’s $d_z = 1.0$ (for active suppression) to $d_z = 1.3$ (for rehearsing prior R items), $d_z = 1.2$ (for stop thinking of F items), and $d_z = 1.2$ (for thinking of other things unrelated to experiment). Thus, the results across both DF methods converge on the same notion that forgetting is an active process that requires the engagement of controlled strategies, and that it does not happen by “doing nothing.”

Two of the theoretically relevant strategies warrant attention because they were selected more frequently—“*stop thinking of F items*” and “*rehearsing previous R items*”—with only three

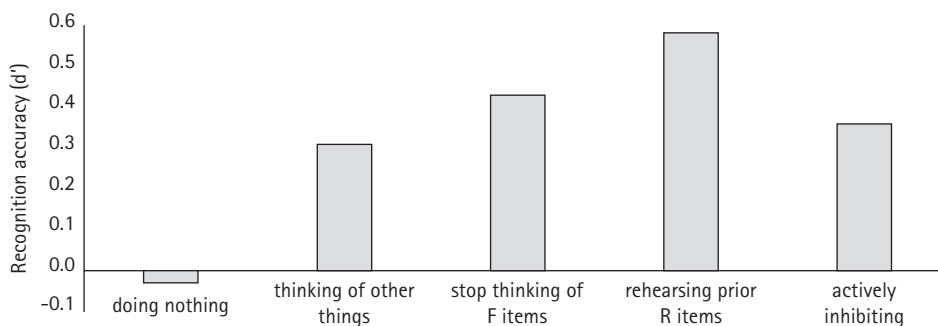


Figure 42.2 Item-method DF effect as a function of self-reported strategies. DF effect is computed as the difference in recognition accuracy (d') between Remember and Forget items.

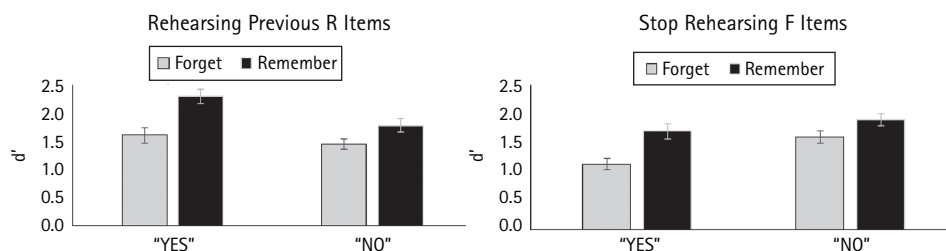


Figure 42.3 Recognition accuracy in F and R conditions across participants reporting rehearsing previous R items (left panel) and participants reporting stop thinking of F items (right panel). Error bars represent SE of the mean. “YES” represent participants who reported the strategy, and “NO” represents participants who did not report the strategy in post-experimental questionnaire.

participants reporting engaging in both of these strategies. These reports validate the current accounts of item-method DF—the rehearsal of R items, and the active termination of processing of F items (see the section titled “Theoretical Accounts of Directed Forgetting”).

Figure 42.3 summarizes discrimination accuracy across R and F conditions for participants reporting “*stop thinking of F items*” and for those reporting “*rehearsing previous R items*.” It validates the strategy reports because memory for R items is higher among those who reported rehearsing previous R items compared to those not reporting such strategy (Figure 42.3, left), whereas memory for F items is lower for those reporting terminating processing the F items compared to those not reporting such strategy (Figure 42.3, right).

Thus, two most frequently reported strategies appear to have different behavioral profiles. Although DF effect is enhanced among those who report rehearsing previous R items, and among those who report stop thinking of F items, the increase in the size of the DF effect is driven by different processes, respectively (enhanced R memory vs. decreased F memory). Interestingly, there was a sizeable negative correlation between these two strategy reports (phi correlation coefficient = -0.44 , $p < .001$), implying that participants who stopped thinking about the F items are different from those who devoted rehearsal to the earlier R items; in fact, only three participants reported engaging in both strategies. These reports and their behavioral outcomes have implications for the theoretical accounts of item-method DF. Terminating processing of F items is not necessarily tied to the extra processing devoted to R items—some participants may stop thinking of F items, without necessarily engaging in rehearsal of previous R items, and vice versa. Both types of strategies produce sizeable DF. Finally, the strategy of “*thinking of other things unrelated to the experiment*” in response to the F cue is fully consistent with the recently proposed unbinding account that invokes the separation of items from their episodic context (Chiu et al., 2021). More in-depth discussion of this account is provided in the section titled “Theoretical Accounts of Directed Forgetting.”

Overall, DF is a complex phenomenon that involves controlled behaviors, with different processes contributing to DF. DF does not emerge if participants do “nothing” in response to the F cue. This is true for both list-method and item-method DF.

