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Radha Appan
Cleveland State University, radha.appan@gmail.com

Glenn J. Browne
University of Virginia, gbrowne@virginia.edu

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Research Article

Investigating Retrieval-Induced Forgetting During Information Requirements Determination*

Radha Appan
Nance College of Business Administration
Cleveland State University
radha.appan@gmail.com

Glenn J. Browne
McIntire School of Commerce
University of Virginia
gbrowne@virginia.edu

Abstract

Successful systems development requires that appropriate and accurate information be gathered from people who use or will use the system. One critical issue in information gathering is the recall of relevant information by users and other stakeholders. Prior research has shown that users do not recall all the relevant information they have about the requirements for systems, and we suggest that this problem is exacerbated by current systems development practice, in which the same users are often interviewed multiple times by analysts. A potential theoretical explanation for recall failure in requirements determination is the psychological phenomenon known as Retrieval-Induced Forgetting. Retrieval-Induced Forgetting (RIF) theory and empirical findings show that when people are asked to recall information about a situation multiple times, they are likely to recall the same information on subsequent attempts as they recalled on the first attempt (to the exclusion of other relevant information). Although the RIF phenomenon has been investigated in several contexts, such as eyewitness testimony, there have been no studies that have examined the issue in applied contexts such as systems development, in which prior domain knowledge exists and has been learned over a period of time by users and other stakeholders. In the current study, experimental results showed the presence of RIF in both short-term and longer-term information requirements determination (IRD) contexts, thereby providing a memory-based explanation for missing requirements in IRD. Our results have strong implications for the type and sequencing of requirements elicitation techniques and demonstrate threats to both traditional and iterative development methodologies.

KEYWORDS: *Information requirements determination, Retrieval-induced forgetting, Systems development, Recall, Memory, Knowledge elicitation, Joint application development*

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Investigating Retrieval-Induced Forgetting During Information Requirements Determination

1. Introduction

Systems development relies upon appropriate and accurate information provided by users and other stakeholders. A critical input to all systems development activities is stakeholders' ability to recall previously learned information (e.g., Bodart, Patel, Sim, and Weber, 2001; Browne and Ramesh, 2002; Moody, Blanton, and Cheney, 1998). However, even when people are motivated to remember information, recall sometimes fails (MacLeod, 2002). In the current research we investigate failure of users to recall important information during the information requirements determination activity of systems development due to a psychological phenomenon known as Retrieval-Induced Forgetting.

Information Requirements Determination (IRD) consists of a series of iterative activities in which systems analysts acquire an understanding of the problem to be solved and users' needs and expectations for a proposed information system (Davis, 1982; Hickey and Davis, 2004; Vessey and Conger, 1994). For systems to be successful, appropriate and accurate requirements must be gathered. Although analysts seek information from a variety of sources, the primary source of information is people who use or will use the system. Many issues influence the success of IRD efforts, including internal cognitive and motivational factors of users and analysts and external organizational factors. One of the most important factors, and the one on which we focus in the present study, is the ability of users to recall information relevant to the business process being considered (Moody et al., 1998). All systems development efforts, including traditional waterfall models and prototyping and agile development methods, typically involve several iterations of requirements elicitation and thus multiple sessions in which users are asked to recall information (Hickey and Davis, 2004; Hofmann and Lehner, 2001; Moody et al., 1998). However, past research has shown that users often do not recall all the relevant information they have available (e.g., Moody et al., 1998; Watson and Frolick, 1993; Wetherbe, 1991). For this reason, understanding factors that contribute to or inhibit users' ability to recall information is of crucial importance to the success of IRD.

The importance of recall in IRD suggests the need to examine psychological literature that has investigated recall issues. Many studies in human memory have demonstrated that recall of information is selective (Anderson, 2001; Bjork, 1989; Koustaal, Schacter, Johnson, and Galluccio, 1999). Recent research has established that this selective recall of items from memory increases the subsequent memory for those items but is accompanied by a significant cost: forgetting related items not previously recalled (Anderson and McCulloch, 1999; Ciranni and Shimamura, 1999; Cull, Shaughnessy, and Zechmeister, 1996). That is, when a person recalls information or items about an event and is subsequently asked to recall information about the event again, the likelihood of him recalling the same information he recalled before is quite high and the likelihood of him recalling other, related (but previously unrecalled) information is quite low. This phenomenon is referred to as Retrieval-Induced Forgetting (RIF) (Anderson, Bjork, and Bjork, 1994), and has been found to occur in contexts such as memory for autobiographical events (Linton, 1978) and for episodic memory in eyewitnesses (Bjork, 1975; Shaw, Bjork, and Bjork, 1995). However, there has been no research on the potential influence of RIF on recall of information that has been learned over a period of time and for which the person has prior domain knowledge, which is the typical situation in systems development efforts.

The information requirements determination activity in systems development seems particularly vulnerable to the effects of RIF since, as noted, the requirements determination process primarily involves users recalling knowledge in multiple sessions with analysts (Hickey and Davis, 2004; Moody et al., 1998). Thus, it is essential to understand how RIF may impact users' memory for such knowledge. Because of its suppression effects on the recall of information, RIF is a potentially significant threat to the elicitation of requirements and therefore to the success of systems development efforts. The purpose of the current study is to determine whether the problems concerning omission of relevant requirements observed in past research are due at least in part to retrieval-induced forgetting.

The rest of the paper is organized as follows. The next section provides background and theory from the IRD literature and cognitive psychology that underlies this research, as well as the hypotheses of the study. We follow with a description of the methodology used. Next, we present the results of an experiment designed to test the hypotheses. The paper concludes with a discussion of the results and implications for theory and practice.

2. Background

2.1. Information Requirements Determination

IRD is arguably the most important activity of systems development (Davis, 1982; Hickey and Davis, 2004; Vessey and Conger, 1994; Wetherbe, 1991). Faulty and missing requirements from IRD have been identified as a chief cause of systems development failure (Bostrom, 1989; Byrd, Cossick, and Zmud, 1992; Hofmann and Lehner, 2001; Pfleeger, 2001; Telem, 1988; Watson and Frolick, 1993; Wetherbe, 1991). Since IRD occurs early in the systems development process, errors made during this stage magnify and multiply by the end of the process (Boehm, 1981; Byrd et al., 1992; Mittermier, Hsia, and Yeh,1982). A good set of requirements acquired early in the process has the potential to improve the overall quality of the systems development effort and reduce development costs dramatically (Boehm, 1981). However, eliciting appropriate and accurate requirements and understanding human and organizational needs is difficult (Eric, Barbara, and Jimmy, 1977; Juergens, 1977), complex (Davis, 1982), and often poorly understood (Watson and Frolick, 1993).

Research on understanding the IRD process has identified four major sources of difficulties that systems analysts need to address effectively to elicit appropriate and accurate requirements: (i) constraints on humans as information processors (cognitive constraints); (ii) variety and complexity of information requirements; (iii) complex patterns of interaction among users and analysts in defining requirements (communication problems); and (iv) willingness of users to provide requirements (motivational issues) (Davis, 1982; see also Browne and Ramesh, 2002; Byrd et al., 1992; Davidson, 2002; Wetherbe, 1991). While each source of difficulties can cause problems during the IRD process, the present study focuses at a general level on the cognitive constraints on humans as information processors.

Cognitive constraints are fundamental to an individual's difficulty in responding to requests for requirements (Davis, 1982), and they often lead to seriously flawed responses during IRD. Difficulties arise because human cognition is subject to constraints on perception, working memory, and long-term memory (Reisberg, 2005). In the context of IRD, perhaps the most important cognitive constraint that needs to be addressed is users' recall, because users must recall how business processes operate, their relevant experiences involving those processes, and information about the problems they have faced in the past (Moody et al., 1998; Zmud, Anthony, and Stair, 1993). During requirements elicitation, a user is typically exposed to questions (oral or written) intended to prod his or her memory for information relevant to the systems development effort. As noted earlier, the process of requirements elicitation is iterative in nature, and users are generally probed for relevant information using different techniques in multiple sessions over a period of time (Browne and Rogich, 2001; Fisher and Geiselman, 1992; Moody et al., 1998). Although some analysts may be quite skilled in asking questions and probing, and users may be well intentioned in their responses, it is inappropriate to think of the IRD process as a simple matter of a user revealing the contents of his or her memory. For a variety of reasons, users simply do not recall all relevant information. These reasons are detailed in the next section.

