LEVELS OF PROCESSING EFFECTS ON TEXT MEMORY IN OLDER ADULTS

By

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To my husband, Ted

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Older adults have difficulty remembering details from what they have read. One theory suggests that age-related declines in processing resources may result in deficient encoding of to-be-remembered information. The Levels of Processing framework maintains that the more deeply and elaborately information is encoded, the better it will be retained. One way of increasing depth and elaboration of encoding is by retrieving information from memory. Read-Attentively-Summarize-Review (RASR) is a deep and elaborate study method that incorporates retrieval practice, in the form of paragraph summaries, into study. RASR was compared to a shallower technique involving rereading. Results of recall testing supported the Levels of Processing framework and the influence of prior testing on delayed recall. Participants in the RASR study group remembered significantly more information on immediate and delayed testing but both groups benefitted on delayed recall testing if they had previously received a recall test after studying. On recognition testing, participants remembered significantly more if they had studied, regardless of technique, than if they had not. Together, findings suggest that explicit instruction in deep and elaborate processing

techniques plus additional immediate testing after study may benefit text recall in older adults.

CHAPTER 1
INTRODUCTION

Memory for text information is important, particularly since reading is one of the predominant modes of learning new information as we age (Stanovich, West, & Harrison, 1995). Older adults have difficulty remembering specific information from what they have read (Johnson, 2003) especially when they cannot rely on compensatory strategies such as routines, schemas, and world knowledge (Budd, Whitney, & Turley, 1995; Craik, 1990). One theory is that due to declines in processing resources, older adults are not encoding (instantiating information into memory) efficiently (Nessler, Johnson, Bersick, & Friedman, 2006). According to Craik and Lockhart (1972) memory for information is contingent on how the material to be learned is processed; the more deeply and elaborately material is encoded, the more potential it has to be retrieved. Thus, memory training that emphasizes semantic associations (deep encoding) that are highly integrated (elaborate encoding) will result in potentially greater recall of information (Craik, 2002).

Research demonstrates that older adults recall more information from training that engages depth and elaboration of encoding at the single word level (Bissig & Lustig, 2007; Froger, Taconnat, Landre, Beigneux, & Isingrini, 2008; Lustig & Flegal, 2008) and at the text level (McDaniel, Ryan, & Cunningham, 1989). One technique proposed to enable deeper processing of text information during encoding is the practice of retrieval (S. C. Brown & Craik, 2000). In the young adult literature, practicing retrieval by testing during and after study has been more beneficial for delayed retention of text information than studying alone (Karpicke & Roediger III, 2008; McDaniel, Howard, & Einstein, 2009; Roediger III & Karpicke, 2006a, 2006b).

Retrieval in the form of summarization is a critical component of learning (Karpicke & Roediger III, 2008). Summarization is also an important element in Attentive Reading and Constrained Summarization (ARCS) (Rogalski & Edmonds, 2008), a discourse treatment that has previously demonstrated its potential as a means of increasing lexical retrieval in a gentleman with primary progressive aphasia. The ARCS treatment involves reading small chunks of text and explicitly verbally summarizing them from memory. Reducing the amount of information to be summarized enables more opportunity to highlight specific encoding of information by mitigating some of the resource challenges whole passage summarization might present. Similar to ARCS, Read Attentively Summarize Review (RASR) is a study technique that incorporates retrieval practice in the form of paragraph summarization to engage deeper and more elaborate encoding in older adults. In the current study, RASR was compared to a shallower method of study called Read and Reread Attentively (RARA) that emphasized massed re-readings of text at the paragraph level. Older adults studied unfamiliar expository text passages using either the RASR or the RARA techniques then were assessed on their recall and recognition memory for details.

The purpose of this study was to evaluate 1) the depth and elaboration of encoding effects, as demonstrated in RASR, on delayed recall in older adults; 2) the additional benefit of immediate recall testing after study on subsequent delayed recall memory; and 3) the benefits of encoding depth and additional testing on delayed recognition memory.

CHAPTER 2
BACKGROUND

Review of the Literature

Hierarchical Division of Text: Details vs. Gist

Older adults have difficulty remembering specific information from what they have read (Johnson, 2003). In an increasingly information-driven society, reading affords a way of staying connected to the world and is one of the primary modes through which older adults learn new information (Stanovich, et al., 1995). Remembering specific information becomes critical when the information to be remembered can potentially impact one's well-being. More than ever, health care institutions are using print to disseminate information related to disease prevention, medical conditions, and treatment, and the majority of these documents can be confusing (Wilson & Park, 2008). Older adults are particularly disadvantaged when it comes to remembering ideas from unfamiliar texts (Hartley, 1993) and information-laden texts (Stine & Wingfield, 1990a, 1990b). It could potentially be beneficial then, for older adults to be exposed to training methods that enhance memory of text details.

