DOES RIF KEEP THE DOCTOR AWAY? EVALUATING HEALTH-RELEVANT COGNITIVE BIASES VIA RETRIEVAL–INDUCED FORGETTING

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Abstract

Retrieval-Induced Forgetting (RIF) is a cognitive paradigm demonstrating that engagement in retrieval processes can lead to subsequent forgetting of competing information. Across two experiments we evaluated whether those with self-reported health anxiety exhibit impaired memory control for health-related material. In the initial phase, participants studied category-word pairs (e.g., HEART-break), after which they practiced retrieving half of the targets from half of the categories using a word-stem (e.g., HEART-br). Finally, they were asked to recall the target words associated with each category. In Experiment 1 (E1), a reduced RIF effect (i.e., worse memory for unpracticed items from practiced categories compared to unpracticed categories) was observed for health-related (e.g., HEART-blockage) word pairs compared to neutral (e.g., CARD-letter) word pairs, but this difference was not statistically significant. Likewise, Experiment 2 (E2) failed to observe a significant difference in the RIF effect between health-related and neutral word pairs, despite the inclusion of a supervised tasked and improved stimulus set. The RIF effect did not significantly correlate with scores from a validated measure of health anxiety in either E1 or E2. Therefore, our hypotheses were not supported. Potential explanations for these conflicting results are discussed, and future directions are provided.

Keywords: retrieval–induced forgetting, memory, anxiety disorders, health anxiety, cognition

General Summary

We often forget unwanted information – both intentionally and unintentionally. However, individuals vary in their ability to do this, as some information may be easy to forget about compared to other information. Interestingly, trying to think of one memory often leads to forgetting another related memory, a phenomenon known as retrieval-induced forgetting. Across two experiments, it was evaluated whether health-related information is harder to forget compared to neutral information and additionally, if this potential difficulty is pronounced in populations who report elevated health anxiety. Experiment 1 was completed online and unsupervised, with participants completing a standard retrieval-induced forgetting paradigm utilizing health-related and neutral word-pairs. In Experiment 2, the task included improved word pairs and video conference supervision. The current results suggest that those reporting low-moderate levels of health anxiety do not appear to demonstrate differential forgetting of health-related or neutral information. This is detailed in the following text.

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Chapter 1: Does 'RIF' Keep the Doctor Away? Evaluating Health Relevant Cognitive Biases via Retrieval–Induced Forgetting

Daily functioning, goal direction, and task completion all require the encoding, storage, and retrieval of relevant information to succeed (McDermott & Roediger, 2018; Melton, 1963). At any given moment, large quantities of information are encoded, combined and abstracted to form long-term memory representations (Craik, 1983; Glenberg, 1997). However, when retrieving information, we typically look to access only a small portion of what was encoded. For example, whereas it is unlikely we would wish to retrieve the entirety of a family vacation to Disneyland all at once, there are many cases in which we would wish to retrieve specific details – such as what was ordered for supper on the first night of the trip. Although, this could prove to be difficult, as the associative nature of memory may lead you to become perplexed and instead recall what was served for supper on the following nights. This example demonstrates that competing information may interfere with the attempt to recall specific information and could lead to a misrepresentation of the memory, or to recalling a similar but unintended memory. Hence, it has been suggested by previous and current research that forgetting can be beneficial in reducing cognitive failure or strain, and increasing cognitive control (Anderson et al., 1994; Bjork, 1970; Fawcett & Hulbert, 2020; Kuhl et al., 2007; Murphy & Castel, 2021; Nørby, 2015).

Nonetheless, being classified as 'forgetful' continues to be viewed negatively. This is because, much like misplacing an important file on your computer, misplacing a memory can feel self-destructive and distressing. One may strive for a more efficient encoding process as a solution; however as hinted above, forgetting may be (at times), more effective by mitigating irrelevant or invalid information that might otherwise interfere with efficient retrieval (Johnson, 1994). For example, remembering your old phone number will not be helpful if you are asked to recall your new phone number. You may also accidently interchange some of the numbers within the sequence during recall. Thus, the inability to forget or reject old information could result in a variety of memory errors (Johnson, 1994). Importantly, forgetting – particularly when enacted intentionally – also provides a protective function: exerting control over unwanted or even aversive memories allows one to maintain emotional regulation and promote subjective well–being (Nørby, 2015). However, not everyone is equally good at controlling memories, and not all memories are equally controllable. When memory control fails, the results can be catastrophic, resulting in relentless thoughts that have the potential of developing into a mental disorder such as post–traumatic stress disorder (PTSD), obsessive–compulsive disorder (OCD), depression, and generalized anxiety disorder (GAD), to name a few (The *Diagnostic and Statistical Manual of Mental Disorders* 5th ed.; DSM–5; American Psychiatric Association, 2013). The typical finding within laboratory research is that participants with such disorders have insufficient memory control abilities compared to healthy populations, reflecting a laboratory analog of their respective conditions (see Delaney et al., 2020; Pevie et al., 2022; Stramaccia et al., 2020).

Whereas much work has been done quantifying control deficits in clinical populations, these studies have often focused on disorders typically characterized by an inability to control unwanted thoughts (e.g., PTSD and OCD; see Cloitre, 2013; Costanzi et al., 2021; Konishi et al., 2011), analyzed with paradigms that focused on either general cognitive biases (e.g., attentional biases, distorted judgment of risk, and selective memory processing) towards threatening information (Craske & Pontillo, 2001; Hallion & Ruscio, 2011; Kircanski et al., 2016) or measuring the explicit control of encoding (e.g., item–method directed forgetting; MacLeod, 1975) and retrieval (e.g., think/no-think; Anderson & Green, 2001). With this in mind, the present study is primarily concerned with understanding the role of memory control within health-anxious populations, measured using a paradigm focusing on the *unintentional* consequences of retrieval – known as the retrieval-induced forgetting (RIF) paradigm. Specifically, the current study will evaluate whether participants reporting health anxiety will exhibit control deficits specific to health-relevant materials (e.g., NEEDLE–Inject). Hence, the present thesis aspires to extend upon previous findings relating anxiety to memory control deficits, with the goal of determining whether similar deficits are observed in health-anxious populations when exerting control over neutral or health-relevant information. However, prior to engaging in a discussion of RIF or health anxiety, it is important to understand the role of forgetting in cognition, the manner in which forgetting is enacted, and the ways in which it is measured in the laboratory.

1.1 What is "Intentional Forgetting" and How is it Measured?

Forgetting – when enacted intentionally – often operates to the benefit of memory; for example, the ability to remove an outdated phone number from mind facilitates retrieval of the correct number. However, there are many ways in which forgetting may be enacted, differing in terms of when and how the control processes are engaged with during the time of presentation. For example, whereas some forms of forgetting act to control encoding, others instead serve to prevent unwanted retrieval. This has given rise to a variety of paradigms used to study forgetting in different ways, often converging on a common finding: enacting control over a memory reduces the ability to retrieve that memory later on. Several of the more prominent techniques are summarized below prior to describing retrieval–induced forgetting, which shall then become the focus of the remaining thesis.

1.1.1 Item-and List-Method Directed Forgetting

Directed forgetting (DF) is one of the earliest laboratory techniques developed to study our ability to control unwanted memories (e.g., Bjork et al., 1968; MacLeod, 1975; Muther, 1965). Within a directed forgetting paradigm, participants learn information that is cued as either ‘to be remembered’ (R–cue items) or ‘to be forgotten’ (F–cue items); although memory is often tested for *all* items regardless of the instruction (Johnson, 1994; MacLeod, 1998). The typical trend, referred to as a directed forgetting effect (DFE), is that participants will remember more R–cue than F–cue items on the subsequent memory test; this phenomenon cannot be explained by demand characteristics (MacLeod, 1999). At least two major variants of this paradigm emerged over time, differing largely with respect to whether the memory instructions were presented following each item or following completion of a list. They were initially thought to be interchangeable; however, it soon became apparent that the commonly named item-method and list-method directed forgetting tasks had different underlying theoretical explanations, each of which are summarized below (for a more detailed discussion of the directed forgetting paradigm, see Golding, 2005).

1.1.1.1 Item-Method DF

An item-method directed forgetting (IMDF) task presents stimuli to participants one at a time, with each stimulus followed by an instruction to “remember” or “forget” (e.g., “RRRR” or “FFFF”) that item. As explained above, participants are later tested for *all* items – and in this case the directed forgetting effect is defined as better memory for the R–cued items than the F–cued items, as observed using either recall and/or recognition tasks. With respect to the cognitive mechanisms involved, it is generally accepted that participants initially engage in maintenance rehearsal of the word (e.g., repeating it in their head) until the instruction is provided (Craik &

Lockart, 1972). Whereas following an R–cue, participants engage in further elaborative rehearsal (e.g., making a story with the words) to ensure retention of the item, following an F–cue they instead remove the item from mind, avoiding further processing (Johnson, 1994). However, there is less agreement with respect to how the F–cue items are removed from mind, or the consequences of doing so. This has resulted in two dominant theoretical accounts that primarily differ with respect to how participants exert control over the F–cue items.

For example, according to the selective rehearsal account, the directed forgetting effect emerges due to the selective rehearsal of R–cue items and the passive exclusion of F–cue items. Specifically, according to this account participants do not engage in any particular control process following an F–cue, but rather allow the study item to decay from thought, possibly replacing it with something else – such as the rehearsal of R–cue items (Bjork 1972; MacLeod, 1975). Historically, this has been known as the dominant theoretical account within this paradigm, although not all of the findings have been supportive; as further elaborated in the following paragraphs, evidence began to emerge that forgetting may involve one or more *active* processes (Fawcett & Taylor 2008; Taylor, 2005; Zacks et al., 1996).

One alternative account that proposed a more active process is known as the attentional inhibition account (Zacks & Hasher, 1997; Zacks et al., 1996). This account claimed that participants engaged in an inhibitory mechanism following each F–cue to push both the unwanted item from mind and suppress the representation in long-term memory, reserving cognitive resources for the rehearsal of R–cue items. These claims were initially supported by the finding that – relative to younger adults – older adults: (a) produced more F–cue items during a recall task, (b) had slower response times when deciding to reject F–cue items during a recognition task, and (c) had better recognition memory of F–cue items when testing was delayed (Zacks et al., 1996). These results were explained with reference to inhibitory deficits thought to emerge in older adults, resulting in impaired control over the F–cued items (Hasher et al., 1991; Stoltzfus et al., 1993).

Although not specifically supporting *inhibition* as the underlying cause, later evidence for an active mechanism arose from the fact that an F–cue slows subsequent responses (Fawcett & Taylor, 2008). For example, Fawcett and Taylor (2008) integrated visual probes into the study phase of an item-method directed forgetting task at several intervals (i.e., 1,400, 1,800, or 2,600 *msec*) following onset of the memory instruction, to which participants made a speeded response. They reasoned that if forgetting were a passive process, responses should be *faster* following F–cues than R-cues; however, they observed *slower* responses following the F–cue compared to the R–cue items, implying that forgetting is more cognitively demanding than remembering. This finding has since been replicated (e.g., Fawcett et al., 2016), and even shown to exist on the initial study phase trial, where there are no prior R–cue items to rehearse (Fawcett et al., 2013). As to the probable nature of this cognitively demanding process, later studies found an F–cue to also interact with attentional orienting in an inhibition of return task (Taylor, 2005). Whereas these findings are incongruent with previous accounts that view forgetting as a passive process, they may implicate some mechanism involved in actively orienting attention away from unwanted information following an F–cue.

In support of these behavioral findings, neural studies have likewise supported a role for an active process as demonstrated by the engagement of frontal control regions during F–cue trials (see Anderson & Hanslmayr, 2014 for a review). For example, Wylie et al. (2008) used functional magnetic resonance imagining (fMRI) to compare the brain areas associated with *intentional* forgetting (i.e., a forgotten F–cued item) to those associated with *unintentional* forgetting (i.e., a forgotten R–cued item) at encoding. They hypothesized that if intentional forgetting is a *passive* process, equivalent to unintentional forgetting, these conditions would not differ from one another. Countering this hypothesis, they further found that intentional (i.e., as opposed to unintentional) forgetting was associated with greater activity in brain regions thought to be associated with cognitive control (e.g., inferior frontal gyrus, superior frontal gyrus; for further evidence, see Banich & Depue, 2015; Rizio & Dennis, 2013; for a review, see Anderson & Hulbert, 2021). Thus, strong evidence exists in support of an *active* process underlying IMDF. Although, an intriguing idea to be further explored is that both processes (i.e., passive and active) may work concurrently to give rise to IMDF (see Fellner et al., 2020).

1.1.1.2 List-Method DF

Whereas item-method directed forgetting presents participants with memory instructions following each item, list-method directed forgetting (i.e., LMDF) instead presents participants with a memory instruction following a *list* of items. Specifically, participants are presented with a series of items (i.e., List 1) that they are initially asked to remember, following which they receive one of two instructions: Participants in the remember group are simply presented with a second list and asked to remember those items too; however, participants in the forget group are instead given a single forget instruction. This is often in the form of an excuse such as “I gave you the wrong list, please forget about the first list and study this new one.” Regardless of the instruction group, all participants are then presented with the second list (i.e., List 2) and are asked to remember it. In this manner, both groups are identical, except that one has been told to forget the initial list and the other has not. As with item-method directed forgetting, participants are later tested for *all* items, with a directed forgetting effect defined as better memory for List 1 in the remember compared to forget condition (i.e., the *costs* of directing forgetting); this finding is often accompanied by better memory for List 2 in the forget compared to remember condition (i.e., the *benefits* of directed forgetting). However, unlike the IMDF effect, the LMDF effect is often only observed for recall (i.e., as opposed to recognition) memory – and becomes eliminated if a recognition task precedes the recall task (Basden et al., 1993; MacLeod, 1999).

Historically, the dominant account of the list-method directed forgetting effect has been that of retrieval inhibition (Bjork et al., 1989; Geiselman et al., 1983). According to this account, participants who are given the forget instruction will inhibit the items from the first list to facilitate the encoding and retrieval of the second list. This account was favored, as it has the ability to explain why inclusion of a recognition task could eliminate directed forgetting as measured by recall: The idea is that re-presentation of the studied items prompts a "release" from inhibition, re-activating those items in such a manner that the entire encoding episode becomes accessible once more (Basden et al., 1993; Sego et al., 2006). This also explains why the effect is often observed when recall testing is used, as a recognition task would inherently undo the effects of inhibition. Further experimental support for this account arises from the fact that list–method directed forgetting appeared to impact the entirety of the encoding episode, including incidentally learnt items (Geiselman et al., 1983). That is, participants showed directed forgetting of information they had not attempted to learn, suggesting that the entire list (i.e., including incidental elements) had been inhibited in memory.

However, more recent theorists have challenged the retrieval-inhibition account, based on the fact that an instruction to forget is not necessary to produce this effect, and instead argued that it could be explained with reference to a change in mental context. Specifically, Sahakyan and Kelley (2002) hypothesized that a list-method instruction to forget will evoke an internal shift in mental context, making the initial list more difficult to access at test. This is because the test phase context would become increasingly similar to that of the second list (and dissimilar to the initial list; Block & Reed, 1978; Mulji & Bodner, 2010; Sahakyan & Kelley, 2002; Sahakyan et al., 2013). To demonstrate this, they modified the typical list-method paradigm to encourage one group of participants to alter their mental context before studying the second list: This was achieved by asking the relevant participants to imagine they were invisible before being further assigned to the "forget" or "remember" conditions following the first list (Sahakyan & Kelley, 2002). The key finding demonstrated that memory for 'context manipulated participants' in the 'Remember' condition approximated the 'Forget' condition – with lower performance than participants *without* the context manipulation (Sahakyan & Kelley, 2002); additionally it was found that when the initial list context was reinstated, participants had better recall memory than when it is not, eliminating the DFE. Thus, contextual change appears to be a plausible theoretical explanation of list–method DF.

