EVENT-METHOD DIRECTED FORGETTING:
THE INTENTIONAL FORGETTING OF EVENTS AND ACTIONS

by

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DEDICATION PAGE

To my wife Emily,
In appreciation of her undying support and constant companionship

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ABSTRACT

In an *event-method* directed forgetting task, instructions to remember (R) or forget (F) were integrated throughout the presentation of four videos depicting common events (e.g., baking cookies). In a concurrent-instruction paradigm (Experiments 1-5) participants were instructed to remember (R) anything presented when the video border was green and to forget (F) anything presented when the video border was purple. In a post-instruction paradigm (Experiments 6-10) participants were instructed to remember anything preceding a green circle and to forget anything preceding a purple circle. The R or F segments lasted 35 s and were randomly assigned such that each video always contained 4 R and 4 F segments. Participants responded more accurately to cued-recall questions (Experiments 1 and 6) and true-false statements (Experiments 2-5 and 7-10) regarding R segments than F segments although this difference was found only for relatively specific (*the woman added 3 cups of flour*) as opposed to general (*the woman added flour*) information (Experiments 5 and 7-10). Participants retain a general representation of the events they intend to forget – even though this representation is not as specific as the representation of events they intend to remember. At encoding, participants were faster to discriminate targets overlaid upon F segments compared to R segments in the concurrent-instruction paradigm (Experiment 3) but were slower to detect targets presented following F compared to R instructions in the post-instruction paradigm (Experiments 6-7 and 9-10). Therefore, whereas both concurrent- and post-instruction paradigms produced comparable effects on subsequent mnemonic performance, the underlying processes are not identical. In the concurrent-instruction paradigm, participants needed to control *access* to working memory; in the post-instruction paradigm, participants needed to control the *contents* of working memory. In the former case, we expect that participants minimized processing of F segments while actively rehearsing R segments. In the latter case, we expect that participants engaged one or more active mechanisms associated with the removal of processing resources from the representation of the F segments (functionally terminating rehearsal) while focusing instead on the elaborative rehearsal of the R segments.

LIST OF ABBREVIATIONS USED

ANOVA	Analysis of Variance
E	Experiment
ERP	Event-Related Potential
F	Forget
IOR	Inhibition of Return
ms	Millisecond
R	Remember
REM	Rapid Eye-Movement
RT	Reaction Time
s	Second

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CHAPTER 1 INTRODUCTION

The following chapter is based in part upon the manuscripts entitled *"Intentional forgetting diminishes memory for continuous events*" submitted for publication to Memory in March 2012 and *"Event-method directed forgetting: Forgetting a video segment is more effortful than remembering it*" submitted for publication to the Journal of Experimental Psychology: Learning, Memory and Cognition in March 2012. Co-authors for either manuscript are Dr. Tracy L. Taylor and Dr. Lynn Nadel. Jonathan Matthew Fawcett was first author for both and in that capacity designed, programmed, and implemented the experiments and then analyzed and interpreted the data; he was also the primary contributing author to the manuscript, producing the initial draft and completing all major revisions.

1.1 INTRODUCTION

Memory refers to processes through which information is encoded, manipulated and stored for later reconstruction. Although much of the psychological research on this topic has focused on encoding or storage, interest has shifted towards how memories change across time (e.g., Bernstein & Loftus, 2009; Schacter, 2001; Roediger & McDermott, 1995). Any change – including the incorporation or loss of information – is often viewed negatively; however, these changes can serve an adaptive purpose and can facilitate cognitive function by "updating" memory (e.g., Bjork & Vanhuele, 1992; Howe, 2011; Hupbach, Hardt, Gomez & Nadel, 2008; Storm, 2011). One important form of updating is the elimination of unwanted or irrelevant information to reduce interference at retrieval or to free cognitive resources at encoding for the processing of wanted or relevant information (e.g., Bjork, 1972). Discarding information in this manner is known as intentional forgetting and has been studied in the laboratory using a variety of different paradigms – each with their own theoretical interpretation. This chapter will provide an overview of the literature characterizing intentional forgetting and its distinction from unintentional forgetting while focusing on the paradigm (item-method directed forgetting) most relevant to my interpretation of the experiments presented in Chapters 2 and 3.

1.2 A BRIEF HISTORY OF FORGETTING

Because the study of human memory tends to focus on the intentional *remembering* of information, the intentional *forgetting* of information has at times been neglected. This is unfortunate, because forgetting is essential to the efficiency of remembering. Forgetting encourages the dissolution of information that is no longer relevant and which could otherwise interfere with information that remains relevant (e.g., Bjork, 1972). William James famously encapsulated this point when he stated "…[i]f we remembered everything, we should on most occasions be as ill off as if we remembered nothing" (James, 1890/1950, p. 680). He defended his position by recognizing the importance of abstraction to the development of a meaningful cognitive representation of our experiences. Jorge Luis Borges (1962) graphically depicted this point in his fictional short-story *Funes, the Memorious* in which the titular character was unable to forget the most trivial minutiae. Funes' lack of abstraction resulted in a wealth of rich, individualized representations for each object he encountered – but he was unable to developed schematic or categorical representations of those objects because doing so entailed a loss of unique details concomitant to the emergence of common features. In a rather literal sense, he could not see the forest for the individual leaves on each tree.[1]

In modern medicine, there is a similar condition known as hyperthymestic syndrome in which the patient possesses an indelible autobiographical memory (Parker, Cahill, McGaugh, 2006). Far from praising their mnemonic abilities, those suffering from this controversial disorder are frequently afflicted with an uncontrollable torrent of past experiences leaving them confused and unable to function (for a personal account, see Price, 2008). This is not unlike the suffering caused by the recurrence of unpleasant thoughts following a trauma or the obsessions inherent in other clinical disorders such as obsessive-compulsive disorder. At such times we find ourselves at the mercy of the same

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[1] "In effect, Funes not only remembered every leaf on every tree of every wood, but even every one of the times he had perceived or imagined it" (Borges, 1962, p. 114).

system that otherwise permits us to re-live our happiest moments. It is for this reason that Cicero (1988) applauded Themistocles for rebuking a young physician – having offered him the means of immaculate recall – that "…he would be doing him a greater kindness if he taught him to forget what he wanted than if he taught him to remember" (pp. 299-300).

Given the philosophical and phenomenological interest in forgetting described above, it is perhaps surprising that only recent decades have seen this topic receive experimental attention commensurate with its role in cognition. Early forgetting research provided important insights into how information is lost over time (see Ebbinghaus, 1885/2003; see also Wixted & Carpenter, 2007), but these studies focused on the loss of information attributable to decay (e.g., Roediger, Knight, & Kantowitz, 1977), interference (see McGeoch, 1932) or the diminished capacity or availability of retrieval cues (e.g., Watkins, 1979). The focus was often on forgetting as the obverse of remembering as opposed to a topic in its own right. These losses were thought to occur without active intercession and may therefore be thought of as *unintentional* forgetting. It should be clear that labeling these influences "unintentional" does not mitigate their potential contributions to efficient cognition. Schooler and Hertwig (2005) argued that passive decay could guide heuristic inference using the ACT-R cognitive architecture, and neural models of human cognition have found that without the occasional loss of outdated connections these networks can produce pathological behaviour (see Crick & Mitchinson, 1983).

However, forgetting is not always a passive or consequential process and indeed humans often have cause to discard specific unwanted information. They are supplemented in their efforts by active, sometimes effortful processes inherent to our nature. In the neural models described above, Crick and Mitchinson (1983; see also, Newman & Evans, 1965) hypothesized an active role of rapid eye-movement (REM) sleep in the "pruning" of superfluous neural connections. Animals that do not exhibit REM sleep (e.g., the *Tachyglossus*) have been found to possess larger cerebrums than expected according to their body mass (Smith, 1902). Crick and Mitchinson (1983) speculated that this could represent an adaption to compensate for the superfluous connections that would otherwise have been removed during REM sleep.[2] The connection between REM sleep and the pruning of unwanted associations has not gone without challenge (see Siegel, 2001) but it is supported by neural models of sleep-consolidation (Walker & Russo, 2004) as well as recent evidence that information people intend to forget is preferentially lost during sleep (Saletin, Goldstein, & Walker, 2011). This evidence of fundamental neural processes capable of targeting and mitigating irrelevant semantic connections offers context to the claim that humans are also capable of intentionally forgetting unwanted information through the application of effortful strategies or processes at encoding and retrieval.

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[2] More recent research on the topic of REM sleep in the *Tachyglossus* has tentatively concluded that they experience an analog of REM and non-REM sleep together in a single phase implicating an early, undifferentiated stage within the development of the sleep-wake cycle (see Siegel, Manger, Nienhuis, Fahringer, & Pettigrew, 1996). The relevance of this discovery to Crick and Mitchinson's (1983) original point regarding neural pruning remains unresolved as the functional properties of this hybrid sleep state (insofar as forgetting is concerned) have not yet been systematically quantified.

1.2.1 Item- and List-Method Directed Forgetting

Since the seminal work of Muther (1965) and later Bjork, LaBerge, and Legrand (1968), intentional forgetting has been increasingly studied in the laboratory using a paradigm known as directed forgetting (for a review, see MacLeod, 1998). There have been many variants of the directed forgetting paradigm since its inception (for a review see Basden & Basden, 1998, or Bjork, 1972), most of which have been categorized as belonging to either the item or list method (see Basden, Basden, & Gargano, 1993). In an item-method task (e.g., Hourihan, Ozubko, & MacLeod, 2009; MacLeod, 1989; Quinlan, Taylor, & Fawcett, 2010), study items are presented one at a time, each accompanied or followed by an instruction to remember (R) or forget (F). Participants are subsequently tested for all study items – regardless of the R or F memory instruction. One common finding, referred to as a directed forgetting effect, is better memory performance for R items compared to F items. This difference is thought to represent a combination of the *costs* (worse memory for F items) and *benefits* (better memory for R items) of the F instructions in relation to a control condition in which participants are instructed to remember everything (e.g., Basden & Basden, 1996; Sahakyan & Foster, 2009). Importantly, intentional forgetting in this paradigm cannot be accounted for by demand characteristics – and offering participants financial incentives for each additional F item that they can produce at retrieval does not eliminate the effect (MacLeod, 1999).

The item method is generally employed to study intentional forgetting at encoding: Superior performance for R compared to F items is observed using measures of either recall or recognition. This finding has proven to be an important theoretical distinction in differentiating the item and list method. Whereas directed forgetting for recognition performance is robust with the item method (for a review, see MacLeod, 1998) it has only recently been observed in the list method and only when the recognition task emphasizes the contextual properties of the test items (see Sahakyan, Waldum, Benjamin, & Bickett, 2009). Overall, this dichotomous finding has been interpreted as evidence that the item- and list-method paradigms are not functionally interchangeable, as they had been considered in the past (Basden et al., 1993).

For this reason, the list method is generally employed to study intentional forgetting at retrieval (e.g., Geiselman, Bjork, & Fishman, 1983; McNally, Clancy, Barrett, & Parker, 2004) and differs from the item method in that only a single R or F instruction is presented following a discrete list of items after which participants are asked to remember a second list. Early theorists attributed the directed forgetting effect observed in this paradigm to the inhibition of the F list at test (e.g., Basden et al., 1993; Geiselman et al., 1983) although others have also speculated that rehearsal strategies might play an important role (see Sheard & MacLeod, 2005). More recent evidence has presented a compelling case that list-method directed forgetting may be related to a change in mental context between F and R list presentation (Sahakyan & Kelley, 2002). According to this view, F items are not readily accessible at retrieval unless the appropriate context is reinstated. True to this prediction, when the context of the F list *is* reinstated by preceding recall with a recognition task (or direct contextual manipulation) the list-method directed forgetting effect typically observed for recall disappears (e.g., Basden et al., 1993).

1.2.2 Other Forms of Intentional Forgetting

The remainder of this chapter and the chapters to follow will focus on findings within the item method (with some discussion of the list method as it relates to events); however, it is instructive to first consider other paradigms included under the rubric of intentional forgetting to draw out paradigmatic and theoretical commonalities.

One paradigm that is often compared to directed forgetting is Wegner et al.'s (1987) thought suppression task. Wegner et al. (1987; for a review, see Wegner, 1994, or Wenzlaff & Wegner, 2000) instructed participants to avoid thinking about a white bear for a brief period, after which they were then permitted to think about whatever they chose. Throughout, participants responded (e.g., rang a bell) whenever they thought of a white bear. The suppression group was unable to prevent the target thought and during the initial suppression period reported a similar number of intrusions as a group not given suppression instructions. Once participants within the suppression group were permitted to think freely, they exhibited a post-suppression rebound effect, suddenly reporting up to twice as many intrusions compared to their earlier performance or the control group. This finding has since been extended to emotional regulation (e.g., Amstadter & Vernon, 2008) and even to complex motor acts such as golf or pendulum-based divination (Wegner, Ansfield & Pillof, 1998; see also, Wegner, 2009). Clearly avoiding a thought or action has the potential to actualize as opposed to diminish the probability of subsequent cognitive or behavioural intrusions.

It is often queried why the paradoxical effects of thought suppression do not undermine any effort to intentionally forget unwanted information. Drawing upon Wegner's (1994) ironic process theory, Whetstone and Cross (1998) argued that the reason other forms of intentional forgetting are generally successful whereas thought suppression fails lies in the requirement that participants report intrusions. According to Wegner (1994), thought suppression involves two separable processes. The first is an effortful distractor search intended to direct conscious thought away from the target. The second is an automatic, potentially unconscious monitoring process that determines whether the target is currently attended. This monitoring process has the ironic consequence of keeping the target primed and ready to intrude should the distractor search fail. Whetstone and Cross (1998) argued that it is this monitoring process that sets thought suppression apart from other forms of intentional forgetting. As support for this conviction, they demonstrated that the list-method directed forgetting effect is negated if participants are required to report whenever they think of an F item (for another discussion of thought suppression and directed forgetting, see Geraerts & McNally, 2008).[3]

Another task relevant to both directed forgetting and thought suppression is the think-no-think paradigm (Anderson & Green, 2001). Whereas thought suppression has participants attempt to avoid spontaneous activation of an undesired thought, the think-no-think

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[3] A modern theoretical interpretation (e.g., Sahakyan & Kelley, 2002) might view this outcome as arising from the maintenance of contextual continuity throughout the study phase. By reporting each time an F item intrudes into consciousness, the context associated with the F list could intermingle with the context associated with the R list – or perhaps participants would maintain mental context in the first place. Despite this possibility, the logic of Whetstone and Cross (1998) remains true: Participants are unlikely to give the unwanted information further consideration unless task demands require them to do so.

paradigm instead requires participants to suppress retrieval of an undesired target when presented with a strong retrieval cue. In this task, participants learn paired-associates such as “dog-chair” until the cue (“dog”) reliably produces the target (“chair”). This is followed by trials in which the cue appears and participants must retrieve (think trials) or suppress (no-think trials) the target. During a later test, participants typically recall fewer no-think words compared to think words or control words excluded from the think-no-think phase. Retrieval suppression in this paradigm is known to down-regulate hippocampal activity, indicating that suppression affects neural structures involved in episodic representation (Anderson et al., 2004). Preliminary evidence also suggests that this may result in a brief interruption in incidental memory formation during the period surrounding the no-think instruction (Anderson, 2011).

One might again wonder why participants are able to successfully suppress retrieval of the target in light of the paradoxical effects of thought suppression summarized above. In a recent review article, Anderson and Huddleston (2012) point out that whereas by its very nature thought-suppression requires participants to think about the undesired thought so that they can respond as required, successfully enacting a no-think instruction does not. Successful suppression on no-think trials requires no (overt or covert) response to indicate success and participants are not instructed to monitor intrusions. This argument is analogous to the account presented above as to why Wegner’s (1994) monitoring process is unlikely to undermine list-method directed forgetting (Whetstone & Cross, 1998).

1.3 MODERN THEORETICAL ACCOUNTS

Despite commonalities among the paradigms used to study intentional forgetting, each has its own theoretical model. List-method directed forgetting is thought to arise from contextual changes associated with enacting the F instruction, making it so the F list is less available than the R list at test (see Sahakyan & Kelley, 2002). Retrieval suppression within the think-no-think paradigm is thought to result in the regulation of hippocampal activity, interrupting retrieval processes and reducing the accessibility of the memory trace (see Anderson & Green, 2001). The theoretical interpretation of item-method directed forgetting is less transparent at this time as new evidence rapidly emerges to challenge traditional views.

1.5.1 Selective Rehearsal: A Conventional View

The selective rehearsal account (e.g., Bjork, 1970, 1972) is perhaps the oldest and most widely supported view of item-method directed forgetting. This account is intuitive in its appeal because it focuses on rehearsal processes, reflecting the strategies often reported following participation (e.g., Bjork & Geiselman, 1978; Sahakyan & Foster, 2009). The idea is that participants initially engage in maintenance rehearsal of the study item in anticipation of the memory instruction (e.g., Woodward, Bjork, & Jongeward, 1973). The expectation is that this form of rehearsal keeps the study item minimally active in working memory without producing any large memory benefits (e.g., Rundus, 1977; Rundus & Atkinson, 1970; although, see Greene, 1987). In the case of an R instruction, participants engage in elaborative rehearsal processes to commit the word to memory; in the case of an F instruction, they remove the study item from their rehearsal set and allow it to decay passively. A variant of this account (e.g., Sahakyan & Foster, 2009; see also, Fawcett & Taylor, 2008) also predicts that participants use the period following an F instruction to retrieve and cumulatively rehearse the preceding R items to further ensure their retention. Rehearsing R items on F trials in this manner may also provide a distraction to ensure that F items do not receive any additional incidental processing.

The selective rehearsal account is capable of explaining many findings associated with item-method directed forgetting. It predicts the directed forgetting effect for recall and recognition but not for measures of implicit memory (e.g., Basden et al., 1993). It also explains the common finding that participants report relatively more recollective experiences for R items compared to F items without any difference for measures of familiarity (e.g., Gardiner, Gawlik, & Richardson-Klavehn, 1994). The explanatory power of the selective rehearsal account combined with its historical precedence and intuitive appeal has resulted in its wide acceptance, even giving rise to a theory of nonverbal selective rehearsal for visual stimuli (Hourihan et al., 2009).

1.5.2 Attentional Inhibition: An Active View

Despite its explanatory power, the selective rehearsal account fails to characterize how participants implement their intentions to forget. This asymmetrical fixation on rehearsal processes ignores the fact that any process capable of increasing memory for R items *or* decreasing memory for F items necessarily influences the magnitude of the directed forgetting effect. This point resulted in Zacks and Hasher (1994) proposing a new theoretical framework relating directed forgetting to inhibitory deficit theory (see also, Hasher & Zacks, 1988; Lustig, Hasher, & Zacks, 2007). They proposed that directed forgetting engages a series of inhibitory processes that act to (a) cease rehearsal, (b) segregate the R and F items in memory, and, (c) suppress subsequent retrieval. Contextualizing this model in terms of their more recent taxonomic framework (see Lustig et al., 2007), their account argues that participants suppress the representation of the F study item (*deletion*) resulting in the active cessation of further processing (*restraint*) and the mitigation of retrieval processes at test (*access*). The segregation of the R and F items in memory is a probable consequence of the other mechanisms listed above in combination with the relational processing of R items but not F items, promoting a shared retrieval context for the former but not the latter.

Zacks, Radvansky, and Hasher (1996) supported their theoretical framework by demonstrating impaired directed forgetting in older compared to younger adults. They attributed this pattern to an age-related decline in inhibitory control processes. The fact that older adults demonstrate a smaller directed forgetting effect has since been replicated and the findings synthesized in a meta-analytic review conducted by Titz and Verhaeghen (2010). Age-related effects were found to be larger for item-method tasks compared to list-method tasks, resulting in the conclusion that older adults demonstrated greater encoding deficits than retrieval deficits. Titz and Verhaeghen (2010) were cautious to point out that the separation of age effects within item- and list-method tasks may be interpreted as evidence against a common genesis of directed forgetting in those paradigms – and that this is at apparent odds with the attentional inhibition hypothesis as described by Hasher and Zacks (1994) and by Zacks et al. (1996).

As summarized above, some theorists have indeed argued for a common theoretical framework. For example, the selective rehearsal account described in the preceding section as a framework for item-method directed forgetting has also been discussed in relation to list-method directed forgetting (see Sheard & MacLeod, 2005). Further, the once popular retrieval inhibition account (e.g., Epstein, 1969) for list-method directed forgetting is still sometimes discussed as a factor in item-method tasks (e.g., Geiselman & Bagheri, 1985). Although the item and list method literatures have theoretically diverged, interest in a "common" mechanism of forgetting is appealing and some degree of theoretical overlap is to be expected. But much of this overlap is a consequence of the abandoned historical belief that the item and list method are interchangeable. This has been shown to be false (e.g., Basden et al., 1993) but only after the selective rehearsal and attentional inhibition accounts were already developed. Inspection of the attentional inhibition hypothesis reveals it to be the combination of each theoretical perspective popular during the time in which it was conceived, applied equally to the item- and list-method tasks (see Zacks et al., 1996).

The over-extension of the attentional inhibition framework has been the source of some confusion regarding whether active processes are involved in directed forgetting. Given that item-method instructions have not been found to influence measures of implicit memory (Basden et al., 1993) the role of retrieval inhibition has been brought into question. Neurophysiological (Paz-Caballero, Menor, & Jimenez, 2004) and imaging (Ullsperger, Mecklinger, & Müller, 2000) studies have implicated increased activity in frontal brain regions during the recognition of F items, but whether this activity is associated with “overcoming inhibition” or resolving the source of a relatively weak F memory trace has never been clearly determined. Ullsperger et al. (2000) addressed this concern by comparing brain waves elicited by the recognition of items that had received shallow or deep encoding at study (see Craik & Lockhart, 1972) – specifically demonstrating topographical differences in the pattern of activity elicited in relation to the recognition of F items. Using a levels-of-processing manipulation as a baseline condition was inventive, but ignored the fact that implementing an F instruction is itself qualitatively different than implementing a shallow (or any other) encoding strategy and therefore qualitative differences in brain topography at subsequent test should not be entirely surprising.

Evidence for the inhibitory processes that Zacks et al. (1996) describe at encoding has not fared much better than the evidence for retrieval inhibition. Although it was never clear what “flavour” of inhibition Zacks et al. (1996) had intended to invoke in this instance, there has been no behavioural support that an F instruction results in the lasting suppression of the preceding study item on any representational level. Marks and Dulaney (2001) demonstrated comparable semantic and identity priming following R and F instructions in the context of a lexical decision task undertaken following each study phase memory instruction. Cheng et al. (2011) have since replicated this finding, although careful inspection of their data in relation to Marks and Dulaney (2001) reveals a very small but consistent trend favoring greater priming for R compared to F items: The F-R differences in priming reported by Marks and Dulaney (2001) were -3 ms, -5 ms, and, -4 ms favoring priming for R items whereas Cheng et al. (2011) observed a difference of -11 ms using similar event timings but a 1 ms difference favoring priming of F items when the instruction duration was significantly shortened. It could be that an F instruction does have some influence on priming, but if this is the case the effect appears to be very small – at least using the procedure favoured by those researchers.

1.5.3 Rehearsal Control: An Integrative View

The equivocal support for the attentional inhibition hypothesis has resulted in the development of an alternative theoretical framework capable of interpreting evidence incompatible with a purely rehearsal based account without recourse to the inhibitory framework proposed by Zacks et al. (1996). According to a strict interpretation of the selective rehearsal account as applied to the item method, intentional remembering requires rehearsal, which is an active process likely to draw heavily upon limited capacity cognitive resources; intentional forgetting requires nothing beyond abstaining from further processing of the study item presented on that trial. This view therefore predicts that implementing an R instruction should be cognitively demanding whereas implementing an F instruction should not.

Recognizing this opportunity to test the selective rehearsal account, Fawcett and Taylor (2008) had participants detect visual probes presented following each study phase memory instruction. They reasoned that as the cognitive demands of the directed forgetting task increased, participants would respond more slowly to the probes because fewer cognitive resources would remain to respond. Insofar as reaction times (RTs) to these probes serve as an indicator of the cognitive load experienced when the probe was presented (see Kahneman, 1973) a passive view of intentional forgetting would predict slower responses to targets following R compared to F instructions whereas an active view of intentional forgetting would permit the opposite prediction. Supporting an active interpretation of intentional forgetting, Fawcett and Taylor (2008) observed slower responses following F compared to R instructions when the probes were presented within 1800 ms of instruction onset (for an independent replication, see Hansen, 2011). They argued that participants actively withdrew processing resources from the representation of the unwanted F item in working memory following each F instruction (Fawcett & Taylor, 2010; Taylor, 2005; Taylor & Fawcett, 2011). The withdrawal of processing resources from the representation of the F items following the memory instruction provides one mechanism through which participants could actively implement a selective rehearsal strategy by minimizing further incidental processing of unwanted information.

The withdrawal of processing resources from the representation of the F item has itself been indexed by variations in the magnitude of the inhibition of return (IOR) effect elicited by peripherally presented R or F study items. The IOR effect refers to a pattern of slower responses for targets presented in the same location as a preceding non-predictive visual cue relative to targets presented in a different location (Posner & Cohen, 1984). Although the visual cue is thought to initiate IOR (e.g., Dorris, Klein, Everling, & Munoz, 2002) attention is not immediately withdrawn meaning that the IOR effect is usually overshadowed by attentional facilitation at short cue-target delays. Therefore, the IOR effect is revealed only after attention has been withdrawn from the location previously occupied by the visual cue (see Danziger & Kingstone, 1999).[4] Viewing the IOR effect as an indicator of attentional withdrawal, Taylor (2005) presented each study item to the left or right of fixation followed by an auditory memory instruction and ultimately a visual localization target in either the same or opposite location in relation to the preceding study item. She found that enacting an F instruction increased the magnitude of the observed IOR effect in relation to R trials and also in relation to a between-subject baseline condition. This outcome suggested that participants more completely or efficiently withdrew processing resources from the study item following an F instruction. Interestingly this effect is limited to responses specific to the location of the study item on any given trial; for this reason, Taylor and Fawcett (2011) have speculated that the intention to forget the study item could bias further processing resources away from the source of the unreliable information. However, further research is required prior to taking a strong stance on this position.

