RETRIEVAL-INDUCED FORGETTING IN KINDERGARTNERS: EVALUATING THE INHIBITORY ACCOUNT

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ABSTRACT

Repeatedly retrieving information from memory can induce forgetting of related, un-retrieved information below baseline, an effect termed *retrieval-induced forgetting* (RIF; Anderson, Bjork & Bjork, 1994). The *inhibitory* account of RIF (e.g., Anderson, 2003) has received extensive support in the literature, especially through studies designed to empirically test inhibitory-based principles of RIF in adults. These principles include *cue independence* (RIF persists in the absence of the cue used during practice), *interference/competition dependence* (inhibition serves to resolve interference/competition between the cue and associated items during practice), *strength independence* (RIF is not strictly due to a target strengthening and competitor forgetting trade-off), *retrieval-specificity* (retrieval attempts are required to create the interference/ competition responsible for triggering inhibition), and *output interference independence* (RIF persists when output interference is controlled). However, *competition-based* explanations do not require an inhibitory component and can also account for many adult RIF findings. Very little RIF research has examined young children's memory, whose immature memory systems might not be capable of demonstrating an inhibitory-driven effect. This dissertation filled this gap in the literature by thoroughly evaluating the inhibitory account of RIF in kindergartners (Ks). Two groups of Ks completed two RIF tasks that tested *cue independence, competition/interference dependence,* and *strength independence* in the first experiment, and *retrieval-specificity, output interference independence,* and *strength-independence* again in the second experiment. When a novel cue was used to test final memory (Experiment 1), and when a cue-free recognition test was used that controlled for output interference (Experiment 2), no RIF was found. These results, along with correlational evidence of *strength dependence*, favour a competition-based account of Ks' RIF. Implications for inhibition theory and the potential development of RIF are discussed.

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LIST OF ABBREVIATIONS

DOF: Degree of forgetting

DOS: Degree of strengthening

NRp: Items (e.g., words, sentences) that are from the no retrieval-practice baseline category during retrieval-induced forgetting tasks

RIF: Retrieval-Induced Forgetting

Rp+: Items (e.g., words, sentences) that receive retrieval-practice during retrieval-induced forgetting tasks

Rp-: Items (e.g., words, sentences) that are from the retrieval-practiced category but do not receive any retrieval-practice during retrieval-induced forgetting tasks

1. CHAPTER 1: INTRODUCTION

1.1. Retrieval-Induced Forgetting In Kindergartners: Evaluating The Inhibitory Account

Forgetting can be generally defined as "the inability to recall something now that could be recalled on an earlier occasion" (Tulving, 1974, p.74) and such forgetfulness is quite a common memory-related complaint (Larrabee & Levin, 1986). What many people do not realize, however, is that forgetting is a necessary component of an adaptive and efficient memory system (Kuhl, Dudukovic, Kahn & Wagner, 2007; Rosenzweig, Barnes & McNaughton, 2002; Storm, 2011a; Wixted, 2005). An efficient memory system is one that cannot only provide adequate amounts of accurate memories (e.g., detailed verbatim representations of the recalled events), but one that can also adequately sift through and discard unrequired or unnecessary memory representations. Consider the task of having to memorize a family member's new telephone number. Your first few attempts at retrieving the new phone number from memory may have also activated the old phone number, creating interference between the cue "X's phone number" and the to-be-retrieved item – the new phone number. Both the old and new numbers remained linked to your family member's name in your memory until further retrieval attempts lead to the suppression, or forgetting, of the old number. *Retrieval-induced forgetting* (RIF; Anderson, Bjork & Bjork, 1994) is argued to operate in much the same manner as in this example – repeated retrieval of some information (Rp+) induces forgetting of related information (Rp-) that competes for conscious awareness through the shared cue. A vast amount of research has examined RIF using a variety of materials and manipulations with adults and much of these data have been interpreted as supporting the *inhibitory account* of RIF (i.e., inhibition or suppression of Rp- below baseline levels), although some theoretical controversy exists (e.g., Camp, Pecher & Schmidt, 2007). However, very few examinations of RIF have been conducted

within the early memory development lifespan period, and of the few available (Aslan & Bäuml, 2010; Ford, Keating & Patel, 2004; Lechuga, Moreno, Pelegrina, Gómez-Ariza, & Bajo, 2006; Marche, Briere & von Baeyer, 2015; Price & Phenix, 2015; Zellner & Bäuml, 2005), no study has evaluated the theoretical mechanism that may be driving the effect. Therefore, the aim of the current thesis is to examine the inhibitory account of RIF in groups of children that are at a very early stage of memory development – kindergarten. Kindergartners were selected for the study due to the immature stage of development of their frontal lobes where many inhibitory functions (including that involved with RIF) are thought to reside (e.g., Rueda, Posner & Rothbart, 2005). The following sections of this document will first provide a brief discussion of why forgetting is an important area of study, followed by a review of what RIF is and how it is studied (Chapter 1). Chapter 2 will provide a review of the relevant research literature regarding the inhibitory account of RIF and the five principles argued to support that explanation will be identified and discussed. The few studies examining RIF in child populations will also be discussed in relation to the inhibitory explanation of the effect as well as some adult RIF studies that provide theoretical grounding for the hypotheses in the current research. The research hypotheses and rationale for two studies aimed at evaluating the inhibitory account of RIF in kindergartners will then be discussed. In Chapter 3, Experiment 1 and 2 will be described, including the method, results, and discussion of each study separately. In Chapter 4, a general discussion is provided that includes the conclusions, limitations, implications, and future directions of this line of research.

1.1.2. Why Study Forgetting?

Consider the last time you went to purchase groceries at your regular grocery store. When you completed your purchases and left the building to find your vehicle it is likely that

you were able to recall where you had parked on that occasion, and you found your vehicle with relative ease. Now imagine instead that when you left the store to find your car, all of the different parking spots in that lot that you had used in the recent past came to mind. Rather than simply recalling where you parked *this* time and walking to your vehicle, you could be left wandering the parking lot checking the areas you had parked on previous occasions. From this example it is clear that being able to forget information serves as an adaptive function in our busy and often repetitive lives (Anderson, 2003; Kuhl et al., 2007; Rosenzweig et al., 2002; Wixted, 2005).

If you tested yourself when you walked out of the grocery store, you should be able to recall where you parked your car on your current visit to the store with ease, and perhaps the previous one or two times you shopped at the same store as well. You would likely have difficulty in recalling all of the spots you parked in on all of your previous visits to that store – this forgetting is a good thing! If we remembered every bit of information that was once stored in memory we would likely be left sifting through a vast number of irrelevant memories in order to find the relevant one needed to satisfy our current goal (e.g., finding your parked car). The most common memory-related complaint may be that of forgetfulness, but as this example illustrates, there are instances when such forgetting does not necessarily reflect memory failure. Rather, forgetting can be seen as an ability that develops with age (Brainerd, Kingma & Howe, 1985; Brainerd, Reyna, Howe & Kingma, 1990), similar to how recall or memory abilities improve during development (e.g., Gathercole, 1998; Kail, 1990).

Even in the few documented cases of exceptional memory (i.e., *hypermnesia* or extreme detail, vividness, and/or accuracy of memory under certain circumstances, Roediger, Weinstein & Agarwal, 2010; *hyperthymnesia*, extremely detailed autobiographical memory, Parker, Cahill

& McGaugh, 2006), everyone forgets. Forgetting may occur because the memory trace has been c*ompletely lost from memory storage,* or has become *unavailable* to conscious awareness (Roediger et al., 2010; Tulving & Pearlstone, 1966). Assuming that the information was stored in memory in the first place, there are two types of forgetting that can occur: intentional and unintentional/incidental forgetting. *Intentional forgetting* occurs when a conscious effort is made to forget information. For example, you may have actively tried to forget a hurtful comment from a family member or friend in the past, or perhaps you have tried to forget something you said or did that you regretted after the fact. These effortful forgetting attempts are similar to the *directed forgetting* line of intentional forgetting research (e.g., Conway, Harries, Noyes, Racsma'ny, & Frankish, 2000; Golding & MacLeod, 2013; MacLeod, 1999). Conversely, *unintentional,* or *incidental, forgetting* occurs when information that has been previously stored in memory is no longer accessible or available to conscious awareness (Anderson, 2009; Roediger et al., 2010). The most widely used incidental forgetting procedure in the learning and memory literature is RIF, which is the focus of the current dissertation, and is described next.

1.1.3. What is Retrieval-Induced Forgetting?

Research on RIF has shown that repeatedly retrieving a subset of information from memory not only leads to the increased recall of that information (i.e., *practice effects*), but also to the forgetting of related, un-retrieved, information below baseline levels (Anderson et al., 1994). The typical RIF procedure involves four phases – *initial study*, *retrieval-practice*, *distractor task,* and *final test*. During *initial study,* participants study a number of category – exemplar word pairs one at time, in random order (e.g., fruit – banana, fruit – apple, insect – beetle, fruit – orange, etc.) at a rate of approximately one word every 2.5 to 5 seconds (Anderson et al., 1994). Following the initial presentation, a subset of the items from some of the categories

(e.g., half of the items from half of the categories) is presented to participants again using a fill-in-the-blanks task (e.g., fruit – ba___). After reading the category – exemplar fragment, participants' task is to retrieve the appropriate item from memory to accurately fill in the blanks using an item from the list they had just studied (e.g., fruit – banana). The act of retrieving the item(s) and filling in the blank(s) is termed *retrieval-practice.* Retrieval-practice is typically repeated three times for each of the to-be-retrieved items. These items are labeled *Rp+* given that the items received retrieval-practice (e.g., fruit – ba__). Items that are from the retrieval-practice category that are left out of the retrieval-practice task are labeled *Rp-* items (fruit – orange) as they are from the retrieval-practiced category but do not receive any extra practice. All of the remaining categories and items are labeled *NRp* or *baseline* items because all of these items receive no retrieval-practice manipulation, are simply studied once during initial study, and are subsequently tested (e.g., all insect paired items).

Following the retrieval-practice task, participants complete a short distractor task (approximately 5 – 20 min.) followed by a final memory assessment. Typically cued recall is used to assess participants' memory following retrieval-practice procedures (Anderson et al., 1994; Murayama, Miyatsu, Buchli & Storm, 2014). Under *original cue recall* conditions, each category cue that was studied during the initial study trial is presented to participants one at a time, in random order. Participants are asked to recall as many exemplars as they can remember that were paired with that category during the initial study trial. A few studies have also used recognition testing as the final memory test following retrieval-practice (e.g., Anderson et al., 1994; Aslan & Bäuml, 2010, 2011; Ciranni & Shimamura, 1999, Ford et al., 2004; Glanc, 2008; Gómez -Ariza, Lechuga, Pelegrina & Bajo, 2005; Hicks & Starns, 2004; Spitzer & Bäuml, 2007, 2009; Verde & Perfect, 2011). For *recognition testing* conditions, participants are presented with

each exemplar, as well as new *lure* exemplars, one at a time, and are asked to make an "old" (the word/sentence was previously studied) or "new" (the word/sentence was not previously studied) judgment for each item. *Implicit recognition tests* have also been used in the literature such as recording participants' reaction time to endorsing items on the recognition test (e.g., Perfect, Stark, Tree, Moulin, Ahmed & Butter, 2004; Veling & van Knippenberg, 2004).

Cued recall and recognition data following retrieval-practice tasks reveal a significant practice effect whereby Rp+ items are enhanced in memory above the NRp baseline level of recall (Anderson et al., 1994) or recognition (e.g., Aslan & Bäuml, 2010; Hicks & Starns, 2004). More importantly for RIF, significant *forgetting* is also found where Rp- items are recalled or endorsed significantly less often than NRp baseline items that received no retrieval-practice manipulation (Anderson et al., 1994; refer to Figure 1 for an illustration of the RIF pattern of results).

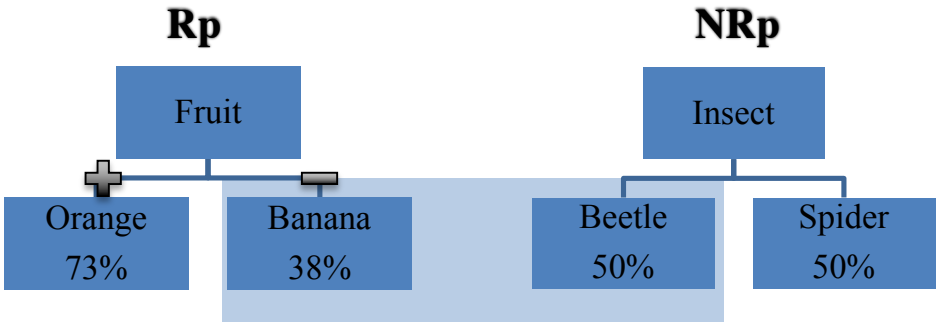


Figure 1.1
The typical retrieval-induced forgetting pattern of recall results is displayed. "Orange" reflects items that received retrieval-practice (Rp+) while "Banana" reflects items from the retrieval-practiced category that do not receive retrieval-practice (Rp-). The "Insect" category is the NRp baseline category that receives no retrieval-practice. Percentages reflect average levels of recall for each item type.

Since RIF first appeared in the literature using category – exemplar word lists (e.g., fruit – apple, fruit – banana, Anderson et al., 1994), it has been extended to a wide variety of materials. For example, RIF has been extended to autobiographical memory (Barnier, Hung & Conway, 2004), stereotypes (Dunn & Spellman, 2003; Lin & Kao, 2008), social metacognitive judgments (Storm, Bjork, & Bjork, 2005), facts about the self (Barnier et al., 2004; Marche et al., 2015), facts about others (Macrae & MacLeod, 1999; MacLeod & Macrae, 2001), eyewitness memory (MacLeod, 2002; Migueles & García-Bajos, 2007; Shaw, Bjork & Handal, 1995), visual locations (Ciranni & Shumamura, 1999), visual scenes (Koutstaal, Schacter, Johnson & Galluccio, 1999), situations involving misinformation (e.g., MacLeod & Saunders, 2005; Saunders & MacLeod, 2002), educational contexts (Carroll, Campbell-Ratcliffe, Murnane, & Perfect, 2007), and arithmetic facts (Campbell & Dowd, 2012; Campbell & Thompson, 2012; Phenix, 2006; Phenix & Campbell, 2004). Varying degrees of RIF have also been found in a number of special populations such as individuals with Alzheimer's dementia (Moulin, Perfect, Conway, North, Jones & James, 2002), schizophrenia (AhnAllen, Nestor, McCarley & Shenton, 2007; Nestor, Piech, Allen, Niznikiewics, Shenton & McCarley, 2005; Soriano, Jimenez, Román & Bajo, 2009), clinical depression (Groome & Sterkaj, 2010), dysphoria (Harris, Sharman, Barnier & Moulds, 2010; Moulds & Kandris, 2006), trait rumination (Whitmer & Banich, 2010), post-traumatic stress disorder (Amir, Badour & Freese, 2009; Brown, 2009; Brown, Kramer, Romano & Hirst, 2012; Koessler, Wohrmann, Zwissler, Pfeiffer, Ertl & Kissler, 2010), obsessive-compulsive disorder (Jelinek, Rietschel, Kellner, Muhtz & Moritz, 2012), social phobia (Amir, Coles, Brigidi & Foa, 2001) and attention deficit/hyperactivity disorder (Storm & White, 2010). The robustness of the effect across materials and populations suggests that RIF is a general phenomenon of human memory. However, as Murayama et al. (2014) discuss, the fact

that RIF is an established phenomenon of human memory does not mean that the theoretical mechanism(s) that contributes to the phenomenon has been identified. Rather, a consistent pattern of results has been identified that could be interpreted through a few theoretical lenses. The primary theoretical explanation of RIF is discussed next.

1.1.4. Cognition Inhibition as a Theoretical Explanation of Retrieval-Induced Forgetting

The induced forgetting found through retrieval-practice tasks is most commonly explained through a *cognitive inhibition* theoretical perspective (e.g., Amir et al., 2009; Anderson, 1995; Anderson, 2003; Andersson & Bell, 2001; Anderson & Bjork, 1994; Anderson et al., 1994; Anderson, Green & McCullock, 2000; Aslan & Bäuml, 2010, 2011, 2012; Aslan, Bäuml, & Pastotter, 2007; Bäuml, 2007; Bäuml & Kuhbandner, 2003; Campbell & Phenix, 2009; Campbell & Thompson, 2012; Carter, 2013; Dehli & Brennen, 2009; Dunn & Spellman, 2003; Edginton & Rusted, 2003; Ford et al., 2004; Garcia-Bajos, Migueles & Anderson, 2009; Gómez -Ariza, Fernandez & Bajo, 2012; Gómez -Ariza, Pelegrina, Lechuga, Surarex & Bajo, 2009; Hiddleston & Anderson, 2009; Hogge, Adam & Collette, 2008; Hulbert, Shivde & Anderson, 2011; Johansson, Aslan, Bäuml, Gabel & Mecklinger, 2007; Lechuga et al., 2006; Levy & Anderson, 2002; Macrae & MacLeod, 1999; Macrae & Rosenveare, 2002; Malmstrom, 2004; Matsuda & Matsukawa, 2010a; Matsuda & Matsukawa, 2010b; Moulin et al., 2002; Pica, Pierro & Kruglanski, 2013; Román, Soriano, Gómez-Ariza & Bajo, 2009; Saunders, 2012; Saunders, Fernandes & Kosnes, 2009; Soriano et al., 2009; Spitzer & Bäuml, 2007; Storm, 2009; Storm, Bjork, Bjork & Nestojko, 2006; Storm & Levy, 2012; Storm & Nestojko, 2010; Veling & van Knippenberg, 2004; Waldhauser, Johansson & Hanslmayr, 2012; Weller, Anderson, Gómez -Ariza & Bajo, 2012; Zellner & Bäuml, 2005). Although, some theoretical controversy exists where authors argue for non-inhibitory, *competition-based* explanations (e.g., Camp et al., 2007;

Dodd, Castel & Roberts, 2006; Hughes, 2007; Jakab & Raainjakers, 2009; Jonker & MacLeod, 2012; Lang, 2000; Perfect et al., 2004; Raaijmakers & Jakab, 2012, 2013; Verde, 2009, 2013; Williams & Zacks, 2001). According to the inhibitory account of RIF, the repeated retrieval of some items in the presence of the category cue creates mental retrieval-competition between those items and the related, un-retrieved items. In order to overcome that interference during retrieval, the previously un-retrieved items are suppressed, or inhibited. That is, the representations of the items in memory demonstrate reduced activation and are thereby less available to conscious awareness at test (Anderson, 2003; Ortega, Gómez -Ariza, Román & Bajo, 2012). This reduced activation, or inhibition, of the un-retrieved items during retrieval-practice leads to below baseline rates of final recall (e.g., Anderson et al., 1994), recognition (e.g., Gómez -Ariza, et al., 2005; Hicks & Starns, 2004), and slower reaction times on implicit memory tests (e.g., Perfect et al., 2004; Veling & van Knippenberg, 2004) for those items, while memory performance for the retrieved items is enhanced. Five sets of findings, hereto referred to as *principles,* are argued by inhibitory proponents to best explain RIF. These principles are discussed next.

1.1.5. Principles in Support of the Inhibitory Account of Retrieval-Induced Forgetting

The inhibitory account of RIF is argued by many researchers to account for a greater amount of empirical data than non-inhibitory competition-based theories (Anderson, 2003, 2009; Anderson & Levy, 2007). There are five principles or characteristics of RIF identified in the literature that are argued to be characteristic of inhibition in RIF; these include: (a) *cue independence* (e.g., Anderson & Spellman, 1995), (b) *interference/competition dependence* (e.g., Anderson et al., 1994), (c) *strength independence* (e.g., Storm & Levy, 2012), (d) *retrieval-specificity* (e.g., Anderson, 2003; Anderson et al., 2000; Ciranni & Shimamura, 1999; Storm,

2011b; Storm et al., 2006), and given that RIF persists in tests of recognition when output interference is controlled (i.e., weak Rp- items are tested first or last on the memory test), (e) *output interference independence* (Murayama et al., 2014). In fact, some researchers argue that recognition tests where output interference is controlled provides the best measure of trace activation and is another form of *cue independence* (Murayama et al., 2014). Each of these principles will be discussed next in turn along with the theoretical interpretations and implications of each. Where applicable, competition-based explanations (e.g., Anderson, 1983; Mensink & Raaijmakers, 1988; McGeoch, 1942; Raaijmakers & Jakab, 2013; Raaijmakers & Shiffrin, 1981) of the reviewed studies will be provided.

1.1.5.1. (A) Cue independence. A core principle of inhibition in RIF is *cue independence* which refers to the finding of significant RIF regardless of the cue used to engage recall (Anderson, 2003, 2009; Anderson & Levy, 2007; Anderson & Spellman, 1995; Hiddleston & Anderson, 2012). According to the inhibitory account, repeated retrieval of Rp+ items leads to the suppression of competing Rp- items such that the activation of those memories themselves are reduced in general, not just in the context of that episode (i.e., that specific pairing). In other words, repeatedly retrieving "fruit – apple" inhibits the activation of "banana" regardless of whether or not the exemplar is paired with the original category cue (e.g., fruit) or a novel one (e.g., monkey). Activation of "banana" in general is reduced rather than merely reducing activation for "fruit – banana" (Anderson, 2003, 2009; Anderson & Spellman, 1995; Anderson & Levy, 2007; Ortega et al., 2012). In order for RIF to demonstrate cue independence then, the forgetting obtained following retrieval-practice must persist even if a cue that is different than the one used during study is provided to guide final recall. That is, RIF may be reduced, but it should not be eliminated if alternate means of accessing the memory traces are provided

(Anderson, 2003; Anderson & Levy, 2007, 2011; Anderson & Spellman, 1995; Veling & van Knippenberg, 2004).

Proponents of competition-based theories of forgetting, on the other hand, argue that inhibition is not necessary to explain RIF and that the forgetting found following retrieval-practice could be the result of competition or insufficient retrieval-cues *during final test* (Camp et al., 2007; Camp et al., 2009; Perfect et al., 2004; Raaijmakers & Jakab, 2013; Verde, 2013). Researchers from this camp would predict the elimination of RIF when independent cues are used at final test: the strengthening of Rp+ through retrieval-practice is cue-specific, therefore, an independent cue should release this competition-based interference and eliminate forgetting of Rp- items. From this perspective then, the forgetting induced through the RIF procedure should be highly cue-dependent, or tied to the specific cue used during the retrieval-practice trials (Camp et al., 2007; Camp et al., 2009; Perfect et al., 2004; Raaijmakers & Jakab, 2013). Impairment of Rp- items (e.g., "fruit – banana") results from strengthening the association between the Rp+ items ("fruit – apple") and the shared category cue (e.g., "fruit") through repeated retrieval. At final test, the Rp+ items associated with a specific category cue consistently interfere, or block retrieval of the Rp- items that are also associated with that cue, resulting in impairment or forgetting. Should an *independent* or *novel test cue* be used at final recall instead (i.e., a cue that was not present during learning but is associated with the target), the interference between the Rp+ and associated Rp- items in the face of that shared cue would be overcome, and no impairment of Rp- items should be found. Referring back to the "fruit" example from a competition-based account, strengthening "fruit – apple" through retrieval-practice should not make a novel cue such as "monkey" less likely to elicit the Rp- item "banana" for it is the "fruit – banana" pair together that should be affected. The strengthening of

certain cue – exemplar pairings (Rp+ "fruit – apple") should leave other cues associated to the remaining items unaffected (Rp- "monkey – banana" at test) thereby eliminating RIF when independent or novel cues are used (Camp et al., 2007; Raaijmakers & Jakab, 2013; Murayama et al., 2014).

A few methods have been used to test this principle of cue independence in RIF. Consider for example, Anderson and Spellman's (1995) study that employed a method similar to the preceding example described above. The authors strategically generated lists of category – exemplar pairs that contained overlapping subcategories. If inhibition occurs during retrieval-practice to resolve competition among related memory traces, then *cross-category inhibition* would be expected when there is a covert relationship among items. For example, in the list "red – blood, red – tomato, food – radish, food – cracker," some items share an additional category such as "red foods." If the "red – bl___" pair is repeatedly retrieved, other "red" related items should compete for retrieval, such as "radish" even though the cue used for these items was different during initial study (red – blood, food – radish). The "red" cue during retrieval-practice should activate all red-related items. In order to facilitate retrieval of the target "blood," all other red-related items are inhibited. Therefore at final test, "radish" should show reduced memorability in spite of the independent cues used during initial study and test. Indeed, Anderson and Spellman found that related, but un-retrieved items demonstrated significantly lower levels of recall relative to their unrelated counterparts (i.e., *food – radish* < *food – cracker*). There are two issues with this study however. First, output interference was not controlled. Once output interference is controlled at final test, RIF is significantly reduced and in fact, can be completely eliminated or cut in half in some circumstances (Murayama et al., 2014). Second, original cue recall was used at final test. Without using a final memory test in

the absence of the original category cues, inhibition-based RIF cannot be discerned from competition-based RIF (Anderson, 2003, 2009; Anderson & Levy, 2007; Anderson & Spellman, 1995; Camp et al., 2007; Camp et al., 2009; Hiddleston & Anderson, 2012; Murayama et al., 2014; Perfect et al., 2004; Raaijmakers & Jakab, 2013).

In an attempt to address these issues, Perfect et al. (2002) conducted three experiments that utilized two cues per exemplar during initial study. In the first two experiments, an image of a face (cue 1), a category name (cue 2) and an exemplar were studied together during the initial study trials (i.e., "face cue – word cue – exemplar" triad). Following retrieval-practice (using the category – exemplar word fragments in Experiment 1, and both the face – category – exemplar word fragments in Experiment 2), participants' memories were then tested by being provided with either the image of the face alone, the category names alone, or the face and categories together to guide recall. In their third experiment, Perfect et al. had participants learn sets of cue – exemplar word pairs where two cues were associated with one exemplar (e.g., A – B, C – B), and presented category cues and word fragments in a final recognition memory test. Seemingly contrary to the inhibitory account, RIF was found only when the same cues used during retrieval-practice were present at the final test, and was eliminated when the second cue used during initial study was used as an independent probe at final test. These cue-dependent RIF results obtained in their first few experiments are contrary to the cue independent principle of inhibitory-based RIF. In Perfect et al.'s fourth and fifth experiments, the previous results were replicated but with either a stem completion task (e.g., Fruit – ap__; Experiment 4), or category verification (Fruit – beetle; Experiment 5) at final test, where reaction times were recorded. RIF was obtained with the stem completion task (conceptual memory) but not with the category verification task (perceptual, implicit memory; however, see Bajo, Gomez-Ariza, Fernandez & Marful, 2006).

Perfect et al.'s results in sum were therefore mixed as cue-dependent, and cue-independent RIF was found with different materials. Taken together, Perfect et al.'s results suggest that, in some instances at least, a competition-based explanation can best account for RIF and that the effect can be influenced by the type of memory materials used.

However, similar to the problems associated with Anderson and Spellman's (1995) study, Perfect et al. (2002) still employed a recall test in their first two experiments, which limits the conclusions that can be drawn regarding the theoretical mechanism that may be driving RIF. Thus, Veling and van Knippenberg (2004) set out to clarify the issue by employing a more direct measure of the level of activation of memory traces – recognition test response latencies and lexical decision response latencies. *Lexical decision* tasks engage participants in decision-making tasks where they are required to make a judgment about whether a word, image, or object represents real things or not (Kroll & Potter, 1984). Reaction times reflect measures of the activation of memory traces – items that are highly activated display shorter reaction times while items that are weak or inhibited demonstrate longer reaction times (Anderson, 1983; Veling & van Knippenberg, 2004).

In both experiments, Veling and van Knippehberg (2004) had participants complete a typical RIF task up until the final test, at which point the methodologies diverged. In Experiment 1, participants completed a computerized recognition test where the length of time needed to recognize a word as "studied" or "not studied" was recorded. Providing the items directly to participants without the category cues should eliminate the retrieval process (and subsequent retrieval-competition) as well as the competition associated with cued recall tests (Veling & van Knippenberg, 2004). In other words, one need not actually retrieve the items from memory in order to make a decision about whether a presented item was previously studied or not, thereby

circumventing retrieval-based competition. Thus, when participants are told to respond as quickly and accurately as possible, reaction times on the recognition test should provide a rather direct measure of the level of activation of the targets (Veling & van Knippenberg, 2004). If active inhibition indeed contributes to participants' RIF, then Rp- items should show reduced activation (i.e., longer response latencies) compared to NRp items. This is precisely what Veling and van Knippenberg found - participants took significantly longer to endorse Rp- items than NRp items, a finding that is in line with the inhibitory account.