1.1.2 The Think/No-Think Paradigm

The above discussion highlights how the directed forgetting paradigm is used to study the intentional control of unwanted memories at the time of encoding; however, the Think/No-Think (TNT) paradigm is instead used to study the mechanisms and consequences involved in controlling unwanted retrieval when presented with a reminder. Specifically, Anderson and Green (2001) developed the TNT paradigm as an in-laboratory analog of the control processes common to retrieving a traumatic memory, intended to quantify the suppression of memories that participants do *not* want to think about but tend to come to mind uninvited, similarly to flashbacks in PTSD.

In a typical TNT paradigm, participants first study a list of cue-target pairs (e.g., Mitten–Ant, Dog–Chair). Once they are able to reliably (e.g., at least 50% of the time) recall the target

(Ant) when presented with the cue (Mitten), they are then presented with a subset of cues (e.g., Mitten) for which they practice either thinking about the associated target (i.e., Ant; think–trials), or preventing it from coming to mind; while attempting to actively remove it from mind if they do think of it (no–think trials). The final memory test consists of presenting cues for all targets, including both the think and no–think items, as well as baseline items that are not originally included in the think/no–think phase. The typical finding, referred to as suppression-induced forgetting (SIF), occurs when participants exhibit worse memory for the no–think items than the baseline items. This final test is most often conducted using the original cues from the initial learning phase (e.g., Mitten–?). However, using this same probe test has been criticized, as the observed results could be explained by a weakening of the association among the target-cue pairings or interference arising from other associated material retrieved during the "no–think" trials as a distraction. To note, this criticism has been countered by Anderson and Green (2001) who observed the same pattern using independent probes, whereby targets were tested via cues that were not presented during the preceding phases (e.g., Insects–A); this finding was interpreted as direct evidence that retrieval suppression acts on the target representation in memory directly (see also, Anderson & Hanslymayr, 2014).

Despite strong evidence favoring the role of suppression in this paradigm, some believe it is best explained via interference. In this context, interference refers to the phenomenon in which the learning of alternative information results in forgetting of the original memory (Racsmány et al., 2011; Tomlinson et al., 2009). According to this account, on no–think trials, participants may bring alternative thoughts or memories to mind in order to avoid thinking of the unwanted target. For example, while attempting to forget 'Ant', when presented with 'Mitten', participants may begin thinking of a winter hat. However, this may lead participants to associate the new item with the original cue. Thus, when shown the cue (e.g., Mitten) at test, the participant may inadvertently retrieve the alternative item (e.g., Hat) as opposed to the target item (e.g., Ant; see Racsmány et al., 2011). Ultimately, according to this account, the participant is blocking their ability to retrieve the target item later, by allocating attention to a novel item in an attempt to avoid retrieval. Thus, suppression of the target (i.e., at least in a mechanistic sense) is not necessary to explain SIF according to this perspective. However, as noted earlier, it remains unclear how interference may explain the emergence of SIF when independent probes are used at test.

1.1.3 Retrieval-Induced Forgetting (RIF) Paradigm

While the previously discussed directed forgetting and think/no–think paradigms generally involve the *intentional* control of encoding or retrieval, the present thesis will focus on the retrieval–induced forgetting paradigm – demonstrating how adaptive forgetting can also emerge *unintentionally* as a result of retrieval. Specifically, Retrieval–Induced Forgetting (RIF) is a memory phenomenon in which the retrieval of "practiced" information induces the forgetting of competing "unpracticed" information (Anderson et al., 1994; Anderson et al., 2000; Storm et al., 2006; see Murayama et al., 2014 for a review). While this can be achieved intentionally, it is best conceptualized as an *unintentional* consequence that may follow the retrieval of a memory in which associated information is present, such that biased competition may occur in favor of target memories at the time of retrieval.

In a typical RIF paradigm, participants are first presented with a study list, displaying a series of 'category–target' word pairs (e.g., FRUIT–banana, ANIMAL–monkey) that have multiple targets per category (e.g., FRUIT-banana, FRUIT-apple). During the first phase (i.e., study phase), participants are shown every word pair from the list. They then undergo a retrieval–practice phase in which they are presented with only half of the category–target word pairs (i.e., Retrieval–Practice [Rp] items) from half of the categories. Furthermore, half of the items from the practiced categories are retrieved (+; i.e., FRUIT–banana) with the remainder being unpracticed (–; i.e., FRUIT–apple). This results in three conditions: Practiced items from practiced categories (Rp+), unpracticed items from practiced categories (Rp–), and unpracticed items from unpracticed categories (Nrp). Regardless of item type (i.e., Rp/Nrp) participants are finally asked to recall all the target words they can remember (e.g., monkey, banana) from each category presented to them during the study phase (e.g., ANIMAL, FRUIT).

The primary effect of interest in this paradigm, known as the RIF effect, is below baseline (i.e., Nrp) memory for Rp– items, although it is also typical to observe above baseline memory for Rp+ items. For example, Anderson et al. (1994) implemented the first RIF paradigm, demonstrating that the repeated retrieval of certain category members (e.g., FRUIT–banana), resulted in lower recall performance of other category members (e.g., FRUIT–apple) on a subsequent memory test. It is generally believed that during retrieval practice, competing information intrudes into conscious awareness (e.g., thinking of apples when retrieving 'banana'), interfering with the activation of the desired, target information. To mitigate this interference, the competing memory is (often unintentionally) suppressed, resulting in worse memory for that item at test. This perspective argues (i.e., similarly to SIF effect in TNT) that the representation of the competing items is inhibited, making it increasingly difficult to re–activate or retrieve. Hence, items strongly associated with the retrieval cue (e.g., 'apple' in the case of FRUIT) are thought to be the ones most negatively affected in this manner, as they are more likely to compete, and therefore engage control processes (Anderson et al., 1994).

Overall, it is thought that this paradigm exemplifies how related items utilize similar cognitive resources to recall relevant information, and that by using a shared cognitive resource to retrieve one aspect of the target information, other competing information is forgotten (Aslan & Bäuml, 2011). Since the Nrp items are unrelated to the practiced (Rp) categories, they are never activated during the retrieval practice phase, do not compete for cognitive resources, and therefore reflect baseline memory performance (Anderson et al., 1994). As most work in this area has provided support that the underlying mechanism involved in the RIF effect is inhibition, the focus of the current literature will be on reviewing that theoretical perspective. However, a modern alternative and fairly recent proposal, known as the contextual account (Jonker et al., 2015; Murayama et al., 2014 for a brief review of current theories) will also be reviewed.

1.1.3.1 The Inhibition Account

The earliest framework proposed to explain retrieval-induced forgetting encompasses an inhibitory process serving to suppress competitors during retrieval practice (Anderson et al., 2000; Anderson 2003; Storm & Levy, 2012; Storm et al., 2006; Weller et al., 2013; Veling & Knippenberg, 2004). Here, memory inhibition refers to any voluntary or involuntary process that serves to restrain access to learnt information through the downregulation of the cognitive or neural representation of that information in memory (Dempster, 1995). In this case, inhibition is thought to be elicited during the retrieval practice (Rp) phase to downregulate the activation of competitors during the processing of a retrieval cue (e.g., FRUIT–ba_ intended to activate retrieval of "banana" but also activating "apple"). As participants repeatedly practice retrieving certain items (e.g., FRUIT–ap_), but not others that had been learnt in the preceding phase (e.g., banana), those competing, unpracticed items become increasingly inhibited through the repeated application of this suppressive process. When the participant is able to successfully inhibit the competing items during retrieval practice, those items are thought to become less accessible at final test as well, resulting in the RIF effect (Anderson et al., 1994; Bjork, 1989).

According to this account, the RIF effect is considered to be competition dependent, which is to say that it only occurs when unpracticed (RP–; e.g., blueberry) items compete with practiced items that are retrieved (Rp+; e.g., strawberry) during the retrieval practice phase (Murayama et al., 2014). It is this competition that leads to either inhibition of the competing item and retrieval of the correct item or failing to inhibit the competing item and retrieving the incorrect item (or potentially failing to output retrieval at all). One important implication of this claim is that items that are either too strongly associated with the cue (e.g., FRUIT-Apple) or too weakly associated with the cue (e.g., FRUIT-Goji), may not exhibit a RIF effect when used as Rp– items.

Supporting the critical role of retrieval competition, early research (e.g., Anderson et al., 2000) demonstrated that RIF only emerges in cases where participants actively recall information (e.g., not during re–study; e.g., retrieval specificity, as discussed by Murayama et al., 2014). Further, studies conducted by Storm and colleagues continuously found that it is the *process* of a retrieval attempt and not the *product* of a retrieval attempt that induces the forgetting of competing information (Storm & Levy. 2012; Storm et al., 2006; Storm et al., 2011). For example, in one study they used a modified RIF task that included cues to induce the generation of related exemplars that were not presented in the study phase, or attempted to make retrieval impossible, by presenting a stem word that did not represent the initial letters of any exemplar associated with the presented category (Storm et al., 2006). Regardless of if the retrieval attempt was successful, or not, a significant RIF effect was observed. By using this modified task, the researchers were able to demonstrate that the level of competition does not necessarily determine if the retrieval practice will succeed or fail, but instead determines if related information is forgotten.

Although, perhaps the strongest support for the inhibitory account derives from research demonstrating that RIF is a cue-independent effect – meaning that the effect emerges even when participants are cued at test with categories or words that were not presented at initial learning (e.g., MONKEY–ba in place of FRUIT–ba; Anderson, 2003). Furthermore, support for non-inhibitory accounts have no basis to predict an effect on items that are cued by using anything other than the original categories or cues, therefore, using a new cue or category to elicit the target – should not result in a memory deficit for the Rp– items. However, despite strong support that inhibition underlies the RIF effect, not all theorists agree and some instead attribute this phenomenon to differences in the context between study and test.

1.1.3.2 The Context Account

According to the context account, observing RIF is attributable to retrieval cues at test, leading participants to retrieve Rp+ and Rp– items from the retrieval–practice context (i.e., where only Rp+ items were present) and NRp items from the learning phase context – preferentially disadvantaging the recall of the Rp– items (i.e., which are absent from the former). In this regard, this account makes two key assumptions: First, a context shift *must* occur between the learning and RP phases. Second, the cues provided during the test phase must differentially activate the learning and retrieval phase contexts (Jonker et al., 2013). According to the inhibition–account, RIF does not occur with an extra study phase, as engagement in extra study does not allow for retrieval competition between the related targets (Anderson et al., 2000). However, Jonker et al. (2013) observed that a RIF–like effect did occur with an extra study phase, when a context change between the study phase and extra phase was present. This provided evidence that internal context may be important for observing a RIF effect.

This account was further supported by Jonker et al. (2015), in which they implemented a RIF paradigm that used short video clips of everyday contexts (e.g., windmill, trees, elevator) during the presentation of the category–exemplar pairs. For example, showing “FRUIT–or_” with a video of a park in comparison to seeing “FRUIT–or_” with a video of a windmill. This allowed a direct manipulation of the study context. This context was reinstated for some participants but not others at test. The research team hypothesized that a RIF effect would be present for participants receiving the context–related videos but would be absent for participants being shown non–context related videos. The results confirmed these hypotheses, leading to the conclusion that mismatching context between study and test is an important component of the RIF effect (Jonker et al., 2015).

While these findings appear to provide evidence in favor of a context–account, more recent research has demonstrated that while RIF may involve shifts of internal context at times, it is not dependent upon them (Buchli et al., 2016; Soares et al., 2016). In particular, claims supporting the context–account have been tested by multiple independent research teams and failed to replicate. For example, in their first experiment, Soares et al. (2016) tested the assumption that the RIF effect is reliant on a context shift between the Rp phase and test phase, observing no significant reduction of RIF performance when participants had a degraded context–shift (e.g., generate condition; context is disrupted) compared to a control group (e.g., typical RIF; context remains intact). Similarly, in their second experiment, the assumption that context differences among the three phases (i.e., study, retrieval–practice, test) would affect RIF, was tested. This was achieved by creating matched contexts (e.g., Learning/Retrieval phase context match) or mismatched contexts (e.g., Learning/Retrieval phase context mismatch) to potentially observe a significant RIF effect when the phases have matched contexts, but not when they are mismatched, supporting the claims made for this account. However, there was no significant difference observed in RIF performance. Hence, RIF does not appear to be dependent on context, and the results claim to support the inhibition account of RIF proposed by Anderson (2003).

As a result of the failed replication attempts described above, the context account does not appear to be as pertinent, with inhibition remaining as the prominent theoretical perspective. Although, individual differences in retrieval inhibition abilities have been highlighted by past and present research as factors that may influence the observations documented when using the RIF paradigm. The findings and conclusions from this research are explained below.

1.1.4 Variation of Retrieval–Processes and Inhibition within RIF

Regardless of the theoretical mechanisms underlying the RIF effect, as with any research procedure, the magnitude of this phenomenon has been shown to vary broadly based on a variety of situational factors. While some of these factors reflect methodological variation controlled by the experimenter themselves (e.g., stimuli type), others reflect individual differences that cannot be directly manipulated (e.g., age). For example, age has been studied in the past, resulting in claims that inhibitory control develops throughout childhood and diminishes over late adulthood (Williams et al., 1999); as a result; if the RIF effect emerges as a mechanism of inhibition, it should likewise vary across the lifespan. However, the impact of age has been inconsistent. Initial evidence reported age to have no significant impact on RIF, shown with both older adults (i.e., participants between the ages of 17–88 years old; Gomez–Ariza et al., 2009), and younger children (i.e., 7–years old; Ford et al., 2010; see also Aslan & Bäuml, 2010; kindergarteners, second graders) in comparison to younger adults (e.g., 21-years old; Ford et al., 2010). However, more recent evidence has found age-related impairments for the RIF effect to occur amongst elderly populations, such that RIF is diminished in ‘old’ (60-65 years) participants and absent in ‘very old’ (over 75 years) participants, as compared to younger participants (Aslan & Bäuml, 2012). This observation counters the previous evidence (i.e., Gomez-Ariza et al., 2009), and taken in combination with the evidence provided by Ford et al. (2010), demonstrates that RIF may begin to vary as one becomes elderly (i.e., ~ 60-90 years), as children and young adults do not appear to show difficulty with the paradigm. Thus, the degree to which the RIF effect varies with age, remains unclear.