The processes described above culminate in the active withdrawal of processing resources from the representation of the F item in working memory resulting in the cessation of rehearsal and the reduction of further incidental processing of that item (Fawcett & Taylor, 2012). Fawcett and Taylor (2008) argued that this process is briefly effortful, but ultimately frees processing resources from the study item so that they may be re-allocated elsewhere. This differs from the attentional inhibition hypothesis because

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[4] The name “inhibition of return” is unfortunate because it implies that attention is inhibited from returning to the spatial location occupied by the visual cue (see Berlucchi, 2006). Whereas this could be true in experiments where visual fixation is enforced (e.g., using eye-tracking; Handy, Jha, & Mangun, 1999), when participants are free to move their eyes the effect has instead been attributed to late-stage motor processes (see Taylor & Klein, 2000).

it does not presuppose the long-term suppression of the study item. Fawcett and Taylor (2008) instead conceptualized item-method directed forgetting in terms of the effortful reallocation of working memory resources in the period immediately following the instruction. The allocation of processing resources from F items implies the probable reallocation of those resources to other tasks including but not limited to the cumulative rehearsal of R items. This view supplements the selective rehearsal account by addressing how rehearsal is controlled following an F instruction and also how these processes relate to further rehearsal efforts during that period.

It should be clarified that the retrieval and cumulative rehearsal of R items on F trials cannot provide a sufficient explanation for the evidence reported by Fawcett and Taylor (2008) or Taylor and Fawcett (2011). A proponent of the selective rehearsal account might argue that following an F instruction participants engage in an effortful retrieval process to identify R items for rehearsal and that it is this effortful process that results in slower detection (Fawcett & Taylor, 2008) and discrimination (Fawcett & Taylor, 2012) responses to subsequent targets. Whereas this account makes intuitive sense, it does not explain why enacting an F instruction impairs incidental memory formation (Fawcett & Taylor, 2012) or magnifies the IOR effect (Taylor & Fawcett, 2011) compared to enacting an R instruction. More importantly, the F > R pattern of probe RTs observed by Fawcett and Taylor (2008) can be observed even on the initial study phase trial before any preceding R items are available for retrieval or cumulative rehearsal (see Appendix A). While recognizing the importance of the cumulative rehearsal of R items on F trials, the available evidence implicates an active mechanism of intentional forgetting that supplements this strategy.

Another account similar to the views held by Fawcett and Taylor (2008) and by Taylor and Fawcett (2011) is the notion that participants eliminate the study item on F trials by suppressing re-activation of the physical trace associated with the study item immediately following the memory instruction at encoding. Paz-Caballero et al. (2004) described an event-related potential (ERP) study in which they observed an early frontal effect associated with intentional forgetting and a late parietal effect associated with intentional remembering. From these observations they argued that following an R instruction participants retrieve the physical trace associated with the study item for further rehearsal whereas following an F instruction participants instead suppress this processing. A broad view of intentional forgetting studies that have measured ERPs at encoding reveals the presence of a potential N2-P3 complex similar to that observed in stop-signal inhibition and think-no-think paradigms (for a comparison, see Mecklinger, Parra, & Waldhauser, 2009). Relating this observation to the think-no-think paradigm, it could be that participants are suppressing re-activation of the study item as opposed to withdrawing processing resources from that item.

The contributions of retrieval suppression to item-method directed forgetting are perhaps worth considering given the overlap observed between this paradigm and the think-no-think paradigm. In the former case, participants are instructed to forget items immediately following initial encoding whereas in the latter case participants are instructed to suppress retrieval of an item following extensive retrieval practice. The result in either case is worse memory for the to-be-forgotten information. Both tasks also produce an N2-P3 complex and briefly interfere with incidental memory formation of task-irrelevant information (for behavioural evidence, see Fawcett & Taylor, 2012; Anderson, 2011). Parallels have also been drawn between both paradigms and tasks that require participants to countermand a behavioural response such as go-no-go and stop-signal tasks. Hourihan and Taylor (2006; see also, Fawcett & Taylor, 2010) observed that within the item method an R instruction is similar to a go signal in that it requires participants to engage rehearsal of the study item and an F instruction is similar to a no-go signal in that it requires participants to withhold rehearsal of the study item. Think and no-think instructions play an analogous role except that the former initiates retrieval as opposed to rehearsal of an already active representation. Whether similar mechanisms are invoked to control behavioural and cognitive responses has become a question of some interest in recent times and past research provides evidence that the behavioural and cognitive acts of control exhibit some commonalities (e.g., see Logan & Barber, 1985; Zbrodoff & Logan, 1986) and activate similar brain regions (Wylie, Foxe, & Taylor, 2008). The search for a common mechanism of cognitive and behavioural control remains an open question, although at least within the item method Fawcett and Taylor (2010) have argued that the mechanisms are analogous but not identical.

1.4 THE INTENTIONAL FORGETTING OF EVENTS

The nomenclature used to describe the experimental techniques with which directed forgetting is frequently studied has become synonymous with their respective methodological features. That is to say that list-method tasks involve the intentional forgetting of lists whereas item-method tasks involve the intentional forgetting of individual items. The relation between these procedures and the ability to intentionally forget more typical experiences is obscured by the fact that most episodes are not easily rendered as either lists or individual items. More frequently our memories involve sequences of experienced or performed events or actions – a fact evident in the examples commonly used to describe intentional forgetting (e.g., Bjork, 1972).[5] Even so, studies using both the list- and item-method paradigms have often used pictures (e.g., Quinlan et al., 2010) or words (e.g., Tekcan & Aktürk, 2001) as the to-be-remembered or to-be-forgotten stimuli. Few studies have addressed the intentional forgetting of continuous episodes.

Recognizing the limitations of these traditional paradigms, Golding and Keenan (1985) and later Gottlob, Golding, and Hauselt (2006) explored whether participants could forget part of a continuous discourse. Golding and Keenan (1985) found that participants remembered erroneous spatial directions to ensure that these errors were not incorporated into future navigational decisions. In other words, marking the directions as irrelevant did not lead to intentional forgetting, as happens when an F instruction is applied to discrete words or lists of words, purportedly because whereas the information became *nominally* irrelevant to the navigational task, being erroneous did not render the directions *functionally* irrelevant because they could still prevent a wrong turn. In contrast, Gottlob

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[5] "…we see things in newspapers and store windows, we add up numbers, we dial phone numbers… nearly all of which we have no use for beyond the point at which we attended to them. To the degree that we have any intentions at all with respect to that information, we intend to forget it." (Bjork, 1972, p. 218)

et al. (2006) found that participants were capable of intentionally forgetting phone numbers that had been labeled as erroneous and replaced by the “correct” number. In this case, there was less inherent value to remembering the irrelevant phone number so it was successfully forgotten. While closer to “real-world” applications of intentional forgetting, whether these studies represent the intentional forgetting of *events* is debatable because the target of the instruction in either case was a single detail embedded within a discourse.

Earles and Kersten (2002) presented a series of verb-noun pairs describing an action (e.g., *break toothpick*) that was either performed or simply studied in a between-subjects design. Following each verb-noun pair, participants were asked either to remember or to forget the action with the hypothesis that performed actions would be more difficult to intentionally forget than read actions. Even though older adults did not show the predicted pattern, younger participants exhibited a smaller directed forgetting effect for actions they had performed relative to those they had only studied. More recently, Sahakyan and Foster (2009) replicated this finding using both the item method (Experiment 4) and the list method (Experiments 1-3). They observed that a list-method instruction to forget *studied* verb-noun pairs resulted in worse memory for List 1 F items and better memory for List 2 R items compared to a remember-all baseline group; however, a list-method instruction to forget *performed* verb-noun pairs resulted only in worse memory for List 1 F items (not better memory for List 2 R items). Taken together, the studies by Earles and Kersten (2002) and Sahakyan and Foster (2009) provide critical evidence that directed forgetting may be applied to simple actions performed in isolation

– however, the relevance of their findings to complex or observed actions requires elaboration (see also Burwitz, 1974).

Toward this goal, Joslyn and Oakes (2005) had participants record personally experienced events throughout a two-week period with an emphasis on events atypical to their routine. Presented as a real-world analog of the list-method paradigm, half of these participants were later instructed they would not be tested for (and therefore could forget) events occurring in the first week of the experiment (as recorded in their diary). The remaining participants were instructed they were required to remember these events in addition to any events that occurred during the second week. A directed forgetting effect was observed in the recall of a two-word descriptive title (e.g., *Shopping Trip*) provided by the participant for each event as part of the diary exercise: Participants who received the F instruction remembered fewer Week 1 events than participants who did not receive this instruction.

While innovative, Joslyn and Oakes' (2005) methodology suffers from a lack of control inherent in any manipulation occurring outside of the laboratory. Therefore, Barnier et al. (2007) investigated the ability to intentionally forget experienced events – this time in a more controlled environment. Participants were presented with two lists each containing several cue words intended to elicit an autobiographical memory (e.g., *university*); once retrieved, the memory and the cue word were recorded. Once again using a list-method task, half of the participants were instructed to forget the memories they had described in response to the first list of cue words prior to receiving the second list. Participants who received the F instruction later recalled fewer List 1 memories than those who did not receive this instruction.

The experiments described above represent an important step toward the application of intentional forgetting to the control of event memory – however, they have made this step within the confines of the item-method and list-method paradigms: In all cases, participants were instructed to remember or forget a list of discrete events or actions – as provided in the form of verb-noun pairs (Earles & Kersten, 2002; Sahakyan & Foster, 2009) or as recorded in a diary (Barnier et al., 2007; Josyln & Oakes, 2005). As a result, the subsequent tests focused on memory for the event more generally (e.g., *Did I break a match?*) as opposed to the details of that event (e.g., *What color was the match that I broke?*). Moreover, several of these studies required participants to provide the initial content that was then used at test (e.g., Barnier et al., 2007; Joslyn & Oakes, 2005): Sampling bias would seem to favor the selection of easily remembered central or salient details (as opposed to peripheral details) for initial report and subsequent inclusion in the memory test (see Joslyn & Oakes, 2005).

One method of circumventing these issues and advancing our understanding of the manner in which events may be intentionally forgotten is to investigate the ability to intentionally forget continuous events presented in the laboratory under controlled conditions. Chapters 2 and 3 explored this goal in a series of experiments using visual vignettes depicting common events such as baking cookies. Following initial study participants are tested for their memory of the events that they had been instructed to remember as well as those that they had been instructed to forget.

1.5 CHAPTER SUMMARY AND CURRENT EXPERIMENTS

This chapter reviewed the paradigms used to study intentional forgetting as well as modern theoretical perspectives within this literature. The item- and list-method paradigms reveal important information regarding the mechanisms through which unwanted information is discarded under controlled circumstances. However, only by studying how we forget natural stimuli may strong conclusions be drawn about how these mechanisms apply outside the laboratory. The remainder of this dissertation will describe a series of experiments that have adopted videos instead of more traditional stimuli such as pictures (e.g., Quinlan et al., 2010) or words (e.g., MacLeod, 1999). By exposing participants to simple recorded events, this dissertation explores how instructions to remember or forget impact event-memory with an emphasis on the quality (as opposed to quantity) of knowledge demonstrated at later test.

CHAPTER 2 THE CONCURRENT-INSTRUCTION PARADIGM

The following chapter is based upon the manuscript entitled *"Intentional forgetting diminishes memory for continuous events*" submitted for publication to Memory in March 2012. Co-authors are Dr. Tracy Taylor and Dr. Lynn Nadel. Jonathan Matthew Fawcett was first author and in that capacity designed, programmed, and implemented the experiments and then analyzed and interpreted the data; he was also the primary contributing author to the manuscript, producing the initial draft and completing all major revisions.

2.1 ABSTRACT

In a novel *event-method* directed forgetting task, instructions to Remember (R) or Forget (F) were integrated throughout the presentation of four videos depicting common events (e.g., baking cookies). Participants responded more accurately to cued-recall questions (Experiment 1) and true-false statements (Experiments 2-4) regarding R segments than F segments. This was true even when forced to attend to F segments by virtue of having to perform concurrent discrimination (Experiment 2) or conceptual segmentation (Experiment 3) tasks. The final experiment (Experiment 5) demonstrated a larger R>F difference for specific true-false statements (*the woman added 3 cups of flour*) than for general true-false statements (*the woman added flour*) suggesting that participants likely encoded and retained at least a general representation of the events they had intended to forget, even though this representation was not as specific as the representation of events they had intended to remember.

2.2 INTRODUCTION

As described in Chapter 1, little work has been conducted exploring how intentional forgetting affects event memory. Past studies have relied upon self-reported events (Barnier et al., 2007; Joslyn & Oakes, 2005) or simple laboratory simulations (Golding & Keenan, 1985; Gottlob et al., 2006). While these approaches provide an important contribution to our understanding of intentional forgetting, self-reported experiences are necessarily uncontrolled and the simulations conducted thus far have dealt with the intentional forgetting of individual details embedded within verbal discourse as opposed to events *per se*. The current chapter will introduce a novel paradigm to extend intentional forgetting to events while maintaining experimental control. It is perhaps surprising that no published studies have yet utilized the potential for videos to accomplish this goal. Videos need not be separated into lists of discrete events followed individually (item method) or as a group (list method) by an instruction to remember or forget. Instructions may instead be incorporated into the videos themselves resulting in an *event-method* directed forgetting paradigm.[6]

In the studies that follow, four videos were presented using this approach. Each video depicted a common event such as baking cookies and lasted for 4 minutes and 40 seconds. Because the current goal was to study how participants could selectively forget segments of continuous visual events we employed a *concurrent* memory instruction (e.g., Basden & Basden, 1996; Brown, 1954; Paller, 1990; Paller, Bozic, Ranganath, Grabowecky, & Yamada, 1999; see also Muther, 1965) as opposed to a *delayed* memory instruction (for a review, see MacLeod 1998). As demonstrated in Chapter 3, similar results are observed if the memory instruction is instead presented following each segment. Videos were superimposed upon a colored rectangular viewing area that was larger than the video presentation port creating the appearance of a colored border

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[6] We have adopted the term *event-method directed forgetting* to describe the paradigm used in the current chapter as well as the following chapter because it emphasizes the target of the R and F memory instructions. Whereas item-method directed forgetting pairs each memory instruction with a specific item and list-method directed forgetting pairs each memory instruction with a specific list, the memory instructions in the current study cannot be ascribed to either. Each segment is no more an item than a list. The segments instead represent the dynamic combination of visual features into a cohesive vignette with numerous sub-elements that are broadly conceptualized as “events”. In adopting this terminology, we recognize that certain past experiments also fall within this definition (e.g., Joslyn & Oakes, 2005) – we do not claim to be the first to study the intentional forgetting of events or actions, we only intend to encourage others to recognize that the item/list-method nomenclature is perhaps unbefitting to such instances.

surrounding the video. This border periodically changed between green and purple. Participants were instructed that whenever the border surrounding the video was green they were to remember everything that was shown (R segments) because they would be tested for that information later; whenever the border surrounding the video was purple participants were instead to forget everything that was shown (F segments).

Following the presentation of the study videos in each experiment, participants were tested for the details of the event using cued-recall questions (Experiment 1) or true-false statements (Experiments 2 – 5). Experiments 1 and 2 demonstrated that participants were more accurate when tested for R segments than F segments, consistent with a directed forgetting effect. Experiments 3 and 4 replicated Experiment 2 while requiring participants to engage in a secondary task intended to ensure that visual attention was focused on the video (Experiment 3) or that encouraged conceptual processing of the video (Experiment 4) at all times – even during the presentation of the F instruction. Experiment 5 demonstrated that the directed forgetting effect observed in Experiment 2 was smaller for general than for specific test statements.

The use of true-false test statements in Experiments 2 – 5 was particularly noteworthy. Because the nature of our paradigm permitted the creation of false statements for each individual R or F segment, separate false alarm rates (i.e., incorrect affirmation of a false statement) could be calculated for R and F conditions. As a result, we were able to calculate measures of *sensitivity* (A') and *response bias* (B''_D) not frequently available in a typical item-method or list-method task where R and F conditions typically share a common false alarm rate (e.g., Zacks et al., 1996, Note 2).

2.3 EXPERIMENT 1: RECALL

In Experiment 1, four videos were presented depicting common events such as baking cookies or preparing for work. For each video, participants were instructed to remember a random half of its segments and to forget the remainder. The R and F instructions were integrated within each video and denoted by a change in the color of the surrounding border (e.g., *remember anything that occurs when the border is green*). Thus, each video played continuously from start to finish, with the surrounding border changing color randomly throughout the presentation. Following the presentation of all four videos, participants were then presented with a series of cued-recall questions testing their memory for *all* video segments regardless of the previously associated memory instruction. We predicted that participants would respond more accurately when tested for segments they had been instructed to remember relative to those they had been instructed to forget. This finding would support our contention that directed forgetting occurs for continuous events and would permit closer examination of this effect in the following experiments.

2.3.1 Method

Participants

Thirty undergraduate students (20 female) enrolled at the University of Arizona participated in this experiment for course credit. The majority of participants were right-handed (26 right, 4 left).

Stimuli and Apparatus

All experimental procedures were presented using custom software developed in the Python programming language (www.python.org) with the Pygame development library (www.pygame.org) loaded on a 17” MacBook Pro computer running Mac OS X 10.5. Responses were recorded via the built-in laptop keyboard. Instructions and test statements were presented against a black background in white, size 18 Gentium Basic Bold (www.sil.org/~gaultney/Gentium/). Each video presented during the study phase was preceded by a title that also served as a retrieval cue during the subsequent test phase; the titles were presented in white against a black background using size 30 of the Gentium Basic Bold font.

Five videos were downloaded from the public domain video sharing website YouTube (www.youtube.com) to serve as stimuli in this experiment: The first video (Folding Laundry) was used for practice, and the remaining four videos (Cleaning a Fish Tank, Baking Assorted Cookies, Making Chocolate Pudding, and Getting Ready for Work) were used during the study phase. Videos were selected on the basis of two criteria: (a) Their content was easily understood in the absence of the associated audio track; and, (b) they contained a linear progression of events resulting in a predetermined, self-evident goal explicated in a short, descriptive title (e.g., Cleaning a Fish Tank). Once downloaded, these videos were converted to MPEG-1 format, resized to 600 x 600 pixels and edited until they contained 7000 frames (1750 frames for the practice video). Presented at an average rate of 25 frames per second, each video lasted 4 minutes and 40 seconds (1 minute and 10 seconds for the practice video). During the video conversion process the audio track was removed from each video.

The colored border that acted as the R or F memory instruction throughout the practice and study phases subtended 35 pixels and surrounded each video: A green border denoted an R segment and a purple border denoted an F segment. The specific shades of green and purple are denoted by the RGB values of (0,100,0) and (128,0,128), respectively, and were selected on the basis that these colors are easily discriminated even in the presence of abnormal colour perception. The assignment of green and purple to remember and forget was constant as it was believed that green was more easily associated with the process of remembering (e.g., like a green traffic light) and we did not want to load participants' working memories with the color-instruction mapping.[7] Each segment consisted of 875 frames (35 s), resulting in 8 segments per video (2 segments for the practice video). R segments and F segments were assigned randomly on a subject-by-subject basis with the caveat that each video always contained 4 R segments and 4 F segments (1 R segment and 1 F segment for the practice video).

Cued-recall questions were designed to test specific details revealed only during a single segment of each video. For example, *how many sticks of butter did the woman add to the mixing bowl?* Two of the videos (Baking Assorted Cookies, Making Chocolate Pudding) were tested with 3 cued-recall questions per segment and the remaining two videos

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[7] This notion that the green colour was easily mapped to the R instruction and the purple to F was supported by post-experimental discussions with the participants regarding their strategies and how they remembered what each colour meant.

(Cleaning a Fish Tank, Getting Ready for Work) were tested with 2 cued-recall questions per segment for a total of 80 cued-recall questions across all four videos. The number of test statements per segment reflected differences in the 'richness' of the videos themselves with regard to the number and testability of events.

Procedure

Participants were told that they would view four videos each depicting an event such as folding laundry during which they would be instructed to remember only some of the information presented. Participants were instructed that whenever the border surrounding the video was green they were to remember everything that was shown because they would be tested for that information later; whenever the border surrounding the video was purple they were to forget everything that was shown. Participants were notified that the color of this border would change after various intervals and that it was important that they continue attending to the computer screen to ensure that they did not miss one of these changes. As represented in the software code, the border color changed at regular intervals of 35 s; however, because the R and F segments were randomly interspersed throughout each video, the border sometimes changed from green to green (or purple to purple) such that, from the participants' perspective, the duration of the instructions seemed variable. One sample study phase progression is depicted in Figure 2.1.

Practice Phase. A practice video (Folding Laundry) was presented to familiarize participants with the task, during which the experimenter offered sample questions pertaining to the practice video so that the participant would understand the type of information they were expected to retain. The practice video lasted 70 s and was comprised of a single R segment and a single F segment lasting 35 s each. Once the practice video was over, participants were presented with a written version of the study phase instructions on the computer screen and told to press ‘ENTER’ when they were ready to begin the experiment proper. The experimenter relocated to a different desk at the far end of the room behind the participant.

Study Phase. Prior to each video, a descriptive title (e.g., “Cleaning a Fish Tank”) was presented in the center of the screen until the participant pressed the ‘ENTER’ key at which point the video began. Videos were presented at an approximate rate of 25 frames per second (40 ms per frame) until all 7000 frames were exhausted. Videos were separated into 8 segments each lasting 875 frames (35 seconds) during which the border surrounding the video was either green (for an R segment) or purple (for an F segment). Prior to beginning each video, half of these segments were designated as R segments and the remaining were designated as F segments. The assignment of R and F segments was randomized for each video on a subject-by-subject basis, as was the presentation order of the videos themselves. Once a given video ended, the title for the next video was presented until the participant pressed the ‘ENTER’ key. This process continued until the participant had watched all 4 videos at which point the study phase ended and the written instructions for the test phase were displayed.

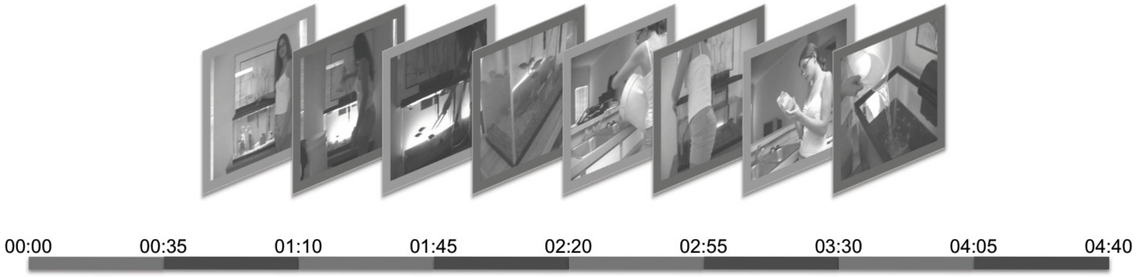

Figure 2.1: This figure depicts a schematic representation of the study phase presentation of "Cleaning a Fish Tank" with a complementary timeline denoting the start and end time of each segment. Each video frame corresponds to one bar within the time line. The light bordered frames represent R segments and the dark bordered frames represent F segments. R and F instructions were randomly assigned to each segment on a subject-by-subject basis such that each video contained four R segments and four F segments. For the purpose of this example only, the R and F segments are shown as alternating one after the other.

Test Phase. Following the study phase, participants were tested using cued-recall questions. Each question was presented in the center of the computer screen immediately below the title of the tested video, which served as the retrieval cue. All questions related to a given video were presented prior to moving on to the next video, although the order in which individual questions were presented and the order in which the videos were tested was otherwise randomized. Participants were instructed to answer each question to the best of their ability using one or two words; although they were told they could use full sentences if they desired, no one did. To avoid participants dwelling for too long on a given question, they were instructed to respond *dnk* (*do not know*) or *idk* (*I don't know*) if faced with a question for which they could not even guess – although the use of this response was discouraged. Responses were visible on-screen immediately below the question and could be modified until the participants submitted their response by depressing 'RETURN' on the keyboard – at which point the next question appeared.

The first author scored each response using an answer key created prior to data collection. During scoring, the R or F instruction associated with the question was obscured to prevent bias. Because some questions had multiple acceptable answers that were unforeseeable prior to data collection, responses that the first author felt were correct – but were not listed on the original answer key – were flagged for independent review by an undergraduate research assistant and either added to the answer key or rejected. For example, the correct answer to the question *with what did the man flatten the chocolate chip cookies after rolling them?* was *his fingers* but *his hands* was also deemed acceptable following independent review. Once all data had been collected, each question was rescored using *only* the answer key (that is, not adding any new responses) to ensure consistency. Misspellings were accepted as correct only if they were unambiguous. For example, *fingur* instead of *finger* would be deemed acceptable whereas *air* instead of *hair* would not be acceptable.

2.3.2 Results

The percentage of correct responses was calculated by dividing the number of responses matching the answer key by the total number of cued-recall questions answered. *Do not know* responses were treated as incorrect and included in the overall count of the number of cued-recall questions answered; excluding these responses as neither correct nor incorrect did not change the reported outcome. This percentage of correct responses was then analyzed as a function of instruction (R, F) using a one-way repeated-measures ANOVA. The analysis was significant, $F(1,29)=5.63$, $MSe=83.52$, $p<.03$, revealing better performance for R segments (M=47%, SE=2%) than F segments (M=42%, SE=2%). The presence of a significant 5.60% R-F difference supports the viability of using continuous videos to study directed forgetting.