Theoretical Accounts of Directed Forgetting

Directed forgetting is a robust phenomenon that emerges across a range of stimuli and memory tests. However, item-method and list-method DF are differentially sensitive to the type of memory test, constraining the theoretical mechanisms proposed to explain them. Below is a brief “biography” of DF to provide a historical perspective of how various theoretical ideas

evolved (for additional reviews on this topic, see Basden & Basden, 1998; E. Bjork et al., 1998; MacLeod, 1998, 2012; Sahakyan et al., 2013; Sahakyan & Foster, 2016).

Selective Rehearsal Account

The selective rehearsal account was one of the early intuitive notions about how DF is accomplished. It was proposed at the time when not much was known about the distinction between list-method and item-method DF. The basic idea is that DF impairment arises because in response to a forget instruction, participants stop rehearsing F items and devote their processing resources to R items (e.g., R. Bjork, 1970, 1972). This view worked well in explaining item-method DF, which emerged in recall, recognition, and implicit memory tests, suggesting that F items were weaker in activation strength compared to R items. However, the suitability of selective rehearsal for explaining list-method DF diminished over time because of two critical sets of findings. First, list-method DF was reliably absent in recognition tests and implicit memory tests (e.g., Basden et al., 1993; Benjamin, 2006; E. Bjork & Bjork, 2003; Block, 1971; Elmes et al., 1970; Geiselman et al., 1983; MacLeod, 1999; Racsmány et al., 2008; Reitman et al., 1973; Sahakyan & Delaney, 2005; Whetstone et al., 1996; Zellner & Bäuml, 2006), whereas item-method DF was always found across a range of memory tests (e.g., Basden & Basden, 1996; Basden et al., 1993; Burgess et al., 2017; Fawcett & Taylor, 2008, 2012; Hockley et al., 2016; MacLeod, 1999; Taylor, 2005). The absence of list-method DF in recognition tests posed a serious constraint for the selective rehearsal account because recognition and recall are sensitive to elaborative rehearsal (Geiselman & Bjork, 1980), and recognition is even more sensitive than recall to rote rehearsal (Benjamin & Bjork, 2000; Craik & Watkins, 1973). Therefore, regardless of the nature of rehearsal process involved in DF, terminating rehearsal of F items should have negative consequences for recognition memory; however, the data did not support this prediction. Importantly, recognition performance is not at ceiling despite the short lists used in many list-method DF studies, and even longer lists do not lead to list-method DF impairment in recognition (Benjamin, 2006; Sahakyan & Delaney, 2005). Thus, any explanation that attempts to revive the selective rehearsal account (for list-method DF) should address this important limitation.

The second major constraint for selective rehearsal account was the presence of list-method DF in incidental learning (Geiselman et al., 1983; Sahakyan & Delaney, 2005, 2010). Because incidental learning by definition does not involve rehearsal, DF impairment in incidental learning must be caused by a mechanism other than withdrawal of rehearsal from F items. Thus, the appeal of the selective rehearsal account as a unifying explanation for both list-method and item-method DF started to wane, and the account was reserved primarily to explain item-method DF. At the same time, the retrieval inhibition account was proposed to explain the list-method DF (Geiselman et al., 1983), and its rise was motivated by several factors.

Retrieval Inhibition Account

Recognition tests did not show list-method DF effects. Implicit memory tests were also insensitive to list-method DF, including word stem and fragment completion tests (Basden et al., 1993; E. Bjork & Bjork, 1996), tests of primed word association or general knowledge (Basden & Basden, 1996, 1998), and lexical decision (Racsmány & Conway, 2006). In all of these tasks, F items show priming that is equivalent to R items, suggesting that they are available in memory at full strength. Conversely, in item-method DF, F items typically showed less priming than R items (e.g., Basden et al., 1993; MacLeod, 1998; MacLeod & Daniels, 2000; Paller, 1990). Furthermore, when two types of items were intermixed in List 1

(in the list-method DF design), with half of them to be learned for a later memory test and the remaining half to be incidentally encoded, both types of items showed list-method DF (Geiselman et al., 1983), suggesting that incidentally encoded items were “at a wrong place, at a wrong time.” All of these findings led to the rise of the retrieval inhibition hypothesis (R. Bjork, 1989; Geiselman et al., 1983). According to retrieval inhibition, the F cue triggers processes that inhibit List 1 items, impairing their recall during the test. Inhibited List 1 items reduce proactive interference on List 2 items, improving List 2 memory compared to the R group. Retrieval inhibition explained the absence of list-method DF in recognition tests (or implicit tests) by proposing that F items are released from inhibition when they are re-presented during the test (e.g., E. Bjork & Bjork, 1996, 2003; R. Bjork, 1989; Geiselman et al., 1983; Zellner & Bäuml, 2006). Although this view is rather popular, note that there is nothing a priori in the inhibition account to propose a release from inhibition on certain tests. For example, assumptions of release are not made for other inhibitory phenomena such as retrieval-induced forgetting (RIF), which emerges reliably in recognition and lexical decision tests (e.g., Aslan & Bäuml, 2011; Hicks & Starns, 2004; Soriano et al., 2009; Spitzer & Bäuml, 2007, 2009; Veling & van Knippenberg, 2004; Verde, 2004). Thus, it is unclear why inhibition would be released in DF but not in RIF. Aside from reduced accessibility in free recall, there is no specific evidence that F items were inhibited in the first place (to be later released from inhibition), and impaired access to F items can be caused by many factors.

