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Putting Retrieval-Induced Forgetting in Context: An Inhibition-Free, Context-Based Account

Tanya R. Jonker, Paul Seli, and Colin M. MacLeod
University of Waterloo

We present a new theoretical account of retrieval-induced forgetting (RIF) together with new experimental evidence that fits this account and challenges the dominant inhibition account. RIF occurs when the retrieval of some material from memory produces later forgetting of related material. The inhibition account asserts that RIF is the result of an inhibition mechanism that acts during retrieval to suppress the representations of interfering competitors. This inhibition is enduring, such that the suppressed material is difficult to access on a later test and is, therefore, recalled more poorly than baseline material. Although the inhibition account is widely accepted, a growing body of research challenges its fundamental assumptions. Our alternative account of RIF instead emphasizes the role of context in remembering. According to this context account, both of 2 tenets must be met for RIF to occur: (a) A context change must occur between study and subsequent retrieval practice, and (b) the retrieval practice context must be the active context during the final test when testing practiced categories. The results of 3 experiments, which directly test the divergent predictions of the 2 accounts, support the context account but cannot be explained by the inhibition account. In an extensive discussion, we survey the literature on RIF and apply our context account to the key findings, demonstrating the explanatory power of context.

Keywords: memory, retrieval-induced forgetting, context, inhibition, competition

Although forgetting is commonly perceived as an inconvenience, it is an exceptionally important function of memory. Forgetting allows us to update memory and to prevent bombardment by irrelevant information. Additionally, it allows us to filter relevant from irrelevant information, thereby freeing us from an overabundance of information that we no longer want or have use for (see Bjork, 1989; James, 1890). To better understand the mechanisms underlying forgetting, memory researchers have focused on conditions that promote forgetting. Surprisingly, one of these conditions is that of retrieval. Although it is well known that retrieving some material from memory benefits the later recall of that practiced material (e.g., Karpicke & Roediger, 2008; McDaniel & Masson, 1985), retrieval also consistently produces forgetting. Specifically, the act of retrieval impairs later memory for nonretrieved but related material. For example, retrieving the item *peach* from memory can impair the later recall of other fruit items that were not previously retrieved, such as *cherry*. This phenomenon has been labeled *retrieval-induced forgetting* (RIF), a term introduced by Anderson, Bjork, and Bjork (1994).

The standard procedure employed to investigate RIF involves three key phases: study, retrieval practice, and a final test. In the initial study phase, participants typically study a number of category–exemplar word pairs individually (e.g., FRUIT–*peach,* FRUIT–*cherry,* SPORT–*golf*; Anderson et al., 1994; Anderson & Spellman, 1995), although other materials have been shown to produce RIF as well (e.g., personality characteristics, Macrae & MacLeod, 1999; visuospatial materials, Ciranni & Shimamura, 1999; eyewitness memory scenes, Shaw, Bjork, & Handal, 1995). During the second phase, participants then practice retrieving some of the exemplars by completing category-cued word stems (e.g., FRUIT–*pe*___ for the retrieval of the studied exemplar *peach*). Critically, this retrieval practice is performed on half of the items from half of the categories, so participants might practice retrieval from the FRUIT category but not the SPORT category, and within the FRUIT category they might practice retrieving *peach* but not *cherry* (see Figure 1). This retrieval practice creates three types of items: the practiced items (*peach,* denoted RP+), the unpracticed items that are related to the practiced items through shared category membership (*cherry,* denoted RP−), and the baseline items from categories in which no items are practiced (*golf,* denoted NRP).

Following a delay, participants complete a final recall test during which they attempt to recall all of the studied exemplars. This procedure typically produces two findings. The first is a benefit of retrieval practice: Practiced items (RP+) are better recalled than items from baseline categories in which no items were practiced (NRP). This finding is not surprising, given that repeated exposures or retrievals typically benefit later memory for

Tanya R. Jonker, Paul Seli, and Colin M. MacLeod, Department of Psychology, University of Waterloo, Waterloo, Ontario, Canada.

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Correspondence concerning this article should be addressed to Tanya R. Jonker, Department of Psychology, University of Waterloo, 200 University Avenue West, Waterloo, Ontario N2L 3G1, Canada. E-mail: trjonker@uwaterloo.ca

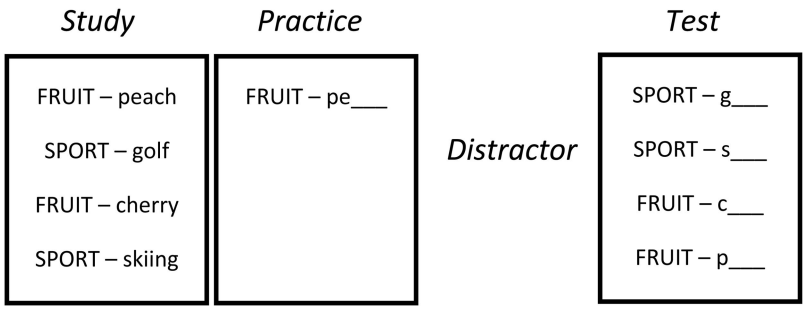

Figure 1. The three-phase procedure of a typical retrieval-induced forgetting (RIF) experiment.

those items (e.g., McDaniel & Masson, 1985; Roediger & Karpicke, 2006). The second finding, however, is rather surprising. In addition to benefiting the practiced items, retrieval practice produces a cost whereby the unpracticed related items (RP−) are recalled more poorly than the unpracticed unrelated items (i.e., NRP; see Figure 2). Thus, retrieval practice of some items induces later forgetting of related items.

The RIF paradigm has enhanced understanding of how we remember and how we forget and, consequently, has become a popular tool in memory research. Much of the excitement about RIF stems from the mechanism most frequently invoked to explain the forgetting: The dominant theory of RIF asserts that an *inhibition* mechanism produces the cost of retrieval. This inhibition account—harking back to Freud's (1896/1962) idea of "repressed memories" and Wundt's (1902) idea of "reactive inhibition"—has a long history in experimental psychology (see MacLeod, 2007, for a review). It was first put forward by Anderson et al. (1994) and Anderson and Spellman (1995) as an explanation of RIF and was more completely articulated by Anderson (2003) in his review article on interference and inhibition. More recently, Storm and Levy (2012) have provided an update on the theory.

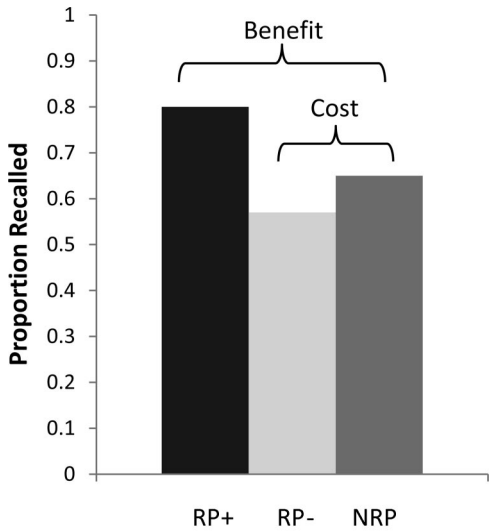

Figure 2. Hypothetical data for recall during the final test, demonstrating the benefit (RP+ > NRP) and cost (RIF: RP− < NRP) of retrieval practice. RP+ = practiced items; NRP = baseline items with no category items practiced; RIF = retrieval-induced forgetting; RP− = unpracticed items sharing category membership with practiced items.

According to the inhibition account of RIF, forgetting of the RP− items occurs because some items are inhibited during retrieval practice. Specifically, when a category label is presented as a retrieval-practice cue, items that are strongly associated with the category name are activated and compete for retrieval, creating substantial competition-induced interference. For example, when one sees the cue FRUIT–*pe*__, strongly associated exemplars such as *orange, banana,* and *cherry* might be activated and compete for retrieval. To reduce the interference caused by these competitors and to facilitate retrieval of *peach,* one suppresses the memory representations of the competitors. Critically, the inhibition account asserts that this suppression is enduring, making these inhibited items (RP−) more difficult to access on a later test.

The mechanism of inhibition was the first and remains the most prominent explanation of RIF. There are a few key properties of this inhibition account (Anderson, 2003). First, although the practiced (RP+) items are strengthened due to retrieval practice, the inhibition account asserts that forgetting of the RP− items is not due to interference from the strengthened RP+ items during the final test. Instead, forgetting of the RP− items occurs because these RP− items cause interference during retrieval practice and are thereby suppressed. Previous experiments have demonstrated that replacing retrieval practice with extra study (i.e., a phase during which participants receive extra study presentations of some items rather than practicing their retrieval) results in better recall of the items that received extra study but no forgetting of the related material that appeared only in the initial study phase (e.g., Anderson & Bell, 2001; Bäuml, 2002). That is, there is a benefit for the items that received extra study without any cost to categorically related items. This finding has been used as support for the inhibition account, which argues that competition-induced interference during retrieval is necessary for inhibition because "inhibition is driven by the need to override interference from competing memories during the selective retrieval of target items" (i.e., interference dependence; Anderson, 2003, p. 420). In the case of extra study presentations, suppression should not occur because retrieval practice—and therefore retrieval competition—is absent.

Another key property of this account is that inhibition occurs on the item's memory representation, rather than on the episodic association between category and exemplar (Anderson & Spellman, 1995). Thus, the suppressed representation should be less accessible—or possibly inaccessible—even when a novel unstud-

ied cue is used to elicit the item. For example, if a participant engaged in retrieval practice of FRUIT–*peach,* and if *cherry* was a competitor and thereby suppressed, the representation of *cherry* should be difficult to recall on the later test even when a novel cue such as *RED–c___* is used. This property of the inhibition account, labeled *cue independence,* has received some support from empirical work (e.g., Anderson & Spellman, 1995; Johnson & Anderson, 2004; Saunders & MacLeod, 2006; see the General Discussion for a review).[1]

Inhibition accounts have also been used to explain other effects in memory and attention, although an inhibition mechanism has not been described consistently across the different domains. In the attention literature, inhibition has been used to explain phenomena such as negative priming, inhibition of return, and preview search. Inhibition has also been used as an explanatory framework for a number of memory paradigms, such as directed forgetting, part-list cuing, and the think/no-think effect. Although the inhibition account was an accepted explanation for a time, it has since been challenged and has even fallen out of favor in several of these areas (e.g., negative priming, Milliken, Joordens, Merikle, & Seiffert, 1998; inhibition of return, Pratt, Spalek, & Bradshaw, 1999; part-list cuing, Basden & Basden, 1995; directed forgetting, Sahakyan & Kelley, 2002; think/no-think, Tomlinson, Huber, Rieth, & Davelaar, 2009; for a review, see MacLeod, Dodd, Sheard, Wilson, & Bibi, 2003).

The directed forgetting literature provides a good example of how an inhibition account has been challenged by a noninhibitory account. In a list-method directed forgetting experiment, participants study one list of items and are then told either to remember that list of items for a later test (remember condition) or to forget that list of items (forget condition). Following the forget or remember instruction, participants study a second list of items, which they are told to remember. Like RIF, this manipulation results in both a cost and a benefit: There is a benefit for List 2 in the forget condition, as participants remember more List 2 items in the forget than the remember condition, and there is a cost for List 1 in the forget condition, as participants remember fewer List 1 items in the forget than the remember condition (for reviews, see Bjork, Bjork, & Anderson, 1998; MacLeod, 1998). The cost to List 1 in the forget condition has been explained as the product of an inhibitory mechanism (e.g., Bjork & Bjork, 1996). Specifically, this inhibition account asserts that the entire set of List 1 items is inhibited (cf. the inhibition account of RIF, where the related item rather than the entire List 1 episode is inhibited; Anderson, 2003). The inhibition of List 1 as a unit means that participants later have difficulty accessing the contents of that list.