Beyond age, a second common individual difference explored in this area is working memory capacity (WMC), which has been observed as a potential variable that impacts RIF performance. Firstly, it has been proposed that working memory (WM) is a cognitive tool useful for keeping information readily available for use by the individual at once. For example, it has been proposed that the typical WMC when using the method of ‘chunking’ is ‘seven plus or minus two chunks’ (Miller, 1956) – thus once exceeding five-to-nine chunks, the WMC will become ‘full’. Once ‘full’, the individual may be unable to store more information, and hence may engage in a method of removal, such as cognitive offloading (Ball et al., 2022). Therefore, it is proposed that individuals with a higher WMC may be more successful at some cognitive tasks than those with lower WMC, as the ability to actively hold information (e.g., holding nine chunks versus four chunks) can be predictive of performance (Ricker et al., 2010). Linking this concept to RIF, Aslan and Bäuml (2011) had participants complete a German version of the operation span task (OSPAN; for explanation see Engle, 2001), in which they were asked to solve arithmetic problems while trying to remember unrelated words (e.g., (8 / 4) + 3 = 5? *moon*) following the completion of a RIF task. It was observed that individuals with a high–WMC (i.e., those able to retain more words despite the working memory load) also reported significantly greater RIF than those with a low–WMC. This finding was subsequently replicated (see Storm & Bui, 2015). Although, it is important to highlight that at least one study failed to replicate these results, observing the opposite trend (i.e., individuals with high–WMC demonstrated significantly worse RIF compared to those with low–WMC; Mall & Morey, 2013), leading to some dispute in the area (resolved by Storm & Bui, 2015 via their replication). However, the findings of Mall and Morey (2013) have not been replicated. Regardless, this research provides support that differences in WMC may affect RIF ability.

Likewise, trait-level factors that may alter the mental or emotional state (e.g., stress) have recently been linked to deficient RIF (Kossler et al., 2009). For example, Kossler et al. (2009) implemented a laboratory stressor (i.e., public speech and arithmetic + committee) or control treatment (i.e., written speech and arithmetic + no committee) directly after the study phase and prior to the retrieval practice phase, and no longer observed the RIF effect among those in the stressor group with elevated salivary cortisol (a known biomarker of stress; Bozovic et al., 2013). Meanwhile, the control treatment group displayed a typical RIF effect, suggesting that elevated stress can reduce RIF. Follow-up experiments have demonstrated that the oral administration of cortisol had no impact on the magnitude of the RIF effect, further isolating this finding to the psychological stressor itself, rather than heightened cortisol levels specifically (Kossler et al., 2013). However, the overall conclusion that stress impacts RIF may be further moderated by the time frame between stressor presentation and the learning phase of RIF, as research conducted following Kossler et al. (2009), has shown no significant difference in RIF performance with *delayed* stress (i.e., stress presented 90 minutes after learning; Dreifus et al., 2014). Thus, participants may need to be stressed immediately following study to show a significant impact. Additionally, it is unclear if the participant could alter their RIF performance when they are no longer feeling stressed. Overall, it appears that the state amount of stress the participant may be experiencing while completing the experiment is an important consideration, especially prior to RIF task completion.

The above examples demonstrate how individual differences may account for variation in memory control across 'healthy' participants. However, there are many disorders characterized by an inability to control unwanted thoughts or memories, which may themselves reflect individual variation in the processes underlying tasks such as RIF; hence this paradigm has also been utilized to compare clinical and non-clinical participants as a means of assessing their memory control abilities.

1.2 Retrieval–Induced Forgetting of Clinical and Non–Clinical Participants

In order to achieve the goal described above (i.e., to compare inhibition of clinical versus non–clinical participants), the retrieval–induced forgetting paradigm is commonly used and potentially modified – to accurately test the desired clinical phenomenon in a laboratory setting. For example, RIF has been utilized to observe potential bias with participants reporting social anxiety and generalized anxiety disorder (Kircanski et al., 2016; Law et al., 2012), depression (Groome & Sterkaj., 2010), ADHD (Storm & White., 2010), post–traumatic stress disorder (Blix & Brennen., 2012), and schizophrenia (Nestor et al., 2005). The typical finding is that participants in a clinical population, or those who score high on self–report measures of related psychopathologies, demonstrated a reduced RIF effect compared to non–clinical participants.

For instance, compared to non–depressed participants, clinically depressed participants demonstrate significantly lower RIF scores (Groome & Sterkaj., 2010), demonstrating a poor ability to unintentionally forget about competing information. Interestingly, this can be associated with a reduced memory performance in general, as shown by the differences in the observed means for Nrp items (e.g., $M = 35.58$ for depressed participants, $M = 57.41$ for control participants; Groome & Sterkaji., 2010). One may not be too surprised by this finding, as poor memory control ability has been found in depressed populations, including children (Lauer et al., 1994; Wagner et al., 2015). Another interesting finding was raised by Storm and White (2010), who compared a group of individuals with ADHD to those without ADHD. They found that while participants with ADHD showed successful RIF when the final test was category-cued recall (e.g., *Metals?*), but not when the final test was category-plus-stem-cued recall (e.g., *Metals: s__).* It was concluded that perhaps participants with ADHD may have a memory defect with respect to inhibition abilities; however, this may depend on the final test utilized (i.e., category-cued recall as opposed to category-plus-stem-cued recall). Again, we may expect these findings, as participants with ADHD typically demonstrate attentional deficits (e.g., poor sustained attention; Tsal et al., 2005), and divided attention may eliminate the RIF effect (Mulligan et al., 2022). For example, if the participant could not keep their full attention focused on the majority of word pairs presented in the initial study phase, they may have failed to successfully encode the correct category–target pairs from the beginning. Taken together, this lends some evidence to the idea that clinical participants differ in their memory abilities in comparison to non–clinical participants.

Interestingly, in some cases, clinical participants demonstrate the same RIF effect as the control group, showing no difference in cognitive ability (Blix & Brennen., 2012; Nestor et al., 2005). For example, participants who experience PTSD as a result of being sexually assaulted, show no significant difference in RIF performance compared to healthy participants (Blix & Brennen, 2012). However, an important consideration of this research is that the final test used a yes/no recognition-cued RIF task. Thus, it appears that perhaps *both* the type of disorder and the nature of the final test may impact RIF results in clinical populations, as RIF performance does not seem to differ in non–clinical populations. Additionally, work done with schizophrenic (i.e., SZ) participants have provided interesting insights to the memory abilities of the disorder (Nestor et al., 2005). Across two experiments, it was demonstrated that while participants with SZ had significant declines in their associative memory (i.e., ability to learn and remember the association between unrelated items), RIF was not impaired. Hence, participants with SZ may struggle with specificity or distinctiveness of encoding and retrieval, but this does not appear to impact their ability to inhibit information (i.e., RIF). While the previously discussed disorders and their observed variations within RIF are fascinating, the motivation of the current study arises from work conducted in the anxiety literature, specifically with respect to worry and generalized anxiety disorder (GAD).

1.2.1 Worry, Anxiety, and RIF

Firstly, it is important to understand how anxiety may function before discussing the relationship between anxiety and RIF. A concept worth introducing in this area is that of worry – typically defined by individuals' tendencies to construct a negative response to intrusive stimuli that they perceive as threatening via a problem-solving approach (Brokovec, 1984; Wells, 1995). For example, an individual who does not like spiders may react negatively to an image of a spider, such as looking away or letting out a fearful scream – as they have determined that the spider is threatening. Interestingly, worry has been conceptualized as a primarily cognitive factor that contributes to the psychological development and maintenance of anxiety (Brokovec, 1984; Mathews, 1990), and has played a central role in models of related disorders (e.g., GAD; Wells, 1995). For instance, it has been demonstrated that worry tends to generate greater anxiety, whereas depression tends to be generated by greater rumination (i.e., repetitive pondering on negative and distressing thoughts; McLaughlin et al., 2007). For example, relatively high levels of worry are typical in those reporting GAD (Thayer et al., 1996). This pattern has also been shown for social anxiety disorder (SAD; Boelen et al., 2010) – demonstrating that adolescents who report higher levels of worry are likely to also report experiencing SAD. As both disorders appear to have similarities, especially with regards to the function of worry, they have been reported as highly comorbid among adolescents (Hearn et al., 2017; Hearn et al., 2018). Interestingly, previous research has shown that participants who are highly anxious, will typically report a memory bias for this self–threatening information (Saunders, 2012; Herrera et al., 2017) – similarly to that expressed previously by the maintenance of worry. With particular relevance to the present thesis, the typical pattern that highly anxious participants will struggle to exert memory control over threat relevant stimuli (i.e., perhaps as a function of worry or attention; Delaney et al., 2020) has been observed using the RIF paradigm with both clinical and non–clinical participants who score 'high' on anxiety relevant measures.

The first known study to use highly anxious participants in a RIF paradigm was conducted by Saunders (2012) and found that highly anxious participants showed a memory bias (i.e., better recall, worse RIF) for negative self–relevant information. It further found that this memory bias did not exist for the neutral items used in this study (i.e., typical RIF effect). Additional early-work in this area provided evidence that the *State–Trait Anxiety Inventory (STAI)* can be utilized within this paradigm as a reliable anxiety measure (developed by

Spielberger 1970). That is, the *STAI* has been correlated with the magnitude of the RIF effect, demonstrating that high scores on state anxiety may be predictive of poor RIF performance (Law et al., 2012). Hence, we may expect individuals who tend to struggle with inhibition, to subjectively perceive situations as highly anxious, compared to those who do not react to situations in an anxious manner. This pattern has further been shown in studies evaluating generalized anxiety disorder (GAD) and RIF.

Kircanski et al. (2016) was the first known study to utilize the RIF paradigm to investigate the inhibition of threat information with participants who experience GAD compared to non–clinical participants. To do this, the research team created four categories (e.g., CARD) paired with neutral cues (i.e., completely neutral cues; CARD–deck, CARD–spade), and four categories (e.g., PATIENT) paired with *either* threat cues (e.g., PATIENT–illness) or neutral cues (e.g., PATIENT–waiting). As predicted, participants diagnosed with GAD exhibited no RIF effect for threat cues (e.g., PATIENT–illness), despite demonstrating a typical RIF for neutral cues (e.g., CARD–deck). This provides evidence that individuals with GAD cannot successfully inhibit threat-relevant information in the RIF paradigm, and have difficulty with the inhibition of threating information compared to neutral information. Having established this phenomenon in patients with GAD, the purpose of the present thesis was to utilize disorder-relevant stimuli to generalize these findings to a novel clinical group, who are also characterized by persistent and unwanted thoughts – individuals reporting health anxiety. While similar research has observed a reduced or eliminated RIF effect among participants experiencing anxiety disorders (e.g., GAD, SAD) and stress (as discussed above); there is no presently known research evaluating if a cognitive bias exists for health–relevant information in the RIF paradigm for individuals who self–report experiencing health anxiety.

1.2.2 Health Anxiety

The term 'health anxiety' encapsulates the fears and concerns that an individual may express about their health and/or potential illness, in the absence of such illness (5th ed; DSM-5; American Psychiatric Association, 2013; Asmundson et al., 2010; Ferguson 2008). The concern surrounding personal health typically arises from the misinterpretation of bodily sensations, such as mistaking heart burn as a heart attack or a serious heart condition (Rachman, 2012). It is recognized as a disorder in the Diagnostic Criteria for Psychosomatic Research (DCPR), and operationally defined by individual patient symptoms (Porcelli & Rafanelli, 2010). Once thought to be a categorial construct that could be evaluated by separating the patients reported health anxiety into 'high' or 'low' levels (Endler et al., 2001; Ferguson, 2008), recent evidence suggests that health anxiety is dimensional – such that individuals will differ across various levels of health anxiety as opposed to expressing the two extremes that could be categorized as 'high' or 'low' (Ferugson, 2008; Fergus & Bardeen, 2013).

Worry may perpetuate cognitive bias in generalized and social anxiety disorders, such that participants may encode stimuli as threatening and struggle to comply with task instructions due to their personal emotional encoding of the stimulus (e.g., they may struggle to intentionally forget negative stimuli; Delaney et al., 2020; Power et al., 2000). This phenomenon has also presented itself with health anxiety, with a recent meta-analysis demonstrating that health-anxious populations are more likely to view ambiguous stimuli as negative compared to non-health-anxious individuals (i.e., interpretation bias; Du et al., 2022). Therefore, it appears plausible that participants reporting health anxiety could demonstrate a bias towards health relevant information such that it may be selectively encoded as threatening to that population. This is an important consideration, given that the prevalence of health anxiety (6% lifetime, 20% in hospital outpatients; Tryer, 2018) has increased over the last three decades (Kosic et al., 2020). Additionally, it has been shown that health anxiety is significantly associated with negative consequences, such as poor occupational functioning and low well-being (Asmundson et al., 2010), making it an important and interesting topic to address. Luckily, health anxiety has shown to be responsive to a variety of treatments, including in response to cognitive-behavioral therapy (CBT) treatment (Olatunji et al., 2014), as well as psychoeducation and behavioural stress management (Taylor & Asmundson, 2004). While these methods of treatment appear to be plausible and well-supported, it is suggested that updated methodology for treatment should be prioritized – as a global health phenomenon (i.e., COVID-19) may have influenced the dimensional levels by which health anxiety is believed to function (see Asmundson and Taylor, 2020; Tyrer, 2020). While a main focus of health anxiety has been how it operates clinically and to determine treatment methodologies, little is currently known about how health anxiety may operate cognitively, particularly with respect to potential impacts on memory. Therefore, the goal of the present study is to evaluate the impact of health anxiety on memory performance.

1.3 The Current Study

The goal of the current study is to evaluate if the pattern reported by Kircanski et al. 2016 (i.e., participants reporting GAD showing an eliminated RIF effect compared to control participants) is observable when participants report being health anxious. As adapted from previous research procedures (i.e., Kircanski et al., 2016), participants will complete a RIF paradigm consisting of both health and neutral categories, in which the health category will have both health (e.g., NEEDLE-Puncture) and neutral (e.g., NEEDLE-Yarn) exemplars; while the neutral category will consist of neutral exemplars only (e.g., CARD-Deck, BALL-Gown). The retrieval-practice phase will test both categories (i.e., health and neutral) in order to compare the magnitude of RIF across both of these categories. It is hypothesized that participants who score high on a measure of health anxiety (i.e., Short Health Anxiety Inventory; i.e., SHAI–14; described below), will feel threatened when presented with health–relevant stimuli (i.e., NEEDLE) compared to neutral stimuli (i.e., CARD); as the health stimuli should be personally relevant to them and may contribute to potential cognitive biases (e.g., biased towards remembering ‘NEEDLE’ word-pairs because they are health-related). The practiced items from these categories are neutral words corresponding to a different meaning of the category word (e.g., NEEDLE–Injection vs. NEEDLE–Yarn). As a balance, the neutral categories used purely neutral words, with half corresponding to one meaning of the category word (e.g., CARD–spade) and half corresponding to a different, neutral meaning of the category word (e.g., CARD–envelope). We predict that across both experiments, participants who self–report high scores on the SHAI–14 (e.g., potential health anxiety) will demonstrate a reduced RIF effect for health targets from the health category (i.e., NEEDLE–puncture) compared to neutral targets from the neutral category (i.e., CARD–deck). In particular, Experiment 1 evaluated our hypothesis using an online, unsupervised task. Experiment 2 replicated our earlier methodology with the inclusion of a video conference with experimenter to supervise participation.

Chapter 2: Experiment 1

Experiment 1 provided an initial test of the hypothesis that participants scoring high in health anxiety would exhibit impaired memory control for health-related words. Although this study had been designed to be conducted in–person, it was modified to occur online without supervision (i.e., no webcam monitoring) due to a global pandemic (i.e., COVID–19). Participants initially completed an online questionnaire including clinical self-report measures pertaining to anxiety, followed by a later session in which they completed a RIF paradigm with health-related and neutral categories and targets. We predicted that participants reporting higher levels of health anxiety would show a reduced RIF effect for health relevant as compared to neutral items.