2.3.3 Discussion

Experiment 1 used a novel event-method directed forgetting paradigm to investigate the ability to intentionally forget segments of a continuous visual event. Results supported the presence of a directed forgetting effect: Participants responded more accurately when tested for R segments than for F segments, as revealed by a 5.60% R-F difference in recall accuracy. This finding supports the assertion that intentional forgetting can occur for segments of continuous events, and is not restricted to discrete items or lists of words or pictures.

2.4 EXPERIMENT 2: TRUE-FALSE STATEMENTS

Experiment 2 replicated the methods of Experiment 1 with the exception that memory was tested using true-false statements instead of cued-recall questions. The use of true-false statements allowed us to separate the ability to discriminate between true-false statements from the response criterion employed to make the response.

2.4.1 Method

Participants

Thirty undergraduate students (25 female) enrolled at the University of Arizona participated in this experiment for course credit. The majority of participants were right-handed (26 right, 4 left).

Stimuli and Apparatus

The stimuli and apparatus were identical to those used in Experiment 1 with the exception that true-false statements were used instead of cued-recall questions. An equal number of true and false statements was created for each segment: For two of the videos (Baking Assorted Cookies, Making Chocolate Pudding), 4 true and 4 false statements were created per segment; for the remaining two videos (Cleaning a Fish Tank, Getting Ready for Work), 3 true and 3 false statements were created per segment. The true statements were created first and referred to a particular event (e.g., *the pudding was served in a clear glass with a stem*) or fact (e.g., *the recipe called for 2 tablespoons of cornstarch*) revealed only during the relevant segment. The false statements were created by replacing a single detail within each true statement, maintaining the general structure whenever possible (e.g., *the recipe called for 2 tablespoons of salt*). Overall, 224 test statements (112 true and 112 false) were created.

Procedure

Practice Phase. The practice phase was identical to Experiment 1.

Study Phase. The study phase was identical to Experiment 1.

Test Phase. Following the study phase, participants were presented with a series of true-false statements, one at a time, in the center of the computer screen, each pertaining to a specific segment within the presented videos. Participants were tested for the content of one video at a time, although the statements for that video were presented in a random order and the videos were tested in a random order. To facilitate performance, the title of the video being tested was presented directly above each test statement. Participants pressed "j" on the computer keyboard to indicate a statement that was true or "f" to indicate that the statement was false (with the mnemonic that "f" was for false to ensure participants did not confuse this response mapping). Responses were self-paced and no feedback was given.

Table 2.1
Mean Percentage of "True" Responses as a Function of Instruction (Remember, Forget) and Statement Validity (True, False) for Experiments 2-4.

	Statement Validity			
	True		**False**	
Instruction	***M***	***SE***	***M***	***SE***
Experiment 2				
R	71	1	33	2
F	60	2	35	2
Experiment 3				
R	68	2	34	2
F	62	2	36	2
Experiment 4				
R	70	1	33	2
F	66	1	35	2

2.4.2 Results

The mean hits and false alarms are provided in Table 2.1. Using the procedure described by Donaldson (1992), non-parametric measures of sensitivity (A') and response bias (B''_D) were calculated and analyzed as a function of instruction (R, F) using paired *t*-tests. Values of A' range from chance ($A' = 0.5$) to perfect performance ($A' = 1.0$); values of B''_D range from liberal (requiring less 'signal' to classify a test statement as true; $B''_D = -1.0$) to conservative (requiring more 'signal' to classify a test statement as true; $B''_D = 1.0$). As depicted in Figure 2.2, participants exhibited greater sensitivity, $t(29)=5.59$,

$p<.01$, and responded more liberally, $t(29)=3.42$, $p<.01$, to statements about R segments than F segments. Analysis of the raw hits and false alarms instead of *A'* revealed a comparable pattern here as well as in the analyses reported for subsequent experiments.

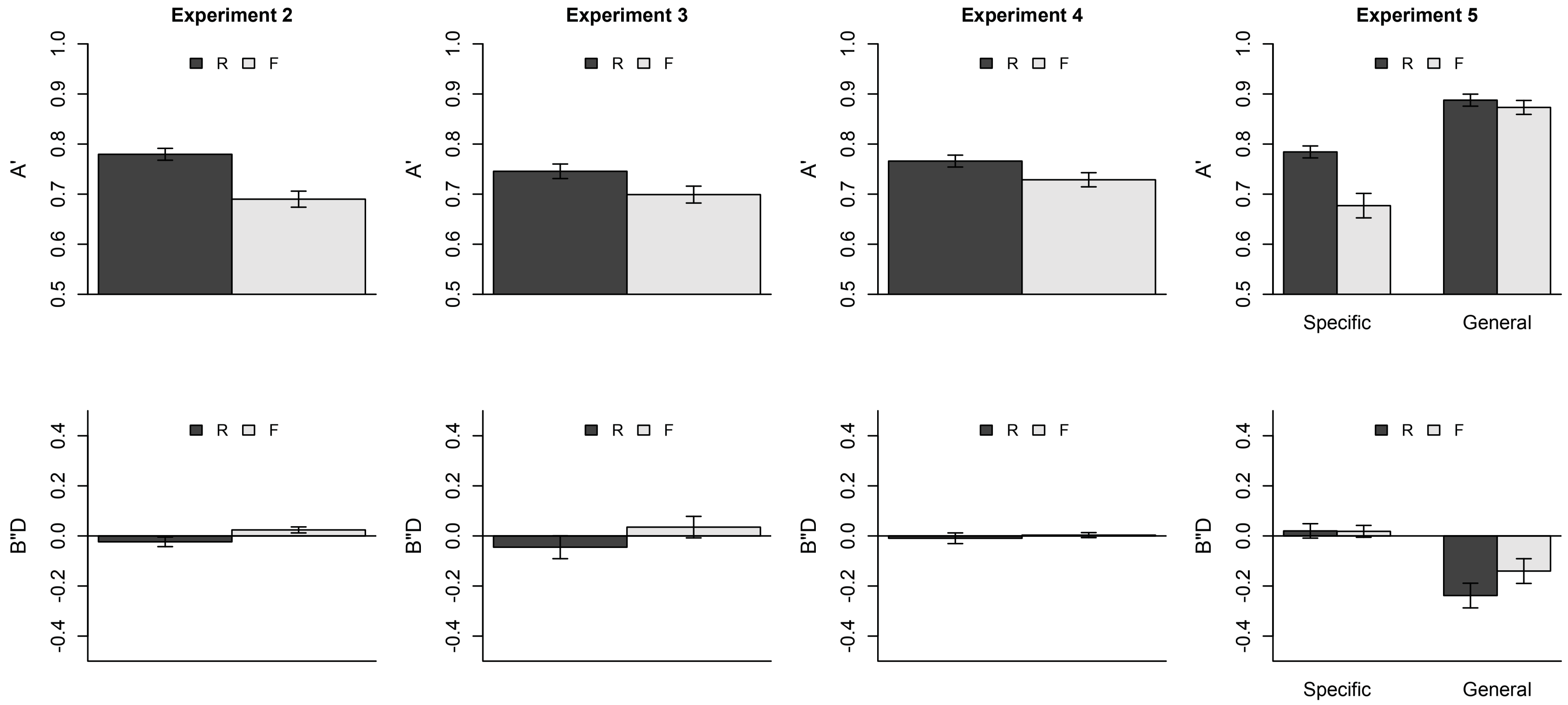

Figure 2.2: Sensitivity (*A'*) and Response Bias (B''_D) as a function of instruction (R, F) and specificity (specific, general) as applicable for Experiment 2 (Concurrent-Instruction, True-False Statements), Experiment 3 (Concurrent-Instruction, Discrimination Task), Experiment 4 (Concurrent-Instruction, Event-Segmentation Task) and Experiment 5 (Concurrent-Instruction, Manipulating Relative Specificity); error bars represent one standard error of the mean.

2.4.3 Discussion

Experiment 2 replicated the findings of Experiment 1 using true-false statements instead of cued-recall questions. Results supported the presence of a directed forgetting effect: Participants were more sensitive to statements about R segments than F segments. Interestingly, participants also responded more conservatively to statements about F segments than to statements about R segments, possibly because they were less able to retrieve additional, supporting details related to these segments.

To the extent that true-false statements represent an analog of recognition memory, the current findings suggest that the directed forgetting effect may be related to encoding differences for R and F segments at study as opposed to differences operating at retrieval. Even so, at this point we are disinclined to make a link between this finding and the item-method paradigm that likewise tends to support differences in the encoding of R and F items (e.g., Basden et al., 1993). Whereas the memory instruction presented in an item-method paradigm refers specifically to the item that is later tested, in our paradigm memory instructions were applied to an ongoing sequence of events that comprised a segment of a continuous video. Although these sequences depicted the individual details that were later tested, the memory instruction was explicitly linked not to these individual details but to the sequence as a whole. The R or F segments represented the aggregation of these individual details and in this manner were more similar in nature to how list-method directed forgetting instructions apply to subgroups of studied materials as opposed to the individual elements themselves. Thus, our paradigm shares features with both the item- and list-method paradigms and yet is different from both.

One concern regarding our findings might be that participants were able to guess which statements were true and which were false on the basis of previously acquired knowledge, or schemas, concerning the tested event. Although we can counter this concern by noting that responses based on activated schemas would not be expected to produce differences in accuracy between R and F segments, we nevertheless decided to address this issue directly. To get a baseline measurement of the discriminability between the true and false statements used in this experiment, we ran 6 new participants in a replication of Experiment 2 that eliminated the practice and study phases. These participants were presented only with the test phase, during which they were asked to guess whether each statement was true or false on the basis of the provided title and *without* having watched the videos. A' and B''_D were calculated as described above. Performance was close to chance ($M = 0.55$, $SE = 0.04$) and was well below the experimental group (regardless of memory instruction), although participants did demonstrate a slightly liberal response bias ($M = -0.10$, $SE = 0.06$). Clearly the performance observed in Experiment 2 cannot be accounted for in any large part by prior, extra-experimental, knowledge of events depicted in the videos.

We interpret our findings as evidence that participants can selectively exclude to-be-forgotten segments from the encoding of an otherwise continuous sequence of visual events. A more mundane explanation that must first be ruled out, however, is the possibility that participants used the colored border that served as the F instruction as a signal to redirect visual attention away from the video. This would account for poorer memory performance for F segments than R segments, but not for the reason we have presumed. Based on the results of Experiment 2, we think it unlikely that participants simply failed to observe the to-be-forgotten segments. If this had been the case, performance for F segments would have approximated performance in the no-video baseline group described above (wherein participants responded to statements regarding segments they had not observed). This was not the case. Nevertheless, to further rule out this possibility, Experiment 3 replicated the basic paradigm developed in Experiments 1 and 2 except that participants were required to attend the videos at all times to respond to visual targets that appeared unpredictably during both R and F segments.

2.5 EXPERIMENT 3: CONCURRENT DISCRIMINATION TASK

In Experiment 3, small triangles served as visual targets that required a speeded discrimination response to indicate the location of their apex. These were superimposed on the video during the study phase. To ensure temporal unpredictability, these targets were presented at intervals ranging from 1 s to 32 s relative to segment onset. Due to the difficulty associated with detecting and discriminating a small visual target within a complex scene, this task encouraged visual attention to remain within the viewing area at all times, even during F segments. To encourage attention to remain roughly centralized, half of the targets appeared at center, with the remaining targets equally distributed between the near and distant periphery of the video.

2.5.1 Method

Participants

Thirty undergraduate students (20 female) enrolled at the University of Arizona participated in this experiment for course credit. The majority of participants were right-handed (26 right, 4 left).

Stimuli and Apparatus

The stimuli and apparatus were identical to those used in Experiment 2 with the exception that Experiment 3 included a blue (RGB values 0,100,0) isosceles triangle that served as a visual target requiring a speeded button press response. This triangle measured 30 pixels along its base and 30 pixels from base to tip presented on its side such that it acted as an arrowhead, with the apex pointing to the left or right of the computer screen.

Procedure

Practice Phase. The practice phase was identical to Experiment 2, with the exception that it incorporated the discrimination task used during the study phase (see below).

Study Phase. The study phase replicated the procedures of Experiment 2 with the exception that a small, blue triangle with its apex pointing to the left or to the right was occasionally superimposed on each video for approximately 600 ms (15 frames). Participants were required to indicate the direction in which these triangles pointed by depressing the “f” key if the triangle pointed to the left and the “j” key if the triangle pointed to the right, regardless of where the triangle appeared relative to center. Participants rested the appropriate index finger on each button at all times so as to be prepared to respond.

Three triangles were presented per segment. To maximize the unpredictability of the target and to avoid targets appearing too rapidly following each other, one of these triangles was presented after a short delay, one after an intermediate delay, and one after a long delay; each delay category included two possible intervals relative to segment onset that were sampled randomly but with equal probability: Short (1 s, 2 s), intermediate (4 s, 8 s) and long (16 s, 32 s). Thus, each video segment contained a single target from each delay category (e.g., a target could be presented 1 s or 2 s following the onset of a given segment, but not both), with the exact timing staggered due to the sampling of two possible intervals within each delay category. The video viewing area was conceptually separated into a grid comprised of 25 squares measuring 30 pixels x 30 pixels each. This grid was further separated into three regions: center (the location immediately at center), middle (the ring of 8 squares surrounding the center position) and outer (the outer ring of 16 squares). Targets were centered in a random square located within the selected region. To encourage attention to remain generally centralized, targets were most likely to appear in the center region (50% of all targets) with the remaining targets equally distributed between the middle and outer regions (25% of all targets, each). A total of 96 targets was presented in this manner.

Collapsing across target direction, the study phase was conceptualized as a 2 (instruction: R, F) x 6 (interval: 1 s, 2 s, 4 s, 8 s, 16 s, 32 s) x 3 (region: center, middle, outer) within-subjects design. For the analyses, the factor of interval was collapsed from 6 to 3 levels (short, intermediate, and long). These factors were balanced across (not within) the videos; each video contained 4 R and 4 F segments and 8 short, 8 intermediate, and 8 long targets.

Test Phase. The test phase was identical to that described for Experiment 2.

2.5.2 Results

Discrimination Reaction Times

Even though the discrimination targets were included primarily to ensure that participants attended to the computer screen at all times – even when instructed to forget the current segment – we nevertheless analyzed these RTs as a function of instruction (R, F), interval (short, intermediate, long), and region (center, middle, outer) using a three-way repeated-measures ANOVA; these data are presented in Table 2.2. The main effect of instruction, $F(1, 29) = 10.05$, $MSe = 33195.29$, $p < .01$, revealed slower responses to target arrows presented during R segments than F segments. The main effects of both interval, $F(2, 58) = 15.29$, $MSe = 16093.59$, $p < .01$, and region, $F(2, 58) = 10.82$, $MSe = 15451.13$, $p < .01$, were also significant representing a tendency for participants to respond most rapidly to targets presented at the intermediate interval and for RTs to increase with increasing visual eccentricity. None of the interactions were significant, all ps>.09.

Table 2.2.
Mean Discrimination RTs (ms) and Accuracies (%) in Experiment 3 as a Function of Region (Center, Middle, Outer), Instruction (R, F) and Interval (Short, Intermediate, Long); Standard Error Presented in Brackets.

	RT (ms)						**Accuracy (%)**					
	Short		**Inter.**		**Long**		**Short**		**Inter.**		**Long**	
Instruction	***M***	***SE***	***M***	***SE***	***M***	***SE***	***M***	***SE***	***M***	***SE***	***M***	***SE***
Center												
R	852	37	738	23	803	36	91	3	91	2	92	2
F	787	25	721	22	793	34	88	3	93	1	92	2
Middle												
R	839	32	769	31	848	37	90	3	88	3	84	4
F	769	21	727	26	814	37	89	3	88	4	86	3
Outer												
R	916	42	849	41	850	36	84	4	86	3	79	3
F	854	37	766	31	817	31	82	4	84	4	82	4

Target Discrimination Accuracy

Because an RT analysis is meaningless without knowing whether there is evidence of a speed-accuracy trade-off, an identical analysis was conducted on the percent correct target discrimination responses (also presented in Table 2.2). The only effect to reach significance was location, $F(2, 58) = 14.45$, $MSe = 0.03$, $p < .01$, demonstrating better accuracy for discriminating the direction of the triangle apex for targets presented at center (the most likely target location) than elsewhere. This finding contradicts a speed-accuracy trade-off, given that targets presented at center were also responded to the fastest. No other effects or interactions even approached significance (all Fs < 1).

Signal Detection Analysis

The mean hits and false alarms are provided in Table 2.1. As in Experiment 2, non-parametric measures of sensitivity (A') and response bias (B''_D) were calculated and analyzed as a function of instruction (R, F) using paired t-tests (see Figure 2.2). Once again, participants exhibited greater sensitivity, $t(29) = 3.46$, $p < .01$, and responded more liberally, $t(29) = 2.06$, $p < .05$, to statements about R segments than F segments.

2.5.3 Discussion

Experiment 3 replicated the results of Experiment 2 using a speeded visual target discrimination task that required participants to maintain their visual attention on the video at all times – even when instructed to forget a given segment. Participants were fastest and most accurate to respond to visual targets that were presented at the expected (most frequent) target location (center), and this tendency was not changed as a function of memory instruction. These results suggest that participants did, in fact, maintain their attention at center throughout the presentation of both R and F segments. Even with visual attention focused on the video throughout all segments, the pattern of memory performance remained essentially unchanged from Experiment 2: Participants showed greater sensitivity when tested for R segments than F segments.

Interestingly, in the target discrimination data, there was a main effect of memory instruction on RT, such that participants were faster to respond to targets presented during F than R segments. The fact that memory instruction did not interact with target location means that there is no evidence that participants adopted a ‘looking away’ strategy during F segments. Nevertheless, the finding of overall slower RTs during R than F segments supports the hypothesis that the directed forgetting effect in memory was likely related to differential encoding of these segments. Where RT to respond to the target can be used to index the cognitive demands associated with remembering and forgetting (Fawcett & Taylor, 2008; see Kahneman, 1973), our pattern of target RTs suggests that encoding the R segments was more demanding than encoding the F segments. This finding is in apparent contrast to results obtained using a simple detection task embedded in a more typical *item-method* directed forgetting paradigm. Fawcett and Taylor (2008) had participants respond to a visual detection probe (“*”) presented 1400 ms, 1800 ms, or 2600 ms following each study phase memory instruction in a task that presented discrete trials that contained a single word each. Participants were *slower* to respond to probes following F than R instructions at the 1400 ms and 1800 ms intervals. Fawcett and Taylor (2008) suggested that instantiating an F instruction in an item-method directed forgetting task is *more* cognitively demanding than instantiating an R instruction.

There are two primary reasons why the current finding of longer target discrimination RTs during R than F segments need not conflict with the apparently opposite RT results reported by Fawcett and Taylor (2008). First, Fawcett and Taylor (2008) measured responses immediately following each memory instruction at delays far shorter than most used in the current investigation. Indeed, they argued that the purpose of the active mechanism engaged by an F instruction – while briefly cognitively demanding – is ultimately to free processing resources for other tasks. These tasks could include the rehearsal of previous R items, responding to a secondary task, or performing some other diversionary cognitive process (see Fawcett & Taylor, 2012; Sahakyan & Kelley, 2002). The finding of faster discrimination RTs during F than R segments could be interpreted as support for the view that at a relatively long interval following the F instruction, processing resources have been successfully diverted from the to-be-forgotten content of the video and to the discrimination task instead. Second, Fawcett and Taylor (2008) used discrete trials that instructed participants to remember or forget information that was already actively represented in working memory in anticipation of the impending memory instruction. The notion was that once the study word had been presented, participants would maintain that word in working memory during the brief period preceding the memory instruction; following an R instruction the study word would be rehearsed whereas following an F instruction the active mechanisms described above would be engaged to stop the continued rehearsal of the item and thereby interfere with its successful encoding to long-term memory (Fawcett & Taylor, 2009). Therefore, according to Fawcett and Taylor (2008; Fawcett & Taylor, 2012; Taylor 2005) the act of forgetting in a typical item method paradigm largely requires the participant to exert control over the *current contents* of working memory. In contrast, in the current experiment each R and F memory instruction was concurrent with the studied information. Instantiating an F instruction in this instance requires the participant to control *access to* working memory.

2.6 EXPERIMENT 4: CONCURRENT EVENT-SEGMENTATION TASK

In Experiment 3, participants were encouraged to attend each video segment by virtue of requiring a speeded discrimination response to targets that appeared briefly during R and F segments. The results of that experiment supported the notion that participants did, in fact, maintain attention on the video segments during both R and F trials so that differences in attentional locus cannot account for the directed forgetting effect in memory. In Experiment 4, we extended this investigation by requiring participants to conceptually separate each video into subjectively determined subordinate events by depressing the spacebar whenever they conceptualized an action as representing the beginning of a new event (see Zacks & Tversky, 2001). For example, while watching the practice video (Folding Laundry), one might depress the spacebar each time a new article of clothing was removed from the laundry basket – or even each time an individual fold was made to a given article of clothing – depending upon the specificity with which one has chosen to define what constitutes an event. While determining event boundaries is necessarily subjective, it requires that participants attend the video at all times, and that they process the content of the video *conceptually* to determine the appropriate time to make each event-segmentation response. Because this task was conducted throughout both R and F segments, this ensured that all portions of the video received some degree of conceptual encoding, especially to the extent that similar numbers of event boundaries are assigned to R and F segments.

2.6.1 Method

Participants

Thirty-one undergraduate students (24 female) enrolled at the University of Arizona participated in this experiment for course credit. The majority of participants were right-handed (24 right, 7 left).

Stimuli and Apparatus

The stimuli and apparatus were identical to those used in Experiment 2.

Procedure

Practice Phase. The practice phase was identical to that described for Experiment 2, with the exception that participants engaged in an event-segmentation task while watching the practice video.

Study Phase. The study phase was identical to that described for Experiment 2, with the exception that participants were instructed to keep the index finger of their dominant hand on the spacebar at all times and to depress it whenever they determined that a new event or action had begun. In accordance with prior work investigating event segmentation (see Zacks & Tversky, 2001), participants were explicitly instructed that there were no right or wrong times at which to depress the spacebar and were provided with a few examples demonstrating how a single event might be segmented in multiple ways depending upon the criterion employed and how the terms were defined (e.g., *While folding laundry, the act of folding a shirt could be a single action or each individual fold could be a separate action*).

Recognition Phase. The recognition phase was identical to that described for Experiment 2.

2.6.2 Results

Event-Segmentation Analysis.

Although included primarily to ensure that participants conceptually encoded the videos at all times – even when instructed to forget the current segment – the average number of event segmentation responses was analyzed as a function of instruction (R, F) using a one-way repeated-measures ANOVA. The effect of memory instruction was not significant, $F(1, 30) = 1.06$, $MSe = 0.45$, $p > .31$, with an equivalent mean number of event boundaries during F segments ($M = 4.85$, $SE = 0.44$) and R segments ($M = 4.68$, $SE = 0.45$). The fact that participants placed event boundaries at a similar rate during F segments and R segments supports the notion that participants encoded these segments at a similar conceptual level. This interpretation is supported by Figure 2.3, which depicts the percentage of segmentation responses made across participants for each video as a function of time and instruction. Spikes indicate points at which participants tended to agree that an event-boundary had occurred. Importantly, the lines depicting R and F trials are highly similar, overlapping almost entirely at points.

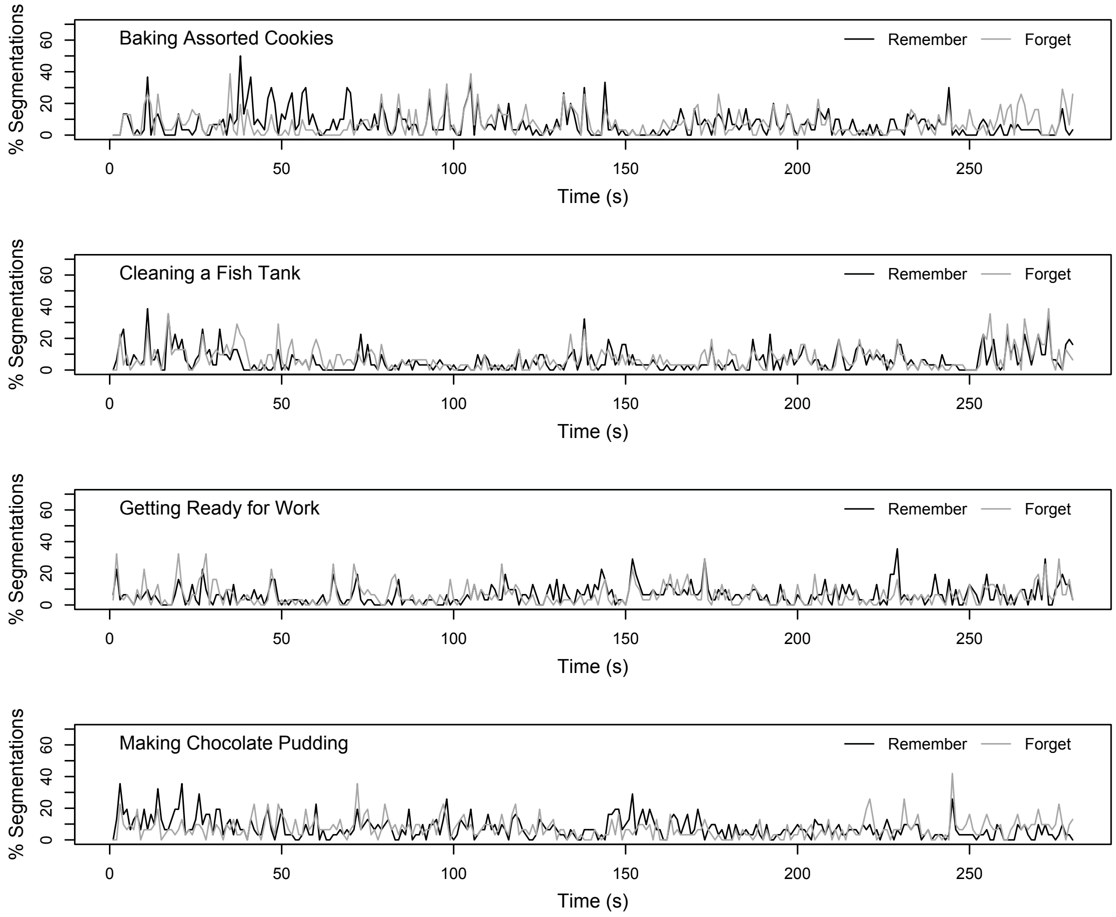

Figure 2.3. The percentage of participants having made a segmentation response for each second of each video in Experiment 4 as a function of instruction (R, F); data are presented with a granularity of 1 second. For example, a value of 50% means that half of all participants made a segmentation response (i.e., depressed the spacebar) at that particular second within that particular video.

