Proactive Interference During Multiple Text Comprehension: Can Readers Intentionally Forget Information That Is No Longer Relevant?

Rebecca McCabe

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PROACTIVE INTERFERENCE DURING MULTIPLE TEXT COMPREHENSION: CAN READERS INTENTIONALLY FORGET INFORMATION THAT IS NO LONGER RELEVANT?

by

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Abstract

The purpose of the current research was to explore the detrimental effects of proactive interference during multiple text comprehension and whether it could be reduced by intentionally forgetting the interfering information using the directed forgetting paradigm. In Experiment 1, a subset of participants read 10 argumentative texts on the same topic (control condition), whereas others read 20. Of those who read 20, some were instructed to remember all texts (proactive interference condition), whereas others were instructed after reading the first 10 texts to forget them and remember only the next 10 (directed forgetting condition). On final recognition tests of the texts’ claims and evidence, the proactive interference and directed forgetting conditions performed similarly—both with higher intrusion errors from earlier-read texts compared to the control condition. Results suggested that directed forgetting instructions did not help participants reduce proactive interference. Experiment 2 added the manipulation of text topic relatedness, which ultimately did not have any bearing on the effectiveness of directed forgetting instructions. Additional exploratory analyses using reading time, response time, $d'$, and investigation of one-sided non-compliance could not shed conclusive light on an explanation for the lack of benefit of directed forgetting. Potential reasons and avenues of future research are discussed.
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Chapter 1

Introduction

Successful comprehension in the information age requires readers to engage with a great number of diverse texts. The increasingly widespread usage of the internet brings with it new challenges for learners. Compared to a few decades ago, someone who is currently trying to learn more about a topic—whether hearing it mentioned by a friend, in the media, or as a writing assignment—is inundated with search results containing many texts with information related to that topic. Learners must access and read several of these available texts, while also retaining the important information that they provide, in order to form a coherent understanding of the topic. Detrimental memory effects may arise from needing to read-to-remember multiple texts in order to comprehend the topic in question. One such detrimental memory effect is proactive interference, in which previously learned information interferes with the learning of new information. However, most research on proactive interference has focused on simple stimuli like word lists rather than on reading comprehension.

There has been much previous research on multiple text comprehension, though it has mostly focused on understanding individual differences between readers (see Barzilai & Strømsø, 2018), including interest and effort (Bråten, Anmarkrud, Brandmo, & Strømsø, 2014), comprehension monitoring (Goldman, Braasch, Wiley, Graesser, & Brodowinska, 2012), and working memory capacity (Braasch, Bråten, Strømsø, & Anmarkrud, 2014), to name but a few. There has also been some research that has investigated readers’ evaluation of the relevance and reliability of a small subset of texts (usually 5-10; Goldman et al., 2012). However, there has been less focus on the potential detrimental memory effects that reading larger numbers of texts might have for comprehension and how this kind of task can be approached in a way that helps
combat such detriments in order to enable readers to remember the information that they read across multiple texts. This was the purpose of the current research. Specifically, we examined the detrimental role that proactive interference might have for multiple text comprehension and whether this could be mitigated or eliminated by instructing readers to actively forget information presented in previously read—yet no longer relevant—texts.

**Proactive Interference**

Proactive interference occurs when information that has been previously studied impairs memory for more recently studied information (Underwood, 1957). In one experimental paradigm that is typically used to study the effects of proactive interference, a subset of participants is asked to study-to-remember additional non-target material prior to studying a target list of information, which from their perspective should all be remembered (Kliegl, Pastötter, & Bäuml, 2015). These participants’ memory performance for the target information is compared to that of other participants who only studied the target information. Indicative of experiencing proactive interference, learning the additional information prior to the target information causes poorer memory for the target information. An additional indicator of proactive interference are intrusion errors, which occur when participants retrieve the previously learned, irrelevant information instead of the target information (Szpunar, McDermott, & Roediger, 2008; Underwood, 1957).

**Determinants of Proactive Interference**

One factor that plays a key role in how much proactive interference is experienced is the number of non-target items that participants are expected to learn prior to learning the target information. In general, the more potentially interfering information that has been previously learned, the less likely it is that the recent target information will be remembered, which
researchers infer reflects stronger proactive interference (Halford, Maybery, & Bain 1988; Keppel & Underwood, 1962). For example, participants who learned four lists of words showed worse recall than participants who learned one list (Watkins & Watkins, 1975).

Another important factor that leads to more profound proactive interference is when the learned items are conceptually related to each other (Bunting, 2006; Hasher, Chung, May, & Foong, 2002; Nairne, Whiteman, & Kelley, 1999; Wickens, Born, & Allen, 1963). In an early study of this effect (Wickens, 1972), participants studied and recalled three lists of fruit names, showing declining recall with each successive list (i.e., more proactive interference with each list). Depending on condition, participants studied and recalled a fourth list of either fruits (same topic) or professions (not conceptually related). Recall performance for the fourth list of fruit names continued to decline; however, recall performance for the fourth list of professions returned to a level similar to that of the first list of fruits—an effect known as release from proactive interference. The degree of release can vary depending on both the degree of conceptual overlap (e.g., studying and recalling a fourth list of vegetables does not produce as much release from proactive interference as does studying a fourth list of professions; Wickens, 1972) and whether or not participants notice the topic change (e.g., differentiating between a list of flowers and a list of wildflowers; Gardiner, Craik, & Birtwistle, 1972).

**The Role of Working Memory**

In dealing with a series of related, to-be-remembered information, the existence of proactive interference is strongly related to working memory and its limited capacity (Anderson & Neely, 1996; Jonides & Nee, 2006). Working memory is a construct broadly referring to the processes responsible for temporarily storing relevant information in an accessible, manipulatable state during the completion of a complex cognitive task (Miyake & Shah, 1999).
As such, working memory ability is related to performance in higher-order cognitive tasks such as reading comprehension and problem solving (Daneman & Carpenter, 1980; Fedorenko, Gibson, & Rohde, 2006; Haarmann, Davelaar, & Usher, 2003; Just & Carpenter, 1992). Of particular importance for proactive interference, two abilities thought to be important in differentiating those with high and low working memory capacity are attentional control and inhibition (Bunting, 2006). Using attentional control, one is able to attend to the current task while evading potential distractions, including interference (Bunting, Conway, & Heitz, 2004). Using inhibition, one is able to suppress information irrelevant to the current task, including information that is highly related to relevant information (Lustig, Hasher, & Tonev, 2001). When a series of related information is learned, and a subset of that information must be retrieved, the related information becomes co-activated in working memory. One must be able to inhibit activation of the competing yet incorrect information (i.e., the information that is related yet currently irrelevant to the task at hand). Research suggests that individuals experience proactive interference when they are unable to actively suppress or inhibit this competing information (Kane & Engle, 2000; Rosen & Engle, 1998). Due to their impoverished attentional control and difficulty inhibiting the competing information, individuals with low working memory capacity are therefore more susceptible to proactive interference than those with high working memory capacity. As such, individuals with low working memory capacity also tend to exhibit more intrusions from previously learned, yet currently irrelevant information (Lustig, May, & Hasher, 2001; Schonfield, Davidson, & Jones, 1983).

Proactive Interference in Multiple Text Comprehension

With the ability to resist proactive interference having a central role in one’s working memory capacity, and with working memory playing an important role in one’s ability to
perform higher-order tasks such as reading comprehension, additional research should focus on the study of proactive interference in the context of reading texts. The negative effects of proactive interference have, however, primarily been tested using simple experimental materials, such as paired-associates (some including nonsense syllables; e.g., Russell & Storms, 1955; Rosen & Engle, 1998; Smets, Wessel, & Raes, 2014; Verwoerd, Wessel, & de Jong, 2009; Wessel, Overwijk, Verwoerd, & de Vrieze, 2008) and lists of words (e.g., Cowan, Johnson, & Saults, 2005; Halford et al., 1988; Kliegl et al., 2015). There have been few studies that have examined proactive interference using more semantically complex materials, such as with full texts. In one such study, participants read a series of 24 argumentative texts on the same topic (split into three sets of eight) for the purpose of developing and remembering a coherent understanding of the topic (McCabe & Braasch, 2022). On a final free recall test, their memory for the information presented in the final set of eight texts (i.e., the target set) was compared to that of a second group of participants who read only that target set of eight texts. Consistent with extant research using simpler materials (e.g., lists of words), participants who studied the additional text sets prior to the target set produced poorer memory for the target texts coupled with more memory intrusions errors from the previously read, yet irrelevant texts.

Reducing Proactive Interference.

Research has suggested ways to reduce proactive interference when learning simpler materials, one of which is through the use of retrieval practice (e.g., Szpunar et al., 2008).

Previous work examining proactive interference when reading a series of texts (McCabe & Braasch, 2022) showed that retrieval practice does reduce—but not eliminate—proactive interference when reading multiple texts. Of the participants who read 24 argumentative texts on the same topic (three sets of eight), some completed retrieval practice on the first 16 texts before
reading the final set of eight target texts. On the final free recall test of the target set, those who completed retrieval practice of the first 16 texts exhibited better memory for the target set. However, their memory for the target set was not as high as that of the group who only read the target set.

Proactive Interference in the Current Research

Following this research, one purpose of the current series of experiments was to further explore the occurrence of proactive interference in the context of learning from multiple texts. Specifically, we examined if proactive interference occurs when reading to remember information found in 20 texts on the same topic (two sets of 10). Following a distractor task, participants completed a final recognition test, which presented them with information from the texts and asked them to identify whether or not they read it in the most recently read set of texts. With the expectation that we would replicate the previous finding—namely that proactive interference occurs when reading a series of related texts—a second purpose of the current research was to explore how detrimental proactive interference effects could be reduced or eliminated.

Directed Forgetting.

Important for the current research, another method that has been used to successfully reduce proactive interference with simpler to-be-remembered materials is directed forgetting (also called intentional, motivated, or positive forgetting; Festini & Reuter-Lorenz, 2013; Festini & Reuter-Lorenz, 2014). Directed forgetting is a memory task in which participants learn a series of information and are tasked with “forgetting” some of that information while retaining the remaining information. To successfully forget in this task, participants must exercise their working memory to be able to both process the to-be-remembered information effectively while
simultaneously inhibiting the to-be-forgotten information (Johnson, 1994). The word *forgetting* in this case is used not in the every-day sense of information being no longer accessible in memory stores, but instead refers to changes in the way that information is mentally represented and how decisions are made about that information.

**Directed Forgetting Methodology**

Two common approaches to studying directed forgetting are the item-method and the list-method. In item-method directed forgetting, participants are presented with a series of items during which they receive a cue after each individual item that tells them to either remember or forget that item (e.g., Hogge, Adam, & Collette, 2008). In general, participants show better memory for the remember-cue items compared to the forget-cue items during a final recall test of all information. In list-method directed forgetting, participants learn a series of information that have been grouped into lists (generally two lists, though sometimes more; Lehman & Malmberg, 2009). They are told between studying the lists to forget the information that they had just learned (often with a cover story that the previous list was only for practice; Conway, Harries, Noyes, Racsma’ny, & Frankish, 2000; Delaney & Sahakyan, 2007; Geiselman, Bjork, & Fishman, 1983; Macrae, Bodenhausen, Milne, & Ford, 1997; Sahakyan & Delaney, 2003; Sahakyan, Waldum, Benjamin, & Bickett, 2009). The current research used the list-method approach—providing participants with two sets of 10 texts each and, after reading the first set, instructing them to forget what they had just read.