2.2. Problems in Recall

Failure to recall pieces of information is attributable to a number of factors. For example, MacLeod (2002) identifies three ways in which problems in recall can arise. First, natural decay of memory traces causes difficulties in recall. Memory traces become fainter over time, particularly those that are not used regularly or those that have been replaced by later cues or tasks (Altmann, 2002). Second, use of inappropriate retrieval cues can lead to appropriately encoded items becoming unavailable for conscious inspection (Johnson, 1994). A cue that leads a user to the wrong "path" to a memory can result in the desired item not being "found" and thus not recalled. A third problem occurs when ambiguously specified retrieval cues cause competition for retrieval between the desired item and related items (MacLeod, 2002; Mensink and Raaijmakers, 1988). That is, general or vague cues may cause several (or many) different memories or associations to become active in memory, and competition for retrieval in limited information processors (humans) causes one or several items to be retrieved and the others to be suppressed. A fourth problem, documented in many studies (e.g., Anderson, Bjork, and Bjork, 1994; Anderson and Spellman, 1995; Saunders and MacLeod, 2006), is that even well-specified cues can cause recall failure due to retrieval of one or more items and suppression of related items. The last two problems, which involve the recall of certain information and the suppression of related information, are the source of Retrieval-Induced Forgetting (Anderson et al., 1994). All of the issues mentioned are of potential importance in IRD and represent significant opportunities for investigation. In the present study we focus on retrieval-induced forgetting. The next section describes this problem in greater detail.

2.3. Retrieval-Induced Forgetting

A given retrieval cue (e.g., a question or statement by a systems analyst) can activate a number of mental representations in a person's mind, thereby causing difficulties in recall (this occurs even with relatively well specified cues due to associative principles in memory). In such cases, retrieval cues access both desired information and potentially useful but currently unwanted information from memory ("unwanted" information does not mean that the information is necessarily unwanted in general, but it is not the precise item the person desires to respond to a particular cue) (MacLeod, 2002). Because of associative principles, the unwanted information is typically related to the desired information. The related but currently unwanted items compete for retrieval with the desired information (MacLeod, 2002), a result of humans' limited information processing capabilities and inability to quickly filter information items in parallel. To recall the appropriate information successfully, human memory suppresses the competing information and retrieves the desired information. However, suppression of related items significantly affects the future recall of those suppressed items. "That is, the task of retrieving certain information can actually impair a person's performance on a future memory task for the unretrieved items" (Shaw et al., 1995, p. 249).[1] Numerous psychological experiments have demonstrated this phenomenon. For example, MacLeod and Macrae (2001) note that remembering where one parked his car in a parking lot typically requires suppression of many other memories of where the person parked his car in the past. RIF is not intentional; rather, it usually evolves from an unintentional process (Anderson and Green, 2001). It is an adaptive mechanism for individuals given the information overload they face on a daily basis, but it can also have undesirable consequences (Macrae and MacLeod, 1999).

The basic operation of RIF can be illustrated in the following way. Figure 1 shows an example of a memory structure for the concept of "Dog" (for simplicity, this example utilizes the hierarchical memory structure theory of human memory (Collins and Loftus, 1975; Collins and Quillian, 1969); however, the operation of RIF is not dependent on which model of memory is assumed (e.g., hierarchical, network, connectionist) (see, e.g., Reisberg, 2005)). The person with this memory structure is relatively knowledgeable about dogs (in the same way someone interviewed for requirements is presumably knowledgeable about business processes). Suppose that he receives a stimulus or cue concerning the herding of animals by dogs, and he retrieves information about Australian Shepherds. Suppose further that he receives additional stimuli within a short period of time that cause him to retrieve the concept of Australian Shepherds again. In subsequent recall attempts responding to the same, similar, or even novel cues, and following a reasonable time interval (e.g., 20 minutes or 24 hours), the person is unlikely to recall information about other herding dogs such as Border Collies or Welsh Sheepdogs because those breeds were suppressed when he previously recalled Australian Shepherds. Similarly, in the context of business processes, an analyst

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[1] The somewhat surprising findings of suppression of related material contrast with theories of priming and associative memory, in which people exposed to a cue are likely to expect information categorically related to that cue and are therefore more likely to recognize or recall it subsequently (Collins and Loftus, 1975; Collins and Quillian, 1969; Loftus and Loftus, 1974; Neely, 1976; Reisberg, 2005; Saunders and MacLeod, 2006). In an important series of RIF experiments utilizing priming, Perfect, Moulin, Conway, and Perry (2002) showed that in cued recall and category-member generation tasks, which require top-down processing, retrieval for related items was impaired (showing RIF) despite the primes. Thus, in semantic and conceptual tasks (e.g., cued recall), such as those in the present experiment, these past results indicate that the negative impacts of RIF overcome any positive effects of priming for subsequent retrieval of related information.

may prompt a user with a question such as the following: "What data do you need to perform this task?" The factual answer to this question may be A, B, and/or C, depending on a variety of causal or contextual factors. However, suppose the user initially remembers and provides only response A. A natural follow-up question from the analyst would be, "Okay, tell me more about A." The user's recall and additional rehearsal of response A suppresses responses B and C. In subsequent recall attempts, the user will likely also provide only response A because B and C were initially suppressed and this suppression remains in the user's memory. These examples illustrate the RIF phenomenon.

Evidence in support of RIF can be found as early as 1900, when Freud proposed that unwanted memories can be forgotten by pushing them into the unconscious, a process he called repression (Freud, 1966). More recently, behavioral and neurobiological research on memory has found that people have executive control processes that operate during memory tasks (Allen, Mahler, and Estes, 1969; Anderson and Green, 2001; Dagenbach and Carr, 1994; Gardiner, Craik, and Bleasdale, 1973; Luria, 1966). Psychological research has shown that these executive control processes allow people to suppress related information (through the process of inhibition) to be able to recall desired information (e.g., MacLeod, 2002; MacLeod and Macrae, 2001; Storm, Bjork, Bjork, and Nestojko, 2006). Neurological research has corroborated the psychological research by showing that patterns of brain activity favor recall of previously considered items and inhibition of related but not previously considered items (for a technical account of the neurological basis of RIF, see Wimber, Bauml, Bergstrom, Markopoulos, Heinze, and Richardson-Klavehn, 2008; see also Norman, Newman, and Detre, 2007).

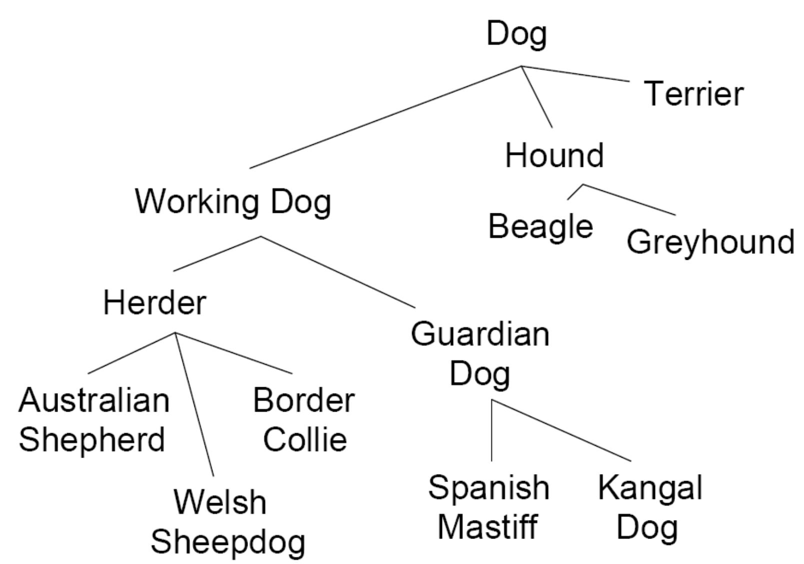

Figure 1: Hierarchical Concept Model

The RIF phenomenon has been demonstrated in a variety of contexts in which people are questioned (Anderson et al., 1994; Anderson and Spellman, 1995; Shaw et al., 1995), particularly in the context of recall for semantic information (Anderson et al., 1994; Blaxton and Neely, 1983; Johnson, 1994). RIF has also been analyzed in the context of recall for recently learned episodic information (Ciranni and Shimamura, 1999; Roediger, 1974; Roediger and Schmidt, 1980), visiospatial materials (Ciranni and Shimamura, 1999), and recall of complex eyewitness events (MacLeod, 2002; Shaw et al., 1995). Long lasting retrieval-based impairment was observed in each of these cases (Anderson and Spellman, 1995), thereby establishing the existence of a general process by which the act of recall reduces access to related memories (Anderson, Bjork, and Bjork, 2000; Dagenbach, Carr, and Barnhardt, 1990; Schooler, Fiore, and Brandimonte, 1997). The findings from the large body of work on RIF can be summarized as follows:

i. Retrieval of certain information facilitates recall of that information subsequently.
ii. Retrieval of certain information leads to suppression of related information and hence to

forgetting of such information during subsequent recall attempts.

iii. Retrieval of unrelated information is better than the retrieval of suppressed related information but worse than the information that was successfully recalled earlier.