2.1 Method

2.1.1. Participants

Participants were recruited in two phases through the Memorial University Psychology Research Experience Pool (PREP) in exchange for partial credit towards an eligible psychology course. Initially, 115 participants completed an online questionnaire, after which they were invited to take part in a separate cognitive task. Of the initial sample, 77 participants continued with completion of the cognition portion. From our remaining sample, 54 participants provided complete data sets from both parts of the experiment. Within this sample, five participants were excluded for reporting distractions (e.g., responding to text messages, chatting with others in the area, failing to maintain attention) while completing the task. We further excluded two participants who admitted to writing down the words during the task. Therefore, the final sample included 45 participants (82% female, 91% white, M_{age} = 20.57).

2.1.2 Study Design

The cognitive portion of the study employed a repeated measures design. The within–subject manipulated variables included: 2 (Item Type: Practiced, Unpracticed) x 2 (Category Type: Practiced, Unpracticed) x 2 (Stimulus Relevance: Health, Neutral). From this cognitive task, we were specifically interested in calculating the overall magnitude of retrieval-induced forgetting (RIF) within-participants to explore correlations between RIF for health or neutral categories, and scales evaluating general health consciousness (e.g., COVID-19) and/or relevant mental disorders (e.g., GAD–7, PHQ, SHAI–14), to determine if participants who are more health-anxious show impairments with respect to RIF. Our design was inspired by (and largely followed) that of Kircanski et al. (2016), with a focus on health anxiety rather than generalized anxiety disorder.

2.1.3 Materials

Online Questionnaire. An online questionnaire was implemented in Qualtrics survey software (Qualtrics, Provo, UT, USA; https://www.qualtrics.com). This questionnaire included self–reported measures pertaining to the individuals' clinical and cognitive characteristics, prior to completion of the task. For example, the Generalized Anxiety Disorder Scale (GAD–7) allowed us to evaluate self–reported levels of participant anxiety, the Thought Control Ability Questionnaire (TCAQ) allowed us to understand the participant's ability to control unwanted thoughts and memories, the Penn State Worry Questionnaire (PSWQ) evaluated levels of worry, the Patient Health Questionnaire (PHQ–9) evaluated levels of depression, and so on. This questionnaire also included measures to assess fear, worry, and thoughts relating to the COVID–19 pandemic. Each measure is detailed below. Finally, the questionnaire gathered general demographic information such as participant age, gender, handedness, and information concerning previous medical history (e.g., mental health).

Generalized Anxiety Disorder 7–item Scale (GAD–7; Spitzer, 2006). The GAD–7 is a seven–item, self-report questionnaire used to evaluate a participant's level of anxiety, during the previous two weeks prior to completion of the question. Participants are presented with a four–point rating scale scoring from zero–three, in which they can indicate experiencing the given symptom "not at all", "several days", "over half of the days', or for 'nearly every day' within the prior two-week period. For example, participants are asked to respond to "Feeling nervous, anxious, or on edge," and would then respond by choosing an option on the scale (zero = not at all, three = nearly every day). The survey is scored out of a total of 21, with research demonstrating that 89% of patients with GAD have scores of ten or greater, and 82% of participants without GAD have scores of less than ten (Johnson et al., 2019). Hence, a cut-off point of less than or equal to ten should demonstrate a good balance between sensitivity and specificity for this measure (Johnson et al., 2019; Spitzer et al., 2006). Previous research has demonstrated the GAD–7 to be a reliable and valid measure in both the psychiatric population (Rutter and Brown, 2017), and the general population (Lowe et al., 2008) for the assessment of GAD symptoms.

Thought Control Ability Questionnaire (TCAQ; Wells and Davies, 1994). The TCAQ is a 30–item self-report questionnaire used to evaluate the participant's ability to effectively use strategies that aid in the control of unwanted thoughts and memories. For the purpose of this study, we utilized the modified 25–item measure, with each item measured using a five–point rating scale, going from "Completely Disagree" to "Completely Agree" (see Luciano et al., 2005). Participants are presented with items such as "I manage to have control over my thoughts even when under stress" and "any setback overwhelms me, no matter how small" and are asked to indicate the degree they agree or disagree with the statement, using the five–point rating scale. Test–retest reliability showed a total correlation score of .83, indicating that the TCAQ is a fairly stable measure (Luciano et al., 2005; see Feliu–Soler et al., 2019 for a review).

The Patient Health Questionnaire (PHQ–9 Depression; Kroenke et al., 2001). The PHQ is a self–administered version of the Patient Health Questionnaire of Mental Disorders, a diagnostic instrument of common mental disorders. In particular, the PHQ–9 is a depression module that scores (using a four–point rating scale of zero = not at all, three = nearly every day) the nine diagnostic criteria for major depression in the DSM–IV (Ganguly et al., 2013). Participants are asked to indicate how often they have been bothered by any of the problems presented, such as "little interest or pleasure in doing things" and "feeling down, depressed, or hopeless" over the previous two weeks. For the purpose of the current study, one item (i.e., Item nine) has been removed from this scale, making it an eight–item scale. The validity of the PHQ–9 score of (> = ten) had both a specificity and sensitivity of 88% for each major depressive disorder in previous research (Kroenke et al., 2001; Molebatsi, 2020), highlighting that it is a reliable and valid measure.

The Penn State Worry Questionnaire (PSWQ; Meyer et al., 1990). The PSWQ is a 16–item self-report measure of worry. Participants are presented with statements, in which they are asked to read and rate how much each of the following statements are "typical" or "not typical" of them by indicating on the rating scale. For example, "my worries overwhelm me" or "I do not tend to worry about things." It is scored on a five–point scale in which one = not at all typical of me and five = very typical of me. These scores are used to differentiate individuals with generalized anxiety disorder from other anxiety disorders (e.g., social anxiety). This measure has shown to be reliable (see Brown, 1992; Wuthrich et al., 2014).

Mental Illness Diagnostic Assessment. The Mental Illness Diagnostic Assessment is a three–item self-report questionnaire created by the researcher, to assess if participants have been previously diagnosed with a mental disorder, and if so, which disorder(s) they have been diagnosed with. Participants are asked to answer each question to the best of their ability and are assured that they can skip any questions that they do not feel comfortable providing a response for. Participants are asked if (a) they have ever been diagnosed or treated for a mental illness (i.e., yes, no, unsure), (b) which illnesses they have been diagnosed and/or treated for (e.g., major depression, GAD, panic disorder, OCD., etc), and (c) if they have an illness we did not provide, to please respond in a text box to notify us of their associated illness. This is simply a self-report measure created by the researcher to gain an idea of if the participants have been previously diagnosed with a mental illness.

The Short Health Anxiety Inventory (SHAI; Salkovskis et al., 2002). The SHAI is an 18–item, self-report questionnaire used to assess both typical levels of concern relating to ones' health, as well as levels of severe health anxiety. For the purpose of the current study, we used the 14–item short-form of the SHAI (i.e., items 15–18 removed; 42 maximum score; sometimes known as 'HAI') as our measure of self–reported healthy anxiety. Researchers commonly report using either the 18–item or 14–item measure as a tool to assess hypochondriacs (see Alberts et al., 2013 for a review). Within the SHAI, each item consists of four reflective statements, in which participants are asked to select the one that most accurately reflects their feelings over the past six months. For example, "I do not worry about my health", "I occasionally worry about my health", "I spend much of my time worrying about my health", or "I spend most of my time worrying about my health". Participants are asked to read each statement carefully and select the choice that best describes their feelings over the past six months. This scale has shown to have good psychometric properties to assess health anxiety in both non–clinical (Abramowitz et al., 2007) and clinical (Albert et al., 2013) samples. The suggested cut-off scores for interpretation (as reported by Österman et al., 2022; Zhang et al., 2015) are: "none to mild health anxiety" (i.e., *Sum* = 0-27), "moderate health anxiety" (i.e., *Sum* = 28-32), and "high health anxiety" (i.e., *Sum* = 33-42).

Coronavirus Reassurance–Seeking Scale (CRBS; Lee et al., 2020). The CRBS is a five-item self-report measure, ranging from zero (*not at all*) to four (*nearly every day*) to evaluate reassurance-seeking behaviors associated with concerns over the coronavirus infection. Participants are asked to indicate how often they have experienced the presented statements (e.g., I took my temperature to see if I was infected with the coronavirus disease, I spoke with other people about my symptoms to see if I was infected with coronavirus disease) over the previous two week period. Items are scored on a five–point rating scale, ranging from "Not at all" to "Nearly every day over the last 2 weeks." This scale has shown to be successful at identifying participants who are feeling severe mental distress due to the COVID–19 pandemic (Lee et al., 2020).

Fear of COVID–19 Scale (Ahorsu et al., 2020). The Fear of COVID–19 Scale is a 7–item self-report measure, evaluating how strongly an individual agrees or disagrees with the statements they are asked to read, portraying the coronavirus disease. For example, "I am most afraid of coronavirus" or "I am afraid of losing my life because of coronavirus". Each of these statements are rated using a 5–point rating scale, ranging from "strongly disagree" to "strongly agree." The maximum score for each question is five, with a total maximum score of 35; in comparison the minimum score for each question is 1, adding up to a total minimum score of 7 (Ahorsu et al., 2020). This scale has shown to be reliable and valid (see Caycho–Rodríguez et al., 2020).

Obsession with COVID–19 Scale (Lee, 2020a). The Obsession with COVID–19 Scale is a four–item self-report mental health screener to evaluate persistent and disturbed thinking about COVID–19. This is evaluated by asking participants how often they have experienced the presented statements within the prior two–week period. Participant responses are recorded using a five–point rating scale that ranges from “not at all” to “nearly every day over the last 2 weeks”. When completing this scale, participants are presented with items such as “I had disturbing thoughts that I may have caught the coronavirus” or “I dreamed about the coronavirus”. A total score of less than or equal to seven indicates possible dysfunctional thinking about COVID–19 (Lee, 2020a). This measure has shown to be reliable and valid across differing samples (Ashraf et al., 2020; Chen et al., 2021).

COVID Anxiety Scale (CAS; Lee 2020b). The CAS is a five–item self–report mental health screener to evaluate dysfunctional anxiety associated with the coronavirus crisis. Participants are asked to respond on a five–point rating scale, ranging from “not at all” to “nearly every day over the last two weeks”, to measure how often they have experienced the presented statements over the prior two-week period. Items presented to participants include “I felt nauseous or had stomach problems when I thought about or was exposed to information about the coronavirus.” A total score of less than or equal to nine may indicate potential dysfunctional anxiety related to the coronavirus pandemic (Lee, 2020b). This scale has been validated (Silva et al., 2020).

Retrieval–Induced Forgetting (RIF) task. Seventy-two cue–target pairs were used in this task, some of which were taken from Kircanski et al. (2016), while the others were generated by Hall (2020). The stimulus set is provided in Appendix A. In total, there were 12 categories, each of which had two meanings (e.g., NEEDLE used for injection or used for knitting). Of these 12 categories, six had neutral related words (e.g., CARD) and six had health related words (e.g., NEEDLE). For each of the six neutral word categories, there were six neutral targets associated with each category (e.g., CARD–deck, CARD–paper). However, for the six health word categories, there were three neutral targets associated with each category (e.g., NEEDLE–mitten) and three health targets associated with each category (e.g., NEEDLE–inject).

To control for primacy and recency effects during each phase of the RIF task, a filler category with six target words was used (e.g., NOVEL–first). The RIF task was completed on the participants personal computer via JavaScript software. The words appeared in white text in Arial size 14–point font on a dark gray background. Participants responded in the practice phase by typing the associated target word into the blank provided on the screen (e.g., CARD–de__). This was similar for the final recall phase, in which participants were shown the category on the top of the screen (e.g., CARD) and were asked to type as many of the target words as they could recall (e.g., deck, spade) into the blank provided on their screen.

Feedback and Debriefing. Following completion of the cognitive task, participants were redirected back into Qualtrics, to complete a short feedback and debriefing questionnaire. Participants were asked if they took part in any other activities during the task, if they found themselves distracted during the task, if they used a study strategy to remember the words, and to briefly explain what they did in each phase of the study. This ensured that the participant actually paid attention to the instructions, as well as the task, for each phase during the study and completed it accordingly. As this was an online study, the feedback questionnaire allowed us to understand the participants' behavior during the task, since it could not be monitored.

2.1.4 Procedure

This study was completed entirely online, without supervision. Participants first completed a digital informed consent form, in which if they selected "agree," the online questionnaire would be presented directly after on the following page. Once participants completed the questionnaire, they were invited to complete the second part of the experiment, at least an hour (and up to seven days) following completion of the online questionnaire. The delay was to reduce fatigue by discouraging participant completion of both parts consecutively. The procedures utilized in this study were approved by the Memorial University Interdisciplinary Committee on Ethics in Human Research (ICEHR; reference number 20181214-SC).

Learning phase. During the initial learning phase, participants were presented with all 72 category–target pairs on a computer screen (representing 12 categories; six health and six neutral, with six target words each) in a randomized order. Each pair (e.g., NEEDLE–mitten) was displayed on the computer screen for eight seconds and participants were instructed to spend this time relating the presented category word (e.g., NEEDLE) to target word counterpart (e.g., mitten). Two filler cues were presented at the beginning of the task, prior to presentation of the first study cue and again at the end of the task, following the presentation of the final study cue – to control for potential primacy and recency effects. See Table A1 in Appendix A for a full word list.

Retrieval Practice phase. Following the learning phase, participants completed a cued recall task, in which the first two letters (e.g., NEEDLE–mi___) of 18 cue target pairs were randomly selected to act as the practice items (i.e., Rp+). These category-target pairs were presented for eight seconds each, one after the other. Participants were instructed to type the correct response into the blank using their computer keyboard (i.e., –tten to complete mi__) and hit the "enter" or "return" key to submit their response. Stimuli presented within the phase included three randomly selected targets (i.e., generated by randomization to be Nrp+ or Rp+) from three all–neutral categories (e.g., CARD–deck), each pertaining to a single category meaning. Meanwhile, the three neutral targets from the health-related categories (i.e., NEEDLE–mitten) are designated as practiced items, with health targets from health-related categories (i.e., NEEDLE-inject) designated as unpracticed items. Each cue–target pair was presented on the screen three times in a randomized order. No cues were repeated twice in a row, and no two cues were presented in the same sequence more than once. The researcher, as well as a trained research volunteer, scored each participants response for accuracy. The scoring was dummy coded with both “STRICT” and “LENIENT” criteria, such that “STRICT” corresponded to the response being completely accurate with the word presented, whereas “LENIENT” allowed for spelling errors or words being recorded as plural (e.g., “roots” as opposed to “root”).