A number of boundary conditions have been identified for list-method DF. For example, list-method DF is observed only when the F cue is followed by encoding of new material, such as List 2 (Gelfand & Bjork, 1985, described in R. Bjork et al. (1998); Pastötter & Bäuml, (2007)), and only when the format of the material matches across the two lists (Hupbach & Sahakyan, 2014). In addition, list-method DF decreases in magnitude with decreasing length of List 2 (Pastötter & Bäuml, 2010) or when List 2 is encoded with divided attention (Conway et al., 2000; Macrae et al., 1997). The inhibitory account explains the need for List 2 encoding by proposing that inhibition is an adaptive mechanism invoked to reduce interference, and in the absence of List 2 learning, there is no need to inhibit List 1 items because there is no material with which List 1 could interfere. Alternative interpretations of these boundary conditions were also offered, having to do with the ease of context reinstatement or the strength of new context representation (Hupbach & Sahakyan, 2014).

Note that different DF researchers have interpreted the term *inhibition* in different ways. Some interpreted inhibition as suppressing the activation level of F items (e.g., Barnier et al., 2007; Conway et al., 2000; Racsmány & Conway, 2006; Racsmány et al., 2008). Others proposed that F items reside in memory at their full strength, as evidenced by an intact recognition or intact implicit memory performance, but the retrieval of List 1 episode is inhibited (e.g., E. Bjork & Bjork, 1996; R. Bjork, 1989). Multiple meanings of the term inhibition can be confusing, especially to researchers outside of the memory field who are likely to interpret “inhibition of List 1 episode” as analogous to “inhibition of items within that episode.” However, for memory researchers, an episode is a complex term that refers not only to the items but also to the context within which those items were learned. The only evidence for impaired inhibition of List 1 items comes from impaired free recall of those items, which can also be caused by a mismatch between the retrieval cues being used to search the memory and the contents of memory.

Context-Change Account

In response to the retrieval inhibition account, I proposed a different explanation of list-method DF having to do with the importance of contextual information in retrieval (Sahakyan &

Kelley, 2002). Broadly, *context* refers to the “setting” in which items are encoded. It includes one’s thoughts, mood, and environment in which learning takes place. When freely recalling lists of items, subjects must search memory without the aid of external cues. In these recall tasks, the list’s “context” and context evoked by previously recalled items serve as the cues for subsequent recalls (see Chapter 38). Dissimilarity between the cues used at retrieval and the cues present at encoding is known to impair retrieval (e.g., Mensink & Raaijmakers, 1988; Smith & Vela, 2001). According to the context-change account of DF, participants actively shift their mental context in response to the F cue, distancing themselves from the context in which they encoded List 1 items. This impairs the ability to reinstate List 1 context during test because the context at test better matches List 2 than List 1, thereby producing DF impairment of List 1. DF enhancement of List 2 is attributed to reduced proactive interference from having encoded the lists in two separate contexts. Note that impaired List 1 and enhanced List 2 are not always observed together in list-method DF studies, and in response to many dissociations, dual-factor accounts have been proposed, attributing List 1 impairment to context-change or inhibition and attributing List 2 enhancement to a change in encoding strategy or a reset of encoding processes (Pastötter & Bäuml, 2010; Sahakyan & Delaney, 2003, 2005). For a more complete review of dual-factor accounts of list-method DF, the reader is referred to Sahakyan et al. (2013).

Neural support for the context-change account came from a functional magnetic resonance imaging (fMRI) study conducted by Manning et al. (2016). In that study, participants performed a modified version of list-method DF. A first list of words was studied, which had task-irrelevant images of scenes interspersed between the words. Participants were told to learn the words for a subsequent memory test and to view the scenes passively. Following the F or R cue presented after the first list, participants studied a second list of words that did not contain any scenes. The scenes were used as “context tags” to decode and track the mental context signal from the first list study episode (Gershman et al., 2013). Manning et al. (2016) observed that in response to the F cue, there was a reduction in the neural representation of the context signal that took place prior to study of the second list, suggesting a downregulation of context. Most important, the magnitude of the reduction of context signal predicted successful DF forgetting during the final test.

How does the context account handle null effects in recognition and implicit memory tests? Implicit tests do not rely on contextual information because they do not direct attention to the original study episode. Because they do not require reinstating prior episodic context, we would not expect to observe DF on such tests, consistent with the observed findings. Environmental context effects also are not found on implicit tests (e.g., Parker et al., 1999).