It remained possible, however, that participants may have thought of, or used, the original category cue to help search their memories while completing the recognition test. If retrieval of the cues occurred during the recognition test, it is possible that facilitation of Rp+ items resulted (e.g., presentation of an Rp- item lead to retrieval of the cue which facilitated subsequent retrieval of the strong Rp+ items). Or, it is also possible that Rp- items were hindered by the cue bringing the stronger Rp+ items to mind which would then interfere or block access to the weaker Rp- items (Veling & van Knippenberg, 2004). This interpretation is consistent with competition-based accounts of RIF and also explains the data rather well. Therefore, in their second experiment, Veling and van Knippenberg (2004) employed a *lexical decision* task as the final memory test. In lexical decision tasks, participants are presented with words and non-words and their task is to respond whether the letters on screen compose a real word or not, as quickly and as accurately as possible. Using an implicit memory test, such as a lexical decision task, eliminates the retrieval process altogether given the task instructions – participants need not consider whether the item was studied but simply decide if it is a real word or not. Therefore, if Rp- items demonstrate longer response latencies in a lexical decision task than NRp items, or in other words *cue independent* RIF, strong support for the inhibitory account of the effect would

be found. Once again, this is precisely what Veling and van Knippenberg found, and the authors concluded that they had found strong support for *retrieval-induced inhibition.*

The *cue independent* nature of RIF has been demonstrated in a number of studies and across a variety of materials (e.g., Anderson & Bell, 2001; Anderson & Green, 2001; Anderson, Green et al., 2000; Anderson et al., 2004; Anderson & Spellman, 1995; Johnson & Anderson, 2004), leading to the conclusion that *cue independence* is a general principle of inhibitory-based RIF that renders competing memories (Rp-) less activated regardless of the cue used to retrieve them (Hiddleston & Anderson, 2012). Although the majority of researchers interested in RIF interpret their results through an inhibitory-based lens, not many studies employ methods that allow a strong theoretical stance to be taken. If the final memory test used does not assess the activation of the items in the absence of the originally studied cue, the influence of competition at test cannot be evaluated (i.e., examine competition-based theories), and therefore cannot be ruled out. According to the inhibitory perspective then, competing memory traces (Rp-) should be suppressed in general, not just in the presence of the original category cue. Given this unique distinction between cue-dependent competition at test (competition-based theories) and cue-independent suppression in general (inhibitory account), evaluating cue-independence in RIF allows one to distinguish inhibition- from competition-based RIF (Anderson, 2003; Anderson & Bell, 2001; Anderson & Green, 2001; Anderson, Green et al., 2000; Anderson & Levy, 2007, 2011; Anderson et al., 2004; Anderson & Spellman, 1995; Camp et al., 2007; Johnson & Anderson, 2004; Miyamoto & Anderson, 2001; Murayama et al., 2014; Raaijmakers & Jakab, 2013; Verde, 2009, 2012, 2013). Cue independence is in fact considered to be a hallmark feature, or diagnostic criteria, of inhibition in RIF (e.g., Hiddleston & Anderson, 2012).

1.1.5.2. (B) Interference/competition dependence. For inhibition of Rp- items to be produced, interference with those items by competitors must first occur, a principle of RIF referred to as *interference dependence*. In adult RIF research, *weak* items refer to exemplars that share a weak association to the category cue (e.g., fruit – guava) while *strong* items refer to exemplars that share a strong association to the cue (e.g., fruit - apple; Anderson et al., 1994). Often, to assess the degree of association among items, measures of *taxonomic frequency* are used which reflect the mean ranking position of items according to their likelihood of being reported as a member of that category (e.g., Battig & Montague, 1969). *Weak* items therefore have low ranking positions (i.e., higher numerical value, lower rank), while *strong* items have high ranking positions (i.e., lower numerical value, higher rank). When participants are tasked with retrieving weak items (i.e., weak Rp+) while leaving strong items un-retrieved (i.e., strong Rp-), a greater degree of impairment is found for those strong Rp- items than if participants attempt to inhibit weak Rp- items (Anderson, 2003, 2009; Anderson et al., 1994; Anderson & Levy, 2007, 2011). This pattern of results provides support for the inhibitory account of RIF, which argues that a greater amount of inhibition is required to resolve the competition between the weak Rp+ items and the strong Rp- items in order to make the weak Rp+ items more retrievable at final test. In other words, a greater amount of inhibition is required in order to suppress strong items from coming to mind during retrieval attempts so that successful retrieval of the weak items can occur; according to the inhibitory account of RIF, strong inhibition of those items is the solution (Anderson, 2003, 2009; Anderson et al., 1994; Anderson & Levy, 2007, 2011). If weak items serve as the Rp- competitors, a smaller degree of inhibition would therefore be required as weak competitor items would result in a correspondingly lower amounts of interference (Anderson, 2003, 2009; Anderson et al., 1994; Anderson & Levy, 2007, 2011).

Support for this principle has been found in Anderson et al.'s (1994) original work that first identified RIF in adults' recall. Specifically, in their third experiment, Anderson et al. manipulated the taxonomic frequency strength of items such that *pure* lists (i.e., all strong or all weak items) and *mixed-strength* lists (i.e., strong Rp+, weak Rp- or weak Rp+ and strong Rp-) were used during the RIF tasks. From an inhibitory perspective, a greater degree of forgetting would be expected when strong exemplars served as the Rp- competitors than when weak exemplars were used – stronger items create more mental competition or interference and thereby require a greater degree of inhibition to effectively suppress their activation. Significantly more forgetting should be obtained when weak Rp+ items are paired with strong Rp- items than the reverse pairing of mixed strength lists (i.e., strong Rp+, weak Rp-). In this latter circumstance, weak Rp- items do not create much mental competition or interference when strong Rp+ items are being retrieved due to their relatively weak strength in memory (as measured by taxonomic frequency). If the weak items do not strongly compete with successful retrieval of strong Rp+ items, then a low degree of inhibition would be required to effectively suppress activation of those items. This is precisely what Anderson et al. observed in the recall data of Experiment 3: more forgetting (Rp- minus NRp) was found when weak Rp+ items were paired with strong Rp- items than when strong Rp+ items were paired with weak Rp- items. In fact, retrieval induced facilitation was found (i.e., above baseline levels of recall) when strong Rp+ items were paired with weak Rp-, as well as in the pure weak lists. Only when strong items served as Rp- competitors was RIF obtained which provides support for the conclusion that strong inhibition is required to resolve interference among strong Rp- competitors and weak Rp+ targets. When competition or interference is high, a greater amount of inhibition is required to resolve that interference than when competition or interference is low (Anderson et al., 1994).

The interference/competition principle of inhibitory-based RIF has also come under some scrutiny in the research literature (e.g., Jakab & Raaijmakers, 2009; Jonker & MacLeod, 2012). For example, in a series of three experiments, Jonker and MacLeod (2012) tested the competition assumption of inhibitory-based RIF, and in sum found evidence that undermined the principle. In their first experiment, after the initial study trials, participants were tasked with retrieving a subordinate meaning of exemplars in the absence of the category cues. For example, after participants studied "Pet – dog, Pet – horse," and so on, only "dog" would appear on screen, and participants would have to retrieve a type of dog, such as "beagle" or "labrador" (Jonker & MacLeod, 2012). This manipulation allowed active retrieval to occur in the absence of the cue and associated interference. In other words, mental retrieval occurred, but without competition between the cue and related exemplars. From an inhibitory perspective, without competition, RIF should not occur and this is indeed what the authors found: a significant practice effect was obtained but Rp- and NRp recall was the same. Jonker and MacLeod used cued recall at final test however, which did not allow for a distinction to be made between competition-based and inhibitory-based RIF. As the authors discuss, having participants retrieve subordinate meanings to the Rp+ targets likely resulted in no interference between the category cue and competing traces, thereby eliminating the need to inhibit the (non-competing) traces. But strengthening Rp+ items along with the category cue is what is central to finding competition-based RIF, and this was not achieved with their subordinate retrieval manipulation. Recall that competition-based accounts would predict that strengthening the cue – exemplar pairs through retrieval practice increases the likelihood of recalling those exemplars in the presence of the cue at final test. When the cue is provided to aid final recall, retrieval of the strong Rp+ items likely occur first and this output of strong items blocks access to the weaker Rp- items (Camp et al., 2007;

Dodd et al., 2006; Hughes, 2007; Jakab & Raainjakers, 2009; Jonker & MacLeod, 2012; Lang, 2000; McGeoch, 1942; Perfect et al., 2004; Raaijmakers & Jakab, 2012, 2013; Raaijmakers & Shiffrin, 1981; Verde, 2009, 2013; Raaijmakers & Jakab, 2013). Without strengthening Rp+ items in the presence of the category cue, there would likely be less interference between the cue and Rp- items as the context during retrieval-practice (i.e., retrieve subordinate meanings to Rp+ items) no longer matches the context at final test (i.e., retrieve all items in the presence of the category cue used during initial study). Given that the cue was not strengthened along with the exemplars in Jonker and MacLeod's first experiment, distinctions between the two theoretical accounts of RIF could not be made. Under these experimental manipulations, both inhibitory- and competition-based accounts would thereby expect the exact pattern of results obtained (Jonker & MacLeod, 2012).

In an effort to further evaluate the competition/interference principle of inhibitory-based RIF in a way that would allow one to eliminate competition-based explanations of the results, Jonker and MacLeod (2012) created a hybrid version of Anderson et al.'s (2000) non-competitive cue retrieval method, and their own subordinate meaning retrieval technique for Experiments 2 and 3. In Anderson et al.'s work, participants repeatedly retrieved the category cues rather than the exemplars during retrieval-practice (e.g., Fr__ - apple). Similar to Jonker and MacLeod's subordinate retrieval method, the Rp+ items were strengthened and showed a significant practice effect, however, Rp- items showed no impairment relative to the NRp baseline (Anderson et al., 2000). This non-competitive retrieval of the category cues was argued by the authors to be in line with the inhibitory explanation of RIF given that competition or interference is necessary in order to trigger the inhibitory component involved with RIF. No competition among exemplars occurred because the cue was retrieved rather than the exemplars

and therefore no inhibition occurred. In Jonker and MacLeod's work, the absence of the category cue during retrieval of subordinate words may not have sufficiently strengthened the cue to create the interference needed at test to produce the RIF pattern of results. Thus, to address this issue, and to use a method previously used in the literature, Jonker and MacLeod first had participants retrieve a subordinate of the Rp+ target presented on screen (e.g., "dog" presented and participants retrieve "beagle"), then engage in retrieval of the cue that fit with that target (e.g., "P__ - dog"). This stepwise retrieval-practice method allowed for the strengthening of the Rp+ targets (e.g., "dog") through retrieval of the subordinate meaning (e.g., "beagle"), as well as strengthening of the cue (e.g., "pet") without creating competition between the cue and associated exemplars. This same method was used in the next two experiments with the means of assessing final memory being the only difference between Experiments 2 and 3; cued recall was used in the second experiment while a recognition test that controlled output interference was used in the third experiment. Contrary to the competition/interference dependence principle, the non-competitive retrieval-practice tasks resulted in significant RIF under both methods of assessing final memory (Jonker & MacLeod, 2012). These results are inconsistent with a purely inhibitory account of RIF because the lack of competition among Rp+ and Rp- exemplars during strengthening should have left no need to inhibit non-competing items thereby resulting in no RIF (i.e., no need to inhibit competing traces if there are no traces that are competing).

The mixed evidence for the competition/interference dependence principle of inhibitory-based RIF indicates that careful manipulations must be made during RIF tasks if theoretical conclusions are to be drawn. From an inhibitory perspective, a highest degree of forgetting should be found when Rp- competitors are of high taxonomic frequency because a greater degree of inhibition would be required to resolve the strong interference resulting from high frequency

competitors. Conversely, Rp- competitors with low taxonomic frequency should show lower levels of forgetting due to the reduced level of interference resulting from those weak competitors.

1.1.5.3. (C) Strength independence. Another principle of inhibition-based RIF is the principle of *strength independence*. This principle states that the degree to which Rp+ targets are strengthened is unrelated to the degree of inhibition induced (e.g., Anderson, 2003, 2009; Anderson & Levy, 2007; Storm & Levy, 2012; Storm et al., 2006). Simple correlations between the strengthening of Rp+ items and the degree of impairment found for Rp- items have been used to evaluate this principle (Hanslmayr et al., 2010; Staudigl et al., 2010; Hulbert et al., 2012). From an inhibitory perspective, the argument is that Rp+ target strengthening is not the sole reason for impairment of Rp- items at test. If RIF was due to a strengthening-weakening trade off, inverse correlations would be expected, but what has been found instead is no relationship between Rp+ strengthening and Rp- forgetting (i.e., $r = 0$). In fact, the strongest support for this principle comes from research that found impairment for Rp- items when impossible retrieval-attempts were used (Storm et al., 2006; Storm & Nestojko, 2010). Storm et al. (2006) provided participants with possible (e.g., fruit – ba__) and impossible (e.g., fruit – lu__, fruit – pu__) retrieval attempts. Possible retrieval trials included those that engaged participants in actual retrieval-practice (e.g., fruit – banana) while impossible retrieval trials included those that participants could not accurately complete, because no such items existed (e.g., no such fruits exist that start with "lu" or "pu"). At final test, Rp- items that were paired with impossible retrieval attempts showed the same degree of impairment as Rp- items that paired with possible retrieval attempts. In other words, impairment was found in the absence of Rp+ target strengthening. The authors argued that the act of attempting to retrieve an item lead to RIF, not

the strengthening that results from successful retrievals, as competition-based theorists would expect (Anderson, 2003, 2009; Anderson & Levy, 2007, 2011; Storm et al., 2006).

A lack of a relationship between these variables is difficult to interpret, however, because extraneous variables or individual differences may disguise potential relationships (Raaijmakers & Jakab, 2013). Further, as discussed in the previous section, competition-based accounts can explain the absence of a Rp+ strengthening/Rp- forgetting correlational relationship under certain circumstances (Jonker & MacLeod, 2012). Thus, although strength independence is argued by inhibitory proponents to support that account, the lack of relationship between Rp+ target strengthening and forgetting cannot be considered diagnostic of one explanation or the other. Both camps can account for a lack of relationship, thus additional evidence is needed to guide interpretation of results that examine strength independence in RIF.

1.1.5.4. (D) Retrieval-specificity. According to the inhibitory account of RIF, strengthening of Rp+ items through retrieval-practice results in mental competition or interference between the cue and to-be-remembered items. In order to overcome interference associated with having multiple representations activated at once that are all associated to the same retrieval cue (e.g., Anderson, 2003, 2009; Anderson & Levy, 2007, 2011; Verde, 2012), active suppression or inhibition is required. At each retrieval-practice trial, items associated with the presented cue compete for mental awareness and those items that are not the target item are supressed to resolve some of this interference. From the inhibitory perspective then, competition or interference at retrieval is necessary to trigger the inhibitory mechanism required to suppress activation of competing traces (Anderson, 2003; Anderson, Bjork & Bjork, 2000; Anderson & Levy, 2007, 2011; Verde, 2012). In other words, when targets are simply strengthened without inducing mental competition (e.g., re-study rather than retrieval-practice), no inhibition is

necessary to suppress competitors, and therefore RIF should not obtained. A variety of evidence in support of the principle of retrieval specificity has been found across an array of materials and paradigms (e.g., Anderson & Bell, 2001; Anderson et al., 2000; Bäuml, 1996, 1997, 2002; Bäuml & Aslan, 2004; Ciranni & Shimamura, 1999; Hanslmayr, Staudigl, Aslan & Bäuml, 2010; Johansson, Aslan, Bäuml, Gäbel & Mecklinger, 2007; Wimber, Rutschmann, Greenlee & Bäuml, 2010). For example, as just discussed, Storm et al. (2006) had participants engage in possible (e.g., fruit – ap__) and impossible retrieval attempts (e.g., fruit – lu__) during retrieval-practice and found reliable RIF under both manipulations. From the inhibitory perspective, the act of attempting to retrieve items resulted in competition between that category cue and all related items in memory. Non-target items are supressed or inhibited as the search for the impossible target items ensues. At final test, reduced recall of items from the impossible retrieval-attempt categories (e.g., Fruit items) is found. Therefore, RIF researchers from the inhibitory camp argue that retrieval-attempts, whether successful or not, are required to create the mental competition necessary to trigger the inhibitory component responsible for RIF. Further evidence of the necessity of retrieval-attempts to induce RIF is the finding of a lack of forgetting when simple target (Rp+) strengthening occurs, such as through re-study trials in place of retrieval-practice (Ciranni & Shimamura, 1999).

Additional evidence to support the principle of retrieval-specificity has been found from functional magnetic resonance imaging (fMRI) research of the pre-frontal cortex during retrieval-practice in a RIF task (Kuhl et al., 2007). In their fMRI examination, Kuhl et al. (2007) found significant prefrontal activity during retrieval-practice, particularly during the first few attempts. As the retrieval-practice trials unfolded, there was a decline in frontal activity that was also significantly associated with the degree of forgetting that participants demonstrated at final

test. This decline in frontal activity was interpreted as evidence of the progressive resolution of retrieval-competition across each retrieval-practice trial. The heightened activation at the outset of the retrieval-practice trials was taken to indicate the large degree of mental competition/interference occurring while attempting to complete the retrieval-practice fragment. In order to successfully complete the trial, related and competing traces were inhibited thereby resulting in reduced activation on each subsequent trial. In other words, inhibition during each retrieval-attempt effectively reduced activation and subsequent interference from competing Rp- items. At final test, the degree to which frontal activation was reduced across trials was also related to the degree of impairment found for the Rp- competitors. Taken together, this pattern of results seems to provide additional evidence of the need, and ability, of the frontal cortex to resolve mental competition through inhibition during retrieval-attempts.

Researchers from the competition-based camps of RIF have also shown that they can demonstrate RIF under non-competitive retrieval-practice trials, and that the results fit well with non-inhibitory perspectives (Raaijmakers & Jakab, 2012). For example, across two experiments, Raaijmakers and Jakab (2012) found significant RIF when participants were tasked with repeatedly retrieving the category cues rather than the exemplars, similar to Anderson et al.'s (2002) cue-retrieval method (e.g., F__ - apple). To make the retrieval of the cues more competitive than in Anderson et al.'s study, Raaijmakers and Jakab used properties of the items as the categories (e.g., Round – button) instead of simple semantic categories (e.g., Fruit – apple) and did not provide the first letter to the cue to aid retrieval (e.g., ____ - button). These materials were considered to be more competitive because the association or link between the to-be-retrieved cues (e.g., round) and Rp+ targets (e.g., button) were not as obvious as with semantic categories. Second, the absence of a letter stem to aid retrieval should also activate more

possible related cues thereby increasing mental competition and interference. The key manipulation is that it is the *cue* that is being retrieved and competed with, not the Rp+ targets. Therefore, this manipulation increases mental retrieval-competition, just not among the Rp+ and Rp- exemplars. The lack of competition among Rp+ and Rp- items should thereby result in no RIF from an inhibitory perspective (i.e., no competition, no need to inhibit competitors) but RIF would be expected from competition-based explanations. Consistent with competition-based explanations, both experiments revealed that strengthening the cues through retrieval-practice resulted in significant RIF.

As with the principles of interference/competition independence and strength independence, both the inhibitory and competition-based accounts of RIF can adequately explain retrieval-specificity results under some circumstances. Assessing the principle of retrieval-specificity therefore does not provide diagnostic evidence of one theory over the other the way cue independence does (Anderson & Levy, 2007, 2011; Hiddleston & Anderson, 2012; Murayama et al., 2014; Storm & Levy, 2012). The final principle, output interference independence, is argued by some researchers to be an alternate test of cue independence because it presents items in the absence of the category cue at final test. This principle is discussed next.

1.1.5.5. (E) Output interference independence. *Output interference* refers to the negative influence that the output of earlier items has on items recalled towards the end of a recall protocol (e.g., Bäuml, 1998; 2002; Roediger, 1973, 1974). Following the typical RIF procedure, when presented with a category cue to recall items, it is possible that stronger memory traces come to mind first, such as the strengthened Rp+ targets. As these stronger items are outputted early in the protocol, this order of output can block access to weaker items that would be outputted later in the protocol. The presence of the category cue at test can further

increase the negative impact of output order as additional interference between that cue and the weaker competitor (Rp-) traces occurs, thereby further reducing the probability of competitor recall (Roediger, 1973, 1974). If *output interference* was indeed responsible for RIF, controlling the order of item output should eliminate RIF (Anderson, 2003; Anderson & Levy, 2007, 2011; Storm & Levy, 2012). One method commonly used to control the order of item output in memory tests is through the use of recognition testing.

Recognition tests are considered to be relatively free of interference given the nature of the task (Hicks & Starns, 2004; Spitzer & Bäuml, 2007). Rather than having to directly retrieve items from memory in order to be recalled and outputted, recognition tests present items to participants to make "old" or "new" judgements (i.e., was the item studied before or not). Both *targets* (items that have been previously studied) and *lures* (items that are similar to studied items but were not actually studied) are used in recognition tests and the proportion of correct endorsements is most often analyzed (e.g., Aslan & Bäuml, 2010; Spitzer & Bäuml, 2007). A number of studies have examined RIF using recognition testing to eliminate the role of output interference, and although typically lower levels of RIF are found, significant RIF still persists (e.g., Anderson, 1995; Anderson et al., 1994; MacLeod, 2002; Spitzer & Bäuml, 2007).

The first meta-analysis on RIF was published by Murayama and colleagues (2014) and revealed clear evidence of the contribution of output interference in RIF. In their examination of the impact of output interference on RIF, Murayama et al. compared studies that controlled output interference to those that did not. The size of the RIF effect was significantly reduced, and in some instances cut in half, when output order was controlled; consistent with the inhibitory account of RIF though, a small but significant RIF effect was still found. These results implicate the role of both inhibition and interference in adult RIF. The two child RIF

studies that used recognition testing also suggest that output interference might contribute to results. In brief, Ford et al. (2004) found RIF across recall and recognition testing in 7 year olds, but more Rp+ items were endorsed when those items were presented before the Rp- items. Finding a significant impact of item order on children's endorsements in Ford et al.'s study provides some evidence that output interference also impacts children's memory performance following retrieval-practice.

The use of recognition testing to control output order has also provided evidence that implicates the role of interference mechanisms in young children's RIF. Aslan and Bäuml (2010) tested kindergartners, second graders, and adults using both recall and recognition testing, and found RIF with recall across all groups, however, the kindergartners no longer demonstrated RIF with recognition testing. The authors therefore concluded that only second graders' and adults' RIF is the result of inhibitory mechanisms (Aslan & Bäuml, 2010). If RIF in the kindergartners in Aslan and Bäuml's study was the result of an inhibitory mechanism, then the Rp- representations should have been suppressed or inhibited in general, regardless of the method of final testing (i.e., recall v. recognition; Anderson, 2003, 2009; Anderson & Levy, 2007, 2011; Hiddleston & Anderson, 2012; Spitzer & Bäuml, 2007). What Aslan and Bäuml found, however, was that providing kindergartners with a recognition test helped to overcome some of the contextual cue-related interference produced through strengthening the Rp+ cue – exemplar pairs during retrieval-practice, thereby eliminating the appearance of forgetting of Rp- items that was observed with category cued recall. Unfortunately, the role of output interference in Aslan and Bäuml's study could not be evaluated because the researchers used two random orders of items for recognition, and did not strategically manipulate where in the test the weakest Rp- items appeared.

RIF that persists in tests that control the impact of output interference provides evidence for the inhibitory account of the effect due to the elimination of both contextual cue-related interference, and output interference on performance. Thus, if kindergartners can demonstrate output interference independent RIF, then it can be concluded that the sample has the inhibitory abilities necessary for inhibition-based RIF. Aslan and Bäuml's (2010) study, however, suggests that kindergartners may not yet possess this inhibitory capacity, and Ford et al.'s (2004) study implicates the influence of output order in 7 year olds' RIF performance. From a purely inhibitory perspective, the lack of RIF in kindergartners' recognition memory seems consistent with the theory given that 4-5 year olds (i.e., kindergartners) should have diminished inhibitory ability due to the immature stage of development of their prefrontal cortex and related executive functions (e.g., Anderson & Weaver, 2009; Bjorklund & Harnishfeger, 1990; Moriguchi & Hiraki, 2013). The potential developmental nature of RIF in young children is discussed next.

1.1.6. Cognitive Inhibition, the Frontal Lobe, Executive Functions and Retrieval-Induced Forgetting

The mental process termed *cognitive inhibition* is rooted in the frontal lobe of the brain (e.g., Bunge, Dudukovic, Thomason, Vaidya & Gabrieli, 2002) and improves with age (e.g., Carlson & Moses, 2001; Passler, Isaac, & Hynd, 1985; Wilson & Kipp, 1998). Inhibition is considered an *executive function*, which is an umbrella term for a number of attention and mental control processes such as planning, working memory, monitoring, and regulating performance (Chan, Shum, Toulopoulou & Chen, 2008). The frontal lobe plays a large role in the organization, coordination, and execution of many brain functions including behaviours that are goal-directed or self-regulatory (Romine & Reynolds, 2005). The differences in performance on many tasks that are mediated by the frontal lobe across age groups have revealed that the

development of this brain area and its functions occur in multiple stages (Romine & Reynolds, 2005). The largest period of development begins around age 4 with a spurt in growth of the prefrontal cortex (Dempster, 1993) and the most marked period of development, as measured through neuropsychological testing, occurs between 6 – 8 years of age (Romine & Reynolds, 2005). During adolescents, slight gains in executive functions are found with peak, adult-like performance occurring sometime between adolescence and the early 20s, depending on the task used to evaluate performance (Romine & Reynolds, 2005). Frontal lobe development has been associated with performance on many tasks involving executive functions such as *directed forgetting* (e.g., Aslan, Staudigl, Samenieh & Bäuml, 2010; Bjorklund & Harnishfeger, 1990; Harnishfeger & Pope, 1996), *Stroop tasks* (e.g., West & Alain, 2000), *working memory* (e.g., Welsh, 2002), *problem solving* (e.g., Welsh, Pennington & Groisser, 1991), *recognition memory* (e.g., Luciana & Nelson, 1998), and *go-no-go tasks* (Casey et al., 1997). Although children and adults demonstrate activation in the same areas of the dorsolateral and orbitofrontal cortical regions during inhibition tasks, the volume of activation is significantly larger for children compared to adults, especially in the dorsal and lateral prefrontal cortices (Casey et al., 1997).

The inhibition that results in RIF has been argued to be a self-regulatory mental process caused by executive control processes (Anderson, 2003; Levy & Anderson, 2002; Román et al., 2009) in the prefrontal cortex (Levy & Anderson, 2002). Inhibition can therefore not only affect memory but also has the ability to control behaviour and allow individuals to selectively attend to, or ignore stimuli (Anderson, 2003; Levy & Anderson, 2002; Román et al., 2009). Some researchers have argued for different forms or types of inhibition (e.g., Aron, 2007; Harnishfeger, 1995) and others have found evidence to suggest developmental differences in *intentional* but not *unintentional inhibition* as found in RIF (Lechuga, Moreno, Pelegrina, Gómez

-Ariza & Bajo, 2006; Ortega et al., 2012). *Intentional inhibition* refers to the voluntary suppression of information, such as the inhibitory process needed to recall only the three smallest objects in a list of five objects (Lechuga et al., 2006). Individual differences in *working memory* (i.e., the mental workbench that temporarily stores and manipulates information to complete cognitive tasks; Baddeley, 1992) have been found to be positively correlated with RIF (Aslan & Bäuml, 2011), which also implicates the role of prefrontal executive functioning. Specifically, Aslan and Bäuml (2011) had young adults complete a RIF task using item recognition as the final test. Participants also completed an operation span task where they had to read a mathematical equation out loud and verify if the answer was correct (i.e., state yes or no) and then read an unrelated word aloud (e.g., [8 ÷ 4] + 3 = 5? *moon*; Aslan & Bäuml, 2011). Then, the next math-word pair would follow until all items in the set were presented. Participants were tasked with recalling the words in the correct order (Aslan & Bäuml, 2011). Higher operation span scores were inversely related to RIF scores – that is, those with greater working memory demonstrated greater inhibition. These results are consistent with other developmental work examining the multidimensional nature of executive functions (e.g., go/no-go task, verbal fluency, Stroop-like performance, digit span), which suggest that there is an interaction between inhibition and working memory (Brocki & Bohlin, 2004; Harnishfever & Bjorklund, 1994; Johnstone, Pleffer, Barry, Clarke & Smith, 2005; Levy & Anderson, 2002; Roberts & Pennington, 1996).