Recall phase. During the final test phase, each category (including those that were NOT presented during the retrieval practice phase) was presented on the top of the screen for 30 seconds (i.e., CARD) with a blank space presented below it. Within the 30 second timeframe, participants were instructed to type as many of the target words as they could remember that were associated with the presented cue. For example, if they were presented with “CARD” they should begin typing and entering “deck”, “spade”., etc. If participants entered all six responses, the screen would proceed to the next category. If participants did not enter all responses, the screen would automatically proceed to the next category, once the 30 second timeframe had passed. Participants were notified both in the instruction section and on the bottom of their screen that the page would proceed automatically within 30 seconds. The categories were presented in a randomized order, with some of the categories presented in the learning phase acting as a baseline (Nrp items), as they were not rehearsed during the practice phase. The remaining categories acted as either Rp+ or Rp– items, suggesting that their associated target words were either learned and rehearsed during the practice phase (Rp+), or they were related to a category that was practiced but that item in question was not rehearsed during the practice phase (Rp–). As mentioned above, all responses were made on the participants’ web browser, by typing their responses into the text box provided. These responses were later coded by a member of the research team, following the same criteria as that of the retrieval-practice phase.

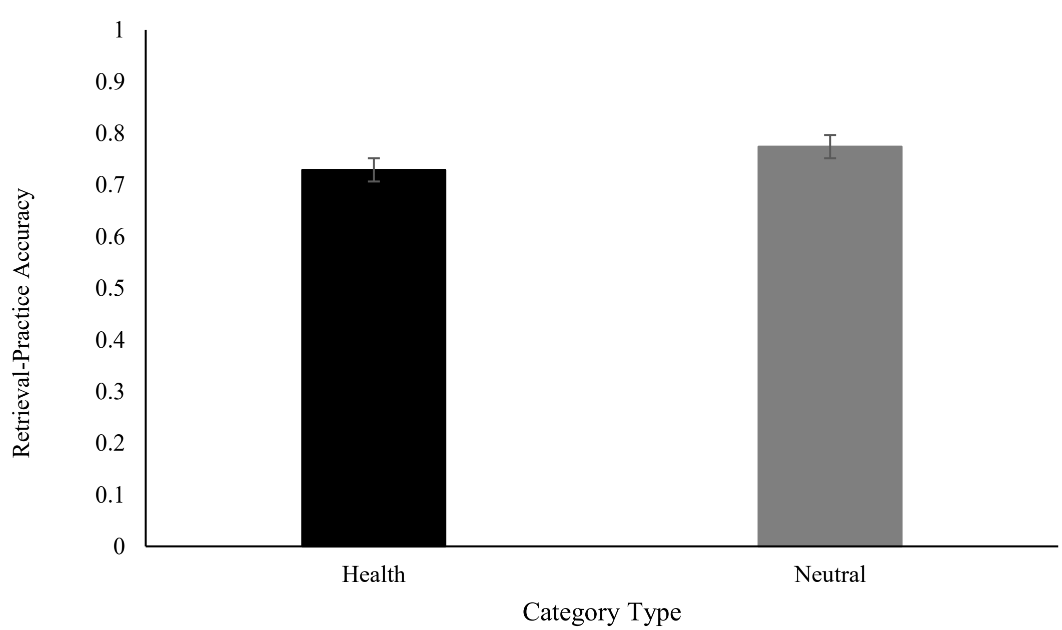
2.2 Results

2.2.1 Retrieval Practice Phase

Prior to analyzing recall performance from the final test phase, we first evaluated performance within the retrieval practice phase to verify compliance with task instruction. As depicted in Figure 2.1, a paired-samples t-test revealed no significance difference in retrieval practice performance between the Health (M = .73, SE = .03) and Neutral (M = .77, SE =.03) categories, t (45) = –1.70, p =.098, d = 0.25. Overall, performance was high (~75%), indicating that participants were successful in retrieving the targets during this phase.

Figure 2.1

Mean Recall Accuracy during the Retrieval-Practice Phase as a function of Item Type (Nrp+, Rp+) and Category Type (Health, Neutral)



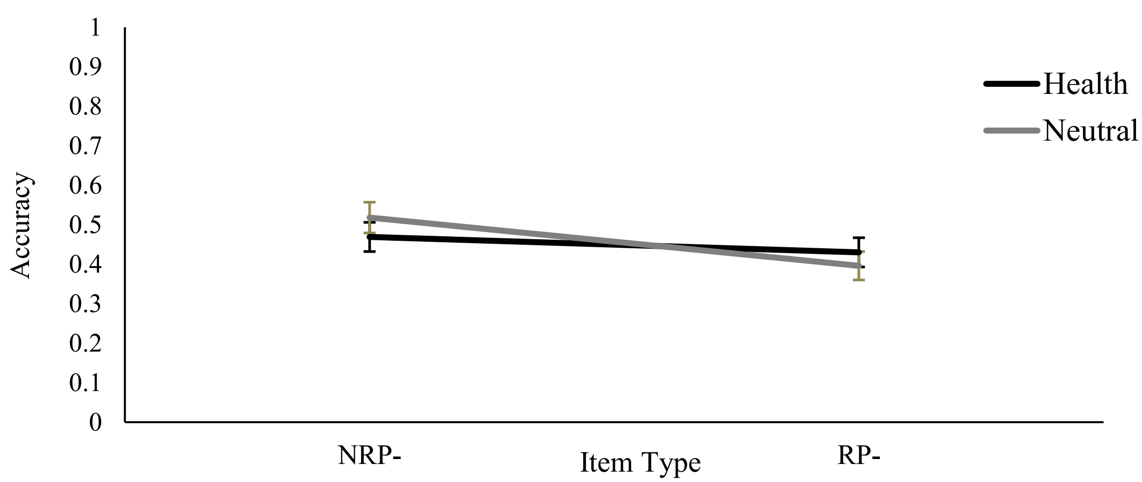
Note: Error Bars reflect the standard error of the mean.

2.2.2 Final Test Phase

Having established participants could retrieve the targets during the retrieval practice phase, we next evaluated the impact of retrieval practice on final recall. These analyses were undertaken in two parts. First, we evaluated the presence of RIF by analyzing final recall accuracy for non–practiced items using a 2 (Category Type: Health or Neutral) x 2 (Item Type: Nrp–, Rp–) Repeated Measures ANOVA. As depicted in Figure 2.2, although the main effect of Item Type was significant, F (1,45) = 9.50, p = .004, η^2_p =.17, there was no significant main effect of Category F (1,45) = 0.09, p = .763, η^2_p = .00. Additionally, there was no significant interaction between Category and Item Type, F (1, 45) = 2.01, p = .164, η^2_p = .04. Planned t–tests evaluating the presence of RIF in each category revealed a significant RIF effect for the Neutral category, t (45) = 3.84, p < .001, d = 0.57, but this pattern was not significantly observed for the Health category t (45) = 0.86, p =.393, d = 0.13.

Figure 2.2

Mean Recall Accuracy during the Final Test Phase as a Function of Item Type (Nrp-, Rp-) and Category Type (Health, Neutral)

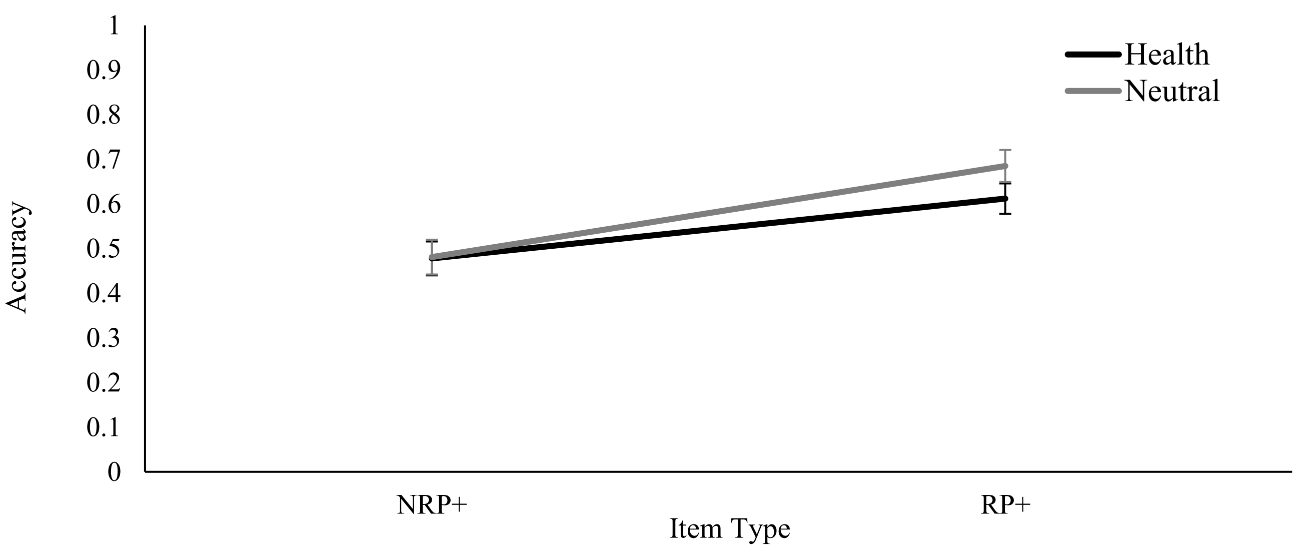


Note: Error bars represent the standard error of the mean

Although not of primary interest, similar analyses were undertaken exploring whether retrieval practice impacted memory for the practiced items at final test. This was evaluated by conducting a similar 2 (Category Type: Health or Neutral) x 2 (Item Type: Nrp+, Rp+) Repeated Measures ANOVA, using the recall accuracy of practiced items as opposed to non–practiced items. The main effect of Item Type was significant F (1,45) = 41.82, p < .001, η^2_p = .48; however, both the main effect of Category Type F (1,45) = 0.07, p = .096, η^2_p = .06, and the interaction between Item and Category Type F (1, 45) = 1.86, p = .179, η^2_p = .04, were not significant. This is depicted by Figure 2.3. Planned t–test revealed that both the Health, t (45) = –3.37, p =.002, d = 0.50 and Neutral categories t (45) = –6.09, p = <.001, d = 0.90, displayed significant practice effects.

Figure 2.3

Mean Recall Accuracy during the Final Test Phase for Unpracticed Categories as a Function of Item Type (Nrp+, Rp+) and Category Type (Health, Neutral)



Note: Error bars represent the standard error of the mean

2.2.3 Descriptive Statistics of Health Anxiety via SHAI-14

With respect to assessing health anxiety in our sample, it appears that on average our participants (*N* = 45) displayed "moderate health anxiety" (M_{sum} = 29.9, *SE* = 1.14) as according to the SHAI-14 indicators (i.e., *Sum* = 28-32; Österman et al., 2022; Zhang et al., 2015). Interestingly, the majority of our participants (*N* = 19) reported "none to mild health anxiety" (M_{sum} = 23.2, *SE* = .724; *Sum* = 0-27; Österman et al., 2022; Zhang et al., 2015). Furthermore, the same number of participants (i.e., *N* = 13) reported "moderate health anxiety" (M_{sum} = 30.4, *SE* = .368), and "high health anxiety" (M_{sum} = 39.8, *SE* = 1.39; 33-42 high health anxiety; Österman et al., 2022; Zhang et al., 2015) respectively. Additional descriptive information pertaining to our health measures can be found in Table B1 in Appendix B.

2.2.4 Correlation of Health Measures with RIF in the Health Category

Finally, we conducted correlations to assess potential relationships between our self-reported measures of health anxiety (i.e., SHAI–14) and the scores obtained from the RIF paradigm. In particular, we looked to assess the relationship between health anxiety (i.e., sum scores on the SHAI–14) and RIF scores for the health relevant material. As demonstrated by Figure 2.4, no correlation was observed between the health anxiety measure and RIF, *r* (45) = .02, *p* = .897. As shown by the correlation matrix in Table 2.1 below, there were also no notable significant correlations between any of our health relevant measures and the RIF scores in either category.

Figure 2.4

The Magnitude of Retrieval-Induced Forgetting (Nrp-, Rp-) as a Function of Health Anxiety, as measured using the Short-Health Anxiety Inventory (SHAI-14)

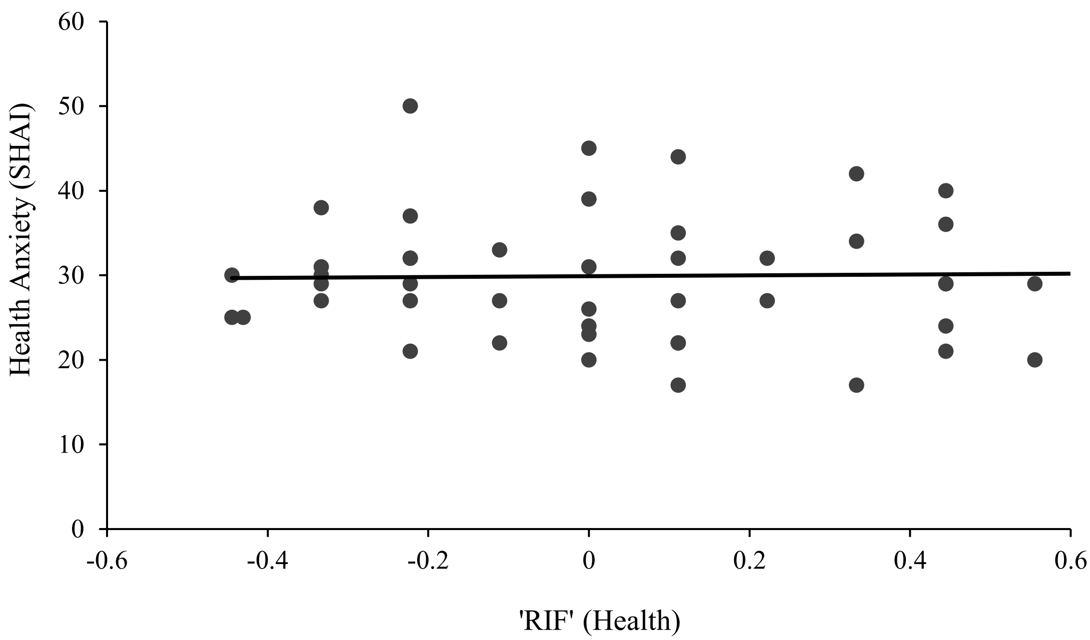


Table 2.1

Correlation Matrix of Health Measures with RIF Scores for Neutral and Health Categories

		Health RIF Effect	Neutral RIF Effect
Health RIF Effect	Pearson's r	–	–
	p–value	–	–
Neutral RIF Effect	Pearson's r	–.117	–
	p–value	.439	–
GAD–7 Sum Scores	Pearson's r	.063	–.048
	p–value	.678	.752
TCAQ Sum Scores	Pearson's r	–.068	.092
	p–value	.654	.543
PHQ–9 Sum Scores	Pearson's r	–.112	–.005
	p–value	.459	.976
PSWQ Sum Scores	Pearson's r	–.026	–.099
	p–value	.861	.513
SHAI Sum Scores	Pearson's r	.020	–.184
	p–value	.897	.221
CRBS Sum Scores	Pearson's r	–.052	–.072
	p–value	.733	.632
COVID Fear Sum Scores	Pearson's r	.072	.192
	p–value	.633	.201
OCS Sum Scores	Pearson's r	.043	–.026
	p–value	.776	.863
CAS Sum Scores	Pearson's r	–.022	.125
	p–value	.882	.406

Note: Health RIF Effect = Retrieval-Induced Forgetting Effect for the Health Category, Neutral RIF Effect = Retrieval-Induced Forgetting Effect for the Neutral Category, GAD = Generalized Anxiety Disorder, TCAQ = Thought Control Ability Questionnaire, PHQ = Patient Health Questionnaire (Depression), PSWQ = Penn-State Worry Questionnaire, SHAI = Short-Health Anxiety Inventory, CRBS = COVID Reassurance-Seeking Scale, OCS = Obsession with COVID Scale, CAS = COVID Anxiety Scale.