In list-method directed forgetting, during final memory tests, participants typically show both poorer memory for List 1 items (i.e., a cost of inhibiting the to-be-forgotten list) and better memory for List 2 items (i.e., a benefit for the to-be-remembered list) relative to participants who do not receive instructions to forget List 1 (i.e., those told to remember both lists; Bjork, 1970).
Importantly this effect is not due to demand characteristics; participants show just as low memory for forget-cued items when they are incentivized by earning money for each forget-cued item retrieved (MacLeod, 1999). Therefore, items from List 1 do appear to be forgotten (or at least unable to be accessed), and memory for items from List 2 appears to benefit as a result of this forgetting. This benefit that directed forgetting has for the memory of post-forget-cue information is why it has been used as a promising way to reduce proactive interference. Because it is earlier-learned interfering information that proactively interferes with the learning and memory of later-learned target information; instructing learners to forget the earlier-learned information aids their memory for the later-learned target information.

Theoretical Background

There are several mechanisms through which these effects of directed forgetting have been proposed to occur, the primary two of which are context change and retrieval inhibition. The context change view suggests that the presence of forget instructions induces a mental context change that serves to assist participants in differentiating between the content of List 1 and List 2 at retrieval. That is, the context at retrieval more closely matches the context during encoding of List 2 compared to List 1, allowing for better retrieval of List 2 (Lehman & Malmberg, 2011; Sahakyan & Kelley, 2002; Sahakyan et al., 2009). In contrast, the retrieval inhibition view suggests that receiving instructions to forget earlier-learned information assists participants in actively inhibiting the to-be-forgotten information, thereby making it more difficult to reactivate during retrieval (Basden, Basden, & Gargano, 1993; Conway et al., 2000; Geiselman & Bagheri, 1985; Geiselman et al., 1983; Hanslmayr et al., 2012).

Directed Forgetting and Proactive Interference

These accounts may not be completely independent from one another (Sahakyan,
Delaney, Foster, & Abushanab, 2013); however, both provide their own explanation for how motivated forgetting of previously learned information can reduce proactive interference. From the retrieval inhibition perspective, the typical results of a study using the list-method directed forgetting paradigm with two lists would be explained such that participants—after receiving instructions to forget—begin to actively inhibit the information presented in List 1 (Geiselman et al., 1983). Doing so allows them to better encode the information that they encounter in List 2. It is because of this inhibition of List 1 that participants show poorer memory for List 1 content during a final test (i.e., the cost of directed forgetting) compared to those in conditions who do not receive instructions to forget List 1 and thus have no reason to inhibit List 1 content. Additionally, because List 1 is inhibited, it does not produce proactive interference on information from List 2, accounting for participants showing higher memory for List 2 content during a final test (i.e., the benefit of directed forgetting).

In contrast, proponents of the context change account contend that the proactive interference reduction seen in memory for List 2 stems from participants’ ability to better differentiate between List 1 and List 2 (Sahakyan & Kelley, 2002). Specifically, the presence of the forget instructions induces a shift in the learners’ mental context. Though in this situation it is purely a mental shift, the resulting memory effect is reminiscent of context-dependent memory research, in which information is easier to remember when the person is in the same physical environment that it was learned in originally, such as in the same room (e.g., Smith, Glenberg, & Bjork, 1978).

Though there is not one agreed-upon mechanism, the results of many studies over the past several decades have suggested that directed forgetting can reduce the negative effects of proactive interference (Bjork, 1970; Bjork & Bjork, 1996; Bjork, LaBerge, & LeGrand, 1968;
Bjork & Woodward, 1973; Festini & Reuter-Lorenz, 2013; Festini & Reuter-Lorenz, 2014; Sahakyan & Delaney, 2005; Sahakyan & Kelley, 2002). In one such study that used list-method directed forgetting, participants were either presented with two lists of eight words and told to remember both (i.e., remember-remember condition), two lists of eight words and told to forget the first list after learning it but remember the second list (i.e., forget-remember condition), or one list of eight words and told to remember it (i.e., a no-proactive interference control condition; Bjork & Bjork, 1996). When tested, the remember-remember condition showed poorer memory performance for second-list words compared to the forget-remember condition. Importantly, memory for these words in the forget-remember condition was no different statistically than in the no-proactive interference control condition. These findings suggest that directed forgetting has the potential to not only reduce proactive interference but to eliminate it by returning memory for later-learned information to what would be expected at baseline. Interestingly, other research has even reported that participants in a forget-remember condition showed memory for second-list items that exceeded that of participants in a no-proactive interference control condition (who were only ever exposed to the second list; Shapiro, Lindsey, & Krishnan, 2006). Additionally, the costly effects of directed forgetting (i.e., poorer memory for the to-be-forgotten information) are attenuated for individuals who are generally more susceptible to proactive interference (including those with low working memory capacity; Aslan & Bäuml, 2013; Aguirre, Gómez-Ariza, Bajo, Andrés, & Mazzoni, 2014; Gómez-Ariza, Iglesias-Parro, García-Lopez, Díaz-Castela, Espinosa-Fernández, & Muela, 2013; Hogge et al., 2008; Kail, 2002).

Simple to Complex Materials

Similar to much of the research on proactive interference, however, previous research on
directed forgetting has focused on using simpler experimental materials, which—for list-method directed forgetting—include digits (Brown, 1954), trigrams (Weiner, 1968; Weiner & Reed, 1969), letter sets (Nee, Jonides, & Berman, 2007), lists of words (Abel & Bäuml, 2013; Abel & Bäuml, 2017; Bjork & Bjork, 1996; Bjork & Woodward, 1973; Kliegl, Pastötter, & Bäuml, 2013; Lehman & Malmberg, 2011; Pastötter & Bäuml, 2007; Pastötter, Engel & Frings, 2018; Sahakyan & Delaney, 2003; Sahakyan et al., 2009; MacLeod, 1975; MacLeod, 1999), lists of nonsense words (Sahakyan et al., 2009), word pairs (Bjork, 1970; Reitman, Malin, Bjork, & Higman, 1973), and pictures (Basden & Basden, 1996). There have, however, been a few exceptions, with some studies using more complex materials such as autobiographical memories (Joslyn & Oakes, 2005), navigation instructions (Golding & Keenan, 1985), and advertisements (Shapiro et al., 2006). Though more complex than traditionally used materials, these studies did not use a series of complex text-based materials nor did they examine proactive interference, as is the purpose of the current research.

In one study that has come close, Geiselman (1974) had participants complete an item-method directed forgetting task using a 10-sentence passage on an expository topic (e.g., winemaking). Though referred to as passages, each sentence within a passage was a declarative statement with no transition words between them. Sentences were presented one at a time to participants, and after each sentence participants received an instruction to either forget or remember the content of the sentence. During the creation of the study materials, the presentation order of the sentences was selected based on input from six judges who rank-ordered the sentences in the order that they felt provided the best flow. Geiselman referred to the sentences of a passage as comprising a “rough continuum.” Due to the nature of the sentences and how they were organized and presented, each passage as a whole read more as a series of thoughts
connected only by overall topic—not by a coherent flow one might expect from a text.

Using a more coherent text, other research has had participants read a 25-sentence passage on tanning leather in which the sentences (presented one at a time) could be categorized into four sub-topics (e.g., length of the process; Geiselman, 1977). In a task resembling list-method directed forgetting, some participants were told to forget the sentences about two of the subtopics (and remember the other two); however, they were told to do so before they began the reading task, which is not typically seen in directed forgetting methodology. Receiving forget instructions before reading may have led participants to process the to-be-forgotten (more like “to-not-be-remembered” in this case) information differently than if they had received the instructions after reading that information.
Chapter 2

Experiment 1

Though these studies have provided important early steps in increasing the complexity of materials typically used to study directed forgetting, there is still much to be explored. Using more authentic, complex material has become increasingly important in a time when a simple internet search can make seemingly endless pieces of related, textual information available in a fraction of a second. When reading several of these websites to gain knowledge on a topic, how does earlier-read information interfere with later-read information, and how might one prevent this interference? With authentic scenarios like this in mind, we thus find it an important step to conduct the current series of experiments, in which we extend decades of previous research on directed forgetting that has used more simple experimental materials to test whether list-method directed forgetting can be used to reduce proactive interference when reading a series of multiple texts.

In Experiment 1, we adapted manipulations from classic memory paradigms described earlier in order to address two research goals using three groups of participants. Our first goal was to explore the occurrence of proactive interference in the context of reading-to-remember multiple texts. Based on previous research (McCabe & Braasch, 2022), a group of participants read 20 texts (two sets of 10) on the same topic (i.e., the proactive interference group). Using a final recognition task, their memory for the information presented in the second set of texts (i.e., the target set)—which for them should have been subjected to the most proactive interference—was compared to that of a group of participants who only read the target set (i.e., the no-proactive interference control group; Sahakyan & Delaney, 2003; Shapiro et al., 2006). Within the context of learning from multiple texts, we expected that proactive interference would produce similar
patterns of forgetting and prior-set intrusions as it does within the context of using simpler experimental materials (Kliegl et al., 2015; Underwood, 1957).

Anticipating the occurrence of proactive interference in this context according to the outcome of previous research (McCabe & Braasch, 2022), our second goal was to explore how the negative effects of proactive interference could be reduced using a different approach. To address this goal, we extended previous research showing the benefit of directed forgetting for reducing proactive interference when using simple experimental materials (e.g., Bjork & Bjork, 1996). We tested whether readers could reduce proactive interference when reading multiple texts by intentionally forgetting a subset of texts that were no longer relevant to their task (i.e., non-target, earlier-learned information). Of the participants who read both sets of 10 texts, we used a list-method directed forgetting task to instruct a subset of them to forget the information that they read in the first set. They were told between sets that only information from the subsequent set would appear on the final memory test (i.e., the directed forgetting group; Sahakyan & Delaney, 2005).

We hypothesized that—consistent with previous research using more simple experimental materials—when tested on their memory for information found in the second set of texts, participants who received directed forgetting instructions between sets would have fewer memory intrusion errors stemming from the to-be-forgotten information read in the first set of texts compared to participants told to remember all 20 texts (i.e., the proactive interference group). We also hypothesized that the forget instructions would improve their memory for later-read information (i.e., the second set of texts) relative to the proactive interference group. If the directed forgetting group showed memory for the to-be-remembered texts both higher than that of the proactive interference group and as high as that of the no-proactive interference control
group, that would suggest that directed forgetting completely eliminated the negative effects of proactive interference when reading multiple texts. If instead the directed forgetting group’s memory was higher than that of the proactive interference group yet lower than that of the no-proactive interference control condition, that would suggest that directed forgetting was able to reduce but not eliminate the negative effects of proactive interference in this context (similar to previous research exploring retrieval practice as a way to combat proactive interference; McCabe & Braasch, 2022).

**Method**

*Participants*

A total of 84 undergraduates (67.9% female) at a large university in the Mid-South participated in this study for course credit. Their ages ranged from 18 to 36 ($M = 19.67, SD = 2.78$).

*Materials*

*Texts.* For the reading task, we used 20 texts (see Appendix), selected from those used in previous work (McCabe & Braasch, 2022). All texts were on the benefits and detriments of social media for society (10 of each), and they were based on information from procon.org (“Social Networking,” n.d.). For the benefits, examples include finding jobs and staying connected; for the detriments, examples include cyber bullying and spreading false information. All texts started with a claim sentence (e.g., “Social networking sites are detrimental for society because they entice people to waste time.”) followed by one or two evidence statements that provided support for that claim (e.g., “When people receive new tweets or Facebook messages, they take 20-25 minutes on average to return to their original task.”). The 20 texts were separated into two sets of 10 (Sets A and B), each with an even number of benefits and detriments. Across
participants, the same 10 texts were always presented as part of the same set, but their order within the set varied randomly. The two sets of texts did not differ significantly from each other on Flesch-Kincaid Grade Level, \( t(18) = 1.66, p = .115 \).

An additional eight texts were created on the same broad topic of benefits and detriments of social media, each comprised of one claim and one evidence statement that were different from those of the other 20 texts. These eight texts were reserved as “novel” texts (i.e., participants did not read them during the reading task). Their claims and evidence statements were used as items during the recognition tests described below. They served as both filler items and as a way to compare across conditions participants’ ability to recognize and discount information that is on the same topic as the target information but had not been previously seen in our experimental texts by any participant.