Given this developmental trajectory of the frontal lobe and associated executive functions such as *inhibition* (e.g., Harnishfeger & Bjorklund, 1994), the very young were not expected to demonstrate RIF when the first RIF study with a sample of child participants was published (Ford et al., 2004). In their first study, Ford et al. found evidence suggestive of RIF in 7 year

olds following a retrieval-practice manipulation that was completed in an "interrogation" style. Given the theoretical implications of finding RIF in a sample that should have underdeveloped inhibitory ability, Ford and her colleagues aimed to replicate the effect in a second study with 7 year olds. as well as a young adult sample, for comparison. The final memory test that Ford et al. selected for their second study was a yes/no recognition test in place of cued recall in order to help evaluate the potential impact of competition-based explanations such as *output interference* (Anderson et al., 1994; Bäuml, 1998; 2002; Roediger, 1973, 1974). As reviewed earlier, from a competition-based perspective of RIF, the repeated strengthening of Rp+ items through retrieval-practice increases the activation of those items in memory in comparison to the un-retrieved Rp- items that share the category cue (i.e., *strength-based competition*). When presented with the category cue at final test, the strong, active Rp+ items are outputted first, resulting in further mental competition and interference among the remaining items in memory (i.e., output interference), which result in lower levels of Rp- recall overall (i.e., RIF). Using a recognition test that controls the order of output of Rp+ and Rp- items (i.e., Rp- items first versus last on the recognition test) without presenting the category cue allows for a direct examination of the influence of output of interference and contextual cue-related interference (e.g., Anderson et al., 1994; Aslan & Bäuml, 2010; Ciranni & Shimamura, 1999, Ford et al., 2004; Soriano et al., 2009). If Rp- items show significantly lower endorsement only when they are presented at the end of the recognition test, then evidence in support of the competition-based accounts of children's RIF would be obtained. Although children endorsed significantly more Rp+ items when they were presented before Rp- items in Ford et al.'s study, their level of Rp- endorsement remained the same across orders and was similar to the adult comparison sample. This suggests that children are susceptible to some output interference but that such interference does not seem

to fully explain 7 year olds' RIF. Ford and her colleagues suggested that the inhibitory account of RIF best explained their results, and that there may be multiple types of inhibition that mature at different rates.

Although some researchers agree with Ford et al. (2004) that multiple types of inhibition may exist (e.g., Lechuga et al., 2006; Harnishfeger, 1995; Román et al., 2009), concluding that their results were consistent with the common inhibitory explanation of RIF might have been premature given what we know regarding the principles that support Anderson and colleagues' inhibitory account of RIF in adults (e.g., Anderson, 2003, 2009; Anderson & Levy, 2007, 2011; Hiddleston & Anderson, 2012; Murayama et al., 2014; Storm & Levy, 2012). Although recognition tests alleviate contextual cue-related interference, output interference also seemed to affect the results. The significant interaction of practice type and output order (Rp+ items endorsed more often if they proceeded Rp- items) indicates that the number of items recalled later on in the memory test were being significantly impacted by earlier outputted items (Ford et al., 2004). Although output interference independence was demonstrated by the maintenance of a significant RIF effect with recognition, order of output significantly affected performance. Further, 7 year olds are at an age when their frontal lobes and associated executive functions should be demonstrating their most marked changes and development (Carlson & Moses, 2001; Dempster, 1993; Romine & Reynolds, 2005; Wilson & Kipp, 1998) so subtle differences in inhibitory ability may have been difficult to detect across participants. Some inhibitory capacity would be expected at this age for most participants, however, research with older adults suggests that these subtle individual differences will not be detectable without dual task demands (e.g., Lechuaga et al., 2006; Ortega et al., 2012). In sum, Ford et al.'s study is not a very

comprehensive examination of children's ability to demonstrate RIF, and does not use adequate measures to identify inhibition in their participants' performance.

The next study to examine RIF in children using recognition testing was Aslan and Bäuml's (2010) study, and it is the only study to examine RIF within a sample young enough to be considered as having underdeveloped frontal lobes (M_{age} = 4.6 years) (Carlson & Moses, 2001). In their study, kindergartners' recall and recognition performance following a retrieval-practice manipulation was compared to second graders' and adults' performance. Second graders' performance was quite similar to adults', however, kindergartners demonstrated RIF only when cued recall was used. Under recognition testing, kindergartners no longer demonstrated RIF; Rp- items and NRp items were endorsed at similar rates. These findings are consistent with the inhibitory explanation of RIF in that individuals who have diminished inhibitory capacity (i.e., those with immature frontal lobes) do not demonstrate RIF with recognition testing. Why though, did kindergartners in Aslan and Bäuml's study demonstrate RIF with category cue recall? It could very well be that in such a young group, strength-based competition mechanisms contribute to performance – the very issue that Ford and her colleagues (2004) attempted to test in their second study with 7 year olds. Thus, neither Aslan and Bäuml, nor Ford et al., have fully evaluated the inhibitory account of RIF in children, and subsequent studies of RIF in children have utilized only category cue recall (e.g., Lechuga et al., 2006; Marche et al., 2015; Phenix & Price, 2012; Zellner & Bäuml, 2005). This dissertation research addressed this dearth in the literature by fully evaluating the five principles in support of inhibitory-based RIF in two groups of kindergartners.

The next chapter will provide the theoretical predictions and study rationale for both experiments in this dissertation. Chapter 3 provides the specific details regarding the first and

second study, respectively, along with brief discussions of the results. In the final chapter, a general discussion of the implications of both studies, as well as limitations and future directions for this line of research, are provided.

2. CHAPTER 2: STUDY OVERVIEW, RESEARCH QUESTIONS, AND HYPOTHESES

Both a competition-based and inhibitory perspective can account for RIF under certain circumstances. Therefore, to gain an empirical and theoretical understanding of the RIF effect, controlled efforts must be made to disentangle the influence of each theoretical mechanism on final memory performance (Anderson & Levy, 2007, 2011; Murayama et al., 2014). Given the developmental nature of cognitive inhibition (e.g., Harnishfeger, 1995), and the vast research literature in support of this account in adult populations (e.g., Murayama et al., 2014), an examination of inhibition in young children's RIF would be a sound starting point for understanding the developmental trajectory of inhibitory-based RIF across the lifespan. The few studies that have examined RIF in young children (Aslan & Bäuml, 2010; Ford et al., 2004; Lechuga et al., 2006; Zellner & Bäuml, 2005; Phenix & Price, 2012; Marche et al., 2015) have not employed methods that allow for a clear distinction to be made between the theoretical mechanisms driving the effect. Thus, as a step towards achieving this goal, the purpose of the current thesis is to evaluate each of the five principles that are argued to support the inhibitory account of RIF in kindergartners: (a) *cue independence*, (b) *retrieval-specificity*, (c) *strength independence*, (d) *interference independence*, and (e) *output interference independence.* The rationale for the manipulations used in each experiment, along with the theory, and hypotheses surrounding each manipulation are discussed next.

2.1. Cue Independence

The first and strongest demonstration of inhibition-driven RIF, *cue independence* (Anderson & Levy, 2007, 2011; Hiddleston & Anderson, 2012; Hulbert et al., 2011), has been evaluated namely in three ways – the *independent probe* (i.e., *novel* cue) method (Camp, Pecher, Schmidt & Zeelenberg, 2009; Hiddleston & Anderson, 2012; Perfect et al., 2004; Saunders &

MacLeod, 2006; Weller et al., 2012), *cross-category cuing* (e.g., Anderson & Spellman, 1995; Murayama et al., 2014), and *recognition testing* (e.g., Aslan & Bäuml, 2010, 2011; Ford et al., 2004; Glanc, 2008; Gómez -Ariza et al., 2005; Weller et al., 2012) techniques. In order to evaluate cue independence, the final memory test used must not involve the cues used during initial study or retrieval practice (Anderson & Levy, 2007, 2011; Hiddleston & Anderson, 2012; Murayama et al., 2014; Storm & Levy, 2012).

2.1.1. Research Question I: Is Kindergartners' Retrieval-Induced Forgetting Cue Independent?

In the current study, an independent probe technique was adopted by presenting participants with the original category cue at recall for one RIF task (e.g., What "Fruits" do you remember studying?), and a novel sentence cue at recall for a second RIF task (e.g., What "different foods or things that you could eat" do you remember studying?). For this reason, some item development work was required to first generate novel independent cues that would be familiar to kindergartners. If inhibition is responsible for the significant reduction in recall of Rp- items compared to NRp baseline items, then the RIF pattern of results should persist when a novel cue is provided to guide final recall. According to the principle of *cue independence*, interference arises between the category cue and the competitor items (Rp-) as retrieval of the targeted items (Rp+) is attempted. In other words, attempting to retrieve Rp+ items produces interference between the cue and the Rp- items as the target is searched for in memory. To aid successful retrieval of the targets, the interference triggers the inhibitory mechanism responsible for the final RIF effect (i.e., reduced recall of Rp- items below NRp items). Therefore, if RIF persists under novel cue testing conditions in kindergartners, it can be argued that the inhibitory mechanism responsible for RIF in older populations (see Anderson, 2003, for a review) is likely

intact in the kindergarten years as well. However, if RIF is eliminated when a novel cue is used to guide kindergartners' recall, the results would support a cue-dependent, competition-based explanation of RIF. In other words, if RIF is not found when a novel cue is used at recall, it is unlikely that kindergartners have developed the inhibitory ability needed to produce inhibition-driven RIF. Instead, the interference that builds between the category cue and competitors (Rp-) as targets (Rp+) are searched for and successfully strengthened through retrieval remains at final test, no inhibitory mechanism is triggered, and the RIF effect is produced. When a novel cue is presented, however, the interference between the cue and competitors is released, resulting in a release from cue-dependent competition-based RIF, thereby eliminating the RIF effect.

2.1.1.1. Hypothesis I. Given the vast empirical evidence that documents the immaturity of kindergartners' frontal lobes and associated cognitive functions such as inhibition (e.g., Carlson & Moses, 2001; Dempster, 1993; Passler et al., 1985; Romine & Reynolds, 2005; Wilson & Kipp, 1998), along with Aslan and Bäuml's (2010) evidence that suggests the involvement of competition-based influences in kindergartners' RIF, kindergartners in the current study were expected to demonstrate *cue-dependent* RIF. In other words, kindergartners were expected to demonstrate RIF when the final memory test utilized the original category cues to guide recall, however, when a novel cue was provided, a release from RIF was expected due to an elimination of the context-related interference that is associated with the original category cue. A novel cue should provide kindergartners with an alternate means of accessing the Rp- memory traces and baseline levels of recall (NRp) should be observed. These findings would be consistent with an inhibitory explanation of RIF because children as young as 5 years have been found to have immature inhibitory ability on other cognitive tasks (e.g., directed forgetting, Bjorklund & Harnishfeger, 1990; Conway & Fthenaki, 2003; memory suppression, Anderson et

al., 2004; episodic memory, Fletcher & Henson, 2001; recognition & working memory, Luciana & Nelson, 1998), and is also consistent with competition-based accounts due to the elimination of contextual cue-related interference (Camp et al., 2007; Perfect et al., 2004).

Cue independent RIF is considered diagnostic of inhibition due to its unique ability to explain impaired memory performance of Rp- items regardless of the final method of testing (Anderson, 2003, 2009; Anderson & Levy, 2007, 2011; Hiddleston & Anderson, 2012; Spitzer & Bäuml, 2007). Therefore, testing the principle of cue independence in kindergartners will provide the strongest evaluation of the role that inhibition plays in their recall.

2.2. Strength Independence

2.2.1. Research Question II: Is Kindergartners' Retrieval-Induced Forgetting Strength Independent?

Strength independence refers to the general finding that the degree of strengthening that occurs during repeated retrieval of Rp+ items is independent of the degree of forgetting observed for the Rp- items. From an inhibitory perspective, it is argued that the impairment found for Rp- items is not simply due to target strengthening as competition-based interference explanations attest (Anderson, 2003; Anderson & Levy, 2007, 2011; Ciranni & Shimamura, 1999; Storm & Levy, 2012). If the reduced recall of Rp- items was the direct result of target strengthening, then an inverse correlation between Rp+ and Rp- would be found – as Rp+ are strengthened, Rp- are weakened. Within the majority of the adult RIF research, the inhibitory explanation has been supported – no correlations between target strengthening and competitor forgetting have been obtained (Hanslmaayr et al., 2010; Hulbert et al., 2011; Staudigl, Hanslmayr & Bäuml, 2010). The method of assessing the relationship between strengthening and forgetting following retrieval-practice has been accomplished in a number of ways. Staudigl et al. (2010) state that

"Enhancement was not significantly correlated with forgetting (r = -.15, p = .49)" (p. 11359), while Hulbert et al. (2011) make claims that are similarly vague as Staudigl et al. and state that there was no "relationship between strengthening and RIF" (p. 16) without clearly defining how strengthening or RIF was being defined (i.e., Rp- versus Rp- minus NRp). Hanslmaayr et al. (2010), as well as Murayama et al. (2014), correlated the degree of target strengthening ([Rp+] – [NRp]) to degree of RIF scores ([Rp-] – [NRp]).

Regardless of the method of comparing strengthening to forgetting, the majority of studies that discuss this principle interpret their results as supportive of the inhibitory account, but there are instances when a competition-based explanation can suffice. For example, Murayama et al.'s (2014) meta-analysis on RIF revealed that a positive correlation was found between strengthening and forgetting when output interference was not controlled, but the relationship was eliminated once it was controlled. The positive correlation between strengthening and forgetting when output interference is uncontrolled suggests that the degree to which targets are strengthened has an effect on the degree of competitor forgetting in the presence of that type of interference (Murayama et al., 2014). The persistence of RIF on tests of item recognition, along with the elimination of the positive strengthening/forgetting relationship once output interference is controlled, "…clearly supports the strength-independence assumption" (Murayama et al., 2014, p .1400) of adult RIF. If inhibition is responsible for kindergartners' RIF, then no relationships should be found among Rp+ target strengthening and Rp- competitor forgetting. If competition-based explanations, such as output interference, better account for kindergartners' RIF, then a significant positive correlation should be obtained between the degree to which Rp+ items are strengthened and the degree to which Rp- items are forgotten, especially when output interference is not controlled (e.g., original cue recall).

2.2.1.1. Hypothesis II. Once again, due to the immature stage of development of kindergartners' executive functions, participants in the current study are expected to demonstrate *strength-dependent* RIF as they should not have the inhibitory abilities needed to demonstrate inhibitory-based RIF. An inverse correlation between strengthening and forgetting would indicate a direct trade-off between the degree to which Rp+ targets are strengthened and the degree to which Rp- competitors are forgotten. If output interference contributes to the forgetting that kindergartners' experience following retrieval-practice, then in instances when output interference is high (e.g., original cue recall, recognition with competitors last), a positive correlation should be found similar to that found in Murayama et al.'s (2014) meta-analysis. However, the correlational evidence obtained from examining this hypothesis will not definitively pinpoint the theoretical mechanism contributing to kindergartners' RIF, but will help evaluate the inhibitory account in kindergartners' RIF if examined under all the current experimental contexts (i.e., original cue recall, novel cue recall, recognition testing with competitors first or last).

2.3. Interference/Competition Dependence

2.3.1. Research Question III: Is Kindergartners' Retrieval-Induced Forgetting Interference/Competition Dependent?

The third principle in support of an inhibitory explanation of RIF that is examined in the current study is that of *interference* or *competition dependence* (Anderson, 2003; Anderson & Levy, 2007, 2011; Storm & Levy, 2012). Recall that *interference/competition dependence* refers to the finding that the greater the interference or competition between targets (Rp+) and competitors (Rp-), the greater the degree of RIF obtained (e.g., Anderson et al., 1994). The argument holds that more inhibition is needed to suppress competitors that produce a high

amount of interference during retrieval attempts, than the degree of inhibition needed to suppress competitors that provide little, or no, interference during retrieval (i.e., *strong* competitors such as Fruit – Apple will produce more interference than *weak* competitors such as Fruit – Guava). In such studies (e.g., Anderson et al., 1994; Anderson et al., 2000), *taxonomic frequency* (i.e., strength of category membership) of items within categories is manipulated. For example, in Anderson et al.'s (1994) pioneer RIF research, items with an average taxonomic frequency of 8 and 50 (Battig & Montague, 1969) were designated as *strong* and *weak* exemplars, respectively. Taxonomic frequencies reflect the average output position of the item when participants are presented with the associated category name, therefore, lower scores mean stronger category membership. When items with greater taxonomic word frequency serve as competitors (Rp-) in RIF tasks, a greater degree of inhibition is required to suppress those items from memory when compared to RIF tasks that employ lower taxonomic frequency competitors (Anderson, 2003; Anderson et al., 1994; Anderson & Levy, 2007, 2011; Storm & Levy, 2012). If items with low taxonomic frequency are repeatedly retrieved during retrieval-practice (Rp+), the items with high taxonomic frequency that serve as competitors (Rp-) create a high degree of interference. In order to overcome this strong interference, a greater degree of inhibition is required to suppress or inhibit the competitors from coming to mind during retrieval, thereby resulting in a high degree of forgetting. On the other hand, if items with high taxonomic frequency are retrieved (Rp+), and items with low taxonomic frequency serve as competitors (Rp-), a lesser degree of interference results, and therefore less inhibition is required to suppress the weak items, which in turn results in lower degrees of forgetting.

According to the competition-based *associative blocking hypothesis* of RIF, however, repeated retrieval of a subset of items in association to a category cue strengthens the activation

of those items in memory (Raaijmakers & Shiffrin, 1981; Román et al., 2009). This strengthening of items through retrieval (Rp+) leads to interference between the cue and the weaker, un-retrieved (Rp-), items resulting in lower recall of the weak competitors. At final test, additional interference accrues between the cue and weak items (Rp-) as the strong items (Rp+) are outputted early, thereby further reducing the recall of competitors, and producing the typical RIF pattern of results (Anderson & Levy, 2007, 2011; Román et al., 2009; Storm & Levy, 2012). According to the interference interpretation of RIF then, no difference in the degree of forgetting obtained is expected when weak or strong items serve as competitors.

No taxonomic word frequency norms exist for kindergartners however, and only two word frequency norm books could be found that included kindergartners at all - only one is printed in English (Zeno, Ivenz, Millard & Duvvuri, 1995). Therefore, rather than relying on taxonomic frequency strength, *word frequency strength* (i.e., scores reflecting the frequency of occurrence of words in kindergartners school-related materials) was used to manipulate competitor strength. If kindergartners demonstrate RIF due to inhibitory mechanisms, a greater degree of RIF should be obtained when higher frequency items serve as competitors (Rp-) than when lower frequency items serve as competitors.

2.3.1.1. Hypothesis III. Both competition-based and inhibitory-based accounts of RIF would expect forgetting of Rp- items following retrieval-practice regardless of word frequency of the items. The key difference between the explanations with regards to interference/competition dependence is that *different degrees of RIF* are predicted from an inhibitory account (Anderson, 2003; Anderson & Levy, 2007, 2011; Hanslmayr et al., 2010; Jonker & MacLeod, 212; Storm, 2009; Storm & Levy, 2012). In other words, both competition-based and inhibitory-based accounts would expect RIF following retrieval-practice, but only the

inhibitory account makes claims regarding how *much* forgetting would be expected based on taxonomic word frequency. If kindergartners are demonstrating RIF from adult-like inhibitory mechanisms, then the interference/competition dependence principle should hold – a greater degree of RIF should be found when Rp- competitors have a high taxonomic frequency, while a lesser degree of RIF would be expected when Rp- competitors have a low taxonomic frequency. In general, competition-based accounts make no predictions regarding different degrees of RIF depending on word frequency, although strength-based accounts would expect stronger items (i.e., high taxonomic frequency and/or strengthened through practice) to be more accessible than weak items overall, and thereby be outputted earlier in recall protocols (Murayama et al., 2014; Raaijmakers & Jakab, 2013).

2.4. Retrieval-Specificity

2.4.1. Research Question IV: Does Kindergartners' Retrieval-Induced Forgetting Demonstrate Retrieval Specificity?

Testing the principle of *retrieval-specificity* in kindergartners' recall was accomplished by eliminating the retrieval-competition that results through retrieval-practice (Anderson, 2003; Anderson et al., 1994). This was achieved by having participants engage in re-study of the targets (Rp+) instead of completing a retrieval-practice task. If kindergartners' RIF is driven by an inhibitory mechanism, then active retrieval attempts are required to produce RIF (Anderson, 2003; Storm, 2011b; Storm et al., 2006). According to the inhibitory account, it is the increased interference that results from retrieval-competition that triggers the inhibitory mechanism responsible for inhibitory-based RIF (Anderson, 2003; Anderson et al., 1994; Ciranni & Shimamura, 1999). In other words, an active attempt to reach into memory is necessary to engage inhibition of competing responses, even if that retrieval attempt is unsuccessful (e.g.,

Storm et al., 2006). Therefore, without engaging the children in retrieval-competition by having them complete a re-presentation task instead of retrieval-practice, no attempt to retrieve a memory trace should be made, and the inhibitory mechanism responsible for inhibition-based RIF should not be triggered. Therefore, the inhibitory account of kindergartners' RIF would predict no RIF with re-study, but reliable RIF with retrieval-practice.

An *associative blocking* interference account of kindergarteners' RIF following re-study instead of retrieval practice would predict a different pattern of results (Glanc, 2008; McGeoch, 1942; Melton & Irwin, 1940). According to the generally accepted *competition assumption* of memory, memory traces that share a common cue automatically compete and interfere with each other's retrieval in the face of that cue (e.g., Anderson et al., 1994). As the association between the cue (e.g., fruit) and target item (e.g., kiwi) is strengthened, whether it be through retrieval or re-study, interference between that cue and competitors (e.g., apple) also increases because it too competes for awareness through the same cue. This strengthening of the cue-target association, and interference with the cue-competitor association, that results from practice leads to an increased probability of the target dominating recall when the cue is provided. At final test, from an *associative blocking* (McGeoch, 1942; also referred to as *response competition theory,* Anderson et al., 1994) interference account, one would expect the dominant targets (e.g., kiwi) to repeatedly come to mind during retrieval attempts using the cue (e.g., fruit – ki__). As those dominant target traces repeatedly come to mind, even more interference (e.g., *output interference*) between the cue and competitors (e.g., fruit – apple) occurs until retrieval attempts are abandoned. Recall of targets (Rp+) would therefore be expected to be significantly higher than recall of both competitors (Rp-) and baseline (NRp) items. In addition, from an *associative blocking* perspective, one would also expect significantly reduced recall of competitors (Rp-) in

comparison to baseline (NRp) items due to the dominant targets (Rp+) blocking access to the competitors. Thus, the typical RIF pattern of results would be expected under an *associative blocking* perspective when either re-study or retrieval-practice is used.

An *associative unlearning* interference account (e.g., Melton & Irwin, 1940) is slightly different from the associative blocking account in that the repeated re-study, or retrieval, of the cue – target pair (e.g., fruit – ki__) effectively punishes, or weakens, the cue – competitor pair (e.g., fruit – apple). This repeated unlearning of the cue – competitor pairs results in reduced levels of Rp- recall when presented with the category cue. What is not established in the literature, however, is whether or not re-study (e.g., fruit – kiwi) results in the same degree of weakening of the cue – competitor pair (e.g., fruit – apple) as does retrieval-practice (e.g., fruit – ap__). Therefore, from an *associative unlearning* perspective, it is possible that re-study will allow kindergartners' RIF to persist, but it is also possible that re-study will weaken the cue – competitor pairs down to baseline levels (e.g., NRp).

2.4.1.1. Hypothesis IV. Given the overwhelming research support for the inhibitory account of RIF (e.g., Anderson, 2003), very few researchers explore interference mechanisms that may be involved. What appears to be done instead is the use of methods that yield results that are explainable by the inhibitory account (i.e., *cue independence*) or test assumptions of the theory. Because no single result will definitively provide support for or against the *associative unlearning* interference perspective, the retrieval specificity data must be interpreted alongside other results (e.g., cue-independence, output interference independence) in order to evaluate the potential role of this type of interference.

2.5. Output Interference Independence

2.5.1. Research Question V: Is Kindergartners' RIF Output Interference Independent?

Although RIF has been found to persist when *output interference* is controlled in adult RIF studies (e.g., Anderson & Bell, 2001; Anderson et al., 1994, 2000; Anderson & McCullock, 1999; Bäuml, 2002; Bäuml & Hartinger, 2002; MacLeod, 2002; Murayama et al., 2014;), the size of the RIF effect is significantly reduced with this method (Murayama et al., 2014). The use of recognition tests are often used to control the order of item output (e.g., Gómez -Ariza et al., 2005; Hicks & Starns, 2004; Racsmany, Conway, Garab, & Nagymate, 2008; Saunders & MacLeod, 2002; Spitzer & Bäuml, 2007, 2009), and recognition tests are also considered to be an additional measure of *cue independence* because the cues are not presented on such tests (Murayama et al., 2014; Veling & van Knippenberg, 2004).

Only one study to date has examined the persistence of RIF in kindergartners using item recognition (Aslan & Bäuml, 2010). In Aslan and Bäuml's (2010) study, kindergartners', second graders', and adults' recall and recognition performance was compared following a retrieval-practice task using category – exemplar word lists. With recognition, kindergartners no longer demonstrated significant forgetting effects as they did with recall, and even demonstrated a slight (non-significant) tendency to recognize more competitor (Rp-) items than baseline (NRp) items. This finding provides some evidence for cue-dependent RIF in kindergartners as the effect was eliminated in the absence of the category cues. However, the construction of the recognition test did not allow for a thorough evaluation of *output interference*. Even though the order of output was controlled in this study, only two fixed random orders (i.e., one random order, one reverse of that order) were generated. For this reason, some *output interference* may still have resulted if competitors (Rp-) were presented after any other items (e.g., the middle or end of the protocol).

At the very start of the recognition test, no *output interference* yet exists – it begins once output commences. Thus, if one is to truly examine the role of *output interference*, all of the competitors (Rp-) should be placed at either the first few, and last few, positions of the test. Such a manipulation would allow one to compare the absolute minimum (competitors first) with the absolute maximum (competitors last) amount of possible *output interference* for that test. Output interference would be implicated in the results if RIF was obtained when competitors were at the end of a recognition test but not when the competitors were placed in the first few positions of the recognition test.

2.5.1.1. Hypothesis V. Based on previous research (Ford et al., 2004), and our theoretical understanding of *inhibition* (e.g., Anderson, 2003; Harnishfeger, 1995), kindergartners in the current dissertation were expected to show significantly reduced, or eliminated RIF, when a recognition test was used to assess memory performance following retrieval-practice. The fact that kindergartners in Aslan and Bäuml's (2010) study demonstrated RIF with category cue recall but not recognition suggests that kindergartners might demonstrate RIF due to competition-based mechanisms rather than inhibitory ones. Based on Ford et al.'s (2004) work, as children's frontal lobe and associated inhibitory capacity develops, a shift towards inhibition-dominant RIF might be made (which might be intact by age 7, Ford et al., 2004). It is possible that very young children's recall protocols conform to the typical RIF pattern of results due to strengthening of some associations through retrieval-practice and subsequent interference at final test (e.g., Raaijmakers & Jakab, 2013). As children age, and their inhibitory capacity develops, there may be shift towards the use of those inhibitory abilities also resulting in a RIF pattern of results, but now due to inhibition rather than interference. Given that recognition tests are cue-independent tests, and that output interference will be

controlled, the findings examining this principle can be considered diagnostic of whether or not inhibition contributes to kindergartners' RIF.