However, despite the numerous past studies, RIF-related research focusing on recall of semantic information has not provided a context for the subjects (MacLeod, 2002), and RIF research in the context of eyewitness recall has not accounted for a subject's experience or expertise. The present research extends previous work on RIF by investigating the existence of the phenomenon in a context in which individuals respond to meaningful stimuli and have a reasonable amount of experience.

The RIF phenomenon is particularly important to investigate in IS research because of the importance of recall in the systems development process in general and because of the iterative nature of the IRD process in particular. Due to both motivational (e.g., time and cost) and cognitive (e.g., cognitive constraints, impatience, and boredom) reasons, systems analysts do not conduct exhaustive elicitation sessions with users, and much relevant information is not elicited (Moody et al., 1998; Pitts and Browne, 2004; Wetherbe, 1991). Because the sessions are not exhaustive, analysts generally rely on several iterations of the IRD process with users with the objective of improving understanding of the requirements in each subsequent iteration (Hickey and Davis, 2004). Analysts often attempt initially to gain only a general understanding of the business process and interview users again at a later date for additional details. Analysts also might choose to elicit as much information as required to achieve the current objectives, but over a period of time the objectives may change. Such changes require the analysts to gather additional information and might also cause previously unimportant information to become critical to the development of the system. It is also possible that during the initial elicitation session, the analyst may fail to grasp the complexities of the situation and hence need to return to the users for more detailed information. Finally, agile development methods such as prototyping, scrum, and extreme programming all rely on multiple development phases or mini-projects and thus require analysts to gather requirements and feedback from users on repeated occasions (Baskerville and Pries-Heje, 2004; Paetsch, Eberlein, and Maurer, 2003). All these situations suggest the possibility that users participating in the IRD process may need to recall a variety of information over different periods of time and thus be subject to the effects of the RIF phenomenon.[2]

A second major issue in RIF is the persistence of the phenomenon. That is, does the suppression of related information last, or is it temporary? If it is temporary, the analyst might simply wait a specified period of time to re-interview the users. Recent research has shown that when there is a 24-hour delay between encoding of information and initial retrieval of that information, the RIF phenomenon emerges significantly (MacLeod and Macrae, 2001; Saunders and MacLeod, 2002). In an even stronger demonstration of RIF, Storm, Bjork, Bjork, and Nestojko (2006) showed that RIF persisted after a one-week delay between initial retrieval and final recall. In the context of IRD, both of these conditions typically exist. There is more than a 24-hour gap (and often more than one week) between encoding (learning of the relevant information by users) and initial retrieval (first requirements elicitation session), and there is also more than a 24-hour gap between initial retrieval and final recall (final elicitation session). Therefore, it is important to test whether RIF, if it occurs, is temporary in a requirements determination context.

Research has shown that RIF is a robust phenomenon, and mitigating its impact is difficult. Providing people with a starting point, e.g., with directed questions, and then asking them to elaborate upon their answers is clearly expected to lead to RIF. Thus, we theorize that one way of reducing the likelihood of RIF is to allow people to engage in free recall, without intervention or commentary by the analyst. Therefore, we employ free recall as a control condition in the current study. We return to the

[2] It is important to note that in this research we did not ask an analyst to resolve differences in responses between users. We performed our data collection at the individual level for purposes of experimental control and to establish the existence (or lack thereof) of the RIF phenomenon as an explanation for missing requirements in IRD. Interviewing multiple users, corroborating requirements, and resolving differences *may* mitigate some influences of RIF, a point to which we return in the discussion section.

issue of mitigating RIF in the discussion section.

2.4. Hypotheses

We used the theoretical background discussed above to generate hypotheses. The hypotheses explore the role of RIF in IRD under three conditions with different types of requirements. We elaborate more fully on the conditions and types of requirements in the Methodology section below. The three conditions were as follows:

1. In the first condition, no cues were used to direct the subjects. Subjects engaged in two rounds of free recall sessions to provide relevant requirements. This is referred to as the Control condition.
2. In the second condition, directed questions were used to gather requirements and then participants were given the opportunity to freely recall all relevant requirements. This is referred to as the Immediate Recall treatment condition.
3. In the third condition, directed questions were used to gather requirements, and after a gap of 24 hours participants were given the opportunity to freely recall all relevant requirements.[3] This is referred to as the Delayed Recall treatment condition.

The hypotheses compare the recall for three types of requirements across the three conditions:

1. R+ items – requirements targeted by the directed questions. These requirements were drawn at random from the coding scheme (discussed below).
2. R- items – requirements related to the R+ items but not targeted by the directed questions.
3. Nrp items – requirements unrelated to the R+ and R- items.

The hypotheses appear in Table 1. We now describe each main hypothesis along with a summary of its theoretical justification as discussed in the previous sections. All hypotheses are stated in the alternative form. Please note that Hypotheses 1 and 2 and Hypotheses 3 and 4 are equivalent except that we are testing immediate recall and delayed recall, respectively, in the first and second hypothesis in each pair.

Hypothesis 1 reflects the notion that people who are exposed to certain information in a problem stimulus are more likely to recall that information later and less likely to recall related information that was not previously considered.

> *H1: Recall for R+, R-, and Nrp items will be significantly different for subjects in the Immediate Recall treatment condition.*

Hypothesis 2 examines the validity of this theory when there is a 24-hour gap between retrieval practice and final recall.

> *H2: Recall for R+, R-, and Nrp items will be significantly different for subjects in the Delayed Recall treatment condition.*

Hypothesis 3 reflects the RIF theory positing that people who are initially directed toward certain information (R+ items) through multiple retrieval practices (which is hypothesized to result in suppression of other related items) will recall less related information (R- items) than people who are not initially directed toward any information. No differences are hypothesized for Nrp items (that is, items unrelated to R+ items) since these items are not suppressed during retrieval practices.

> *H3: Recall for R- items will be significantly different for subjects in the Control condition and the Immediate Recall treatment condition. (Subjects in the Control condition will recall more R- items than subjects in the Immediate Recall treatment condition.)*

[3] In addition to following previous literature, noted above, that has investigated RIF using a 24-hour gap (e.g., MacLeod and Macrae, 2001; Saunders and MacLeod, 2002), our choice of this gap was partially for control purposes. Since subjects in our study had classes together and other opportunities to interact, we did not want them discussing the experiment with each other. It is worth noting that this problem would have existed regardless of whether we used a university or an organizational setting for our study.

Table 1. Hypotheses

Hypothesis 1
H1: Recall for R+, R-, and Nrp items will be significantly different for subjects in the Immediate Recall (IR) treatment condition. H1a: Subjects in the IR treatment condition will recall more R+ items than R- items in the free recall stage. H1b: Subjects in the IR treatment condition will recall more R+ items than Nrp items in the free recall stage.
Hypothesis 2
H2: Recall for R+, R-, and Nrp items will be significantly different for subjects in the Delayed Recall (DR) treatment condition. H2a: Subjects in the DR treatment condition will recall more R+ items than R- items in the free recall stage. H2b: Subjects in the DR treatment condition will recall more R+ items than Nrp items in the free recall stage.
Hypothesis 3
H3a: Subjects in the Control condition will recall more R- items during their Control-1 stage than subjects in the IR treatment condition will recall during their free recall stage. H3b: No significant difference will exist between the number of Nrp items recalled by subjects in the IR condition during their free recall stage and Control condition during the Control-1 stage.
Hypothesis 4
H4a: Subjects in the Control condition will recall more R- items during their Control-1 stage than subjects in the DR treatment condition will recall during their free recall stage. H4b: No significant difference will exist between the number of Nrp items recalled by subjects in the Control condition during the Control-1 stage and by subjects in the DR condition during their free recall stage.
Hypothesis 5
H5: Recall for new items will be significantly different for subjects in the Control condition and the treatment conditions. H5a: Subjects in the Control condition will recall more new items (items not recalled during Control-1 stage) during their Control-2 stage than subjects in the IR condition will recall during their free recall stage. H5b: Subjects in the Control condition will recall more new items (items not recalled during Control-1 stage) during their Control-2 stage than subjects in the DR condition will recall during their free recall stage.
Hypothesis 6
H6: Subjects in the Control condition will recall more items during their Control-2 stage than they will recall during their Control-1 stage.
Notes: The following abbreviations are used in the table. For further information, please see Figure 2. R+ = Requirements used as stimulus materials in tasks 1, 3, and 5 (retrieval practice items), i.e., items in the content categories mentioned by the experimenters R- = Other requirements from the categories from which R+ items were selected (during tasks 1, 3, and 5), i.e., items not mentioned in the experimental materials but that were in the same content categories used in tasks 1, 3, and 5 (related items) Nrp = Requirements from the three categories not used during elicitation sessions (tasks 1, 3, and 5) (unrelated items) IR = Immediate recall group. Recall for this group was tested in the same session that included exposure to the experimental information. DR = Delayed recall group. This group's recall of items was gathered 24 hours after the initial exposure to the experimental information. Control-1 = First free recall stage of the control group: Control-2 = Second free recall stage of the control group

Hypothesis 4 investigates the validity of the RIF theory proposed for Hypothesis 3 when there is a 24-hour gap between initial retrieval practice and final recall. Specifically, it examines the theory regarding the transient nature of the RIF phenomenon, that is, whether RIF can affect recall of items over a period of time. If RIF is long lasting (and not transient), then the pattern of results should be similar to that found in H3.