Signal Detection Analysis.

The mean hits and false alarms are provided in Table 2.1. As in the previous experiments, non-parametric measures of sensitivity (A') and response bias (B''_D) were calculated and analyzed as a function of instruction (R, F) using paired *t*-tests (see Figure 2.2). Although participants remained more sensitive to statements about R segments than F segments, $t(30) = 2.74, p < .02$, they did not differ in their response bias, $t(30) = 0.62, p > .54$.

2.6.3 Discussion

Memory performance in Experiment 4 replicated the findings of Experiments 2 and 3 even while participants engaged in an event-segmentation task designed to ensure that each video was encoded conceptually during both R and F segments. Analysis of the secondary event-segmentation task revealed that participants placed an equivalent number of event boundaries in R and F segments – a task that requires careful and attentive analysis of the events occurring in each video. Despite requiring participants to process F segments at a conceptual level, they still responded with greater sensitivity when tested for R segments than F segments. Clearly, the directed forgetting effect for continuous event sequences cannot be easily dismissed as an artifact of a 'looking away' strategy on F trials.

Thus far, the directed forgetting effect has been discussed as the difference in memory performance observed for R and F video segments. However, the directed forgetting effect is thought to arise from an aggregation of processes acting to strengthen memory for R items as well as processes acting to weaken memory for F items. For this reason, the R-F difference score that defines a directed forgetting effect can be conceptualized as consisting of *costs* (worse memory for F items) plus *benefits* (better memory for R items). To separate costs from benefits, in a between-subjects manipulation, a remember-all control group is used to measure memory performance when all items must be committed to memory. Benefits are measured as better performance for R items in the directed forgetting task compared to the remember-all baseline, and costs are reflected in worse performance for F items in the directed forgetting task compared to the remember-all baseline (e.g., Basden & Basden, 1996; Sahakyan & Foster, 2009).

Despite reservations over whether a remember-all control group is an appropriate baseline against which to measure performance in the directed forgetting task (see Taylor & Fawcett, 2012), 17 additional participants were run in a complete replication of Experiment 4 with the exception that the random changes in the colored border from green to purple and vice versa was not ascribed any meaning. Participants were instructed to remember every segment of the videos that they watched, while also engaging in the event segmentation task. A signal detection analysis was performed on their test data resulting in a mean *A'* score of 0.77 (*SE* = 0.01). Planned *t*-tests evaluated whether *A'* scores for R or F segments in the experimental version of the task differed from the overall *A'* scores for the control version of the task. These analyses revealed significant *costs*, with worse discriminability of F segments than the remember-all control segments, $t(46) = 2.12, p < .04$. There was no evidence of *benefits*, such that the discriminability of R segments was statistically indistinguishable from that of the remember-all control segments, $t(46) = 0.35, p > .73$. This suggests that our overall directed forgetting effect, reflected in the difference between R and F performance, reflects primarily costs to memory associated with the instruction to forget.

The fact that we observed costs without benefits may appear at odds with the results of Sahakyan and Foster (2009) who observed both *costs* and *benefits* for list- and item-method directed forgetting tasks. It is possible that the absence of benefits is a defining feature of event-method directed forgetting. Also possible is that benefits depend on the dependent variable that is used to assess memory performance. Both Basden and Basden (1996) and Sahakyan and Foster (2009) used a recall task to measure memory performance in their experiments and observed both costs and benefits. In contrast, Taylor and Fawcett (2012) observed costs without benefits in the context of an item-method directed forgetting task that measured yes-no recognition performance. To the extent that true-false statements are more akin to recognition than recall, it follows that the benefits of directed forgetting may be larger and more robust for tasks that depend on recall rather than recognition. This is assuming, of course, that one accepts the remember-all control group as a suitable baseline against which to measure costs and benefits of directed forgetting instructions; one could certainly argue that remembering *all* items is not neutral with respect to memory demands (see Taylor & Fawcett, 2012; Jonides & Mack, 1984). In any case, it is clear that the costs of the forget instruction are robust across paradigms and dependent measures, supporting our contention that the difference in performance for R and F segments is due primarily to intentional forgetting of the F segments.

To compare the directed forgetting effect across experiments, the *A'* data were collapsed and analyzed using a mixed-effects ANOVA with experiment (Experiment 2, Experiment 3, Experiment 4) as the between-subjects factor and instruction (R, F) as the within-subjects factor. Although the main effect of experiment was not significant, *F*(2, 88) = 1.02, *MSe* = 0.01, *p* > .36, the main effect of instruction, *F*(1, 88) = 48.00, *MSe* < 0.01, *p*<.01, and the interaction of experiment and instruction were significant, *F*(2, 88) = 3.75, *MSe* < 0.01, *p* < .03. The magnitude of the directed forgetting effect was larger in Experiment 2 than in Experiment 3, *t*(58) = 2.06, *p* < .05, or Experiment 4, *t*(59) = 2.49, *p* < .02; the magnitude of the directed forgetting effect in Experiments 3 and 4 did not differ, *t*(59) = 0.48, p > .63.

Figure 2.2 suggests that the difference between Experiment 2 and Experiments 3 and 4 may arise from separate sources. Participants in Experiment 3 demonstrated *diminished* sensitivity to statements testing R segments (*A'*=0.75) relative to participants in Experiment 2 (*A'*=0.78) whereas sensitivity to statements testing F segments did not differ between these experiments (*A'*=0.69 for both). This suggests that the Experiment 3 speeded target discrimination task might have interfered with the retention of R segments by disrupting the participant's encoding or rehearsal strategy. In contrast, participants in Experiment 4 demonstrated *enhanced* sensitivity to statements testing F segments (*A'*=0.73) than participants in Experiment 2 (*A'*=0.69) whereas sensitivity to statements testing R segments differed minimally between these experiments (*A'*=0.78 *v. A'*=0.77). This suggests that the Experiment 4 event-segmentation task improved memory for F segments by forcing participants to adopt a conceptual encoding strategy. The fact that the event-segmentation task (in Experiment 4) did not negate the directed forgetting effect completely may represent the contribution of an active rehearsal strategy that favoured R over F segments.

2.7 EXPERIMENT 5: MANIPULATING RELATIVE SPECIFICITY

Having demonstrated that memory for relatively specific details of a visual event is impaired for F segments relative to R segments, it is reasonable to consider whether the same is true for relatively general details. At least with respect to *unintentional* forgetting, specific and general details appear to be forgotten at different rates. Whereas specific item information about a categorized word list is lost relatively quickly over a one-week delay, gist memory for the categories remains relatively stable (Dorfman & Mandler, 1994). The finding that general information is more resilient to unintentional forgetting may imply that it is similarly resilient to intentional forgetting. By exploring how intentional forgetting influences details relative to general information we may also learn more about the granularity of the processes involved.

Experiment 5 replicated the methods developed in Experiment 2 with the exception that half of the true-false statements were modified to test relatively specific details (*the woman added two measuring cups of milk to the mixture*) whereas the remaining half tested relatively general details (*the woman added milk to the mixture*). We expected participants to derive a general representation for each event that was presented, even those contained in segments that they had been instructed to forget. Accordingly we predicted a pattern of results similar in direction and magnitude to Experiment 2 for the specific statements and a pattern of results similar in direction albeit smaller (or non-significant) for the general statements. Because we were primarily concerned with the magnitude of the directed forgetting effect as a function of granularity, there was no need to include a secondary task during the study phase. Even though our previous experiments ruled out any major influence of a 'looking away' strategy on the directed forgetting effect, to the extent that such a strategy emerged on F trials due to the lack of a secondary task, memory for both gist and specific details would be affected.

2.7.1 Method

Participants

Twenty undergraduate students (11 female) enrolled at the University of Arizona participated in this experiment for course credit. Participants were all right-handed.

Stimuli and Apparatus

The stimuli and apparatus were identical to Experiment 2 with the exception that the true-false statements were modified such that half tested relatively specific details (*the women added two measuring cups of milk to the mixture*) whereas the remaining half tested relatively general details (*the women added milk to the mixture*). In most cases specific statements were taken directly from Experiments 2, 3, and 4 with general statements created by removing the specific details from these statements. Each video was tested using a total of 8 test statements per segment (2 true specific, 2 true general, 2 false general, 2 false specific) for a total of 64 test statements per video and 256 test statements overall.

Procedure

Practice Phase. The practice phase was identical to Experiment 2.

Study Phase. The study phase was identical to Experiment 2.

Test Phase. The test phase used true-false statements and was identical to Experiment 2 with the exception that half of these statements tested more specific details whereas the remaining half tested more general details. General and specific test statements were presented randomly.

2.7.2 Results

The mean hits and false alarms are provided in Table 2.1. Non-parametric measures of sensitivity (A') and response bias (B''_D) were calculated and analyzed as a function of instruction (R, F) and relative specificity (specific, general) using separate two-way repeated-measures ANOVAs (see Figure 2.2). For the A' analysis, there was a main effect of instruction, $F(1,19) = 15.66$, $MSe = 0.01$, $p < .01$, with greater sensitivity to statements about R segments than F segments. The main effect of relative specificity, $F(1,19) = 100.07$, $MSe = 0.01$, $p < .01$, was also significant, with greater sensitivity to general statements than specific statements. Importantly, these effects were qualified by a significant instruction x relative specificity interaction, $F(1,19)=9.84$, $MSe=0.01$, $p<.01$. Planned contrasts on A' revealed a significant 0.11 directed forgetting effect for specific statements, $t(19) = 3.96$, $p < .01$. With a mean R-F difference of 0.02, there was no significant directed forgetting effect for general statements, $t(19) = 1.08$, $p > .29$.

The B''_D analysis revealed only a significant main effect of relative specificity, $F(1,19)=59.76$, $MSe=0.05$, $p<.01$, with participants employing a more liberal response bias for general statements than specific statements; neither the main effect of instruction, $F(1,19) = 2.01$, $MSe = 0.11$, $p > .17$, nor the instruction x specificity interaction, $F(1,19) = 0.57$, $MSe = 0.02$, $p > .45$, was significant.

Table 2.3
Mean Percentage of "True" Responses as a Function of Instruction (Remember, Forget), Specificity (Specific, General) and Statement Validity (True, False) for Experiment 5.

	Statement Validity			
	True		**False**	
Instruction	***M***	***SE***	***M***	***SE***
Specific				
R	70	2	29	2
F	59	3	36	2
General				
R	88	2	23	2
F	85	2	23	2

2.7.3 Discussion

Experiment 5 explored the level of specificity at which the directed forgetting effect could be measured. The *A'* difference for the specific test statements (*A'* = 0.11) approximated the difference observed in Experiment 2 (*A'* = 0.09). However, the R-F difference was numerically smaller (*A'* = 0.02) for general test statements and failed to reach significance. This finding is interesting because it suggests that successful intentional forgetting is not an all-or-nothing phenomenon. General information is more resilient to intentional forgetting than relatively specific information. While important, this finding is not shocking. There is a rich literature exploring instructions to disregard inadmissible information in court and a comparable literature dealing with instructions to disregard information in social settings that have periodically found that despite earnest attempts at suppressing such information, the to-be-forgotten information continues to influence behavior (see Isbell, Smith, & Wyer, 1998; Johnson, 1998; Kassin & Studebaker, 1998). The current findings suggest that the locus of this influence could reside in a residual gist-based trace.

As was done for Experiment 4, a remember-all control study was also conducted for Experiment 5. A total of 12 participants completed an exact replication of Experiment 5, except that no meaning was ascribed to the colored border; participants were instructed to commit all segments to memory. The mean *A'* score was 0.77 (*SE* = 0.01) for specific test statements and 0.90 (*SE* = 0.01) for general test statements. Planned *t*-tests on the *A'* scores for the specific test statements revealed significant *costs*, $t(30) = 2.92$, $p < .01$, but no evidence of *benefits*, $t(30) = 0.54$, $p > .59$. Given that the general test statements showed no significant overall directed forgetting effect (i.e., costs + benefits ≈ 0), it is not surprising that when considered separately there were neither significant *costs*, $t(30) = 1.12$, $p > .27$, nor *benefits*, $t(30) = 0.47$, $p > .64$ for these statements.

To rule out any effects of pre-existing schematic representations of the event itself, we ran 10 new participants in a replication of Experiment 5 that presented only the test statements, without any prior exposure to the videos. Performance for the specific condition was numerically equivalent to chance (*M* = 0.50, *SE* = 0.02), whereas performance for the general condition was only slightly above chance (*M* = 0.59, *SE* = 0.04). Liberal response biases were observed for both the specific (*M* = -0.16, *SE* = 0.12) and general (*M* = -0.51, *SE* = 0.07) conditions. Although participants were slightly better at guessing the correct responses for the general test statements, performance was still far below the performance in both the R (.90) and F (.88) conditions of the experimental group. In addition to removing serious concerns regarding the contribution of guessing to test performance, these findings also demonstrate that participants were attending to the videos: Had they looked away during F segments, performance for those segments would have approximated the no-video control group.

2.8 GENERAL DISCUSSION

Five experiments investigated the influence of intentional forgetting on subsequent memory for continuous visual events. In each experiment, four videos were presented surrounded by a colored border that changed from green to purple at variable intervals: Participants were instructed that whenever the border was green they would need to remember everything that was presented for a later test (R segment); whenever the border was purple they could forget everything that was presented (F segment). Following the presentation of the study videos, participants demonstrated better memory for information presented during R segments than for information presented during F segments using cued-recall questions (Experiment 1) and true-false statements (Experiments 2, 3, 4, and 5); this pattern was replicated even in the presence of tasks intended to maintain visual attention on the video (Experiment 3) or to encourage conceptual processing of the video (Experiment 4). The R-F differences observed in these experiments were limited to relatively *specific* as opposed to relatively *general* test statements (Experiment 5).

These experiments extend the framework of intentional forgetting from static information such as pictures or words to dynamic information such as continuous visual events. This is a critical step if intentional forgetting is to be applied to real-world experiences. Equally important is the revelation that intentional forgetting does not reduce memory in an all-or-nothing fashion. Rather, there is a graded loss of information – largest for relatively specific details and smallest or even absent for relatively general details. In Experiments 4 and 5, these differences were entirely attributable to the *costs* without *benefits* of intentional forgetting (see also, Taylor & Fawcett, 2012).

Our findings are remarkable because they demonstrate that participants are capable of intentionally forgetting segments that were integrated into a cohesive visual vignette. One might reasonably have expected no directed forgetting effect because participants were motivated to encode the F segments so as to maintain continuity with the R segments. Past research using semantically related word lists (e.g., Golding, Long, & MacLeod, 1994) or structured narratives (e.g., Geiselman, 1974, 1977) has found that meaningful connections between to-be-remembered and to-be-forgotten information undermine intentional forgetting (see also, MacLeod, 1998). Despite these factors, our effects were remarkably robust.

Although we favour a differential rehearsal interpretation of our directed forgetting effects, with better encoding of R segments than F segments, we do not exclude the possibility that limiting access of the F segments to working memory involves one or more active processes. When considering the current results, one must remain mindful that remembering and forgetting in an intentional forgetting paradigm represent independent strategies/processes that combine to produce a directed forgetting effect. We have concluded that participants likely engaged in an active rehearsal strategy during R segments, accounting for slower responses to visual discrimination targets; however, the manner in which participants behaved during F segments remains uncertain. Recent research using the list method has begun exploring the contribution of diversionary thoughts to the intentional forgetting of lists (e.g., Sahakyan & Kelley, 2002; for discussion of a similar idea in the item method, see Fawcett & Taylor, 2012). While it seems clear that participants did not adopt a 'looking away' strategy during the presentation of F segments in the current study, it is possible that they attempted to think about something else as a means of ignoring the to-be-forgotten information. To the extent that reallocating attention from external to internal representations might be expected to slow RTs to discrimination targets presented during F compared to R segments, the use of a diversionary strategy does not seem likely. Such a strategy would also have difficulty explaining the survival of the directed forgetting effect in Experiment 4: Even if diversionary thoughts played some role in the participants' strategy, the act of segmenting each F segment still required conceptual consideration of the events for which they were tested. In contrast, it seems possible that the encoding of the F segments could be actively controlled as argued by some researchers using the item method (e.g., Fawcett & Taylor, 2008).

Regardless of exactly how directed forgetting is achieved in our concurrent-instruction event-method paradigm, it is clear that intentional forgetting can occur even for segments of continuous visual events. The current data demonstrate that our paradigm is capable of producing a robust directed forgetting effect as measured by both recall and true-false statements. This directed forgetting effect is not attributable to a ‘looking away’ strategy during F segments, as it occurs even during the performance of a secondary task that requires sustained visual or conceptual encoding of the F segments. Even so, this robust directed forgetting effect extends to relatively specific but not to relatively general information, arguing that the costs of forgetting may be due to changes in how specific information is encoded into memory; the gist trace may be relatively unaffected by an F instruction. We propose that specific information regarding the R segments (but not the F segments) is retained by limiting access of to-be-forgotten segments to working memory resources and also by selectively rehearsing to-be-remembered segments.

2.9 CHAPTER SUMMARY

The current chapter presented five experiments using a novel event-method directed forgetting task to investigate whether participants could selectively forget certain segments of an otherwise continuous event presented as a video. Participants were instructed to remember everything that occurred when the border surrounding the video was green (R segments) and to forget everything that occurred when the border surrounding the video was purple (F segments). At test, participants responded more accurately to cued-recall questions (Experiment 1) and relatively specific true-false statements (Experiments 2-4) regarding R segments than F segments even when forced to conceptually process the F segments. No difference was observed for relatively general true-false statements (Experiment 5). It was concluded that participants are capable of intentionally forgetting the details of an event – although a general representation of that event may persist.

CHAPTER 3 THE POST-INSTRUCTION PARADIGM

The following chapter is based upon the manuscript entitled *“Event-method directed forgetting: Forgetting a video segment is more effortful than remembering it*” submitted for publication to the Journal of Experimental Psychology: Learning, Memory and Cognition in March 2012. Co-authors are Dr. Tracy Taylor and Dr. Lynn Nadel. Jonathan Matthew Fawcett was first author and in that capacity designed, programmed, and implemented the experiments and then analyzed and interpreted the data; he was also the primary contributing author to the manuscript, producing the initial draft and completing all major revisions.

3.1 ABSTRACT

Videos were presented depicting events such as baking cookies or cleaning a fish tank. Periodically, the video paused and an instruction to Remember (R) or Forget (F) the preceding video segment was presented; the video then resumed. Participants later responded more accurately to cued-recall questions (Experiment 6) and to true-false statements (Experiments 7-10) regarding R segments than F segments. This difference was larger for specific information (*the woman added 3 cups of flour*) than for general information (*the woman added flour*). Participants were also slower to detect visual probes presented following F instructions compared to those presented following R instructions (Experiments 6-7 and 9-10). These findings suggest that intentional forgetting is an effortful process that can be performed even on segments of otherwise continuous events and that the result is a relatively impoverished representation of the unwanted information in memory.

3.2 INTRODUCTION

As described in Chapter 1, little work has been conducted exploring how intentional forgetting affects event memory. Experiments 1-5 (contained in Chapter 2) addressed this concern using a novel *event-method* directed forgetting paradigm in which we embedded R and F instructions into videotaped vignettes that depicted a continuous sequence of events aimed at accomplishing a single goal (e.g., baking cookies). In the experiments reported in that chapter, participants watched four videos depicting common events (e.g., baking cookies) during which they were instructed to remember certain segments of the otherwise continuous event and to forget others. Each video consisted of eight segments lasting 35 s that were presented sequentially without interruption so that, from the participants' perspective, the video was a continuous sequence of events. Memory instructions were represented by changing the color of the border that surrounded the viewing port containing the video: Participants were required to remember everything that was presented in the video while the border was green and to forget everything that was presented in the video while the border was purple. The assignment of the R and F instructions was randomized across segment, with the restriction that each video contained four R segments and four F segments.

Across five experiments, Chapter 2 demonstrated better subsequent memory performance for R segments compared to F segments using cued-recall questions or true-false statements. This difference remained even when an event segmentation task (see Zacks, Tversky, & Iyer, 2001) was employed to encourage conceptual encoding of the *entire* video (i.e., all R and F segments). In Experiment 5, the effect of intentional forgetting was smaller (or even non-existent) for relatively general test statements (e.g., *the woman added 3 cups of flour*) compared to the robust effect observed for relatively specific test statements (e.g., *the woman added flour*). This finding suggests that intentional forgetting has a graded effect on the to-be-forgotten information, with a greater loss of details relative to gist (although see Joslyn & Oakes, 2005).

The preceding experiments provided a strong test of the hypothesis that participants could selectively forget the details of unwanted events when the memory instructions were presented concurrent to the studied material. Concurrent memory instructions unobtrusively indicated the R and F information without interrupting the events to which they referred and therefore emulated a natural viewing experience. However, this finding would be ever more compelling if demonstrated in a paradigm wherein the memory instruction was presented after the to-be-remembered or to-be-forgotten segment had already been encoded. Whereas a concurrent memory instruction requires the participant to control the manner in which the R or F information is encoded, a delayed memory instruction requires the participant to control the representation of the R or F information within memory. Accordingly, Experiments 1–5 demonstrated that participants could preferentially ignore F segments and process R segments as they were encoded, impacting the specificity of the resulting memory trace. It is our current goal to determine whether participants are capable of preferentially suppressing F segments and processing R segments immediately after they have been encoded – and whether this effect will also be limited to relatively specific information.

To address this question, the current experiment adapted the event-method paradigm to use a delayed as opposed to concurrent memory instruction: Following each segment, the video paused, the screen cleared and participants received a green- or purple-filled circle instructing them to remember or forget the *preceding* segment. Further, to explore the mechanisms via which the R and F instructions are instantiated in our task, we presented a visual probe (‘*’) requiring a speeded detection response following most of the R and F memory instructions (see Fawcett & Taylor, 2008; see also, Fawcett & Taylor, 2010, 2012; Taylor, 2005; Taylor & Fawcett, 2011).

3.3 EXPERIMENT 6: RECALL

In Experiment 6, participants viewed videos of common events such as baking cookies or cleaning a fish tank. The videos were each separated into eight discrete segments lasting 35 s: Participants were instructed to remember a random half of the segments contained within each video and to forget the remainder. The R and F instructions, were colored circles presented during a pause that followed each 35 s video segment. To quantify the cognitive demands associated with instantiating each R and F instruction we presented a visual probe following the instruction. Participants were required to make a speeded response to report the detection of this probe and longer reaction times (RTs) were taken as an index of relatively increased cognitive demands (see Kahneman, 1973). Following the study phase trials, participants responded to cued-recall questions testing their knowledge for *all* video segments regardless of the associated memory instruction. In addition to predicting that participants would respond more accurately when tested for segments they had been instructed to remember relative to those they had been instructed to forget, to the extent that instantiating an F instruction is more effortful than instantiating an R instruction (Fawcett & Taylor, 2008) we also predicted that they would exhibit slower probe RTs following F than R instructions.

3.3.1 Method

Participants

Twenty-nine undergraduate students (18 female) enrolled at Dalhousie University or the University of Arizona participated in this experiment for course credit. Most participants were right-handed (18 right).

Stimuli and Apparatus

The experimental task used a custom script developed in the Python programming language (www.python.org) with the Pygame development library (www.pygame.org). The script was loaded on either a 17” MacBook Pro computer running Mac OS X 10.5 or a 24” iMac computer running Mac OS X 10.5. Responses were recorded via the built-in laptop keyboard. Instructions and test statements were presented against a black background in white, size 18 Gentium Basic Bold (www.sil.org/~gaultney/Gentium/); the title of each video was presented in size 30 of the same font.

Four videos depicting common events (Baking Assorted Cookies, Getting Ready for Work, Cleaning a Fish Tank, Making Chocolate Pudding) were retrieved from the public domain video sharing website YouTube and used during the study phase; a 5th video (Doing Laundry) was retrieved and used during a preceding practice phase. Each video contained a linear progression of events resulting in a predetermined, self-evident goal as described by the title of that video (e.g., “Baking Assorted Cookies”). Videos were resized to fit into a view area measuring 600 x 600 pixels and were comprised of 7000 frames (1750 frames for the practice video). Videos were presented at an average rate of 25 frames per second, for a total duration of 4 minutes and 40 seconds (1 minute and 10 seconds for the practice video). Throughout the practice and study phase, participants were instructed to remember (R) a random half of segments from each video and to forget the remaining (F) segments in accordance with green- or purple-filled circles presented following each segment. Each circle measured 75 pixels in diameter and was surrounded by a 3-point white border. Each segment lasted 875 frames (35 s), resulting in

8 segments per video (2 segments for the practice video). R and F instructions were randomly assigned to the ordered sequence of video segments on a subject-by-subject basis with the restriction that each video always contained 4 R segments and 4 F segments (1 R segment and 1 F segment for the practice video).

Cued-recall questions were used to test memory for the contents of each video. Each cued-recall question tested information revealed only during a single segment. Because of inherent differences in the amount of unique information contained within the segments, two of the videos (Baking Assorted Cookies, Making Chocolate Pudding) were tested with 3 cued-recall questions per segment and the remaining two videos (Cleaning a Fish Tank, Getting Ready for Work) were tested with 2 cued-recall questions per segment for a total of 80 cued-recall questions overall. These were the same stimuli used as in Experiment 1 (see Chapter 2).