2.3 Discussion of Experiment 1

Experiment 1 (i.e., E1) evaluated the hypothesis that individuals scoring high on a self-report measure of health anxiety would exhibit an impaired RIF effect for health-related words as compared to neutral words. The present results failed to support this hypothesis. While participants did exhibit a significant RIF effect overall, planned tests revealed the effect to be significant for the Neutral Category, but not significant for the Health Category. However, the difference between the magnitude of the Health and Neutral RIF effect itself was not statistically significant (i.e., $p = .164$). We additionally predicted that the magnitude of the Health RIF effect would be smaller in health-anxious populations (i.e., reflecting their inability to control health-relevant information); however, SHAI-14 scores did not significantly correlate with the magnitude of the Health RIF effect (i.e., $r = .02$; $p = .897$). These findings suggest that a link between health anxiety and memory control for either health-related or neutral information may not exist, particularly with respect to the low-medium health anxiety range that was observed in the present study (i.e., Mean health anxiety scores observed < 32; this point will be discussed further in the general discussion).

With regards to potential theoretical implications of the present findings, our observations suggest that participants reporting low-moderate levels of health anxiety may not demonstrate difficulty when inhibiting health (e.g., NEEDLE-Puncture) or neutral (e.g., CARD-deck) related items. It is unexpected that health-related information is as easily controlled as neutral information, as previous research has established that negatively related information is difficult to control in general (Marx et al., 2008; Zimmerman & Kelley, 2010). Furthermore, threat-related information has shown to be particularly difficult to inhibit in comparison to neutral information (Beck et al., 1992; Mitte, 2008), and so it was hypothesized that the health-related information would have been perceived as particularly threatening (e.g., HEART-Blockage) to a health-anxious population; nonetheless, this pattern was not observed in our current study. The statistical findings suggest that populations reporting low-moderate levels of health anxiety do not have memory control impairments or attentional biases for health-related or neutral information. However, previous research in this area would disagree with our current observations, as it has been shown that health-anxious populations *do* have attentional biases relative to health and/or threat related information (Ferguson et al., 2007; Shi et al., 2022). A plausible explanation for this contradiction in our current work may be that our participants reported low-moderate levels of health anxiety, as opposed to reporting high levels or a verified diagnosis. This critique and limitation will be expanded upon further in the general discussion.

However, there are also several alternate explanations arising from the present methods that could account for the observed results. For example, the current sample included a primarily young female population, who may be experiencing high levels of stress (i.e., potentially due to the global pandemic impacting their financial and educational environment; Aristovnik et al., 2021; Prowse et al., 2021). Previous research (i.e., Kossler et al., 2009; 2013) demonstrated that stress could eliminate the RIF effect – which may have reduced the magnitude of RIF in the neutral condition, masking any difference between it and the health condition; however, perceived stress of the stimulus was not measured –therefore we cannot elaborate any further on this speculated confound. Furthermore, almost one quarter of our participants (n = 8) reported ADHD and found it difficult to pay attention for the duration of the experiment. Additionally, previous research has shown that participants reporting ADHD (e.g., Storm & White, 2010) typically show a reduced RIF effect; therefore, this may also be a potential explanation as we did not exclude participants on the basis of reporting ADHD or any other disorders that may result in increased distraction and reduced attention. Due to this possibility, a follow-up analysis was conducted, excluding these participants to explore if it would make a statistical difference to the observed magnitude of the RIF effect. However, removing the data from these participants (n = 4; some participants reporting ADHD had been excluded from analyses previously as per exclusion criteria) did not alter the observed results (i.e., Item Type: p = .007, Category Type: p = .971, Item Type * Category Type: p = .159). Therefore, it may be possible that experiencing heightened distraction from ADHD did impact the participants personal ability to complete the RIF task (i.e., as reported in the feedback section), but this did not impact the overall results. Thus, while a diagnosis of ADHD has impacted the RIF paradigm in previous studies (i.e., Storm & White, 2010) it does not appear to be a plausible explanation for observing a reduced magnitude of the RIF effect in the current study.

Secondly, a number of methodological limitations may have contributed to the observed results. In particular, this study was completed online during the COVID-19 pandemic and participants were not supervised by the research team during the task. Therefore, participants may have split their attention while completing the study or may have taken part in distracting tasks (e.g., texting, talking to others), leading to reduced attention, without notifying the experimenter. Due to our online design, there was a section provided in our feedback form for participants to notify the research team if they had any issue with the study or had experienced distraction – although it is possible that this was not always reported. Furthermore, participants did not complete the study in a controlled environment, and therefore the inconsistent environment (e.g., completing the study at a busy and loud household as compared to a calm and quiet household) between participants may have contributed statistical noise to the observed results. Finally, some of the chosen word stimuli (e.g., NEEDLE-Puncture) appeared to be too similar to others (e.g., NEEDLE-Pain), which may have contributed to confusion when attempting to practice and retrieve the word pairs. Hence, a second experiment (i.e., Experiment 2) was developed to account for these limitations with the additions of supervised methodology, newly balanced word-pairs, and an additional sample of participants to assess health anxiety and RIF abilities further.

Chapter 3: Experiment 2

As Experiment 1 was conducted unsupervised, it permitted the possibility that participants may have been off–task or inattentive throughout the experiment, which could not be further documented by the research team. Hence, Experiment 2 was created to address this concern, incorporating live supervision of each participant. As per Experiment 1, participants completed the same online questionnaire to report information about their health, followed by a session in which they completed the RIF paradigm while on WebEx with a member of the research team. Our predictions remained the same, such that participants reporting higher levels of health anxiety, would demonstrate a reduced RIF effect for health–relevant items, compared to neutral items.

3.1 Method

The Method for Experiment 2 was identical to that of Experiment 1, with one minor change to the materials and one minor change to the procedure.

3.1.1 Participants

Participants were recruited in two phases through the Memorial University Psychology Research Experience Pool (PREP) in exchange for partial credit towards an eligible psychology course. Initially, 172 participants completed an online questionnaire, after which they were invited to take part in the cognitive task. Of the initial sample, 22 participants continued with completion of the cognition portion. From our remaining sample, 16 participants provided complete data sets from both parts of the experiment. Within this sample, one participant was excluded for moving spots and missing data for an entire category set (i.e., NEEDLE). Therefore, the final sample included 15 participants (73% female, 80% white, $M_{age} = 21.47$).

3.1.2 Study Design

This was exactly the same as Experiment 1.

3.1.3 Materials

The materials used in this experiment were the same as Experiment 1, with slight alterations to some of the word-pairs to balance the properties of the words (e.g., valance, arousal, length), as well as reduce the potential similarity between target items within the same category. For example, the pair “PANEL–Discussion” was altered to “PANEL–Debate” to balance word length. As an example of reducing similarity, the pair “NEEDLE–Puncture” had been altered to “NEEDLE–Vial”, to avoid similarity with the pair “NEELDE–Pain” – as “NEEDLE–Pa” versus “NEEDLE–Pu”, may become confusing to participants during the retrieval-practice phase. In total, seven word-pairs had been altered from Experiment 1 to Experiment 2. See Table A1 in Appendix A for full word list. No other changes to the materials had been made.

3.1.4 Procedure

The procedure for this experiment differed slightly from that of Experiment 1, as this experiment was conducted to be supervised, such that the participant could still complete the study from a location of their choice – but they needed to share their screen and remain on camera while completing the experiment, under the observation of a research assistant. This was done to ensure that participants were following the instructions, and to create an environment that more–closely mimics in–laboratory research.

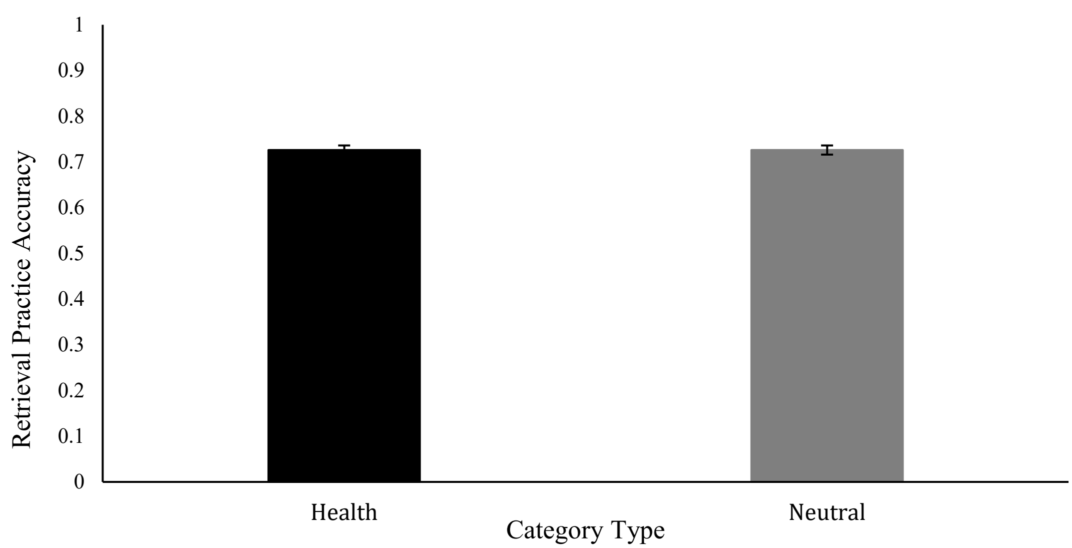
3.2 Results

3.2.1 Retrieval Practice Phase

Once again, prior to analyzing recall performance from the final test phase, we evaluated the mean performance of the retrieval–practice (Rp) phase between the Health and Neutral categories to verify compliance with the task instructions. A paired–samples t–test revealed no significant difference with respect to mean performance between the Health (*M* = .73, *SE* = .05) and Neutral (*M* = .73, *SE* = .06) categories *t* (14) = 0.000, *p* = 1.000, *d* = 0.000. As demonstrated by Figure 3.1 below, performance was high (~73%) indicating that participants were successful in retrieving the targets during this phase.

Figure 3.1

Mean Recall Accuracy during the Retrieval-Practice Phase as a function of Item Type (Nrp+, Rp+) and Category Type (Health, Neutral)



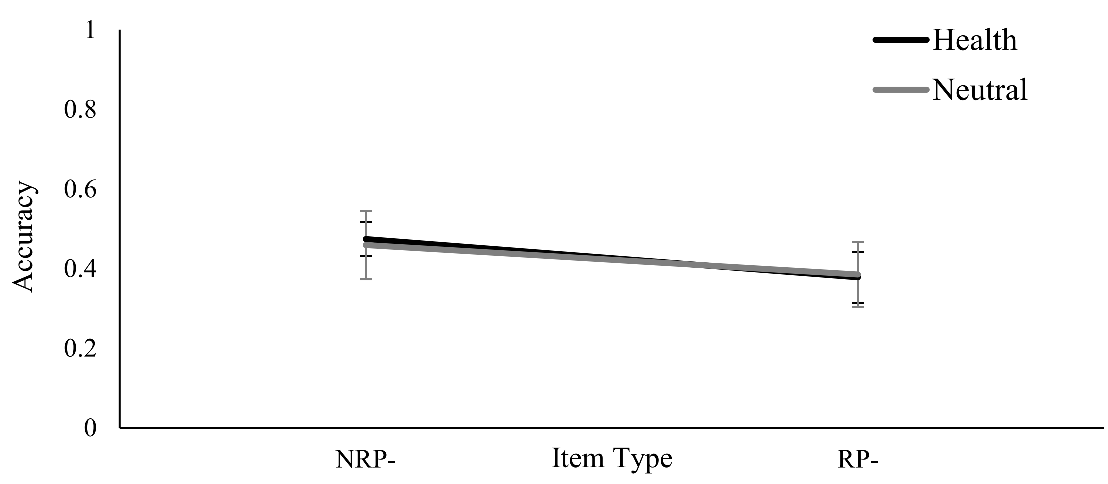
Note: Error Bars reflect the standard error of the mean.

3.2.2 Final Test Phase

As the previous analysis has demonstrated the successful retrieval of targets during the retrieval practice phase, we next evaluated the impact of retrieval practice on final recall. These analyses were again undertaken in two parts, as in Experiment 1. First, we evaluated the presence of RIF by analyzing the final recall accuracy of non–practiced items using a 2 (Category Type: Health or Neutral) x 2 (Item Type: Nrp–, Rp–) Repeated Measures ANOVA. The main effect of Item Type was not significant, F (1,14) = 3.75, p = .073, η^2_p = .21, and there was no significant main effect of Category Type, F (1,14) = 0.01, p = .935, η^2_p = < .001. Additionally, there was no significant interaction between Category and Item Type, F (1,14) = 0.07, p = .800, η^2_p = .01. These results are displayed below in Figure 3.2. Planned t–tests were then conducted evaluating the presence of RIF in each category, demonstrating that both the Health, t (14) = 1.78, p = .097, d = 0.46, and Neutral categories, t (14) = 1.09, p = .296, d = 0.28, did not demonstrated the presence of a significant RIF effect.

Figure 3.2

Mean Recall Accuracy during the Final Test Phase as a Function of Item Type (Nrp-, Rp-) and Category Type (Health, Neutral)

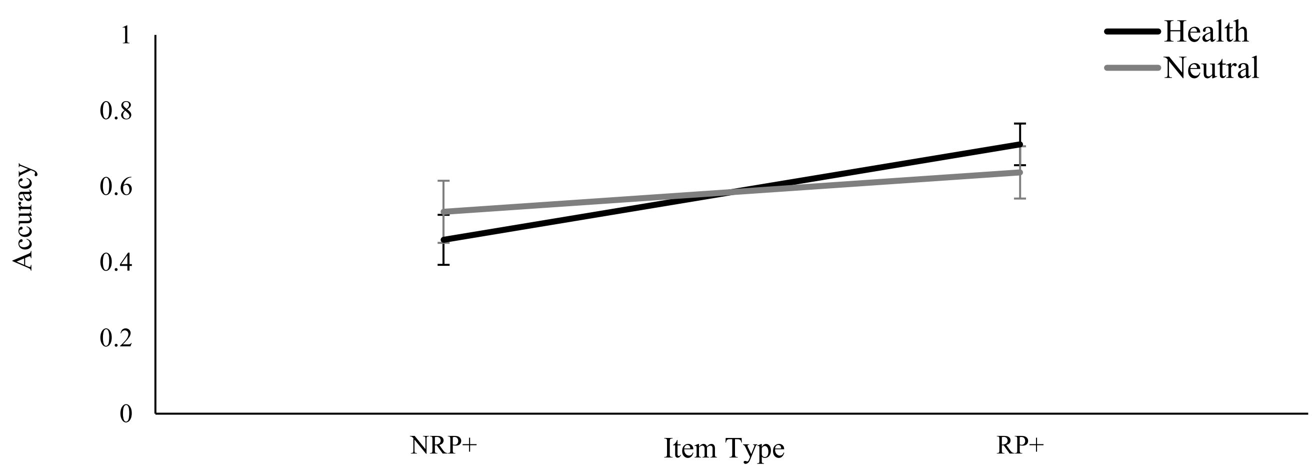


Note: Error bars represent the standard error of the mean.