_Distractor task._ Following the reading task, participants completed a distractor task, consisting of a demographics questionnaire and a vocabulary test. The demographics questionnaire asked participants their age, gender, and GPA. The vocabulary test asked participants to identify the correct definition of 15 words (e.g., equivocal, perjure, indifferent), each with five possible answer choices. These 15 words were selected from a 30-item vocabulary test that had been previously normed for a college population (Campbell & Raney, 2016), performance on which is correlated with reading ability \( (r = .52) \).

_Claim recognition test._ The claim recognition test consisted of 24 items designed to assess participants’ memory for the claims that were put forth by the texts that they had read. Of the 24 items, eight originated from the interfering texts, eight from the target texts, and eight from the novel texts (a categorization similar to that used in previous research; e.g., Bjork & Bjork, 1996). Participants were instructed to select “yes” if they remembered reading the claim
in the most recently read set of texts or “no” if they did not remember reading it in that set. Accurate responses were therefore selecting “yes” for claims from Set B texts and “no” for claims from Set A or novel texts. Participants were awarded one point for each correct response. The number of accurate responses on items from the interfering (Set A), target (Set B), and novel texts were calculated separately, with a total possible score of eight for each text type.

Evidence recognition test. The evidence recognition test consisted of 24 items designed to assess participants’ memory for the evidence statements that supported the claims of the texts that they had read. As in the claim recognition test, eight of the 24 items originated from the interfering texts, eight from the target texts, and eight from the novel texts. Participants were instructed to select “yes” if they remembered reading the evidence statement in the most recently read set of texts or “no” if they did not remember reading it in that set. Accurate responses were therefore selecting “yes” for evidence statements from Set B texts and “no” for evidence statements from Set A or novel texts. Participants were awarded one point for each correct response. The number of accurate responses on items from the interfering (Set A), target (Set B), and novel texts were calculated separately, with a total possible score of eight for each text type.

Procedure.

Participants were randomly assigned to the proactive interference, directed forgetting, or no-proactive interference control condition. All completed the reading task (the exact task and its instructions differed between the conditions, detailed below), followed by a distractor task, a final recognition test for text claims, and a final recognition test for text evidence statements. All materials were presented on a computer screen using Qualtrics, and participants could continue through at their own pace. Each text and recognition test item was presented on its own page with no ability to go back and re-read or change previous answers. Reading time for each text
and response time for each recognition test item was recorded.

*Proactive interference condition.* In the proactive interference condition, participants read two sets of 10 texts on the same topic: Set A (the interfering set) and Set B (the target set). They were instructed between sets to continue on to the next set and that they would be tested on information from both sets. The instructions that they received were as follows: “You have now completed reading the first set of texts. Now we would like you to read a second set of texts. Please continue to focus on the texts as you read because you will be tested on your memory of these texts as well as the previous set that you read.”

*Directed forgetting condition.* In the directed forgetting condition, participants also read Sets A and B, and they completed a list-method directed forgetting task. Their instructions between Sets A and B specified that what they had just read was a practice set that was designed to familiarize them with the reading task (Conway et al., 2000; Delaney & Sahakyan, 2007; Macrae et al., 1997; Sahakyan & Delaney, 2003; Sahakyan et al., 2009). They were told to forget the texts from the practice set because they would not be tested on them, and they were told to instead focus on the next set of texts, which they would be tested on. The instructions that they received were as follows: “You have now completed reading the practice set of texts, which was designed to get you used to the reading task. There is no need to remember any of the texts that you just read because you will not be tested on them. Please forget them and focus on the texts that you will read in the reading task that follows.” Unbeknownst to the participants at this time, their memory would later be tested for both to-be-forgotten (Set A) and to-be-remembered (Set B) texts.

*No-proactive interference control condition.* In the control condition, participants only read the 10 texts from Set B, and they were told ahead of time that they would be tested on the
information presented within the texts.

**Results**

To examine participants’ memory for the texts’ claims and evidence, we conducted two 3 (Condition: proactive interference, directed forgetting, control) x 3 (Item Origin: Set A, Set B, Novel) mixed ANOVAs. Condition served as the between-subjects variable, and item origin served as the within-subjects variable. Note that item origin allows two different proactive interference effects to be tested: every point lost for Set A represents an intrusion into Set B, and every point lost for Set B represents a failure to recognize an item from set B.

**Claim memory.**

The analysis of claim memory showed a significant main effect of item origin, $F(2, 162) = 112.32, p < .001, \eta^2_p = .58$, a significant main effect of condition, $F(2, 81) = 26.51, p < .001, \eta^2_p = .40$, and a significant interaction, $F(4, 162) = 14.39, p < .001, \eta^2_p = .26$. In following up the interaction, the only significant simple main effect was for Set A, $F(2, 81) = 63.03, p < .001, \eta^2_p = .44$. Participants in the proactive interference ($t(55) = -8.13, p < .001, \text{Cohen’s } d = 2.15$) and directed forgetting ($t(53) = 9.70, p < .001, \text{Cohen’s } d = 2.63$) conditions more frequently misattributed that claims from Set A were seen in Set B (i.e. had higher intrusions) compared to participants in the control condition (see Table 1 for descriptive statistics). No other effects reached statistical significance.

**Evidence memory.**

The analysis of evidence memory also produced a significant main effect of item origin, $F(2, 162) = 76.48, p < .001, \eta^2_p = .49$, a significant main effect of condition, $F(2, 81) = 13.72, p < .001, \eta^2_p = .25$, and a significant interaction, $F(4, 162) = 10.88, p < .001, \eta^2_p = .21$. In following up the interaction, the only significant simple main effect was again for Set A, $F(2,
As with their memory for claims, participants in the proactive interference ($t(55) = -7.02, p < .001, \text{Cohen's } d = 1.85$) and directed forgetting ($t(53) = 6.65, p < .001, \text{Cohen's } d = 1.80$) conditions more frequently misattributed that evidence statements from Set A were seen in Set B (i.e. had higher intrusions) compared to participants in the control condition. No other effects reached statistical significance.

**Discussion**
The results of Experiment 1 provided partial support for our proactive interference hypothesis, which predicted that, when tested on their memory for information found in the second set of texts, participants who received directed forgetting instructions between sets would have fewer memory intrusion errors stemming from the to-be-forgotten information read in the first set of texts compared to participants told to remember all 20 texts. Extending prior research, they demonstrate that in studying information in a multiple text comprehension context, exposure to earlier-read related information during study leads to more memory intrusion errors from both components of the arguments (claims and evidence) when asked to retrieve later-learned information, presumably due to proactive interference. The expected concomitant negative effects on memory for later-read information, however, were not present. In the case of the intrusion errors, the irrelevant—yet highly related—information likely became activated and available during participants’ attempted retrieval of the relevant target information (O’Brien, Cook, & Guéraud, 2010; Seifert, 2014), despite the fact that only a subset of that related information was actually pertinent. It is also possible that these proactive interference memory intrusions may reflect source monitoring errors (Johnson, Hashtroudi, & Lindsay, 1993), whereby readers are unable to focus memory search to differentiate the origins of irrelevant (Set A) versus relevant (Set B) information.

Contrary to our directed forgetting hypothesis, which predicted that the instructions to forget would improve participants’ memory for later-read information (i.e., the second set of texts) relative to the proactive interference group, it did not appear that readers were able to intentionally forget information from the irrelevant, earlier-read texts, as intrusion errors from irrelevant prior-read texts—as measured by lower accuracy in responding to Set A items—were equally as prevalent in the proactive interference and directed forgetting conditions. This may
reflect that a high degree of semantic relationships between outdated and target texts creates proactive interference intrusions (Golding, Long, & MacLeod, 1994), resulting in a continued influence of these items, even when forget instructions were given. Readers may have encoded earlier-read related information in order to establish a stable, coherent situation model of the topic (akin to the primacy effect). As such, it is possible that directed forgetting may be an insufficient strategy for reducing proactive interference when reading-to-remember more complex materials, in general. It is, however, also possible that directed forgetting may be an insufficient strategy for reducing proactive interference when specifically reading several texts on the same topic, which are inherently highly semantically related (as they were in Experiment 1).
Chapter 3

Experiment 2

A second experiment was conducted to investigate the unexpected null effect of directed forgetting in Experiment 1. Because Golding et al. (1994) demonstrated that the effectiveness of directed forgetting instruction on memory was influenced by how semantically related the study materials were, Experiment 2 was designed to test whether directed forgetting instructions when reading a series of texts on the same topic (i.e., the semantically related condition) are less effective at reducing proactive interference than when the texts are semantically unrelated (i.e., the control condition). To do so, we had participants read two sets of 10 texts, and we manipulated the sets’ topics to either be on the same (semantically related) or different (semantically unrelated) topics. We first hypothesized that memory intrusion errors stemming from prior-read irrelevant information would occur more frequently when participants read texts that were highly semantically related compared to those on completely different topics. Second, we hypothesized that, when the two sets of texts were not semantically related, directed forgetting instructions would both reduce memory intrusion errors stemming from prior-read information and improve memory for later-read, target information.

Method

Participants.

A total of 115 undergraduates (75.7% female) at a large university in the Mid-South participated in this study for course credit. Ages ranged from 18 to 37 ($M = 19.29$, $SD = 2.48$).

Materials.

The distractor task, claim recognition task, and evidence recognition task were the same as those used in Experiment 1.
Texts. We used the same texts on the benefits and detriments of social media as in Experiment 1. Additionally, we created 10 new texts on the benefits and detriments of standardized testing for society (five of each). These texts were created in the same manner and with the same format as the social media texts, and they were also based on information from procon.org (“Standardized Tests,” n.d.). The benefits included helping teachers focus on essential content and preparing students for college, and the detriments included narrowing the curriculum and not improving student achievement. The order of the 10 texts within this set was randomized across participants. Participants who read these texts continued to afterwards read the same set of target texts (i.e., Set B) from Experiment 1. These two sets did not differ significantly from each other on Flesch-Kincaid Grade Level, $t(18) = -.341$, $p = .737$.

Procedure.

The semantic relatedness of text set topics and the presence of directed forgetting instructions were manipulated in a 2 x 2 between-participants design, such that set topics were either related or unrelated, and instructions to forget the first set of texts were either presented or not presented after reading the first set. Therefore, participants were randomly assigned to one of four conditions: the related proactive interference condition (related sets, no instructions to forget), the related directed forgetting condition (related sets, instructions to forget first set), the unrelated condition (unrelated sets, no instructions to forget), and the unrelated directed forgetting condition (unrelated sets, instructions to forget first set).

The related proactive interference and related directed forgetting conditions were the same as those in Experiment 1. Both of these conditions read two sets of 10 texts on the benefits and detriments of social media for society. For the two unrelated conditions, the first set of 10 texts was on the benefits and detriments of social media, and the second set of 10 texts was on
the benefits and detriments of standardized testing. The instructions that participants received between sets (either to continue reading and remembering or to forget the just-read set) were the same as those given to participants in Experiment 1. All participants completed the reading task, followed by a distractor task, a final recognition test for text claims, and a final recognition test for text evidence statements. All materials were presented self-paced on a computer screen using Qualtrics. Each text and recognition test item was presented on its own page with no ability to go back and re-read or change previous answers. Reading time for each text and response time for each recognition test item was recorded.

Results

To analyze participants’ memory for texts’ claims and evidence, we used two separate three-way mixed ANOVAs: 2 (Instructions: forget, remember) × 2 (Topic Relatedness: semantically related, unrelated) × 3 (Item Origin: Set A, Set B, Novel). Directed Forgetting Instructions and Topic Relatedness were between-subjects variables, whereas Item Origin was a within-subjects variable. Note that item origin allows two different proactive interference effects to be tested: every point lost for Set A represents an intrusion into Set B, and every point lost for Set B represents a failure to recognize an item from Set B.

Claim memory.