For some time, the inhibition account of list-method directed forgetting was the dominant explanation (for a review, see MacLeod, 1998). However, Sahakyan and Kelley (2002) provided data that could not be explained by the inhibition account (see also Mulji & Bodner, 2010; Pastötter & Bäuml, 2007; Sahakyan, 2004; Sahakyan & Goodmon, 2010). Sahakyan and Kelley (2002) instead argued for a context account, maintaining that the forget instruction that separates List 1 from List 2 encourages participants to shift their internal context for the presentation of the second list; this shift creates a context marker between List 1 and List 2. The impairment for List 1 in the forget condition results because the final test context retains the context of List 2 (the immediately preceding context) rather than that of List 1 (the earlier context). Thus, the distinct instructions between List 1 and List 2 make the List 1 items less accessible, because these items are associated with a context that is no longer in place. In support of their theory, Sahakyan and Kelley found that the induction of context reinstatement for List 1 significantly reduced both the cost and the benefit of directed forgetting.

Although the inhibition account has lost momentum as the sole explanatory framework in some of these other areas in attention and memory, it is still the most widely accepted explanation of RIF. Indeed, RIF is seen as the best support for inhibitory mechanisms in memory research, and the literature suggests that "retrieval-induced forgetting" and "inhibition" have become nearly synonymous. Some researchers have used the RIF paradigm as a tool in studies of clinical populations with the purpose of measuring the inhibitory faculties of these special populations (e.g., Alzheimer's disease, Moulin et al., 2002; schizophrenia, Nestor et al., 2005; Soriano, Jiménez, Román, & Bajo, 2009; dysphoria, Moulds & Kandris, 2006). This equation of RIF with inhibition has led researchers to make very bold claims, such as "Inhibitory processes in memory are impaired in schizophrenia" (Soriano et al., 2009), which can lead to fundamental misunderstandings about clinical populations (this error has also occurred in the directed forgetting literature; e.g., depressed individuals, Power, Dalgleish, Claudio, Tata, & Kentish, 2000; repressors, Myers, Brewin, & Power, 1998). Indeed, equating a theoretical mechanism with a behavioral effect is highly problematic in any area of research, as it limits openness to exploring the effect and can lead to erroneous conclusions about the cognitive processes involved.

If RIF is to be treated as an appropriate litmus test for inhibition, its primary assumptions must be explicitly tested and verified. Yet, with only a handful of exceptions, published articles on RIF have focused on evidence supportive of the inhibition account rather than on tests of its assumptions. Recently, we and others have applied rigorous testing to some of the fundamental assumptions of the inhibition account, showing RIF when inhibition predicts none (e.g., Jonker & MacLeod, 2012) and a lack of RIF when inhibition predicts its presence (e.g., Jonker, Seli, & MacLeod, 2012). Such findings suggest that the inhibition account does not hold up under direct testing. Furthermore, in recent reviews, Verde (2012) and Raaijmakers and Jakab (2013) have extensively examined the claims of the inhibition account and have argued that the account is poorly specified and that its theoretical status is problematic.

With this backdrop, we set out to consider an alternative explanation, to which we now turn. (The findings that challenge the inhibition account are more extensively reviewed in the General Discussion.)

A Context Account

In this article, we present and test an alternative approach to the inhibition account of RIF. Our account instead emphasizes the pivotal role of context in the RIF paradigm.

[1] A neural network model by Norman, Newman, and Detre (2007) employs inhibition as a mechanism, but this model predicts cue independence only under certain conditions (see also Hanczakowski & Mazzoni, 2013). In the present article, we focus specifically on the inhibition account put forward by Anderson and colleagues (e.g., Anderson, 2003).

Memory is highly contextual: Reactivating context information during retrieval can facilitate remembering (for reviews, see Eich, 1980; Smith & Vela, 2001) and, in fact, context can be represented in a number of ways. Memory can benefit from the use of context information from the physical environment (e.g., Smith, 1979), semantic relations (e.g., Pan, 1926), background features such as color (e.g., Dulsky, 1935), and mood (e.g., Eich, 1995; Macht, Spear, & Levis, 1977), to name a few. Furthermore, even thinking about the physical study environment can benefit memory when the testing environment is novel (Smith, 1979), and thinking about what the test environment will be like (i.e., preinstatement) can result in memorial benefits on that later test (Brinegar, Lehman, & Malmberg, 2013).

Interestingly, context can be represented internally when moving from one task to another. An example of internal context comes from Jang and Huber (2008), who demonstrated that engaging in a retrieval process caused participants to shift their internal context such that words studied before retrieval of an irrelevant set of items were more poorly remembered than words studied in a condition with no retrieval task (see also Sahakyan & Hendricks, 2012). Indeed, across a wide range of memory phenomena, researchers have considered the role of internal contexts and the use of these contexts as memory aids (e.g., Bäuml & Samenieh, 2010, 2012a, 2012b; Howard & Kahana, 2002; Mulji & Bodner, 2010; Polyn, Norman, & Kahana, 2009; Sederberg, Gershman, Polyn, & Norman, 2011; Unsworth, Spillers, & Brewer, 2012).

Given this central role of context in remembering, we undertook to consider the role that internal context might play in the RIF paradigm. In fact, a possible role for context in RIF has been mentioned previously, first by Anderson and Bjork (1994) and later in work by Perfect et al. (2004); Camp, Pecher, and Schmidt (2007); Verde and Perfect (2011), and Jonker et al. (2012). However, no one has (a) clearly articulated the predictions of a context account of RIF, (b) explicitly tested the role of context in RIF, or (c) applied a context explanation to the body of RIF literature. Our purpose in the present article is to do precisely these things.

Our context account of RIF is based on recent research demonstrating that retrieval processing can cause participants to shift their mental context (e.g., Jang & Huber, 2008; Sahakyan & Hendricks, 2012). Extending this finding to the standard RIF paradigm, we postulate that moving from the study phase to the subsequent retrieval practice phase produces a context shift that results in there being two distinct contexts—a study context and a practice context—either of which may be reinstated during the final test.[2]

Our context account has two fundamental tenets, and we postulate that RIF will occur only when both of these tenets are met. The first is that there must be a context change between the study phase and the practice phase. The second is that the practice context—not the study context—must be reinstated when the practiced categories are tested during the final test.

Tenet 1: A Context Change Must Occur Between Study and Practice

During the study phase in the RIF paradigm, participants concentrate on learning the presented items (e.g., FRUIT–*peach*). During the retrieval practice phase, they switch to active consideration of multiple alternatives with the goal of selecting the best fit with the retrieval cue. Given previous work demonstrating that retrieval can cause a context shift (Jang & Huber, 2008; Sahakyan & Hendricks, 2012), it is plausible that the standard RIF paradigm routinely invokes a context shift between the study phase and the practice phase.[3] We argue that this context shift produces two distinct internal contexts: the study context and the practice context.

Tenet 2: The Practice Context Must Be Active During Testing of Items From Practiced Categories

The second tenet that we propose as necessary for producing RIF is differential context cuing for RP− and NRP items. According to our account, the category name that is presented as a cue during the final test prompts reinstatement of either the study context or the practice context. We predict that RIF will occur on the final test only when the practice context is reinstated for the practiced categories and when the study context is reinstated for the NRP categories. When the practice context is reinstated for the practiced categories during the final test, the RP− items, which unlike the RP+ items belong only to the study context, will not benefit from context reinstatement. However, when the study context is reinstated for the NRP items—something that happens routinely because the study context is the only context that contained NRP items—there will be a memorial benefit for these items. This difference is critical for RIF because when this tenet is met, the NRP items will benefit from context reinstatement, whereas the RP− items will not, impeding their recall relative to the NRP items and thereby producing the RIF effect.

To clarify the effect that context reinstatement could have on item retrieval in the RIF paradigm, we provide an example, illustrated in Figure 3. When an NRP category label (e.g., SPORT) is presented during the final test, there is only one relevant context—the study context—because NRP items only occurred during study. Thus, presentation of an NRP category name will necessarily prompt the reinstatement of the study context such that all of the NRP exemplars will benefit from context reinstatement. This event is depicted in Panel A of Figure 3. Practiced categories (FRUIT), on the other hand, have two relevant contexts because exemplars from these categories were presented during both the study phase and the practice phase; that is, the category name is closely tied to both the study and the practice contexts. In the standard RIF paradigm, our context account predicts that the practice context will be preferentially reinstated because it is more recent and/or because

[2] We will sometimes refer to the intervening context as simply the practice context rather than the retrieval practice context, because, in addition to the standard retrieval practice condition, it could involve a number of different types of practice, including extra-list generations (e.g., Jonker & MacLeod, 2012), impossible retrievals (e.g., Storm, Bjork, Bjork, & Nestojko, 2006), or extra study (e.g., Anderson & Bell, 2001; Bäuml, 2002).

[3] The active consideration of multiple alternatives is also part of the inhibition account, but the inhibition account then argues that a suppression mechanism acts on many of these competitors. We instead suggest that it is the act of active search for a target that causes a distinct shift in context; when participants are faced with a task that involves search, they shift their mental context to more appropriately deal with the demands of the new task.

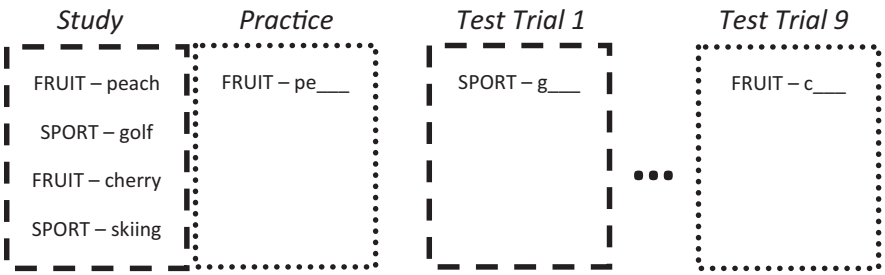

Figure 3. An illustration of the prevailing context during the study phase, the practice phase, and two sample trials from the test phase in the RIF paradigm. The study phase and the practice phase each constitute distinct contexts, represented by boxes with different border patterns. The border of each test box represents the context present during that specific test trial. In the standard RIF paradigm, we propose, the study context is reinstated during the test of an unpracticed (NRP) category (Test Trial 1), whereas the practice context is available during the test of a practiced category (Test Trial 9), producing a reinstatement benefit for NRP items but not for RP− items. Note that Test Trials 2 through 8 would be of NRP items, because all of the items from one category were tested sequentially. RIF = retrieval-induced forgetting; RP− = unpracticed items sharing category membership with practiced items.

the encoding of the RP+ is more elaborative. When the practice context is reinstated, the RP− items (*cherry*), which are tied only to the study phase, will not benefit from context reinstatement (see Panel B of Figure 3).

The difference in the use of context during the final test can entirely explain the recall difference between RP− and NRP items: RP− items are more poorly recalled because they do not have the advantage of appropriate context information at the time of test, whereas NRP items do benefit from the appropriate context information.