While considered a secondary finding, similar statistical analysis was undertaken to explore whether retrieval practice impacted memory performance for the practice items at final test. Similarly, to the analysis described above, a 2 (Category Type: Health or Neutral) x 2 (Item Type: Nrp+, Rp+) Repeated Measures ANOVA was utilized – looking at final recall accuracy of practiced as opposed to non–practiced items. This analysis revealed that while the main effect of Item Type was significant, F (1,14) = 20.21, p <.001, η^2_p = .59, the main effect of Category Type was not significant, F (1,14) = 0.00, p = 1.00 , η^2_p = < .001, and the interaction between Item and Category Type, F (1, 14) = 4.38, p = .055, η^2_p = .24, was also not significant. This is depicted by Figure 3.3. Planned t-test revealed the Health category, t (14) = –5.72, p = <.001, d = 1.48, had significant practice effects, while Neutral category did not significantly display this pattern, t (14) = –1.71, p = .110, d = 0.44.

Figure 3.3

Mean Recall Accuracy during the Final Test Phase for Practiced Categories as a Function of Item Type (Nrp+, Rp+) and Category Type (Health, Neutral)



Note: Error bars represent the standard error of the mean.

3.2.3 Descriptive Statistics of Health Anxiety via SHAI-14

Interestingly, participants in the second experiment ($N = 15$) displayed “none to mild health anxiety” ($M_{sum} = 23.3$, $SE = 1.18$) on average, as according to the SHAI-14 indicators (i.e., *Sum* = 0-27; Österman et al., 2022; Zhang et al., 2015). Thirteen participants ($N = 13$) reported experiencing “none to mild health anxiety” ($M_{sum} = 22.1$, $SE = .937$), while only one participant ($N = 1$) reported experiencing “moderate health anxiety” ($M_{sum} = 28.0$; *Sum* = 28-32; Österman et al., 2022; Zhang et al., 2015), and one participant ($N = 1$) reported experiencing “high health anxiety” ($M_{sum} = 34.0$; *Sum* = 33-42 high health anxiety; Österman et al., 2022; Zhang et al., 2015). See Table B2 in Appendix B for additional descriptive information pertaining to our health measures.

3.2.4 Correlation of Health Measures with RIF in the Health Category

Finally, we conducted correlations to assess potential relationships between our self–reported measures of health anxiety (i.e., SHAI–14) and the scores obtained from the RIF paradigm. In particular, we looked to assess the relationship between health anxiety (i.e., sum scores on the SHAI–14) and RIF scores for the health relevant material. As demonstrated by Figure 3.4, no correlation was observed between the health anxiety measure and RIF, r (14) = –.09, $p = .736$. As shown by the correlation matrix in Table 3.1 below, there were no other significant correlations between any of our health relevant measures and the RIF scores in either category.

Figure 3.4

The Magnitude of Retrieval-Induced Forgetting (Nrp-, Rp-) as a Function of Health Anxiety, as measured using the Short-Health Anxiety Inventory (SHAI-14)

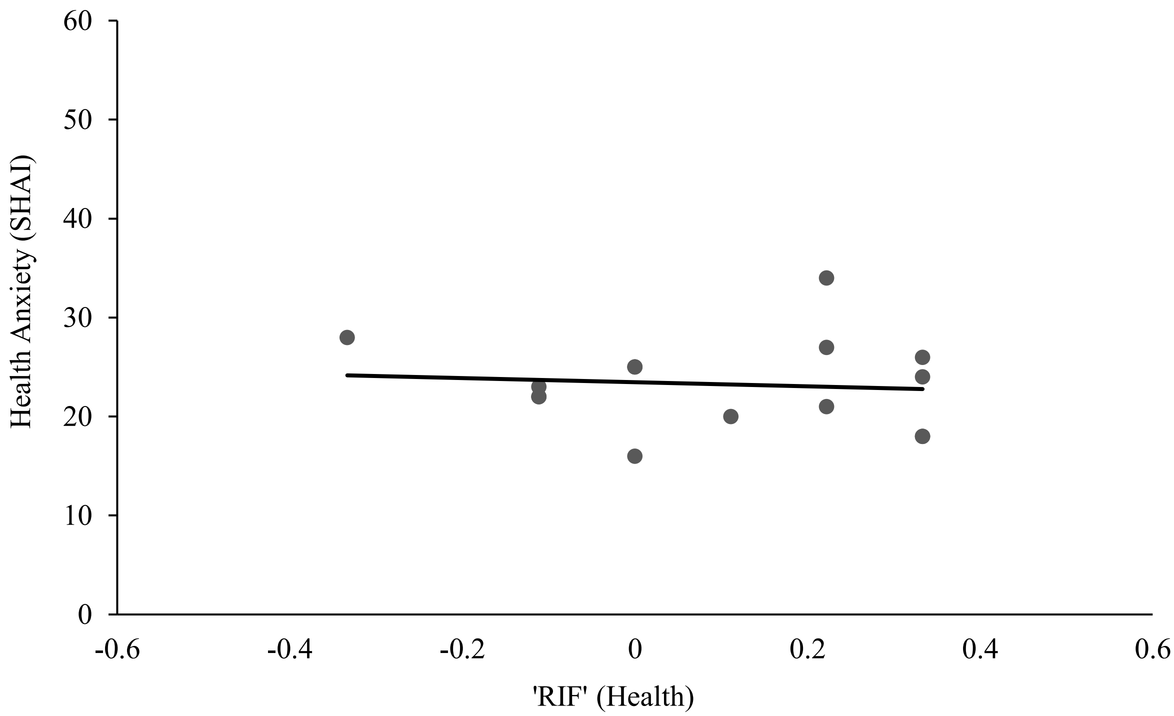


Table 3.1

Correlation Matrix of Health Measures with RIF Scores for Neutral and Health Categories

		Health RIF Effect	Neutral RIF Effect
Health RIF Effect	Pearson's r	–	–
	p–value	–	–
Neutral RIF Effect	Pearson's r	.021	–
	p–value	.940	–
GAD–7 Sum Scores	Pearson's r	–.105	–.254
	p–value	.710	.362
TCAQ Sum Scores	Pearson's r	–.263	–.116
	p–value	.344	.679
PHQ–9 Sum Scores	Pearson's r	.011	–.101
	p–value	.969	.732
PSWQ Sum Scores	Pearson's r	–.026	–.347
	p–value	.927	.206
SHAI Sum Scores	Pearson's r	–.095	–.254
	p–value	.736	.362
CRBS Sum Scores	Pearson's r	–.035	.444
	p–value	.902	.097
COVID Fear Sum Scores	Pearson's r	–.317	.224
	p–value	.249	.422
OCS Sum Scores	Pearson's r	–.510	.207
	p–value	.052	.459
CAS Sum Scores	Pearson's r	.027	–.482
	p–value	.924	.069

Note: Health RIF Effect = Retrieval-Induced Forgetting Effect for the Health Category, Neutral RIF Effect = Retrieval-Induced Forgetting Effect for the Neutral Category, GAD = Generalized Anxiety Disorder, TCAQ = Thought Control Ability Questionnaire, PHQ = Patient Health Questionnaire (Depression), PSWQ = Penn-State Worry Questionnaire, SHAI = Short-Health Anxiety Inventory, CRBS = COVID Reassurance-Seeking Scale, OCS = Obsession with COVID Scale, CAS = COVID Anxiety Scale.

3.3 Discussion of Experiment 2

As with Experiment 1, the goal of Experiment 2 (i.e., E2), was to evaluate the hypothesis that participants who self-report high health anxiety would demonstrate a reduced RIF effect when presented with health-related compared to neutral-related word-pairs. The present experiment was designed to address the unsupervised nature of E1, which may have resulted in challenges common to that of online experiments (e.g., uncontrolled environment, participant attention, cannot note distractions), potentially reducing the magnitude of the RIF effect for the Health category. Additionally, E2 slightly varied the word-pairs to adjust for similarities between the word characteristics (i.e., word length, beginning letters) that may have contributed to how the stimuli became encoded. Interestingly, unlike in Experiment 1, the present experiment failed to observe a statistical RIF effect for either the Health or Neutral categories. This did not support our hypothesis. We additionally predicted that a reduced RIF effect could be accounted for by health anxiety (i.e., the SHAI-14 scores) – but this correlation was not statistically significant ($r = -.09$; $p = .736$); hence the eliminated RIF effect cannot be explained by health anxiety. It is additionally unclear why the Neutral RIF effect was not significant in this experiment, as participants were supervised, which would presumably improve the data quality compared to E1.

Although the main effect of Item Type was marginally significant (i.e., $p = .073$), which may suggest a RIF effect collapsing across the health and neutral items, a strict interpretation of the present findings suggest no statistical RIF effect. This may suggest the RIF effect to be unreliable via poor statistical power, discussed in detail below. As the main effect of item type failed to reach significance, it is not surprising that the magnitude of these non-significant RIF effects failed to vary as a function of category type. Furthermore, self-reported health anxiety did not relate to the reduced magnitude of the RIF effect observed in E2 for the health-related or neutral items. When taken together, these findings appear to suggest that participants reporting low-moderate levels of health anxiety may not demonstrate difficulties when inhibiting health-related or neutral items. These observations bring into question if health-related information is inherently more difficult to control, and to which extent the inability to control this information may play a role in the development or maintenance of health anxiety. As noted by the E1 discussion, this does not appear to be a reliable conclusion considering previous research in the area has observed an attentional bias within memory for highly health-anxious participants (Ferguson et al., 2007; Garbóczy et al., 2021; Shi et al., 2022).

One consideration that may have contributed to the absence of a significant RIF effect in the present study was the potential added stress of online supervision. While this task was designed to be conducted online as a method to reduce statistical noise, it may have also applied social pressure, reducing the magnitude of the RIF effect overall. Previous evidence has suggested that specific social situations (i.e., social stressors, trust, contagion) may impact the magnitude of the RIF effect (Cuc et al., 2007; Koppel et al., 2014; Storm et al., 2016). Thus, future research may wish to consider exploring the impact of supervising participants during online experiments (e.g., either actively including a social presence or passively via recording) to evaluate the costs and benefits of including this variable for complex cognitive tasks.

Furthermore, while Experiment 2 did address several shortcomings of Experiment 1, the present study also had a particularly low sample size in comparison to E1 (i.e., n = 15 versus n = 46). Therefore, to evaluate low statistical power, a sensitivity analysis was conducted to evaluate the smallest effect size that the present study was powered to detect (i.e., target statistical power; $1-\beta = .80$). With a sample size of 16 participants, we were only sufficiently powered to reliably detect a RIF effect within each word category with an effect size of Cohen's $d \sim 0.78$ or larger. Notably, a recent meta-analysis demonstrated that the RIF effect is typically close to Cohen's $d \sim$

0.30 (Murayama et al., 2014). To compare, Experiment 1 – in which a RIF effect was observed – was powered to detect an effect size relative of Cohen's *d* = 0.42 or larger, which was close to the expected effect size. Therefore, it appears plausible that the non-significant RIF effect within the Neutral category can be accounted for by low statistical power in E2 relative to E1. Unfortunately, we had a large drop-off rate in this experiment (i.e. 172 total participants reduced to 15 total participants), which may be explained by the participants return to in-class as opposed to online University (i.e., as with E1), following the COVID-19 pandemic. Additionally, students at this University experienced a month-long strike in which research was halted, which may have contributed to our lack of participation from E1 to E2. Further critiques of the present experiment will be reserved for the general discussion (following below) to permit a direct comparison with the results of Experiment 1.

Chapter 4: General Discussion

The present thesis explored two experiments that evaluated whether self-reported health anxiety would correlate with the magnitude of the RIF effect for health-related (e.g., NEEDLE-Puncture) or neutral (e.g., CARD-deck) word-pairs, amongst a university population. It was hypothesized that participants reporting high health-anxiety would demonstrate a reduced RIF effect for health-related compared to neutral word-pairs. However, the present findings did not support this hypothesis, and instead demonstrated that participants with low-moderate health anxiety may not have cognitive biases impacting their ability to control competing information during retrieval, even if that information is health-related. Across both experiments, results favoured a RIF effect overall, but this was only statistically significant in Experiment 1, with a marginal trend in Experiment 2. Planned comparisons demonstrated a numerically greater RIF effect for the neutral category compared to the health category; however, this difference was not statistically significant in either experiment. Additionally, the RIF effect for the neutral category was only statistically significant for Experiment 1 and was not observed for Experiment 2. Furthermore, the RIF effect for the health-related items failed to reach significance in either experiment. Importantly, the magnitude of the RIF effect for the health-related items did not correlate with our measure of health anxiety (i.e., as demonstrated by the SHAI-14 scores) or any other health relevant measures (i.e., as demonstrated by the GAD-7, PHQ-9, and COVID-19 sum scores) reported by participants in our study.

From a theoretical perspective, it is plausible that participants experiencing low-moderate health anxiety do not experience the same attentional biases as those who report high-severe health anxiety. For example, a previous meta-analysis showed that in comparison to a control group, a health-anxious group expressed greater attentional bias towards health-threat, with the magnitude varying as a function of type of bias, paradigm, and stimuli (Shi et al., 2022). However, health-anxious participants in previous research were likely to experience greater health anxiety than our current sample. Whereas historically health anxiety has been viewed as categorical (i.e., high or low levels), it is more recently viewed as a continuum (Ferguson, 2008). It is possible that the relationship between health anxiety and memory control is non-linear, such that participants with low-moderate health anxiety do not have the same memory control impairments as those reporting higher levels of health anxiety; however additional research would need to confirm this speculation.

Another possibility is that our stimuli and/or paradigm (i.e., RIF with word stimuli) may not have been salient enough for the health-related items to be perceived as threatening. Even so, a similar RIF paradigm has previously demonstrated that participants with generalized anxiety disorder (GAD) tend to display memory deficits for threat-related word stimuli (Kircanski et al., 2016). This suggest that a RIF paradigm that utilizes word-stimuli is suitable to explore the control of threatening information and serves as the basis for our hypothesis that health-anxious individuals would demonstrate a similar memory phenomenon for health relevant material. With this in mind, it would still be important in follow-up research to confirm that the stimuli utilized are perceived as threatening to a health-anxious population.

With respect to applications, the present study may contribute to our understanding of the circumstances under which those with health anxiety may or may not demonstrate control impairments. The current study observed participants with low-moderate health anxiety, who demonstrated memory abilities contradictory to those found in previous research that evaluated participants reporting high levels of health anxiety (Ferguson et al., 2007). Therefore, it may be plausible that health anxiety is a predictor of memory ability with regards to inhibiting threatening and/or health relevant information, but it needs to reach a higher level (i.e., SHAI score > 33) to be observed. Additionally, these results suggest that university students within our sample may not experience severe health anxiety, or perhaps they are unsure of how to report their health anxiety. If this is the case, it may be worth considering if university students have the internal awareness to assess their own health anxiety.

This may be an important consideration, as previous research observed that health anxiety has a positive relationship with perceived stressed (Garbóczy et al., 2021); therefore, if participants cannot perceive their internal stress levels accurately, this may lead to misreported health anxiety. An interesting finding of the study conducted by Garbóczy et al. (2021) is that international students reported significantly higher health anxiety and perceived stress levels, compared to local students. Hence, a possible explanation for obtaining an overall lower level of health anxiety is that our sample was composed primarily of local students who may experience lower levels of health anxiety and perceived stressed overall. Although, this study further found a significant sex difference, such that female students (regardless of being international or local) had significantly higher levels of health anxiety compared to males. Hence, it is surprising that we obtained such a low level of health anxiety reported in our current study, as the majority of our participants identified as female (i.e., $n = 37$, E1; $n = 11$, E2). Therefore, it may be interesting for future research to obtain a more diverse sample of participants to compare with the current results.