The absence of DF in recognition is consistent with a body of literature which shows that environmental context effects are substantially smaller (Hockley, 2008; Macken, 2002) or even absent (Godden & Baddeley, 1975). However, under certain conditions, environmental context effects do emerge in recognition, especially with configural stimuli, such as faces or nonwords (for a review, see Smith & Vela, 2001). For example, recognition of nonwords suffers when they are tested in a different environmental context, and the explanations involve stronger associations with episodic context due to their smaller pre-experimental fan, or greater reliance on context cues to discriminate one nonword from another nonword, because in the absence of semantic information they are highly similar to each other (e.g., Russo et al., 1999). Given the prominent role of contextual information in recognition of nonwords, we predicted and obtained list-method DF using nonwords in recognition, despite not obtaining DF effects with words (Sahakyan et al., 2009). In another experiment, we predicted and obtained list-method DF in recognition by manipulating whether the test required distinguishing



the targets from similar or dissimilar distractors (Sahakyan et al., 2009). Similar distractors involved plurality-reversed versions of the target words (e.g., *napkin* was a List 1 target item, whereas *napkins* was a similar distractor on a recognition test). The reasoning was that plurality discrimination engages more direct retrieval of contextual information at test (i.e., using a recall-to-reject strategy), which might enable detecting DF in recognition even with word stimuli. Indeed, the results confirmed our predictions: We obtained DF in plurality-reversed recognition of words, but there was no DF when the distractors were completely new and dissimilar words (e.g., *napkin* was a List 1 target item, whereas *beans* was a dissimilar distractor on a recognition test). Lehman and Malmberg (2009) also found list-method DF in recognition of words using an exclusion manipulation. The typical recognition tests in DF studies ask participants to endorse any item regardless of which list it appeared on (i.e., inclusion condition). Under such conditions, participants do not have to rely on context cues to differentiate one study episode from another, and they can rely on item familiarity as the basis of recognition. In contrast, under exclusion instruction, participants have to endorse only the words from a designated list (only List 1 or List 2, but not both) and reject the words from another list, along with rejecting the new items. Performing exclusion recognition accurately requires relying heavily on context cues to differentiate one list from another, and indeed Lehman and Malmberg (2009) obtained robust DF under exclusion instructions.

Obtaining list-method DF in some conditions of recognition suggests that the typical conditions of recognition rather than the recognition test itself were the reasons for the observed lack of DF in previous research. Simply stated, when stimuli or test conditions encourage greater utilization of contextual information, list-method DF is observed in recognition. These results challenge the inhibitory interpretation, which explained the null recognition findings through the assumption of release of inhibition. It is problematic because the inhibitory account does not a priori predict the conditions under which inhibition is *not* released. The inhibition account also does not explain why list-method DF is found in recognition using a remember/know procedure, but only for “remember” responses, which rely heavily on contextual information (Racsmány et al., 2008). The inhibitory account also has to make new assumptions to explain why List 1 items can be released from inhibition, but their source information is not released. For example, Gottlob and Golding (2007) found that the F cue impaired source memory for color and case of List 1 items, even though they confirmed the typical null effect in recognition of List 1 items. In summary, although list-method DF effects are typically absent in recognition, the above-listed findings indicate that they do emerge under conditions that require utilization of contextual information and greater reliance on recollection.

Because the assumption of release is an important premise of inhibitory theory, it is worth considering another set of studies that re-exposed F items on an intervening test, and depending on the nature of the intervening test, list-method DF was either subsequently eliminated or preserved. The design of those studies involved (a) giving an initial recall test to confirm that list-method DF was obtained, then (b) re-exposing all or a subset of items from both lists on an intervening test and (c) administering a final recall test to reassess DF. The intervening tests included recognition (Basden, Basden, & Wright, 2003; Basden et al., 1993; E. Bjork & Bjork, 1996), word fragment completion (Basden, Basden, & Wright, 2003; E. Bjork & Bjork, 1996), implicit free association test (Basden et al., 1993), or lexical decision (Racsmány & Conway, 2006). Initial recall revealed DF in these studies confirming the DF effect. The intervening tests did not show any DF, consistent with previous findings. Importantly, the final recall findings differed depending on the nature of the intervening task. When the intervening test involved a recognition test that included a subset of F items as lures, DF was



eliminated on a final recall test. In contrast, intervening word fragment completion, lexical decision, or free association tests did not release DF. If List 1 items were inhibited, as suggested by the inhibitory account, then subsequent exposure to those items during the intervening test should have released them from inhibition, and the final test should have produced a null DF effect. However, some intervening tasks did not eliminate DF, whereas others did, suggesting that re-exposure by itself does not release those items from inhibition. The way those items are processed, particularly if they retrieve the contextual information associated with the study episode, is critical for reinstating access to List 1 items.