In sum, our context account predicts that RIF will occur only when there are two discrete contexts (Tenet 1) and when the practice context is active during the final test for practiced categories (Tenet 2). In situations where there is no context shift between the study phase and the practice phase or when the test cues reinstate the study context rather than the practice context, RIF will not occur because the study context will now be active during the final test for both the NRP items and the RP− items and, therefore, the NRP items and the RP− items will benefit equally from context reinstatement.

The Present Study

In the present experiments, we tested this context account of RIF, focusing on the two tenets that we have proposed as necessary for the production of RIF-like effects. In Experiments 1 and 2, we tested the first tenet: that a context change between study and practice is necessary for producing RIF. To do so, we made use of the extra-study variant of the RIF paradigm. In this variant, retrieval practice is replaced by additional presentations of some of the items for further study (RP+).[4] Typically, the extra-study variant of the RIF paradigm produces a recall advantage for the extra-study items but no forgetting of the related items (RP−) relative to the NRP items.

The inhibition account claims that RIF is absent in the extra-study variant because no retrieval competition is present (Anderson, 2003). Our context account, however, holds that a context shift is necessary for a RIF-like effect to arise (Tenet 1). In the extra-study variant, moving from study to extra study does not involve retrieval. Consequently, there should be no context change. By analogy to Sahakyan and Kelley's (2002) list-method directed forgetting work, the extra-study variant of the RIF paradigm is much like the remember condition, where no context shift occurs between List 1 and List 2, whereas the standard RIF paradigm parallels the forget condition, where a context shift is thought to occur between List 1 and List 2. Thus, in cases where participants perform extra study rather than retrieval practice, our account predicts no context change; instead, there will be only one context that contains both study and practice phases. Because the first tenet of our account is not met in the extra-study variant, our account predicts the absence of RIF, which is precisely what has been observed in the extant literature (e.g., Anderson & Bell, 2001).

In Experiment 1, we first replicated the finding that engaging in extra study during the practice phase does not result in a RIF-like effect.[5] Then, in Experiment 2a, we built on the extra-study variant by including a context-shift manipulation between study and practice, again with the practice phase involving only extra study of some of the items. Under the inhibition account, there should be no RIF-like effect for the RP− items because the extra study during practice does not produce competition-induced interference between related exemplars and therefore precludes the need for inhibition. Under the context account, however, the shift in context satisfies our first required tenet, and likely our second required tenet of the use of the practice context during the final test, due to the recency and/or the stronger encoding in the practice context. Therefore, our context account predicts a RIF-like effect in Experiment 2a, even though practice involves extra study without retrieval practice.

[4] Although no retrieval practice occurred, for continuity, we use the standard notation for the items receiving extra study (RP+) and for their relatives without extra study (RP−).

[5] To be accurate in our labels, we refer to this behavioral effect as "the RIF-like effect" rather than as "RIF" because the extra-study variant of the RIF paradigm does not involve retrieval. Thus, the RIF-like effect refers to the pattern of poorer recall for items that are categorically related to the practiced items.

Experiments 2b and 3 tested the second tenet of our context account: namely, that the practice context, rather than the study context, must be reinstated during testing of practiced categories for RIF to occur. As stated earlier, our account postulates that in the standard RIF paradigm, the category name guides context reinstatement. In the case of NRP categories, only the study context is relevant because items from this category appeared exclusively during the study phase. Thus, when testing NRP categories, the category name will lead to reinstatement of the study context, and retrieval of these items will benefit from context reinstatement. In the case of practiced categories, on the other hand, both study and practice contexts are relevant because items from practiced categories appeared in the study context (i.e., RP+ and RP− items) and in the practice context (i.e., RP+ items). Therefore, when testing practiced categories, the category name is an undiscriminating cue because it is associated with two distinct learning contexts (study and practice). Thus, in the absence of additional cues, participants must rely on the category name alone to guide retrieval, which will lead to the reinstatement of the practice context for practiced categories, due to the recency and/or elaboration that occurred in the practice context, and consequently to RIF. If, however, additional information were provided to assist in discriminating between the study and practice contexts, participants would likely give this additional information priority over the category label when tested on practiced categories. Indeed, recent research has demonstrated that cues function best when they are discriminative (e.g., Goh & Lu, 2012; Poirier et al., 2012). The category name for practiced categories is not discriminative because it is associated with both the study context and the practice context. Therefore, it is plausible that participants would use the additional context cues, rather than the category label, to aid retrieval. If participants do in fact use this information to guide their search to the appropriate context, they will be able to reinstate the study category during testing of RP− items. This would in turn lead to context-reinstatement benefits for RP− items, thereby eliminating RIF.

To test the second tenet of our account and to provide converging methods and conceptual replications, we employed two different techniques that have been successfully used to reinstate context. Experiment 2b explored context reinstatement in the extra-study variant. Experiment 3 explored context reinstatement in the standard RIF paradigm. In both of these experiments, we hypothesized that RIF would not occur when the study context is reinstated during the final test because the RP− items would now benefit from context reinstatement, equating their recall with that of the NRP items.

We designed these experiments so that the inhibition account and our context account made opposing predictions in some cases. Specifically, the inhibition account predicts no RIF-like effect in Experiments 1, 2a, and 2b because there is no retrieval competition between related exemplars (due to the practice phase involving only additional study) and therefore no need for suppression of competitors. However, our context account predicts a RIF-like effect in Experiment 2a because a context change occurs. Furthermore, the inhibition account predicts RIF in Experiment 3 regardless of context reinstatement because—according to that account—the representations of competing items are inhibited during retrieval practice and therefore any attempts to access the inhibited representations should be prone to failure (Anderson, 2003). Our context account, on the other hand, predicts no RIF when the study context is reinstated during the final test in Experiment 3 (i.e., failure to meet Tenet 2).

Experiment 1: Extra Study During Practice

Our first experiment was a replication of the extra-study variant of the RIF paradigm, which typically yields no RIF-like effect (e.g., Anderson & Bell, 2001; Ciranni & Shimamura, 1999; Hulbert, Shivde, & Anderson, 2012). Participants first studied category–exemplar word pairs, then restudied half of the items from half of the categories, and finally performed a cued-recall test on all of the items. Critically, the middle phase involved extra study rather than retrieval practice.

The inhibition account and our context account make similar predictions for the results of Experiment 1 but for different reasons. The inhibition account predicts no RIF-like effect because extra study should not cause retrieval competition between exemplars, hence obviating the need to inhibit the unpracticed related items. The context account also predicts no RIF, instead attributing the absence of the RIF-like effect to the absence of a context shift between study and practice: Practice is simply extra study, thereby resulting in a single learning context containing both study and practice. This is represented visually in Panel A of Figure 4. Because the study and extra-study practice phases are represented as one context, the first required tenet of our context account is not met. Further, the second required tenet—cuing of the practice phase for practiced categories—cannot be met because two distinct contexts do not exist. Experiment 1 allowed us to replicate the extra-study effect using our stimuli and procedure, and it provided us with the foundation to explore the two competing accounts in Experiment 2.

Method

Participants. Thirty students (6 male, 24 female, ages 18 to 23 years, $M = 19.4$ years) were recruited from the University of Waterloo's Research Experiences Group and received partial course credit in exchange for their participation. All participants reported normal or corrected-to-normal vision and English as their most fluent language. Participants in all subsequent experiments were recruited in the same manner and under the same parameters, with no individual taking part in more than one experiment in this series.

Materials. As in much of the previous RIF research, category–exemplar stimulus pairs were selected from the category norms provided by Battig and Montague (1969). Exemplars were selected such that each had a unique first letter within its category. Participants studied stimuli from six categories, each with eight exemplars, resulting in 48 category–exemplar word pairs. These stimuli were used in all subsequent experiments.

Stimuli were displayed in 20-pt Times New Roman font on a 17-in. monitor by a PC computer, and all responses were captured with E-Prime 2.0 software.

Procedure. Upon their arrival at the experiment, participants read and signed informed consent while the *Star Wars* theme song played. This method was borrowed from Sahakyan and Kelley (2002) and was used to clearly mark the beginning of the experiment. This addition became important in Experiment 2b and was included in Experiments 1 and 2a for the purpose of maintaining consistency across these experiments.

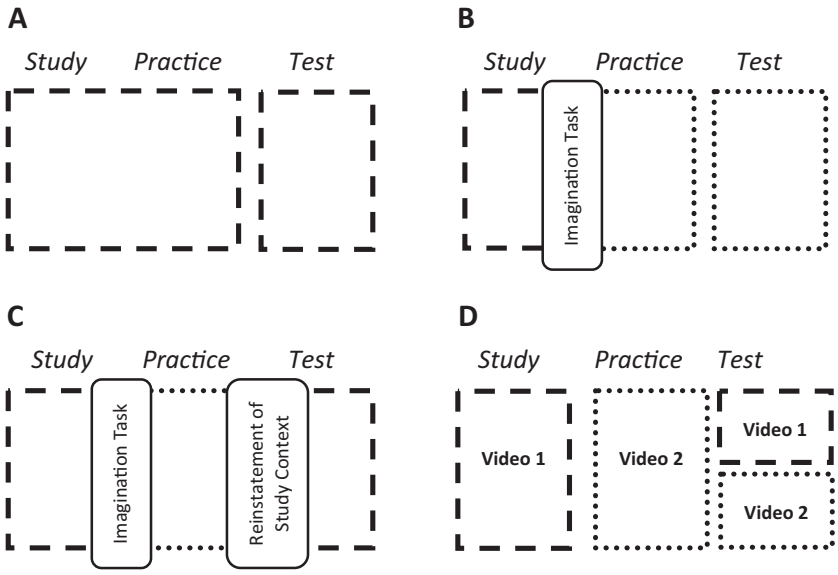

Figure 4. The predicted representation and use of context for practiced categories in Experiments 1, 2a, 2b, and 3. The border of each test box represents the context present during each phase (note that the reinstated test context in this figure is for the practice categories only; for NRP categories, the reinstated context during test will always be the study context). In Experiment 1 (Panel A), study and practice are represented as one context, because, in the absence of retrieval, a context shift does not occur. In Experiment 2a (Panel B), the study and practice contexts are made distinct through the use of the imagination task; during testing of the practice categories, the practice context is reinstated, which leads to RIF. In Experiment 2b (Panel C), the study and practice contexts are again distinct, but the study context is reinstated prior to the final test, which abolishes RIF. In Experiment 3 (Panel D), the video presented at test is either from the study or from the practice phase, which encourages reinstatement of either the study context or the practice context, respectively. NRP = baseline items with no category items practiced; RIF = retrieval-induced forgetting.

Following consent, participants completed four phases: a study phase, an extra-study phase (i.e., practice), a distractor task, and a final test. During the study phase, participants saw the 48 category–exemplar word pairs on the computer screen. Each pair was displayed individually at the center of the screen in white font against a black background for 5 s. The category names were always displayed in uppercase font, and the exemplars were always displayed in lowercase font, with a dash separating them (e.g., FRUIT–*peach*). The presentation order of the category–exemplar pairs was randomized throughout the study phase with the restriction that no two pairs from the same category appeared back-to-back.

Following the study phase, half of the exemplars from half of the categories were randomly selected for extra study (i.e., four exemplars from each of three categories). To ensure that participants were attending to and encoding the items presented during the extra-study phase, they were required to say the pairs aloud. Each pair was presented three times during this extra-study phase, with items from the same category separated by a minimum of one pair from another category.

Following the retrieval-practice phase, participants completed a 5-min distractor task during which they produced the names of as many countries as they could (Macrae & Roseveare, 2002).