The analysis of accuracy of claim memory showed a significant main effect of item origin, $F(2, 222) = 120.53, p < .001, \eta_p^2 = .52$. Specifically, participants’ memory accuracy for Set A claims was significantly worse than that for both Set B and Novel claims (see Table 2 for descriptive statistics), with no significant difference between Set B and Novel. There was also a significant main effect of topic relatedness, $F(1, 111) = 80.33, p < .001, \eta_p^2 = .42$, such that participants who read texts that were unrelated showed more accurate claim memory compared
### Table 2

*Experiment 2: Means and standard deviations for the claim recognition test across conditions.*

<table>
<thead>
<tr>
<th>Condition</th>
<th>Item origin</th>
<th>Interfering Set</th>
<th>Target Set</th>
<th>Novel</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$M$ (SD)</td>
<td>$M$ (SD)</td>
<td>$M$ (SD)</td>
</tr>
<tr>
<td>Instructed to forget</td>
<td>Related topics</td>
<td>1.61 (1.31)</td>
<td>6.71 (1.21)</td>
<td>6.86 (1.30)</td>
</tr>
<tr>
<td></td>
<td>Unrelated topics</td>
<td>6.41 (1.80)</td>
<td>6.83 (1.31)</td>
<td>6.69 (1.79)</td>
</tr>
<tr>
<td>Instructed to remember</td>
<td>Related topics</td>
<td>1.97 (2.04)</td>
<td>6.07 (1.57)</td>
<td>5.83 (1.82)</td>
</tr>
<tr>
<td></td>
<td>Unrelated topics</td>
<td>6.00 (1.59)</td>
<td>7.14 (1.04)</td>
<td>6.36 (1.68)</td>
</tr>
</tbody>
</table>

*Note.* Higher scores indicate a greater accuracy for each variable.

...to those who read texts that were semantically related. The interaction between item origin and topic relatedness was also significant, $F(2, 222) = 74.61, p < .001, \eta^2_p = .40$. In following up the interaction, participants had significantly more accurate memory for claims from both Set A, $t(113) = -13.84, p < .001, d = -2.58$, representing fewer intrusions, and Set B, $t(113) = -2.45, p = .016, d = -0.46$, when topics were semantically unrelated, compared to when they were semantically related. No other main effects or interactions reached statistical significance.

Importantly, the instructions (i.e., forget or remember Set B texts) had no effect.

**Evidence memory.**

The analysis of accuracy of evidence memory showed nearly identical patterns of statistical significance. There was a significant main effect of item origin, $F(2, 222) = 91.60, p < .001, \eta^2_p = .45$. Specifically, participants’ memory for Set A evidence was significantly less
accurate than that for both Set B and Novel evidence, and Set B was significantly less accurate than Novel (see Table 3 for descriptive statistics). There was also a significant main effect of Table 3

*Experiment 2: Means and standard deviations for the evidence recognition test across conditions.*

<table>
<thead>
<tr>
<th>Condition</th>
<th>Item origin</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Interfering Set</td>
<td>Target Set</td>
<td>Novel</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$M$ ($SD$)</td>
<td>$M$ ($SD$)</td>
<td>$M$ ($SD$)</td>
<td></td>
</tr>
<tr>
<td>Instructions to forget</td>
<td>Related topics</td>
<td>2.00 (1.39)</td>
<td>6.71 (1.49)</td>
<td>7.36 (1.31)</td>
</tr>
<tr>
<td></td>
<td>Unrelated topics</td>
<td>6.93 (1.62)</td>
<td>6.55 (1.40)</td>
<td>7.03 (1.52)</td>
</tr>
<tr>
<td>Instructions to remember</td>
<td>Related topics</td>
<td>2.33 (1.71)</td>
<td>5.90 (1.63)</td>
<td>6.60 (1.65)</td>
</tr>
<tr>
<td></td>
<td>Unrelated topics</td>
<td>6.79 (1.95)</td>
<td>6.82 (1.44)</td>
<td>6.82 (1.72)</td>
</tr>
</tbody>
</table>

*Note.* Higher scores indicate a greater accuracy for each variable.

topic relatedness, $F(1, 111) = 73.86$, $p < .001$, $\eta^2_p = .40$, such that participants who read texts that were unrelated showed more accurate evidence memory compared to those who read texts that were semantically related. The interaction between item origin and topic relatedness was also significant, $F(2, 222) = 93.54$, $p < .001$, $\eta^2_p = .46$. In following up the interaction, participants had significantly more accurate memory for evidence from Set A when topics were unrelated, representing fewer intrusions, compared to when they were semantically related, $t (113) = -15.05$, $p < .001$, $d = -2.81$. No other main effects or interactions reached statistical significance. Importantly, the instructions (i.e., forget or remember Set B texts) had no effect.
Discussion

Taken together, the results of Experiment 2 again show more intrusion errors (i.e., worse memory for Set A) for participants in the proactive interference condition; however, they did not show poorer memory accuracy for the target texts (i.e., Set B) as would be expected in the typical proactive interference paradigm (e.g., Szpunar et al., 2008; Underwood, 1957). Regarding topic relatedness, we saw overall that readers exposed to unrelated text sets were better able to correctly identify the origin of a text, consistent with the release from proactive interference paradigm (e.g., Wickens, 1972). Importantly, however, the directed forgetting instructions did not influence the results, as we also saw in Experiment 1.
Chapter 4  
Exploratory Analyses

The null effects of directed forgetting on proactive interference found in both Experiments 1 and 2 were largely inconsistent with the literature. We conducted a series of exploratory analyses in an effort to uncover details that may help to explain why directed forgetting did not help to reduce the negative effects of proactive interference in either Experiment 1 or Experiment 2. Here we analyzed the time that participants spent reading the target texts (Set B) and the time that they spent responding to items from the target texts on the recognition memory test, and we examined reading time as a potential moderator of the effects of directed forgetting. Additionally, we compared conditions’ performance on the memory task using a metric (d’) that provides a more detailed look at task performance, beyond that of the raw recognition memory scores. Lastly, we completed a series of analyses investigating one-sided non-compliance.

Reading Time

We first examined participants’ reading time for the target set of texts in order to explore potential differences in encoding efforts brought about by the directed forgetting instructions. In Experiment 1, two participants were removed from the analysis for having Set B reading times that were more than three standard deviations above the mean. A one-way ANOVA, using condition (proactive interference, directed forgetting, control) as the independent variable and total reading time on Set B texts (proportionalized as reading time per word) as the dependent variable, showed no significant difference between the groups, $F (2, 79) = .54, p = .585, \eta^2 = .01$. Although one should interpret a null effect with a degree of caution, this suggests that whether or not participants read an additional set of texts before the target set did not affect the amount of
time that it took them to read the second set of texts. Additionally, this importantly suggests that receiving instructions to either forget or to continue to remember earlier-read texts made no difference on the effort spent reading the texts that followed (see Table 4 for descriptive statistics).

Table 4

*Experiment 1: Means and standard deviations for reading time on Set B texts (as words per minute) for participants in the three conditions.*

<table>
<thead>
<tr>
<th>Measure</th>
<th>Condition</th>
<th>Control</th>
<th>Proactive</th>
<th>Directed Forgetting</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
</tr>
<tr>
<td>Set B Reading Time</td>
<td></td>
<td>226.50 (124.42)</td>
<td>204.70 (99.81)</td>
<td>184.08 (95.76)</td>
</tr>
</tbody>
</table>

*Note.* Higher scores indicate faster reading speed.

For Experiment 2, we completed a similar analysis to explore potential differences in encoding efforts brought about by the directed forgetting instructions and topic differences. Three participants were removed from the analysis; one had a Set B reading time that was more than three standard deviations above the mean, and two had total Set B reading times under 10 seconds. We conducted a 2 (Instructions: forget, remember) × 2 (Topic Relatedness: semantically related, unrelated) ANOVA with total reading time on Set B texts (proportionalized as reading time per word) as the dependent variable. The results showed no significant main effect of instructions, $F(1, 108) = 1.90, p = .171, \eta^2_p = .02$. The main effect of topic relatedness was significant, with participants who read semantically related texts having longer reading times, $F(1, 108) = 4.10, p = .047, \eta^2_p = .04$. The interaction effect was not significant, $F(1, 108)$
=.207, \( p = .650, \eta^2 = .002 \) (see Table 5 for descriptive statistics).

Table 5

*Experiment 2: Means and standard deviations for reading time on Set B texts (as words per minute) for participants across conditions.*

<table>
<thead>
<tr>
<th>Condition</th>
<th>Related Topics</th>
<th>Unrelated Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( M (SD) )</td>
<td>( M (SD) )</td>
</tr>
<tr>
<td>Related Topics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Instructed to forget Set B</td>
<td>293.16 (117.37)</td>
<td>247.49 (138.58)</td>
</tr>
<tr>
<td>Instructed to remember Set B</td>
<td>252.48 (105.76)</td>
<td>220.95 (96.74)</td>
</tr>
</tbody>
</table>

*Note.* Higher scores indicate faster reading speed.

Across both experiments, these results suggested that receiving instructions to either forget or to continue to remember earlier-read texts did not make a difference in regards to the amount of encoding effort spent reading the later texts, but semantic relatedness of the earlier-read texts compared to the later-read, interfering texts led participants to read the interfering texts slower.

**Response Time**

We next examined participants’ total response times to recognition items for the target items reflective of Set B in order to explore potential differences in retrieval efforts brought about by the directed forgetting instructions. This measure of response time included the time spent on both claim and evidence recognition test items as one variable, allowing us to examine how the different instructions given during the reading task (and the relatedness of the texts in Experiment 2) may have affected the speed with which participants were able to respond—and
presumably process their knowledge—when asked to access and assess all information they had read in the texts. For Experiment 1, we conducted a one-way ANOVA, using condition

Table 6

*Experiment 1: Means and standard deviations for response time on information from Set B texts (as words per minute) for participants in the three conditions.*

<table>
<thead>
<tr>
<th>Measure</th>
<th>Condition</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control</td>
<td>Proactive Interference</td>
<td>Directed Forgetting</td>
<td></td>
</tr>
<tr>
<td>Set B Response Time</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>99.69 (21.55)</td>
<td>108.92 (25.25)</td>
<td>117.66 (38.45)</td>
<td></td>
</tr>
</tbody>
</table>

*Note.* Higher scores indicate faster response time.

(proactive interference, directed forgetting, control) as the independent variable and total time spent responding to items originally from Set B (proportionalized as response time per word) as the dependent variable. The results did not show a significant difference between the groups, though the difference was trending toward significance, $F (2, 81) = 2.65, p = .076, \eta^2 = .06$ (see Table 6 for descriptive statistics).

For Experiment 2, we completed a similar analysis to explore potential differences in retrieval efforts brought about by the directed forgetting instructions and topic differences. Again, this included time spent on both claim and evidence recognition test items as one variable. We conducted a 2 (Instructions: forget, remember) \( \times \) 2 (Topic Relatedness: semantically related, unrelated) ANOVA with total time spent responding to items originally from Set B (proportionalized as response time per word) as the dependent variable. The results showed no significant main effect of instructions, $F (1, 111) = .41, p = .524, \eta^2 = .004$, and no
significant main effect of topic relatedness, $F(1, 111) = .17, p = .682, \eta^2_p < .002$. The interaction was not significant, $F(1, 111) = 2.94, p = .089, \eta^2_p = .026$ (see Table 7 for descriptive statistics).

Table 7

*Experiment 2: Means and standard deviations for response time on information from Set B texts (as words per minute) for participants across conditions.*

<table>
<thead>
<tr>
<th>Condition</th>
<th>Related Topics</th>
<th>Unrelated Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relatedness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reading Instructions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Instructed to forget Set B</td>
<td>116.01 (36.00)</td>
<td>129.49 (62.71)</td>
</tr>
<tr>
<td>Instructed to remember Set B</td>
<td>122.97 (36.22)</td>
<td>109.61 (38.20)</td>
</tr>
</tbody>
</table>

*Note.* Higher scores indicate faster response time.