Without a full examination of the principles of the inhibitory explanation of RIF, one cannot conclude that inhibitory mechanisms are involved in kindergartners' RIF performance. Only careful manipulations and methods of testing final memory performance will elucidate the likely contributing mechanism to kindergartners' RIF. Thus, prior to concluding that the inhibitory mechanisms responsible for RIF are intact in young children, a full examination of the principles in support of the inhibitory account should be conducted. Given that both competition-based and inhibition explanations can account for RIF using original category cues at final test, and that no study to date has evaluated the principles in support of inhibition-based RIF in children, this is the goal of the current dissertation. In Experiment 1, the principles of *cue independence, strength independence,* and *interference/competition dependence* were evaluated, while Experiment 2 evaluated *strength independence* again, along with *retrieval-specificity,* and *output interference independence.* Each study had sets of kindergarten students from one of two rural Saskatchewan schools complete two RIF tasks in counterbalanced order. Experiment 1 and Experiment 2 are each discussed in turn next.

3. CHAPTER 3: EXPERIMENTS

3.1. Experiment 1 – Examining Cue Independence, Strength Independence, and Interference Dependence in Kindergartners' Retrieval-Induced Forgetting

3.1.1. Method

3.1.1.1. Participants

A total of 33 children (M_{age} = 5.38 years, *SD* = .30, 14 boys) were tested with the majority (*n* = 32) of children being recruited from Outlook Elementary School in Outlook, Saskatchewan. Two male participants were excluded from analysis due to a failure to follow instructions (e.g., one boy proceeded to recall all the words he knew that would fit under each category). The final sample consisted of 31 children (M_{age} = 5.37 years, *SD* = .30, 12 boys).

3.1.1.2. Materials

3.1.1.2.1. Recruitment packages. A total of 60 recruitment packages were prepared. A letter of invitation from the researcher (Appendix A), and from the Outlook Elementary School Principal (Appendix B), were enclosed in an envelope along with a parental consent form (Appendix C), and brochure for potential child participants (Appendix D).

3.1.1.2.2. Word lists. Aslan and Bäuml (2010) and Zellner and Bäuml (2005) are the only two published RIF studies with children that have used word lists. Zellner and Bäuml's word lists were unavailable, however, the German words used in Aslan and Bäuml's study were obtained and translated into English. Their word lists consist of eight categories with 12 items in each category (e.g., Animals – lion, elephant, tiger, dog, cat, horse, blackbird, crocodile, giraffe, pig, monkey, mouse; Aslan & Bäuml, 2010), and served as a starting point for developing the materials for the current English speaking Canadian sample.

The original eight categories used by Aslan and Bäuml (2010) were retained, as were the majority of items, however a number of items could not be found in the word frequency norms (Zeno et al., 1995) for English speaking kindergartners (e.g., vegetable – kohlrabi, vehicle – excavator), and were therefore omitted. In Aslan and Bäuml's study, the average recall rate for Rp+ items hovered around 50%. Given that Rp+ items typically demonstrate the greatest recall rate in RIF tasks, 50% accuracy suggests that four categories with 12 items in each category (48 words) may have been too taxing for their participants. Thus, the eight items with the lowest word frequency ratings from each category were removed from the current set of materials in order to simplify the task for participants.

In order to further reduce the chance of floor effects, a total of eight categories with four items in each category were sought. Thus, four additional categories with six items per category were also selected from the word frequency norms (Zeno et al., 1995) and reviewed by a set of judges to ensure that the items used were considered familiar to Canadian kindergartners. The seven judges included undergraduate (n = 3) and graduate students (n = 2) as well as two psychology faculty members (n = 2) at the University of Saskatchewan (Dr. Marche's Memory Research Team). The researcher attempted to strategically arrange the categories into one of two lists such that no semantic relationships existed among categories within a single list. The researcher generated a number of novel sentence cues that encompassed all items within a given category, but did not include any exemplars or the category name (e.g., for the *insects* category a novel cue option was *Different kinds of bugs*). These novel cues were arranged alongside the category-exemplar pairs for judges to review. To narrow the materials down from six categories per list to four, and to choose the most salient novel cues, a set of eight judges: (a) rank ordered the category – exemplar pairs according to how familiar the judges felt the category and items

would be to Canadian kindergartners (see Part 1 of Appendix E); (b) rank ordered items within each category according to how familiar they felt the items would be to kindergartners and how strongly the item fit with the category cue (see Part 2 of Appendix E); (c) rank ordered the novel cues provided for each category, and in instances when only a few options had been generated, provided any novel cue that the judges themselves could generate and included those item(s) in their ranking (see Part 3 of Appendix E); and (d) assigned each potential item to the category or categories that it fit with (e.g., *tomato* could be a *vegetable* or a *fruit* to young children, and both are *foods* which is part of a novel cue to be used; see Part 4 of Appendix E). Items that were identified as fitting with more than one category were either removed, replaced, or the categories were assigned to different lists (i.e., Set 1 or Set 2). The majority of judges agreed upon the best cue for each category, and in these instances, that cue was selected. When disagreement arose, the second best option was considered and the cue with the highest mean rank among the judges was selected. The revised lists were then re-administered to seven judges for review. This process was repeated until four categories remained, and all judges agreed that all items were rated as belonging to only a single category.

For counterbalancing purposes, each of the four categories within a set were assigned a number from 1 – 4. Two sets of unique random numbers ranging from one to four were then generated using a random number generator (www.randomizer.org). The final sets of categories were then determined by replacing the generated numbers with the categories that matched those numbers. The order of items within each category was generated in the same fashion – each item within a category was assigned a number from 1 – 4 and were ordered according to the random number generator. Two random orders of each set were then created with two categories from each set serving as the retrieval-practice categories (i.e., two Rp+ items and two Rp- items for

each of the two categories), and the remaining two categories serving as the NRp baseline categories. Refer to Table 3.1 and 3.2 for the two sets of word lists used in the study.

To select and counterbalance the items needed for the word frequency manipulation, items within the selected retrieval-practice categories described earlier were rank ordered according to word frequency strength (Zeno et al., 1995). The two items with either the highest or lowest word frequency rating were selected and assigned as Rp- competitors for half of the trials each.

3.1.1.2.3.Word list pictures. Each word presented to participants needed an accompanying picture to help ensure that the children encoded the items during the initial study trial. A sample of clipart pictures for the majority of the words could be found online, however, pictures that could be found for the *body* list cued more than one feature at a time. For example, pictures associated with *face* that could be found had noses while *nose* was also an item on the *body* list. Therefore, a digital graphic designer was contracted to create the pictures for the *body* list. A variety of clipart images for each item were tabulated, along with a number of versions of the designed *body* items, and presented to a group of seven judges (see Appendix F for the image selection sheet). The judges read each item and selected an image that best represented the item presented. See Table 3.2 for the finalized materials.

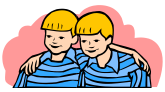
Table 3.1
Equated word list materials and memory cues for Set 1, which were used in both Experiment 1 and Experiment 2.

Set 1

Category Cue	**Novel Cue**		
Item 1	Item 2	Item 3	Item 4
Clothes	**Different things we could put on to get dressed.**		
Shoes 	Coat 	Socks 	Pants 
Vegetables	**Different food that you could eat or get from a garden.**		
Corn 	Tomatoes 	Potatoes 	Carrots 
Animals	**Things that are alive.**		
Dog 	Cat 	Bird 	Duck 
Vehicles	**Things with wheels that someone could use to go places.**		
Car 	Bus 	Truck 	Train 

Table 3.2
Equated word list materials and memory cues for Set 2, which were used in both Experiment 1 and Experiment 2.

Set 2

Category Cue Item 1	**Novel Cue** Item 2	Item 3	Item 4
Family	**People who could be related to you or related to each other.**		
Dad 	Mom 	Brothers 	Sisters 
Fruit	**Different foods of things that someone could eat.**		
Apple 	Orange 	Grapes 	Blueberry 
Insect	**Different kinds of bugs**		
Spider 	Butterfly 	Fly 	Caterpillar 
Body	**Different parts of people or parts of ourselves.**		
Nose 	Hair 	Face 	Head 

3.1.1.2.4. Slideshows. The counterbalancing and study orders for both RIF tasks that participants completed were then arranged into separate Microsoft PowerPoint slideshows. The slideshows began with an example initial study task using four items, two from each of two categories. An example retrieval-practice trial was also provided; the instructions were presented on screen for the experimenter, but the task was completed verbally by the children. Following the instructions slides was a clipart happy face image with the question "Ready?" The next slide depicted the first item in the initial study trial: the category – exemplar pair was

written at the top of the screen and at the midpoint of the screen was the clipart image of the item. These slides were timed to remain on screen for 5 seconds, after which a 1 second blank screen displayed, followed by the next item for 5 seconds. Once all items were presented once, the instructions for the retrieval-practice task was presented on screen for the experimenter to refer to while the child completed the task verbally. Upon a button press, the next slide would appear that said "Fun Break Time!" The slide remained on screen for two minutes, after which a "Yahoo!" sound played indicating the end of the distractor task and that it was "Time to test your memory!"

The second RIF task in each slide show did not begin with the same practice instructions as the first RIF task. Instead, children were informed that the next task that would be completed would be the same as the first, except this time a new set of words and a different memory test would be used.

3.1.1.2.5. *Jacob's Shapes* iPhone application. *Jacob's Shapes* is a picture puzzle game rated for children aged 3 – 6 years. Shapes have to be dragged and dropped into the appropriate places on the puzzle (Murray, 2010).

3.1.1.2.6. Data sheet. Individual data sheets were created that kept track of participants' initial study order, retrieval practice order, and recall order. Space was allocated to keep track of the testing date, participants' birthday (from the parental consent form), gender, retrieval-practice success, and items recalled (see Appendix G for a sample data sheet).

3.1.1.2.7. Assent and debriefing. Child assent (Appendix H), and parent (Appendix I) and child (Appendix J) debriefing forms were prepared.

3.1.1.3. Design

The overall study design was a 2 (Cue Type [original, novel]) × 2 (Rp- Word Frequency

[low, high]) × 3 (Practice Type [Rp+, Rp-, NRp]) mixed-subjects design. *Cue type* and *practice type* were within-subjects variables, and *Rp- word frequency* was between-subjects due to the limited number of word list materials available.

3.1.1.4. Procedure

Recruitment packages were mailed to *Outlook Elementary School*, which were then distributed to each kindergartener in the three kindergarten classes in that school. Parents were invited to meet with the researcher at the school one evening approximately one week following distribution of the packages. Although no parents showed up for the meeting, a total of 33 (55%) parents consented to their child's participation. Approximately two weeks later, the researcher returned to Outlook Elementary for three consecutive days to test 10 – 11 participants per day during their regular class time.

The researcher selected a participant to test and met the student in his/her classroom. On the way back to the testing room, the researcher began rapport building by asking about recent events (e.g., testing occurred after the first winter snowfall so most children were excited to talk about playing in the snow). As the researcher set up, further rapport was established by showing interest in the child's activities and responses. Once the slideshow was prepared and the child seemed comfortable, the researcher began data collection. The child assent form was read out loud to the participant and signed by the researcher once the child provided verbal assent. Next, the child's attention was drawn to the slideshow, and the researcher began describing the initial study task as the example slides played. The following script was used:

> "On the screen here (researcher points to the computer screen), different pictures of different groups of words will show up. I'll say the picture or word out loud, and your job is to try and remember that we studied it. Ok? Like this… (the researcher starts the

slideshow). Different pictures will show up that can fit with different groups, like this 'Toy – ball.' So 'Toy' is the group word and your job is to remember that we saw a 'ball'… 'Toy – Puzzle.' Now try to remember that we also saw a 'puzzle.'"

The researcher continued naming the items that appeared on screen, and when the second category appeared, the difference was pointed out to the participant: "'Tool – Hammer.' So now we'll see some words from a new group – 'Tool – Saw…' Your job is to remember as many of the 'toys,' and as many of the 'tools' as you can." Once all the examples were named, the computer screen went blank, and the researcher explained the retrieval-practice task:

"There's going to be a lot of words for you to try to remember. To help you remember them, I'll help you practice remembering some. I'll give you a little hint. Your job is to try and tell me the word that we saw that would go with the hint. I'll tell you the first sound of the word - that will be your hint. You tell me the whole word. Ok? Want to give it a try?"

Once the participant agreed, the researcher began the retrieval-practice task: "What 'Toy' did we see that started with the sound 'Puh…'?" Most children understood the task immediately and shouted out "Puzzle," at which point the researcher replied "Good job! How about…" and presented the next pairing. For the few children that did not understand the task right away, the researcher explained what should have happened. After waiting approximately 10 seconds for a response from the participant, the researcher further prompted "What picture did we study on there (pointed at the computer) that starts with the sound 'puh...'?" If no answer was provided, the researcher provided the answer and tried the next pairing "Puzzle. Puzzle starts with the sound Puh. That's ok, everyone remembers different amounts. There's no good or bad amount to remember. How about Toy – Ba…?" Only one child did not seem to understand the retrieval-

practice task. Once the retrieval-practice task was explained, the researcher told the participant:

> "After we practice remembering words like that a few times, we'll take a break and play a game on my iPhone. Then, after the break, you tell me all the words you can remember. We'll do that twice, and then you get to pick your prize! Are you ready to go?"

After the participant agreed, the researcher started the initial study trial for the first RIF task. Once initial study, retrieval-practice, and 2 minutes of *Jacob's Shapes* filler activity were complete, the researcher began either *original word cue recall* or *novel sentence cue recall*. To commence recall, the researcher asked "Ok, tell me all of the '*X'* (insert either category or sentence cue) that you remember studying." After recall seemed exhausted, the researcher asked, "Are there any other '*X'* (insert either category or sentence cue) that you remember studying?"

Once testing was finished, the researcher read the child debriefing form out loud, and attached it to the parental debriefing form that the child was asked to give to his/her parent/guardian. The participant then picked his/her prize from a prize box, and was escorted back to his/her classroom.

3.1.2. Results

The number of items correctly recalled from each practice type was counted, and converted into a proportion, for both RIF tasks that participants completed. Data were then screened for missing values ($n = 0$), and outliers by transforming the proportion of items recalled from each practice types (Rp+, Rp-, NRp) for both *original* and *novel cue* RIF tasks into *z*-scores. Participants with *z*-scores ≥ 1.96 were deemed outliers (Field, 2009) and were excluded from analysis that used those variables. For the *original word cue* RIF task that participants completed, three participants' *z*-scores were identified as outliers and were omitted from

analysis. Three participants' *z*-scores on the *novel sentence cue* RIF task were identified as outliers; thus, these participants' data were omitted from analysis that used the *novel sentence cue* RIF data. Retrieval-practice accuracy was then examined in order to exclude any participant who did not meet or exceed at least 75% accuracy (Anderson et al., 1994). One participant fell below the accuracy criterion on both the original word and novel sentence cue RIF tasks and one other participant fell below accuracy on the novel cue RIF task (completed second for that participant). However, these two participants were already deemed outliers based on their practice type *z*-score transformations; thus, no additional participants were excluded from analysis.

All post-hoc procedures used the Bonferroni correction to control for Type 1 (familywise) error (Field, 2009).

3.1.2.1. Research Question I: Is Kindergartners' Retrieval-Induced Forgetting Cue Independent?

To determine whether or not RIF persisted or was eliminated under novel cue recall conditions, a completely within-subjects 2 (Cue Type [original, novel]) × 3 (Practice Type [Rp+, Rp-, NRp]) repeated measures (RM) analysis of variance (ANOVA) was conducted on the proportion of items recalled from each practice type. No main effect of *cue type* was found, F (1, 27) = .85, p = .366, η_p^2 = .030, but a significant main effect of *practice type,* F (2, 54) = 118.29, p < .001, η_p^2 = .814, and an interaction of *cue type* × *practice type,* F (2, 54) = 7.98, p = .001, η_p^2 = .228, was found. With regards to the practice type main effect, significantly more Rp+ items (M = .884, SEM = .017, 95% CI [.85, .92]) were recalled than both Rp- (M = .379, SEM = .037, 95% CI [.30, .46]) and NRp items (M = .493, SEM = .030, 95% CI [.43, .55]), ps < .001. The RIF effect was also obtained with significantly fewer Rp- items being recalled than

NRp items, $p = .015$. For the *cue type* × *practice type* interaction, post-hoc comparisons revealed significantly higher Rp+ recall over both Rp- and NRp recall for both the *original* and *novel cue* RIF tasks, $ps < .001$. A significant RIF effect was only obtained for the *original cue* RIF task however, with significantly fewer Rp- items recalled than NRp items, $p = .001$. Under *novel cue* recall conditions, the proportion of Rp- items recalled did not differ from the proportion of NRp items recalled, $p = .787$. Refer to Figure 1 for the means and standard error of the means for the *cue type* × *practice type* interaction.

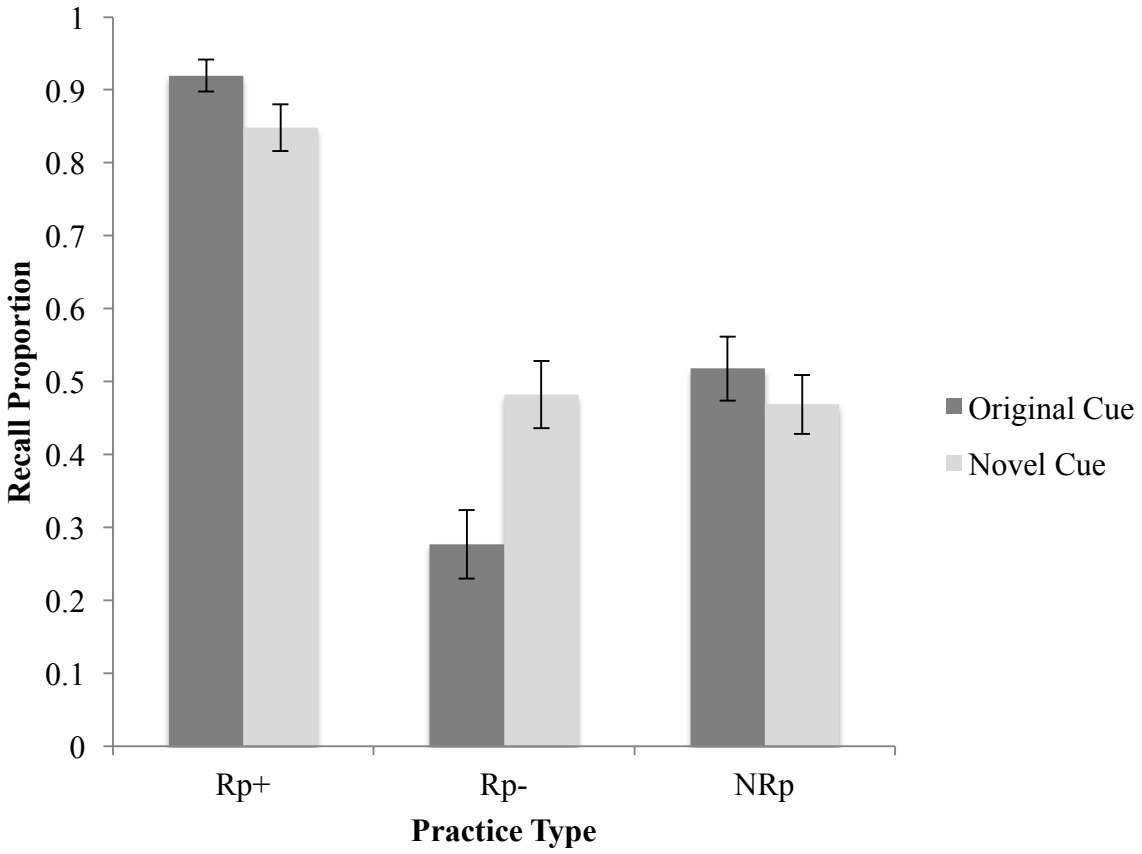


Figure 3.1
The proportion of items recalled for each practice type across the two cue types. Error bars represent the standard error of the means.

3.1.2.2. Research Question II: Is Kindergartners' Retrieval-Induced Forgetting Strength Independent?

The proportion of items recalled from each practice type (Rp+, Rp-, NRp) under *original* and *novel cue* conditions were entered into a bivariate correlation matrix to test the principle of *interference/competition dependence. Degree of strengthening* scores (DOS = [Rp +] – [NRp]) and *degree of forgetting* scores (DOF = [Rp-] – [Nrp]) have also been used to examine this principle and were therefore examined here as well.

For original cue recall, no significant correlation was found between Rp+ and Rp- scores, r (28) = -.08, p = .681. However, a significant positive relationship emerged between DOS and DOF scores, r (28) = .60, p = .001. For novel cue recall, no relationship was found when comparing Rp+ and Rp-, r (28) = .32, p = .097, but a significant positive relationship emerged again when examining DOS and DOF scores, r (28) = .49, p = .008.

3.1.2.3. Research Question III: Is Kindergartners' Retrieval-Induced Forgetting Interference/Competition Dependent?

Only the *original word cue* RIF task that participants completed was analyzed when testing the principle of *interference/competition dependence*. No RIF was obtained under *novel sentence cue* recall conditions, thus, there is no reason to examine differences in the degree of RIF. To determine whether or not greater RIF is observed when high frequency items served as competitors (Rp-) than when low frequency items served as competitors, DOF scores were calculated for each participant for their *original word cue* RIF task. DOF scores are typically negative with more negative numbers demonstrating a greater degree of forgetting. An *independent samples t-test* on mean DOF scores between those participants whose Rp-

competitors were low frequency (M_{DOF} = -.29, *SD* = .33, *SEM* = .08,) and those whose competitors were high frequency (M_{DOF} = -.19, *SD* = .36, *SEM* = .10,) was run on the calculated DOF scores. No significant difference emerged, t (28) = .74, p = .468.

To ensure that an interaction of *competitor strength* and *practice type* did not occur, a 2 (Rp- Word Frequency [low, high]) × 3 (Practice Type [Rp+, Rp-, NRp]) mixed subjects ANOVA was conducted on participants' original cue recall data only. *Rp- word frequency* was a between-subjects variable and *practice type* was a within-subjects variable. A main effect of *practice type* was obtained, F (2, 56) = 77.62, p < .001, η_p^2 = .735, but the *Rp- word frequency* main effect, F (1, 28) = 1.50, p = .23, η_p^2 = .051, and the *Rp- word frequency x practice type* interaction was non-significant, F (2, 56) =.70, p = .502, η_p^2 = .024. Regardless of competitor frequency the *practice type* main effect remained where significantly more Rp+ items (*M* = .925, *SEM* = .022) were recalled than Rp- (*M* = .265, *SEM* = .046) and NRp items (*M* = .504, *SEM* = .041), *p*s < .001, and significantly fewer Rp- items were recalled than NRp items, p = .002.

It was possible that the items designated as *low* and *high word frequency* within each retrieval-practice order were not statistically distinct *word frequency* categories. To evaluate this possibility, paired-samples t-tests were conducted on mean word frequency scores between the *low* and *high word frequency* retrieval-practice items for each of the four orders of the *original word cue* RIF tasks that participants completed. Non-significant differences were found, *p*s > .122. See Table 3.3 for word frequency ratings across the four retrieval-practice orders.

Table 3.3
Word frequency means (*M*) and standard deviations (*SD*) across items within the *high* and *low frequency* competition manipulation for the Rp+ and Rp- retrieval-practice groups used for the original word category cue RIF task.

	Low Competition		High Competition	
	M (SD)	*M (SD)*	*M (SD)*	*M (SD)*
Rp+	290.00 (335.18)	553.75 (614.62)	164.50 (121.71)	41.00 (29.88)
Rp-	140.75 (147.19)	240.75 (266.09)	355.75 (273.51)	100.75 (85.08)

3.1.3. Discussion

Past research examining RIF in young children has not employed a methodology that allows one to discern RIF arising from interference from RIF arising from inhibition. The purpose of this dissertation is to address this dearth in the literature by determining whether interference of inhibition best accounts for RIF in kindergartners' recall. Experiment 1 examined three principles in support of the inhibitory explanation of RIF in a kindergarten population, *cue independence, interference/competition dependence*, and *strength independence*.

3.1.3.1. The Principle of Cue Independence

The Experiment 1 data that examine the principle of *cue independence* (the feature of RIF that is considered to be diagnostic of inhibition, Anderson & Levy, 2007, 2011; Storm & Levy, 2012), support an interference account of RIF in kindergartners, rather than an inhibitory one. Kindergartners demonstrated the typical RIF effect when the *original word cue* was used as the final memory test, but the effect was eliminated when a *novel sentence cue* was used instead. This release from RIF suggests that kindergartners do not yet have the inhibitory mechanism in place that is likely responsible for cue independent RIF found in adults. As in adults, interference builds during retrieval-practice as retrieval attempts are made. Unlike adults

however, kindergartners do not engage an inhibitory mechanism that suppresses competitors in order to overcome the interference. Instead, the interference from retrieval-practice persists, and at final recall, the weak competitors succumb to forgetting when compared to baseline items that were not interfered with through retrieval. When kindergartners are presented with a novel sentence cue however, the interference that accrues between the category cue and non-practiced exemplars during retrieval-practice is released, and RIF is eliminated.

3.1.3.2. The Principle of Interference/Competition Dependence

The effort made to examine the principle of *interference/competition dependence* in Experiment 1 was not experimentally strict enough to allow a clear interpretation of the theoretical mechanism responsible for RIF in kindergartners' recall. First, taxonomic frequency norms for kindergartners' could not be found, thus, word frequency norms (Zeno et al., 1995) were used instead. Typically, the strength of category membership (i.e., average output positions of items when participants are presented with the category cue, Van Overschelde, Rawson, & Dunlosky, 2004) is used to manipulate the degree of retrieval-competition that occurs through retrieval-practice. Thus, the use of kindergartners' word frequency norms (i.e., the number of times items appeared in textual materials for a given population) in the current study to attempt to manipulate retrieval-competition strength may not have actually accomplished that task. Lending further weight to this argument, in Anderson et al.'s (1994) pioneer RIF research, word frequency was kept constant in a subset of experiments while taxonomic word frequency was manipulated. The finding of *interference/competition dependence* in Anderson et al.'s experiments further suggests that word frequency alone is not a good measure of retrieval-competition strength.

3.1.3.3. The Principle of Strength Independence

The examination of *strength independence* in Experiment 1 provided somewhat mixed results. For original category cue recall, the lack of correlation between the proportion of items recalled from the Rp+ and Rp- practice types seems to suggest an inhibitory account of kindergartners' RIF. However, when DOS and DOF scores were used, which eliminate the individual differences involved with baseline NRp performance, a rather strong positive correlation emerged. Recall that DOF scores are negative (Rp- minus NRp) when RIF is obtained, thus, this positive correlation between DOS and DOF indicates that better memory for strengthened items is associated with less forgetting (lower, or more positive, DOF scores). This finding is contrary to an inhibitory explanation, and instead is complimentary to competition-based accounts. It could be that strengthening the targets through retrieval practice in turn strengthens the Rp- competitors as spreading activation would attest which could result in a positive correlation. Output interference as well as contextual cue-related interference may also contribute to the positive correlation for a number of reasons. First, order of output was not controlled in Experiment 1 so the likelihood of recalling Rp+ items might also predict recall of Rp- items especially given that the word frequency manipulation was unsuccessful using the current set of materials. Rp+ and Rp- items might have been similarly activated during retrieval-practice due to their similarity in frequency, thus, recalling some items from the Rp+ category may also facilitate recall of Rp- items from that same category as the recall protocol unfolds. Second, when original cues were used to guide recall a strong correlation emerged, and the correlation was slightly reduced when the relationship was examined again under novel cue recall. This pattern of results seems consistent with competition-based accounts that argue that the strength of the cue-exemplar pairing may result in strong interference between the cue and

the weaker Rp- items. Thus, the presence of the cue facilitates recall such that both stronger (Rp+) and weaker (Rp-) items can be outputted. When cue-related interference is eliminated with novel cue testing, however, that positive relationship is reduced yet remains significant. These results seem to suggest that the degree of forgetting obtained from kindergartners during RIF tasks is positively impacted by the degree of strengthening of Rp+ targets. It remains possible though that the impact of output interference is contaminating the relationships between target strengthening and competitor forgetting under both original and novel cue recall because order of output was not controlled. Indeed, Murayama et al.'s (2014) meta-analysis identified a similar positive correlation that was eliminated when only those studies that controlled the order of output were included. Thus, as proposed in Experiment 2, to properly evaluate the principle of *strength independence* in kindergartners' recall following retrieval-practice, *output interference* must be controlled.