For the final test, we included a control for the influence of output interference. It has been suggested that reductions in recall of RP− items can be due to output interference from the strengthened RP+ items, which might be recalled first in a free recall test as a result of their greater strength (Anderson et al., 1994). The NRP items are recalled in all output positions, however; therefore, comparing the recall of the RP− items to NRP items would include the confound of different output order and, consequently, different degrees of output interference. To minimize this possibility, we provided item-specific cues during the test (e.g., FRUIT–*p*___). With this, we prompted the recall of the four RP− items in a category first, followed by the four RP+ items from that category (e.g., Jonker & MacLeod, 2012; Jonker et al., 2012).[6] A one-letter word stem was shown along with its category name, and participants were given up to 10 s to make a response. As is usually done in RIF studies (e.g., Anderson et al., 1994), testing was blocked by category such that all items from one category were tested together before any items from another category were tested.

Results and Discussion

All statistical analyses throughout this article used an alpha level of .05 for determining statistical significance. To provide an ap-

[6] It is worth noting that this procedural detail biases the results against the context account, because testing of the RP− items first—which occurred only in the study context—might lead the participants to reinstate the study context rather than the practice context.

propriate baseline for RP− and RP+ items, which occurred in different testing positions, we divided NRP items in each category in half based on their own testing positions. NRP1 items, like RP− items, were from testing positions 1 to 4 of a category; NRP2 items, like RP+ items, were from testing positions 5 to 8 (see Table 1). Recall data were analyzed with a repeated-measures analysis of variance for each condition. Two planned comparisons examined (a) the benefit of extra study for the practiced items (RP+ > NRP2) and (b) the cost of extra study for the related items (RP− < NRP1).

The mean proportions of correct recall during the final test are presented in Figure 5. Overall, recall for RP+, RP−, NRP1, and NRP2 items differed, $F(3, 87) = 9.75$, $MSE = 0.02$, $p < .001$, $\eta_p^2 = .25$. The first planned comparison revealed a significant benefit of extra-study practice for the practiced items: Participants recalled more RP+ items than NRP2 items, $t(29) = 3.46$, $SE = .04$, $p < .01$, $d = 0.63$. More important, the second comparison revealed no significant cost to the RP− items: Participants recalled an equal proportion of RP− and NRP1 items, $t(24) = 0.40$, $SE = .03$, $p = .70$.

The predictions of both the inhibition account and the context account were confirmed: A RIF-like effect did not occur when extra study occurred in the place of retrieval practice, replicating previous findings (e.g., Anderson & Bell, 2001; Ciranni & Shimamura, 1999). According to the inhibition account, a RIF-like effect was not observed because the absence of retrieval practice precludes competition; consequently, there was no need for inhibition. Our context account, on the other hand, predicts the absence of the RIF-like effect because the context did not shift between the very similar phases of study and extra study, much as in the remember condition of a list-method directed forgetting experiment.

Experiment 2a: Extra Study Plus Context Change

In our second experiment, we designed a procedure for which the inhibition account and the context account make divergent predictions (see Table 2 for a summary of predictions made by the two accounts across all of our experiments). The first required tenet of our context account is that of context change. If the study phase and the extra-study phase are represented as one context (as depicted in Panel A of Figure 4), the RIF-like effect is not expected to occur. Rather, our account predicts a RIF-like effect only if (a) a context change occurs and (b) the extra-study context is reinstated for practiced categories during the final test (this tenet is assumed to be routinely met anytime there are two distinct contexts). To test this hypothesis, we induced a context shift between study and extra-study using an instruction that has previously been shown to induce context change (Sahakyan & Kelley, 2002; see Panel B of Figure 4). With two discrete contexts, we met the first required tenet of our context account. Additionally, given that the practice context will likely be highly accessible for the final test because of its recency and/or relative strength over the initial study context, we also met the second required tenet of our account. Having met these two conditions, our context account predicts that the RP− items will be deprived of the context reinstatement benefit that the NRP items receive and will consequently result in a RIF-like effect.

The inclusion of a context change does not change the prediction of the inhibition account, which maintains that a RIF-like effect will not be observed because there is no competition between items in the absence of retrieval practice; therefore, suppression of competitors is not required. Thus, Experiment 2a pits the context and inhibition accounts against each other.

Table 1
Examples From the Stimulus Set, Together With a Demonstration of Exemplar Type Based on Position Within an Item's Category During the Final Test

Testing position	Item type	FRUIT	Item type	SPORT
1	RP−	peach	NRP1	golf
2	RP−	blueberry	NRP1	fishing
3	RP−	mango	NRP1	lacrosse
4	RP−	grape	NRP1	hockey
5	RP+	cherry	NRP2	rugby
6	RP+	tangerine	NRP2	volleyball
7	RP+	watermelon	NRP2	skiing
8	RP+	raspberry	NRP2	polo

Note. RP− = unpracticed items sharing category membership with practiced items; RP+ = practiced items; NRP = baseline items with no category items practiced; NRP1 items, like RP− items, were from testing positions 1 to 4 of a category; NRP2 items, like RP+ items, were from testing positions 5 to 8.

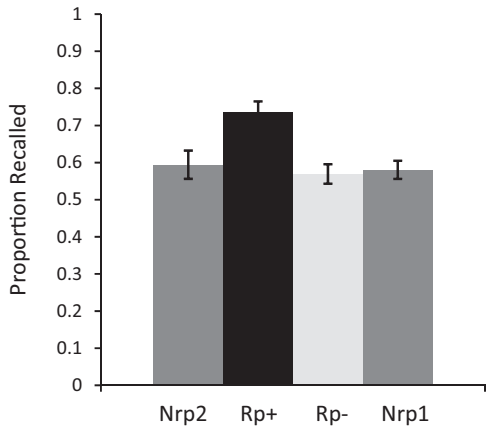

Figure 5. Experiment 1: Mean proportions of exemplars recalled during the final test. The error bars represent one standard error of their respective means. RP+ = practiced items; RP− = unpracticed items sharing category membership with practiced items; NRP = baseline items with no category items practiced; NRP1 items, like RP− items, were from testing positions 1 to 4 of a baseline category; NRP2 items, like RP+ items, were from testing positions 5 to 8.

Method

Participants. Data from one participant were removed from analyses due to a number of fast response times (RTs) without exemplar recall during the final test (RT < 1,000 ms). Thus, analyses included data from 30 participants (14 male, 16 female, ages 18 to 27 years, $M = 19.3$ years).

Procedure. The procedure was identical to that of Experiment 1 with one change: After the initial study phase and before the extra-study phase, participants were guided through an imagination task that was intended to produce a context change. During

Table 2
Predictions of the Inhibition Account and of the Context Account of Retrieval-Induced Forgetting in Our Experiments

Theory	Experiment 1	Experiment 2a	Experiment 2b	Experiment 3	
				Video 1	Video 2
Inhibition account	No RIF	No RIF	No RIF	RIF	RIF
Context account	No RIF	RIF	No RIF	No RIF	RIF

Note. Experiments 1 and 2 incorporated extra study during the practice phase; Experiment 3 incorporated retrieval practice during the practice phase. RIF = retrieval-induced forgetting.

this imagination task, participants were given 1 min to imagine their parents' house, including the furniture and rooms, and to draw a quick sketch of the layout. This context-setting task was derived from the directed forgetting research of Sahakyan and Kelley (2002).

Results and Discussion

The data are presented in Figure 6. Overall, recall for RP+, RP−, NRP1, and NRP2 items differed, $F(3, 87) = 11.69$, $MSE = 0.02$, $p < .001$, $\eta_p^2 = .29$. The first planned comparison revealed a significant benefit of extra-study practice for the practiced items; participants recalled more RP+ items than NRP2 items, $t(29) = 5.39$, $SE = .03$, $p < .001$, $d = 0.98$. Critically, the second planned comparison showed that the RP− items were more poorly recalled than were the NRP1 items, $t(29) = 2.20$, $SE = .03$, $p = .04$, $d = 0.40$; that is, we observed a RIF-like effect in the extra-study variant.

Although it has previously been shown that replacing retrieval practice with extra study does not produce a RIF-like effect (e.g., Anderson & Bell, 2001; Bäuml, 2002; our Experiment 1), inserting a context change between the initial study phase and the extra-study phase did produce a RIF-like effect. These results are entirely consistent with the prediction of the context account, but they directly conflict with the prediction of the inhibition account (see Table 2). This experiment is the first demonstration of a RIF-like effect under conditions where the practice phase involved extra study rather than retrieval practice.

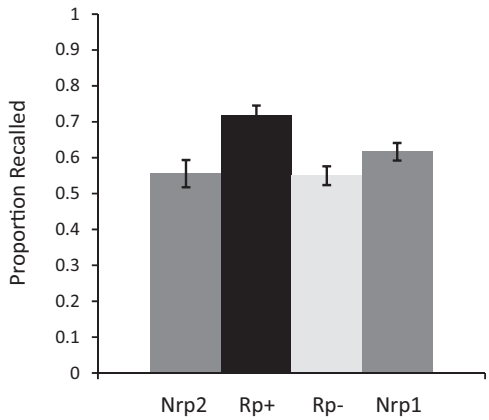

Figure 6. Experiment 2a: Mean proportions of exemplars recalled during the final test. The error bars represent one standard error of their respective means. RP+ = practiced items; RP− = unpracticed items sharing category membership with practiced items; NRP = baseline items with no category items practiced; NRP1 items, like RP− items, were from testing positions 1 to 4 of a baseline category; NRP2 items, like RP+ items, were from testing positions 5 to 8.

Experiment 2b: Extra Study, Context Change, and Context Reinstatement

According to our context account, the RIF-like effect occurred in Experiment 2a because both of the required tenets of our account were met: First, there was a context change between study and practice, and second, participants accessed the practice context rather than the study context upon presentation of any test cue associated with RP+ and RP− items. This should, according to our account, deprive the RP− items of the memorial benefit of context reinstatement that is afforded to the NRP items. Consistent with this line of reasoning, our account predicts that a RIF-like effect will not occur if the study context, rather than the practice context, is accessed during the final test, because the RP− items will benefit from context reinstatement and will be recalled at a rate that is equivalent to that of the NRP items (see Figure 7). In such a scenario, although the first required tenet of our account will be met (i.e., a context shift between study and extra study), the second required tenet of accessing the extra-study context will not be met.

To test this prediction, we next included a context-reinstatement instruction (Sahakyan & Kelley, 2002) prior to the final test (see Panel C of Figure 4). In using this reinstatement method, we assume that reinstating the study context just once, prior to the final test, is sufficient to provide access to the study context throughout the entire testing period. Consistent with this assumption are results from experiments involving mental reinstatement of a study environment, in which the initial reinstatement instructions aided participants throughout a free recall task, even though the instructions were provided only once, prior to beginning the final test (see, e.g., Fisher, Geiselman, MacKinnon, & Holland, 1984; Krafka & Penrod, 1985; Malpass & Devine, 1981; Smith, 1979, 1984).