> *H4: Recall for R- items will be significantly different for subjects in the Control condition and the Delayed Recall treatment condition. (Subjects in the Control condition will recall more R- items than subjects in the Delayed Recall treatment condition.)*

Hypothesis 5 reflects the notion that people who are *not* initially directed toward particular information items will recall significantly more information beyond what they originally recalled than people who were initially directed toward certain information items. If this hypothesis is supported, it will provide exceptionally strong support for the consequences of the RIF phenomenon in IRD.

> *H5: Subjects in the Control condition will recall more new items during a second recall opportunity than subjects in the Immediate Recall and Delayed Recall treatment conditions will recall during their free recall opportunity.*

Hypothesis 6 proposes that in the absence of any suppression mechanism, RIF does not occur, and people's recall of some information triggers the recall of other related information.

> *H6: Subjects in the Control condition will recall more items during their second recall opportunity than they recalled during their first recall opportunity.*

3. Methodology

3.1. Subjects

Sixty students in the college of business at a large research university participated in the experiment for course credit.[4] The task for participants involved evoking requirements for a new computer-based system, which is a common task in organizations. In this task, the new system was an online grocery shopping system. The current "system" for grocery shopping was the one familiar to nearly all adults: in-store shopping. The current business processes, such as moving through the store, selecting items for purchase, and checking out, were the same business processes that would be important in the computer-based system. Participants in our study had experience in grocery shopping in stores, and thus with both the current system and the associated business processes. Furthermore, participants had experience in shopping online. (This was indicated by the results of questions on our data collection instrument. Additionally, external evidence corroborates that college students are the heaviest users of the internet in the U.S. (emarketer, 2008) and are extensive online shoppers (Seock and Chen-Yu, 2006).) This allowed them to envision how the current grocery shopping system and processes might be translated into the online environment. In the experimental task, participants were asked to use their knowledge of the existing system and processes to help the analyst design a new system. This is a typical context for requirements determination and systems development in organizations. Thus, our population of participants was appropriate for the task.

3.2. Memory Retrieval Principles

Moody et al. (1998) suggest several principles of memory retrieval that need to be considered during requirements elicitation sessions to help users articulate an appropriate set of requirements. To examine the influence of RIF while controlling for any other phenomena that could affect subjects' ability to recall relevant information, the present study addressed each of these principles while designing and conducting the experiment. The principles and the ways in which they were implemented in the present experiment are summarized in Table 2. Care was taken to ensure that

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[4] This sample size is consistent with numerous studies in the psychology literature concerning RIF. For example, Smith and Hunt (2000) used 48 total subjects with three treatment groups, Saunders and MacLeod (2002) used 100 total subjects with four treatment groups, and Macrae and MacLeod (1999) used 16 subjects in a single-treatment experiment and 32 subjects in a two-treatment experiment. Effect size in our experiment was difficult to predict a priori because our context was novel; thus, we elected to utilize a sample size similar to prior research in RIF.

recall performance was facilitated for all subjects and that outside factors did not influence or harm such performance.

Table 2: Memory Retrieval Principles(adapted from Moody et al., 1998)	
Principle of Memory Retrieval	**Implementation of the Principle in this Study**
Context Re-Creation – Recall is enhanced when the physical and psychological stimuli surrounding the original event are recreated.	Every subject completed the experiment in an executive office and was provided with a detailed explanation of the experimental context and the role he or she was to play.
Focused Concentration – Recall is facilitated by not interrupting the users during a response and by minimizing extraneous noises, gestures, and so forth.	Subjects participated in the experiment one at a time, and each subject sat separately in an office with absolutely no interruption during the experiment. (Pilot studies had revealed that having subjects complete the experiment with more than one subject present reduced the time subjects spent on the experiment and also reduced the number of requirements they provided.) Each subject took at least 40 minutes to complete the entire experiment.
Multiple Retrieval Attempts – Repeated search through memory is likely to improve recall.	Subjects in the treatment conditions participated in three rounds of requirements elicitation tasks focusing on a given set of requirements.
Varied Retrieval and Multiple Representation – Since individuals store information in memory in various formats, using varied cues such as focusing on single item or category-level information will enhance recall.	The three rounds of requirements elicitation tasks employed a variety of cues, such as individual item level questions and category level cues. Subjects' responses ranged from answering questions in detail to rating requirements and providing true or false responses.

3.3. Procedure

An overview of the experiment appears in Figure 2. Subjects were randomly assigned to one of three conditions: Control group, Immediate Recall treatment group, or Delayed Recall treatment group. The stages of the experiment are described in the following paragraphs.

Preliminary Phase: All subjects were first provided with a brief introduction to a supermarket chain called Foodco. The passage explained the increasing competition faced by Foodco and its recent decision to implement an online shopping system whereby customers can do their grocery shopping from home via computer. The passage informed the subject that he or she is a Foodco employee (to ensure that requirements from both the consumer side and the vendor side were considered) who has been asked to help define the requirements for the new online shop-from-home system. The passage concluded by stating that a systems analyst would be administering a survey to the participant to gather relevant information that will help in developing the new online computer system. Narrative scenarios such as these have been used in the few past RIF studies that have not simply used words (such as "red" or "apple") as stimulus materials (e.g., Saunders and MacLeod (2002) used a narrative describing a theft occurring at a house). The Foodco case itself has been used successfully in several past IRD studies (e.g., Browne and Pitts (2004); Browne and Rogich, 2001). The case is appropriate for the college student population because, as noted, students understand both grocery shopping and online shopping well.

Requirements Elicitation Phase: After reading the introductory passage, each subject was given a booklet. The subjects were informed that the booklet contained six timed tasks, some of which related to the introductory passage that they had just read. They were instructed to proceed one task at a time through the booklet. For the Control group, the first task involved a free recall procedure that required subjects to articulate and explain in detail all the information that would be useful in developing the new online grocery shopping system. Tasks 2, 4, and 6 (distractor tasks) consisted of word search exercises (two minutes each) and Tasks 3 and 5 (distractor tasks) consisted of simple anagrams (two minutes each).