Across both experiments, similar to the results of the reading time analyses, these results suggested that receiving instructions to either forget or to continue to remember earlier-read texts did not make a difference in regards to the amount of retrieval effort spent recognizing the later-read texts, nor did the semantic relatedness of the earlier-read texts compared to the later-read texts.

**Reading Time as Moderator**

Next, we explored reading time as a potential moderator of how directed forgetting affects recognition accuracy. Similar to the response time analyses, this measure of recognition accuracy included participants’ claim and evidence recognition test items as one variable. We conducted two hierarchical multiple regressions—one for each experiment. For Experiment 1, Mahalanobis and Cook’s distances identified two outliers that were removed from the analysis.
Directed forgetting instructions (a dichotomous variable differentiating the proactive interference condition from the directed forgetting condition) and total reading time on Set B were entered at Step 1, explaining 32.9% of the variance in total recognition test score (see Table 8). The

Table 8

*Experiment 1: Hierarchical Regression Analysis with Directed Forgetting Instructions, Reading Time on Set B, and their Interaction Predicting Recognition Memory*

<table>
<thead>
<tr>
<th>Step and predictor variable</th>
<th>B</th>
<th>SE B</th>
<th>β</th>
<th>R²</th>
<th>ΔR²</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Directed forgetting</td>
<td>.231</td>
<td></td>
<td></td>
<td>.231</td>
<td></td>
<td>12.480**</td>
</tr>
<tr>
<td>instructions</td>
<td></td>
<td></td>
<td></td>
<td>.187</td>
<td>1.253</td>
<td></td>
</tr>
<tr>
<td>Set B reading time</td>
<td></td>
<td></td>
<td></td>
<td>.034</td>
<td>.007</td>
<td>.576**</td>
</tr>
<tr>
<td>Step 2:</td>
<td></td>
<td></td>
<td></td>
<td>.250</td>
<td>.019</td>
<td>8.928**</td>
</tr>
<tr>
<td>Directed forgetting</td>
<td></td>
<td></td>
<td></td>
<td>-.316</td>
<td>2.962</td>
<td>-.294</td>
</tr>
<tr>
<td>instructions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Set B reading time</td>
<td></td>
<td></td>
<td></td>
<td>.028</td>
<td>.009</td>
<td>.473**</td>
</tr>
<tr>
<td>Directed forgetting</td>
<td></td>
<td></td>
<td></td>
<td>.018</td>
<td>.015</td>
<td>.341</td>
</tr>
<tr>
<td>instructions × Set B reading time</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note. N = 56.*

*p < .05. **p < .01.*

interaction between instructions and reading time on Set B was entered at Step 2. The model as a whole explained 34.9% of the total variance in overall recognition accuracy, F (3, 50) = 8.93, p < .001. The interaction between instructions and reading time on Set B explained an additional
2.0% of the variance in recognition test scores, after controlling for instructions and reading time on Set B, though this was not significant, $R^2$ change = 0.020, $F$ change (1, 50) = 1.55, $p = .218$. Only reading time on Set B ($\beta = .473; p = .002$) was a significant predictor of recognition test scores in the final model.

For Experiment 2, we conducted the second hierarchical multiple regression. Mahalanobis and Cook’s distances identified one outlier that was removed from the analysis. Instructions (forget or remember) and total reading time on Set B were entered at Step 1, explaining 6.2% of the variance in total recognition test scores (see Table 9). The interaction between instructions and reading time on Set B was entered at Step 2. The model as a whole explained 7.9% of the total variance in overall recognition accuracy, $F$ (3, 110) = 3.13, $p = .028$. The interaction between directed forgetting and reading time on Set B explained an additional 1.7% of the variance in recognition test scores, after controlling for instructions and reading time on Set B, though this did not reach significance, $R^2$ change = 0.017, $F$ change (1, 110) = 1.98, $p = .162$. Again, only reading time on Set B ($\beta = .373; p = .01$) was a significant predictor of recognition test scores in the final model.

In both experiments, the results suggested that the more time participants took to read the texts in Set B, the better they performed on the recognition tests. Whether participants received instructions to forget or continue to remember the previous set of texts did not affect overall recognition memory scores, and there was no evidence of reading time acting as a moderator of the instructional manipulation.

**Signal Detection Analysis**

As a further exploratory analysis, we next calculated a sensitivity index known as $d$ prime ($d''$) to serve as an additional measure of task performance on the claim and evidence recognition
Experiment 2: Hierarchical Regression Analysis with Directed Forgetting Instructions, Reading Time on Set B, and their Interaction Predicting Recognition Memory

<table>
<thead>
<tr>
<th>Step and predictor variable</th>
<th>$B$</th>
<th>$SE_B$</th>
<th>$\beta$</th>
<th>$R^2$</th>
<th>$\Delta R^2$</th>
<th>$F$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Directed forgetting instructions</td>
<td>1.324</td>
<td>1.433</td>
<td>.086</td>
<td></td>
<td></td>
<td>3.678*</td>
</tr>
<tr>
<td>Set B reading time</td>
<td>.014</td>
<td>.006</td>
<td>.220*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Step 2:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Directed forgetting instructions</td>
<td>5.489</td>
<td>3.286</td>
<td>.357</td>
<td></td>
<td></td>
<td>3.134*</td>
</tr>
<tr>
<td>Set B reading time</td>
<td>.024</td>
<td>.009</td>
<td>.373**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Directed forgetting instructions $\times$ Set B</td>
<td>-.017</td>
<td>.012</td>
<td>-.357</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. $N = 115$.  
*p < .05. **p < .01.

This set of analyses is guided by signal detection theory, which assumes that within each choice to be made in the recognition task there is both a signal and noise (Abdi, 2010). The stronger the signal is, the easier it is for participants to make the correct choice. The stronger the noise is, the more difficult it is for participants to make the correct choice. These analyses go beyond the previously-analyzed raw recognition scores as they take into account both the signal strength and the noise strength in the recognition task as a way to determine the overall effect of
the signal. In other words, the ANOVAs in Experiments 1 and 2 used item origin as a factor with different levels representing intrusions (noise) and correct recognitions (signal), and the $d'$ measure allows these two quantities to be combined in a single measure with more sensitivity. Thus, we would expect the $d'$ analysis to replicate our existing findings and hope the increased sensitivity will allow us to find additional effects.

To do this, we calculated $d'$ for each participant—a metric often used for yes-no discrimination tasks (e.g., Wickens, 2001; Wixted, 2020). First, we coded participants’ responses as either hits or false alarms. For recognition test items originating from Set B, those that a participant correctly identified as having been presented in Set B were coded as a hit. For items originating from Set A or Novel texts, those incorrectly identified as having been presented in Set B were coded as a false alarm. Next, we computed participants’ hit rate and false alarm rates by dividing their number of hits or false alarms by the total number of possible hits or false alarms. We then computed the $z$-scores for participants’ hit rates and false alarm rates. Lastly, we subtracted the $z$-score of their false alarm rate from the $z$-score of their hit rate in order to calculate $d'$. This was done as an aggregate of both the claim and evidence recognition tasks. A higher $d'$ value indicates higher accuracy in a participant’s overall response pattern (i.e., a better ability to discriminate information learned in Set B from information not learned in Set B).

For Experiment 1, we analyzed participants’ $d'$ scores across conditions using a one-way ANOVA with condition (proactive interference, directed forgetting, control) as the independent variable and $d'$ as the dependent variable. The results were significant, $F (2, 81) = 29.35, p < .001, \eta^2 = .42$. Post-hoc Tukey HSD tests showed that the control condition ($M = 1.29, SD = 1.54$) had a significantly higher $d'$ score than both the proactive interference ($M = -.69, SD = .96$) and directed forgetting ($M = -.93, SD = .97$) conditions. The proactive interference and directed
forgetting conditions did not significantly differ from one another. These results suggest that participants in the control condition showed better discrimination between the information that they read in Set B and information from elsewhere than did the other two conditions, whereas the instructional manipulation did not affect discrimination ability. These findings using d’ replicate existing findings on intrusions in Experiment 1.

For Experiment 2, we analyzed participants d’ scores across manipulations using a 2 (Instructions: forget, remember) × 2 (Topic Relatedness: semantically related, unrelated) ANOVA. The results showed a significant main effect of Topic Relatedness, such that participants who read the two sets of texts that were semantically unrelated (M = 1.04, SD = 1.22) had higher d’ scores than those who read semantically related texts (M = -1.02, SD = .95), F (1, 111) = 103.15, p < .001, ηp² = .48. There was no significant main effect of directed forgetting instructions, F (1, 111) = .62, p = .432, ηp² = .006, nor was there a significant interaction effect, F (1, 111) = 2.0, p = .160, ηp² = .018. These results using d’ replicate existing findings on intrusions in Experiment 2, suggesting that participants who had read two sets of texts on the same topic were less able to discriminate between information that they had and had not read in the second set, whereas participants who had read two sets of texts that were on different topics were better able to both identify information from texts that they had read in the second set and reject information that did not come from that set.

Across both experiments, the d’ analyses only replicated existing findings using ANOVA and did not reveal any new effects, predicted or otherwise.

**Investigating One-Sided Non-Compliance**

One-sided non-compliance occurs when participants in one condition opt into another condition, but not the reverse (which would be two-sided). In practice, one-sided non-
compliance typically happens when experimental participants do not comply with treatment (Huang, 2018). Because the directed forgetting results that we saw in the initial basic analyses of both experiments were unexpected, we wondered whether one-sided non-compliance might be occurring in these experiments. Specifically, this would present itself if the participants who received the directed forgetting instructions did not read them or did not follow them. If this were to happen, these participants would behave more in line with the proactive interference participants who were instructed to remember both sets of texts.

To test whether one-sided non-compliance was occurring, we operationalized compliance as the amount of time (in words per minute) that participants spent reading the instructions presented between the two sets of texts. We had no corresponding measure for participants who read the instructions but chose not to follow them. For the proactive interference condition, the instructions told them to keep reading and remembering, whereas for the directed forgetting condition, the instructions told them that the first set of texts was only practice and that they only needed to remember the upcoming set of texts. Rather than defining a specific time cutoff for what is considered enough time reading the directed forgetting instructions vs. not enough time (i.e., compliance vs. non-compliance), we instead allowed the variable to remain continuous by using mediation analyses to test whether one-sided non-compliance was indeed occurring.

**Experiment 2 Mediation Analysis**

Because Experiment 2 was designed to explain the unexpected findings of Experiment 1, we first ran a mediation analysis using data from Experiment 2. Specifically, we used data from participants in the proactive interference condition and the directed forgetting condition, each collapsed across topic overlap conditions. For this analysis we used R (R Core Team, 2021) and the R package mediation (Tingley et al., 2014). The predictor variable was condition (directed
forgetting vs. proactive interference), the outcome variable was claim memory for Set B texts, and the mediating variable was the amount of time (words per minute) that it took participants to read the instructions given between their reading of Set A and Set B texts. The results showed a significant overall mediation effect (Effect = .19, \( p = .038 \), 95% CI [.01, .41]). The effect of condition (i.e., whether participants received directed forgetting instructions or not) on participants’ memory for claims originating from texts read in Set B was significantly mediated by the amount of time that they spent reading the instructions between Sets A and B.

The direct effect of condition on claim memory for Set B texts was not significant (Effect = -.01, \( p = .948 \), 95% CI [-.47, .47]). The lack of a direct effect of assignment to condition on claim memory is consistent with the original finding of no effect in the ANOVA. Together, the indirect and direct effect findings of the mediation analysis suggest that assignment to condition alone was insufficient to cause an effect on claim memory for Set B texts and that compliance to the assignment to condition was required (as operationalized by the time spent reading the directed forgetting instructions).