The inhibition account predicts the same outcome for this experiment as does our context account, but it does so for a very different reason. As with Experiments 1 and 2a, the inhibition account predicts no RIF-like effect given that there is no competition among items because retrieval practice does not take place; consequently, there is no need to suppress competitor items. Thus, if we fail to observe a RIF-like effect in Experiment 2b, this outcome will be consistent with both accounts. However, a failure to observe a RIF-like effect here, in conjunction with the observed

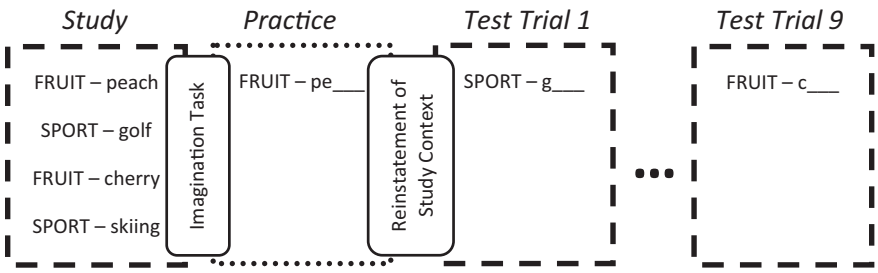

Figure 7. An illustration of the prevailing context during the study phase, the practice phase, and two sample trials from the test phase in Experiment 2b. In contrast with Figure 3, the study context is reinstated during testing of both NRP and practiced categories. Consequently, according to our context account, there should be no RIF-like effect.

RIF-like effect in Experiment 2a, would clearly indicate that the use of context successfully predicts when RIF-like effects will be present and when they will be absent.

Method

Participants. Thirty students participated in Experiment 2b (6 male, 24 female, ages 18 to 23 years, $M = 19.3$ years).

Procedure. The procedure differed from that of Experiment 2a in two ways: (a) The distractor task was shortened to 2 min, and (b) participants were guided through a 3-min context reinstatement task following the distractor task and immediately prior to the final test. The distractor task was shortened to keep the interval between extra study and the final test at 5 min, as was the case in Experiments 1 and 2a. During the context reinstatement task, participants heard a series of questions pertaining to their experiences prior to arriving at the study room, upon arriving at the study room, and during the study phase; they were given time to write responses to each question. This task was borrowed from Sahakyan and Kelley (2002, p. 1068) and was designed to reinstate the initial study context at the time of test.

Results and Discussion

The data are presented in Figure 8. Overall, recall for RP+, RP−, NRP1, and NRP2 items differed, $F(3, 87) = 6.56$, $MSE = 0.03$, $p < .001$, $\eta_p^2 = .19$. The first planned comparison revealed a significant benefit of extra-study practice for the practiced items; participants recalled more RP+ items than NRP2 items, $t(29) = 5.62$, $SE = .03$, $p < .001$, $d = 1.03$. Critically, the second planned comparison revealed a nonsignificant difference in the recall of RP− items and NRP1 items, $t(29) = 0.39$, $SE = .05$, $p = .70$; that is, no RIF-like effect was observed.

Although we demonstrated a RIF-like effect following the context change manipulation in Experiment 2a, the added manipulation of study context reinstatement in Experiment 2b abolished this RIF-like effect. The context account predicts no RIF-like effect in Experiment 2b, because rather than relying solely on the category name to reinstate context—which would favor the practice context in the case of practiced items—participants could instead use the reinstatement instructions as a cue to the more appropriate study context when being tested on items from practiced categories. Given that the study context is always reinstated during testing of NRP items, these items would likewise benefit from context reinstatement. Hence, according to our context account, both the RP− and the NRP items benefited equally from context reinstatement such that no RIF-like effect occurred.

Recall that our context account suggests that, during testing of single items, participants switch back and forth between the study and the practice contexts, with this switching being dependent on the presented category name. Specifically, presentation of NRP category names will lead to reinstatement of the study context (because this is the only context in which NRP items were presented), whereas presentation of category names of the practiced items (i.e., RP+ and RP−) will lead to reinstatement of the practice context in the absence of any additional context cues. Thus, one might claim that, because participants effectively switch back and forth between these two contexts on the basis of the category names, the presence of context-reinstatement instructions prior to the final test should be negligible. This claim would require that the category names themselves be the sole determinants of context reinstatement and, consequently, that RIF should

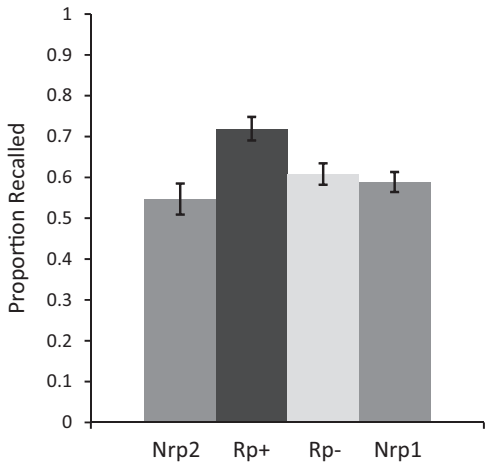

Figure 8. Experiment 2b: Mean proportions of exemplars recalled during the final test. The error bars represent one standard error of their respective means. RP+ = practiced items; RP− = unpracticed items sharing category membership with practiced items; NRP = baseline items with no category items practiced; NRP1 items, like RP− items, were from testing positions 1 to 4 of a baseline category; NRP2 items, like RP+ items, were from testing positions 5 to 8.

be observed irrespective of whether context is reinstated prior to the final test. We theorize instead that, although participants can (and do) use the category names to guide reinstatement, when they are provided with additional information that can guide context reinstatement, and especially when that additional information is better able to discriminate between the contexts than is the category name, participants will use this information rather than the category name to guide reinstatement. Thus, for each category during the final test, participants can use the context information provided to them during the reinstatement instructions, rather than the category name; this will provide them with access to the study context when tested on practiced categories, which will abolish the RIF-like effect.

The interpretation of the absence of the RIF-like effect in Experiment 2b rests on the demonstration of the presence of the RIF-like effect in Experiment 2a, making the results of Experiment 2a crucial. To ensure that our results are robust, we replicated Experiments 2a and 2b.

Replications of Experiments 2a and 2b

Method

Participants. Thirty students (4 male, 26 female, ages 18 to 33 years, $M = 19.7$ years) participated in the replication of Experiment 2a. For the replication of Experiment 2b, data from one participant were removed from analyses due to a number of extremely fast RTs without exemplar recall during the final test (RT $<$ 1,000 ms). This resulted in data from 30 students in Experiment 2b. Demographic information for five participants was lost (of the 25 participants with this information, there were 11 male and 14 female participants, with ages 18 to 36 years, $M = 20.4$).

Results and Discussion

Replication of Experiment 2a. The results of Experiment 2a replicated. Overall, recall for RP+, RP−, NRP1, and NRP2 items differed ($M = .72, .54, .63, .51$, respectively), $F(3, 87) = 17.65$, $MSE = 0.02$, $p < .001$, $\eta_p^2 = .38$. As in Experiment 2a, there was a significant benefit of extra-study practice for the RP+ items relative to the NRP2 items, $t(29) = 6.00$, $SE = .04$, $p < .001$, $d = 1.09$. Critically, there was also a significant cost for the RP− items relative to the NRP1 items, $t(29) = 2.78$, $SE = .03$, $p = .01$, $d = 0.51$.

Replication of Experiment 2b. The results of Experiment 2b also replicated. Overall, recall for RP+, RP−, NRP1, and NRP2 items differed ($M = .66, .56, .57, .49$, respectively), $F(3, 87) = 6.66$, $MSE = 0.02$, $p < .001$, $\eta_p^2 = .19$. As in Experiment 2b, there was a significant benefit of extra-study practice for the RP+ items relative to the NRP2 items, $t(29) = 4.36$, $SE = .04$, $p < .001$, $d = 0.80$, but there was no significant difference in recall between the RP− and NRP1 items, $t(29) = 0.21$, $SE = .04$, $p = .84$.

Interaction for Extra-Study Practice Experiments

These replications demonstrate (a) the consistent presence of a RIF-like effect with just the context-shift manipulation between study and practice, and (b) the consistent absence of the RIF-like effect following the study context reinstatement instruction. To analyze this difference in the RIF pattern, we combined the data from the original Experiments 2a and 2b with their replications. The interaction between RIF (RP− recall, NRP1 recall) and the two experimental groups (context change, context change + study reinstatement) was significant, $F(1, 118) = 4.74$, $MSE = 0.02$, $p = .03$, $\eta_p^2 = .04$. This pattern is exactly as predicted by our context account, but it contradicts the predictions of the inhibition account.

Experiment 3: Video Contexts

In Experiment 3, we explored the effects of context using retrieval practice rather than extra study. Here, we investigated whether reinstatement of the study context during the final test would eliminate the RIF effect, paralleling the goal of Experiment 2b. To do so, we incorporated context cues into the study and practice phases, which allowed us to manipulate the particular context that was reinstated during the final test. As was the case in Experiment 2b, reinstatement cues should be better than category names at discriminating between the study and practice contexts, and should therefore be preferred when reinstating context. Thus, when reinstatement cues are relevant to the practice context, that context should be reinstated and the RP− items should not benefit from context reinstatement; under these conditions, our account predicts the presence of RIF. In contrast, when the reinstatement cues are relevant to the study context, that context should be reinstated and the RP− items should benefit from context reinstatement; under these conditions, our account predicts the absence of RIF.

In our exploration of the context literature, we sought to identify a context manipulation that would produce a strong effect. The environmental context effect, as realized through changing physical environments, has been shown to be relatively small ($d = 0.28$, Smith & Vela, 2001). However, in a recent article, Smith and Manzano (2010) demonstrated that manipulating context by superimposing study items onto a video of an everyday context produced a considerably larger context effect than did changing physical environments (d greater than 2.00). We therefore adopted this method for our manipulation of context in Experiment 3.

In Experiment 3, participants studied category–exemplar word pairs along with a set of context videos and then performed retrieval practice on half of the items from half of the categories while viewing a second set of new context videos. During the final test, some participants were provided with the videos that they had viewed during retrieval practice as additional cues to help them reinstate the practice context (mimicking what we propose happens in a standard RIF experiment; herein called the standard condition). Other participants were provided with the videos that they had viewed during the study phase to help them reinstate the study context (study reinstatement condition; see Panel D of Figure 4).

Under the inhibition account, both the standard condition and the study reinstatement condition should produce RIF because retrieval practice is present and because context is irrelevant to inhibition. Under the context account, however, RIF should occur only in the standard condition because the practice context is reinstated for practiced categories during the final test; in the study reinstatement condition, RIF should not occur because the study

context is reinstated during the final test (see the summary of predictions in Table 2).

Method

Participants. Prior to conducting the experiment, we set a minimum criterion for retrieval practice requiring that participants complete at least half of the retrieval practice stems if their data were to be included in the analyses. Our logic was that if participants are not practicing retrieval, they are not undergoing the key manipulation. On this basis, we removed data from four participants due to low retrieval practice success rates (< 50%). Data from two participants with NRP recall less than 2.5 standard deviations below the mean were also removed.[7] Thus, analyses included data from 164 participants (69 male, 95 female, ages 18 to 28 years, $M = 19.8$ years).

Materials. Nine 5-s video clips were selected from a set of clips provided by Smith and Manzano (2010). They were selected to be distinct from one another (e.g., a panorama of a kitchen, a fire truck racing down the street).

Procedure. During the study phase, a video clip was presented at the center of the screen and a category–exemplar word pair was presented immediately above the video. The total duration of each presentation was 8 s, as the word pair remained on the screen for an additional 3 s after the video stopped. Participants were instructed to remember the word pair along with its associated video. The same video was paired with all of the items from the same category. Thus, there were six unique videos presented during the study phase, one randomly assigned to each category.