Procedure

Participants were told that they would view a series of videos each depicting a common event – such as baking cookies – some portion of which they would be instructed to remember for a subsequent memory test.

Practice Phase. A practice video about folding laundry was presented to familiarize participants with the task. During this video the experimenter provided sample questions so that the participant would understand the type of information they were expected to retain. The presentation of the practice video was identical to the study phase trials except that only a single R segment and a single F segment were presented. Participants were then presented with a written version of the study phase instructions on the computer screen and told to press ‘RETURN’ when they were ready to begin the experiment proper. The experimenter then relocated to a different desk at the far end of the room behind the participant or to an adjacent room.

Study Phase. Prior to each video, a descriptive title (e.g., “Baking Assorted Cookies”) was presented in the center of the screen until the participant pressed the ‘RETURN’ key at which point the video began. Videos were separated into 8 segments each lasting 35 seconds and followed by a green- or purple-filled circle instructing the participant to remember or forget that segment: Each video contained a total of 4 R and 4 F segments. At the end of each 35 s segment, the video paused and the screen cleared. Following a 3000 ms delay, the memory instruction was presented for 300 ms and then removed, resulting in a blank screen. To assess relative cognitive load associated with instantiating the R and F instructions, on the majority of trials, a single visual probe (“*”) lasting 400 ms was presented at a stimulus onset asynchrony (SOA) of 1800 ms in relation to onset of the memory instruction; participants made a speeded detection response to this probe by pressing the spacebar as quickly as possible. We selected 1800 ms for the instruction-probe SOA because Fawcett and Taylor (2008) found the F > R differences in probe RTs to be most robust at this interval. On the remaining one-quarter of the trials (no-probe catch trials) no visual probe was presented. Catch trials were included to measure the false alarm rate associated with the detection response. Probe and catch trials were equally distributed across memory instruction and video.

Following the disappearance of the memory instruction, there was a delay of 8700 ms before the video resumed, such that the total duration of the pause between sequential video segments was 12000 ms. The timing of events within a single video is depicted in Figure 3.1 and was repeated until all 8 segments (and their associated memory instructions) had been presented. The presentation order of the four study phase videos was randomized; the segments contained within each video were presented in sequential order, interrupted only by the 12000 ms pause described above. Once a given video ended, the title for the next video was presented until the participant initiated play by pressing the ‘RETURN’ key. This process continued until all 4 videos were completed, at which point the instructions for the test phase were displayed.

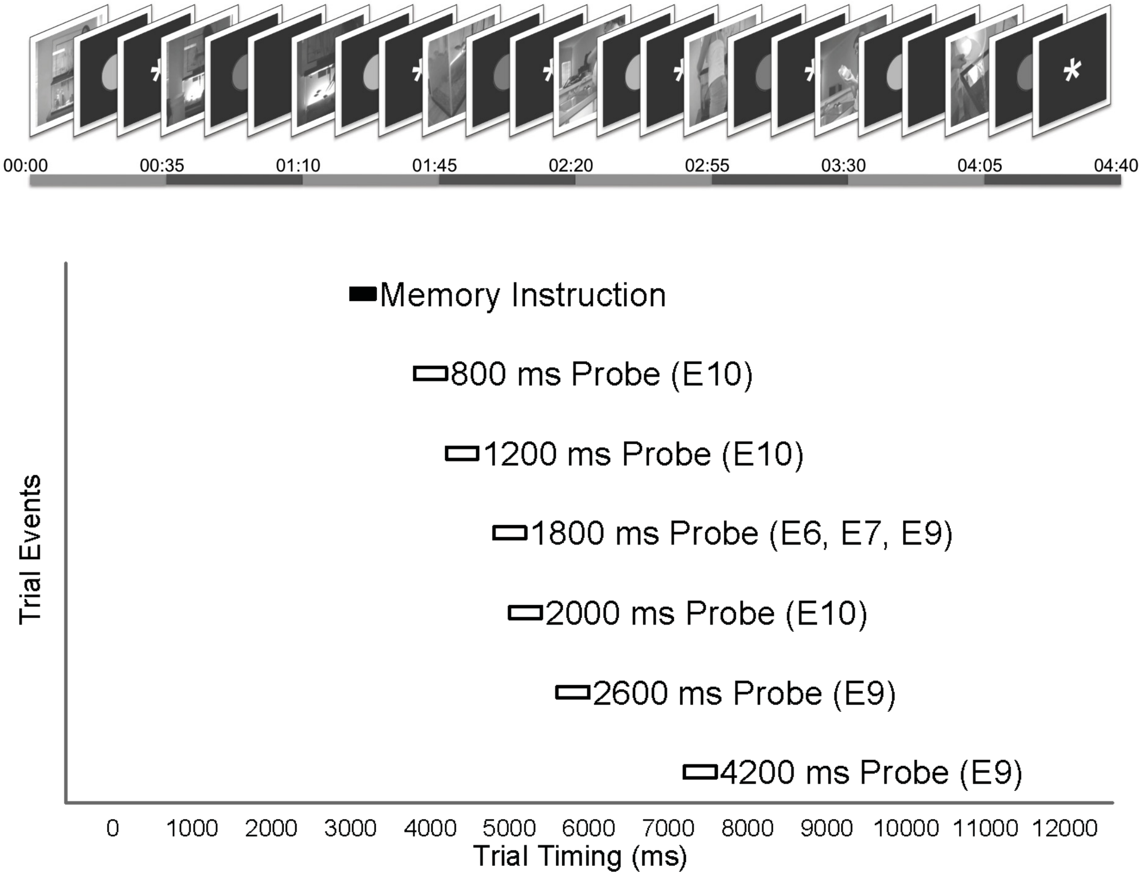

Figure 3.1: The top panel depicts a schematic representation of the study phase presentation of "Cleaning a Fish Tank" with a complementary timeline denoting the start and end time of each segment if the video were to run uninterrupted. Each video segment corresponds to one bar within the timeline; a single still frame capture is used to represent the 35 s segment. For the sake of this depiction, the light circles represent R instructions and the dark circles represent F instructions. The bottom panel depicts the trial events that occurred during the pause following each segment and timed in relation to video offset (which is denoted as 0 ms). Only a single probe was presented on each study phase trial with the exception of no-probe catch trials. Experiment 8 did not contain any probes.

Test Phase. During the test phase, participants were presented with a series of cued-recall questions, individually in the center of the computer screen, each pertaining to a specific R or F segment within the presented videos. Participants were tested for the content of one video at a time; the statements for a given video were otherwise presented in a random order. Participants were instructed to answer each question to the best of their ability using one or two words. To avoid participants dwelling on a given question, they were instructed to respond *dnk* (*do not know*) or *idk* (*I don't know*) if faced with a question for which they could not even guess – although the use of this response was discouraged.

The first author scored each cued-recall question using an answer key created prior to data collection. During scoring, the R or F instruction associated with the scored question was obscured to prevent bias. Responses that the first author felt were correct but were not listed on the original answer key were flagged for independent review by an undergraduate research assistant and either added to the answer key or rejected. Once all data had been collected, each question was rescored using *only* the answer key to ensure consistency. Misspellings were accepted as correct only if they were unambiguous. For example, *fingur* instead of *finger* would be acceptable whereas *air* instead of *hair* would not be acceptable.

3.3.2 Results

Recall Data

The percentage of correct responses made on the cued-recall test was calculated by dividing the number of responses matching the answer key by the total number of cued-recall questions answered; *do not know* responses were treated as incorrect, since the participant had asserted that they did not know the correct answer – excluding these responses instead did not change the pattern or significance of the results. The percentage of correct responses was then analyzed as a function of instruction (R, F) using a one-way repeated-measures ANOVA. This analysis was significant, $F(1, 29) = 8.17$, $MSe = 39.81$, $p < .01$, $\eta_g^2 = .065$, with better performance for cued-recall questions pertaining to R segments ($M = 49.11\%$, $SE = 1.78\%$) than F segments ($M = 44.38\%$, $SE = 1.60\%$). This effect of memory instruction confirms a significant directed forgetting effect. The magnitude of this effect, 4.73%, was not significantly different from the 5.60% directed forgetting observed in Experiment 1 (reported in Chapter 2) which used concurrent as opposed to delayed memory instructions, $t(57) = 0.30$, $p > .77$.

Probe Detection RTs

A response on a probe-present detection trial was considered correct if executed within 100 ms and 2000 ms of probe onset; correct detection responses were made on 96.84% of F trials (SE=1.62%) and on 99.14% (SE=0.48%) of R trials, which did not differ significantly, $F(1, 28) = 2.22$, $MSe = 34.47$, $p = .147$, $\eta_g^2 = .032$. Mean probe RTs for correct trials were analyzed as a function of instruction (R, F) using a repeated-measures ANOVA. This analysis revealed probe RTs to be significantly longer following F instructions ($M = 532$ ms, $SE = 26$ ms) than R instructions ($M = 475$ ms, $SE = 24$ ms), $F(1, 28) = 18.35$, $MSe = 2595.96$, $p < .01$, $\eta_g^2 = .044$. This finding replicates the F > R probe RT difference observed by Fawcett and Taylor (2008) in a typical item-method paradigm.

Probe False Alarms

Finally, we analyzed the percentage of false alarms made on no-probe catch trials as a function of instruction (R, F). There were numerically fewer false alarms committed for F trials (M = 2.59%, SE = 1.44%) compared to R trials (M = 3.44%, SE = 1.63%; see Fawcett & Taylor, 2008); however, this difference was not significant, $F(1, 28) = 0.32$, $MSe = 33.10$, $p = .57$, $\eta_g^2 = .003$.

3.3.3 Discussion

Despite presenting the memory instruction after (as opposed to concurrent with) the studied material, a significant directed forgetting effect was observed as measured by recall. Further, the finding that participants were slower to respond to probes presented following an F than following an R instruction suggests that intentional forgetting in this paradigm may require engagement of an effortful cognitive process that helps limit further processing of the F segment. Fawcett and Taylor (2008) identified a similar pattern of F > R probe RTs for up to 1800 ms after instruction onset in an item-method paradigm. They argued that enacting an F instruction was associated with a brief, effortful process that discouraged further processing of the to-be-forgotten information. This effortful process may involve activation of frontal control mechanisms (see, Wylie et al., 2008) that limit further rehearsal of F items (Fawcett & Taylor, 2008) – as well as items that appear shortly thereafter (Fawcett & Taylor, 2012) – likely by withdrawing attentional resources from the F item representation during encoding (Taylor, 2005; see also, Fawcett & Taylor, 2010; Taylor & Fawcett, 2011). The current findings provide the first evidence that similar active mechanisms may be engaged flexibly to prevent the encoding of segments of otherwise continuous events. This is quite an important finding because it suggests that the withdrawal of processing resources from to-be-forgotten information can occur even when that information is otherwise integrated in a continuous event sequence. Certainly, if intentional forgetting were to be useful in the ‘real world’ we would expect it to be applied flexibly to enable selective encoding of portions of the otherwise continuous episodic events that comprise life experiences.

3.4 EXPERIMENT 7: TRUE-FALSE STATEMENTS

Having demonstrated a directed forgetting effect using recall, we next explored whether enacting an F instruction retroactively impoverishes the representation of an event after encoding. To address this question, Experiment 7 replicated the method of Experiment 6 with the exception that memory was tested using relatively specific or relatively general true-false statements as in Experiment 5. Whereas directed forgetting is typically measured as an all-or-nothing phenomenon based on a comparison of overall memory performance for R and F information, by manipulating the relative specificity of the test statements, we explored whether intentional forgetting differentially impacts the details and the gist of the targeted event. Given that we presented the memory instruction after the presentation of the video segment, a differential impact of the memory instruction on detail versus gist would suggest that the instruction operates retroactively to influence the *quality* of the encoded information.

3.4.1 Method

Participants

Thirty undergraduate students (19 female) enrolled at Dalhousie University or the University of Arizona participated in this experiment for course credit. Most participants were right-handed (25 right).

Stimuli and Apparatus

The stimuli and apparatus used in the current experiment were identical to those used in Experiment 6 with the exception that true-false statements were presented instead of cued-recall questions. Eight true-false test statements were created for each segment. True statements were created first and referred to a particular event (e.g., *the pudding was served in a clear glass with a stem*) or fact (e.g., *the recipe called for 2 tablespoons of cornstarch*) revealed only during the relevant segment. False statements were most often created by replacing a single detail within each true statement, maintaining the general structure whenever possible (e.g., *the recipe called for 2 tablespoons of salt*); in some cases, this was not possible. General statements sometimes were created by removing details from the specific statements (e.g., *the recipe called for cornstarch*) although in other cases alternative information was tested. Overall, 256 test statements (128 true and 128 false) were created equally distributed across specificity (128 specific and 128 general). The stimuli and apparatus used in this experiment were the same as those used in Experiment 5 reported in Chapter 2.

Procedure

The procedure was identical to Experiment 6 with the exception that instead of cued-recall questions at test, participants were presented with a series of true-false statements. Participants were tested for the content of one video at a time, although the statements for that video were presented in a random order. The specific and general statements as well as the true and false statements were randomly interspersed. The title of the video being tested was presented directly above each test statement. Participants pressed "j" on the computer keyboard to indicate a statement that was true or "f" to indicate that the statement was false (with the mnemonic that "f" was for false to ensure participants did not confuse this response mapping). Responses were self-paced and no feedback was given.

3.4.2 Results

Signal Detection Analysis

The raw hits and false alarms are provided in Table 3.1. Using the procedure described by Donaldson (1992), non-parametric measures of sensitivity (A') and response bias (B''_D) were calculated and analyzed as a function of instruction (R, F) and relative specificity (specific, general) using separate two-way repeated-measures ANOVAs. These data are provided in Figure 3.2. For the A' analysis, the main effect of instruction was significant with greater sensitivity to statements about R segments than F segments, $F(1, 29) = 4.22$, $MSe = 0.005$, $p = .049$, $\eta_g^2 = .028$. The main effect of specificity was also significant with greater sensitivity to general statements than specific statements, $F(1, 29) = 183.22$, $MSe = 0.004$, $p < .001$, $\eta_g^2 = .536$. Importantly, these effects were qualified by a significant instruction x specificity interaction, $F(1, 29) = 7.50$, $MSe = 0.003$, $p = .010$,

$\eta_g^2 = .033$. Planned contrasts revealed a significant 0.05 directed forgetting effect in *A'* for specific test statements, $t(29) = 2.76$, $p = .010$. There was a non-significant 0.01 *reverse* directed forgetting effect for general statements, $t(29) = 0.18$, $p = .862$.

Table 3.1

Mean Percentage of "True" Responses (i.e., Hits for True Statements and False Alarms for False Statements) as a Function of Instruction (Remember, Forget), Specificity (Specific, General) and Statement Validity (True, False) in Experiments 7, 8, 9, and 10.

	Specific				**General**			
	True		**False**		**True**		**False**	
Instruction	***M***	***SE***	***M***	***SE***	***M***	***SE***	***M***	***SE***
Experiment 7								
R	68	2	28	2	88	1	17	2
F	62	2	32	2	87	2	17	2
Experiment 8								
R	68	2	33	2	87	2	23	3
F	64	2	38	3	89	2	25	3
Experiment 9								
R	63	2	29	2	89	1	19	2
F	60	2	33	2	89	1	19	2
Experiment 10								
R	70	2	29	2	84	3	20	2
F	63	3	30	2	84	2	19	2

The B''_D analysis revealed only a significant main effect of relative specificity, $F(1,29) = 1.26$, $MSe = 0.06$, $p < .001$, $\eta_g^2 = .156$, with participants employing a more liberal response bias for general statements than specific statements; neither the main effect of instruction, $F(1,29) = 1.26$, $MSe = 0.08$, $p = .270$, $\eta_g^2 = .008$, nor the instruction x specificity interaction, $F(1,29) = 0.19$, $MSe = 0.05$, $p = .665$, $\eta_g^2 < .001$, were significant

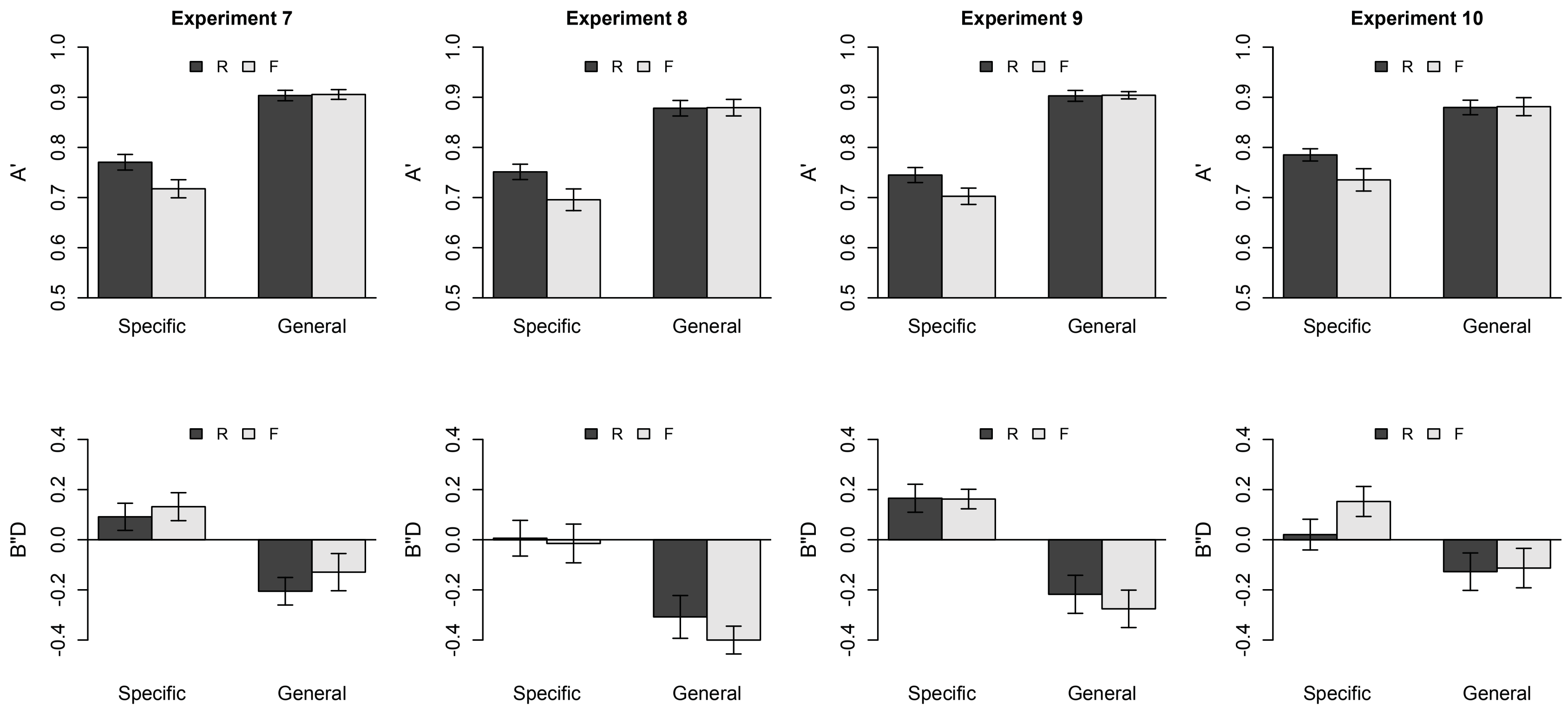

Figure 3.2. Sensitivity (*A'*) and Response Bias (B''_D) as a function of instruction (R, F) and specificity (specific, general) for Experiments 7 (Post-Instruction, True-False Statements), 8 (Post-Instruction, No Probe Task), 9 (Post-Instruction, Late Instruction-Probe Intervals) and 10 (Post-Instruction, Early Instruction-Probe Intervals); error bars represent one standard error of the mean.

Probe Detection RTs

A probe-present detection trial was considered correct if the participant executed a response within 100 ms and 2000 ms of probe onset; correct detection responses were made on 97.78% of F trials (*SE*=1.19%) and on 99.72% (*SE*=0.28%) of R trials, which did not differ significantly from one another, $F(1, 29) = 2.45$, $MSe = 23.19$, $p = .129$, $\eta_g^2 = .042$. Mean probe RTs for correct trials were analyzed as a function of instruction (R, F) using a repeated-measures ANOVA. This analysis revealed probe RTs to be significantly longer following F instructions ($M = 504$ ms, $SE = 34$ ms) than R instructions ($M = 460$ ms, $SE = 32$ ms), $F(1, 29) = 10.52$, $MSe = 2784.18$, $p = .003$, $\eta_g^2 = .015$.

Probe False Alarms

The percentage of false alarms was numerically equivalent for R trials ($M = 2.50\%$, $SE = 1.39\%$) and for F trials ($M = 2.50\%$, $SE = 1.84\%$) and so these were not significantly different, $F<1$.

3.4.3 Discussion

Experiment 7 replicated Experiment 6 with the exception that true-false statements were used instead of cued-recall questions. Our signal detection analysis revealed a significant directed forgetting effect for specific test statements as measured by *A'*. Instruction did not affect sensitivity to general test statements and there was no effect of instruction on response bias (B''_D) for either level of specificity. The interaction between directed forgetting and relative specificity for *A'* suggests that participants are capable of using a memory instruction to retroactively control the level of representation that is encoded for recently viewed events: R items appear to be represented with greater detail than F items, with no effect of instruction on the gist representation.

Because the general test statements necessarily queried information that might otherwise be part of a general schema activated by the video title (e.g., “Baking Assorted Cookies”), it is important to know whether the failure to observe a directed forgetting effect for general statements (e.g., *the woman added cornstarch*) was due to the fact that participants responded based on schema activation (e.g., making assorted cookies usually requires adding cornstarch) rather than based on memory for the presented video events (e.g., remembering that the woman in the video actually did add cornstarch). Data from a control condition presented in the preceding chapter speak directly to this issue. Using the same test statements presented above, the data presented within the Discussion section for Experiment 5, 10 participants guessed the correct answer for each, based only on the title of the event; in this “no-study” control condition, participants did not view the videos prior to answering the test statements. If participants had been able to guess the answer to many of the general test statements, this control group would have shown relatively high sensitivity (i.e., a high *A'* score) to general test statements despite not having watched the videos. In fact, performance in this no-study control condition was equivalent to chance for specific test statements ($M = 0.50$, $SE = 0.02$) and only slightly better than chance for the general test statements ($M = 0.59$, $SE = 0.04$). And, more to the point, in both cases, the *A'* score for this no-study control group was drastically lower than the *A'* score obtained for the specific ($M_R = .77$ and $M_F = .72$) and general test items

(M_R = .90 and M_F = .91) in the current experiment. This provides evidence that participants responded to the general test statements based on memory, and not schema activation, such that the failure to obtain a directed forgetting effect suggests equivalent representation of gist for R and F traces.

Another control condition sometimes discussed in the directed forgetting literature involves presenting participants with an exact replication of the experimental task with the exception that participants are instructed to remember *all* study items as opposed to a subset of items (e.g., Basden & Basden, 1996; Sahakyan & Foster, 2009). To tease apart the costs and benefits, performance in each condition of the experimental task is compared to performance in the remember-all baseline task. Benefits are measured as better performance for R items in the experimental task compared to the remember-all baseline whereas costs are measured as worse performance for F items in the experimental task compared to the remember-all baseline (e.g., Basden & Basden, 1996; Sahakyan & Foster, 2009). Together the costs and benefits are thought to combine to produce what we have thus far referred to as the directed forgetting effect.

Despite our reservations as to whether a between-subject remember-all condition is an appropriate baseline for assessing costs and benefits (see Taylor & Fawcett, 2012), we collected data from an additional 26 participants, replicating Experiment 7 with the exception that the colored circles were not ascribed any meaning; instead, participants were instructed to remember every segment of the videos they watched, while also responding to the visual probes. This remember-all instruction resulted in mean *A'* scores of 0.76 (*SE* = 0.01) for the specific statements and 0.92 (*SE* = 0.01) for general statements. Planned *t*-tests comparing performance for the specific test statements between the baseline and experimental groups revealed marginally significant costs, *t*(54) = 1.72, *p* = .090, but no evidence of benefits, *t*(54) = 0.76, *p* = .451. For the general test statements, performance was slightly higher in the remember-all baseline group than in either the R or F condition of the experimental group; this difference was not significant for either R segments, *t*(54) = 0.97, *p* = .339, or F segments, *t*(54) = 0.84, *p* = .403.

The finding of marginally significant costs and no benefits of directed forgetting for the specific test statements may appear surprising at first. Past research using a remember-all baseline has reported both costs *and* benefits using both the item and list methods (e.g., Basden & Basden, 1996; Sahakyan & Foster, 2009). However, these studies have largely used recall tasks (e.g., Sahakyan & Foster, 2009; although, see Sahakyan et al., 2009). Taylor and Fawcett (2012) observed costs but not benefits when using a recognition task in the context of item-method directed forgetting and the same pattern is present in Experiments 4 and 5 of Chapter 2 of this document. It is possible that whereas the costs of directed forgetting are robust across dependent measures, the benefits are only robust using a generative task such as recall at least insofar as item- or event-method directed forgetting are concerned.