The two linear models comprising the mediation analysis further support this interpretation. The first model—predicting reading speed (words per minute)—found a significant effect of condition, \( p = .046 \) with the directed forgetting condition reading the instructions slower (i.e., fewer words per minute; \( M = 310.01, SE = 88.27 \)) compared to the proactive interference condition (\( M = 488.23, SE = 62.15 \)). The second model—predicting claim memory for Set B texts—found a significant effect of reading speed, \( p < .001 \) and a non-significant effect of condition assignment, \( p = .98 \). The mediated effect of condition assignment through reading speed on claim memory for Set B texts can be illustrated by computing the average reading speed for the two groups based on the first model through the second model.
Using this approach, the directed forgetting condition—reading instructions at an average of 310.01 words per minute—scored an average of 6.77 on their test of claim memory for Set B texts. Notably this speed is at the upper end of the range for English silent reading based on a recent meta-analysis (Brysbaert, 2019). The proactive interference condition—reading instructions at an average of 488.23 words per minute—scored an average of 6.59 on their test of claim memory for Set B texts. These results from the mediation analysis for Experiment 2 suggest that the null effect of directed forgetting in Experiment 2 might be explained by one-sided non-compliance.

Experiment 1 Mediation

Given the success in explaining the null findings in Experiment 2 based on one-sided non-compliance, we decided to run an equivalent mediation analysis using the data from Experiment 1. As with Experiment 2 data, the predictor variable here was the condition (directed forgetting vs. proactive interference), the outcome variable was the claim memory for Set B texts, and the mediating variable was the amount of time in words per minute that it took participants to read the instructions given to them between their reading of Set A and Set B texts. In Experiment 1, these instructions were split across two screens for the directed forgetting condition.

Contrary to the results of Experiment 2, the results did not show a significant overall mediation effect (Effect = .07, \( p = .370 \), 95% CI [-.08, .29]). Any influence that condition (i.e., whether participants received directed forgetting instructions or not) on participants’ memory for claims originating from texts read in Set B was not mediated by the amount of time that they spent reading the instructions between Sets A and B.
In line with Experiment 2, the direct effect of condition on claim memory for Set B texts was not significant (Effect = -.39, \( p = .17 \), 95% CI [-.95, .16]). The lack of a direct effect of assignment to condition on claim memory is consistent with the original finding in Experiment 2 of no effect. Together, the indirect and direct effect findings of this two-tailed mediation analysis suggest that neither assignment to condition nor compliance to the assignment to condition (operationalized by the time spent reading the directed forgetting instructions) were sufficient to cause an effect on claim memory for Set B texts.

Regarding the two linear models comprising the mediation analysis, the first model—predicting reading speed (words per minute)—did not find a significant effect of condition, \( p = .318 \). The second model—predicting claim memory for Set B texts—found no significant effect of reading speed (\( p = .062 \)) or of condition (\( p = .187 \)). In contrast to the Experiment 2 mediation analysis, where the path from condition through reading speed to claim memory was significant across the two models, only the path in the second model from reading speed to claim memory was close to significance (\( p = .062 \)), explaining the lack of overall mediation. Although the mediated effect of condition assignment through reading speed on claim memory for Set B texts was not significant, it can be illustrated by computing the average reading speed for the two groups based on the first model through the second model. Using this approach, the directed forgetting condition—reading instructions at an average of 383.37 words per minute—scored an average of 6.46 on their test of claim memory for Set B texts. The proactive interference condition—reading instructions at an average of 521.78 words per minute—scored an average of 6.78 on their test of claim memory for Set B texts. Comparing these results to the Experiment 2 mediation analysis, it appears that although the reading time means and claim memory scores are
comparably well separated, the larger standard errors in the present mediation analysis are prohibitive for finding a significant effect.

Across the two experiments, the mediation analyses provided suggestive but not conclusive evidence for explaining the null effect of directed forgetting through one-sided non-compliance. Although a mediated effect of directed forgetting on claim memory was found for Experiment 2, no such effect was found for Experiment 1.
Chapter 5

General Discussion

Summary of Current Findings

The purpose of the current research was twofold. First, we explored proactive interference as a potential detriment to memory in a situation requiring multiple text comprehension. Second, we examined whether this proactive interference could be effectively reduced or eliminated when the reader adopts a directed forgetting strategy by trying to intentionally forget earlier-read, no longer relevant texts. Proactive interference has been traditionally researched in the context of learning materials that are less complex (e.g., word lists; e.g., Cowan, Johnson, & Saults, 2005; Halford et al., 1988; Kliegl et al., 2015), and recent research has demonstrated the detrimental effects of proactive interference when reading-to-remember multiple texts (McCabe & Braasch, 2022), such that later-read texts are more difficult to remember than earlier-read texts. Directed forgetting has likewise been traditionally researched with learning in simpler experimental materials (e.g., Abel & Bäuml, 2013; Abel & Bäuml, 2017; Bjork & Bjork, 1996; Bjork & Woodward, 1973; Kliegl, Pastötter, & Bäuml, 2013; Lehman & Malmberg, 2011; Pastötter & Bäuml, 2007; Pastötter, Engel & Frings, 2018; Sahakyan & Delaney, 2003; Sahakyan et al., 2009; MacLeod, 1975; MacLeod, 1999), with the common finding that learners who have been instructed to forget previously-learned information are better able to remember the information that followed. A better understanding of proactive interference and directed forgetting in the context of multiple document comprehension would illuminate the generality of these effects and their practical implications in the information age, where tasks like reading multiple web pages on a topic are commonplace.

The general design in Experiments 1 and 2 used two sets of text, Set A and B, in order to
measure the effect of proactive interference and directed forgetting on claim memory and evidence memory. When reading Set A followed by Set B, proactive interference should cause intrusion of Set A items and worse memory for Set B. In Experiment 1, this factor was either Set A followed by Set B or Set B alone. To measure the effect of directed forgetting, participants in both experiments either received instructions to forget Set A or did not receive such instructions. The main difference between the designs of Experiment 1 and 2 is that Experiment 2 dropped the Set B only condition and added a factor of semantic relatedness between Set A and B (related or unrelated). Thus, the designs of both experiments support finding effects for proactive interference and directed forgetting, but Experiment 1 additionally supports contrasts between Set A followed by B and B alone, and Experiment 2 additionally supports contrasts between semantic relatedness of Set A and B.

Our hypothesis regarding proactive interference was that participants who read-to-remember two sets of 10 texts would show memory patterns similar to that seen in research using comparatively simple experimental materials (e.g., Underwood, 1957): poorer memory for the later-read target set of texts and more memory intrusion errors from the earlier-read non-target set of texts. Regarding directed forgetting, we hypothesized in Experiment 1 that—compared to participants who were told to remember both sets of texts—participants who received directed forgetting instructions would have better memory of the later-read, target texts, and fewer memory intrusion errors from the earlier-read, to-be-forgotten texts. In other words, we expected directed forgetting instructions to eliminate the negative effects of proactive interference. In Experiment 2, we more specifically hypothesized that this would be the case only when participants read two sets of texts that were not semantically related. We additionally hypothesized in Experiment 2 that overall, participants who read semantically unrelated texts
would have fewer intrusion errors than participants who read semantically related texts. Overall, the results were consistent across Experiments 1 and 2, and while many aligned with our original expectations, there were some that did not.

**Proactive Interference**

Regarding the potential effect of proactive interference when reading multiple texts, based on previous research on more simple experimental materials (e.g., Kliegl et al., 2015; Szpunar et al., 2008; Underwood, 1957), in Experiment 1 we had hypothesized that participants who read-to-remember two sets of texts (1) would show worse memory for the second set of texts (i.e., the target texts) and (2) have more memory intrusion errors stemming from what they had read in the first set of texts compared to participants who only saw the target texts. This hypothesis was partially supported. In this multiple text comprehension context, reading-to-remember related—presumably interfering—information prior to the target information led participants to exhibit more memory intrusion errors during a test of their memory for the later-read target texts. Specifically, information that they had learned from the interfering set was more frequently misattributed as being from the target set. This was consistent on both the claim and evidence memory tests and was replicated in Experiment 2. Participants, however, did not exhibit the anticipated negative effects of proactive interference on their memory for the later-read target texts. Experiment 2 likewise did not show anticipated effects of proactive interference on the target set.

As the current results are in contrast with the results of McCabe & Braasch (2022), it is important for future research to explore why this is. The overlying difference between these two sets of experiments is the type of memory participants had to access. The current studies required participants to utilize recognition memory, whereas McCabe and Braasch (2022) required recall
memory by using a test in which participants were told to write down everything that they remember from Set B with no available cues. If this memory measure difference indeed caused the difference in the two proactive interference findings, together it would give us insight into daily life. We often turn to physical texts or texts on the internet to answer a question that we have, but it is not usually the case that we are preparing ourselves for a recognition test at the end of it. Forming a coherent mental model of the topic at hand often draws upon our ability to recall the series of texts that we have read. Future research should directly examine the differences in how proactive interference in a multiple document context presents using a recognition memory measure compared to a recall memory measure as it appears that they may provide different results.

Due to the nature of the recognition memory task, it is possible that the current results lacked the ability to show the memory deficits associated with proactive interference in a multiple document comprehension context based on the literature on yea-saying and the dual process theory (e.g., Knowles & Condon, 1999). Yea-saying—part of the acquiescence or agreement bias—is participants’ tendency to agree or say yes to questions that they are asked. The dual process theory can account for yea-saying as it states that a judgment using recognition memory happens in two stages (e.g., Hintzman, Caulton, & Levitin, 1998; Jacoby, 1991; Jacoby, Kelley, Brown & Jasechko, 1989; Mandler, 1980; Yonelinas, 2002). Essentially, the dual-process theory of recognition memory suggests that familiarity and recollection are two separate constructs within a given recognition task. When a participant first sees an item, they must first access their memory to determine whether it is familiar—determining whether it is something that they have seen before. Then the participant must take an extra step to determine whether or not it is something that they know that they have seen from a specific source that is relevant to
the task at hand.

Therefore, in the current research, it may be the case that participants were using familiarity judgements as opposed to actually recollecting their memory of the item in question. Specifically, participants may have been quick to attribute claim and evidence items to Set B merely because they appeared familiar to them, not because they were actually recollected as having been in Set B. Because of this possibility, future research might consider including remember/know judgements alongside the recognition items. Using this method, participants are asked to provide a judgement for each item whether it is something that they remember (i.e., recollected from episodic memory) or whether the item is something that they know (i.e., familiar from semantic memory; Wixted & Mickes, 2010).

*Release From Proactive Interference.*

In addition, the semantic relatedness manipulation in Experiment 2 provides further insight into the role of proactive interference. The manipulation is similar to that used in previous research to test the release from proactive interference paradigm (e.g., Bunting, 2006; Gardiner et al., 1972; Hasher et al., 2002; McCabe & Braasch, 2022; Nairne et al., 1999; Wickens, 1972; Wickens et al., 1963). Typically, participants are given lists or sets of semantically related items to learn, and their ability to remember the information declines with each set. Then when given a set of information that is not semantically related to the previous sets, their ability to remember the new unrelated items returns to a level near that of the first list (i.e., the list that had no interference), thereby releasing them from proactive interference. This highlights the importance of semantic relatedness as a factor leading to the occurrence of stronger proactive interference.

The results of Experiment 2—in which we manipulated semantic relatedness—demonstrated findings consistent with the previous release from proactive interference research.
Overall, across both the claim and evidence memory measures, memory performance was better after reading two sets of semantically unrelated texts compared to semantically related texts. Specifically, participants were better able to identify which information did and did not come from the later-read target texts when both sets were unrelated, suggesting that the earlier-read texts had a stronger interfering effect on the target texts when they were semantically related. Additionally, this suggests that the results of Experiment 1 were not merely due to fatigue effects, wherein simply reading 20 texts on any topic would reduce memory for later-read texts due to fatigue. If fatigue was involved, here—because they read the same number of texts—we would have seen equally poor memory performance for the target texts regardless of whether the two sets of texts were related or not related.