During the retrieval-practice phase, a new video was paired with each category (three videos for the three practiced categories). For example, during the study phase, FRUIT and all of its exemplars might have been paired with a video displaying a fire truck racing down the street, whereas during the retrieval-practice phase, the RP+ items from the FRUIT category might have been paired with a video displaying a home kitchen. During the final test, one of these two videos was presented while participants were tested on the items from that practiced category. Participants assigned to the study reinstatement condition were shown the video presented with the relevant category during the study phase (e.g., fire truck), whereas participants assigned to the standard condition were shown the video presented with that category during the retrieval-practice phase (e.g., home kitchen). Given that NRP items appear only during the study phase, each NRP category was paired with only one video. Therefore, in both the study reinstatement and the standard conditions, the categorically relevant video was displayed as a testing cue for each of the NRP categories.

During the final test, the video clip began 2 s prior to the presentation of the category cue and the one-letter word stem; once the test cue appeared, participants were allowed to type their response. This procedure was used to encourage participants to attend to the context video before making their response. All of the other parameters of the final test were identical to those of Experiment 1.

Results and Discussion

Participants performed well on the retrieval-practice task, correctly completing 90% of the word stems in the standard condition and 91% of those in the study reinstatement condition.

The data are presented in Figure 9. Overall, recall for RP+, RP−, NRP1, and NRP2 items differed in the standard condition, $F(3, 243) = 61.45$, $MSE = 0.02$, $p < .001$, $\eta_p^2 = .43$, and in the study reinstatement condition, $F(3, 243) = 36.35$, $MSE = 0.02$, $p < .001$, $\eta_p^2 = .31$. In both standard and study reinstatement conditions, there was a significant benefit of practice for the retrieval-practiced items, $t(81) = 10.25$, $SE = .02$, $p < .001$, $d = 1.13$, and $t(81) = 10.77$, $SE = .02$, $p < .001$, $d = 1.19$, respectively. The conditions differed, however, in comparisons of RP− and NRP1 recall. Significant forgetting of RP− items occurred in the standard condition, $t(81) = 6.49$, $SE = .02$, $p < .001$, $d = 0.72$, but not in the study reinstatement condition, $t(81) = 1.63$, $SE = .02$, $p = .11$.

Most critically, the interaction between RIF (RP−, NRP) and the two experimental groups (standard, study reinstatement) was significant, $F(1, 162) = 7.50$, $MSE = 0.02$, $p < .01$, $\eta_p^2 = .04$. This finding is as predicted by our context account but contradicts the predictions of the inhibition account.

To further investigate the interaction, we performed four independent-samples t tests comparing the standard to the study reinstatement conditions for each of RP+, RP−, NRP1, and NRP2. Recall of RP+, NRP1, and NRP2 items did not differ across the two conditions, $t(162) = 0.42$, $SE = .02$, $p = .68$; $t(162) = 0.14$, $SE = .004$, $p = .89$; and $t(162) = 0.04$, $SE = .001$, $p = .97$, respectively. Recall of RP− items, however, differed significantly across groups, $t(162) = 3.03$, $SE = .08$, $p < .01$, $d = 0.47$. Thus, reinstating the study context rather than the practice context during the testing of practiced categories had no impact on the recall of RP+ or NRP items; reinstatement benefited only the RP− items, which typically incur a cost when the study context is not reinstated.

General Discussion

Numerous experiments have demonstrated that extra study of a subset of categorized items does not lead to forgetting of other previously studied members of that category (e.g., Experiment 1 of the present work; Anderson & Bell, 2001; Ciranni & Shimamura, 1999). According to the inhibition account, RIF does not occur with extra study because extra study does not elicit retrieval competition between related exemplars, which makes suppression of the unpracticed related exemplars unnecessary.

However, when we induced a context change (using an imagination task) between the initial study phase and the extra study phase, we observed a RIF-like effect (Experiment 2a and its replication). The presence of a RIF-like effect during the extra-study phase provides support for our context account by confirming that the first of our two required context-based tenets for RIF is indeed necessary: The emergence of RIF requires a context change between the study phase and the extra-study phase.

[7] The pattern of results did not differ if these participants' data were included in the analyses.

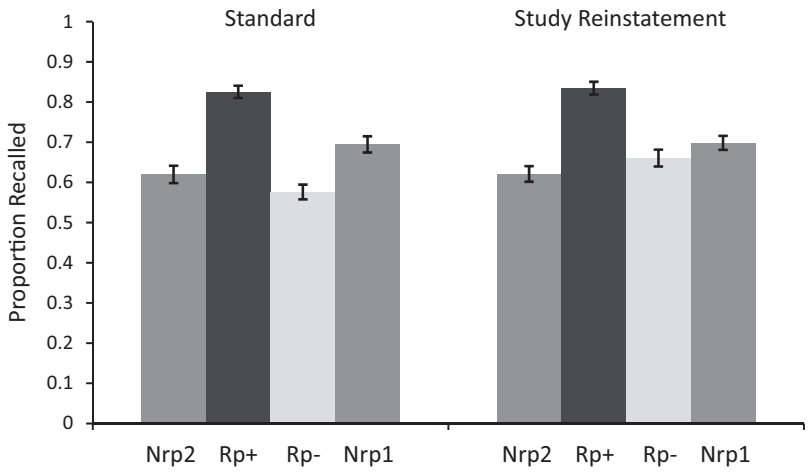

Figure 9. Experiment 3: Mean proportions of exemplars recalled during the final test by condition. The error bars represent one standard error of their respective means. RP+ = practiced items; RP− = unpracticed items sharing category membership with practiced items; NRP = baseline items with no category items practiced; NRP1 items, like RP− items, were from testing positions 1 to 4 of a baseline category; NRP2 items, like RP+ items, were from testing positions 5 to 8.

Moving a step further, we then included a context-reinstatement manipulation immediately prior to the final test. When participants were led to reinstate the study context, the RIF-like effect no longer occurred (Experiment 2b and its replication). This finding provides additional support for our context account by confirming that the second of our two required tenets is also necessary: The practice context (rather than the study context) must be cued when testing recall of items from practiced categories to produce the RIF pattern. In Experiment 3, which involved retrieval practice instead of extra study, we further tested the second required tenet of our account using context videos, and we again observed RIF when the practice context was reinstated but no RIF when the study context was reinstated.

These results provide powerful evidence for the effect of context on forgetting in the RIF paradigm. Indeed, the importance of context becomes clear when one examines the different processes that occurred across the study and practice contexts. In Experiment 3, the study items were viewed only once, whereas the RP+ items underwent retrieval practice three times. This would clearly result in much stronger encoding of the items in the practice context relative to those in the study context; yet, RIF did not occur when the study context was reinstated despite the disproportionate strengthening of items across the two contexts. This finding suggests that participants did in fact rely on the context cues (i.e., the videos in this experiment) to guide their memory search to the study context rather than the practice context. When these results are viewed in this light, it is quite clear that the context manipulations were critical in determining RP− recall.

RP+ Recall and Context

There is one result that might at first glance appear to conflict with our context account: The recall of the RP+ items was not affected by our context manipulations. Specifically, during the final test in Experiments 2b and 3, although participants reinstated the study context rather than the practice context, we did not observe a change in RP+ recall. It might be argued that RP+ recall should have been adversely affected by reinstating the study context because when the study context is accessed during testing of practiced categories, participants might not have access to the additional RP+ strengthening that occurred during the practice phase.

To better understand this apparent puzzle, consider previous research on encoding in multiple contexts. Indeed, Smith (1982) conducted an experiment in which he had participants study a list of words either three times in one physical environment or three times in three different environments. Participants were then tested either in one of the environments in which they had studied or in a novel environment. Smith found that participants recalled more items when they were tested in a studied environment—replicating the context-dependent memory effect—but only when they had encoded the list three times in the same environment. When participants had instead encoded the list in three different environments, the testing environment had no effect on their ability to recall the words, and recall was equivalent whether testing occurred in a novel environment or in a study environment (see also Smith, 1984).

This finding might explain why we did not find differences in RP+ recall across our different conditions. Specifically, RP+ items are encoded in multiple contexts and are therefore, according to Smith's (1982, 1984) work, not vulnerable to forgetting due to context change. Rather, RP+ items encoded in multiple contexts will be recalled at a similar rate irrespective of the context available at final test precisely because their encoding is distributed across multiple contexts. Therefore, at final test, the presentation of the category name will prompt access to the practice context, but this will provide no benefit to recall; indeed, participants would recall these RP+ items well irrespective of the reinstated context.

Applying the Context Account to the RIF Literature

In a recent metatheoretical article, De Houwer (2011) discussed the logic of inferring a mental construct (in this case, inhibition) based on behavioral effects (in this case, RIF). Specifically, he wrote,

> For a behavioral effect [e.g., RIF] to be a proxy of a mental construct [e.g., inhibition], it does not suffice that the effect can be explained on the basis of the mental construct. . . . To make the reverse inference from the presence of the effect to the presence of the mental construct, the mental construct needs to be a necessary condition for the effect (i.e., the effect can be present only if the mental construct is present). If it turns out that the behavioral effect [RIF] can be caused by other mental constructs [context] in the absence of the to-be-registered mental construct [inhibition], then the presence of the behavioral effect [RIF] does not allow one to draw firm conclusions about the to-be-registered mental construct [inhibition]. (De Houwer, 2011, p. 203)

In our experiments, we have demonstrated that the behavioral effect—RIF—can be caused by manipulations of context in the absence of any possible inhibition, which challenges the status of inhibition in RIF as conceptualized by Anderson (2003). Although it is quite possible that more than one mechanism underlies RIF, one must question whether inhibition is a necessary theoretical mechanism. Recent work from our laboratory (Jonker & MacLeod, 2012; Jonker et al., 2012) and from other laboratories (e.g., Jakab & Raaijmakers, 2009; Perfect et al., 2004; Raaijmakers & Jakab, 2012), together with extensive reviews of the problematic status of the inhibition account (Raaijmakers & Jakab, 2013; Verde, 2012), suggests that explicit tests of the fundamental assumptions of the inhibition account fail to support it.

This body of research lays the groundwork for alternative theoretical accounts of RIF. To demonstrate that our context account is a viable candidate beyond our own data, we now review key findings in the RIF literature. Here we cover both cases viewed as being supportive of the inhibition account and cases in which inhibition has failed at proving itself to be necessary for RIF. Our goal is to reframe these findings under our context account.

In his theoretical article on the role of inhibition in RIF, Anderson (2003) laid out four properties that provide unique support for the inhibition account of RIF. These properties are (a) retrieval specificity, (b) interference dependence, (c) strength independence, and (d) cue independence. In the section that follows, we list the key findings that support each of these properties of inhibition, review the empirical findings that challenge these properties, and then reframe these findings in terms of context and context change. In so doing, we intend to broaden understanding of the context account and to provide fertile terrain for future research on the role of context in RIF.

Retrieval specificity. According to the inhibition account, RIF "should only arise [when] a related memory interferes with the retrieval of a target item and triggers inhibitory control" (Anderson, 2003, p. 420). In other words, suppression of RP− items will occur only when retrieval attempts elicit retrieval competition from RP− items. At least two predictions can be derived from this assumption: (a) strengthening the RP+ items through extra study or some other nonretrieval process will not produce RIF-like effects, and (b) a retrieval task that does not elicit retrieval competition from RP− items during practice of RP+ items will not produce RIF.