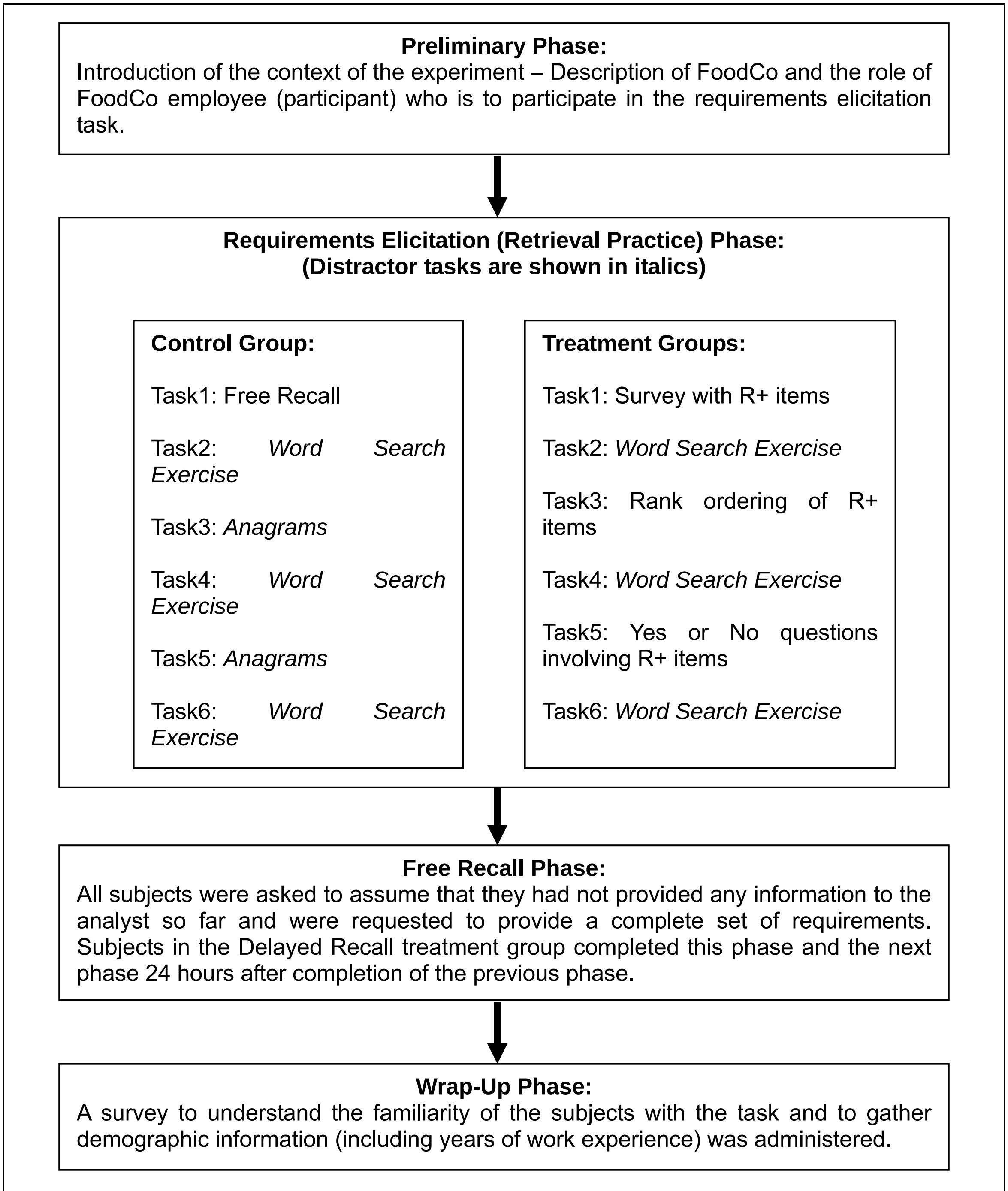

Figure 2: Experimental Procedure

For both treatment groups, the first task consisted of a survey containing 20 directed questions pertaining to the requirements of the new system. The questions were generated from three of the six high-level categories from the coding scheme (discussed below) that were randomly chosen for the purposes of the experiment. The questions were based on half of the items in each of these three categories. The questions for one of the categories from the coding scheme, as well as all items from this category in the coding scheme, are shown in Appendix A. Tasks 2, 4, and 6 (distractor tasks) consisted of word search exercises (five minutes each for Tasks 2 and 4 and 10 minutes for Task 6). Task 3 involved rank-ordering the items used in Task 1 and providing rationale for why the subject thought some requirements were more critical for the proposed system than other information. Task 5 consisted of yes/no questions relating to the same items used in Tasks 1 and 3. None of the questions in Tasks 1, 3, and 5 was misleading or contained inconsistent or wrong information. The distractor tasks were used to ensure that subjects indulged in multiple retrievals of the requirements in the stimulus materials, which is a precondition for the RIF phenomenon. The distractor tasks employed were similar to those used in earlier studies that have examined RIF (e.g., Shaw et al., 1995). The lengths of the distractor tasks were different in the control group and the treatment groups to ensure that 10 minutes occurred between the final retrieval practice (Task 5 in the treatment groups and the first free recall task in the control group) and the final free recall task for all conditions. This allowed us to control for potential incubation effects concerning the requirements across the three conditions. Subjects in all conditions (treatments and control) spent 15-20 minutes on the free recall tasks.

The R+ items (retrieval practice items) discussed above in the hypothesis section were the cues from the content categories mentioned by the experimenters in the directed questions (Task 1) and repeated in Tasks 3 and 5. The requirements content categories (discussed more fully in the coding section below), including those categories used in the treatments and those not used, are shown in Table 3.

Table 3: Requirements Categories

High-Level Requirements Categories	Use in Treatments
I. Data Needed from Customers	R+ items drawn from this category
II. Interface (Information to Provide to Customers)	R+ items drawn from this category
III. Orders	R+ items drawn from this category
IV. Moving Goods to Customers	No items drawn from this category
V. Systems	No items drawn from this category
VI. Reports to Management	No items drawn from this category

Free Recall Phase: For subjects in the Control group and the Immediate Recall group, the final task was a free recall task in which they were asked to write any information they thought would be useful for developing the new online system, irrespective of the information they had provided thus far in the experiment (that is, all subjects were asked just prior to the final recall stage to provide all requirements they could think of regardless of whether those requirements had been discussed before). For subjects in the Delayed Recall treatment group (designed to test whether RIF is long-lasting), the Free Recall phase and the following Wrap-Up phase were administered 24 hours after completion of the Requirements Elicitation phase.

Wrap-Up Phase: The procedure ended with subjects completing a survey about their familiarity with online shopping, their prior online shopping experience, and work experience. There was also a question to ensure that they had not participated in such an experiment or requirements elicitation task before. Additional demographic information was also collected.

3.4. Design

We designed the experiment in the following way. Retrieval practice items (R+) were manipulated between groups (they were provided in the Immediate Recall and Delayed Recall groups, but not the Control group). Requirements were measured for subjects in all three groups and had three levels: retrieval practice items (R+), unpracticed items from the same category as the practiced items (R-), and unpracticed items from categories not used during the requirements elicitation phase (Nrp). For all subjects, the number of items recalled in the free recall tasks served as the dependent measure.

3.5. Coding

The coding scheme used for the present research was developed in a prior study that used the same Foodco task (Browne and Pitts, 2004). Content categories were developed using a task analysis procedure and were validated by five employees at a large regional grocery store chain. The employees' jobs ranged from Chief Information Officer and Vice-President to Data Analyst, and these employees represented a considerable range of experience and expertise within the grocery business. The coding scheme contained six high-level requirements categories (shown in Table 3) and 75 total sub-categories. The full coding scheme is available upon request from the authors and is also available in Browne and Pitts (2004).

This coding scheme was used to code the responses of the subjects to identify R+, R- and Nrp items. One of the researchers coded all of the subjects' responses, and a second independent coder who was unfamiliar with systems development and blind to the hypotheses of the study coded 25 percent of the responses (five subjects from each condition chosen randomly). The two coders agreed on 163 of 171 items across the 15 subjects, for an interrater agreement of .95. This coding was deemed highly reliable. Given this high reliability, we used the codes of the first coder in the analyses. Examples of requirements provided by subjects and the categories into which they were coded are shown in Appendix B.

4. Results

Analyses of the demographic information provided by the subjects revealed that they were highly familiar with online systems (with an average rating of 6.2 on a 7-point scale). The average work experience of the participants was 2.9 years, with a majority (72 percent) of subjects having worked in staff or managerial positions (especially sales, inventory management, or financial management) in retail stores.

We analyzed the data using the analysis of variance (ANOVA) procedure and t-tests. Table 4 presents the mean number of items recalled by members of each group in their free recall stages. Table 5 summarizes the results of the tests (all tests were performed at the $\alpha = .05$ level) and planned comparisons. To test Hypothesis 1, we conducted a single factor (item type: R+, R-, and Nrp) within subject ANOVA on items recalled by members of the Immediate Recall treatment group during their free recall stage. The overall F-test was significant ($F_{(2,57)} = 80.96$; $p < .001$). Contrasts using the Tukey multiple comparison procedure showed that the number of R+ items recalled was significantly greater than the number of R- items recalled, and the number of R+ items was significantly greater than the number of Nrp items. These results support H1a and H1b, providing evidence for the facilitative role of retrieval practice for items recalled earlier. That is, requirements suggested in the earlier stages of the study (Tasks 1, 3, and 5) were more likely to be mentioned by subjects in the free recall stage than requirements not suggested earlier in this treatment group.

To test H2, we performed a one-way ANOVA comparing the three types of items in the Delayed Recall treatment group. The overall F-test was again significant ($F_{(2,57)} = 72.26$; $p < .001$). Contrasts using the Tukey method showed that the number of R+ items was significantly greater than the number of R- items, and that the number of R+ items was significantly greater than the number of Nrp items. Thus, H2a and H2b were supported, suggesting that despite the 24-hour gap between retrieval practice and final recall, retrieval practice facilitated future recall of practiced items.

We tested Hypotheses 3 and 4 using two-sample t-tests intended to ensure that retrieval practice had produced the anticipated effects that are at the core of RIF theory, i.e., (1) decreased likelihood of recalling suppressed items as a result of retrieval practice and (2) lack of significant difference for unsuppressed items for subjects in treatment conditions when compared to those in the Control condition. For H3, the test revealed that subjects in the Control condition (Control-1) recalled significantly more R- items than subjects in the Immediate Recall condition ($t_{(23)} = 6.07$; $p < .001$). These results suggest that free recall does not cause inhibition, but that cued recall does. We also tested whether there were any differences between the two groups in terms of Nrp items recalled. As hypothesized, the difference between the groups was not significant ($t_{(29)} = 1.56$; $p = .13$). Participants in the two groups did not differ in terms of their recall of the categorically unrelated items. Therefore, support was found for H3a and H3b. These results provide strong evidence of the presence of RIF during requirements elicitation. Requirements related to items previously recalled were suppressed by subjects in the Immediate Recall condition and hence were not recalled in their subsequent free recall stage. No such inhibition in recall of related items was found in Control group subjects. Additionally, this inhibition did not extend to items that were unrelated to the categories used in the cued recall procedures in the Immediate Recall group.