The fragment completion test is an indirect memory test because it does not direct participants to the original study episode. Likewise, lexical decision tasks or free association tasks do not require reinstating previous episodic context. The intervening recognition test, however, is a direct measure of memory because the participant has to think back to the learning episode and make a decision about a specific item (note that E. Bjork and Bjork [1996] included an exclusion instruction on the intervening recognition test, which would further enhance retrieval of contextual information about the original study episode). Thus, DF is eliminated when the episodic context associated with the original study episode is reinstated by the intervening task. In contrast, DF is not released by indirect tests that do not make connections with the earlier study episode.

Note that selective retrieval of a subset of List 1 items on the final test also enhances recall of the remaining List 1 items in the F condition (Bäuml & Samenieh, 2010, 2012a, 2012b). Part-set cuing affects DF in a similar fashion: Providing a subset of List 1 items on the final test and instructing participants to use them as cues improves the recall of remaining List 1 items in the F condition (e.g., Goernert & Larson, 1994). To explain the effects of part-set cuing or part-set retrieval in DF, Bäuml and colleagues also invoked the notion of context reinstatement, such that when the original study context is reinstated through part-set cuing or part-set retrieval, DF is substantially reduced.

Context reinstatement in general reduces or eliminates the DF effect. For example, before giving the final recall test, Sahakyan and Kelley (2002) attempted to mentally reinstate the original study context by making it memorable and distinctive. They played the *Star Wars* theme at the start of the experiment and presented the consent form appearing on the computer screen akin to the way the words scrolled on the screen at the start of the movie. Their instructions given before the final test were aimed at mentally reinstating the context of the start of the experiment, and indeed mental reinstatement reduced list-method DF.

The importance of the interaction between the retrieval cues used at test and the contents of memory is also evident in a list-method DF study (Lehman & Malmberg, 2011) that included items drawn from a single taxonomic category for some participants or unrelated items for other participants (List 2 always contained unrelated items). Category-specific retrieval cues should greatly reinstate the original context compared to general temporal context cues (e.g., Raaijmakers & Shiffrin, 1981), and indeed when memory was probed with the category cue (e.g., “Use the word *clothing* to help you retrieve the words from List 1”), DF was eliminated, whereas temporal context cues (e.g., “Retrieve the items from List 1”) produced DF effect. Thus, the *same* categorical list can either show DF or be released from DF depending on the type of retrieval cues used during the test. The more specific the cue is to List 1 study context, the less likely is DF to be observed.

If List 1 items were inhibited as a result of DF, then why did they recover from contextual reinstatement (e.g., Sahakyan & Kelley, 2002), utilization of specific category cues but not general context cues (e.g., Lehman & Malmberg, 2011), part-set cuing (Goernert & Larson, 1994), part-list retrieval (e.g., Bäuml & Samenieh, 2010), or certain types of intervening tests



(e.g., E. Bjork & Bjork, 1996)? To explain the recovery, the inhibitory account would have to assume that reinstating or changing the context at the time of final test has consequences for memory and that a mismatch of cues being used to search memory and the contents of memory leads to reduced accessibility. Because these are general claims made by many theories of memory, it is unclear what is gained by postulating an inhibitory mechanism if reduced accessibility of List 1 items has to be explained through contextual mechanisms. If it is the List 1 context that is being inhibited as opposed to List 1 items (e.g., Anderson, 2005; Anderson & Hanslmayr, 2014), then we need a brand new theory of inhibition of context. Such a new theory needs to be able to explain more than what we already can explain through existing models. In other words, it should demonstrate that without postulation of inhibition of context, one cannot explain the data.

Further evidence that contradicts the assumption of release from inhibition was provided by Sahakyan and Goodmon (2010), who demonstrated that strong retrieval cues produce *larger* DF effect, whereas the inhibitory account would predict *smaller* DF effect with strong retrieval cues on the assumption of release. Sahakyan and Goodmon's (2010) testing methods departed from the traditional recall and recognition tests and instead used the associative cuing procedure. Specifically, participants studied unrelated words, which at the time of test were cued with meaningfully related but unstudied words (e.g., studied the word UNIVERSE, but at test was probed with a meaningfully related but unstudied word such as PLANET to help retrieve UNIVERSE). Importantly, in some experiments, the authors varied the associative strength of the target items (strong vs. weak targets) while testing them with cues of equal associative strength, whereas in other studies, they varied the strength of the test cue (strong vs. weak test cues) while holding the strength of the target items constant. The associative cuing procedure is fully dependent on the interaction of information provided by the test cue and the information activated by the target item (for reviews, see Nelson et al., 1998, 2007). In other words, it is an intersection process determined by test cue and the target. This means that before the cues are presented at test, the cognitive system has no way of anticipating which List 1 items it should impair more or should impair less (in response to the F cue). One might think that targets tested with stronger test cues should be released from inhibition based on the assumption of release of inhibition. In other words, the inhibitory account would predict smaller DF in the conditions in which the cue strength is high. In contrast, the results showed the opposite: DF was larger in the conditions in which the cue strength was high. DF was also larger when the target strength was high versus low. These effects were predicted by the theoretical model that explained how associative cuing works. According to the model, episodic context cues and associative strength combine (in a multiplicative fashion) to elicit retrieval. Therefore, the model made a rather strong prediction that regardless of the source of the strength (be it from the target strength or the cue strength), DF should be larger under the conditions in which the cue strength or the target strength was high. Indeed, the results of five experiments confirmed these predictions.