The property of retrieval specificity has been supported by empirical findings. As noted earlier, replacing retrieval practice with extra study presentations has been shown to produce no impairment to RP− items (prediction 1; e.g., Anderson & Bell, 2001). As further support for the property of retrieval specificity, Anderson, Bjork, and Bjork (2000) used noncompetitive retrieval in the place of standard retrieval practice in an attempt to test the second prediction of retrieval specificity (i.e., that a retrieval task that does not elicit retrieval competition will not produce RIF). Anderson et al. replaced exemplar retrieval (e.g., *FRUIT–pe__*) with category retrieval (*FR__–peach*). According to the inhibition account, category retrieval should not produce competition from related exemplars (*apple, pear, orange*) because the participant is searching for a single unique category name rather than searching for one exemplar among many competitors. Thus, according to the second prediction of retrieval specificity, RIF should not be observed under these conditions because the retrieval task is noncompetitive. Indeed, this second prediction was supported by Anderson, Bjork, and Bjork (2000): When participants retrieved the category name using the exemplar word rather than the exemplar word using the category name, RIF did not occur.

At first blush, it would seem that the results of Anderson, Bjork, and Bjork (2000) conflict with our context account, because, according to our account, retrieval should produce context change, which should in turn lead to RIF. However, in recent work, Raaijmakers and Jakab (2012) were unable to replicate the category retrieval results of Anderson et al., instead finding RIF in the absence of retrieval competition in two separate experiments. Critically, in their experiments, Raaijmakers and Jakab made category retrieval more difficult by withholding the first two letters of the category name (e.g., *?–peach* rather than *FR__–peach*). We suspect that the category retrieval used by Anderson et al. was not difficult enough to induce significant long-term retrieval, which would be necessary for a context shift to take place. Consistent with this explanation, Jang and Huber (2008) demonstrated that context change effects do not occur following recognition but do occur following recall, which led them to postulate that episodic recall "more effectively causes change in the temporal context" (p. 118). Thus, it is quite possible that the simple category retrieval task employed by Anderson et al. was not difficult enough to produce long-term retrieval.

In addition to Raaijmakers and Jakab's (2012) results, there are other findings that challenge the inhibition account's property of retrieval specificity. In previous research, we tested the property of retrieval specificity by replacing standard retrieval practice with subordinate generation (Jonker & MacLeod, 2012). For example, instead of prompting retrieval of the exemplar *dog* with the retrieval cue PET–*do__*, we prompted subordinate generation with the cue *dog–?*. In this task, participants were instructed to generate a type of *dog,* such as *beagle.* Because the exemplar (*dog*) was provided during the practice phase, there should be no need for participants to retrieve this item; hence, there should not have been any retrieval competition between the exemplar *dog* and other studied exemplars from the category PET (e.g., *cat, horse*). In the absence of retrieval competition, there should not have been a requirement for inhibition. We nevertheless observed RIF. This result is clearly problematic for the inhibition account because it

directly conflicts with the requirement of exemplar competition for inhibition. On the other hand, however, these results can be fully explained by our context account, because subordinate generation is a retrieval process and should therefore produce a context change between study and practice (Tenet 1), thereby producing RIF.

It is clear, then, that a number of studies have posed serious challenges to the assumption of retrieval specificity. Furthermore, whereas the inhibition account cannot explain these results, our context account can. In the cases of Raaijmakers and Jakab (2012) and of our earlier work (Jonker & MacLeod, 2012), a retrieval process occurred during the practice phase, even though the retrieval did not target the exemplar. As mentioned earlier, switching from study to retrieval has been shown to spontaneously produce a shift in context (Jang & Huber, 2008; Sahakyan & Hendricks, 2012). Thus, in cases where a retrieval process occurs, the context account predicts RIF because the required tenet of context shift will have been met (assuming that, during the final test, participants are by default accessing the practice phase rather than the study phase for practiced categories; i.e., our second required tenet). The common factor in the case of Raaijmakers and Jakab, our earlier work, and Experiment 2a of the present work is that of context change, occurring either routinely or through manipulation. The results of all of these studies support our context account.

Interference dependence. The property of interference dependence is closely related to the property of retrieval specificity in that it too emphasizes the necessity of retrieval competition during the practice phase. However, the property of interference dependence makes specific predictions about individual items rather than broad predictions based on the type of processing that occurs during the practice phase. According to this property, a RP− exemplar that is strongly associated to the category cue will compete more fiercely and thereby require more suppression than a RP− exemplar that is weakly associated to the category cue.

Anderson et al. (1994) provided support for this property by selecting exemplars that were either strongly or weakly semantically associated to the cue. They found RIF when RP− items were strongly associated to the category cue (e.g., *apple* to FRUIT) but no RIF when RP− items were weakly associated to the category cue (e.g., *kiwi* to FRUIT). On the basis of these results, Anderson et al. argued that strongly associated exemplars compete most for retrieval, and, therefore, that only strongly associated exemplars are inhibited.

However, recent work by Sahakyan and Goodmon (2010) suggests that the presence or absence of forgetting for strongly and weakly associated exemplars could be explained by a context account. Sahakyan and Goodmon examined the effects of target-to-cue strength in the list-method directed forgetting paradigm.[8] In their Experiment 4, participants studied two lists of targets with half of the targets in each list having high cue-to-target strength and half having low cue-to-target strength. Importantly, the cues were not presented during study. The remember/forget instruction, which has been shown to produce a shift in context, occurred between the two lists. During the final test, participants received the cues for the first time and were told to use these cues to recall items from either list. Sahakyan and Goodmon found a List 1 cost following the forget instruction when target-to-cue strength was high but no List 1 cost when target-to-cue strength was low. Thus, List 1 costs are dependent on the associative strength between the extralist cue and its studied target; costs will occur only when associative strength is high. In terms of context change, targets with high cue-to-target strength were the only ones affected by the context change presumably caused by the forget instruction; targets with low cue-to-target strength were not affected. Thus, extending this logic, it is plausible that the findings of Anderson et al. (1994) were driven by context change. Specifically, when the cue–target associations are strong for RP− items, these items might be vulnerable to the RIF-like effect following context change; however, when the associations are weak, these items might not be vulnerable to forgetting following context change (for an alternative explanation that does not rely on either inhibition or context, see Jakab & Raaijmakers, 2009).

Although the finding of RIF for strongly associated items (Anderson et al., 1994) can be explained by the context account, it should be emphasized that the finding itself is not a robust one. Indeed, this finding was not replicated by Williams and Zacks (2001), nor was it conceptually replicated using an experimental manipulation of strength (Jakab & Raaijmakers, 2009). Jakab and Raaijmakers took the very direct route of varying the number of presentations in the study phase to make some items episodically stronger than others. Although these repeated items were shown to be stronger and hence should have provided more competition during practice, which in turn should have produced more RIF, Jakab and Raaijmakers found no difference in RIF between strong and weak items, which directly challenges the property of interference dependence. Thus, the RIF effect for strongly associated items might be a spurious finding, or it might occur and be driven by context change (by analogy to the findings by Sahakyan & Goodmon, 2010, in the list-method directed forgetting paradigm). In either case, the finding is not inconsistent with the context account.

Experiments that vary the episodic or semantic similarity of exemplars have also been put forth as support for the property of interference dependence (e.g., Anderson, Green, & McCulloch, 2000; Anderson & McCulloch, 1999).[9] In these studies, high similarity between competitors and targets does not produce RIF (e.g., *orange* and *lemon* are highly similar because they both have the shared features of citrus fruits). Proponents of the inhibition account have argued that these results provide unique support for the inhibition account because "strengthening features of the practiced items [e.g., the shared citrus features] will enhance the ability to recall competitors" (Goodmon & Anderson, 2011, p. 432). In other words, practicing a RP+ item strengthens all of the individual features that make up the representation of the RP+ item. RP− items that share many of these features will also benefit from the feature strengthening, even though the RP− items themselves were not practiced. The unshared features of a RP− item, however, will be suppressed. Therefore, their argument is that when a

[8] They also examined other strength relations, such as cue-to-target indirect strength. For simplicity, we discuss the target-to-cue strength only.

[9] It is worth nothing that neuroimaging and electrophysiological studies of brain activity in the RIF paradigm have been used as support for an inhibition mechanism during a RIF experiment (e.g., Johansson, Aslan, Bäuml, Gäbel, & Mecklinger, 2007; Kuhl, Dudukovic, Kahn, & Wagner, 2007). However, although the findings can be seen as consistent with an inhibition account, they do not necessitate an inhibition mechanism and could instead indicate the deliberate use of context information (also, care should be taken to avoid the consistency fallacy; Mole & Klein, 2010).

RP− item shares more features with RP+ items, it will be more resilient to forgetting because fewer of its features will be suppressed.

Although the inhibition account has an explanation for the similarity effect, the context account can also explain this effect. In studies examining context and memory, associative encoding has been found to weaken context effects (see Smith & Vela, 2001, pp. 205–206, for a review). Specifically, when similarity between RP+ items (in the practice context) and RP− items (in the study context) is high, participants may tend to rely less on contextual cues and more on associative information at test. In other words, having studied a number of citrus fruits (e.g., *orange, lime, lemon, tangerine*), and then having practiced some of these citrus fruits (e.g., *orange, lime*) in the retrieval practice phase, a participant may rely more heavily on "citrus-ness" as a recall cue during the final test rather than on contextual information (i.e., reinstating the practice phase and accessing the RP+ items). This would suggest that participants are weighting the "citrus-ness" cue more heavily than the category name (e.g., search of associative memory model; Raaijmakers & Shiffrin, 1981). Were this the case, RIF should not occur because the RP− items would not be disadvantaged by being in a context that has not been reinstated.

Further support for the property of interference dependence has been obtained through the use of an individual differences approach. For example, Aslan and Bäuml (2011) observed a positive relation between working memory capacity (WMC) and RIF, with individuals high in WMC producing stronger RIF. They claimed that individuals with higher WMC exhibit better executive control and, consequently, can respond to interference more effectively by deploying inhibition. However, other researchers have observed a relation between WMC and the use of temporal-contextual cues (e.g., Unsworth & Spillers, 2010), with individuals high in WMC making better use of context information while retrieving. Thus, it seems equally plausible that the positive relation between WMC and RIF exists because individuals with higher WMC make better use of context information. Indeed, a similar argument has been made in the directed forgetting literature by Delaney and Sahakyan (2007), where those with high WMC showed more forgetting following a context change and a greater directed forgetting effect following a forget instruction.

Strength independence. According to the property of strength independence, the amount of RIF is independent of the amount of retrieval-induced facilitation for RP+ items. This assumption is also based on the notion of competition during retrieval: RIF occurs because RP− items compete for retrieval and are suppressed; RIF does not occur because RP+ items are strengthened and later block recall of other items during the final test.

This assumption can by evaluated by examining the correlation between strengthening of RP+ items and RIF. In support of the prediction, Hulbert et al. (2012) found no significant correlation between recall of RP+ items and RIF, which led them to argue that retrieval strengthening does not predict later forgetting, contradicting what would be predicted if RIF were due to interference from recalling the RP+ items during the final test. Of course, this is a null result and is subject to the usual concerns surrounding null results.

Further support for the property of strength independence has been provided by Storm and colleagues (Storm et al., 2006; Storm & Nestojko, 2010), who employed a variant of the RIF procedure in which successful retrieval practice was not possible because there was no appropriate exemplar for some of the cues (e.g., WEAPON–*wo*___). During the final test, all of the studied exemplars were tested. Although successful retrieval was impossible (i.e., participants did not successfully retrieve any items from the practiced categories during retrieval practice), RIF nevertheless occurred. On the basis of this result, Storm and colleagues argued that the product of retrieval is not important for producing inhibition and forgetting; rather, they maintained, it is the process of retrieval that is important for producing inhibition and forgetting.