The influence of topic relatedness is particularly salient after taking into account the origin of the items on the memory tests—items from the earlier-read interfering texts, items from the target texts, or items previously unseen during the reading task. When the items were from the earlier-read texts, the same pattern of results held, with readers of unrelated text sets outperforming readers of related text sets (i.e., being better able to correctly identify these items as not coming from the target text set). This was true for memory for both the texts’ claims and evidence. When the items were from the later-read target texts, again the same pattern was seen for claim memory, with previous readers of unrelated texts being better able to correctly identify these claims as having been read in the target text set. For evidence memory, however, whether or not the text sets were related did not influence participants’ memory accuracy. When the items were from novel, unseen texts, neither claim nor evidence memory accuracy was affected by whether or not the text sets were related.

These findings regarding item origin suggest that the overall memory advantage that
comes from reading unrelated texts compared to related texts stems both from being able to make more correct rejections of information from earlier-read texts and from being able to make more correct identifications of information from the target texts. Importantly, the current findings continue to expand our understanding of the release from proactive interference paradigm in a multiple document comprehension context. Traditionally, this paradigm has been studied using more simple experimental materials (usually lists of words; e.g., Kliegl et al., 2013; Kane & Engle, 2000; Öztekin & McElree, 2007), and it has only recently been extended to a multiple document comprehension context (McCabe & Braasch, 2022) with results consistent with those in the current study.

Though we did not see the expected memory deficit for the target texts, Experiment 1 and Experiment 2 taken together suggest that the increased memory intrusion errors stemming from earlier-read information, coupled with the important role of semantic relatedness in leading to these effects, suggests that participants experienced proactive interference in this multiple document context. This is consistent with the findings of our previous research (McCabe & Braasch, 2022).

**Directed Forgetting**

Regarding directed forgetting, in both Experiment 1 and Experiment 2 we had expected that when tested on their memory for information found in the second set of texts (i.e., the target set), participants given directed forgetting instructions between reading the two sets of texts would show better memory and fewer memory intrusion errors from the to-be-forgotten first set of texts compared to the participants who were told to remember all 20 texts. The results, however, did not support this outcome. The directed forgetting and proactive interference conditions showed equal memory and equal prevalence of prior-set intrusions from earlier-read
non-target texts. This was consistent for both the claim and evidence memory tests. This suggested that readers were not able to intentionally forget information that they had encountered in the no longer relevant, earlier-read texts, which we had expected to have helped their memory for the texts in the target set.

This may have occurred because the memory test required participants to use recognition memory rather than recall. Results in previous literature have uncovered divided findings regarding whether or not directed forgetting is successful when using recognition memory measures, with some showing that it is (e.g., Sahakyan & Delaney, 2005) and others showing that it is not (e.g., Basden & Basden, 1996; Geiselman, Bjork, & Fishman, 1983). One study has even suggested that directed forgetting is successful with recognition memory only when the item-method is used (but not the list-method; Basden, Basden, & Gargano, 1993).

The current recognition memory test may have reactivated participants’ memories for the presented non-target texts that were previously being inhibited. In one study using lists of paired words (Basden et al., 1993), some participants were asked to complete a recognition test prior to completion of a final recall test. This recognition test essentially released the participants from the benefit of directed forgetting, leading them to make more errors on the final recall test compared to participants who did not complete the initial recognition test. This suggested that the learned words were available in memory yet inhibited until their presentation in the recognition test reactivated them. Other studies have found similar results (e.g., Bjork & Bjork, 1996; Schmitter-Edgecombe, Marks, Wright, & Ventura, 2004). A similar effect may have occurred in the current series of studies, with the presentation of the given item reactivating it in participants’ memory.

Another explanation is that the participants did not comply with directed forgetting
instructions (one-sided non-compliance). The mediated effect of directed forgetting on Set B memory in Experiment 2 supports this explanation, but no such mediated effect was found for Experiment 1.

*Topic Relatedness*

Consulting previous research findings, we ran Experiment 2 with the goal of understanding why we did not find our expected results. Golding et al. (1994) showed that directed forgetting instructions may be less effective at providing a benefit to memory when the to-be-learned material is semantically related. In their study, participants learned 20 word pairs, with some pairs being semantically related to each other (e.g., crab-leg) and other pairs being unrelated (e.g., crab-belt). Each word was followed by either the word remember or the word forget (e.g., crab...remember...leg...forget; i.e., item-method directed forgetting). Participants demonstrated more difficulty in forgetting the second word in a semantically related remember-forget pair compared to an unrelated pair.

We hypothesized in Experiment 2 that when the two sets of texts were not semantically related, directed forgetting instructions would reduce proactive interference more efficiently than when both sets were semantically related (with related texts being the case in Experiment 1). This included both reducing memory intrusion errors from earlier-read, no longer relevant information and improving memory for later-read, target information. Contrary to our hypothesis, the results of Experiment 2 were not consistent with those of Golding et al. (1994). In fact, the results remained consistent with the results of Experiment 1 when the two sets of texts were related.

Two main differences between the Golding et al. (1994) methodology and our methodology in Experiment 2 do remain, and these may have contributed to the inconsistency of
our results with theirs. Specifically, Golding et al. utilized the item-method directed forgetting paradigm, whereas we utilized the list-method. Additionally, Golding et al.’s memory tasks involved paired words, whereas we used texts. Previous research involving item-method and list-method directed forgetting has shown evidence that they produce very different results (e.g., Basden et al., 1993; Woodward, Park, & Seebohm, 1974), suggesting that there are two different mechanisms involved behind memory for one versus the other. More research will need to be done to determine if the above differences were enough to create this discrepancy in the two sets of results.

**Exploratory Analyses**

Because we did not see the expected negative effects of proactive interference or the expected benefit of directed forgetting in the memory measures, we explored possible differences in processing time between the two groups within our exploratory analyses. *Reading time* is often used as a measure of encoding efforts, with longer times signaling stronger effort, and *response time* is often used as a measure of retrieval efforts (e.g., Lowder & Gordon, 2015), with longer times again signaling stronger effort.

According to the temporal discrimination theory of proactive interference, one would expect to see the proactive interference condition taking longer to respond due to the non-target, interfering information becoming reactivated in their memory as they attempted to retrieve the target information (Kliegl et al., 2015; Wixted & Rohrer, 1993). Though one must be careful in interpreting null effects, the current results suggest that—when reading-to-remember texts—the time that it takes to read a target set of texts is the same whether or not an additional, interfering set of texts is read prior to the target set. The same pattern appears to be true of the time that it takes to later recognize information from the target texts.
This is not what we had expected to find based on previous research (e.g., Kliegl et al., 2015; Öztekin & McElree, 2007). Using previous results as a guide, we would expect to see differences in the response time data, with the proactive interference taking longer to respond to items than other conditions. However, our exploratory analyses showed that this was not the case in the current research. Taken together across both experiments, the reading and response time analyses suggested that neither the encoding efforts nor the retrieval efforts directed toward the target texts changed with the addition of earlier-read interfering texts or instructions to forget the these interfering texts. It is possible that the inconsistency of our results with those of previous studies may be due to the fact that our experimental materials were a series of texts instead of a list of words, but additional research is needed to thoroughly explore potential explanations such as this.

If one considers the encoding perspective of proactive interference for memory accuracy (Baüml & Kliegl, 2013; Kliegl et al., 2015; Pastötter, Schicker, Niedernhuber, & Baüml, 2011), the lack of timing differences during encoding is consistent with our finding a lack of memory deficits for the target texts when interfering texts were read beforehand, regardless of whether or not participants were instructed to forget the interfering texts or not. The encoding perspective says that the mechanism of proactive interference occurs at encoding due to the presence of an interfering list creating a lack of attentional resources needed to process the target list. From this perspective, the proactive interference readers in the current study did not differ in their encoding efforts, therefore they did not experience the same attentional issues as one would expect, leading them to not show a difference in memory accuracy for the target texts.

We additionally pursued another avenue of examining timing during the encoding period by using differences in participants’ reading time as a moderator of the relationship between the
instruction manipulation and memory for the target texts. We had expected those who spent more time reading to show a benefit of directed forgetting compared to those who spent less time reading; however, this was not the case, as the analysis was not significant. We cannot tell based on our moderation analysis whether that means that there was not a big enough difference in encoding in the directed forgetting condition or whether existing differences just did not moderate the relationship between instructions and memory for target items. Our results are inconsistent with previous literature suggesting that the mechanism behind directed forgetting is that readers are able to more deeply encode the second, target set of texts when they are given instructions to forget previously read interfering texts (e.g., Sahakyan & Delaney, 2003).

Previous research has additionally provided support for the retrieval perspective of proactive interference for memory accuracy (Wixted & Rohrer, 1993), which says that people have trouble restricting their search set during retrieval to just the target information and thus include even the non-target information. According to this theory, we would expect to see longer response times for the proactive interference condition compared to the control and directed forgetting conditions because there are more items to mentally search through in order to respond correctly; however, as previously stated this was not the case. We speculate that this is due to our use of recognition items on the memory test since participants have an easier time correctly responding to recognition items compared to recall items (Freund, Brelsford, & Atkinson, 1969). Therefore, the participants across conditions might have been able to respond to the recognition items equally as quickly as each other as compared to how they may have responded if the items tapped into recall memory. Future research comparing recall and recognition memory in this context is needed to explore this potential explanation.

Of note are the marginally significant increased response time in the proactive
interference condition. As such, it must be considered with caution and should not be used as support for conclusions in the current research; however, it may provide an interesting route for future research to explore as it may be significant with more statistical power.

These findings are further supported exploring the sensitivity index \(d'\) of both groups. This measure took into account both the signal strength (the target texts) and the noise strength (the earlier-read texts) that participants experienced during the memory tasks in order to understand the effect of the signal more clearly (Abdi, 2010). This more sensitive measurement suggests that reading a set of interfering texts before a set of related target texts impairs readers’ ability to discriminate between the information read in the target texts versus information from elsewhere. This is in line with the retrieval perspective of proactive interference (Wixted & Rohrer, 1993), where people are not able to restrict their search set to just the target information (i.e., they have trouble discriminating target from non-target information). This supports our suspected sourcing issue. Specifically, participants may have had trouble focusing their search in order to differentiate relevant from irrelevant items (Johnson, Hashtroudi, & Lindsay, 1993), and/or they may have had their memory for irrelevant items activated, causing trouble for them as they tried to limit their search set to only the relevant target information (O’Brien, Cook, & Guéraud, 2010; Seifert, 2014).

The analysis of \(d'\) did provide additional evidence to support the interaction between item origin and topic overlap—specifically the earlier mentioned findings regarding item origin that suggested that the memory advantage coming from reading unrelated texts compared to related texts entails both the ability to make correct rejections of information from earlier-read non-target texts coupled with the ability to better correctly identify information from target texts. The interaction was supported further by the difference in the sensitivity index \(d'\) between the
unrelated and related text set readers suggesting that reading several related texts makes it more difficult to discriminate between the potential origins of the related information during a later retrieval attempt (i.e., what is target information and what is non-target information, be it from non-target texts or from elsewhere). This gives us insight into the mechanisms behind the benefit of unrelated texts since, in order for the unrelated text condition to score a higher $d'$ score (which they did), they essentially need to have a higher hit rate and a lower false alarm rate.

The $d'$ analysis also provided additional support for the lack of benefit of directed forgetting instructions on proactive interference effects when comparing the sensitivity index $d'$ of those who received directed forgetting instructions and those who did not. Consistent across both experiments, it suggests that attempting to intentionally forget the already-read texts midway through reading a series of texts does not increase the ability to discriminate between target information (i.e., that read after the forget instructions) and non-target information beyond that of trying to instead remember all of the read texts. Additionally, there was again no influence of the relatedness of texts on the effectiveness of directed forgetting instructions at reducing proactive interference effects, which is inconsistent with the results of Golding et al. (1994). Altogether, despite $d'$ being a more sensitive measure, the effects found through these analyses for both Experiments 1 and 2 mirrored the effects found in preceding ANOVA analyses and thus did not add notably to our findings.