We also investigated the experimental probe RTs in relation to this remember-all condition. Participants in the remember-all task had an overall mean RT of 398 ms (*SE* =

25 ms).[8] Although probe RTs were significantly shorter in the baseline task compared to F trials, *t*(54) = 2.45, *p* = .018, they did not differ significantly compared to R trials, *t*(54) = 1.51, *p* = .136. In addition to the issue of whether a remember-all condition is an appropriate neutral condition for measuring costs and benefits in memory, we recommend caution in interpreting these probe data because the baseline is between-subjects and past theorists have challenged the validity of a between-subject baseline in attentional tasks (see Jonides & Mack, 1984). Allowing this, these findings converge with conclusions drawn from prior within-subject baseline comparisons conducted in the context of item-method directed forgetting. For example, in an item-method paradigm that incorporated reaction time probes, Fawcett and Taylor (2008, Experiment 2) interspersed trials on which a meaningless string of Xs was presented instead of a study word. This provided an online, within-subjects measurement of probe RTs on trials where there was no memory demand imposed by the presented item (i.e., the string of Xs). In a similar vein, Fawcett, Lawrence, and Taylor (2011) preceded the study phase of their experiment with a brief practice session with the probe task in which the same study item was repeated from trial-to-trial and no meaning was ascribed to the memory instruction. Responses to probes in this practice block provided a within-subjects measure of probe RTs in the absence of a memory demand. In both cases, probe RTs from the R trials roughly equated with the baseline probe RTs, whereas probe RTs from F trials tended to be longer. Together, these comparisons suggest that (a) R trial probe RTs are more

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[8] Overall mean RT is presented because the memory instructions were meaningless, making the distinction between R trial and F trial RTs superfluous. Nonetheless, inspection of these RTs may assuage any concerns that the nature of the R and F instructions (i.e., a green- *vs.* purple-filled circle) influenced our results. Counter to this possibility, mean F trial RT was 390 ms (*SE* = 21 ms) and mean R trial RT was 406 ms (*SE* = 30 ms).

similar to baseline performance than F trial probe RTs regardless of design (between, within) or task type (remember-all, etc.); and, (b) the F > R pattern of probe RTs is driven by slower responses following F instructions as opposed to faster responses following R instructions.

The observation of slower probe RTs following F instructions compared to R instructions serves as a bridge between our event-method paradigm and the more classic item-method paradigm. Using the item method, Fawcett and Taylor (2008) also observed that within 1800 ms of memory instruction onset, probe RTs were slower following F than R instructions. They proposed that this pattern was evidence of a brief cognitive mechanism that discouraged rehearsal of the discarded study item. Fawcett and Taylor (2012) provided further evidence that instantiating an item-method F instruction interferes with the formation of incidental memory for other, task-irrelevant items presented during the post-instruction period and Taylor (2005; Fawcett & Taylor, 2010; Taylor & Fawcett, 2011) observed a relatively larger inhibition of return effect for F trials relative to R trials. Evidence continues accumulating in support of an active mechanism of intentional forgetting that is associated with exerting control over the contents of working memory (Fawcett & Taylor, 2012) with the possible benefit of subsequently biasing processing resources away from unreliable sources (see Taylor & Fawcett, 2011). The current findings provide preliminary evidence that the mechanism proposed in the context of intentionally forgetting discrete words or pictures is also relevant to continuous, contextually rich information such as provided by our video vignettes.

3.5 EXPERIMENT 8: NO PROBE TASK

Experiment 7 demonstrated a robust directed forgetting effect for specific but not general test statements. However, before we accept this finding, we would like to ensure that it has not been influenced by the presence of the probe task. For example, it is conceivable that dedicating cognitive resources to the secondary probe detection task detracted from the resources available to rehearse the R segments or to forget the F segments. If so, the magnitude of the directed forgetting effect could be artificially reduced, masking any effects of the memory instruction on responses to the general test statements. To investigate this issue, Experiment 8 replicated Experiment 7 with the removal of the study phase probe response task.

3.5.1 Method

*Participants***.**

Twenty undergraduate students (14 female) enrolled at the University of Arizona or Dalhousie University participated in this experiment for course credit. Most participants were right-handed (18 right).

Stimuli and Apparatus

The stimuli and apparatus were identical to Experiment 7.

Procedure

The procedure was identical to Experiment 7 with the exception that the probe response component of the experiment was removed from the study phase trials.

3.5.2 Results

The mean hits and false alarms are provided in Table 3.1. Non-parametric measures of sensitivity (*A'*) and response bias (*B''_D*) were calculated and analyzed as a function of instruction (R, F) and relative specificity (specific, general) using separate two-way repeated-measures ANOVAs (see Figure 3.2). For the *A'* analysis, there was a marginal effect of instruction with greater sensitivity to statements about R segments than F segments, $F(1, 19) = 3.76$, $MSe = 0.004$, $p = .068$, $\eta_g^2 = .031$. The main effect of specificity was significant with greater sensitivity to general statements than specific statements, $F(1, 19) = 165.38$, $MSe = 0.003$, $p < .001$, $\eta_g^2 = .511$. Importantly, these effects were qualified by a significant instruction x specificity interaction, $F(1, 19) = 7.47$, $MSe = 0.002$, $p = .013$, $\eta_g^2 = .034$. Planned contrasts revealed a significant 0.06 directed forgetting effect in *A'* for specific test statements, $t(29) = 2.60$, $p = .018$. Once again, there was no directed forgetting effect in *A'* for general test statements, $t(29) = 0.09$, $p = .927$.

The B''_D analysis revealed only a significant main effect of relative specificity, $F(1, 19) = 38.37$, $MSe = 0.06$, $p < .001$, $\eta_g^2 = .231$, with participants employing a more liberal response bias for general statements than specific statements; neither the main effect of instruction, $F(1, 19) = 1.10$, $MSe = 0.06$, $p = .307$, $\eta_g^2 = .008$, nor the instruction x specificity interaction, $F(1, 19) = 0.59$, $MSe = 0.04$, $p = .452$, $\eta_g^2 = .003$, was significant.

3.5.3 Discussion

Experiment 8 replicated the interaction between instruction and specificity for *A'* that was observed in Experiment 7, thus demonstrating that the presence of the probe task in Experiment 7 was not responsible for the interaction of the memory instruction and item specificity. Whether a probe task is included (Experiment 7) or not (Experiment 8), there is a directed forgetting effect in *A'* for specific test statements but not for general test statements.

As in Experiment 7, a remember-all baseline experiment was conducted with 14 new participants resulting in a mean *A'* value of 0.75 (*SE* = 0.02) for the specific statements and 0.89 (*SE* = 0.02) for the general statements. Comparison of these values to performance in the experimental task revealed marginally significant costs, *t*(32) = 1.79, *p* = .082, and no benefits, *t*(32) = 0.14, *p* = .892, for specific test statements. Once again, performance for the general test statements was equivalent for R and F segments so neither costs nor benefits were possible although performance was numerically (but not significantly) higher in the baseline group than in either the R condition, *t*(32) = 0.31, *p* = .762, or F condition, *t*(32) = 0.25, *p* = .808, of the experimental group.

Given that the pattern of memory performance did not differ between Experiments 7 and 8, a further analysis was conducted pooling these experiments as well as their baseline conditions to maximize statistical power. In this analysis, the costs observed for the specific statements reached significance, *t*(88) = 2.52, *p* = .013, although the other comparisons remained non-significant as reported above (all *p*s > .333).

3.6 EXPERIMENT 9: LATE INSTRUCTION-PROBE INTERVALS

Having clearly demonstrated that F segments are less specific in memory than R segments and that this is associated with an active mechanism following F instructions, Experiment 9 expands upon the latter by exploring the time-course of the mechanism(s) indexed by the probe RTs. Fawcett and Taylor (2008) hypothesized that the processes associated with intentional forgetting resolved within approximately 2600 ms of instruction onset (for a replication, see Hansen, 2011). The few studies that have explored the time-course of the F > R probe RT difference stay within this temporal window (e.g., Fawcett & Taylor, 2012) so the time-course following 2600 ms remains unknown. Experiment 9 replicated Experiment 7 with the inclusion of 2600 ms and 4200 ms as well as 1800 ms instruction-probe SOAs to characterize the time-course at these later intervals.

3.6.1 Method

Participants

Twenty-four undergraduate students (15 female) enrolled at the University of Arizona or Dalhousie University participated in this experiment for course credit. Most participants were right-handed (22 right).

Stimuli and Apparatus

The stimuli and apparatus were identical to Experiment 7.

Procedure

The procedure was identical to Experiment 7 with the exception that the visual probes were presented with equal likelihood at 1800 ms, 2600 ms, or 4200 ms following memory instruction onset while maintaining the same proportion of no-probe catch trials. The timing of the study phase trials otherwise remained unchanged.

3.6.2 Results

Signal Detection Analysis

The mean hits and false alarms are provided in Table 3.1. Non-parametric measures of sensitivity (A') and response bias (B''_D) were calculated and analyzed as a function of instruction (R, F) and relative specificity (specific, general) using separate two-way repeated-measures ANOVAs (see Figure 3.2). For the A' analysis, there was a marginal effect of instruction with greater sensitivity to statements about R segments than F segments, $F(1, 23) = 4.12$, $MSe = 0.002$, $p = .054$, $\eta_g^2 = .027$. The main effect of specificity was also significant with greater sensitivity to general statements than specific statements, $F(1, 23) = 292.32$, $MSe = 0.003$, $p < .001$, $\eta_g^2 = .680$. Importantly, these effects were qualified by a significant instruction x specificity interaction, $F(1, 23) = 6.06$, $MSe = 0.002$, $p = .022$, $\eta_g^2 = .030$. Planned contrasts revealed a significant 0.05

directed forgetting effect in *A'* for specific test statements, $t(23) = 2.66$, $p = .014$. There was no directed forgetting effect in *A'* for general test statements, $t(23) = 0.11$, $p = .910$.[9] The B''_D analysis revealed only a significant main effect of relative specificity, $F(1, 23) = 40.96$, $MSe = 0.10$, $p < .001$, $\eta_g^2 = .315$, with participants employing a more liberal response bias for general statements than specific statements; neither the main effect of instruction, $F(1, 23) = 0.28$, $MSe = 0.08$, $p = .601$, $\eta_g^2 = .003$, nor the instruction x specificity interaction, $F(1, 23) = 0.43$, $MSe = 0.04$, $p = .518$, $\eta_g^2 = .002$, was significant.

Probe Detection RTs

A probe-present detection trial was considered correct if the participant executed a response within 100 ms and 2000 ms of probe onset; as depicted in Table 3.2, correct detection responses did not differ as a function of instruction, $F(1, 23) = 0.05$, $MSe = 94.92$, $p = .833$, $\eta_g^2 < .001$, or SOA, $F(1, 23) = 1.94$, $MSe = 96.05$, $p = .155$, $\eta_g^2 = .029$, and these factors did not interact, $F(1, 23) = 0.86$, $MSe = 65.48$, $p = .429$, $\eta_g^2 = .009$.

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[9] Following each true-false judgment made during the test phase, we also included an exploratory task in which participants judged the temporal placement of the tested event. A solid white line 20-pixels in height was used for this purpose, appearing below the true-false statement after each true-false judgment. This line represented the timeline of the tested video and disappeared once the participant used the computer mouse to indicate where along the line the event occurred. The purpose of this task was to determine whether intentional forgetting affected the temporal specificity of the to-be-forgotten events. Each judgment was converted into a proportion representing the amount of the video preceding that point. The absolute difference between this value and the true position of the event within the video was calculated for true statements and analyzed as a function of instruction (R, F) and specificity (specific, general). Nothing was significant (all *p*s > .476 and all $\eta_g^2 = .001$). For F segments, the mean deviation was 0.15 (*SE* = 0.01) for general statements and 0.15 (*SE* = 0.01) for specific statements; for R segments, the mean deviation was 0.15 (*SE* = 0.01) for general statements and 0.15 (*SE* = 0.01) for specific statements. It appears that the task was simply too difficult. The magnitude of the absolute difference scores converts to an approximate granularity of 42 milliseconds. This suggests that participants had only an approximate notion of the segment in which any given event occurred.

Mean probe RTs for correct trials were analyzed as a function of instruction (R, F) and SOA (1800 ms, 2600 ms, 4200 ms) using a repeated-measures ANOVA. This analysis revealed probe RTs to be significantly longer following F instructions (M = 634 ms, SE = 56 ms) compared to R instructions (M = 567 ms, SE = 54 ms), $F(1, 23) = 15.25$, MSe = 10621.57, $p < .001$, $\eta_g^2 = .015$. The main effect of SOA was not significant, $F(1, 23)$ = 1.54, MSe = 12940.20, $p = .226$, $\eta_g^2 = .004$. There was, however, a marginal instruction x SOA interaction, $F(1, 23) = 3.10$, MSe = 7232.33, $p = .055$, $\eta_g^2 = .004$. Planned contrasts evaluated the difference between the F and R trials for each SOA. A significant 91 ms R > F difference was observed for the 1800 ms condition, $t(23) = 3.25$, $p = .003$, as well as a significant 93 ms R > F difference for the 2600 ms condition, $t(23) = 2.81$, $p = .009$. However, the 17 ms R > F difference observed for the 4200 ms condition failed to reach significance, $t(23) = 1.15$, $p = .261$.

Table 3.2
Mean Probe Reaction Times (in Milliseconds) and Associated Accuracies (%) as a Function of Instruction and SOA for Experiments 9 and 10.

	Reaction Time (ms)				**Accuracy (%)**			
	R		**F**		**R**		**F**	
SOA	***M***	***SE***	***M***	***SE***	***M***	***SE***	***M***	***SE***
Experiment 9								
1800 ms	577	54	667	57	94	2	96	3
2600 ms	553	58	646	64	99	1	97	1
4200 ms	578	54	590	54	99	1	98	1
Experiment 10								
800 ms	471	23	576	34	99	1	97	1
1200 ms	441	28	537	39	97	1	97	1
2000 ms	440	23	489	39	99	1	99	1

Probe False Alarms

The percentage of false alarms was analyzed as a function of instruction (R, F) revealing a significant difference, $F(1, 23) = 7.67$, MSe = 61.14, $p = .011$, $\eta_g^2 = .250$. Participants did not commit any false alarms (i.e., 0.00%) for F trials whereas for R trials on average 6.25% (*SE* = 2.26%) of catch trials resulted in a false alarm.

3.6.3 Discussion

Once again a significant directed forgetting effect was observed for specific but not general test statements as measured by *A'*. Further, a time-course was revealed for which the F > R probe RT difference was largest at 2600 ms and dissipated by 4200 ms following instruction onset. This finding contrasts with the time-course observed by Fawcett and Taylor (2008) in which the F > R probe RT difference was most robust at 1800 ms and dissipated by 2600 ms following instruction onset. While it could be that the time-course differed simply because we employed a novel range of SOAs (see Cheal & Chastain, 2002), it is also possible that the more complex nature of our stimuli (segments of continuous visual events) makes them more difficult to intentionally forget than the words used by Fawcett and Taylor (2008).

3.7 EXPERIMENT 10: EARLY INSTRUCTION-PROBE INTERVALS

Experiment 10 replicated the methods of Experiments 7 and 9 with the exception that specificity was manipulated between- as opposed to within-subjects. In Experiments 7 and 9 (and indeed, in Experiment 5 of the preceding chapter), there was necessarily overlap between the information tested by some of the specific statements (e.g., *the woman added 3 cups of flour*) and some of the general test statements (e.g., *the woman added flour*). In cases where there was conceptual overlap between the general and specific statements, it seems possible that exposure to one type of statement might influence subsequent performance on the other; it seems particularly likely that exposure to the specific test statement might provide sufficient information to influence the response made to subsequent presentation of the conceptually overlapping general test statement. Demonstrating a comparable pattern of results, with a directed forgetting effect for specific but not for general statements in a between-subjects manipulation, would eliminate this concern. Experiment 10 also further explored the time-course revealed in Experiments 7 and 9 by presenting probes at 800 ms, 1200 ms and 2000 ms instruction-probe SOAs.

3.7.1 Method

Participants

Thirty-six undergraduate students (31 female) enrolled at Dalhousie University participated in this experiment for course credit. Most participants were right-handed (32 right). Half of these participants were randomly assigned to receive the specific test statements and the remaining half of these participants were randomly assigned to receive the general test statements.

Stimuli and Apparatus

The stimuli and apparatus were identical to Experiment 7.

Procedure

The procedure was identical to Experiment 7 with the following exceptions. First, during the study phase, visual probes were presented 800 ms, 1200 ms, or 2000 ms following memory instruction onset. These particular SOAs were selected to more fully explore the time-course in close temporal proximity to the memory instruction. The timing of the study phase trials otherwise remained unchanged. Second, during the test phase either the specific *or* the general test statements were presented and this variable was manipulated between-subjects.

3.7.2 Results

Signal Detection Analysis

The mean hits and false alarms are provided in Table 3.1. Non-parametric measures of sensitivity (A') and response bias (B''_D) were calculated and analyzed as a function of instruction (R, F) and relative specificity (specific, general) using separate two-way mixed ANOVAs (see Figure 2). For the A' analysis, there was a significant effect of instruction with greater sensitivity to statements about R segments than F segments, $F(1, 34) = 4.63$, $MSe = 0.002$, $p = .039$, $\eta_g^2 = .028$. The main effect of specificity was also significant with greater sensitivity to general statements than specific statements, $F(1, 34) = 31.18$, $MSe = 0.008$, $p < .001$, $\eta_g^2 = .419$. Importantly, these effects were qualified by a significant instruction x specificity interaction, $F(1, 34) = 5.27$, $MSe = 0.002$, $p = .028$, $\eta_g^2 = .032$. Planned contrasts revealed a significant 0.04 directed forgetting effect in A' for specific test statements, $t(17) = 2.66$, $p = .017$. There was no difference in A' measured on R and F trials for general test statements, $t(17) = 0.13$, $p = .897$.

The B''_D analysis revealed only a significant main effect of relative specificity, $F(1, 34) = 6.94$, $MSe = 0.11$, $p = .013$, $\eta_g^2 = .116$, with participants employing a more liberal response bias for general statements than specific statements; neither the main effect of instruction, $F(1, 34) = 1.58$, $MSe = 0.06$, $p = .217$, $\eta_g^2 = .016$, nor the instruction x specificity interaction, $F(1, 34) = 1.02$, $MSe = 0.006$, $p = .319$, $\eta_g^2 = .011$, was significant.

Probe Detection RTs

The specific and general groups were collapsed for the purpose of this analysis (as well as the following analyses) because the study phase was identical for these groups. A probe-present detection trial was considered correct if the participant executed a response within 100 ms and 2000 ms of probe onset; as depicted in Table 3.2, correct detection responses did not differ as a function of instruction, *F*(1, 35) = 1.70, *MSe* = 42.58, $p = .201$, $\eta_g^2 = .006$, or SOA, *F*(2, 70) = 1.29, *MSe* = 63.16, $p = .284$, $\eta_g^2 = .014$, and these factors did not interact, *F*(2, 70) = 2.17, *MSe* = 53.24, $p = .805$, $\eta_g^2 = .002$. Mean probe RTs for correct trials were analyzed as a function of instruction (R, F) and SOA (800 ms, 1200 ms, 2000 ms) using a repeated-measures ANOVA. As in the preceding experiments, probe RTs were significantly longer following F instructions (*M* = 534 ms, *SE* = 35 ms) compared to R instructions (*M* = 451 ms, *SE* = 22 ms), *F*(1, 35) = 18.60, *MSe* = 20059.00, $p < .001$, $\eta_g^2 = .047$. The main effect of SOA was not significant, *F*(2, 70) = 6.76, *MSe* = 9390.36, $p = .002$, $\eta_g^2 = .016$, nor was the instruction x SOA interaction, *F*(2, 70) = 2.22, *MSe* = 7304.73, $p = .116$, $\eta_g^2 = .004$. Despite the non-significant interaction, planned contrasts evaluated the difference between F and R trials for each SOA. A significant 105 ms difference was observed for the 800 ms condition, *t*(35) = 4.21, $p < .001$; a significant 96 ms difference was observed for the 1200 ms condition, *t*(35) = 3.76, $p < .001$; and, a marginally significant 49 ms difference was observed for the 2000 ms condition, *t*(35) = 1.91, $p = .065$.

Probe False Alarms

The percentage of false alarms was analyzed as a function of instruction (R, F) using a repeated-measures ANOVA. Although fewer false alarms were committed following F instructions (*M* = 4.17%, *SE* = 1.86%) compared to following R instructions (*M* = 8.33%, *SE* = 2.23%), this difference was not significant, *F*(1, 35) = 2.06, *MSe* = 151.7857, *p* = .160, $\eta_g^2 = .056$.

3.7.3 Discussion

Experiment 10 revealed a directed forgetting effect for specific but not general test statements, even though specificity was manipulated between subjects. This precludes the possibility that exposure to specific test statements unduly influenced performance for the general test statements (or vice versa) in our preceding experiments. Experiment 10 also explored much earlier instruction-probe SOAs than previous experiments using simple detection. The time-course for the probe RTs in the current experiment was generally consistent with the time-course observed for the preceding experiments.

3.8 GENERAL DISCUSSION

Five experiments investigated the intentional forgetting of visual vignettes in a paradigm that presented an R or F instruction following discrete video segments that otherwise comprised a continuous event sequence. In these experiments, four videos were presented, each depicting a common activity (e.g., baking cookies). Every 35 s the video paused and a green- or purple-filled circle appeared at center: Participants were instructed to remember all of the segments that were followed by a green-filled circle (R segment) and to forget all of the segments followed by a purple-filled circle (F segment).

Participants subsequently demonstrated superior memory performance for R segments compared to F segments when tested using relatively specific cued-recall questions or true-false statements but not when tested using relatively general true-false statements. In other words, there was a directed forgetting effect (for specific information) that occurred despite the fact that participants had no basis for predicting *a priori* whether a given video segment would be followed by an R or F instruction; pre-instruction encoding of R and F segments was thus equated, leaving only post-instruction processes to account for the directed forgetting effect observed for the specific details depicted in those segments.

The notion that intentional forgetting may affect memory in a graded fashion – with specific details more affected than general details by memory instruction – speaks to the representation of to-be-forgotten information in memory. If intentional forgetting were viewed as an all-or-nothing process, then the unwanted F-instructed information should either be accurately reported on a subsequent memory test despite the intention to forget (unintentional remembering) or it should not be reported according to the formulated intention (intentional forgetting). Instead, the current results suggest that although the details of a to-be-forgotten memory are lost, a more general representation of the memory persists. This conclusion is supported by evidence that the to-be-forgotten information may also influence subsequent social judgments (Bodenhausen, Macrae & Milne, 1998; Golding & Hauselt, 1994) or jury decisions (for a review, see Kassin & Studebaker, 1998, or Steblay, Hosch, Culhane, & McWethy, 2006).

Experiments 6, 7, 9, and 10 also included a visual probe following the R or F memory instructions to gauge the cognitive load required to instantiate each instruction. Experiments 6 and 7 measured detection RTs at 1800 ms following the onset of the memory instruction, whereas Experiments 8 and 9 manipulated the instruction-probe SOA to include 800 ms, 1200 ms, 2000 ms, 2600 ms, and 4200 ms intervals as well. The time-course revealed by the combination of these experiments is plotted in Figure 3.3 along with a regression line calculated by fitting a linear-mixed effects model to the mean F–R RT difference using SOA as a fixed-effect and participant and experiment as random effects (see Bates, 2007). The F > R pattern of RTs was evident as early as 800 ms although it diminished in magnitude as the trial progressed. This finding is similar to that of Fawcett and Taylor (2008) who observed that the F>R RT difference dissipated within 2600 ms of memory instruction onset.

The relative protraction of the time-course for events beyond an SOA of 2600 ms in Figure 3.3 may be attributable to differences in the effort required to intentionally forget complex event sequences used in the current study (see also Chapter 2) as compared to isolated words or pictures (as in Fawcett & Taylor, 2008). Nowicka, Marchewka, Jednorog, Tacikowski, and Brechmann (2011) recently observed greater and more widespread neural activation associated with successfully forgetting emotionally salient rather than neutral pictures. They argued that forgetting emotional memories requires greater effort. To the degree that the neural activation measured by Nowicka et al. (2011) and the probe RTs measured in the current study index a common pool of cognitive processes that are marshaled by an intention to forget, their argument could be extended to converge upon the hypothesis that the effort required to intentionally forget a memory is proportional to the salience or contextual “richness” of the to-be-forgotten trace.

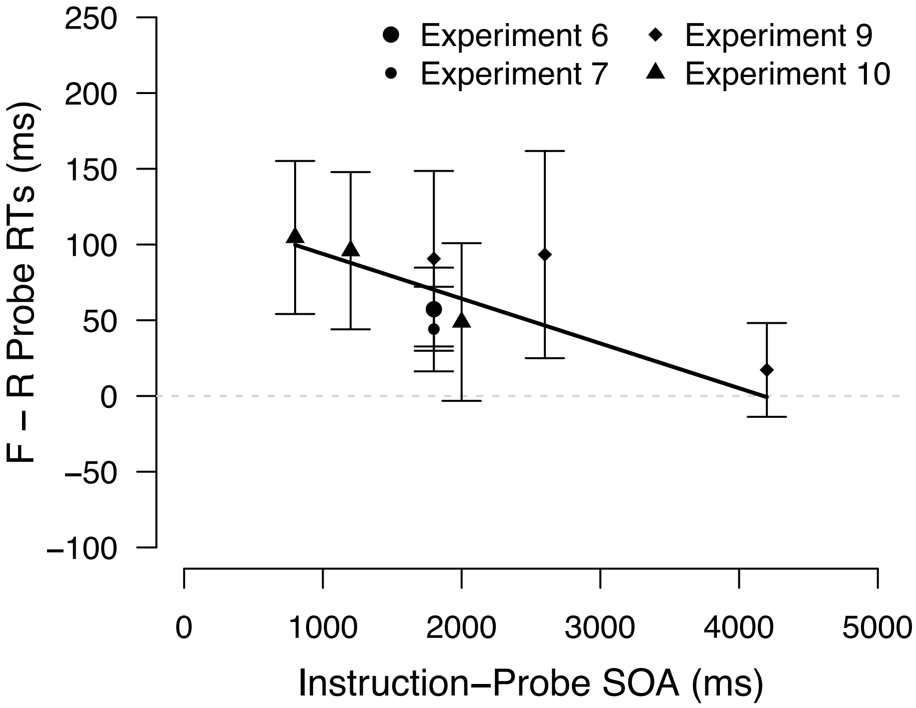

Figure 3.3. Time course of the F > R probe reaction time difference for Experiment 6 (Post-Instruction, Recall), Experiment 7 (Post-Instruction, True-False Statements), Experiment 9 (Post-Instruction, Late Instruction-Probe Intervals) and Experiment 10 (Post-Instruction, Early Instruction-Probe Intervals); error bars represent the 95% confidence interval of the mean difference and the regression line was calculated using a linear-mixed effects regression model with SOA as a fixed effect and participant and experiment as random effects (Bates, 2007).