3.2. Experiment 2: Principles of Retrieval-Specificity, Output Interference Independence, and Strength Independence

The purpose of Experiment 2 is to further evaluate the inhibitory account of RIF in kindergarteners by examining the principle of *retrieval-specificity* and *output interference;* due to the ease with which strength independence can be evaluated (i.e., correlation), this principle was re-evaluated under the current experimental manipulations. To accomplish these objectives, kindergarten participants completed two RIF tasks using a subset of the Experiment 1 materials that deviated from the typical RIF procedure in the following ways. To examine *retrieval-specificity* one RIF task engaged participants in simple re-study of the category-item word-picture pairs in place of retrieval-practice. The other RIF task utilized a recognition test in place of cued recall to assess *output interference* – half of the recognition tests assessed Rp- items first

while the remaining half presented them last. The order of completion of the two RIF tasks was counterbalanced across participants. Finally, the principle of *strength-independence* was re-evaluated by correlating the degree to which Rp+ items were strengthened with the degree to which Rp- items are forgotten. The principle of *retrieval-specificity* holds that RIF is only obtained when active retrieval attempts are made (Anderson, 2003; Storm, 2011b; Storm et al., 2006). Proponents of the inhibitory account of RIF also argue that the persistence of RIF on tests of item recognition (Gómez -Ariza et al., 2005; Hicks & Starns, 2004; Racsmany et al., 2008; Saunders & MacLeod, 2002; Spitzer & Bäuml, 2007, 2009), regardless of where competitors (Rp-) are located in that test (Anderson & Bell, 2001; Anderson et al., 1994, 2000; Anderson & McCullock, 1999; Bäuml, 2002; Bäuml & Hartinger, 2002), further supports the inhibitory view – those items are inhibited in memory in general, not only when the cue is present, or when output interference is at its highest (i.e., end of the output protocol). According to findings in support of the *strength-independence* principle of inhibitory-based RIF, no correlational relationship is expected among targets and competitors; that is, the degree of target strengthening is unrelated to the degree of forgetting obtained.

3.2.1. Method

3.2.1.1. Participants

A total of 40 kindergarteners (24 males) were tested (M_{age} = 5.85 years, SD = .32) from the *Sunwest School Division* at *Walter Aseltine Elementary School* in Rosetown, SK.

3.2.1.2. Materials

3.2.1.2.1. Recruitment packages. A total of 50 recruitment packages were prepared and distributed to all kindergarten students at *Walter Aseltine Elementary School* in Rosetown, SK. The letter of invitation from the researcher (Appendix A), and from the *Walter Aseltine*

Elementary School Principal (Appendix K), were enclosed in an envelope along with a revised parental consent form (Appendix L), and new brochure for potential child participants (Appendix M).

3.2.1.2.3. Word lists, word list pictures, and slideshows. The same two sets of word lists and accompanying pictures used in Experiment 1 were also used in Experiment 2. Two of four counterbalanced orders employed in Experiment 1 were also used for Experiment 2. Consistent with past RIF research (e.g., Anderson et al., 1994), the two orders selected were those that used the strongest exemplars as competitors (i.e., higher taxonomic frequency).

The slideshows used in Experiment 1 to display these two orders were adjusted such that half of the slideshows engaged participants in three verbal retrieval-practice trials of the Rp+ items while the other half of the slideshows re-presented the Rp+ items on screen, which were also read aloud by the researcher, three times each. Half of the slideshows started with the retrieval-practice RIF task followed by the re-study RIF task, and the other half of the slideshows were prepared in the reverse order.

3.2.1.2.3. Recognition tests. One high, and one low, frequency item per category was selected from Price and Connolly's (2006) child word norms to serve as *lures* (i.e., items from studied categories that were never actually studied) on the recognition test. The lures (n = 8), targets (Rp+, n = 4), and baseline (NRp, n = 8) items were randomized into two orders. The order of presentation for the competitors (Rp-, n = 4) was counterbalanced such that two of the recognition test orders presented these items in the first four positions of the test while the remaining two orders presented them in the last four positions of the test.

3.2.1.2.4. *Jacob's Shapes* iPhone application. The iPhone application, *Jacob's Shapes* (Murray, 2010) that was used in Experiment 1 was also used in Experiment 2.

3.2.1.2.5. Data sheet. Individual data sheets from Experiment 1 were adjusted to reflect the re-study and recognition RIF task results instead of original cue, and novel cue recall RIF tasks (see Appendix N for a sample data sheet).

3.2.1.2.6. Assent and debriefing. Changes were made to the child assent (Appendix O), and parent (Appendix P) and child (Appendix Q) debriefing forms used in Experiment 1 to reflect the two new RIF tasks that participants would complete.

3.2.1.3. Procedure

Recruitment packages were delivered to *Walter Aseltine Elementary School*, which were then distributed to each kindergartener in the three kindergarten classes in that school. Parents were invited to meet with the researcher at the school one evening approximately one week following distribution of the packages. Although only one parent showed up for the meeting, 80% of parents consented to their child's participation following a reminder sent out on the third day of testing. Two days following the parent meeting, the researcher began testing at the school. The kindergarten classes alternated on a six-day schedule thus the researcher tested at the school for six days across two and a half weeks. Approximately seven participants were tested each day during their regular class time.

The same general procedure used in Experiment 1 was used for the second experiment. The researcher selected a participant to test, built rapport, obtained assent, and began data collection using the revised slideshows. The script instructions from Experiment 1 were slightly adjusted depending on which RIF task the participant was to complete first. When the recognition RIF task was to be completed first, the script followed the same script used in Experiment 1 except the method of testing final memory was described differently. Before the recognition test, participants were told the following:

"Let's see how many words you remember! I'll say a word out loud to you. Your job is to listen to the word and decide if you remember studying it on the computer or not. Some words will be words that we studied (researcher shakes head up and down to indicate 'yes'). Other words will be ones that we didn't study (researcher shakes head side to side to indicate 'no'). If you remember studying the word, you can say 'Yes' or shake your head yes. If you don't remember studying the word, you can say 'No' or shake your head no. If you're not sure if you studied the word or not, it's ok to say 'I don't know' or 'I don't remember' because everyone remembers differently. There's no good or bad amount to remember."

To start the recognition test the researcher said, "Do you remember studying the word '*X*' (insert item from recognition test)?" The researcher recorded participants' responses that were provided either verbally, or with a headshake.

If the RIF task using re-study in place of retrieval-practice was completed first, instead of telling participants that they would receive hints (i.e., verbal retrieval-practice) to help them remember some of the words, they would be allowed to study some of them a few more times. If this RIF task was completed second, the script was adjusted as follows:

"Ok, we're going to do that one more time. But this time, instead of giving you hints to help you remember the word, I'll show you the words on the computer again. We'll practice them three times each like that. Are you ready to go?"

To commence recall for the re-study RIF task, the researcher asked "Ok, let's see how many words you remember! Tell me all of the '*X'* (insert category cue) that you remember studying." After recall seemed exhausted, the researcher asked, "Are there any other '*X'* (insert category cue) that you remember studying?"

The participant was then verbally debriefed and provided with a parental debriefing form that he or she was asked to give to his/her parent/guardian. The participant then picked his/her prize from a prize box and was escorted back to his/her classroom.

3.2.2. Results

The number of items correctly recalled (Rp+, Rp-, NRp) or recognized (Rp+, Rp-, NRp, lures) from each practice type were counted and converted into proportions. Data were then screened for missing values ($n = 0$), and the proportion of items recalled or recognized were converted into z-scores to screen for outliers (z-scores ≥ 1.96; Field, 2009). For the re-study RIF task that examined the *retrieval-specificity* principle, two participants' z-scores were identified as outliers and their data were therefore omitted from analysis examining that task ($n = 38$). For the RIF task using recognition at final test, the two participants identified as outliers for the re-study task were also identified as outliers on the recognition test; one additional participant's z-score was identified as an outlier; thus, this participant's data were omitted also from analysis on recognition data ($n = 37$). Retrieval-practice accuracy was then examined for the recognition-based RIF task in order to exclude any participant who did not meet or exceed at least 75% accuracy (Anderson et al., 1994). One participant, who was already excluded due outlying performance, fell below the accuracy criterion. All post-hoc procedures used the Bonferroni correction to control for Type 1 (family-wise) error.

3.2.2.1. Research Question IV: Does Kindergartners' Retrieval-Induced Forgetting Demonstrate Retrieval-Specificity?

To examine the principle of retrieval-specificity, a 2 (Review Type [retrieval-practice, re-study]) × 3 (Practice Type [Rp+, Rp-, NRp]) repeated measures analysis of variance (RM ANOVA) was run on the proportion of Rp+, Rp-, and NRp items recalled. *Practice type* was a

within-subjects factor while *review type* was a between-subjects factor that compared participants' Experiment 1 original cue RIF task data (*retrieval-practice*) with Experiment 2 re-study RIF task data (*re-study*). A main effect of *practice type* was found, F (2, 132) = 127.78, p < .001, η_p^2 = .659, as well as a main effect of *review type,* F (1, 66) = 11.02, p = .001, η_p^2 = .143, and a *practice type* × *review type* interaction, F (2, 132) = 14.02, p < .001, η_p^2 = .175. The main effect of *practice type* demonstrated that overall, significantly more Rp+ items (M = .92, SD = .13) were recalled than both Rp – (M = .43, SD = .27), and NRp items (M = .51, SD = .19), ps ≤ .034. The main effect of *review type* revealed that participants recalled significantly more items under *re-study* conditions (M = .66, SD = .11) than *retrieval-practice* conditions (M = .57, SD = .11), p = .001. More importantly however, the significant *practice type* × *review type* interaction revealed persistent practice effects across *review type* with significantly higher Rp+ items recalled than both Rp-, and NRp items, ps < .001, but forgetting was only found for the retrieval-practice RIF task, p < .001, and not the re-study RIF task, p = .152. Refer to Figure 2 for a graphical representation of the means.

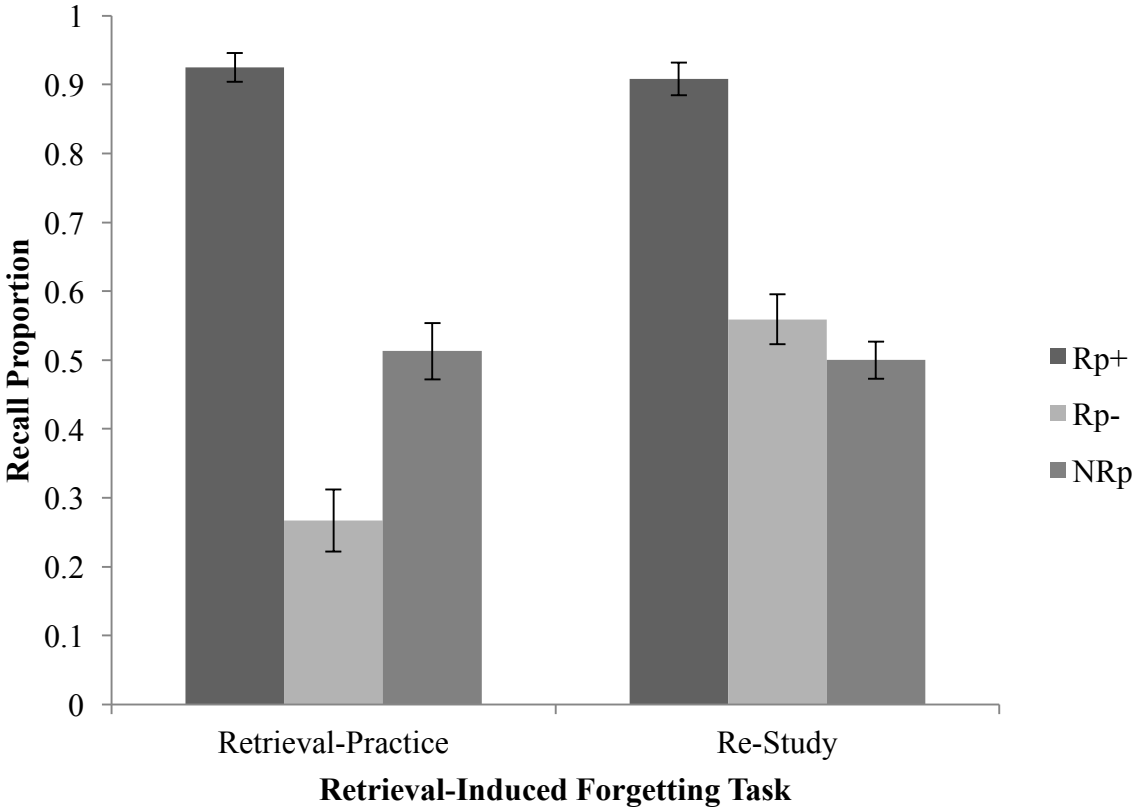


Figure 3.2
The proportion of items recalled from each practice type across the two retrieval-induced forgetting tasks. Error bars represent the standard error of the means.

3.2.2.2. Research Question V: Is Kindergartners' Retrieval-Induced Forgetting Output Interference Independent?

On the recognition test, one participant demonstrated a consistent *yes bias* where every item was responded to with a "yes" response (indicating that the item was previously studied), thus this participant's data were excluded from analysis. The proportion of *hits* (endorsing studied items as "old") and *false alarms* (endorsing lure items as "old") for each item type are summarized in Table 3.4.

Table 3.4
The proportion of *hits* (endorsement of studied items) and *false alarms* (endorsement of lure items) across practice types.

	Hits			False Alarms		
Practice Type	**M**	**SD**	**SEM**	**M**	**SD**	**SEM**
Rp+	.95	.11	.019	.06	.14	.023
Rp-	.86	.15	.025	.06	.14	.023
NRp	.85	.15	.025	.09	.17	.028

The proportions of items correctly recognized from each practice type were entered into a 2 (Competitor Order [first, last]) × 3 (Practice Type [Rp+, Rp-, NRp]) RM ANOVA where *competitor order* was manipulated between-subjects and *practice type* was manipulated within-subjects. A main effect of *practice type* was found, F (2, 70) 7.56, $p = .001$, $\eta_p^2 = .178$, but no main effect of *competitor order,* F (1, 35) = .54, $p = .467$, $\eta_p^2 = .015$, and no *practice type* × *competitor order* interaction was obtained, F (2, 70) = .07, $p = .932$, $\eta_p^2 = .002$. Post-hoc comparisons for the *practice type* main effect revealed a significant practice effect with Rp+ (M = .95, SD = .12) items being endorsed significantly more often than both Rp- (M = .86, SD = .15) and NRp (M = .85, SD = .15) items, ps ≤ .015. No differences were found between recognition of Rp- and NRp items, $p = 1$.

Given that *competitor order* did not influence performance, this variable was collapsed, and a 2 (Testing Type [recall, recognition]) × 3 (Practice Type [Rp+, Rp-, NRp]) RM ANOVA was run using the original cue RIF task data from Experiment 1, and the current recognition RIF task data as the between-subjects *testing type* factor. A main effect of *practice type* was found, F (2, 130) = 89.45, $p < .001$, $\eta_p^2 = .579$, as well as a main effect of *testing type,* F (1, 65) = 151.61,

$p < .001$, $\eta_p^2 = .700$, and a *practice type* × *testing type* interaction, $F(2, 130) = 48.05$, $p < .001$, $\eta_p^2 = .425$. The main effect of *practice type* showed that overall, significantly more Rp+ items ($M = .94$, $SD = .11$) were recalled and recognized than both Rp- ($M = .56$, $SD = .36$) and NRp items ($M = .68$, $SD = .25$), ps $\leq .002$. The *testing type* main effect demonstrated that significantly more items were endorsed with *recognition* ($M = .89$, $SD = .10$) than with recall ($M = .57$, $SD = .12$), $p < .001$. The significant interaction of *practice type* × *testing type* once again revealed a significant and persistent practice effect regardless of *testing type* as Rp+ items were recalled or endorsed more often than both Rp- and NRp items, ps $\leq .004$. Once again however, the forgetting effect was only evidenced with cued recall, $p < .001$; with recognition, no differences in NRp and Rp- endorsements were found, $p = .741$. Refer to Figure 3.3 for a graphical representation of the interaction.

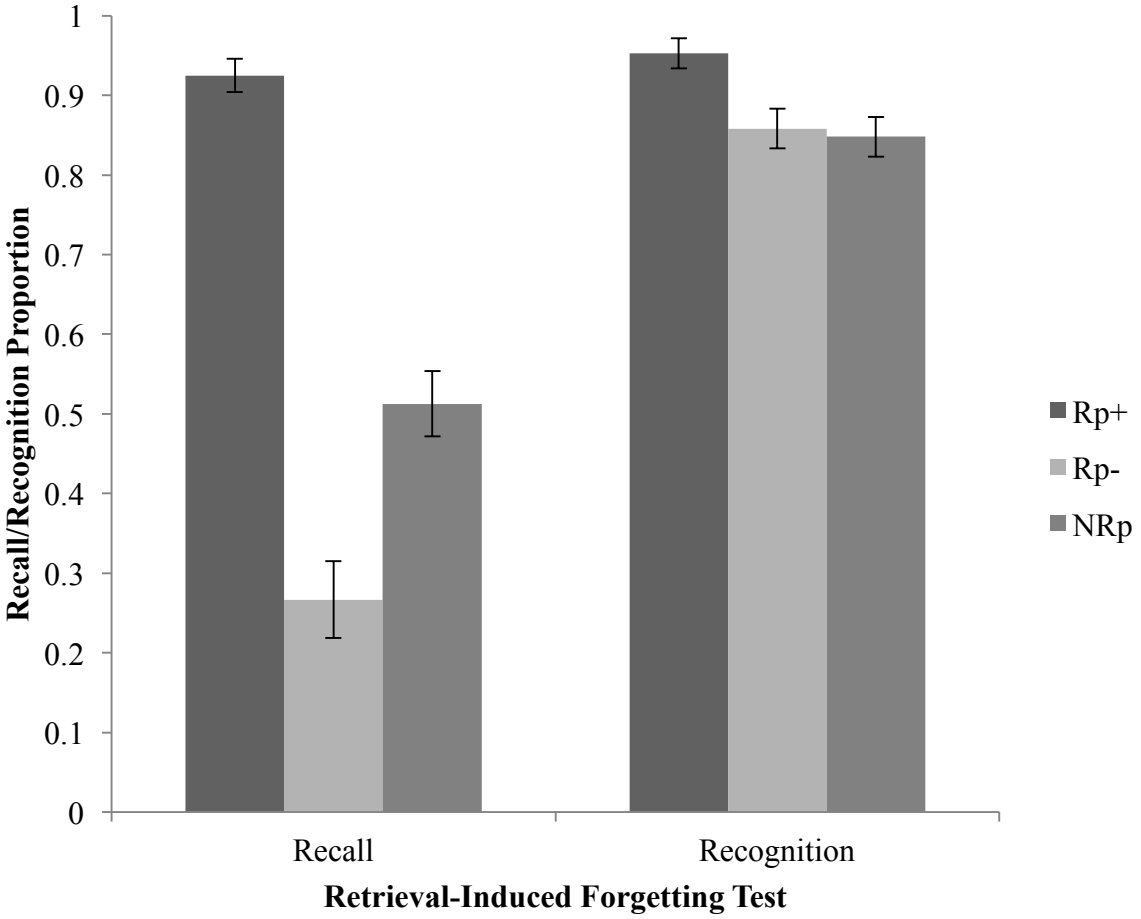


Figure 3.3
The proportion of items recalled or recognized from each practice type. Error bars represent the standard error of the means.

3.2.2.2.1. Signal Detection Theory. To examine kindergarteners' recognition performance while accounting for individual differences in *response bias* (i.e., tendency to bias responses in a certain way in the face of uncertainty), and *sensitivity* to *signal* (i.e., hits) among a combination of signal and *noise* (i.e., false alarms), *signal detection theory* (SDT) was employed (Macmillan & Creelman, 1991, 2005). In SDT, a set of mathematical computations is used to obtain a statistical estimate (*d'* pronounced d-prime) of participants' sensitivity to *signal* (i.e., hits) among a combination of signal and *noise* (i.e., false alarms), as well as to obtain estimates of participants' *response bias,* or *criterion* (*c*). A *liberal response bias* or *liberal criterion* will

yield a negative *criterion* (*c*) statistic that indicates a propensity to respond "no" or "new" in the face of uncertainty, whereas a *conservative response bias* or *conservative criterion* will have a positive *c* that illustrates an aptness to respond "yes" or "old" when uncertain. For those cells where performance was perfect (i.e., endorsed all old items or rejected all lures), an adjustment to avoid infinite values (Macmillan & Creelman, 1991, 2005) was required prior to calculating *d'*. Specifically, for those cells that contained perfect hits (1) or lure rejections (0), 1/2*N* (where *N* is the number of items for that practice type) was either subtracted or added to the cell, respectively (Macmillian & Creelman, 1991, 2005). Across the Rp+, Rp-, and NRp cells, a total of 33, 19, and 14 cells needed adjustment, respectively. For false alarms, 25 cells required adjustment. The corresponding *d'* and *c* statistics were then calculated as follows:

$d' = z$ (Hits) – z (False Alarms)

where *z* is the inverse of the standard normal cumulative distribution with a mean of 0 and standard deviation of 1.

c = -0.5 (zHits + zFalse Alarms)

c was then converted into *normalized c* or *c'* (*relative criterion location*) in order to scale the criterion relative to participants' performance*:*

$c' = c / d'$

The *d'* and *c'* statistics for each practice type were then entered into two separate 2 (Competitor Order [first, last]) × 3 (Practice Type [Rp+, Rp-, NRp]) RM ANOVAs where *competitor order* was a between-subjects variable and *practice type* was a within-subjects variable. A main effect of *practice type* was found for *d', F* (2, 70) = 3.66, p = .031, η_p^2 = .095, but no main effect of *competitor order, F* (1, 35) = 1.45, p = .237, η_p^2 = .040, and no *practice type* × *competitor order* interaction, *F* (2, 70) = .07, p = .931, η_p^2 = .002, was obtained. For the

practice type main effect, post-hoc comparisons demonstrated that Rp+ *d'* (*M* = 2.36, *SD* = .56) and NRp *d'* (*M* = 2.34, *SD* = .71) were no different from each other (*p* = 1), however Rp- *d'* (*M* = 2.17, *SD* = .49) was significantly lower than Rp+ *d'* (*p* = .025) but not NRp *d'* (*p* < .142). See Figure 3.4 for a graphical representation of participants' sensitivity index across the three practice types.

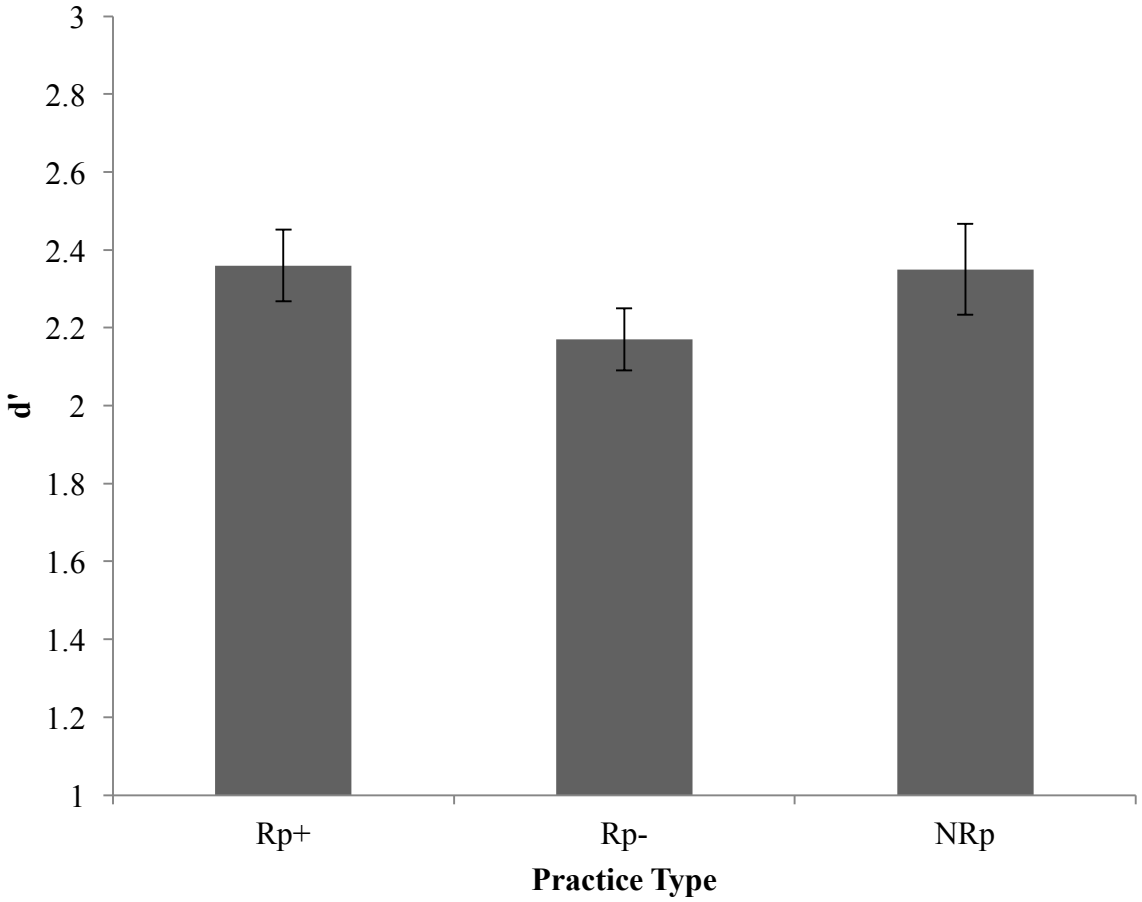


Figure 3.4
D-prime (*d'*), or *sensitivity,* estimates across the three practice types. Error bars represent the standard error of the means.

For *c'* (M = .05, SD = .19), the ANOVA revealed no main effect of *practice type,* F (2, 70) = 1.22, p = .303, η_p^2 = .034, no main effect of *competitor order,* F (1, 35) = .81, p = .375, η_p^2 = .023, and no *practice type* × *competitor order* interaction, F (2, 70) = .46, p = .633, η_p^2 = .013.

3.2.2.3. Research Question II Revisited: Is Kindergartners' Retrieval-Induced Forgetting Strength Independent?

An examination of the principle of *strength independence* was also conducted under both re-study and recognition conditions by correlating Rp+ and Rp- across RIF tasks as well as DOS and DOF scores. No significant correlations were found with neither re-study, r (37) = -.22, p = .184, nor with recognition, r (37) = -.04, p = .804, using proportions of Rp+ and Rp- items recalled/endorsed.

DOS and DOF were not significantly correlated with re-study in place of retrieval practice, r (37) = .27, p = .104. However, with recognition testing, a significant positive correlation was found, r (37) = .75, p < .001. To evaluate whether or not the presence of output interference influenced this correlation, DOS and DOF scores were compared between those who completed the test with Rp- competitors in the first few positions (i.e., very low output interference) and those who had the competitors in the last few positions (i.e., very high output interference). The significant positive correlation remained when the competitors were first, r (17) = .64, p = .005, but was slightly reduced when competitors were last, r (16) = .54, p = .032.

3.2.3. Discussion

The purpose of Experiment 2 was to further evaluate the inhibitory account of RIF in a kindergarten sample. The principles of *retrieval-specificity, output interference independence,* and *strength independence* were evaluated by having participants engage in two RIF tasks. One task used re-study instead of retrieval-practice to assess *retrieval specificity*, and the other RIF

task used a recognition test in place of recall to evaluate *output interference*. The principle of *strength independence* was also evaluated by correlating *practice type* (Rp+, Rp-, NRp) within each RIF task as well as correlating the degree of strengthening (Rp+ minus NRp) with the degree of forgetting (Rp- minus NRp) obtained. Each principle will be discussed in turn.