Several additional DF studies involving stimuli that varied on pre-experimental context variability (Sahakyan et al., 2013), or items that varied in the strength of associations with episodic context (e.g., Sahakyan, Delaney, & Waldum, 2008; Waldum & Sahakyan, 2012), or individual differences in the processing of temporal context (e.g., Delaney & Sahakyan, 2007; Sahakyan, Delaney, & Waldum, 2008; Sahakyan et al., 2014) produced specific interactions with list-method DF that were predicted a priori by the context account, because they were derived from other research about how episodic context is involved in various memory phenomena or certain populations.



When the context-change account was initially proposed, its empirical support came from thought substitution studies in which, between the two lists, participants were asked to think of things unrelated to the experiment (i.e., imagine being invisible), and such instructions produced effects similar to the F cue without instructing anyone to forget (e.g., Sahakyan & Delaney, 2003; Delaney et al., 2010; Sahakyan & Kelley, 2002). Some researchers might therefore see the strongest support for the context account in those thought-substitution studies. Over time, however, it appears that thought substitution studies provide a proof of concept rather than an exclusive affirmation of the context account. This reflects that some thought substitutes were less effective than others for as yet unknown reasons. Not having a theory about why some thought substitutes produce forgetting and others do not limits their appeal because we *infer* about context change when a manipulation produces forgetting in the experiment, whereas manipulations that do not produce forgetting serve as a “baseline/control” against which we may compare these effects. This appears dissatisfying because (a) there is circularity in reasoning about what does or does not produce a mental context change; and (b) it is extremely challenging to predict which novel thought substitution manipulations might work, and we resort to using the same tasks that had worked in the past. We may be risking developing a theory of specific tasks rather than a theory of context change.

Thought substitution studies aside, what makes the context account appealing is its *predictive utility*, its ability to anticipate certain interactions with DF based on existing literature on the effects of context. It is this specific component that makes the context account valuable. For example, as discussed previously, we had anticipated obtaining a DF effect in recognition using nonword stimuli based on the previous research that did not involve DF and instead explored the strength of associations of certain types of stimuli with their episodic context. The notion that low-frequency items in general and nonwords in particular are more strongly associated with their episodic context led us to predict that they would suffer more from the context shift induced by DF instructions compared to the words. The results confirmed those predictions demonstrating list-method DF in recognition testing with nonwords but not with words (e.g., Sahakyan et al., 2009). The fact that some memory strengthening manipulations enhance the association with episodic context more than other strengthening manipulations (i.e., spaced repetitions) led us to predict that spaced items would suffer more from DF instructions than other items, which are strengthened through additional study time or through depth of processing (e.g., Sahakyan, Delaney, & Waldum, 2008). Additional examples of interactions with DF that were predicted based on a different line of research can be found in Sahakyan and Goodmon (2010). Finally, Sahakyan et al. (2019) examined DF in a population with vulnerability to mental illness because the latter were shown to have deficits in processing episodic context (Sahakyan & Kwapil, 2018). The results confirmed the predicted interactions with DF in this special population.

Note that the context-change mechanism is not uniquely suited to explain list-method DF. Instead, the context-change interpretation brings DF under the umbrella of other memory phenomena that are explained by existing models of memory. These models and the rich empirical foundation of the environmental context literature serve as a foundation for new quantitative and qualitative predictions.

Active/Inhibitory Account of Item-Method Directed Forgetting

Based on the previous discussion, readers would likely think that the debate about the role of inhibitory mechanisms has concerned primarily the list-method DF. They would not be wrong because that was the state of research for quite some time. However, these days the role of inhibitory processes is gaining momentum, especially in the item-method DF literature.



Furthermore, the unbinding of items from their context has been recently proposed as a mechanism involved in item-method DF. As one can see, there has been a sea change in DF research in the 21st century.

The initial interpretation of item-method DF involved selective rehearsal (e.g., Basden et al., 1993; R. Bjork, 1970; MacLeod, 1999), according to which participants maintain an item in working memory until they receive the memory cue. The F cue leads participants to terminate rehearsal, which leads to the eventual decay of its representation, whereas the R cue leads to more elaborate and continued encoding of that item. In other words, this account views item-method DF as the absence of rehearsal.