The current study fits into a much larger literature providing evidence of an effortful mechanism associated with intentional forgetting. Fawcett and Taylor (2012) found that in addition to slowing discrimination responses, instantiating an item-method F instruction also interfered with incidental memory formation. This is in addition to work conducted by Taylor (2005; see also, Taylor & Fawcett, 2011) that demonstrated a larger inhibition of return effect following F instructions rather than R instructions. Taylor and Fawcett (2011) speculated that enacting an F instruction might lead the participant to respond more cautiously towards subsequent information arising from the source of the to-be-forgotten information. Indeed, Fawcett and Taylor (2010) observed that participants were better at countermanding an unwanted motor response in a stop-signal task when the stop signal was preceded by an F instruction rather than an R instruction: Instantiating the F instruction slowed subsequent responding, which in turn increased the likelihood that the participant was able to use the stop signal to successfully cancel the prepotent motor response. Together with recent neuroimaging studies (e.g., Nowicka et al., 2011; Paz-Caballero et al., 2004; Wylie et al., 2008), these findings implicate an active mechanism that discourages the continued processing of unwanted information.

One possible mechanism proposed to account for the F > R RT effect using the item-method paradigm has been the retrieval and cumulative rehearsal of the preceding to-be-remembered materials following each F instruction. Fawcett and Taylor (2008; see also, Fawcett & Taylor, 2010, 2012) discussed and rejected this notion in the context of their original item-method probe studies, although other researchers have continued to favour this account (e.g., Sahakyan & Foster, 2009). Indeed, when participants are asked to describe the strategies that they employed during the study phase of a directed forgetting task they will often include cumulative rehearsal of the preceding R items among other strategies. According to this view, the pattern of slower probe RTs following F compared to R instructions is attributable to the effortful search required to retrieve the prior R items. While Fawcett and Taylor (2008) did not dispute that participants may indeed engage in cumulative rehearsal across trials, they discussed several reasons why this strategy was not primarily responsible for their F > R RT probe findings. Nevertheless, one might question whether cumulative rehearsal could account for the current F > R RT difference for responding to the probe.

One way to address the concern of cumulative rehearsal would be to demonstrate the presence of an F > R probe RT difference under circumstances in which cumulative rehearsal was unlikely to occur. We reasoned that cumulative rehearsal was likely to occur within but not between videos. According to this reasoning, the initial segment of each video offered a scenario in which participants were unlikely to retrieve or rehearse preceding R segments – allowing measurement of the F > R probe RT difference without contamination from retrieval processes. We collapsed the probe RTs from the initial segment of each video for Experiments 6, 7, 9, and 10 and analyzed them as a function of instruction (R, F) using a linear-mixed effects model with participant and video as random effects (Bates, 2007). We had initially included presentation order (1, 2, 3, 4) in our model but this factor was removed because neither it, ß = 10.90, $t = 0.836$, $SE = 13.03$, nor the instruction x order interaction, ß = -6.68, $t = -0.32$, $SE = 20.80$, was significant. There was, however, a significant 70 ms F > R RT difference, ß = -69.63, $t =$

2.95, *SE* = 23.60, which was of consistent magnitude across presentation order. This finding provides compelling evidence that the active mechanism(s) indexed following each F instruction occur even when cumulative rehearsal is improbable or even impossible.[10]

Although it remains to be seen whether the mechanisms identified in the current event-method paradigm are indeed comparable to those previously identified in an item-method task, the current experiments provide evidence that in the context of the delayed presentation of each memory instruction this may be the case. This conclusion is limited to item-method tasks in which the memory instruction is also presented following (as opposed to concurrent with) the study items. Chapter 2 argued that when the memory instruction was presented concurrent with the studied materials that instead of controlling the *contents* of working memory resources, participants must instead control *access* to working memory resources. It is probable that this is just as true when dealing with pictures and words as when dealing with events. The consequence of intentional

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[10] We recognize that the ideal analysis would be to demonstrate the F > R RT difference for only the first trial as opposed to the first segment of each video. Such an analysis relies upon a very small sample of data – a single RT from each subject – resulting in low statistical power, especially for a between-subjects analysis. There are two reasons that we feel our first segment analysis is still a suitable response to the notion of cumulative rehearsal. First, as discussed in text we initially included presentation order as a factor and found that neither its main effect nor the instruction x presentation order interaction reached significance. That is to say that the F > R RT difference was of similar magnitude for the first segment of the first video as it was for the first segment of the second, third, and fourth videos. Second, an analysis that pooled data from several experiments (including those in the current study) revealed a significant R > F RT difference for the initial trial (see Appendix A). Combined with the breadth of evidence concerning this active mechanism (e.g., Fawcett & Taylor, 2008; Taylor & Fawcett, 2011) the cumulative rehearsal of preceding R information on F trials cannot provide a complete or compelling explanation of the F > R RT difference.

forgetting appears to be a relatively impoverished memory trace for the to-be-forgotten materials in relation to the to-be-remembered materials. This robust directed forgetting effect for specific but not general details is true whether the R and F instructions are presented concurrent with or following the studied materials and is attributable to the costs rather than the benefits of intentional forgetting.

3.9 CHAPTER SUMMARY

The current chapter presented five experiments using an event-method directed forgetting task with delayed (as opposed to concurrent) memory instructions to investigate whether the findings presented in Chapter 2 persisted even when the R and F instructions were presented after the target segment had already been encoded. All major findings from Experiments 1-5 were replicated using this post-cuing paradigm in Experiments 6-10: At test participants responded more accurately to cued-recall questions (Experiment 6) and relatively specific true-false statements (Experiments 7-10) regarding R segments than F segments. No difference was observed for relatively general true-false statements (Experiments 7-10). Replicating past research using the item-method paradigm (e.g., Fawcett & Taylor, 2008), participants were slower to detect visual probes presented following F compared to R instructions (Experiments 6-7 and 9-10). This implicates the presence of an active mechanism perhaps similar to that observed within item-method directed forgetting. It was concluded that participants engage an effortful process following each F instruction to facilitate the cessation of rehearsal, releasing processing resources for other tasks – including but not limited to the retrieval and cumulative rehearsal of preceding R segments.

CHAPTER 4 GENERAL DISCUSSION

Chapters 2 and 3 reported a total of ten experiments using variations of a novel *event-method* directed forgetting paradigm to explore how intentional forgetting impacts memory for events. They were motivated in part by the scarcity of evidence relating intentional forgetting to natural experiences. Whereas humans are often motivated to forget their experiences, the literature exploring *how* humans intentionally forget information has with few exceptions used pictures (e.g., Quinlan et al., 2010), symbols (e.g., Hourihan et al., 2009) or words (e.g., MacLeod, 1999) as stimuli. One goal was to bridge the gap between the application and study of intentional forgetting while maintaining a high degree of experimental control (see also, Barnier et al., 2007). A second goal realized in Experiments 5, 7, 8, 9, and 10 was to investigate how intentional forgetting affects the *quality* of the targeted information. Much of the literature in this area has focused on relative differences in the *quantity* of information retained following an instruction to forget. One notable exception has been research using the remember-know paradigm (e.g., Gardiner et al., 1994), which has revealed a greater incidence of recollective experiences (“Remember” responses) following R compared to F instructions but no difference in terms of familiarity (“Know” responses). The experiments contained in Chapters 2 and 3 adopted a different approach and instead evaluated the specificity of the knowledge associated with portions of the studied events that participants had been instructed to remember compared to those that they had been instructed to forget. The current chapter will summarize these findings as well as their contributions to our understanding of intentional forgetting as it applies to the quality and integrity of event memory.

4.1 OVERVIEW OF CURRENT RESULTS

4.1.1 Summary of Concurrent-Instruction Experiments

Chapter 2 developed a novel event-method paradigm to investigate the application of intentional forgetting to visual vignettes depicting events such as baking assorted cookies. During this task, participants viewed four videos each lasting 4 minutes and 40 seconds. Because the goal was to study how participants could selectively forget segments of continuous visual events, *concurrent* memory instructions were used (e.g., Basden & Basden, 1996; Brown, 1954; Paller, 1990; Paller et al., 1999; see also Muther, 1965) instead of *delayed* memory instructions (for a review, see MacLeod, 1998). To accomplish this, a colored border surrounded each video and changed periodically between green and purple. Participants were instructed that whenever the border surrounding the video was green they were to remember everything that was shown (R segments) because they would be tested for that information later; whenever the border surrounding the video was purple participants were instead to forget everything that was shown (F segments).

In Experiment 1, the study phase was followed by a recall task in which participants answered cued-recall questions regarding the details presented in the R and F segments of the preceding videos. A significant directed forgetting effect was observed for correct recall, providing evidence that participants were capable of selectively forgetting segments of an otherwise continuous event. Experiment 2 replicated this finding using true-false statements instead of cued-recall questions. The use of true-false statements was noteworthy because it resulted in separate false alarm rates for R and F segments permitting the calculation of independent measures of sensitivity (A') and response bias (B''_D; see, Donaldson, 1996). Participants were more sensitive to statements about R segments compared to those about F segments providing confirmation of the effect observed for recall in Experiment 1.

Experiment 3 demonstrated a comparable effect of memory instruction on sensitivity even when participants were required to respond to discrimination targets overlaid on the video itself. Discrimination RTs indicated that participants were slower during R segments compared to F segments. The R > F pattern of discrimination RTs suggests that encoding an R segment was more effortful than encoding an F segment (see Kahneman, 1973). Experiment 4 instead incorporated an event-segmentation task (see Zacks & Tversky, 2001) into the study phase requiring participants to depress the spacebar each time an event or action occurred. The number of segmentation responses was unaffected by memory instruction suggesting that participants were encoding the R and F segments at a similar conceptual level. Nonetheless, a significant directed forgetting effect was still observed for sensitivity.

Experiment 5 explored the representational level at which intentional forgetting operates using the paradigm developed in Experiment 2 while employing relatively specific as well as relatively general true-false statements. Whereas a directed forgetting effect was observed for relatively specific statements, no difference was observed for relatively general statements. This finding is remarkable because it suggests that intentional forgetting affects memory in a graded fashion – with specific details more affected by memory instruction than general details. If intentional forgetting were instead viewed as an all-or-nothing process, then both the specific and general details associated with the R and F segments should be affected. Instead, the current results suggest that although the specific details of a to-be-forgotten event are lost, a more general representation of the event persists.

4.1.2 Summary of Post-Instruction Experiments

Chapter 2 demonstrated that participants are capable of selectively forgetting certain segments of a continuous event when the memory instruction is presented concurrent with the encoded materials. The experiments reported in Chapter 3 modified the event-method paradigm to address whether participants were also capable of selectively forgetting information when the memory instruction followed each segment instead. In this post-instruction variant of the paradigm developed in Chapter 2, the videos paused every 35 s and a green- or purple-filled circle appeared at center: Participants were instructed to remember any segments followed by a green-filled circle (R segment) and to forget any segments followed by a purple-filled circle (F segment). This procedure equated the pre-instruction encoding of each segment because participants had no way of knowing whether an R or F instruction would follow.

Visual detection probes were presented following most study phase memory instructions in Experiments 6, 7, 9, and 10 as an index of the cognitive load experienced during the post-instruction interval (see Kahneman, 1973). Probe RTs were expected to increase commensurate with the cognitive demands associated with enacting each instruction. An analogous probe paradigm has been used in the item method to gauge the relative cognitive demands associated with remembering and forgetting. Participants are typically slower to detect probes following F instructions relative to following R instructions or during control trials (see Fawcett & Taylor, 2008; Fawcett et al., 2011). There has also been evidence of more complete attentional withdrawal (see Fawcett & Taylor, 2010; Taylor, 2005; Taylor & Fawcett, 2011) and impaired incidental memory formation (Fawcett & Taylor, 2012) during F compared to R trials. These findings support the conclusion that item-method intentional forgetting is associated with the effortful withdrawal of processing resources from the representation of the preceding study item. The current probe task addressed whether analogous mechanisms are applied to events.

Experiments 6 and 7 replicated Experiments 1 and 5 with the exception that the study phase memory instructions were presented following each segment and were themselves followed 1800 ms post-onset by a visual probe on 75% of all trials. Experiment 6 found a significant directed forgetting effect using cued-recall questions; Experiment 7 found a significant directed forgetting effect for sensitivity to specific but not general true-false statements. Both experiments demonstrated slower responses following F instructions compared to R instructions, suggesting that forgetting a video segment is more effortful than remembering it (see also, Fawcett & Taylor, 2008).

Experiments 9 and 10 explored the time-course of the F > R probe RT difference identified in Experiments 6 and 7 by varying the instruction-probe interval to include probes as early as 800 ms following instruction onset and as late as 4200 ms following instruction onset. Experiment 10 also manipulated the relative specificity of the true-false statements between- as opposed to within-subjects. This manipulation ensured that overlap in the details queried by the specific or general test statements was in no manner responsible for the instruction x specificity interaction observed in the preceding experiments. Both experiments demonstrated a significant directed forgetting for sensitivity to specific but not general true-false statements as well as slower responses to the study-phase detection probes presented following F compared to R instructions.

4.1.3 Conclusions

Chapters 2 and 3 clearly demonstrate that participants are capable of selectively forgetting part of an otherwise continuous event as revealed by superior performance when tested for R segments compared to F segments. This effect was evident using concurrent (Chapter 2) or delayed (Chapter 3) memory instructions and when performance was measured using recall (Experiments 1 and 6) or relatively specific true-false statements (Experiments 2-5 and 7-10). The fact that participants can selectively forget part of an event is an interesting finding. One might have expected participants to encode the F segments to maintain continuity with the R segments. Past research has found that any meaningful connection between to-be-remembered and to-be-forgotten information can undermine intentional forgetting (see, Geiselman, 1974, 1977; Golding et al., 1994; MacLeod, 1998). But in spite of these factors, only the relatively general statements failed to demonstrate a reliable directed forgetting effect. Whereas participants were capable of intentionally forgetting the details of an event, their memory for the gist of that event was unaffected.

The notion that intentionally forgotten information persists in some form has precedent. Research investigating the effectiveness of instructions to disregard inadmissible evidence in court has found that the to-be-disregarded information can still influence jury decisions (for a review, see Kassin & Studebaker, 1998, or Steblay et al., 2006). Similar findings have also been observed when participants are instructed to disregard other socially relevant information (see Isbell et al., 1998; Johnson, 1998; Kassin & Studebaker, 1998). It is possible that a residual gist-based representation of the to-be-forgotten information is partially responsible for the lingering effects of the to-be-forgotten material. However, further research is required to validate this claim.

4.2 CONNECTION TO MODERN THEORETICAL ACCOUNTS

Despite similarities in the pattern of results reported for true-false statements in Experiments 2, 3, 4, 5, 7, 8, 9, and 10, close inspection of the methodological features of those experiments as well as secondary task performance suggests separate processes for the concurrent- and post-instruction findings. An integrative interpretation of the findings from the concurrent-instruction paradigm suggests that participants avoided conceptually encoding F segments while actively encoding and rehearsing R segments. According to this view, the discrimination task used in Experiment 3 disrupted rehearsal during R segments, impairing memory performance relative to Experiment 2. Memory for F segments was unaffected because participants were unlikely to be rehearsing information presented during those segments: Slower discrimination RTs during R compared to F segments would then reflect the interference caused by rehearsal during R segments but not F segments. The event-segmentation task (see Zacks & Tversky, 2001) in Experiment

4 encouraged participants to conceptually encode the F segments, improving performance relative to Experiment 2. Memory for R segments was unaffected because those segments were already processed on a conceptual level. It should be clarified that this interpretation makes no claim as to the manner in which the F instructions were implemented. It could be that use of a concurrent memory instruction obviated the need for an active mechanism because the to-be-forgotten information never entered working memory. Lustig et al.'s (2007) taxonomic framework argues that participants would still actively control *access* to working memory to minimize incidental processing of unwanted events. The current experiments were not designed to address this possibility, but slower discrimination responses during R compared to F segments within Experiment 3 suggest that the mechanism(s) associated with intentional forgetting were less effortful than the mechanism(s) associated with intentional remembering at the intervals where discrimination responses were measured.

The post-instruction paradigm used in Experiments 6, 7, 8, 9, and 10 equated pre-instruction encoding of the R and F segments, leaving only post-instruction processes to account for the directed forgetting effect observed for the specific details depicted in those segments. In addition to a significant directed forgetting effect, participants were slower to detect visual probes presented following F instructions compared to R instructions at instruction-probe stimulus-onset asynchronies of 800 ms, 1200 ms, 1800 ms, 2000 ms, 2600 ms, or 4200 ms. As depicted in Figure 3.3, the magnitude of the F > R difference in probe RTs decreased across this interval (see also, Fawcett & Taylor, 2008). The observation of slower probe RTs following F instructions compared to R instructions serves as a bridge between the event-method paradigm and the more classic item-method paradigm. Within the item method, Fawcett and Taylor (2008) interpreted slower probe RTs following F than R instructions as evidence of a brief cognitive mechanism that discouraged rehearsal of the discarded study item. Similar research has found intentional forgetting within this paradigm to temporarily interfere with the formation of incidental memory (see Fawcett & Taylor, 2012) and to interact with secondary tasks thought to index attentional withdrawal (Fawcett & Taylor, 2010; Taylor, 2005; Taylor & Fawcett, 2011).

The current findings provide preliminary evidence that one or more active mechanisms are also associated with the intentional forgetting of contextually rich information such as the video segments used in Chapter 3. Whether these mechanisms are analogous to those described in relation to the item method remains to be seen. In particular, further research is required to determine whether intentionally forgetting part of an event influences attentional withdrawal (see Taylor, 2005) or incidental memory formation during the post-instruction interval (see Fawcett & Taylor, 2012). Either would provide strong evidence for a common process. At the very least, both paradigms appear to involve a briefly effortful cognitive mechanism thought to be associated with the cessation of rehearsal (Fawcett & Taylor, 2008, 2010; Hourihan & Taylor, 2006).

Notably, the time-course of the F > R RT difference described in Figure 3.3 appears protracted when compared to the time-course described by Fawcett and Taylor (2008): Fawcett and Taylor (2008) found that the F > R difference dissipated within 2600 ms of instruction onset whereas Experiment 9 found that the F > R difference dissipated within 4200 ms of instruction onset. This protraction may be attributable to differences in the effort required to intentionally forget words (as in Fawcett & Taylor, 2008) compared to event sequences. Nowicka et al. (2011) argued that intentionally forgetting emotional memories requires greater effort than intentionally forgetting neutral memories. It could be that the effort required to intentionally forget a memory is proportional to the salience of the to-be-forgotten trace.

An alternative interpretation might instead attribute any differences between the current experiments and Fawcett and Taylor (2008) to the specific range of SOAs used in either study (see Cheal & Chastain, 2002). Figure 3.3 reveals that the F > R difference failed to reach significance at the latest SOA used in Experiments 9 and 10, although these intervals (4200 ms and 2000 ms) were sampled from different positions within the time-course. It could be that the hazard function of a probe appearing across the post-instruction period interacts with instruction to produce the current time-course: That is to say that in Experiment 9, until 1800 ms post-instruction there was a 25% chance that a probe would appear at each of the intervals or that no probe would be presented; following 1800 ms post-instruction there was a 33% chance that a probe would appear at each of the two remaining intervals or that no probe would be presented; finally, following 2600 ms there was an even 50%-50% chance that the probe would appear at the latest interval or that no probe would be presented. It could be that participants responded more readily at the latest interval in each experiment because the odds were relatively greater that a probe would appear. This "readiness" could then mask the F > R probe difference. This question cannot be resolved by the current data, and although Figure 3.3 does suggest that the hazard function could influence the time-course it does not appear to be a sufficient explanation. The combined analysis of the probe data from Experiments 6, 7, 9, and 10 produce a significant linear trend approaching 0 (F = R) as the interval increases. Although the F > R difference is only marginally significant at 2000 ms (as measured in Experiment 10) it is compatible with the time-course revealed by the regression line and similar in magnitude to the F > R difference measured with greater precision at 1800 ms (in Experiments 6 and 7). This is in contrast to the relative lack of an F > R difference at 4200 ms (as measured in Experiment 9).

Despite compelling evidence of an active mechanism associated with the intentional forgetting of event segments, a proponent of a purely rehearsal-based account might instead argue that the F > R RT difference reflects the rehearsal of R segments following F instructions. According to such an interpretation, participants would effortlessly discard the preceding segment following an F instruction and instead retrieve and rehearse preceding R segments (see Sahakyan & Foster, 2009). The retrieval process would briefly draw upon limited-capacity working memory resources, slowing responses following the F instruction until the participant began rehearsing the re-activated R segment. Fawcett and Taylor (2008) discussed and rejected this cumulative rehearsal interpretation of their item-method probe findings, pointing out that it appears to argue that participants retrieve and cumulatively rehearse previous R items only on F trials. In fact, participants often report employing a cumulative rehearsal strategy following *both* memory instructions (e.g., Bjork & Geiselman, 1978). Fawcett and Taylor (2008) reasoned that this view would therefore predict no effect of memory instruction on probe RTs because the effortful retrieval process should occur during both R and F trials and thereby equate relative effort and therefore relative probe RTs. One could further argue that the retrieval process is merely delayed for R trials – but this modified account is not supported because the F > R RT difference dissipates but does not demonstrate a reversal at late SOAs. Even ignoring the logical inconsistencies associated with this view, the cumulative rehearsal account is also unable to account for the impact of intentional forgetting on incidental memory formation (Fawcett & Taylor, 2012) or attentional withdrawal within the item method (see Taylor & Fawcett, 2011).

The current data are able to address the cumulative rehearsal account more directly than the logical arguments provided by Fawcett and Taylor (2008, 2010, 2012) and Taylor and Fawcett (2011): An analysis of the initial segment within each video (pooled across Experiments 6, 7, 9, and 10) demonstrated a significant F > R RT difference when cumulative rehearsal was unlikely or even impossible. This analysis was motivated by the belief that participants would cumulatively rehearse *within* as opposed to *across* videos. If so, they would be less likely to retrieve preceding R segments following F instructions on the initial trial for each video. The F > R RT difference was not only significant for the initial segment of each video, but the magnitude of this difference was statistically consistent across presentation order (i.e., initial segment of the first video, initial segment of the second video, etc.). Appendix A describes additional analyses replicating this outcome using only the initial study phase trial aggregated across the preceding experiments as well as two item-method experiments in which participants were instructed to remember or forget abstract images: Despite there being *no* preceding R items to retrieve during the first study-phase trial, participants were still slower to respond following F instructions compared to R instructions. Cumulative rehearsal is clearly unable to account for the first trial F > R difference, bringing this interpretation of the probe RT data into question more broadly. Neither Fawcett and Taylor (2008) nor the current experiments deny that participants engage in cumulative rehearsal following the R and F instructions – however, cumulative rehearsal alone does not provide a sufficient explanation for the impact of intentional forgetting on secondary task performance in a post-instruction event- or item-method paradigm.

4.3 COMPARISONS WITH PAST RESEARCH

Experiments 5, 7, 8, 9, and 10 demonstrated a significant directed forgetting effect for specific but not for general information. This may appear at odds with Joslyn and Oakes (2005), who observed a significant directed forgetting effect in their diary study for general information but *not* for specific information. Joslyn and Oakes' (2005) measurement of gist memory was comprised of a two-word label (e.g., *Shopping Trip*) provided by participants for each event they recorded in their diary. Joslyn and Oakes (2005) tested memory for specific details only when the gist statement for the relevant event (*Shopping Trip*) had already been recalled. The "details" in this experiment were central features (e.g., time of day) of the relevant event unlikely to be forgotten should the gist be retrieved: Indeed, their study provides an interesting contrast to the current experiments because their "general" information (e.g., *Shopping Trip*) was of a granularity similar to the event titles associated with each video in the current experiments (e.g., *Baking Assorted Cookies*) and their “specific” information was of a nature similar to the general test statements. Therefore, the fact that there was no directed forgetting effect for the “details” of their events could be viewed as congruent with the current findings.

This leaves unresolved the issue that the current experiments would also have predicted no directed forgetting effect for the event titles in Joslyn and Oakes’ (2005) paradigm. One possibility is that recall is more sensitive to representational differences at this level of specificity compared to the true-false statements used in Chapters 2 and 3. Another is that the precise procedure associated with their experiment (i.e., instructing participants to forget the events from the preceding week) required the application of different cognitive processes compared to the current task, resulting in a slightly different outcome. At face value, this seems almost certain: As described in the preceding section, during the concurrent-instruction paradigm, participants attempted to minimize processing of the F segments while rehearsing the R segments; during the post-instruction paradigm, participants engaged an active mechanism, putatively associated with the cessation of rehearsal. Neither theoretical position is entirely applicable to Joslyn and Oakes’ (2005) task: Their participants were instructed to forget an event that had occurred several days prior to the memory instruction. Encoding had already occurred and the to-be-forgotten information was no longer present in working memory or under consideration for imminent rehearsal. In this manner, their paradigm was more similar to the list method than to the current experiments.