3.2.3.1. The Principle of Retrieval-Specificity

To evaluate the principle of retrieval-specificity, active retrieval attempts must be made, or, strengthening of Rp+ items must occur without retrieval attempts (Murayama et al., 2014; Raaijakers & Jakab, 2012). The key argument from an inhibitory perspective is that a retrieval attempt is necessary in order to activate the competing representations (i.e., Rp-). It is this competition at retrieval that triggers the inhibitory component necessary to produce RIF (Anderson, 2003; Anderson et al., 2000; Anderson & Levy, 2007, 2011; Ciranni & Shimamura, 1999; Verde, 2012). If there is no mental retrieval competition, such as when items are simply re-presented, then there is no need to inhibit activation of those competing Rp- items to successfully strengthen the Rp+ targets (Ciranni & Shimamura, 1999).

The principle of *retrieval-specificity* garnered some support in Experiment 2 by finding that kindergartners no longer demonstrated RIF when re-study was used instead of retrieval-practice. However, these data do not provide a diagnostic measure of inhibition but rather provide a pattern of results that is consistent with both an inhibitory and *associative unlearning* interference perspective. To attempt to tease these two explanations apart, the finding of *retrieval-specificity* must be interpreted alongside the Experiment 1 finding *of cue dependent* RIF in kindergartners. *Cue independence* is the hallmark of inhibition in RIF and is widely accepted to be diagnostic of such a mechanism (e.g., Anderson & Levy, 2007, 2011; Storm & Levy, 2010). Given that *associative unlearning* may also predict retrieval-dependent RIF, and that the

hallmark indicator of inhibition was not found in Experiment 1, the data more likely support the interference-based *associative unlearning* account.

First, consider how associative unlearning would explain recall following the typical RIF procedure. The interference that builds by repeatedly strengthening the cue – target pair through retrieval-practice would effectively punish the cue – competitor pair below baseline levels when that cue is provided at recall. When a novel cue is provided, the weakened associations between the cue – competitor pairs that occurred from strengthening the cue – target pairs would no longer impact the recall protocol and baseline rates of recall would be obtained. This is precisely the pattern of results obtained in Experiment 1: kindergarteners' RIF was cue-dependent.

When these results are considered alongside the finding of baseline levels of competitor recall following re-study in Experiment 2, further support for an *associative unlearning* account can be found. In this interference-based explanation, it may be that retrieval-practice weakens the cue – competitor pair to a greater extent than simple re-study does. In fact, the principle of retrieval-specificity itself suggests a differential impact of retrieval versus re-study. According to Anderson, "There appears to be something special about the need to reach into memory and retrieve something that induced forgetting," (Anderson, 2009, p. 212). This statement can be applied to the *associative unlearning* perspective as well, which would predict the same pattern of results. What might be special about retrieval is that it may weaken the cue – competitor association *below* baseline levels, whereas re-study simply returns the pair to baseline levels. There is no direct empirical examination of this issue in the literature, however, perhaps due to the degree of support for the inhibitory account in adult populations. Thus, future research aimed at determining the exact interference mechanism involved with kindergartners' RIF should evaluate this potential difference between retrieval and re-study.

3.2.3.2. The Principle of Output Interference Independence

Very strong support against an *output interference* explanation of kindergartners' RIF was obtained in Experiment 2. According to the inhibitory account of RIF, the order of item output should not eliminate the forgetting found – that is, RIF is not dependent on output interference. In the current study, when kindergartners' memory for Rp- competitors was tested when it was at its maximum (i.e., the last four items in the test), no forgetting occurred. In other words, in an instance when the strongest output interference-based RIF should occur, it did not. Rp- competitors were consistently recognized at rates comparable to baseline items regardless of their location on the recognition test. Although there was a small, significant reduction in the sense of familiarity of the Rp- competitor items when *d'* scores were examined, this pattern is not exclusively supportive of the inhibitory account. Again, interpreting the data from an *associative unlearning* perspective best fits the data overall, especially if the notion of differential weakening of cue – competitor pairs through retrieval, rather than re-study, is correct. In the recognition test RIF task, the repeated retrieval of the cue – target pairs weakened the cue – competitor pairs below baseline levels. The recognition test, much like the novel cue recall task, is free of the interference that results from sharing a cue, thus, baseline levels of hits were attained. When individual differences to sensitivity were examined (i.e., *d'*), this slightly reduced sense of familiarity of Rp- competitors in comparison to Rp+ targets was captured, and a small, but significant difference was attained.

3.2.3.3. The Principle of Strength Independence

The lack of correlation among targets (Rp+) and competitors (Rp-) follows an inhibitory explanation of kindergartners' RIF, however, it is not sufficient to fully accept the account. Using the DOS and DOF scores make much more theoretical sense given that baseline

performance is eliminated from the variability in DOS and DOF scores. This variability may eliminate relationships that would otherwise emerge, and this is precisely what was observed in both Experiment 1 and 2.

In Experiment 2, when re-study was used in place of retrieval-practice, no correlation was found between DOS and DOF scores which seems consistent with an inhibitory account that predicts no strengthening/weakening trade off. It is possible, however, that strengthening through re-study does not strengthen items to the same extent as retrieval-practice, or that output interference, and cue-related interference, mask relationships that might otherwise emerge. The experimental manipulations were designed to assess the inhibitory account of the effect, not the various competition-based accounts, so a firm conclusion regarding this principle under re-study is not permissible. Examining the pattern with recognition testing helps with understanding the potential mechanisms involved.

A strong and significant positive relationship between DOS and DOF was found when recognition testing was used, and this relationship remained evident when Rp- competitors were both first, and last, in the recognition test. Recall that recognition testing eliminates both cue-related interference (i.e., no cue is provided), as well as output interference, if the competitors are at the start of the test. Finding a correlation between DOS and DOF scores when competitors were at the start of the recognition test suggests that a strength-based relationship exists in the absence of both output interference and cue-related interference. When the competitors are located at the end of the recognition test, this relationship is reduced due the increased influence of output interference under these circumstances.

As mentioned earlier, only cue independence is currently considered diagnostic of the involvement of inhibition in RIF, and only when output interference is controlled can an output

interference explanation of the effect be eliminated from consideration. Thus, the lack of cue-independence, output interference independence, along with significant target strengthening – competitor forgetting correlation under some circumstances does not support an inhibition perspective of kindergartners' RIF. A discussion of the results of Experiment 1 and 2 along with the implications of the findings are reviewed next in the final chapter.

4. CHAPTER 4: GENERAL DISCUSSION

Research on retrieval-induced forgetting (RIF) has been accumulating since the first work in the area was published in 1994 (Anderson et al., 1994). Since that time, the RIF pattern of results has been found across a variety of materials, and within a number of populations, with various individual differences identified leading to the conclusion that RIF is a general phenomenon of human memory. What is worthy of note, however, is that a phenomenon itself does not indicate the underlying cause or mechanism of that finding. A phenomenon by its very definition is something that is difficult to explain, or whose cause in under question (Merriam-Webster.com). The underlying cause of RIF is indeed under debate with two theoretical accounts finding mixed support throughout the literature; authors seem to take a stance that is either rooted in *inhibition* or *competition* (e.g., Anderson, 1983; Camp et al., 2007; Dodd, Castel & Roberts, 2006; Hughes, 2007; Jakab & Raainjakers, 2009; Jonker & MacLeod, 2012; Lang, 2000; Mensink & Raaijmakers, 1988; McGeoch, 1942; Perfect et al., 2004; Raaijmakers & Jakab, 2012, 2013; Raaijmakers & Shiffrin, 1981; Verde, 2009, 2013; Williams & Zacks, 2001). From the inhibitory perspective, RIF occurs because of competition during retrieval-practice between the target memories (Rp+) and related competitor memories (Rp-). To overcome this competition, the activation of the Rp- items is supressed resulting in below baseline (NRp) levels of memorability at test (e.g., Anderson, 2003; Anderson et al., 1994; Anderson & Spellman, 1995; Ciranni & Shimamura, 1999; Gómez-Ariza, et al., 2005; Hicks & Starns, 2004; Storm & Levy, 2012; Ortega et al., 2012; Perfect et al., 2004; Veling & van Knippenberg, 2004). From a competition-based stance, strengthening during retrieval results in competition and interference at test, which creates below baseline levels of performance without the need to inhibit that information (Camp et al., 2007; Jakab & Raaijmakers, 2009; Jonker & MacLeod, 2012;

McGeoch, 1942; Melton & Irwin, 1940; Raaijmakers & Jakab, 2013; Raaijmakers & Shiffrin, 1981).

Much RIF research has been conducted with adults, and an abundance of evidence in support of the inhibitory account exists in adult populations. However, very few studies have been conducted with children (Aslan & Bäuml, 2010; Ford et al., 2004; Lechuga et al., 2006; Marche et al., 2015; Price & Phenix, 2015; Zellner & Bäuml, 2005), and of those that have, evidence for the influence of competition-based interference has emerged in the youngest samples (Aslan & Bäuml, 2010; Ford et al., 2004). In order to evaluate whether or not kindergartners demonstrate RIF due to inhibitory mechanisms, five principles that are argued to support that account in adults were evaluated in the current dissertation. Experiment 1 examined the principles of *cue independence* and *strength independence,* while the manipulation to examine *competition/interference dependence* was unsuccessful with the currently available word norms. Experiment 2 evaluated the remaining principles of *retrieval-specificity,* and *output interference independence,* as well as re-evaluated the principle of *strength independence* when re-study was used in place of retrieval-practice, and when using a recognition test to assess final memory. Three of five principles (cue independence, strength independence, output interference independence) demonstrated evidence that supported competition-based accounts of RIF in kindergartners rather than inhibitory ones, and two of those principles are considered diagnostic of inhibition in RIF (Anderson, 2003, 2009; Anderson & Levy, 2007, 2011; Hiddleston & Anderson, 2012; Murayama et al., 2014; Spitzer & Bäuml, 2007). Finding non-inhibitory driven RIF in kindergartners is consistent with the cognitive development literature regarding the development of cognitive inhibition (e.g., Harnishfeger, 1995) as well as research regarding individual differences in cognitive inhibition (Lechuaga et al., 2006; Ortega et al., 2012). The

following sections of this discussion will first review the results of the examinations of each principle while pointing out the implications the results have on current theory. The limitations of the examination of each principle, and future directions for research in the area, will also be suggested. It will be proposed that a more unified dual-account of RIF is required to accommodate the current evidence of RIF in the literature rather than exclusive endorsement of one over the other. The general conclusions of the research will end the discussion.

4.1. Current Results

Although many researchers claim that their study results are consistent with the inhibitory explanation of RIF, very few have employed a methodology that would allow one to make such conclusions with confidence. Relying only on original cue recall tests following retrieval-practice tasks will very likely reveal the RIF pattern of results, however, such methodology does not allow one to conclude what cognitive mechanism may be driving the effect. In order to evaluate the inhibitory account of RIF, a measure of memorability of items must be tested in the absence of the original learning context (i.e., *cue independence*), and the impact of *output interference* must be controlled (Anderson, 2003, 2009; Anderson & Levy, 2007, 2011; Hiddleston & Anderson, 2012; Murayama et al., 2014; Raaijmakers & Jakab, 2013; Spitzer & Bäuml, 2007). As discussed in the previous chapters, these two principles are the only ones that can clearly diagnose the role of one mechanism over the other in RIF. The remaining principles (interference/competition dependence, strength independence, retrieval-specificity) can be adequately explained from either perspective.

4.1.1. The Principle of Cue Independence. Demonstrating persistent RIF when an independent or novel cue is used in place of the original cue at final test is considered to be a hallmark feature of inhibition in RIF (Camp et al., 2009; Hiddleston & Anderson, 2012; Perfect

et al., 2004; Saunders & MacLeod, 2006; Weller et al., 2012). In Experiment 1, kindergartners completed both an original cue, and a novel cue, RIF task. The typical RIF pattern of results was obtained under the classic retrieval-practice procedure with original cue recall, but kindergartners demonstrated a release from RIF when a novel cue was used at final test. If kindergartners' recall was bound by inhibitory mechanisms, they should have continued to show significantly lower levels of recall of Rp- items in comparison to NRp baseline items, regardless of the method of final testing. Therefore, Experiment 1 provides strong empirical evidence against an inhibitory explanation of RIF in kindergartners. This release from RIF with a novel recall cue suggests that some contextually-based interference influences kindergartners' memory for Rp- items. When a novel cue is provided, that contextual interference between the original cue and the paired Rp items (+ and -) seems to be released and Rp- items return to baseline (NRp) levels of recall.

Some researchers consider recognition tests to also be a test of the cue independent nature of RIF, and according to the inhibitory account, forgetting should persist with recognition testing as well (Aslan & Bäuml, 2010, 2011; Ford et al., 2004; Glanc, 2008; Gómez-Ariza et al., 2005; Weller et al., 2012). In recognition tests, the category cue is not provided, and direct retrieval attempts are not necessary given that the item is presented to the participant to either endorse as studied, or reject as a new item (e.g., Hicks & Starns, 2004). Therefore, similar to Aslan and Bäuml's (2010) study, kindergartners' lack of RIF when recognition tests were conducted after retrieval-practice in the present study also demonstrates the cue dependent nature of kindergartners' RIF.

The finding of *cue dependent RIF* (i.e., whether or not forgetting is found depends on the use of the original cue; Tulving, 1974) in kindergartners has a number of theoretical and practical

implications. From a theoretical perspective, researchers adopting either an *inhibition* or *interference* theoretical perspective are all informed regarding the development and performance of young memory systems. When researchers first began looking for developmental differences in RIF, inhibition theory pointed them in the direction of studying very young samples in an attempt to identify individual differences in the effect. It is theorized that inhibition is rooted in the frontal lobe along with many other executive functions (e.g., Aslan et al., 2010; Dempster, 1993; Romine & Reynolds, 2005; West & Alain, 2000; Welsh, 2002), and children as young as 8 years of age demonstrate differential brain activation and inefficient inhibition in comparison to adults (Bunge et al., 2002). The greatest shift in the development of behavioural inhibition occurs at 6 and 8 years of age with 10 year olds performing similarly to 12 year olds (Passler et al., 1985). Therefore, if RIF was in fact mediated by inhibitory mechanisms, 5 year olds (Aslan & Bäuml, 2010) and 7 year olds (Ford et al., 2004) should show little to no RIF. What the current results suggest, as well as Aslan and Bäuml's findings, is that kindergartners indeed do not yet possess the inhibitory capacity required to demonstrate cue independent RIF. Theoretically, this is consistent with the history of research identifying the developmental nature of executive functions. Practically, this indicates that, assuming the information was stored in their memory in the first place, kindergartners' may be especially susceptible to context related memory interference. Efforts should therefore be made to help circumvent this issue when attempting to test kindergarteners' memory, or when trying to uncover what kindergartners' actually remember on a given task. For example, if questioning a kindergartner about an incident, and a comprehensive report from the child is desired, alternate means of tapping memory traces should be used, other than cues used during initial encoding or subsequent retrieval. It is quite possible, and quite likely given the current results, that access to weaker

memory traces is simply being interfered with or blocked through retrieval and recall of the stronger, more dominant, memory traces.

Other RIF research examining cue independence has been criticized as not using cues that are truly independent of the cues used during encoding (Veling & van Knippenberg, 2004), and that *covert cueing* (participant initiated use of the original cue to aid recall, Perfect et al., 2004) cannot be ruled out as potentially influencing results. These limitations are also found in the current research. It is possible that kindergartners thought of the original cues when presented with the novel cues thereby contaminating the novel cue recall data with original cue interference. In other words, when presented with "different things we could eat" participants may have thought of the cue "Food" that was used during initial study, and used that original cue to retrieve the studied items. However, if this was a likely explanation, then one would not expect a distinct RIF pattern of results when original cues were used, but a clear elimination of RIF when novel cues were used at test. One method used in the adult RIF literature to address this concern is by using a lexical decision task that measures reaction time (Veling & van Knippenberg, 2004). Future research with young children that intends to evaluate this principle further should also make use of such a task to ensure that cues are not thought of at all. Judgments about whether a word is a real word or not does not require one to consider the cue that was used during encoding, therefore, a more pure measure of cue independence can be obtained.

Future research examining this principle should aim to make use of age-appropriate lexical decision tasks, which should also provide a relatively interference-free assessment of trace activation. In lexical decision tasks, participants make a decision as quickly as possible about whether the word, object, or picture that they are viewing represents a real thing or not

(Kroll & Potter, 1984). The order of output could be controlled and examined by having participants make judgements about the Rp- competitors at the start of the final memory test versus at the end of the test. Further, such assessments would be free of cue or context-related interference that could result in associative blocking (e.g., Raaijmakers & Shiffrin, 1981). Using a lexical decision task using pictures, written, and verbally stated words and non-words might also help tease apart potential difference in interference and inhibition that occurs for different types of memory (e.g., interference in visual memory, Logie, Zucco & Baddeley, 1990; inhibition in semantic memory, Anderson et al., 1994; etc.).

4.1.2. The Principle of Interference/Competition Dependence. The principle of *interference/competition dependence* could not be reliably evaluated in the current study due to a lack of available materials given kindergartners' small vocabularies, and few category norms available for that age group. Although this is a limitation of the study, evidence for the interference/competition dependence principle of inhibitory-based RIF is also somewhat controversial in the adult RIF literature. Although Anderson et al. (1994) evaluated the principle in their pioneer RIF research, subsequent efforts to replicate (Williams & Zacks, 2001), and extend the principle to other competitive situations (e.g., Jakab & Raaijmakers, 2009; Jonker & MacLeod, 2012) have provided mixed support. For example, Anderson et al. (1994; Anderson, 2003, 2009; Anderson & Levy, 2007, 2011) concluded that a greater degree of competition and interference during retrieval-practice results in greater degrees of forgetting, which they argue is due to a greater amount of inhibition needed to suppress highly active, strong exemplars in memory. Yet, Williams and Zacks (2001) were unable to demonstrate support for the *interference/competition dependence* principle of inhibitory-based RIF. In Williams and Zacks' study, RIF was obtained, but strong and weak Rp- competitors demonstrated similar levels of

impairment, contrary to the inhibitory account of the effect (Anderson et al., 1994). Further, Jakab and Raaijmakers (2009) used a competitive retrieval-practice trial where participants retrieved category-cues rather than exemplars (a method used by Anderson as well, Anderson et al., 2000), and they too failed to find increased forgetting of strong Rp- competitors. Thus, the support for the interference/competition dependence principle is not overwhelmingly clear in the adult literature, and it proves to be difficult to assess in young samples such as kindergartners as well. It is also possible that certain principles, such as interference/competition dependence principle, show relatively smaller effect sizes that would thereby require larger sample sizes and greater statistical power to detect differences. Future research aimed at evaluating this principle in young children should ensure adequate norms are available for the sample under investigation, ensure adequate statistical power will be obtained, and perhaps use a more sensitive measure of trace activation (e.g., reaction time data) at final test.

4.1.3. The Principle of Strength Independence. According to the inhibitory account of RIF, the degree of strengthening of Rp+ items through retrieval-practice does not influence the degree of forgetting obtained for Rp- items (Anderson, 2003; Anderson & Levy, 2007, 2011; Ciranni & Shimamura, 1999; Storm & Levy, 2012). This principle did not appear to be supported in the current research. Instead, kindergartners appear to demonstrate *strength dependence* when original and novel cues are used at recall, during recognition tests, and especially when competitors are tested first in a recognition test. These positive correlations fit better with alternate accounts of RIF such as *spreading activation* (e.g., Collins & Loftus, 1975), *cue-dependent interference* (e.g., Tulving, 1974) and *output interference* (e.g., Roediger, 1973).

The *spreading activation* model is a model of semantic memory (Anderson, 1983; Collins & Loftus, 1975) could explain a positive correlation between Rp+ strengthening and Rp-

weakening in the context of RIF tasks. According to this model, whenever someone sees, hears, or thinks about a concept, that representation in memory is strongly activated and this activation spreads to related concept representations (e.g., seeing a robin activates "robin" and "bird") (Anderson, 1983; Collins & Loftus, 1975). The more closely related two concepts are, the stronger the spread of activation, while distantly related concepts are less activated (e.g., "robin" strongly activates "bird" and also activates "red" but to a lesser degree than "bird"). During a typical retrieval-practice task then, the repeated retrieval of Rp+ items will strengthen those items, but will also activate and strengthen related, Rp- items, only to a lesser degree than the Rp+ items. It is possible then that a positive correlation between Rp+ strengthening and Rp- weakening may be found. This interpretation is consistent with the significant positive correlations obtained when both original category cue, and novel cue recall was used as well as with the recognition test. First, consider the data that reflects the RIF tasks using recognition testing. Overall, a strong positive correlation was found between DOS and DOF scores for kindergartners when recognition testing was used to assess final memory. This positive correlation may suggest that as Rp+ items were repeatedly retrieved, the related Rp- items were also activated. Recall that kindergartners have limited vocabularies, thus, the materials used in the current study are all considered relatively strong members of their assigned category. Items that are more strongly associated are more likely to experience spreading activation due to that close association; thus, Rp- items were likely strengthened somewhat along with the Rp+ items.

The DOS and DOF correlation was especially strong when the Rp- competitors were tested at the start of the recognition test, and a weaker, but significant, correlation was found when competitors were located at the end of the test. The only theoretical difference between these two manipulations is the degree of output interference that is influencing the results. When

Rp- competitors are tested first, output interference is considered to be at its weakest point – the first item should be free of output interference, while the subsequent items are interfered with by the preceding items. When the Rp- competitors are last, output interference is assumed to be at its peak as the items are at the end of the output protocol. A strong positive correlation in the absence of output interference thereby provides some support for a spreading activation account of kindergartners' memory following retrieval-practice. At the start of the protocol, when there is the least amount of interference affecting the relationship, a strong positive DOS/DOF correlation can be observed. When the Rp- competitors have suffered from the effects of output interference, the relationship is affected by that interference, and the correlation is reduced.

Why then, was a moderate positive correlation between DOS and DOF scores found with original cue recall? Again, a competition-based explanation seems to best account for the results. Although a significant forgetting effect was obtained, the positive correlation seems to indicate that the recall of Rp+ items reduces the degree of forgetting found for Rp- competitors. In other words, the likelihood of outputting Rp+ items influences the likelihood of outputting Rp- items. DOF scores are negative when RIF has been obtained, as was found in the original category cue recall data in the current dissertation. Thus, a significant positive correlation between positive DOS and negative DOF scores means that as degree of strengthening increased, the degree of forgetting decreased (i.e., become less negative, or more positive).

Output interference was not controlled in the original cue RIF task, nor in the novel cue RIF task, and in both of these instances a cue of some sort was present. If one or both of the retrieval-practiced categories were tested later in the output protocol (not necessarily last), output interference likely influenced the results and may have thereby weakened the DOS/DOF correlation without completely eliminating it (similar to the reduced correlation found when Rp-

competitors were located at the end of the recognition test). Further, the cue dependent nature of kindergartners' RIF could also suggest that cue-related interference affects their final memory performance, and this too could have contaminated and reduced the DOS/DOF correlation in instances when a cue was present. The positive correlation may indicate the facilitative nature of having any cue present to guide recall, especially when output interference is controlled, which is contrary to the principles of *cue independence, strength independence,* and *output interference independence* of inhibitory-based RIF. Future research aimed at evaluating the strength-dependent nature of kindergartners' RIF would be well served to address these limitations by strategically manipulating the order of output across all experimental manipulations.

The fact that an inverse correlation between DOS and DOF scores was not obtained also helps to eliminate some competition-based explanations, such as *associative unlearning* (e.g., Melton & Irwin, 1940), or pure strength dependent interference. From these perspectives, target strengthening is directly responsible for competitor forgetting by either punishing the cue-exemplar pair, or weakening it (McGeoch, 1942). Thus, from these views, the proportion of Rp+ targets recalled would be inversely correlated to the proportion of Rp- competitors recalled. Evidence of an inverse correlation was not found in the current kindergarten sample. No correlation was obtained when re-study was used in place of retrieval-practice, which might reflect differential strengthening that occurs through both processes. From the inhibitory perspective, re-study is considered a non-competitive form of strengthening Rp+ targets, thus, it would be reasonable to assume that strengthening through re-study might not yield as strong, or as much activation, as strengthening through retrieval-practice. If this were the case, a non-significant correlation between DOS and DOF following re-study might fit a competition-based account of kindergartners' memory performance quite well.

A strong stance regarding one competition-based explanation over the other cannot yet be taken, but what can be concluded from the current results is that kindergartners' RIF does not demonstrate strength independence. Therefore, results for this principle support a competition-based account of kindergarteners' RIF in that final memory performance was strength dependent under certain circumstances. To gain better theoretical understanding of the dynamics of kindergartners' RIF, future research should aim to document when kindergartners' RIF demonstrates strength dependence and attempt to evaluate specific competition based explanations of the effect in this age group.

4.1.4. The Principle of Retrieval-Specificity. To test retrieval-specificity in kindergartners' RIF, re-study trials were used in place of retrieval-practice trials. At final test, no RIF was obtained with this manipulation which is consistent with an inhibitory account of RIF. According to the inhibitory account, active retrieval attempts are necessary to trigger the inhibitory mechanism responsible for RIF. Under re-study conditions, strengthening of Rp+ items occurs without mental retrieval competition between the un-practiced Rp- items, thus, no interference/competition exists to trigger inhibition, and no forgetting is found. However, competition-based explanations can also account for a lack of RIF under re-study conditions (e.g., Verde, 2012). From a relative strength perspective for example (Raaijmakers & Shiffrin, 1980), Rp- and NRp items should have the same relative strength in memory given that they were both only studied once; Rp+ items however, would have significantly stronger memory traces due to their repeated re-study. Although it is a simple explanation of the results, it may be an accurate one.

Other means of assessing the principle of retrieval-specificity are available such as having participants engage in impossible retrieval attempts (e.g., attempt to retrieve a "fruit" that

starts with "lu"), versus possible ones (e.g., fruit – ap__; Storm et al., 2006); pursuing this line of research might help shed light on subtle differences in kindergartners' RIF across retrieval manipulations. Given the small vocabularies of kindergartners and likely confusion that would result from instructing them to try and retrieve impossible words, the current research utilized re-study trials instead. However, this limitation may be easily addressed by providing participants with clear instructions that some of the words that they will be asked to practice will be "pretend" words that we did not study, but that they should try to find a word that they know that would fit with the pair. Possible increases in false recall or intrusions may result from the manipulation and instructions, however, recall of the Rp+, Rp- and NRp items would be of primary interest to evaluate the principle.

The retrieval-specificity results of the current research can be explained by both competition-based, and inhibitory based accounts of RIF, thus, it is important to consider the findings alongside the other study results – namely the *cue dependent* and *strength dependent* findings. RIF did not persist with a novel cue and kindergartners' memory was strength dependent under some circumstances. As discussed next, RIF did not occur in tests of item recognition either. All of these results thus far, when considered together, strongly refute the involvement of inhibition in kindergartners' RIF.

4.1.5. The Principle of Output Interference Independence. The finding that kindergartners no longer demonstrated RIF when a recognition test was used again provides support for cue dependent forgetting in kindergartners. No cues were present in the recognition test, and RIF was eliminated. Output interference can be ruled out as the primary factor contributing to kindergartners' RIF, because even when output interference was at its peak during the recognition test (i.e., competitors last), RIF did not occur. In other words,

kindergartners' RIF is neither output interference independent nor dependent; in the current sample, output interference appeared to have little to no impact on the results. In research with adults, the RIF effect can be significantly reduced, or even eliminated in some studies, once output interference is controlled (Murayama et al., 2014), thus, persistent RIF in these controlled memory tests can be considered diagnostic of output interference in RIF. The lack of influence of output interference in kindergartners' memory following retrieval-practice, along with the elimination of RIF with a novel cue at test, provides some relatively strong evidence against the inhibitory account of RIF in kindergartners. Taken together, this pattern of results suggests that some form of competition-based interference influences kindergartners' RIF instead of inhibitory mechanisms. Future research that attempts to replicate this finding would be well advised to utilize a few more items, such as an additional category or two, in order to increase variability on the recognition test because near ceiling performance was obtained.