The recent literature, however, challenges this passive view of DF forgetting and suggests that the actual process of removal of F items from working memory engages active processes to withdraw attention from the representation of F items, as a result of which F items become inhibited and cannot regain access to working memory at retrieval (Fawcett & Taylor, 2008, 2010, 2012; Hauswald et al., 2011; Lee et al., 2013; Ludowig et al., 2010; Nowicka et al., 2011; Oberauer, 2018; Oehrn et al., 2018; Paz-Caballero, 2004; Reber et al., 2002; Rizio & Dennis, 2013; Wylie et al., 2008; Zacks et al., 1996). Whereas the passive rehearsal account highlights processes aimed at remembering the R items, active accounts of item-method DF highlight processes aimed at terminating encoding of F items, which are presumably inhibitory in nature.

Evidence for these claims comes from several domains. For example, behavioral studies have shown that reaction times (RTs) on a secondary task that is performed along with DF task are slower during the execution of the F cue (Fawcett & Taylor, 2008, 2010, 2012). For example, Fawcett and Taylor (2008) had participants detect a visual probe following the F and R instructions, and they found that probe RTs were slower following the F cue than the R cue, indicating that forgetting is not only effortful and resource demanding but also may be more effortful than remembering (at least in the first seconds of cue instantiation). If forgetting was simply accomplished through passive decay of F items and extra rehearsal of R items, then such a passive view would predict longer RTs for R trials than for F trials. One might wonder if the slower RT after F cues could be because participants are actively searching and retrieving previous R items while they stop rehearsing the F items. However, the authors included “irrelevant” trials into their design—that is, in addition to F and R words, on some trials they showed a string of X’s instead of a word, making the R and F instructions that followed the string of X’s irrelevant for that trial. Importantly, they found that RTs were identical between the X and R trials, and they were substantially faster for X trials than for F trials. Thus, the RTs on the X trials argue against the effortful search of the previous R words, which should have also taken place during the X trials, not just the F trials.

Studies also demonstrated that there is reduced processing of other information that is presented in temporal or spatial proximity to F items (Taylor, 2005; Taylor & Fawcett, 2011, 2012; Thompson & Taylor, 2015). For example, in a study that combined DF with visual attention manipulation, Taylor (2005) presented study items and localization targets in the right or left visual periphery so that the study items served as nonpredictive spatial cues for the targets. Taylor found that participants withdrew visual attention from a spatial location that was previously occupied by an F item more easily than from a location occupied by an R item, indicating that inhibition of return is increased following F instructions. In summary, these studies suggest that intentional forgetting is not just the absence of remembering but it is associated with processes that are distinct from remembering.

Neural evidence also confirms that successful intentional forgetting (F items that are subsequently forgotten) recruits additional processes beyond those that are associated with passive



forgetting (R items that are subsequently forgotten) (for a review, see Anderson & Hanslmayr, 2014). For example, during an attempt to forget, prefrontal and parietal regions are more active than during an attempt to remember an item, suggesting that successful forgetting may be more demanding and recruits additional resources (Paz-Caballero et al., 2004; Rizio and Dennis, 2013; van Hooff and Ford, 2011; Wylie et al., 2008). Connectivity analyses demonstrate that activity in right dorsolateral prefrontal cortex (DLPFC) on F trials predicts decreased activity in the left hippocampus, particularly during successful intentional forgetting, suggesting that right PFC exerts inhibitory control over encoding activity in medial temporal lobe (e.g., Rizio & Dennis, 2013). Intracranial ERPs show that F items that are subsequently forgotten show reduced memory-related negativity in anterior hippocampus compared to R items that are subsequently forgotten, providing further evidence that successful forgetting is correlated with suppressed memory activity, driven down by DLPFC (Ludowig et al., 2010; Oehrn et al., 2018). Overall, growing evidence indicates that item-method DF engages an active process that suppresses ongoing encoding.

Role of Context in Item-Method Directed Forgetting

So far, the discussion of item-method DF accounts has involved the selective rehearsal theory and the inhibitory theory. What about the role of contextual information? Does context play any role in item-method DF? This is a complex question that has started to receive attention in the literature. It is a difficult one to tackle because there is ample indication that F items are weaker than R items in memory (unlike in list-method DF, in which they appear to reside at full strength, but access to them is impaired). In item-method DF, however, access to F items and the fidelity of representations of F items are degraded (e.g., Fawcett et al., 2013a, 2013b, 2016). Therefore, probing for contextual information and finding that it is less accessible for F items makes it difficult to know if it was a consequence of impoverished representation arising from poor encoding or whether it was causally involved in producing impaired retrieval in item-method DF.