Table 4: Mean Number of Items Recalled and Standard Deviations for Control and Treatment Groups

	R+		*R-*		*Nrp*		*Total*
	Mean	SD	Mean	SD	Mean	SD	
IR	6.40	1.64	.95	.89	1.50	1.79	8.85
DR	6.75	2.38	.85	.75	1.35	1.63	8.95
Control-1	4.90	2.57	4.70	2.62	2.80	3.27	12.40
Control-2	7.15	2.80	9.20	4.24	2.70	2.00	19.05

Note: IR = Immediate Recall; DR = Delayed Recall; Control-1 = First Free Recall session in Control condition; Control-2 = Second Free Recall session in Control condition

Table 5: Summary of Results

Hypotheses	Test Employed	Supported/Not Supported
Within Group Comparisons for Treatment Groups		
Group: Immediate Recall (IR)		
H1: IR – Overall Comparisons	One Way ANOVA – $F_{(2,57)} = 80.96$; $p < .001$	Supported
H1a: IR(R+) > IR(R-)	Contrasts using Tukey	Supported
H1b: IR(R+) > IR(Nrp)	Contrasts using Tukey	Supported
Group: Delayed Recall (DR)		
H2: DR – Overall Comparisons	One Way ANOVA – $F_{(2,57)} = 72.26$; $p < .001$	Supported
H2a: DR(R+) > DR(R-)	Contrasts using Tukey	Supported
H2b: DR(R+) > DR(Nrp)	Contrasts using Tukey	Supported
Between Group Comparisons for Control and Treatment Groups		
Groups: Free Recall Session 1 (Control-1) and Immediate Recall (IR)		
H3a: Control-1(R-) > IR(R-)	Two-Sample t-test $t_{(23)} = 6.07$; $p < .001$	Supported
H3b: Control-1(Nrp) = IR(Nrp)	Two-Sample t-test $t_{(29)} = 1.56$; $p = .13$	Supported (Fail to Reject)
Groups: Free Recall Session 1 (Control-1) and Delayed Recall (DR)		
H4a: Control-1(R-) > DR(R-)	Two-Sample t-test $t_{(22)} = 6.33$; $p < .001$	Supported
H4b: Control-1(Nrp) = DR(Nrp)	Two-Sample t-test $t_{(27)} = 1.77$; $p = .09$	Supported (Fail to Reject)
H5: Control-2, IR, DR (New) – Overall Comparisons	$F_{(2,57)} = 52.44$; $p < .001$	Supported
H5a: Control-2(New) > IR (New)	Contrasts using Bonferroni	Supported
H5b: Control-2(New) > DR (New)	Contrasts using Bonferroni	Supported
Within Group Comparisons for Control Group		
Groups: Free Recall Session 1 (Control-1) vs. Free Recall Session 2 (Control-2)		
H6: Control-2(Total) > Control-1(Total)	Paired t-test $t = 4.82$; $p < .001$	Supported

H4 examines whether the results in support of RIF that were found in H3 are temporary or long lasting. A t-test revealed a significant difference between items recalled by subjects in the Control (Control-1) and Delayed Recall conditions ($t_{(22)} = 6.33$; $p < .001$), thereby supporting H4a. Similar to the subjects in the Immediate Recall condition, subjects in the Delayed Recall condition recalled significantly fewer R- items than did subjects in the control condition. Additionally, results showed that there were no significant differences between the recall for the Nrp items in the two groups ($t_{(27)} = 1.77$; $p = .09$). These results support H4b. Together, the results for H4 suggest that RIF during requirements elicitation is long lasting and not temporary. They also provide further support for the contention that the free recall procedure does not lead to RIF during subsequent recall procedures, since the free recall procedure did not cause subjects to suppress any kind of information (as shown in the Control group). That is, this finding provides evidence that the absence of suppression mechanisms during recall procedures prevents RIF. This finding is consistent with prior findings in the RIF literature.

We used a one-way ANOVA to test H5. The overall F-test was significant ($F_{(2,57)} = 52.44$; $p < .001$). Contrasts using the Bonferroni procedure revealed that the number of new items recalled by the Control group was significantly higher than the number of items recalled during the free recall session in both the Immediate Recall group and the Delayed Recall group. Thus, H5a and H5b were supported. These results show that people not directed toward particular information in previous recall sessions will recall more new information than people who are directed toward particular information in previous sessions. This is powerful evidence for the impact of the RIF phenomenon in requirements determination contexts.

H6 examines whether multiple recall sessions that do not involve active suppression of any kind of information improve subsequent recall. Analysis of the data from the two rounds of free recall by subjects in the Control group suggested a significant improvement in the number of items recalled in the second round of recall ($t = 4.82$; $p < .001$). This result suggests that the initial free recall process activates related nodes in memory, which in turn results in higher recall of items during the second recall procedure. These results are consistent with the spreading activation theory of memory, described earlier, in which memory of some information activates related nodes in memory (Collins and Loftus, 1975), and contrast with the findings in our treatment groups. Increased activation of related memory nodes and their subsequent recall in the absence of initial directed cues provides further evidence of the powerful impact of initial directed cues on memory.

5. Discussion

5.1. Implications for Theory

The findings of this study have important theoretical implications for requirements determination, systems development, and the RIF phenomenon. Our results provide support for the general proposition that the success of the iterative requirements elicitation process is vulnerable to RIF. In particular, we have shown that prior requirements elicitation tasks enhance later recall for suggested items (R+) when compared to recall for unrelated items (Nrp) or items bearing a categorical similarity to the suggested items (R-). This leads to reduced recall of requirements by users, and is consistent with findings in other contexts (Anderson et al., 1994; Shaw et al., 1995).

The present study contributes to a theoretical understanding of the strengths and weaknesses of conducting IRD iteratively. Multiple iterations of the IRD process may not be useful if the iterations involve the same set of users. Results of this study suggest the disheartening possibility that previously interviewed users might show poorer recall of some details about a system or business process than users who were not interviewed at all. Since most elicitation efforts are iterative in nature, with analysts interviewing users multiple times, the suppression of future recall because of prior elicitation sessions is a serious potential threat to IRD. Additionally, attempts by analysts to stimulate users' recall using different cues in later iterations are unlikely to help. Psychologists have recently found evidence that recall of suppressed information is not enhanced even with the use of novel cues (referred to as "cue independence"); suppressed information remains suppressed irrespective of the cues used subsequently (Anderson, 2003; Anderson and Green, 2001; Anderson and Spellman, 1995; Bauml, 1998). Further, research has demonstrated that the suppression mechanism can have negative consequences on a memory item's accessibility well beyond the immediate context in which the item was retrieved (Anderson et al., 1994; Anderson and Spellman, 1995; Bauml, 1998). Thus, attempts to spur users to think creatively in subsequent iterations or to imagine themselves in different contexts or environments, as is sometimes recommended, are also likely to be unsuccessful in addressing the problem of RIF. These difficulties are not likely to be considered by most systems analysts. Thus, iterative IRD may benefit substantially from using new sets of users when the objective of iterations is to gather new, additional information.

It may be argued that suppression of some information by users in IRD contexts is desirable, particularly if it concerns details of "as-is" systems. However, although there may be potential benefits of forgetting some details in moving to higher levels of abstraction, there are at least two problems with this notion. First, analysts need to participate in judgments about what is relevant and important in a new system design. Although quantity and quality of requirements are both important, quality is often difficult to assess a priori or in real time, and users therefore should evoke as much relevant information as possible during IRD sessions (Pitts and Browne, 2004). In practice, analysts use various stopping rules based on their reasoning and judgment to limit the quantity of requirements evoked by individual users (Pitts and Browne, 2004). Second, evidence from the RIF literature does not suggest that people will forget only the less important information. Rather, much relevant and important information that is not thought of initially (for various reasons, such as ambiguous cues, cues that lead people to inaccurate information, or simply random selection) will be suppressed. Thus, there are no clear advantages to users forgetting information in this context.[5]

Relatedly, in all systems development projects some requirements are "emergent"; that is, they could not be specified in advance because they emerged through learning and refinement during the development process. These requirements are also threatened by RIF because users who have recalled certain requirements in the past are (as we have shown) less likely to recall requirements related to the previously recalled requirements. Emergence is not a direct function of recall (although it is indirectly, since users must make associations or otherwise use past experiences to apply in the current context), but emerging requirements rely on open-mindedness and creativity on the part of users, and RIF in general reduces information considered and thus theoretically the scope of options users will consider. As noted, it has been shown that novel cues attempting to elicit new information from people are not successful in overcoming RIF (Anderson, 2003; Anderson and Green, 2001; Anderson and Spellman, 1995; Bauml, 1998). Users are thus less able to utilize their full memory store of experiences to recall information that may be valuable in identifying and developing emerging needs.