In fact, the very nature of "forgetting" as studied by Joslyn and Oakes (2005) may differ from the construct studied in Chapter 2 and 3. Scrutiny of their findings reveals that the event titles were sometimes esoteric (e.g., *Crow Chase*) and they were spread across a week populated by many other experiences. It could be that the to-be-forgotten events remained accessible within memory but participants instead forgot which events had been recorded within the diary or even the specific title given to that event. The distinction between forgetting the event and forgetting the relation between the event and the experiment has important implications for understanding Joslyn and Oakes' (2005) findings. This leaves unanswered whether Joslyn and Oakes' (2005) paradigm has long-term implications for the management of unwanted autobiographical memories: Does this manner of intentional forgetting decrease future intrusions of the to-be-forgotten events or is retrieval impaired only in the context of the experimental task?

The same point could be made regarding Barnier et al.'s (2007) experiments in which they found that participants could intentionally forget self-reported autobiographical memories elicited in response to arbitrary retrieval cues. Whereas Joslyn and Oakes (2005) had participants record their experiences in a diary, Barnier et al. (2007) presented two lists each containing several cue words intended to elicit an autobiographical memory (e.g., *university*). Half of the participants were instructed to forget the memories that they had retrieved in the initial list whereas the remaining participants were instructed to retain all of the memories. Participants who received the F instruction later recalled fewer List 1 memories than those who did not receive this instruction. However, it is unclear whether their F instruction influenced memory for (a) the cues, (b) the autobiographical memories, or, (c) the episode in which the autobiographical memories were retrieved at study.

Barnier et al. (2007) addressed this concern with an experiment in which participants recalled "event clusters" as opposed to singular events (see Wright & Nunn, 2000). They had participants generate an autobiographical memory in response to several cue words as before, but for each cue word, the initial memory was also used to cue an additional memory, and then the second memory was used to cue yet another memory. This procedure was repeated resulting in several "clusters" of memories that the authors felt were independent of the originating cue words. The presentation of an F instruction reduced subsequent recall for List 1 memories equally across the "cluster" and standard cue-word generation conditions – although simple effects analyses revealed the directed forgetting effect to be significant only in the latter. Similarly, whereas there was a robust directed forgetting effect for the initial memory in each cluster, this effect was only marginal for the other memories in a cluster. Barnier et al. (2007) nonetheless interpreted their findings as evidence that intentional forgetting operated on the autobiographical memories as opposed to the cue words in their paradigm. Acceptance of this proposal seems premature without direct evidence that participants did not use the initial cue word to retrieve the "clusters" at test. If participants used a cue-based retrieval strategy, the independence of the individual memories is uncertain, undermining Barnier et al.'s (2007) theoretical arguments.

One feature common to both Joslyn and Oakes (2005) and Barnier et al. (2007) is the observance of significant "costs" but no "benefits" of intentional forgetting. As summarized in the preceding chapters, intentional forgetting is believed to arise from an aggregation of processes acting to strengthen memory for R items as well as processes acting to weaken memory for F items. Some theorists have therefore conceptualized the directed forgetting effect as consisting of *costs* (worse memory for F items) plus *benefits* (better memory for R items). The costs and benefits are often quantified using a between-subjects control group where participants are instructed to remember everything (i.e., no F instruction is presented). Benefits are measured as better performance for R items compared to the remember-all baseline, and costs are reflected in worse performance for F items compared to the remember-all baseline (e.g., Basden & Basden, 1996; Sahakyan & Foster, 2009). In the context of the list method, Sahakyan and Delaney (2005) have attributed the costs and benefits of intentional forgetting to a shift in mental context and a shift in rehearsal strategy following the F instruction, respectively. More recently Sahakyan and Foster (2009) have made a similar claim within the item method, linking the benefits of intentional forgetting to the cumulative rehearsal of the preceding R items.

Like Joslyn and Oakes (2005) and Barnier et al. (2007), Experiments 4, 5, 7, and 8 described in Chapters 2 and 3 also failed to observe reliable benefits despite producing significant costs in relation to a remember-all condition. Given the consistency of this finding across a range of experimental paradigms dealing with memory for events as opposed to words (although, see Sahakyan & Foster, 2009), it is tempting to conclude that whatever processes are responsible for the benefits are less relevant to events than words. Relating Sahakyan and Foster’s (2009) interpretation of the costs and benefits to the current experiments, this could mean one of two things: Either cumulative rehearsal was *ineffective* – suggesting that additional processing of R segments following F instructions produced minimal increments in subsequent performance; or, cumulative rehearsal was *improbable* – suggesting that cumulative rehearsal was relatively less likely to be applied (or applied as consistently) to video segments compared to other stimuli.

Within the concurrent-instruction paradigm (Chapter 2) cumulative rehearsal is perhaps least likely because participants were required to monitor the video at all times. During the post-instruction paradigm (Chapter 3) cumulative rehearsal following an F instruction would require re-activation of an earlier segment or part thereof and could detract from the coherence of the event as a whole. Without any reason to expect additional rehearsal to be less effective when applied to events, the most reasonable conclusion is that cumulative rehearsal is simply less likely to occur on any given trial. Joslyn and Oakes (2005) and Barnier et al. (2007) both recognize similar interpretations, although they ultimately favoured specific methodological explanations for the lack of benefits in their respective paradigms. In the current experiments, it could be that the true-false statements used to measure memory were simply insensitive to the benefits although this raises questions regarding why the costs would still be so prominent (see also, Taylor & Fawcett, 2012). It could also be that such benefits exist but are very small and unreliable when dealing with complex representations. These possibilities deserve further exploration – although the fact that past research has reliably failed to observe benefits when dealing with event memory implicates the stimuli as opposed to methodological features.[11]

4.4 CONNECTION TO THE INTENTIONAL FORGETTING OF "REAL" EVENTS

The realization that intentional forgetting influences the relative specificity of unwanted events in memory has important implications for understanding the role of intentional forgetting in the real world. The current paradigm was designed to study the control of event memory at the time of encoding. The central question was whether participants could selectively forget information as it was encoded (Chapter 2) or immediately following encoding (Chapter 3). These conditions emulate real world scenarios in which someone wishes to forget an event as it is witnessed or in the period immediately following the experience. At that time, participants could engage active mechanisms to minimize encoding of the experience or withdraw processing resources from the representation of the unwanted event in working memory once the event was over. Whereas Experiments 5, 7, 8, 9, and 10 would predict these processes to be successful at reducing the detail of the resultant memory trace, they would also predict that a general representation of the event would exist nonetheless. Therefore, intentional forgetting of

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[11] One possible exception is the work dealing with performed actions conducted by Sahakyan and Foster (2009). This experiment used discrete actions characterized by a brief phrase (e.g., "break a match") making it unclear whether the phrase or the event was the ultimate target of the memory instruction. More importantly, the findings of Sahakyan and Foster (2009) were not entirely inconsistent with the current results. They observed costs but no benefits for performed actions using the list method; for the item method they observed benefits for performed actions only when their analysis was conditionalized to focus on the first few study-phase trials, although they also observed no evidence of costs. They discussed these findings in relation to the manner in which performed actions are represented in memory.

this nature might be thought of as mitigating but not eliminating the impact of the unwanted experience.

However, there is no reason to believe that humans approach the matter of intentional forgetting with a single strategy – even though this is the manner in which it is often studied. When faced with an unwanted experience, it seems reasonable to expect that multiple forms of intentional forgetting could be marshaled against that information. While Chapters 2 and 3 provide a model of the mechanisms used to control encoding of the event (see Fawcett & Taylor, 2008), participants could also actively change their mental context (see Sahakyan & Kelley, 2002) and suppress retrieval of the event when faced with reminders (e.g., Anderson & Greene, 2001). The culmination of these (and other) processes would be to destabilize the memory trace by discouraging retrieval, segregating it within memory and depriving it of elaboration.[12] Preliminary evidence even suggests that some forms of intentional forgetting interact with consolidation during sleep to further diminish the probability of retention (see Saletin et al., 2011). Unfortunately, participants might also begin monitoring their thoughts for evidence of the unwanted information – either without provocation or in response to environmental triggers. Whetstone and Cross (1998) have argued that this monitoring process undermines intentional forgetting (see also, Anderson & Huddleston, 2012), resulting in the perseverance or even predominance of the unwanted memory (Wegner, 1994; Wenzlaff & Wegner, 2000). The complex interplay among these processes urges the

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[12] The fact that these processes are thematically related to the mechanisms proposed by Zacks et al. (1996) is no accident. Their model was informed by years of theoretical speculation (e.g., Bjork, 1972) regarding the manner in which information is intentionally forgotten, including many functional models based on real-world scenarios.

study of intentional forgetting *in situ* to better understand how they interact and the circumstances under which they are most likely to succeed or most likely to fail.

Despite “real world” applications, there are several ways in which the paradigms used to study intentional forgetting differ from the probable implementation of intentional forgetting in everyday life. One issue addressed in Chapters 2 and 3 is the common reliance on pictures or words as stimuli (see Quinlan et al., 2010). With the exception of Joslyn and Oakes (2005) and Barnier et al. (2007), the current experiments are the first to study intentional forgetting of complete events. These experiments have employed a relatively artificial means of inducing intentional forgetting. In the real world, the intention to forget is most often an endogenous exercise involving the self-selection of information to be forgotten. For example, having experienced an embarrassing event we require no prompting that it is best forgotten – we instead clear our minds and move on, avoiding triggers and limiting retrieval as required. In the laboratory, participants are often explicitly instructed to remember or forget, removing the locus of control from the participant and placing it in the hands of the researcher. Whether endogenously and exogenously generated intentions to forget differ functionally is a matter of speculation as no one has systematically investigated this research question.

The problem with studying endogenously generated intentional forgetting is that information will be labeled as relevant or irrelevant according to the circumstances – not necessarily according to the experimenter’s wishes. For example, Golding et al. (1994) found that participants were capable of intentionally forgetting an erroneous phone number whereas Golding and Keenan (1985) found that participants tended to remember erroneous navigational directions. Golding and Keenan’s (1985) participants retained the erroneous directions to ensure that this otherwise irrelevant information did not lead them to make an incorrect navigational decision when enacting those directions. Participants sometimes report a similar strategy in the laboratory where they attempt to retain the F items to ensure that they are not later confused for the R items. Such a strategy is similar to the process of segregating R and F items in memory as proposed by Bjork (1972) and incorporated into Zacks and Hasher’s (1994) theoretical framework. But when is this “remembering to forget” strategy most likely to be adopted over intentional forgetting?

Past studies using structured study materials such as semantically related word lists (e.g., Golding et al., 1994) or textual materials (e.g., Johnson, 1998; see also, Delaney, Ngheim, & Waldum, 2009) have revealed that connections between the R and F information mitigate directed forgetting. It may be the case that the efficacy of an instruction to intentionally forget depends, at least in part, on whether the to-be-forgotten information is deemed both nominally and functionally irrelevant to the ongoing task. That is, even if the information is nominally tagged as irrelevant by virtue of receiving an F instruction, it may be functionally relevant for building an understanding of (and possibly for more easily retaining) the to-be-remembered information. Of course, this view is *post hoc* and is more relevant to how participants engage the memory instruction as opposed to the cognitive or neural processes involved.

4.5 CONCLUSION

From an evolutionary perspective, the functional role of memory is to aggregate prior experiences and motivational states into a cognitive model of the world capable of guiding future behaviour. Surprisingly to some, the most adaptive model is not necessarily the most accurate or complete model. For this reason, memory is itself a reconstructive process that draws as much upon general experience as it draws upon the original event (e.g., Bjork & Vanhuele, 1992; Howe, 2011, Hupbach et al., 2008; Storm, 2011). The inaccuracies that emerge have historically been thought of as the "sins" of memory but we now view them as blessings in disguise (see Schachter, 2001).[13] As Jorge Luis Borges (1962) points out, "[t]o think is to forget a difference, to generalize, to abstract" (p. 114). The abstraction to which he refers requires us to discard certain information but it also compresses our experiences. If not for this "foreshortening" of memory, William James (1890/1950) has argued that "[i]t would take as long for us to recall a space of time as it took the original time to elapse, and we should never get ahead with our thinking" (p. 680). It was this reason that Ribot (1881) concluded that we have "…thus reach[ed] the paradoxical result…[that o]blivion, except in certain cases, is thus no malady of memory, but a condition of its health and its life" (p. 46).

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[13] The inaccuracies introduced when memory is updated provide editorial control over the self-narrative that emerges as we age. However, our ability to "editorialize" the past has been challenged in recent years by our obsession with digital media. Mayer-Schönberger (2009) recognized that "[w]hile we are constantly forgetting and reconstructing elements of our past…digital remembering can access the unreconstructed facts" (pp. 106). The antagonistic role of digital media as it relates to natural or intentional changes to human memory (e.g., Mayer-Schönberger, 2009) suggests that we live not unlike Jorge Luis Borges' (1962) character *Funes* – it is only that we now externalize much of the minutiae that is not of immediate relevance (see Sparrow, Liu, & Wegner, 2011).

In recognition of James' (1890/1950) point regarding event memory, the preceding chapters describe two variants of a novel *event-method* paradigm in which participants were asked to selectively forget portions of an event. Chapters 2 and 3 differed in terms of the placement of the R or F instructions: Chapter 2 used a concurrent-instruction variant to explore intentional forgetting of events as they were encoded; Chapter 3 used a post-instruction variant to explore intentional forgetting of events once they were actively represented in working memory. In either paradigm, the intention to forget (as opposed to remember) an event reduced the relative specificity of the memory trace while sparing general information. This finding provides a novel understanding of the qualitative changes associated with intentional forgetting. In the concurrent-instruction paradigm, participants were thought to avoid encoding the F segments while rehearsing the R segments; in the post-instruction paradigm, participants were thought to engage one or more active mechanisms to withdraw processing resources from the representation of the F segment in working memory. The presence of an active mechanism in the post-instruction paradigm was supported by slower responses to visual detection probes presented following F instructions compared to R instructions. This F > R RT difference was also observed when the analysis was limited to the initial trial of each video when participants were unlikely to retrieve and cumulatively rehearse preceding R segments or even on the initial study-phase trial when there *were* no R segments to retrieve and cumulatively rehearse (see Appendix A). These findings in particular addressed concerns that retrieval processes were slowing responses on F trials.

In conclusion, intentional forgetting appears to result in a relatively impoverished memory trace for the to-be-forgotten materials in relation to the to-be-remembered materials. On the one hand, by selectively forgetting the details of an unwanted event humans are able to maintain cognitive efficiency while focusing on the retention of functionally relevant information. On the other hand, the maintenance of general event details may help synthesize F segments into useful schematic representations. Whether the processes hypothesized above bear any connection to those discussed in relation to the item method remains to be more resolved. However, it is clear that the general process of intentional forgetting is just as relevant to events as it is to more basic stimuli such as pictures or words.

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APPENDIX A FIRST-TRIAL PROBE ANALYSIS

A.1 Abstract

In a typical item-method directed forgetting task, study items are presented individually, each followed by an instruction to remember (R) or forget (F). After the study trials, memory is tested for *all* study items regardless of the preceding memory instruction; a directed forgetting effect is defined as better memory for R than F items. To assess the cognitive load associated with instantiating R and F instructions, Fawcett and Taylor (2008) integrated visual probes into each study phase trial following the memory instruction. Longer probe RTs following F compared to R instructions were used to argue that forgetting in an item-method task is not only effortful, it is more effortful than remembering. Although Fawcett and Taylor attributed their results to the active withdrawal of processing resources from the study item following each F instruction, longer RTs following F than R instructions could conceivably have arisen due to the active retrieval and rehearsal of prior R items. The current article addressed this possibility empirically by aggregating and analyzing data obtained on the initial trial of five experiments. Longer probe RTs were still observed following F compared to R instructions despite there being no prior R items to retrieve. These findings support Fawcett and Taylor's (2008) assertion that forgetting is an effortful process and demonstrates that retrieval processes during the encoding epoch cannot account for their results.

A.2 Introduction

Counter to popular conceptions of forgetting as a *failure* of memory, research has consistently demonstrated that when engaged intentionally forgetting may act in the *service* of memory instead (for a review, see MacLeod, 1998). Specifically, by eliminating irrelevant information that might otherwise interfere with the storage or retrieval of relevant information, memory becomes more efficient and less susceptible to loss or decay. One paradigm used to study intentional forgetting in the laboratory is directed forgetting and – although there are several variants of this paradigm (see Basden & Basden, 1998) – the current article shall focus on item-method directed forgetting exclusively.

In the study phase of an item-method directed forgetting task, participants are presented with a series of study items each followed by an instruction to remember (R) or forget (F) that item. Following the completion of the study phase, participants enter the test phase in which they are then asked to recall or recognize *all* of the study items regardless of their previously associated memory instruction. The typical finding is that participants will recall or recognize significantly more R items than F items. This difference is referred to as a directed forgetting effect and cannot be accounted for by demand characteristics (MacLeod, 1999).

The traditional account of directed forgetting in this paradigm attributes the directed forgetting effect to the active rehearsal of R items and the passive exclusion of F items (e.g., Basden et al., 1993). That is to say that following an R instruction participants rehearse the current study item. Following an F instruction, participants drop the current study item from their rehearsal set, permitting it to decay passively from working memory. Therefore, remembering is attributed to active encoding processes whereas forgetting is attributed to the absence of such processes.

More recently, evidence has mounted supporting the notion that the instantiation of an item-method F instruction is effortful. Fawcett and Taylor (2008) presented participants with visual probes 1400 ms, 1800 ms, or 2600 ms following the onset of each R and F memory instruction within the study phase of a typical item-method directed forgetting task. Each probe was an asterisk ('*') presented at the center of the computer screen requiring a speeded detection response. They reasoned that if remembering were an active process and forgetting were a passive process as predicted by the selective rehearsal account (see above), reaction times (RTs) should be longer following R than F instructions due to the cognitive demands associated with rehearsal following R but not F instructions (Kahneman, 1973). However, equivalent or longer RTs might have been expected following F than R instructions if forgetting were viewed as an active process. The results demonstrated that participants were slower to respond following F instructions than following R instructions, suggesting that forgetting is an active cognitive process that is not only effortful – it is *more* effortful than remembering. Later analyses found that long probe RTs following F instructions were predictive of a subsequent failure to recognize the item, whereas no such relation was observed following R instructions (see also, Fawcett & Taylor, 2010).

Although longer RTs following F than R instructions lend support to an interpretation of intentional forgetting as an active cognitive process, an alternative explanation is that the RT difference at encoding is due to the retrieval and cumulative rehearsal of prior R items on F trials (e.g., Sahakyan & Foster, 2009; see Greene, 1989). Such an account argues that, following the presentation of an F instruction on a given study trial, participants effortlessly discard the F item and engage in the effortful retrieval and rehearsal of the study items from preceding R trials in an ongoing effort to commit them to memory. The effortful retrieval and cumulative rehearsal of prior R items would slow probe responses following F instructions, resulting in the RT difference observed in the visual probe task used by Fawcett and Taylor (2008). Such an interpretation based on the study-phase retrieval and cumulative rehearsal of R items on F trials – hereafter referred to more simply as a *cumulative rehearsal* strategy – was described and rejected by Fawcett and Taylor (2008, p. 1177) and again by Fawcett and Taylor (2010, p. 807).

While a cumulative rehearsal strategy is superficially consistent with the findings of Fawcett and Taylor (2008), it cannot account for another key finding in support of an active view of forgetting: A larger inhibition of return effect (Taylor, 2005; see also, Fawcett & Taylor, 2010; Taylor & Fawcett, 2011) following F relative to R instructions. Taylor (2005) presented study items to either the left or right of fixation followed by an R or F instruction and ultimately a visual probe in either the same or opposite location relative to the study item. Each probe required a speeded localization response. The RT difference for probes appearing in the same versus a different location as the peripheral word was used to provide a measure of inhibition of return (IOR; for a brief review, see

Klein, 2000). The results demonstrated that the intervening memory instruction modulated the magnitude of the IOR effect imposed upon the probe by the peripheral onset of the preceding study item (see also, Fawcett & Taylor, 2010; Taylor & Fawcett, 2011), with larger IOR following F than R instructions. If participants were retrieving and cumulatively rehearsing previous R items following each F instruction, such retrieval would occur regardless of where the subsequent visual probe was presented. Thus, an increase in RTs due to the effortful study-phase retrieval and cumulative rehearsal of preceding R items would be expected on trials in which the probe occurred in the same location as the preceding F item as well as on trials in which the probe occurred in a different location from the preceding F item. Given that IOR is measured as an RT difference on same- and different-location trials, the effects of cumulative rehearsal would be subtracted out in the measurement and produce no net change in the magnitude of IOR on F relative to R trials. Instead, the finding of larger IOR on F than R trials is consistent with the view that attentional resources are differentially withdrawn following F and R instructions (see also Taylor & Fawcett, 2011).

Converging evidence that instantiating an F instruction exerts control over processing resources comes from neuroimaging data that reveal increased frontal brain activity following F instructions that is predictive of successful intentional but not unintentional forgetting (e.g., Wylie et al., 2008). Together, Taylor and Fawcett (2011) interpreted these findings as demonstrating the active withdrawal of working memory resources from the representation of the study item following each F instruction. Although such a mechanism would briefly consume limited capacity working memory resources, those resources would ultimately be made available for the rehearsal of prior R items. In this manner, the active withdrawal of processing resources following each F instruction facilitates the selective rehearsal of R items.

Although I do not deny that cumulative rehearsal of previous R items probably does occur on some portion of F trials, it is not clear that this can fully account for the data obtained in support of an active view of forgetting (for discussion, see Fawcett & Taylor, 2008, 2010). Although logic can rule out a cumulative rehearsal strategy as the root cause of longer post-F than post-R probe RTs, and past research has incorporated experimental controls designed to limit the use and impact of a cumulative rehearsal strategy (e.g., Fawcett & Taylor, 2008, Experiment 2), an empirical test is obviously preferred. The purpose of the current article is therefore to replicate the longer post-F than post-R probe RTs reported by Fawcett and Taylor (2008) in an analysis that eliminates the possibility that prior R items are retrieved following each F instruction.

A.3 Evidence from First Trial Reaction Times

If participants are slower to respond to visual probes following F relative to R instructions because they are retrieving prior R items following each F instruction, this difference should not occur on the first trial. This is because there are no prior R items to retrieve. Thus, we performed a between-subjects analysis to determine the difference in RT to respond to a post-F versus a post-R probe presented on the first study trial in an item-method paradigm. Both the between-subjects nature of this analysis – as well as the fact that each subject contributed only a single RT from a single trial – necessitated a large sample to ensure sufficient statistical power. Therefore, data from five experiments were collapsed together for the purpose of this analysis, resulting in a total of 104 participants. Of these participants, 53 received an F instruction and 51 received an R instruction on the first trial. In these experiments, participants were presented with an image (Fawcett et al., 2011) or brief video clip (see Chapter 3 of this document) in the center of a computer monitor, followed by a visual or auditory instruction to remember or forget the preceding item. A visual probe requiring a speeded detection response was presented at center 1400 ms 1800 ms, 2600 ms, or 4200 ms following the onset of the memory instruction. Each experiment included no-probe catch trials and participants receiving a catch trial as their initial trial or those failing to respond to their initial probe were excluded and are not counted in the total provided above. Data from Fawcett and Taylor (2008, 2010), Taylor (2005), and Taylor and Fawcett (2011) were not included because those experiments preceded their study phase task with a number of buffer items to control for primacy effects, each of which received an R instruction. The data included in this analysis came from experiments that did not include buffer trials, ensuring that there were no previous R items that participants could retrieve in the initial trial. Each experiment produced a significant directed forgetting effect with better memory for R than F items as measured using a yes-no recognition task (in the case of images) and true-false statements (in the case of video clips).

The combined post-instruction probe RTs were log-transformed to control for the skew common to RT data; analysis of the raw RTs or inverse-transformed RTs produced the same basic pattern described below. The log-transformed RTs were subject to a linear-regression with memory instruction (R, F) as the independent variable. Experiment was initially included in our model but removed because it failed to reach significance or interact with memory instruction. There were insufficient data to properly analyze the interval at which the probe was presented, so this variable was collapsed. The main effect of memory instruction was significant, *F*(1, 102) = 4.13, *MSe* = 0.09, *p* < .05, demonstrating slower log-transformed RTs following F instructions (*M* = 6.24, *SE* = 0.04) than following R instructions (*M* = 6.11, *SE* = 0.05). When back-transformed, these values correspond to mean RTs of 513 ms following F instructions and 450 ms following R instructions, resulting in a 63 ms difference. This difference was also significant when analyzed using a linear-mixed effects model with memory instruction as the fixed effect and with stimulus and experiment as random-effects.

While consistent with the growing body of literature suggesting that item-method directed forgetting is an effortful process, our current analysis clearly excludes any retrieval-based mechanism operating at encoding because there was nothing for the participants to retrieve following an F instruction on the first trial. Therefore, the finding of longer probe RTs following F compared to R instructions does not depend upon the presentation of preceding information. Fawcett and Taylor (2008) argued that longer RTs following F than R instructions is consistent with the characterization of forgetting as an active cognitive mechanism; the current findings rule out a cumulative rehearsal account as a counter-argument to this claim.

A.4 Conclusion

Our first-trial analysis clearly demonstrates that the retrieval and cumulative rehearsal of prior R items cannot account for longer RTs observed following F compared to R instructions. This finding strengthens existing evidence for the active nature of item-method directed forgetting by eliminating a reasonable alternative interpretation. We would like to be clear that we are *not* suggesting that the cumulative rehearsal of prior R items never occurs following an F instruction or that it serves no useful purpose; we are merely indicating that within the first seconds following the presentation of a memory instruction there is a processing difference associated with F and R instructions that cannot be accounted for by a retrieval and cumulative rehearsal strategy. Instead, immediately following an F instruction, it appears that processing resources are made relatively unavailable for further task-irrelevant processing, presumably so they can ultimately be freed to be re-allocated to other task-relevant processing – including but not limited to the cumulative rehearsal of prior R items. In this manner, the active withdrawal of processing resources hypothesized to occur following each F instruction could both encourage and facilitate the implementation of the selective rehearsal of R items that ultimately leads to better memory performance for these, relative to F, items.