Although research on these questions is still in its infancy, there are indications that processing of contextual information is involved as a mechanism in successful item-method DF. Measuring context processing separately from item processing has not been possible in previous item-method DF studies. Our recent fMRI study was designed to do just that. We used independent data to train pattern classifiers to simultaneously identify and track neural signatures of two types of information—*item* information (word-related activity) and *context* information (scene-related activity) in an item-method DF study (Chui et al., 2021). The manipulation of item information and context information was quantified on each trial and related to subsequent recognition outcomes in the final memory test. Initially, in a preview phase, participants viewed a series of words, with task-irrelevant scene images (used as “context tags”) interspersed between them, akin to Manning et al.’s (2016) list-method DF study. Later, these words reappeared (without the scenes) and were followed by an F or R instruction after each word. We observed robust differences in the modulation of item and context information by DF instruction. Namely, the instruction to remember was associated with an increase in item processing, with no modulation of context. However, the instruction to forget an item was associated with a downregulation of the item representation, along with an upregulation of context information from the initial preview phase, implicating a separation/unbinding of item from its context in response to intentional forgetting. Importantly, a larger magnitude of that neural separation was associated with successful DF on a trial-by-trial basis. This neural separation was not observed following the instruction to remember, however, where successful remembering was associated only with strong item processing. These results demonstrate a



previously unappreciated role for context processing in the intentional forgetting of individual items. We proposed that these processes may reflect an active unbinding of an item from its context, which accounts for successful item-method DF.

Conceptually, the unbinding hypothesis is similar to the mechanism proposed for the context-change account for list-method DF (Sahakyan & Kelley, 2002). In the section titled “Directed Forgetting Is a Controlled Process,” I discussed a variety of strategies that participants reported in item-method DF studies, and some participants reported engaging in thought substitution in response to the F cue (i.e., “thinking of other things unrelated to experiment”). This strategy was associated with substantial item-method DF effect, akin to thought substitution effects in list-method DF studies. These strategy reports provide empirical support to the notion that shifting, distancing, or unbinding the item from its context might also be involved as a mechanism for accomplishing intentional forgetting in item-method DF. We do not claim that it is the sole mechanism responsible for item-method DF; plenty of research has confirmed the role of encoding differences between the F and R items. We simply suggest that item-method DF not only reflects a failure to encode information but also is driven by impaired retrieval at test that may arise from the unbinding of items from their context.

Consistent with these claims, recent behavioral and eye-tracking studies from our lab demonstrated that item-method DF impairs item-to-context associations (Whitlock et al., 2020, 2022). Using object–scene pairings, Whitlock et al. demonstrated that the association between the scenes and the object was impaired by the F cue and that it was *independent* of item impairment, such that participants could recognize the object during the final test (i.e., unsuccessful DF despite the F cue) and yet fail to recognize the background scene that was previously paired with that object (Whitlock et al., 2022).

Finally, multinomial modeling analyses that disentangle encoding and retrieval components of memory effects indicate that worse memory of F items is driven not only by impaired encoding of F items but also by impaired retrieval, which presumably could be voluntarily controlled (Marevic et al., 2018; Marevic & Rummel, 2020; Rummel et al., 2016). Overall, accumulating evidence from different domains highlights the previously neglected role of context in item-method DF.

Conclusion

Forgetting has long been recognized to play an adaptive role in healthy cognitive functioning (e.g., R. Bjork, 1989). William James (1890) succinctly summarized this notion: “If we remembered everything, we should on most occasions be as ill off as if we remembered nothing” (p. 680). Forgetting is an active process, over which we have control. It requires engagement of controlled behaviors to diminish access to unwanted information, and it does not happen by simply having an intention to forget. The decisions to engage in those controlled processes may be mediated by a myriad of factors, including one’s metacognitive beliefs about their own memory and forgetting. Thus, it is important to attend to behaviors that people engage to have a better understanding of why DF occurs and why it may be diminished or absent (especially in special populations).

Much of the research discussed in this chapter has focused on either list-method or item-method DF paradigms. This raises several important issues. To what extent are these methods related to the actual practice of intentional forgetting in the real world? The processes involved in list-method DF appear akin to our efforts to dispose of no-longer-needed information, such as our parking location at the market, our hotel room number, or an out-of-service telephone or outdated PIN number. This is information that we initially strive to encode and maintain but subsequently wish to forget. Item-method DF involves an immediate desire



not to encode and maintain information, such as our experience of encountering frivolous/specious information and/or embarrassing and upsetting events. This raises a subsequent question of whether we should consider DF as unitary construct or consider these as separate, albeit related phenomena, with distinct processes related to truncating encoding or impairing retrieval of unwanted memories.

Understanding why some items are successfully remembered or forgotten has received considerable attention in cognitive neuroscience of memory. The advent of imaging and electrophysiological measures has made it possible to have a “window” into the mind by obtaining concurrent measures of neural activity that unfold in memory studies and relating them to successful and unsuccessful memory outcomes, thereby enhancing our understanding of the processes that contribute to forgetting (Paller & Wagner, 2002; Wagner et al., 1999). Although basic cognitive research on DF has come a long way, it has been somewhat hesitant to embrace the growing neural literature on this topic, and in doing so might risk becoming compartmentalized. We should strive to incorporate more sensitive measures of behavior and look beyond overall accuracy scores. By decomposing summary measures of performance into meaningful components and processes, we will advance our understanding of DF and constrain theoretical interpretations. Fortunately, our repertoire of tools has grown markedly in the past decades, and we must continue to advance those tools, as well as the theoretical and computational models for exploring and understanding DF.

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