Support for the property of strength independence also comes from the extra-study variant of the RIF paradigm. As previously shown (e.g., Anderson & Bell, 2001; Bäuml, 2002) and as demonstrated in Experiment 1 of the present article, the RP+ items are strengthened by the extra study during practice, but there is no forgetting of the related items (RP−).

Although the inhibition account can explain these effects—and although they have been viewed as providing support for the inhibition account—they also can be readily explained by the context account. According to the context account, it is not the product of the practice context that is important; instead, it is the process of context change and of cuing the practice context during testing of practiced categories that produces RIF. When a retrieval process occurs, the practice phase becomes contextually distinct from the study phase. Because the practice phase is more recent and/or contains more elaborative encoding, later testing using these category names preferentially cues the practice context. The result is a lack of context reinstatement benefit for the RP− items, which were presented only during the study context (which is not typically reinstated). Put simply, the context account would predict the occurrence of RIF even if retrieval attempts were impossible because the initiation of the retrieval process would still create a context shift.

Cue independence. According to the inhibition account, it is the exemplar's representation, not the association between cue and exemplar, that is suppressed. Thus, any cue that is used to access the exemplar's representation should reveal RIF. In other words, inhibition is thought to be cue independent. Support for the property of cue independence takes two forms: RIF in recognition testing and RIF using independent probes. We first examine the recognition findings.

Recognition. Although the practice phase characteristically involves retrieval and the final test involves cued recall, sometimes the final test involves recognition. In a recognition test, the category name is typically not presented, yet RIF has been found under these testing conditions (e.g., Starns & Hicks, 2004). Therefore, because the cue was not presented, proponents of the inhibition account have argued that RIF in recognition demonstrates that the exemplar itself must be inhibited, rather than the association between the cue and target.

However, RIF in recognition has not been found consistently (e.g., Koutstaal, Schacter, Galluccio, & Stofer, 1999). And, considering the number of articles reporting RIF, there are relatively few reports of RIF using recognition as the final test. Furthermore, a number of our own attempts to replicate the recognition findings in RIF have failed, suggesting that RIF with recognition might be a very small effect or that it is possibly reflective of the "file-drawer problem" (Rosenthal, 1979).

Alternatively, however, findings of RIF using recognition might be relatively few because researchers have not conceptualized RIF in a way that allows them to design effective recognition experiments. Within explorations of context and memory, researchers have demonstrated that recognition can be context dependent (e.g., Bodner & Lindsay, 2003; Bodner & Richardson-Champion, 2007; Craik & Schloerscheidt, 2011; Godden & Baddeley, 1980; Tousignant & Bodner, 2012). If context plays a role in recognition in other paradigms, it is quite plausible that RIF will occur on recognition tests when the testing conditions encourage the use of context information.

Consistent with this view, recent work by Verde and Perfect (2011) provides support for the role of context in recognition in RIF. In their experiment, participants were to recognize the studied exemplars during the final test; this recognition test was either self-paced or speeded. Critically, it has been demonstrated that speeded recognition judgments discourage the use of context information and the process of mental reinstatement (e.g., Rutherford, 2004). Verde and Perfect observed RIF when recognition judgments were self-paced by participants but did not observe RIF when the recognition judgments were speeded. This work is corroborated by earlier work by Verde (2004), in which he found that retrieval practice impaired the recollection of RP− items relative to NRP items when participants made remember–know (i.e., recollection–familiarity) judgments during a recognition task; retrieval practice did not impair the familiarity judgments of the RP− items, however. In other words, RIF was seen only in the recollection component of memory. According to our context account, when participants are given ample time, they may make use of context information and rely more on recollection than familiarity, which leads to forgetting of items in the noncued context (i.e., the RP− items in the study context); on the other hand, when participants are instructed to respond quickly, they may rely more heavily on familiarity (given that they do not have enough time for recollective processes) and, as a result, neglect context information.

These results from Verde and colleagues suggest that the characteristics of the final test can encourage or discourage the use of context information even during recognition tests. When an exemplar is presented during a recognition test in the RIF paradigm, participants might use context information if they are able; if that usage favors the practice context, they will show more RIF. For example, when the item *peach* is presented at test without its category label, the category is rather obvious. If the test context encourages recollection (e.g., the judgments are not speeded and the distractors are difficult to distinguish from the targets [see Bodner & Richardson-Champion, 2007], which would likely be the case when they are from the same category), the participant might covertly retrieve the superordinate category and make use of the context associated with that category in their retrieval attempt. In the case of practiced categories, the most relevant and accessible context will—according to our context account—be the practice context, which will deprive the RP− items of a reinstatement benefit and produce RIF instead.

We hypothesize that the inconsistent findings of RIF in recognition are attributed to the use (or lack of use) of context. Indeed, subtle differences in method or items could influence whether the participant uses context information. If the features of a recognition experiment favor the use of context during the final test, as was the case in Verde and Perfect's (2011) self-paced recognition judgment task, RIF will occur. If, however, the features do not favor the use of context, as was the case in Verde and Perfect's speeded recognition judgment task, RIF will not occur. Admittedly, there is some circularity here, but that is no less true for the inhibition account. This is clearly an aspect of RIF that warrants further investigation. The context account, importantly, makes testable predictions regarding recognition tests, providing motivation for further investigation.

Independent probes. The property of cue independence is also supported by the independent probe method. In fact, cue independence using independent probes is arguably the cornerstone of the support for the inhibition account. Indeed, Anderson and Levy (2007) state that "to make a strong claim in any study about the presence or absence of inhibition, or about variations in the magnitude of inhibition as a function of condition or population, it is necessary to include an independent probe of the impaired items' accessibility" (p. 82). Thus, to claim definitively the presence of inhibition, proponents of the inhibition account state that RIF is not enough; instead, one must show impairment using independent probes. We agree with Anderson and Levy that this is the strongest argument in favor of the inhibition account. It is not, however, unassailable.

Anderson and Spellman (1995) first demonstrated cue independence using a stimulus set that contained exemplars from two categories, rather than one. For example, a participant might have studied RED–*tomato,* RED–*blood,* FOOD–*radish,* and FOOD–*crackers*. Critically, the exemplar *tomato* was studied as a RED item, but it also belonged to the FOOD category. Anderson and Spellman demonstrated that retrieval practice of FOOD–*crackers* impaired later recall of *radish* (the RP− item) and, surprisingly, of *tomato.* Since Anderson and Spellman's study, other researchers also have found RIF using independent cues by replacing the studied cue with a different cue (e.g., Johnson & Anderson, 2004; Saunders & MacLeod, 2006).

Although some have found evidence for cue independence in recall, others have failed to produce the effect (e.g., Camp et al., 2007; Jonker et al., 2012; Perfect et al., 2004; Williams & Zacks, 2001). For example, in recent work in our laboratory (Jonker et al., 2012), we introduced a novel test of cue independence to RIF; we designed a stimulus set where exemplars within a single category could be divided into one of two distinct subcategories (e.g., within the category BODY PART, some exemplars were *organs* and others were *joints*). Participants were not aware of this information during study or practice. Inspired by the classic release-from-proactive-interference article by Gardiner, Craik, and Birtwistle (1972), we provided some participants with this extra subcategory information during the final test, but withheld it from others. RIF occurred when no subcategory information was provided at test, replicating the standard paradigm and effect. However, RIF was eliminated when subcategory information was provided along with the category cue during the final test and all RP+ items belonged to the same subcategory (e.g., *organs*).

These results emphasize the cue dependence of RIF and therefore cannot be explained by the inhibition account. Instead, these results are better explained by our context account. When subcategory information is provided, the subcategory cue associated with the RP− items (e.g., *joints*) uniquely cues the study context and provides access to these items, which only occurred within that

context and so would not otherwise be cued. Providing further support for the context account, we demonstrated that when RP+ items are from both subcategories (e.g., *organs* and *joints*) and subcategory cues are provided during the final test, RIF does occur. By our account, this is because the subcategory cues do not discriminate between the study and practice contexts when items from a subcategory occurred in both contexts. In this situation, both subcategory cues point to the stronger, more recent practice context, thereby satisfying our second required tenet and producing RIF.

Failures to observe cue independence are not limited to our laboratory. Perfect et al. (2004) also failed to find support for cue independence in a set of experiments in which they presented two cues during study—both a category name and a picture of a face—along with the exemplar. When the two cues were also used for both retrieval practice and test, RIF occurred. However, when the two cues were presented at test, but only one of them (i.e., the category name) had been used during the retrieval practice phase, RIF did not occur. These results cannot be explained by the inhibition account because they demonstrate the cue-dependent nature of RIF, but they readily align with the predictions of the context account. Specifically, when two cues were used for both practice and test, the practice context would closely match the test context and likely continue to be the active context. However, when two cues were presented at test but only one of them was used during practice, the study context would more closely match the test context and so the study context would likely be reinstated, eliminating RIF.

These demonstrations of cue dependence directly challenge the fundamental assumption of the inhibition account: cue independence. Indeed, the inhibition account cannot explain the elimination of RIF with the addition of cues in our research (Jonker et al., 2012); nor can it explain the cue-dependent findings of Perfect et al. (2004). In our research and that of Perfect et al., cues were added rather than replaced, and—under these conditions—RIF was found to be cue dependent, consistent with the context account. When contrasting this approach of adding cues with studies that have found RIF with extra-list cues, we note that the use of extra-list cues is a *cue-replacement* method, whereas we and Perfect et al. employed a *cue-addition* method. Although there is current debate over the exact mechanism underlying the small number of experiments that have previously shown cue independence with the cue-replacement method (see Camp, Pecher, Schmidt, & Zeelenberg, 2009; Huddleston & Anderson, 2012; Hulbert et al., 2012), the above-mentioned examples demonstrate that when one strays from the cue-replacement method of Anderson and colleagues, cue independence no longer occurs, challenging this key assumption of the inhibition account.

In sum, despite the property of cue independence having been cited as the strongest evidence for inhibition, published results do not consistently find support for cue independence. Indeed, considering that cue independent tests are the hallmark of inhibition, it is remarkable how few of the published studies demonstrating RIF included tests of cue independence. Furthermore, existing results that demonstrate the cue dependence of RIF can be explained with our context account but cannot be explained with the inhibition account.

Conclusion

Findings such as cue independence in recall and RIF using recognition tests have been used as strong support for an inhibition account, and this inhibition account has been highly influential. In fact, it has been so influential that some have used the RIF paradigm as a measure of the "inhibitory abilities" of clinical populations. Yet, the RIF effect can be accounted for by other explanations—in particular, by the context account that we have set forth in this article. In the present experiments, we demonstrated the important role of context in RIF. Specifically, we observed that RIF is absent following manipulations that reinstate the original study context, a finding that fundamentally challenges inhibition as the mechanism necessary for RIF. Not only does the inhibition account fail to encompass our new results but retrieval-induced forgetting seems to be a misnomer, as shifts in context can produce the forgetting effect even in the absence of retrieval practice. Moreover, we show that the context account can handle the major existing findings in the RIF literature at least as successfully as the inhibition account can.

Although it is quite possible that more than one mechanism underlies RIF—even likely the case, as is true for many phenomena—our results suggest that context might be the most plausible driving force. We therefore suggest that RIF is one more instance of the powerful and ubiquitous influence that context exerts on memory. Indeed, memory is exquisitely contextual, and RIF appears to provide an excellent demonstration of this property.

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