While not of primary interest, each experiment observed a practice effect (i.e., greater memory for Rp+ than Nrp items) for both the health-related and neutral items. Although not theoretically informative, this demonstrates that participants successfully practiced the Rp+ items, and that this practice improved memory performance for those items. Within Experiment 1, the practice effect observed was numerically larger for the health-related than the neutral items, perhaps suggesting that the associated health items were generating greater competition. For example, perhaps seeing "NEEDLE" led individuals to contemplate the retrieval of additional related targets, such as "nurse" or "hospital." However, while this pattern failed to reach statistical significance; a marginally significant pattern was observed in the opposite direction for Experiment 2. Considering this inconsistent finding, it is difficult to interpret what may have resulted in this pattern – particularly given the low statistical power for Experiment 2 – and more data are required before a firm conclusion can be drawn.

4.1 Methodological Critiques and Limitations

There are several methodological concerns to be considered when interpreting the current findings. Firstly, it appears that our sample of participants were not particularly health-anxious as the mean sum score for both Experiment 1 (i.e., M_{sum} = 29.91) and Experiment 2 (i.e., M_{sum} = 23.27) was on par with what the SHAI-14 would describe as "moderate health anxiety" (i.e., *Sum* = 28-32; Österman et al., 2022; Zhang et al., 2015) and "none to mild health anxiety" (i.e., *Sum* = 0-27; Österman et al., 2022; Zhang et al., 2015). As noted above, it seems plausible that the reduced Health RIF could not be accounted for by health anxiety, as participants in our study did not report as being highly health-anxious (i.e., *Sum* = 33-42 high health anxiety; Österman et al., 2022; Zhang et al., 2015). Supporting this notion, as previous research that observed memory impairments looked specifically at participants diagnosed with an anxiety disorder (e.g., GAD; Kircanski et al., 2016) or scoring above a nominal "high" cut-off measure on health anxiety (Hall et al., 2020).

However, additional variables may moderate or contribute to observing a relationship between health anxiety and poor memory control. For example, Lees et al. (2005) found that high health-anxious individuals did not report significantly greater attentional bias for health-threatening cues compared to a low health-anxious group. Interestingly, the reported levels of anxiety sensitivity *did* significantly determine if greater initial attentional bias was observed for threatening images. Furthermore, previous research demonstrating memory biases have focused on variables such as quicker reaction times when recognizing health words in highly health-anxious participants (Ferguson et al., 2007) or attentional bias for threat pictures in those with heightened anxiety sensitivity (Lees et al., 2005); it is possible that these impairments do not generalize to inhibition or memory control as measured in the current work. Hence, future work could explore this idea by evaluating memory control of salient health-relevant stimuli (e.g., photographs, videos) using an alternative memory control paradigm, such as Think/No-Think or Item-Method Directed Forgetting.

Finally, participants completed the experiment in two parts – starting with a self-report questionnaire on one day and then the RIF paradigm on a different day (i.e., approximately up to two weeks later). While this was done to account for potential fatigue effects and a lack of participant attention being carried over to the RIF task following completion of the questionnaire, it is very possible that the reported health anxiety varied between sessions, contributing to statistical noise and potentially masking any effects. Furthermore, while Experiment 2 was supervised, it was still completed online; therefore, participants were able to complete the experiment from a location of their choosing. It may be possible that the comfort of the environment may have reduced any potential feelings of perceived threat that may have arisen from reading the word, therefore – reducing the potential for health anxiety to interact with the RIF effect. Hence, it remains unclear how participants' perceived health anxiety may impact their memory abilities within the RIF paradigm.

4.2 Future Directions

As the present experiments did not observe statistical support for the hypotheses (i.e., health-related control impairments in health-anxious populations), there are several considerations and questions for future research to address. Firstly, a general population that does not have health anxiety should be evaluated in a RIF task with health-related stimuli to ensure that this phenomenon is specific to health anxiety. As the current study could not attribute any reduction in the magnitude of RIF for the health category to health anxiety, this reduced magnitude may be a general defect among the population; that cannot be predicted by reported health measures. Additionally, previous research has demonstrated that stress can contribute to eliminating the RIF effect (Kossler et al., 2009; 2013), and so future research may wish to evaluate stress as a moderator of this observed phenomena. Additionally, based on previous research, it had been assumed that health-relevant stimuli may be encoded as threatening to those reporting health anxiety; however, this was not actually evaluated.

Hence, a suggestion for future research would be to use a word list that has been rated by health-anxious individuals as threatening or not, to ensure that the stimuli are salient enough to have an impact. This appears plausible, as a study utilizing a recognition memory task found higher hit rates for health-related words, but this effect was mediated by the extent to which the health words were evaluated as emotionally unpleasant (Ferguson et al., 2007). Furthermore, the health words being evaluated as emotionally unpleasant was moderated by individuals reporting higher levels of health anxiety. Therefore, it appears possible that health-relevant material is perceived as unpleasant to the general population but is viewed differently by those reporting higher levels of health anxiety. Accordingly, future research is directed to use stimuli with increased magnitude of presentation (e.g., a video of someone being punctured by a needle instead of seeing the words 'NEEDLE–Puncture'), and that has confirmed to be rated as emotionally unpleasant and threatening by those reporting high health anxiety.

Furthermore, it is of interest that all of the health-relevant measures utilized for this experiment (e.g., GAD-7. PHQ-9), failed to significantly correlate with either the Health or Neutral RIF effects reported in the current study. This is of interest, as previous research evaluating psychological disorders (e.g., depression; Groome & Sterkaj., 2010; social anxiety; Law et al., 2012) has observed significant differences in the magnitude of a RIF effect when individuals are presented with stimuli that are relevant to their disorder. Therefore, we may have experienced potential self-selection bias, in which participants who may have reported high scores on health-relevant measures (i.e., > 33), avoided continuing onto the second portion of the experiment. However, as all participants in this study were psychology students, it may be likely that they have a greater awareness for assessing and treating their poor mental well-being, resulting in them reporting lower scores on the questionnaires assessing psychological disorders compared to students outside of psychology. This possibility is supported by a previous research study (Skead & Rogers 2016), in which law students reported significantly greater psychological distress than psychology students. Hence, other fields (such as law students) may experience higher levels of health anxiety than psychology students. Additionally, as participants in our study were taking part in both experiments from a location of their choice, it is possible they chose a familiar and comfortable location – which may have reduced their perception of threat. If instead the context was made to be similar to that of a hospital or doctor's office, the participants perceived level of threat to the health stimuli, may have been altered. Therefore, context of the environment and how it interacts with perceived threat may be an additional consideration for future research.

4.3 Conclusion

In conclusion, it appears that potential memory control deficits pertaining to health-related information, may not occur in participants reporting low-moderate levels of health anxiety – although it remains possible that a memory deficit to suppress health-related information would be observed amongst participants with higher levels of health anxiety (see Ferguson et al., 2007; Shi et al., 2022). Additionally, the RIF paradigm measures forgetting as a consequence of retrieval, whereas previous research has used memory paradigms focused on remembering. Therefore, it is plausible that health anxiety will impact memory when an individual is attempting to remember health-related information, but not when they are attempting to inhibit or forget about it. Therefore, health anxiety should be evaluated more closely in additional forgetting paradigms (i.e., TNT, IMDF) to gain additional insight to how various levels of health anxiety may be interacting with memory to impact retrieval and suppression abilities.

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Appendix A: Word Lists Used During Experiments 1 and 2

Table A1.

Category-Word Pairs utilized for each Experimental Phase

Experiment 1		Experiment 2	
Learning	Retrieval-Practice	Learning	Retrieval Practice
Card-Deck	Card-De	Card-Deck	Card-De
Card-Spade	Card-Sp	Card-Spade	Card-Sp
Card-Table	Card-Ta	Card-Table	Card-Ta
Card-Letter	Card-Le	Card-Letter	Card-Le
Card-Paper	Card-Pa	Card-Envelope*	Card-En*
Card-Holiday	Card-Ho	Card-Holiday	Card-Ho
Wrap-Envelope	Wrap-En	Wrap-Ribbon*	Wrap-Ri*
Wrap-Gift	Wrap-Gi	Wrap-Gift	Wrap-Gi
Wrap-Package	Wrap-Pa	Wrap-Package	Wrap-Pa
Wrap-Around	Wrap-Ar	Wrap-Around	Wrap-Ar
Wrap-Cover	Wrap-Co	Wrap-Cover	Wrap-Co
Wrap-Shawl	Wrap-Sh	Wrap-Shawl	Wrap-Sh
Bowl-Cereal	Bowl-Ce	Bowl-Cereal	Bowl-Ce
Bowl-Fruit	Bowl-Fr	Bowl-Fruit	Bowl-Fr
Bowl-Spoon	Bowl-Sp	Bowl-Spoon	Bowl-Sp
Bowl-Alley	Bowl-Al	Bowl-Alley	Bowl-Al
Bowl-Game	Bowl-Ga	Bowl-Game	Bowl-Ga
Bowl-Pins	Bowl-Pi	Bowl-Pins	Bowl-Pi
Panel-House	Panel-Ho	Panel-House	Panel-Ho
Panel-Siding	Panel-Si	Panel-Siding	Panel-Si
Panel-Wall	Panel-Wa	Panel-Wall	Panel-Wa
Panel-Group	Panel-Gr	Panel-Group	Panel-Gr
Panel-Jury	Panel-Ju	Panel-Jury	Panel-Ju
Panel-Discussion	Panel-Di	Panel-Debate*	Panel-De*
Ball-Catch	Ball-Ca	Ball-Catch	Ball-Ca
Ball-Throw	Ball-Th	Ball-Throw	Ball-Th
Ball-Play	Ball-Pl	Ball-Play	Ball-Pl
Ball-Dance	Ball-Da	Ball-Dance	Ball-Da
Ball-Gown	Ball-Go	Ball-Gown	Ball-Go
Ball-Music	Ball-Mu	Ball-Music	Ball-Mu
Bark-Tree	Bark-Tr	Bark-Tree	Bark-Tr
Bark-Leaves	Bark-Le	Bark-Leaves	Bark-Le
Bark-Roots	Bark-Ro	Bark-Roots	Bark-Ro
Bark-Dog	Bark-Do	Bark-Dog	Bark-Do
Bark-Fur	Bark-Fu	Bark-Fur	Bark-Fu
Bark-Paw	Bark-Pa	Bark-Paw	Bark-Pa

Patient-Calm	Patient-Ca	Patient-Calm	Patient-Ca
Patient-Kind	Patient-Ki	Patient-Kind	Patient-Ki
Patient-Waiting	Patient-Wa	Patient-Wait*	Patient-Wa
Patient-Illness	N/A	Patient-Illness	N/A
Patient-Nurse	N/A	Patient-Nurse	N/A
Patient-Sick	N/A	Patient-Sick	N/A
Heart-Break	Heart-Br	Heart-Sympathy*	Heart-Sy*
Heart-Love	Heart-Lo	Heart-Love	Heart-Lo
Heart-Giving	Heart-Gi	Heart-Giving	Heart-Gi
Heart-Attack	N/A	Heart-Attack	N/A
Heart-Irregular	N/A	Heart-Irregular	N/A
Heart-Blockage	N/A	Heart-Blockage	N/A
Growth-Expand	Growth-Ex	Growth-Expand	Growth-Ex
Growth-Learn	Growth-Le	Growth-Master*	Growth-Ma*
Growth-Progress	Growth-Pr	Growth-Progress	Growth-Pr
Growth-Cancer	N/A	Growth-Cancer	N/A
Growth-Tumour	N/A	Growth-Tumour	N/A
Growth-Lump	N/A	Growth-Lump	N/A
Needle-Yarn	Needle-Ya	Needle-Yarn	Needle-Ya
Needle-Mitten	Needle-Mi	Needle-Mitten	Needle-Mi
Needle-Sew	Needle-Se	Needle-Sew	Needle-Se
Needle-Inject	N/A	Needle-Inject	N/A
Needle-Pain	N/A	Needle-Pain	N/A
Needle-Puncture	N/A	Needle-Vial*	N/A
Tissue-Clean	Tissue-Cl	Tissue-Clean	Tissue-Cl
Tissue-White	Tissue-Wh	Tissue-White	Tissue-Wh
Tissue-Paper	Tissue-Pa	Tissue-Paper	Tissue-Pa
Tissue-Scar	N/A	Tissue-Scar	N/A
Tissue-Damage	N/A	Tissue-Damage	N/A
Tissue-Torn	N/A	Tissue-Torn	N/A
Spread-Jam	Spread-Ja	Spread-Jam	Spread-Ja
Spread-Bread	Spread-Br	Spread-Bread	Spread-Br
Spread-Toast	Spread-To	Spread-Toast	Spread-To
Spread-Infect	N/A	Spread-Infect	N/A
Spread-Flu	N/A	Spread-Cough*	N/A
Spread-Disease	N/A	Spread-Disease	N/A

Note: "" indicates a changed word-pair from Experiment 1 to Experiment 2. N/A reflects an item that was never tested in the retrieval practice phase (i.e., health-related target items that were always unpracticed).*

Appendix B: Descriptive Statistics of Health Measures for Experiments 1 and 2

Table B1.

Descriptive Statistics for Health Measures for E1

Health Measure	N	Mean	SE
SHAI_SUM	45	29.913	1.139
GAD_SUM	45	17.174	.818
TCAQ_SUM	45	82.152	2.739
PHQ_SUM	45	20.478	.998
PSWQ_SUM	45	59.717	2.050
CRBS_SUM	45	7.000	.441
COVID_FEAR_SUM	45	13.109	.712
OCS_SUM	45	6.326	.437
CAS_SUM	45	5.391	.122

Note: SHAI = Short-Health Anxiety Inventory, GAD = Generalized Anxiety Disorder, TCAQ = Thought Control Ability Questionnaire, PHQ = Patient Health Questionnaire (Depression), PSWQ = Penn-State Worry Questionnaire, CRBS = COVID Reassurance-Seeking Scale, OCS = Obsession with COVID Scale, CAS = COVID Anxiety Scale.

Table B2.

Descriptive Statistics for Health Measures for E2

Health Measure	N	Mean	SE
SHAI_SUM	15	23.267	1.181
GAD_SUM	15	13.333	1.245
TCAQ_SUM	15	74.133	3.415
PHQ_SUM	15	15.857	1.382
PSWQ_SUM	15	47.133	3.293
CRBS_SUM	15	5.733	.431
COVID_FEAR_SUM	15	11.600	1.073
OCS_SUM	15	4.800	.449
CAS_SUM	15	5.200	.145

Note: SHAI = Short-Health Anxiety Inventory, GAD = Generalized Anxiety Disorder, TCAQ = Thought Control Ability Questionnaire, PHQ = Patient Health Questionnaire (Depression), PSWQ = Penn-State Worry Questionnaire, CRBS = COVID Reassurance-Seeking Scale, OCS = Obsession with COVID Scale, CAS = COVID Anxiety Scale.