We have demonstrated the threat to individual users in requirements determination in the current research. In addition, there are implications for reduced "information recall" (Dennis, 1996) in groups of users during Joint Application Development (JAD) sessions. Our results, combined with prior work in RIF, suggest that information initially discussed in JAD sessions will make participants vulnerable to RIF in subsequent recall sessions concerning information requirements. Experiments in "socially shared retrieval-induced forgetting" have demonstrated that people who engage in conversations with others (Coman, Manier, and Hirst, 2009) and who listen to others in conversation (even if they do not actively participate in the conversation) can be subject to RIF by processing the information discussed by others (Cuc, Koppel, and Hirst, 2007). As noted by Cuc et al. (2007, p. 727), "listening to a speaker remember selectively can induce forgetting of related information in the listener." In other words, the same suppression of related (R-) items documented in individual settings has been observed in social settings. Thus, JAD sessions, although highly recommended for the benefits of surfacing and sharing diverse information, are likely to be vulnerable to RIF. Although JAD sessions may appear on the surface to be successful, they may impact participants' recall of related items during subsequent IRD sessions.

[5] The benefits of forgetting information in some contexts have been noted in the psychology literature; e.g., it can be beneficial to forget memories of traumatic events (Anderson, 2001). However, findings in this line of research have been limited primarily to autobiographical events rather than to professional contexts such as requirements determination.

This discussion illustrates the wide-ranging repercussions of RIF in requirements determination. The results from all types of systems development methodologies are threatened, and the phenomenon is a concern for both requirements that are easily specifiable in advance (sometimes referred to as “fixed”) and for requirements that are unknown a priori and emerge during the systems development process. Both people recalling information individually and those participating in or simply listening to conversations with others are vulnerable to RIF.

Our results also contribute to a continuing understanding of the RIF phenomenon. Employment of a control group, which is rarely found in the RIF literature, provides important insights. The number of categorically-related items recalled by subjects in the Control group in the first free recall session (Control-1) and the total number of new items recalled in the second free recall session (Control-2) were significantly higher than that of subjects in the treatment groups. This finding provides even stronger evidence for the presence of the RIF phenomenon in the context of requirements elicitation. Subjects who did not undergo focused retrieval sessions (Control group) did not exhibit any symptoms of RIF and exhibited greater recall in terms of depth of the information recalled while not differing significantly in terms of breadth of the information recalled.

Our results also support the medium-term impact of RIF on recall of knowledge. Our data show that RIF is not temporary, but rather remains a cognitive constraint on recall 24 hours later. The recall of R+ items in the Delayed Recall group was clearly at the expense of memory for related items. This result extends the findings of Saunders and MacLeod (2002) by demonstrating that when there is a delay between encoding and initial retrieval, and between initial retrieval and final recall, the RIF phenomenon continues to affect the recall process. These results suggest that RIF cannot be overcome by simply providing a moderate time interval between two iterations of requirements elicitation.

5.2. Implications for Practice

This study also makes important contributes to IRD practice. To this point in time, the literature on selection of elicitation techniques has been mostly anecdotal and atheoretical (Moody et al., 1998). However, the theory and empirical findings presented here lead to important practical implications. For example, the results of this study demonstrate the utility of open interviews or uncued recall techniques, which have been largely written off in the IRD literature as "incomplete and unstructured" (Byrd et al., 1992, p. 130). Our findings show that multiple iterations of free recall procedures help users in recalling more information than cued recall procedures.

We noted earlier that interviewing several users and resolving differences in requirements provided may also be a strategy for mitigating RIF in requirements determination. This may be accomplished either in a JAD session or in individual one-on-one sessions with users. Both types of sessions theoretically may help if the user group is diverse in terms of its experiences. However, in addition to the problems discussed above concerning JAD sessions, it is worth noting that in any situation with multiple informants, an analyst will need to sift through the requirements provided and use her judgment to make assessments about them. Specifically, she will need to decide whether consistent requirements are consistent because they represent the truth or because all the users recalled the same requirements and suppressed the rest (that is, user responses could be consistent, though incorrect, because of common experiences or due to cognitive biases such as ease of recall (e.g., due to a vivid event that everyone experienced or observed) (Bazerman and Moore, 2009)). Thus, even if the analyst returns to users because she suspects something is amiss in the requirements, or is simply checking for comprehensiveness, she is likely in many instances to remain unaware of various problems. In cases in which inconsistent requirements are provided by users, the analyst will need to decide who is right and whose opinions should be given more weight. If some users are subject to RIF and others are not, the analyst is likely to make mistakes in her judgment. In sum, requirements specifications are at best compromised, and at worst seriously threatened, by RIF. Therefore, while attempting to corroborate requirements and resolve differences with users is a potential mitigation strategy, there is no empirical evidence that it would overcome RIF. Thus, its usefulness is not without potential problems and is currently untested.

Additionally, the findings of this study have implications for agile systems development approaches such as extreme programming, agile modeling, scrum, and adaptive software development (see, e.g., Boehm, 2002). Such methods have increased in popularity over the past few years, and mature use of agile methods may now represent between 15 percent and 25 percent of systems development projects (Norton, 2008).[6] The usefulness of such methods appears limited primarily to small projects with small teams and co-located members (Boehm and Turner, 2003; Reifer, 2002), although some industry surveys suggest that the methods are increasingly being implemented with larger projects.[7] All of the agile techniques rely on short, iterative development processes that require multiple interactions with users over time. For example, the output of extreme programming consists of a series of small releases that pass all the tests the customer or user has defined (Beck, 1999). After each release the customers specify the features desired in the next release. At each release, although customers are reacting to working models of the software, RIF may influence the process because much relevant information may not be recalled by users and thus not be reflected in the feedback analysts receive. Therefore, despite the advantages of extreme programming and similar techniques (e.g., in adaptability to changing requirements), these methodologies are still vulnerable to the influence of RIF. In fact, because of the greater number of iterations with users, if users consistently provide the same information (R+ items) it may lead to increased overconfidence on the part of analysts. Based on the consistency of users' feedback, analysts may believe they have identified the most important requirements and have not missed anything critical (when in fact that may not be the case). Thus, analysts need to adopt strategies to overcome the possible effects of RIF in all types of development methodologies. We address two specific strategies in the next section.

5.3. Mitigating the Effects of RIF

The results of this study extend previous robust findings concerning the prevalence and effects of RIF. Nonetheless, our results suggest one potential technique for reducing the effects of RIF, and existing psycholical literature suggests another potential method.

First, our results have implications for the type and ordering of elicitation techniques. Kendall and Kendall (2010) describe three requirements elicitation ordering techniques that may increase the amount of information elicited. The "pyramid" technique starts with specific questions to a user and moves toward more general questions. The "funneling" technique starts with general questions and moves toward more specific ones. The "diamond" method combines the two approaches, starting with specific questions, moving to general ones, and then moving back to specific ones. The findings in the present research clearly implicate the funneling strategy (similar strategies, also termed "funneling," are used in other disciplines; see, e.g., Waters, Salipante, and Notz, 1978).

We expand on previous descriptions of the funneling strategy based on our findings in the current study. Our results suggest that analysts use a three-stage funneling approach to IRD. In the first stage, to avoid active suppression of relevant information, analysts should use a free recall procedure (or a fundamentally similar technique) during the initial phases of the requirements elicitation process. This practice should lead to a wider range of requirements and should reduce the impact of RIF on the users in subsequent stages of IRD, since the process will involve little or no active suppression of information. Additionally, based on our findings in the present study, multiple free recall sessions lead to a significant increase in the number and variety of items recalled by the users. Multiple free recall sessions during this stage may also reduce RIF in subsequent stages of the IRD process.

In the second stage of the funneling strategy, after the analyst has hopefully gathered a diverse range of requirements, it is important for him to focus on the desired level of depth (particularly suspected R- items) for the various areas identified in the previous session. To obtain in-depth information on each area, it may be beneficial to employ techniques such as cognitive interviews (Fisher, Geiselman, and Amador, 1989; Moody et al., 1998). One of the primary objectives of methods such as cognitive interviews is to encourage subjects to use multiple retrieval routes during recall that

[6] See also, e.g., http://www.methodsandtools.com/dynpoll/oldpoll.php?Agile2..
See ,http://searchsoftwarequality.techtarget.com/news/article/0,289142,sid92_gci1318992,00.html for a somewhat higher estimate.
[7] See, e.g., http://www.versionone.com/AgileSurvey2008/index.asp.

will facilitate in-depth recall of information from memory (Shaw et al. 1995). JAD sessions may also be useful starting in this stage. Use of such techniques may reduce the low rates of recall of R- items observed in the present study.