4.1.6. Conclusions. Spreading activation (Collins & Loftus, 1975), and cue-dependent interference (Tulving, 1974), can better explain the recall and recognition test results in the current set of studies than the inhibitory account. Spreading activation posits that related concepts in memory are activated whenever a concept is seen or heard (e.g., "robin" activates "bird"), and the more closely related the concepts are, the more activation they will experience (e.g., "bird" will be more highly activated compared to "red" when "robin" is read) (Collins & Loftus, 1975). During retrieval-practice trials, Rp+ and Rp- items are from the same semantic category, thus, it is possible that as the Rp+ targets are repeatedly retrieved, the Rp- items are also activated. At this point, an inhibitory explanation would expect the trigger of an inhibitory mechanism that supresses the activation of Rp- competitors in order to successfully retrieve the

Rp+ targets (Anderson et al., 1994). If no inhibitory mechanism is available, or is not efficient enough to suppress activation, then this step would not be completed.

Final test results using the original category cues, novel cues, and recognition tests help shed light on the types of interference that might come into play at final test for kindergartners. With original cue recall, both cue-related interference (Tulving, 1974), and output interference (Roediger, 1973) are present due to the presence of the category cues and randomized order of recall, respectively. When a novel cue was used at test, cue related interference was eliminated and a release from RIF was found. It is possible that some output interference was still contributing to participants' performance with novel cue testing, because random orders were again used to organize recall. The contribution of output interference in kindergartners' memory following retrieval-practice cannot be considered a significant contributing factor either, because when the Rp- competitors were placed at the end of the recognition test, when output interference is at its highest, RIF was not obtained.

The positive correlations obtained between the degree of strengthening (DOS) of Rp+ items and the degree of forgetting (DOF) of Rp- items also follows the logic of multiple interference contributions. A positive correlation was obtained between DOS and DOF scores when the original category cues, novel sentence cues, and recognition testing were used, which suggests the role of spreading activation (Collins & Loftus, 1975), and seems to follow a relative strength argument (Raaijmakers & Shiffrin, 1980). The degree to which targets are strengthened influences the memorability of related, activated concepts. This spreading activation may differentially strengthen related memory traces depending on how the Rp+ items are activated during retrieval, or at final test. For example, during retrieval attempts of Rp+ items (original cue recall, novel cue recall, recognition test), the related Rp– competitors may be strengthened

more so than during simple re-presentations (re-study), which would subsequently reduce or eliminate the correlation as found in the re-study RIF task. The differential impact of retrieval versus re-presentation has been used as a means of manipulating the degree of competition among items in other RIF research (e.g., Ciranni & Shimamura, 1999), thus, it is reasonable to assume that differential activation could also result from such competitive versus non-competitive strengthening trials. Differential activation at test may also be contributing to the significant correlations obtained. When a novel cue is used at recall, context or cue-related interference (Tulving, 1974) is eliminated, which provides kindergartners with an alternate means of accessing the memory traces. Rp+ items are still enhanced in memory, but Rp- and NRp traces are recalled at similar rates.

Why though, would a significant positive correlation still be found between DOS and DOF scores when novel cue recall is used? Consideration of the positive correlations found for recognition testing helps with interpretation. When Rp- competitors are first, cue-related interference, and output interference are both eliminated as much as possible. With this relatively pure, interference-free test of the memory traces, the true strength of the DOS/DOF relationship is revealed. As output interference is added, the correlation is reduced as can be seen with the significant, but reduced, DOS/DOF correlation with recognition testing when Rp- competitors were last. When cue-related interference is also added, as with original cue recall, the significant correlation is still obtained, but again is reduced compared to recognition testing. The significant positive correlation with novel cue testing was the lowest significant correlation, and may have also been contaminated by output interference due to the random orders used to guide recall. These strength-dependent correlations found in kindergartners' RIF need to be further evaluated with strategic manipulations that will help elucidate the likely competition-

based mechanism contributing to the relationships. Currently, however, it can be concluded that kindergartners' RIF is not strength-independent due to finding significant correlations among strengthening and weakening across a variety of RIF tasks.

Of the five principles argued to support the inhibitory account of RIF, three (cue independence, strength independence, output interference independence) demonstrate the lack of an inhibitory contribution to the effect in kindergartners. One principle (competition/interference dependence) could not be adequately evaluated with the materials available, and findings regarding the retrieval-specificity results can be interpreted from both an inhibition- and competition-based stance. The differential relationship between DOS and DOF scores when different memory tests are used also suggests that more than one type of interference can influence kindergartners' memory performance. These results are not necessarily inconsistent with the inhibitory account of RIF given that kindergartners' are expected to have immature executive functions, which include inhibition (e.g., Bjorklund & Harnishfeger, 1990; Rueda et al., 2005). Rather, they support the notion that multiple mechanisms might contribute to RIF effects, and that RIF can occur without inhibition. Therefore, all possible explanations of RIF should be evaluated to confidently move RIF theory forward. The next section discusses the need for a comprehensive, and unified theory of RIF that can account for the different findings under different manipulations.

4.2. Toward a Unified Account of Retrieval-Induced Forgetting

The study of interference and other competition-based explanations of remembering and forgetting have a long history, and can account for many memory-related results other than RIF (e.g., Anderson, 1983; Anderson & Neely, 1996; Dempster, 1995; McGeoch, 1942; Mensink & Raaijmakers, 1988; Raaijmakers & Shiffrin, 1980, 1981). A variety of types of interference have

been documented to contribute to forgetting. For example, new experiences can lead to forgetting of old experiences (e.g., *retroactive interference*, Barnes & Underwood, 1959), and recent experiences can affect the formation of new ones (*proactive interference*, Underwood, 1957). Competition-based explanations that involve interference are also well established in the literature (e.g., *search of associative memory* model, Raaijmakers & Shiffrin, 1980, 1981; *response competition,* McGeoch, 1942, Mensink & Raaijmakers, 1988; Raaijmakers & Shiffrin, 1981). Interference and trace decay accrues over time, and subsequent forgetting of information can result unless that information is strengthened through retrieval or practice (e.g., Ebbinghaus, 1885/1913); simple changes in context at retrieval can also negatively impact memory (e.g., Mensink & Raaijmakers, 1988). In fact, some of the very principles that are argued to support the inhibitory account of RIF implicate interference. First, in the interference/competition dependence principle, interference or competition between the to-be-retrieved Rp+ targets and related, but un-retrieved Rp- items *is necessary* in order to trigger the inhibitory mechanism required to demonstrate inhibitory-based RIF. Second, in the retrieval-specificity principle, active retrieval attempts are required to trigger the interference or competition necessary to subsequently trigger the inhibitory component of RIF. Therefore, retrieval-attempts must first occur, in order to create the interference/competition that must then occur in order to create the need to inhibit memory traces. Interference or competition among memory traces is, therefore, a necessary precondition of inhibitory-based RIF.

Efforts to generate comprehensive models of executive functions and other cognitive abilities highlight the need to acknowledge the subtle differences among, and diversity of, cognitive functions (e.g., Miyake et al., 2000). For example, in addition to different types of inhibition in general (e.g., *behavioural* versus *cognitive* inhibition), some researchers are

beginning to argue for different forms of cognitive inhibition such as intentional (e.g., directed forgetting), and unintentional (Aron, 2007; Harnishfeger, 1995; Lechuga et al., 2006; Ortega et al., 2012) inhibition. These different forms of inhibition may have different developmental trajectories (e.g., Román et al., 2009); only careful manipulations and memory assessments across the lifespan will identify this possibility.

For these reasons, researchers should attempt to accommodate and explain RIF results from both perspectives and carefully document when, under what circumstances, and in what population samples, each form of RIF occurs. Rather than using the typical RIF paradigm with original cue recall at final test, more nuanced approaches must be made to tease apart inhibition from competition-based explanations. Further efforts should be made into identifying the type of competition or interference involved in studies where the inhibitory explanation fails. It is quite possible that interference mechanisms contribute to RIF early in life but that as executive and inhibitory functions develop, these mechanisms take hold to shape memory. As the literature is beginning to demonstrate, a dual-account of RIF would predict both developmental (e.g., Aslan & Bäuml, 2010) and individual differences (e.g., Aslan & Bäuml, 2011) in the effect.

4.3. Implications and Future Directions

The lack of support for the inhibitory account of RIF in kindergartners is informative to anyone who relies of children's memory (e.g., interviewers, parents, teachers). The data seem to suggest that interference mechanisms dominate kindergartners' memory. When children appear to have forgotten information, the accessibility of that information may simply be impaired, but the information might still be available. Providing children with an alternate cue to release cue-related interference appears to help alleviate their forgetting. Thus, when questioning children and examining their memory, many retrieval-cues should be provided in attempt to circumvent

as much cue-related interference as possible. Specific questioning is problematic to young children (e.g., Rocha, Marche & Briere, 2013), and the finding of cue-dependent memory helps explain such findings. If kindergartners' memory systems are inefficient at inhibiting competing memory traces, it may be difficult to access the correct memory trace and false responses, or strength-related biases in responding (e.g., yes-bias), may result. The potential increased susceptibility to interference that young children experience can adequately explain much of the child RIF research results as well. For example, in the current studies, as well as Aslan and Bäuml's (2010) study, kindergartners did not demonstrate RIF with a recognition test, which is free of cue-related interference. This, along with the finding of RIF with original cue recall (current studies; Aslan & Bäuml, 2010), suggests that the presence of contextual (cue-related) interference is necessary to induce RIF in this population (Price & Phenix, 2015). Young children have also been found to demonstrate RIF for true but not false memories (Price & Phenix, 2015), which could be explained through cue-dependent and spreading activation explanations. It may be that as cue – target pairs are strengthened through retrieval-practice, the unpresented, semantically related lure words are also activated. At test, the lures, which were repeatedly activated through each retrieval-practice trial, dominate recall and no RIF of these false items is obtained.

The current set of studies adds to an increasing amount of evidence that is building against the inhibitory explanation of RIF in young children (Aslan & Bäuml, 2010; Price & Phenix, 2015). Given the vast amount of support for the inhibitory explanation of RIF in adults (e.g., Murayama et al., 2014), and our current understanding about the development of executive functions (e.g., Romine & Reynolds, 2005), this conclusion is not necessarily contrary to the existence of inhibitory-based RIF. Rather, data are beginning to suggest that inhibition is an

ability that develops as one ages, and that various forms of interference, and perhaps different forms of inhibition, also affect memory performance. It is the role of the scientific community to identify the precise mechanisms contributing to memory performance across the lifespan; utilizing controlled methods and procedures such as the RIF procedure is a promising model for revealing these subtle, but distinct differences in memory.

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APPENDIX A: EXPERIMENT 1 & 2 LETTER OF INVITATION FROM RESEARCHER

Letter of invitation sent home with each kindergarten student from the targeted schools. This letter accompanied the letter of support from the school principal, parental consent form, and child activity and information pamphlet.

Research Supervisor
Tammy A Marche, PhD
Phone 966-8314
Fax 966-8904
tmarche@stmcollege.ca

Memory Research Lab
UNIVERSITY OF SASKATCHEWAN

Student Researcher
Jennifer L Briere, MEd
Phone 966-8314
Fax 966-8904
jennifer.briere@usask.ca

Dear Parent or Guardian,

My name is Jennifer Briere and as part of my PhD, I am conducting a study through the University of Saskatchewan regarding children's memory for related words. The main purpose for conducting the study is to gain an understanding of how children remember and forget related information by examining their memory performance after some information is reviewed. Research with adults and older children has shown that related, but un-reviewed information is often forgotten in order to more accurately remember the reviewed information. This phenomenon, called *retrieval-induced forgetting,* occurs when learning new information or when reviewing previously learned information. We need to learn about the development of *retrieval-induced forgetting* in order to inform teaching practices (e.g., learning and reviewing information at school), as well as parents (e.g., the impact of selective review of experiences) and practitioners that rely on children's memory (e.g., questioning styles by police or councilors).

Your child is invited to participate in my brief, 30 minute study aimed at examining how young children remember and forget information. <u>As a gift of thanks for their help, children will be asked to choose a small age-appropriate toy.</u> I have enclosed a parental consent form that describes the task that your child would be asked to complete. If you consent to allowing your child to participate, please complete the consent form and return it to school with your child where testing will occur in consultation with his/her teachers. Your child will also be asked if s/he would like to participate prior to testing. Should you have any questions or concerns, please do not hesitate to contact my research supervisor, Dr. Tammy Marche, or myself, using the contact information above.

Thank you in advance for your time and consideration.

Kind regards,

Jennifer Briere

APPENDIX B: EXPERIMENT 1 LETTER OF SUPPORT FROM KATHY GRAD (OUTLOOK PRINCIPAL)

The following letter of support from Kathy Grad (Outlook Elementary Principal) accompanied the letter of invitation from the researcher and parental consent form in the recruitment package sent home to each Kindergarten student at Outlook Elementary.

SUN WEST SCHOOL DIVISION
Success for all

Outlook Elementary School
Ms. Kathy Grad, Principal
Mrs. Darla Thorstad, Vice Principal
Box 820 • Outlook, Saskatchewan • S0L 2N0
Phone: 306-867-8653 • Fax: 306-867-8675
Email: laura.rafoss@sunwestsd.ca

OES "Learning Together"

October 21, 2013

Dear Parents,

Enclosed you will find a letter and some information from Jennifer Briere (University of Saskatchewan). She would like to conduct a study in our building regarding memory. Tracy Dollansky (our superintendent) and I have met with Jennifer to discuss this study and we feel it is a very good study. We hope that you will allow your child to be a part of this study by completing and returning the enclosed parental consent form by October 25, 2013.

We would also like to invite you to a meeting on Wednesday, October 23, 2013 from 7:00 to 9:00 p.m. at OES. At that time, Jennifer will be here to talk more about the study and answer any questions you may have.

We hope that you will allow your child to be part of such an important study as we continue to look for ways to help students learn most effectively.

Thank you.

Educating together,

Principal

Vice Principal

APPENDIX C: EXPERIMENT 1 PARENTAL CONSENT FORM

Research Supervisor
Tammy A Marche, PhD
Department of Psychology
St. Thomas More College
University of Saskatchewan
Phone 966-8314
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tmarche@stmcollege.ca

UNIVERSITY OF SASKATCHEWAN

Student Researcher
Jennifer L Briere, MEd
Department of Psychology
University of Saskatchewan
Phone 966-8314
Fax 966-8904
jennifer.briere@usask.ca

Parental Consent Form

Your child is invited to participate in a project called **"Children's Memory for Related Words."** Please read this form carefully and feel free to ask any questions you may have.

Purpose: When trying to learn new information, or when reviewing already learned information, children may experience forgetting of the un-reviewed information. This phenomenon of memory is called *retrieval-induced forgetting* and has been found in a variety of settings with young, old and elderly adults. For example, studying some information leads to better memory for that information when studying for exams, but at the cost of forgetting the related, but non-studied information. Similar results have been found with interrogation or questioning procedures. Memory for parts of eyewitness-like events is enhanced when adults are repeatedly questioned about those events. However, memory for other parts of the events that are not reviewed through questioning are subsequently forgotten.

Although this forgetting has been found in a variety of settings with adults and seems to be a general phenomenon of adults' memory ability, very little research has been done with children, especially very young children. Such research is imperative in order to understand how children remember and forget information, which could have far-reaching implications. Methods of learning, treatment, counseling, and interrogation styles with children will be informed through this study by learning whether or not selective review leads to forgetting of non-reviewed information and the age at which such forgetting develops. Therefore, the purpose of the current project is to determine whether or not young children (aged 4.5 – 6 years) also demonstrate retrieval-induced forgetting so that researchers and practitioners can begin to learn how such forgetting may impact young children's memory.

Procedure: This study involves a short memory task that should take no longer than 30 minutes to complete. Children will be asked to try and remember groups of words that are related to each other. They will be shown pictures of the words and the researcher will say the words out loud (e.g., "Here are some fruits for you to try and remember – apple, blueberry, banana, and orange," with the researcher pointing to each picture as the words are said out loud). Half of the words from half of the groups will then be reviewed again. The researcher will say the category name out loud, followed by a hint that consists of the first few sounds of the target word (e.g., "That is a lot of words to remember, so I will help you practice some of them by giving you a hint to help you remember the word. I will say the name of the group and the starting sound of the word.

Your job will be to tell me the full word. Fruit – ban…"). Next, children will take a short break and play an age-appropriate iPhone game called *Jacob's Shapes,* which involves puzzles where the child has to drag and drop shapes into the appropriate place on screen. Once the break is over, children will be asked to tell the researcher all of the words that they remember studying (e.g., "Now I'd like you to tell me all the words you remember. I will tell you the group name and you tell me as many of the words or pictures that you remember studying. What 'fruits' do you remember?").

If you have any concerns regarding any of these activities, please feel free to talk to us before consenting to your child's participation.

Potential Risks: There are no risks associated with participating in this project that are beyond those encountered in everyday life.

Potential Benefits: Learning about whether or not young children demonstrate retrieval-induced forgetting will inform not only memory researchers, but also other professionals that deal with children's memory. For example, teachers trying to help children learn information in school will be informed about whether or not practicing some information will increase the chance of forgetting the related, but un-reviewed information. Future research may be aimed at trying to overcome such potential downfalls of practice with children. Parents, legal professionals and counsellors or therapists will also be able to evaluate whether or not practicing some information through questioning or reminiscing will help reframe negative memories, or lead to forgetting of the un-reviewed information.

Learning whether or not retrieval-induced forgetting influences children's memory will have an impact on a vast number of areas. Also, it is our hope that your child enjoys the challenge, the novel experience, and the opportunity to contribute to science.

Storage of Data: Dr. Tammy Marche will securely store all data and materials used for this project at the University of Saskatchewan. Data and consent forms will be stored separately. All data and materials will be stored for a minimum of five years following publication.

Confidentiality: The information that your child provides will remain completely anonymous and confidential. Your child's name will not be released to any source, nor will it appear on any completed materials. A random numbering system will be used to identify all collected data. Data collected during this project may be published or presented at a future date. However, only aggregate data, not individual scores, will be reported.

Right to Withdraw: Your child may withdraw from the project for any reason, at any time, without penalty of any sort. If your child withdraws from the project at any time, any data that he/she has contributed will be immediately destroyed. The researcher may choose to discontinue a participant's involvement in the project at any time. This would occur if a participant seemed to be experiencing undue discomfort during the project, or if unforeseen circumstances arose that would compromise successful data collection. You and your child's right to withdraw data from the study will apply until the data has undergone data entry and analysis. After this it is possible

that some form of research dissemination will have already occurred and it may not be possible to withdraw the data.

Questions: If you have any questions concerning the project, please feel free to ask at any point; you are also free to contact the researcher or research supervisor at the numbers provided above if you have questions at a later time. This research project has been approved on ethical grounds by the University of Saskatchewan Research Ethics Board on August 6, 2013 (Beh-REB#: 13-266). Any questions regarding your child's rights as a participant may be addressed to that committee through the Research Ethics Office (306-966-2975). Out of town participants may call toll free 1(888) 966-2975. To request a letter outlining the project results include your mailing address or email address below your signature on this form.

Consent to Participate: I have read and understood the description provided above; I have been provided with an opportunity to ask questions and my questions have been answered satisfactorily.

I consent to allow my child (*please print child's full name and birthday*),

_____

(Child's Full Name)

_____/_____/_____

Month / Day / Year

(Child's Birthday)

to participate in the project described above, understanding that I may withdraw this consent at any time. A copy of this consent form has been given to me for my records. Please provide your mail/email address if you would like to receive a letter detailing the study results.

_____ _____

(Signature of Parent/Guardian) (Date)

_____

(Signature of Research Assistant)

(Detach from Form if Completed)

Mailing or Email Address

(Please provide your mailing address or e-mail address if you would like to receive a letter detailing the results of the study.)

_____

_____

_____

APPENDIX D: EXPERIMENT 1 CHILD ACTIVITY & INFORMATION PAMPHLET

Help Mommy Dog find her Puppy

ZiggityZoom.com
A fun place to zoom around...
©SPMc

If you're interested, ask your Mom, Dad or guardian to contact me!

Jennifer L Briere, MEd
Department of Psychology
University of Saskatchewan
Phone 966-8314
Fax 966-8904
jennifer.briere@usask.ca

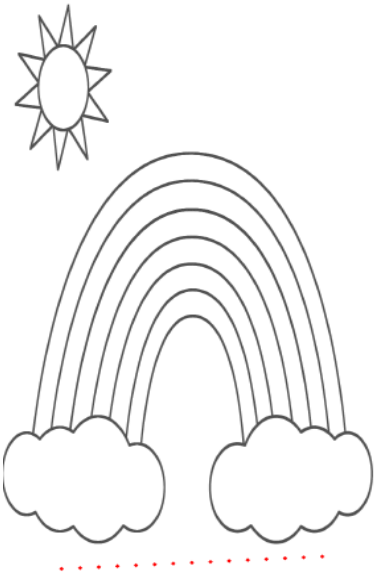
HELLO!

Do you like testing your memory?

How about playing games?

If you do, and you'd like a prize for doing so, maybe you'd like to help me with my project!

Can you remember all the colors of the rainbow?



Here's a *hint*: ROYGBIV

Would you like to help me with a research project?

in this activity, you will be asked to try to remember lists of words that are related to each other. You will be given a chance to practice remembering some of the words. Then we will have a short break and you can play a game on my iPhone. After the break, I will ask you to tell me all the words that you can remember. And if you want to do the activity, you will be able to quit at any time you want

Also, if you were to take part in this project, you would be helping scientists learn more about how children 's memory's work! And to say thank you, I'll ask you to pick a prize!

IF YOU LIKE:

- ☐ SCIENCE
- ☐ PLAYING GAMES

AND,

- ☐ LEARNING NEW THINGS

Then tell your parents to return the form that would allow you to do the activity!

APPENDIX E: RATING SHEET FOR JUDGES

Background: My PhD research involves memory for word lists in a kindergarten population (4.5 years – 5.5 years). Therefore, I need to generate two separate sets of category – item (e.g., animals – bird, dog, cat) word lists that will be as familiar with Canadian Kindergartners as possible. To finalize my word lists, I would like your help in rank ordering the items, and categories according to how familiar you think each would be to Canadian kindergarteners. I also need to have a phrase or sentence that will cue my participants to recall the items from each given category, without using the category cue word itself. I also need to make sure that each item in a particular set only belongs to a single category. Please follow the instructions provided below.

Part 1: Read each category and accompanying items. Please place a 1 beside the category that you think would be most familiar to Canadian 4.5 – 5.5 year olds, a 2 beside the next most familiar category, and so on until all categories are ranked. Please rank each set from 1 – 6.

Set 1

Rank	CATEGORY - Items
	ANIMALS – dog, cat, bird, rabbit, mouse, duck
	SCHOOL – paper, paint, pen, glue, crayons, scissors
	VEGETABLE – beans, corn, tomatoes, potatoes, carrots, mushroom
	VEHICLE – car, boat, bus, truck, train, bike
	FAMILY – dad, mom, brother, uncle, sister, grandma
	JOBS – doctor, teacher, nurse, policeman, dentist fireman

Set 2

Rank	CATEGORY - Items
	BODY – back, head face, hair, nose, arm
	CLOTHES – hat, shoes, coat, socks, dress, pants
	FRUIT – apples, orange, grapes, plumb, blueberry, peach
	FURNITURE – door, bed, table, desk, clock, chair
	TOOLS – saw, nail, rake, hammer, shovel, brick
	INSECTS – fly, ant, spider, worm, butterfly, caterpillar

Part 2: Please read each item in each category. In the first box, rank order the items from 1 – 6 with two things in mind: (a) how familiar the item would be to a Canadian kindergartener and (b) how strongly related to the category name that the item would be to a Canadian Kindergartner. Use 1 to represent the most familiar and most strongly related item to the category, 2 to represent the next most familiar and strongly related item, and so on until all are ranked. Leave the "Phrases…" box blank for now.

Set 1.1

Rank	**Category: ANIMAL**
	dog
	cat
	bird
	rabbit
	mouse
	duck

Rank	**Phrases to cue recall of the category ANIMAL**
	Things that are alive.
	Things with feet.
	Things with legs.
	Things that breathe.
	Things that are born.
	Things with teeth.
	Things that can sleep.

Set 1.2

Rank	**Category: SCHOOL**
	paper
	paint
	pen
	glue
	crayons
	scissors

Rank	**Phrases to cue recall of the category SCHOOL**
	Things you could use during art class.
	Things you could use for arts and crafts.
	Things you could keep in your desk.
	Things found in your desk.
	Things you could craft with.

Set 1.3

Rank	Category: VEGETABLE
	beans
	corn
	tomatoes
	potatoes
	carrots
	mushroom

Rank	Phrases to cue recall of the category VEGETABLE
	Things someone could eat.
	Things that come from a plant.
	Things that grow from the ground.
	Things you find in a garden.
	Things you need to pick.
	Food you could get from a garden.

Set 1.4

Rank	Category: VEHICLE
	car
	boat
	bus
	truck
	train
	bike

Rank	Phrases to cue recall of the category VEHICLE
	Ways to get around.
	Things with wheels.
	Ways to travel.
	Ways to move around.
	Different kinds of transportation.
	Things you can use to go places.
	Things that go.

Set 1.5

Rank	Category: FAMILY
	dad
	mom
	brother
	uncle
	sister
	grandma

Rank	Phrases to cue recall of the category FAMILY
	People close to you.
	People who are related to you.
	People who could be related to you.
	People who are related to each other.

Set 1.6

Rank	Category: JOBS
	doctor
	teacher
	nurse
	policeman
	dentist
	fireman

Rank	Phrases to cue recall of the category JOBS
	Different kids of work.
	What some people do for work.
	Some things you could be when you grow up.

Set 2.1

Rank	Category: BODY
	back
	head
	face
	hair
	nose
	arm

Rank	Phrases to cue recall of the category BODY
	Parts of ourselves.
	Different parts of us.
	Parts of people.

Set 2.2

Rank	Category: CLOTHES
	hat
	shoes
	coat
	socks
	dress
	pants

Rank	Phrases to cue recall of the category CLOTHES
	Things that can be worn.
	Things that a person could wear.
	Things someone could wear.
	Things to keep you warm.
	Things to use in dress up.
	Things people put on to get dressed.

Set 2.3

Rank	Category: FRUIT
	apples
	orange
	grapes
	plumb
	blueberry
	peach

Rank	Phrases to cue recall of the category FRUIT
	Things someone could eat.
	Things that come from a plant.
	Things that grow on trees.
	Things with seeds.

Set 2.4

Rank	Category: FURNITURE
	door
	bed
	table
	desk
	clock
	chair

Rank	Phrases to cue recall of the category FURNITURE
	Things found in a house.

Set 2.5

Rank	Category: TOOLS
	saw
	nail
	rake
	hammer
	shovel
	brick

Rank	Phrases to cue recall of the category TOOLS
	Things we could use to build something.
	Things to help build something.

Set 2.6

Rank	Category: INSECTS
	fly
	ant
	spider
	worm
	butterfly
	caterpillar

Rank	Phrases to cue recall of the category INSECTS
	Different kinds of bugs.

Part 3: Now please rank order each of the phrases in the box beside the rankings you just completed. Place a 1 beside the phrase that you think would be the best sentence/phrase to cue Kindergartners' recall of the items in the box on the left, a 2 beside the next best sentence/phrase and so on until you have ranked all phrases. If there is a sentence/phrase that you feel would be a better cue and it is not on the list, please write it in.

Part 4: Below are two separate lists of words that could fit into different categories (e.g., animal – dog, cat, horse, etc.). Please read each word in the first column of the table below then indicate any and all categories that that specific word could belong to by circling each appropriate category/categories.