Of particular importance are the results of our analyses examining reading time of the instructions given between the interfering and target text sets as a mediator of the relationship between the instructions (i.e., to either forget or remember the interfering set) and memory for the target texts. Specifically, we were interested in investigating the possibility of one-sided non-compliance, where participants in one condition opt into another condition, which typically
happens when participants in the experimental condition do not comply with the treatment (the directed forgetting instructions in this case; Huang, 2018). In the current situation, we suspected that participants in the directed forgetting condition did not follow the instructions that we gave to them (i.e., forgetting the first set of texts and only needing to remember the second set of texts). Though the results showed inconsistencies across experiments, they suggest that one-sided non-compliance may contribute to why we did not see the expected results for the directed forgetting condition—namely that they would have better memory for target texts than the proactive interference condition.

**Limitations and Future Directions**

Counter to our expectations, the current research was importantly not able to find evidence that directed forgetting instructions can help reduce the detrimental effects of proactive interference when reading a series of texts. We encourage future studies to examine the research question further by using different materials or methodology. It is possible that our use of recognition memory measures may have contributed to these null results as previous research has shown inconsistent findings with some studies using recognition measures finding an effect of directed forgetting and others not finding an effect (e.g., Basden & Basden, 1996). Thus, we encourage future research to explore if this was indeed the case. Research that directly compares recognition memory measures to recall measures in this context of reading multiple texts, or research that implements remember/know judgments after each questions would help to unravel the reasons behind this null effect.

Additionally, though we found increased intrusions from non-target texts in the proactive interference condition, we did not find poorer memory for target texts as expected. Again, using recognition memory measures may have also led to this unexpected finding (see yea-saying and
the dual-process theory; e.g., Yonelinas, 2002). Studies such as those outlined above would help us to also better understand these results.

Furthermore, in Experiment 2 when we used two sets of texts that were not semantically related to each other, based on research by Golding et al. (1994) we expected to see that the directed forgetting condition would help to eliminate the effects of proactive interference (compared to when both sets of texts were related). It is important to note that the current research used texts and list-method directed forgetting, whereas Golding et al. used paired words and item-method directed forgetting. Either or both of these differences may have contributed to our difference in findings, and future research will need to be done to determine if this was the case.

Several of our analyses showed results that were trending toward significance, thus it may be the case that our experiments were underpowered. A priori power analyses using G*Power (Faul, Erdfelder, Lang, & Buchner, 2007) suggest that we would likely have been able to find medium-sized effects using a sample size of around 125-150 with a significance criterion of $\alpha = .05$ and power $= .80$. Future research is encouraged to include data from more participants in order to increase power.

**Conclusion**

Overall, the results of the current work were mixed regarding their alignment with our hypotheses. Several analyses and results have been discussed, but there are perhaps four main findings from this research that ought to be addressed. First, regarding proactive interference, we found the expected increased intrusion rates from non-target texts in the proactive interference condition, though we did not find poorer memory for target texts as expected. In other words, readers of related texts were less accurate in their attempt to differentiate earlier-read, irrelevant
texts from target texts. Second, this detrimental effect of proactive interference was more prevalent when the presented sets of texts were on related topics compared to when they were unrelated. Third, in regards to directed forgetting, we were unable to find results suggesting that directed forgetting instructions helped eliminate or reduce the detrimental effects of proactive interference in this context of reading a series of texts. Fourth, though we had expected directed forgetting to have a stronger effect when the two sets of texts were on unrelated topics compared to when they were on the same topic, this was not the case. Exploratory analyses using reading time, response time, $d'$, and one-sided non-compliance could not shed conclusive light on a secure explanation for these results. We encourage future research in this context of multiple text comprehension that either incorporates a direct comparison between recognition and recall memory measures and/or a direct comparison between item-method and list-method directed forgetting.
References


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Appendix

Experiment 1 Texts

Set A. Social media outlets are beneficial for society because colleges and universities can use them to recruit and retain students. Colleges and universities use Facebook apps and other social media tools to increase student retention. Social networking sites are also being used to give commuting students a support system, especially when they have no in-person social network.

Social networking sites are beneficial for society because they allow students to improve their current relationships and make new friends. 52% of teens using social media report that the sites help to maintain their current friendships with people they cannot see regularly, while 69% report social networking sites encourage students to make new connections with classmates at their school.

Being a part of a social networking site can benefit a person's quality of life and reduce their risk of health problems. Social media can improve life satisfaction, stroke recovery, memory retention, and overall well-being by providing users with a larger social group. Additionally, friends on social media can have a "contagion" effect for healthy living, promoting exercise, dieting, and smoking cessation goals.

Social networking sites are detrimental for society because users are vulnerable to security attacks such as hacking, identity theft, and viruses. Many social media users share their birth date publicly, as well as their high school name, phone number, or pet's name; each of those pieces of information is frequently used for account security verification and can be used for identity theft.

Social networking sites are detrimental for society because they lack privacy and expose
users to government and corporate intrusions. The 2009 IRS training manual teaches agents to scan Facebook pages for information that might "assist in resolving a taxpayer case." Five million Facebook users have "liked" a health condition or medical treatment page, information that is sometimes used by insurance companies to raise rates.

Social media outlets are detrimental for society because they harm employees' productivity. Two-thirds of US workers with Facebook accounts access the site during work hours. Even spending just 30 minutes a day on social media websites while at work would cost a 50-person company 6,500 hours of productivity a year.

Social media is detrimental for society because, if users do not use networking sites conscientiously, artists’ content can be posted without license, attribution, or payment. Vogue Spain, for example, was accused of stealing New York street photographer Sion Fullana's Instagram photos and posting them to their own Instagram feed without acknowledging the source.

Social media is beneficial for society because educators from around the world can interact with each other and bring guest teachers, librarians, authors, and experts into class via social networking tools like Skype. Edmodo, an education-specific social networking site designed for contact between students, teachers, and parents, reached over ten million users on Sep. 11, 2012.

Social media networking sites are beneficial for society because they spread information faster than any other media. Over 50% of people learn about breaking news on social media. For example, Twitter and YouTube users reported the 2012 Aurora, Colorado theater shooting before news crews could arrive on the scene, and the Red Cross urged witnesses to tell family members they were safe via social media outlets.
Social networking sites are detrimental for society because their location-based “checking in” services could expose sensitive whereabouts and endanger military personnel and journalists. For example, in 2011, a Mexican journalist was murdered by the Zetas drug cartel because she used Twitter to report on cartel crime.

**Set B.** Social media outlets are beneficial for society because they allow people to collectively accomplish a goal through "crowdsourcing" and "crowdfunding". A mother was able to find a kidney donor for her sick child by posting a video on her Facebook page. Also, crowdfunding charity projects raised $845,989 for Hurricane Sandy victims.

Social networking sites are detrimental for society because they aid the spread of hate groups and hateful speech. A 2012 Baylor University study examined Facebook hate groups focused on President Barack Obama and found a resurgence of racial slurs and stereotypes not seen in mainstream media in decades. Also, a splinter faction of the white supremacist group Aryan Nation uses social media to recruit new members and to redistribute their propaganda.

Social networking sites are beneficial for society because they help senior citizens feel more connected to society. According to a 2010 study, people over 74 years of age are the fastest growing demographic on social media sites with the percentage quadrupling from 2008 to 2010. Seniors report feeling happier due to online contact with family and their church community.

Social networking sites are detrimental for society because they encourage amateur advice and self-diagnosis for health problems, which can lead to harmful or life-threatening results. For example, a Twitter search for "eczema" found in the first 100 results, 84 were spam and several others gave harmful advice.

Social networking sites are detrimental for society because they entice people to waste time. 40% of 8 to 18 year olds spend an hour a day on social media sites. When people receive
new tweets or Facebook messages, they take 20-25 minutes on average to return to their original task. In 30% of cases, it took two hours to fully return attention to the original task.

Social networking sites are beneficial for society because they offer a way for musicians and artists to build audiences even if they don’t have a corporate contract. 64% of teenagers listen to music on YouTube, trumping radio and CDs as today’s music "hit-maker." For example, pop star Justin Bieber was discovered on YouTube when he was 12 years old, and, in 2012 at 18 years old, his net worth was estimated at $80 million.

Social networking sites are beneficial for society because they can facilitate political change. Social networking sites give social movements a quick, no-cost method to organize, disseminate information, and mobilize people. In 2011, the Egyptian uprising, organized largely via social media, motivated tens of thousands of protest demonstrations and, ultimately led to the resignation of Egyptian President Mubarak.

Social networking sites are detrimental for society because they facilitate cyberbullying. 49.5% of students reported being the victims of bullying online and 33.7% reported committing bullying behavior online. Adults can also be victims of cyberbullying, from social, familial, or workplace aggression being displayed on social media sites.

Social media sites are beneficial for society because they help employers find employees and job-seekers find work. 64% of employment companies use two or more social networks for recruiting because of the wider pool of applicants and more efficient searching capabilities. Moreover, one in six recent hires credit social media in helping them find their current job.

Social networking sites are detrimental for society because they enable the rapid spread of unreliable and false information resulting in real world impacts. Earlier this year, hackers took over the Associated Press Twitter account and falsely claimed that there had been explosions at
the White House and that the president was hurt, triggering financial panic at the stock market (which plunged 143 points).

Additional Experiment 2 Texts

**Set A-Unrelated.** Standardized tests are beneficial for society because teacher-graded assessments involve subjective and unreliable scoring. Research has shown that many teachers take into account non-cognitive outcomes, including participation, effort, progress, and behavior, which are irrelevant to subject-matter mastery.

Standardized tests are detrimental for society because they drastically narrow the curriculum that is covered. Since 2001, 44% of school districts have reduced the time spent on science, social studies and the arts by an average of 145 minutes per week in order to focus on reading and math, subjects that are on standardized tests.

Standardized tests are detrimental for society because they are not objective. A 2002 study found that scores vary due to subjective decisions made during test design and administration. Simply changing the relative number of algebra and geometry questions in the National Assessment of Educational Progress altered the score gap between African American and Caucasian students.

Standardized testing is beneficial for society because it helps prevent "social promotion," the practice of allowing students to advance to the next grade even if they have not met the academic standards. Florida's initiative to end social promotion, holding back students who failed year-end standardized tests, improved those students' scores by 9% in math and 4% in reading after one year.

Standardized testing is beneficial for society because it helps to prepare students for college. In 1998, 66% of college professors said "elementary and high schools expect students to
learn too little.” By 2002, after a surge in testing related to the passing of No Child Left Behind, that figure dropped to 47% “in direct support of higher expectations, strengthened standards and better tests.”

Standardized tests are beneficial for society because they can help diagnose schools’ strengths and weaknesses. In 2013, high schools in Middletown, NJ outperformed those in Trenton, NJ on the standardized test on science. Because of this comparison, high schools in Trenton are now working toward improving their science program based on some of the teaching methods used in Middletown.

Standardized testing is detrimental for society because each state develops its own No Child Left Behind standards and assessments, providing no basis for meaningful comparison. A student taking the Connecticut Mastery Test (CMT), for example, is asked a completely different set of questions from a student in California taking the Standardized Testing and Reporting (STAR) test. While the former includes essay questions, the latter is entirely multiple-choice.

Standardized tests are detrimental for society because "teaching to the test" is replacing good teaching practices with "drill n' kill" rote learning. A five-year study found the pressures associated with No Child Left Behind lead to declines in teaching higher-order thinking, and in the actual amount of high cognitive content in the curriculum.

Standardized tests are beneficial for society because they help teachers and students focus on essential content and skills. This eliminates time-wasting activities that don't produce learning gains, and motivates students to excel. The US Department of Education stated in 2004 that "if teachers cover subject matter required by the standards and teach it well, then students will master the material on which they will be tested--and probably much more."
Standardized tests are detrimental for society because they have not improved student achievement. After the No Child Left Behind act passed in 2002, the US slipped from 18th in the world in math on the Program for International Student Assessment to 31st place in 2009, with a similar drop in science and no change in reading. The report found no evidence that test-based incentive programs are working to improve achievement and education.