In the third stage of the funneling strategy, the analyst can shift to more focused techniques such as directed questioning and standardized questionnaires that address specific issues. This will help ensure that any other important information is not left unspecified.

Overall, this funneling strategy is likely to yield a more comprehensive set of system requirements over the full requirements determination process. It is important to note that once users have participated in the second and third stages of the process, they are vulnerable to the RIF phenomenon. Therefore, if an analyst needs a fresh perspective or new information, it will be beneficial to use a different set of users who have not participated in the funneling process.

A second method that may potentially reduce the impact of RIF in requirements elicitation is based on a psychological phenomenon termed “integration” (Anderson and McCulloch, 1999; see also Smith, Adams, and Schorr, 1978). Integration refers to the spontaneous connections, or associations, made in memory between facts relevant to a situation. For example, Anderson and McCulloch (1999) found that instructing subjects in an experiment to make associations between words they were memorizing had some ameliorating effects on RIF. They also speculated using theoretical arguments (e.g., from Smith, Adams, and Schorr, 1978), but did not test, that experts may be less prone to RIF than novices when integration can take place (but note that experts are still subject to RIF, only perhaps less so than novices). This is due to experts being able to encode information into deep and rich knowledge structures (i.e., assimilate into well-developed mental models) and thus to have better recall ability due to the integrated connections within those knowledge structures. (This reasoning is consistent with findings concerning expertise in many disciplines, including information systems; for example, in problem-solving tasks for requirements determination and conceptual modeling, respectively, Schenk, Vitalari, and Davis (1998) and Khatri et al. (2006) showed that people with greater domain knowledge performed better than people with less domain knowledge.) These studies suggest a possible path toward mitigating RIF in requirements elicitation. If an analyst were to suggest to users prior to a free recall session to think holistically about the task, problem, or process being described, and to consider interconnections between facts, episodes, and other information being recalled, some information that otherwise might be suppressed due to RIF may be subsequently available. Further, using domain experts, rather than people only casually familiar with a domain, may also reduce RIF in requirements determination. Although these suggestions are only speculative at this point, they are worth investigating in future research.[8]

5.4. Limitations and Areas for Future Research

Since this is the first study to examine RIF in the context of requirements elicitation, there are some limitations that need to be discussed. However, given the presence of RIF in this context, the limitations of this study can also serve to stimulate further research in the area. To understand whether the comprehensiveness of requirements is threatened by RIF, this research utilized a laboratory task. A laboratory task was needed for adequate control and to manipulate the variables of interest. However, people performing requirements determination tasks in other settings may or may not react in exactly the same way as did our subjects. Thus, replication of this study in an organizational setting, in which a new IS is being developed, could prove useful in further explaining the role of RIF during IRD. Another area of future research concerns the choice of subjects. People in other IRD contexts may have differing levels of experience and/or expertise (they may have more or may have less than our subjects). This could also affect the results obtained. Therefore, as noted in the previous section, examining whether experience and expertise moderate the influence of RIF on the appropriateness and accuracy of requirements gathered could have important implications for

[8] Another strategy for eliciting additional requirements is to use qualitative, ethnographic methods involving extensive interviewing of a relatively small number of users with multiple approaches and question types (see, e.g., Coffey and Atkinson, 1996 for descriptions of such methods). Although such methods have been used in requirements elicitation (e.g., Alvarez and Urla, 2002), their use is not widespread and we do not address them in detail here. Whether our findings would apply with the use of such methods is a question for future research.

strategies on selecting participants for the requirements elicitation task during systems development. Further, the present study used the number of items recalled as a measure of elicitation process success. As noted earlier, both quantity and quality of requirements are important, and more requirements do not necessarily mean better requirements. Often, experts recall less information than novices, but such information tends to be more important (Shanteau, 1992). Therefore, qualitative analyses of the requirements gathered might provide useful and important perspectives to researchers and analysts. Additionally, this study used a 24-hour gap to examine the transient nature of RIF. However, in IRD contexts in organizations, the time duration between multiple iterations of the IRD process is typically longer. Therefore, examining whether RIF persists over longer periods of time would be useful for practicing analysts in developing strategies to overcome this phenomenon. Finally, research on additional strategies for mitigating RIF is necessary.

5.5. Conclusion

This study has shown that Retrieval-Induced Forgetting is one potential cause of unarticulated requirements during systems development. Given the importance of IRD, and the potentially huge costs of missing important requirements, the RIF phenomenon should be acknowledged and managed in systems development efforts. Future research can provide additional insights into this important issue in requirements elicitation.

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Appendix A

Example Questions Asked in Task 1 in Treatment Groups

Information to Provide to Customers

1. What information about the products would you like to provide to the customers?
2. Would you like to provide your customers with a search feature?
3. If you answered yes to question 2, what feature would you like the customer to be able to search by?
4. How can the customers contact Foodco?
5. Would you like to provide information about store locations? If yes, what information would you like to provide?
6. What kind of online promotions would you like to offer?
7. Would you like to send periodic emails to customers with promotions?
8. Would you like to display information about sale items? If yes, how would you like to display that information?

Coding Scheme for "Information to Provide to Customers" Category

A. Product information
  1. Picture of product
  2. Brand name
  3. Size
  4. Unit cost
  5. Price
  6. Nutritional information

B. Locating products
  1. Ability to search by generic product name
  2. Ability to search by actual brand name
  3. Provide map of actual standard store aisles; can choose class of products to browse by clicking on item name on "shelf"

C. Comparison feature allows comparing products on various attributes, such as unit cost

D. When an item is not in stock, have feature that suggests possible substitute products

E. Shopping cart
  1. Have shopping cart feature
  2. Can empty shopping cart at any time
  3. Can remove individual items from cart at any time
  4. Have running total of cost of items in cart available on-screen
  5. Have calculator function available

F. Have recipes available on the website

G. Customers can add notes to order items (e.g., "green bananas")

H. Promotions
  1. Have sale item page that customers can click on from homepage
  2. Have instant coupons available that customers can access and use
  3. Provide promotional items on product pages to increase impulse buying
  4. Send periodic emails to customers with promotions and "click-throughs"

I. Ease-of-use features
  1. Allow customers to set a default order list for themselves (when they log on, these items will already be in their basket)
  2. Provide back buttons and other easy navigational tools
  3. Customer can "save" an order for several days until has time to finish order

J. Locating stores
  1. Have list of store locations so customer can locate closest one
  2. Have closest store helper function—system can prompt customer with closest store based on customer's zip code

K. Contacting vendor
  1. Provide telephone number customers can call to speak with a manager
  2. Have facility so customers can leave feedback about their shopping experiences

Appendix B

Sample Requirements Stated by Subjects	High-Level Category – Item Belonging to that Category - Coding
“Product Listing – contain all information you could get from a store (nutritional facts, size, brand, picture) and cost”	Information to Provide to Customers – Product Information – R+
“Company info – contact info (email, address, phone) store location and hours, phone, address, and map”	Information to Provide to Customers – Contact Vendor – R+ Information to Provide to Customers – Locating Stores – R+
“Product comparison feature”	Information to Provide to Customers – Comparison Feature – R-
“Substitutes for unavailable items”	Information to Provide to Customers – When at item is not in stock, have feature that suggests possible substitute products – R-
“Shipping Page – track your order by # given after payment. Who is doing the shipping?”	Moving Goods to Customers – Order Number and Tracking – Nrp Moving Goods to Customers – Specific Employee Packing Order – Nrp

About the Authors

Radha Appan (Ph.D., Texas Tech University) is an Assistant Professor of Computer and Information Science at Cleveland State University. Her work has been published in or has been accepted for publication in *Decision Support Systems*, *Information and Management*, *International Journal of Information Management*, *Journal of Information Technology and Information Management*, *Management Research Review*, and *Psychology & Marketing*. In addition, she has also published her work in the proceedings of several national and international conferences. Her research interests include strategy and information systems, systems analysis and design, online auction markets, human decision making, and e-commerce related trust issues.

Glenn J. Browne is an associate professor at the McIntire School of Commerce at the University of Virginia. His research focuses on cognitive and behavioral issues in systems development, managerial decision making, and project management. Particular areas of interest include information requirements determination, information search, and stopping rules. He is an associate editor for *Information Systems Research*, and his articles have appeared in *MIS Quarterly*, *Management Science*, *Journal of the Association for Information Systems*, *Journal of Management Information Systems*, *Organizational Behavior and Human Decision Processes*, *Decision Sciences*, *Communications of the AIS*, *International Journal of Electronic Commerce*, and other journals.

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