Set 1

Word	Animals	Clothes	Vegetable	Vehicle	Tools	Jobs
teacher	Animals	School	Vegetable	Vehicle	Family	Jobs
potatoes	Animals	School	Vegetable	Vehicle	Family	Jobs
rabbit	Animals	School	Vegetable	Vehicle	Family	Jobs
cat	Animals	School	Vegetable	Vehicle	Family	Jobs
policeman	Animals	School	Vegetable	Vehicle	Family	Jobs
doctor	Animals	School	Vegetable	Vehicle	Family	Jobs
grandma	Animals	School	Vegetable	Vehicle	Family	Jobs
pen	Animals	School	Vegetable	Vehicle	Family	Jobs
bird	Animals	School	Vegetable	Vehicle	Family	Jobs
mouse	Animals	School	Vegetable	Vehicle	Family	Jobs
mom	Animals	School	Vegetable	Vehicle	Family	Jobs
carrots	Animals	School	Vegetable	Vehicle	Family	Jobs
crayons	Animals	School	Vegetable	Vehicle	Family	Jobs
paint	Animals	School	Vegetable	Vehicle	Family	Jobs
tomatoes	Animals	School	Vegetable	Vehicle	Family	Jobs
duck	Animals	School	Vegetable	Vehicle	Family	Jobs
glue	Animals	School	Vegetable	Vehicle	Family	Jobs
brother	Animals	School	Vegetable	Vehicle	Family	Jobs
fireman	Animals	School	Vegetable	Vehicle	Family	Jobs
paper	Animals	School	Vegetable	Vehicle	Family	Jobs
corn	Animals	School	Vegetable	Vehicle	Family	Jobs
bus	Animals	School	Vegetable	Vehicle	Family	Jobs
scissors	Animals	School	Vegetable	Vehicle	Family	Jobs
nurse	Animals	School	Vegetable	Vehicle	Family	Jobs
dentist	Animals	School	Vegetable	Vehicle	Family	Jobs
uncle	Animals	School	Vegetable	Vehicle	Family	Jobs
bike	Animals	School	Vegetable	Vehicle	Family	Jobs
mushroom	Animals	School	Vegetable	Vehicle	Family	Jobs
train	Animals	School	Vegetable	Vehicle	Family	Jobs
car	Animals	School	Vegetable	Vehicle	Family	Jobs
beans	Animals	School	Vegetable	Vehicle	Family	Jobs
dog	Animals	School	Vegetable	Vehicle	Family	Jobs
sister	Animals	School	Vegetable	Vehicle	Family	Jobs
dad	Animals	School	Vegetable	Vehicle	Family	Jobs
truck	Animals	School	Vegetable	Vehicle	Family	Jobs
boat	Animals	School	Vegetable	Vehicle	Family	Jobs

Set 2

Word	Animals	Clothes	Vegetable	Vehicle	Tools	Jobs
ant	Body	Clothes	Fruit	Furniture	Tools	Insects
plumb	Body	Clothes	Fruit	Furniture	Tools	Insects
hair	Body	Clothes	Fruit	Furniture	Tools	Insects
head	Body	Clothes	Fruit	Furniture	Tools	Insects
worm	Body	Clothes	Fruit	Furniture	Tools	Insects
fly	Body	Clothes	Fruit	Furniture	Tools	Insects
brick	Body	Clothes	Fruit	Furniture	Tools	Insects
coat	Body	Clothes	Fruit	Furniture	Tools	Insects
face	Body	Clothes	Fruit	Furniture	Tools	Insects
nose	Body	Clothes	Fruit	Furniture	Tools	Insects
nail	Body	Clothes	Fruit	Furniture	Tools	Insects
blueberry	Body	Clothes	Fruit	Furniture	Tools	Insects
dress	Body	Clothes	Fruit	Furniture	Tools	Insects
shoes	Body	Clothes	Fruit	Furniture	Tools	Insects
grapes	Body	Clothes	Fruit	Furniture	Tools	Insects
arm	Body	Clothes	Fruit	Furniture	Tools	Insects
socks	Body	Clothes	Fruit	Furniture	Tools	Insects
rake	Body	Clothes	Fruit	Furniture	Tools	Insects
caterpillar	Body	Clothes	Fruit	Furniture	Tools	Insects
hat	Body	Clothes	Fruit	Furniture	Tools	Insects
orange	Body	Clothes	Fruit	Furniture	Tools	Insects
table	Body	Clothes	Fruit	Furniture	Tools	Insects
pants	Body	Clothes	Fruit	Furniture	Tools	Insects
spider	Body	Clothes	Fruit	Furniture	Tools	Insects
butterfly	Body	Clothes	Fruit	Furniture	Tools	Insects
hammer	Body	Clothes	Fruit	Furniture	Tools	Insects
chair	Body	Clothes	Fruit	Furniture	Tools	Insects
peach	Body	Clothes	Fruit	Furniture	Tools	Insects
clock	Body	Clothes	Fruit	Furniture	Tools	Insects
door	Body	Clothes	Fruit	Furniture	Tools	Insects
apples	Body	Clothes	Fruit	Furniture	Tools	Insects
back	Body	Clothes	Fruit	Furniture	Tools	Insects
shovel	Body	Clothes	Fruit	Furniture	Tools	Insects
saw	Body	Clothes	Fruit	Furniture	Tools	Insects
desk	Body	Clothes	Fruit	Furniture	Tools	Insects
bed	Body	Clothes	Fruit	Furniture	Tools	Insects

Age:_____ Gender: Male / Female Thank you for your help!

APPENDIX F: IMAGE SELECTION SHEET

Please highlight the number of the picture that you feel would be the best pictorial cue for young kids (kindergarteners). The picture will appear on a card with the written word. The researcher will say the word out loud as the children view the picture. Also note that the pictures will be resized such that they are all the same approximate size on the cards.

Cat

1 2 3 4




5 6


Dog

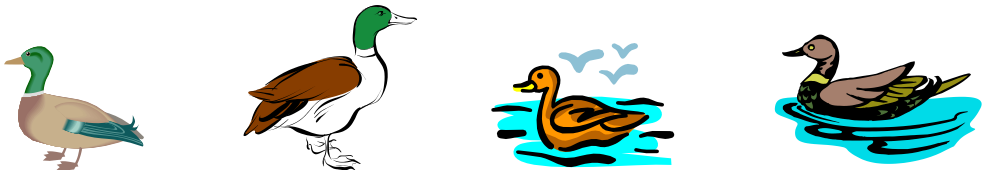
1 2


Bird

1 2


Duck

1 2 3 4



5 6

Pants

1 2 3 4 5

Head

1 2 3

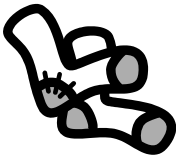
Coat

1 2 3 4 5

Socks

1 2 3 4



Shoes

1 2 3

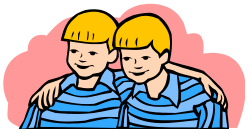


Sister

1

Brother

1



Mom

1

Dad

1 2


Apple

1 2

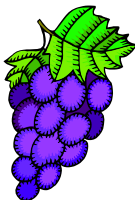

Orange

1 2


Grapes

1 2 3





Blueberry

1 2

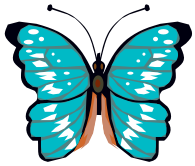

Spider

1

2

Butterfly

1



2

3

4

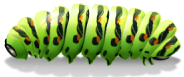
Fly

1

2

Caterpillar

1



2

3

Carrot

1

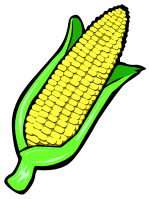
2

3

4

Corn

1



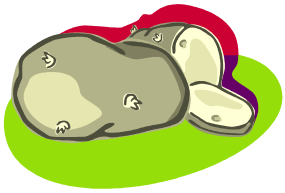
2

Potatoes

1

2

3

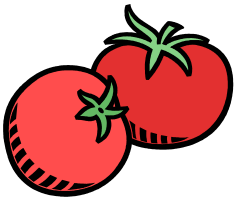


Tomatoes

1

2

3



Car

1

2

3

4

5

6

Truck

1

2

3

4

5

6

Bus

1

2

3

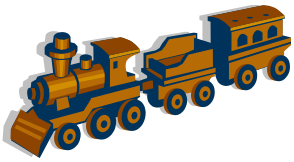
Train

1

2

3

4



Nose

1

Hair

1

2

3

Face

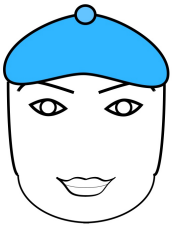
1

2

3

4

5



6

7

8

APPENDIX G: EXPERIMENT 1 SAMPLE DATA SHEET

PID:____ Name:_____ Slideshow Number: 1

Today's Date: _____/_____/_____
Month / Day / Year /

Birthday: _____/_____/_____
Month / Day / Year /

Gender: Male / Female

SET 1

Retrieval-Practice

Fragment	Rp+ T1	Rp+ T2	Rp+ T3	Total Success (Total Correct/12 * 100)
Animals – Do___ (dog)				
Animals – Ca___ (cat)				
Vegetables – Co___ (corn)				
Vegetables – To___ (tomatoes)				

Recall

Cue/Phrase	Clothes		Animals		Vehicles		Vegetables	
Item 1								
Item 2								
Item 3								
Item 4								

Rp+ Count: _____/4 = _____; Rp- Count: _____/4 = _____; NRp Count: _____/8 =_____

SET 2

Retrieval-Practice

Fragment	Rp+ T1	Rp+ T2	Rp+ T3	Total Success (Total Correct/12 * 100)
Fruit – Ap___ (apples)				
Fruit – Or___ (orange)				
Family – Da___ (dad)				
Family – Br___ (brother)				

Recall

Cue/Phrase	People who could be related to you or related to each other.		Different foods or things that someone could eat.		Different kinds of bugs.		Parts of people or parts of ourselves.	
Item 1								
Item 2								
Item 3								
Item 4								

Rp+ Count: _____/4 = _____; Rp- Count: _____/4 = _____; NRp Count: _____/8 =_____

APPENDIX H: EXPERIMENT 1 CHILD ASSENT

Research Supervisor	UNIVERSITY OF SASKATCHEWAN	**Student Researcher**
Tammy A Marche, PhD		Jennifer L Briere, MEd
Phone 966-8314	**Assent Protocol for Children**	Phone 966-8314
Fax 966-8904	**Study Title: Children's Memory for Related Words**	Fax 966-8904
tmarche@stmcollege.ca		jennifer.briere@usask.ca

Would you like to help me with a research project? The project is to see how well kids remember different groups of words. You do not have to do the activity if you do not want to. In this activity, you will be asked to try to remember lists of words that are related to each other. You will be given a chance to practice remembering some of the words. Then we will have a short break and you can play a game on my iPhone. After the break, I will ask you to tell me all the words that you can remember. I will read everything out loud to you and I will write down your answers. If you want to do the activity, you will be able to quit at any time you want. You may ask any questions at any time.

Would you like to do our project? **Yes / No**

I read and explained this Assent Form to the participant before receiving the participant's assent, and the participant had knowledge of its contents and appeared to understand it.

_____	_____	_____
(Name of Participant)	(Researcher's Signature)	(Date)

APPENDIX I: EXPERIMENT 1 PARENTAL DEBRIEFING

Research Supervisor
Tammy A Marche, PhD
Department of Psychology
St. Thomas More College
University of Saskatchewan
Phone 966-8314
Fax 966-8904
tmarche@stmcollege.ca

UNIVERSITY OF SASKATCHEWAN

Student Researcher
Jennifer L Briere, MEd
Department of Psychology
University of Saskatchewan
Phone 966-8314
Fax 966-8904
jennifer.briere@usask.ca

Your child participated in a project called **"Children's Memory for Related Words."**

Your child's participation in this study will help us better understand children's memory, and whether or not selective review of information leads to forgetting of the un-reviewed information. The findings from this research study will inform not only memory researchers, but also other professionals that rely on, or deal with, children's memory, such as parents, legal professionals, educators and therapists/councilors. For example, teachers trying to help children learn information in school will be informed about whether or not practicing some information will increase the chance of forgetting the related, but un-reviewed information. Methods of treatment, counselling and questioning/interrogation styles with children will also be informed by learning about how children remember and forget information and the age at which such forgetting develops. Future research may be aimed at trying to overcome the potential downfalls of selective review with children (e.g., questioning styles that may be resistant to retrieval-induced forgetting), as well as harnessing the potential benefits of selective review (e.g., practicing positive information through questioning or reminiscing that may help reframe negative memories, or lead to forgetting of the negative un-reviewed information).

A copy of the study results will be provided at your request. If you have any questions or concerns about your child's participation in this study, please feel free to contact Dr. Tammy Marche (306-966-8314) or the Office of Research Services as the University of Saskatchewan (306-966-4053).

Thank you for helping us with our project!
Sincerely,

Student Researcher
Jennifer L. Briere
Department of Psychology
University of Saskatchewan

Research Supervisor
Dr. Tammy Marche
Department of Psychology
St. Thomas More College
University of Saskatchewan

APPENDIX J: EXPERIMENT 1 CHILD DEBRIEFING

Research Supervisor
Tammy A Marche, PhD
Phone 966-8314
Fax 966-8904
tmarche@stmcollege.ca

UNIVERSITY OF SASKATCHEWAN

Student Researcher
Jennifer L Briere, MEd
Phone 966-8314
Fax 966-8904
jennifer.briere@usask.ca

Debriefing Form for Children
Study Title: Children's Memory for Related Words

The reason I asked you to remember groups of words was so that I can learn about how kids remember and forget things.

By doing this study, you are helping me to understand more about kids' memory and how they remember and forget things. Sometimes it is easier to remember things that we practice a few times. But sometimes practicing can make us forget other related things. Your help with my project will let me learn about whether or not practice of some things makes young kids forget related things.

If you have any questions about what we did together, please ask your mom or dad to call Dr. Tammy Marche (966-8904). They can also call the Office of Research Services at the University of Saskatchewan (966-4053).

Thank you for taking the time to help me with my project!

APPENDIX K: EXPERIMENT 2 LETTER OF SUPPORT FROM LAURIE SLOCOMBE (WALTER ASELTINE SCHOOL)

The following letter of support from Laurie Slocombe (Walter Aseltine School) accompanied the letter of invitation from the researcher and parental consent form in the recruitment package sent home to each kindergarten student at Walter Aseltine School.

Walter Aseltine School

Box 1117 • Rosetown, Saskatchewan
Canada • S0L 2V0
Phone: 306-882-2644 • Fax: 306-882-2420
www.sunwestsd.ca

March 24, 2014

Dear Parents,

Enclosed you will find a letter and some information from Jennifer Briere (University of Saskatchewan). She would like to conduct a study in our building regarding memory. Tracy Dollanksy (our superintendent) and I have met with Jennifer to discuss this process and we feel it is very beneficial. We hope that you will allow your child to be a part of this by completing and returning the enclosed parental consent form by April 2, 2014.

We would also like to invite you to a meeting on Tuesday, April 1, 2014 from 7:00 – 8:00 p.m. at Walter Aseltine School. At that time, Jennifer will be here to talk more about the study and answer any questions you may have.

We hope that you will allow your child to be part of such an important study as we continue to look for ways to help students learn most effectively.

Thank you.

Educating together,

Laurie Slocombe
Principal

APPENDIX L: EXPERIMENT 2 PARENTAL CONSENT FORM

Research Supervisor
Tammy A Marche, PhD
Department of Psychology
St. Thomas More College
University of Saskatchewan
Phone 966-8076
Fax 966-8904
tmarche@stmcollege.ca

UNIVERSITY OF SASKATCHEWAN

Student Researcher
Jennifer L Briere, MEd
Department of Psychology
University of Saskatchewan
Phone 966-8314
Fax 966-8904
jennifer.briere@usask.ca

Parental Consent Form

Your child is invited to participate in a project called **"Children's Memory for Related Words."** Please read this form carefully and feel free to ask any questions you may have.

Purpose: When trying to learn new information, or when reviewing already learned information, children may experience forgetting of the un-reviewed information. This phenomenon of memory is called *retrieval-induced forgetting* and has been found in a variety of settings with younger and older adults. For example, studying some information leads to better memory for that information when studying for exams, but at the cost of forgetting the related, but non-studied information. Similar results have been found with interrogation or questioning procedures. Memory for parts of eyewitness-like events is enhanced when adults are repeatedly questioned about those events. However, memory for other parts of the events that are not reviewed through questioning are subsequently forgotten.

Although this forgetting has been found in a variety of settings with adults and seems to be a general phenomenon of adults' memory ability, very little research has been done with children, especially very young children. Such research is imperative in order to understand how children remember and forget information, which could have far-reaching implications. Methods of learning, treatment of disorders, counselling, and forensic interrogation styles with children will be informed through this study by learning whether or not selective review leads to forgetting of non-reviewed information and the age at which such forgetting develops. Therefore, the purpose of the current project is to determine whether or not young children (aged 4.5 – 6 years) also demonstrate retrieval-induced forgetting so that researchers and practitioners can begin to learn how such forgetting may impact young children's memory.

Procedure: This study involves a short memory task that should take no longer than 30 minutes to complete. Children will be asked to try and remember groups of words that are related to each other. They will be shown pictures of the words and the researcher will say the words out loud (e.g., "Here are some fruits for you to try and remember – apple, blueberry, banana, and orange," with the researcher pointing to each picture as the words are said out loud). Half of the words from half of the groups will then be reviewed again. On one task, these items will be reviewed by simply re-studying them on screen with the researcher (e.g., "That is a lot of words to remember, so I will help you practice some of them. We'll study them again on the computer."). For the other task, the researcher will say the category name out loud, followed by a hint that consists of the first few sounds of the target word (e.g., "That is a lot of words to remember, so I

will help you practice some of them by giving you a hint to help you remember the word. I will say the name of the group and the starting sound of the word. Your job will be to tell me the full word. Fruit – ban…"). Next, children will take a short break and play an age-appropriate iPhone game called *Jacob's Shapes,* which involves puzzles where the child has to drag and drop shapes into the appropriate place on screen. Once the break is over, children will be asked to tell the researcher all of the words that they remember studying. Children will be asked to either freely report all of the words that they remember (e.g., "Now I'd like you to tell me all the words you remember. I will tell you the group name and you tell me as many of the words or pictures that you remember studying. What 'fruits' do you remember?"), or will be asked whether or not they remember studying each item, as well as some not-studied related items (e.g., "Do you remember studying the Animal – Duck?").

If you have any concerns regarding any of these activities, please feel free to talk to us before consenting to your child's participation.

Potential Risks: There are no risks associated with participating in this project that are beyond those encountered in everyday life.

Potential Benefits: Learning about whether or not young children demonstrate retrieval-induced forgetting will inform not only memory researchers, but also other professionals that deal with children's memory. For example, teachers trying to help children learn information in school will be informed about whether or not practicing some information will increase the chance of forgetting the related, but un-reviewed, information. Future research may be aimed at trying to overcome such potential downfalls of practice with children. Parents, legal professionals and counsellors or therapists will also be able to evaluate whether or not practicing some information through questioning or reminiscing will help reframe negative memories, or lead to forgetting of the un-reviewed information.

Learning whether or not retrieval-induced forgetting influences children's memory will have an impact on a vast number of areas. Also, it is our hope that your child enjoys the challenge, the novel experience, and the opportunity to contribute to science.

Storage of Data: Dr. Tammy Marche will securely store all data and materials used for this project at the University of Saskatchewan. Data and consent forms will be stored separately. All data and materials will be stored for a minimum of five years following publication.

Confidentiality: The information that your child provides will remain completely anonymous and confidential. Your child's name will not be released to any source, nor will it appear on any completed materials. A random numbering system will be used to identify all collected data. Data collected during this project may be published or presented at a future date. However, only aggregate data, not individual scores, will be reported.

Right to Withdraw: Your child may withdraw from the project for any reason, at any time, without penalty of any sort. If your child withdraws from the project at any time, any data that he/she has contributed will be immediately destroyed. The researcher may choose to discontinue a participant's involvement in the project at any time. This would occur if a participant seemed to be experiencing undue discomfort during the project, or if unforeseen circumstances arose that would compromise successful data collection. You and your child's right to withdraw data from

the study will apply until the data have undergone data entry and analysis. After this it is possible that some form of research dissemination will have already occurred and it may not be possible to withdraw the data.

Questions: If you have any questions concerning the project, please feel free to ask at any point; you are also free to contact the researcher or research supervisor at the numbers provided above if you have questions at a later time. This research project has been approved on ethical grounds by the University of Saskatchewan Research Ethics Board on August 6, 2013 (Beh-REB#: 13-266). Any questions regarding your child's rights as a participant may be addressed to that committee through the Research Ethics Office (306-966-2975). Out of town participants may call toll free (888) 966-2975. To request a letter outlining the project results include your mailing address or email address below your signature on this form.

Consent to Participate: I have read and understood the description provided above; I have been provided with an opportunity to ask questions and my questions have been answered satisfactorily.

I consent to allow my child, (*please print child's full name*)
_____, to participate in the project described above, understanding that I may withdraw this consent at any time. A copy of this consent form has been given to me for my records (please provide your mail/email address if you would like to receive a letter detailing the study results).

Child's birthday: _____/_____/_____
Month / Day / Year

_____ _____

(Signature of Parent/Guardian) (Date)

_____

(Signature of Research Assistant)

(Detach from Form if Completed)

Mailing or Email Address

(Please provide your mailing address or e-mail address if you would like to receive a letter detailing the results of the study.)

_____

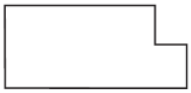
_____

_____

APPENDIX M: EXPERIMENT 2 CHILD ACTIVITY & INFORMATION PAMPHLET

Test Your Memory!

Can you remember what is missing? Fill in the missing parts of the picture that are shown in the inside of this pamphlet!



Help Mommy Dog find her Puppy

If you would like to let your child participate, please return the completed <u>Consent Form</u> to your child's school.

Jennifer L Briere
Department of Psychology
University of Saskatchewan
Phone 966-8314
Fax 966-8904
jennifer.briere@usask.ca

Help Me with My Memory Project!

Do you like to test your memory?

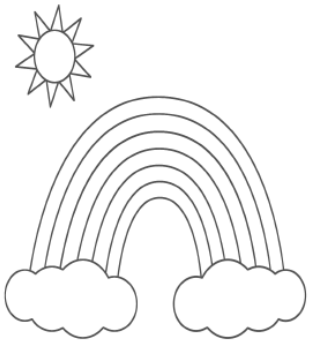
Do you like playing games?

If you do, help me with my memory project!

You will be able to pick a prize for your help!

Test Your Rainbow Memory!

Can you remember all the colors of the rainbow?
If you do, color the picture!



Here's a *hint*: ROY G BIV

<u>Would you like to help me with my project?</u>

<u>We would do a Memory Activity together!</u>

In this activity, you will be asked to try to remember words and pictures that are related to each other.

You will be given a chance to practice remembering some of the words.
I will tell you hints to help you remember.

Then we will have a short break and you can play a game on my iPhone called *Jacob's Shapes*.

After the break, I will ask you to use your memory and tell me all the words that remember studying with me.

Then
<u>PICK A PRIZE</u>
as a Gift of Thanks!

Test Your Memory!

Look at these pictures.
Try to remember what they look like.

Flip over to the next page. Use your memory to fill in the missing parts of the pictures!

APPENDIX N: EXPERIMENT 2 SAMPLE DATA SHEET

PID:_____ Slideshow Number: 2.1

Today's Date: _____/_____/_____ **Birthday:** _____/_____/_____
Month / Day / Year / Month / Day / Year /

Gender: Male / Female

SET 1

Re-Study: Vegetables – Carrots, Vegetables – Potatoes, Clothes – Socks, Clothes - Pants

Recall

Cue/Phrase	Vegetables		Vehicles		Clothes		Animals	
Item 1								
Item 2								
Item 3								
Item 4								

Rp+ Count: _____/4 = _____; Rp- Count: _____/4 = _____; NRp Count: _____/8 =_____

SET 2

Retrieval-Practice

Fragment	Rp+ T1	Rp+ T2	Rp+ T3	Total Success (Total Correct/12 * 100)
Body – No___ (nose)				
Body – Ha___ (hair)				
Family – Br___ (brother)				
Family – Si___ (sister)				

Recognition Test: Let's see how many words you remember! I'll say a word out loud to you. Your job is to listen to the word and decide if you remember studying it on the computer or not. Some words will be words that we studied. Other words will be ones that we didn't study. If you remember studying the word, you can say "Yes." If you don't remember studying the word, you can say "No." If you're not sure if you studied it or not, it's ok to say "I don't know." Everyone remembers differently. There's no good or bad amount to remember.

CL	Item	Old/Yes	New/No		Item	Old/Yes	New/No		Item	Old/Yes	New/No
1N	Caterpillar			9N	Orange			17+	Brother		
2N	Butterfly			10N	Blueberry			18N	Grapes		
3+	Hair			11N	Apples			19L	Lime		
4L	Grandma			12L	Aunty			20L	Tongue		
5N	Spider			13+	Nose			21-	Face		
6L	Banana			14L	Cockroach			22-	Head		
7L	Ladybug			15L	Leg			23-	Dad		
8+	Sister			16N	Fly			24-	Mom		

Rp+ Count: _____/4 = _____; Rp- Count: _____/4 = _____; NRp Count: _____/8 =_____

Lure Count: _____/8 = _____

APPENDIX O: EXPERIMENT 2 CHILD ASSENT

Research Supervisor
Tammy A Marche, PhD
Department of Psychology
St. Thomas More College
University of Saskatchewan
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Fax 966-8904
tmarche@stmcollege.ca

UNIVERSITY OF SASKATCHEWAN

Child Assent Form:
Children's Memory For Related Words

Student Researcher
Jennifer L Briere, MEd
Department of Psychology
University of Saskatchewan
Phone 966-8314
Fax 966-8904
jennifer.briere@usask.ca

Would you like to help me with a research project? The project is to see how well kids remember different groups of words. You do not have to do the activity if you do not want to. In this activity, you will be asked to try to remember lists of words that are related to each other. You will be given a chance to practice remembering some of the words. Then we will have a short break and you can play a game on my iPhone. After the break, I will ask you to tell me all the words that you can remember. I will read everything out loud to you and I will write down your answers. If you want to do the activity, you will be able to quit at any time you want. You may ask any questions at any time.

Would you like to do our project? **Yes / No**

I read and explained this Assent Form to the participant before receiving the participant's assent, and the participant had knowledge of its contents and appeared to understand it.

_____	_____	_____
(Name of Participant)	(Researcher's Signature)	(Date)

APPENDIX P: EXPERIMENT 2 PARENTAL DEBRIEFING

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UNIVERSITY OF SASKATCHEWAN

Student Researcher
Jennifer L Briere, MEd
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Phone 966-8314
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Debriefing Form for Parents/Guardians

Your child participated in a project called **"Children's Memory for Related Words."**

Your child's participation in this study will help us better understand children's memory, and whether or not selective review of information leads to forgetting of the un-reviewed information. The findings from this research study will inform not only memory researchers, but also other professionals that rely on, or deal with, children's memory, such as parents, legal professionals, educators and therapists/councilors. For example, teachers trying to help children learn information in school will be informed about whether or not practicing some information will increase the chance of forgetting the related, but un-reviewed information. Methods of treatment, counselling and questioning/interrogation styles with children will also be informed by learning about how children remember and forget information and the age at which such forgetting develops. Future research may be aimed at trying to overcome the potential downfalls of selective review with children (e.g., questioning styles that may be resistant to retrieval-induced forgetting), as well as harnessing the potential benefits of selective review (e.g., practicing positive information through questioning or reminiscing that may help reframe negative memories, or lead to forgetting of the negative un-reviewed information).

A copy of the study results will be provided at your request. If you have any questions or concerns about your child's participation in this study, please feel free to contact Dr. Tammy Marche (306-966-8314) or the Office of Research Services as the University of Saskatchewan (306-966-4053).

Thank you for helping us with our project!

Sincerely,

Student Researcher
Jennifer L. Briere
Department of Psychology
University of Saskatchewan
jennifer.briere@usask.ca
Phone 306-966-8314

Research Supervisor
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APPENDIX Q: EXPERIMENT 2 CHILD DEBRIEFING

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UNIVERSITY OF SASKATCHEWAN

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Debriefing Form for Participants

Thank you for taking the time to help me with my project!

The reason I asked you to remember groups of words was so that I can learn about how kids remember and forget things.

By doing this study, you are helping me to understand more about kids' memory and how they remember and forget things. Sometimes it is easier to remember things that we practice a few times. But sometimes practicing can make us forget other related things. Your help with my project will let me learn about whether or not practice of some things makes young kids forget related things.

If you have any questions about what we did together, please ask your mom or dad to call Dr. Tammy Marche (966-8076). They can also call the Office of Research Services at the University of Saskatchewan (966-4053).

Thank you for taking the time to help me with my project!