Text memory is commonly divided into two levels: the text-base and the situation model. The text-base constitutes the meaning or semantic representation of the text which can be divided into idea units or propositions (van Dijk & Kintsch, 1983). For example, "The happy dog played" contains two propositions: "The dog was happy" and "The dog played." The situation model, however, is the interpretation of the text including inference generation, personal and social associations, and prior knowledge and experience integration (van Dijk, 1995). Whereas text-based memory is specifically tied to the text's original meaning (details), the situation model is a generalized subjective construction of propositional meaning integrated with one's associative experience or world knowledge base (gist).

Studies comparing older and young adults' free recall of text information have demonstrated that older adults have poorer text memory for detail-level than for gist-level information (Radvansky, Copeland, & Zwaan, 2003; Radvansky & Dijkstra, 2007; Radvansky, Zwaan, Curiel, & Copeland, 2001). This age-related discrepancy between details and gist has been confirmed using both narrative (Adams, Smith, Nyquist, & Perlmutter, 1997) and expository (informational) genres (De Beni, Borella, & Carretti, 2007; Stine-Morrow, Soederberg Miller, Gagne, & Hertzog, 2008; Tun, 1989; Wingfield & Stine-Morrow, 2000). Within genres, certain text manipulations facilitate recall of details in older adults. Adams (Adams, Labouvie-Vief, Hobart, & Dorosz, 1990) found that older adults remembered more detail-level ideas when narrative texts were fables than when they were non-fables, and Hartley (1993) showed that expository passages with familiar ideas assisted recall more than those with unfamiliar ideas. Across genres, narrative texts facilitate recall more than expository texts, and texts that have fewer ideas aid memory more than those that are densely integrated with ideas (Stine & Wingfield, 1990a, 1990b). In essence, older adults may have poorer detail than gist recall but factors such as text genre, familiarity, and reductions in complexity can facilitate text memory. These patterns of text memory and their influences have been examined in light of age-related declines in processing resources and their subsequent effects on encoding efficiency (memory formation) in older adults.

Processing Resources and Gist Reliance in Older Adults

Craik and colleagues maintain that the resources needed to carry out mental operations decline with age (Craik, Routh, & Broadbent, 1983). It has been hypothesized that older adults' declines in processing resources result in a compensatory shift away from detail encoding toward gist encoding as an adaptive mechanism for allocating resources more efficiently (Adams, 1991; Adams, et al., 1990). Indeed, a common finding is that older adults appear to allocate more attention to situation model processing (gist) than to text-based processing (detail) (Noh, et al., 2007; Stine-Morrow, Gagne, Morrow, & De Wall, 2004) and tend to process text meaning more generally than young adults (McGinnis & Zelinski, 2003). Moreover, older adults are disadvantaged when engaging in memory tasks requiring greater attention and effort, as these tasks will induce increased competition for already limited resources (Craik, et al., 1983). Detail processing is considered more attention-demanding than main point processing because there are fewer opportunities for details to be integrated with the text as a whole during learning (Kintsch & van Dijk, 1978).

Expository texts are thought to place greater demands on working memory than narrative texts because they are less structured and may contain more novel information for which the reader may not have background knowledge (Budd, et al., 1995). Unfamiliar expository passages present even fewer opportunities for integration with world knowledge, thus imparting an even greater resource challenge (Hartley, 1993). Conversely, the familiar, predictable organizational scaffold provided by fables and narratives often facilitates memory (Adams, et al., 1990; Tun, 1989), possibly because fables and narratives are more conducive to situation model construction and provide greater chances for assimilation with a person's world knowledge.

Evidence suggests that encoding for text-based and situation model information is distinct and reliant on different processing systems (Shake, Noh, & Stine-Morrow, 2008;

Stine-Morrow, Shake, Miles, & Noh, 2006). Several studies have proposed that older adults do not allocate resources efficiently to the encoding of text-based information but instead rely on their preserved ability to encode at the situation model level (Noh, et al., 2007; Radvansky & Dijkstra, 2007; Radvansky, et al., 2001; Shake, et al., 2008; Stine-Morrow, et al., 2004; Stine-Morrow, Loveless, & Soederberg, 1996; Stine-Morrow, Soederberg Miller, & Hertzog, 2006; Stine, Cheung, & Henderson, 1995; Zabrucky & Moore, 1994).

Craik (1990) hypothesized that age decrements in memory performance occur when older adults need to initiate, organize and execute processing without the aid of environmental prompts or well-practiced routines. It can be argued that reliance on situation models and world knowledge provides a well-routinized base for remembering text. Yet age-related increases in the strength of over-learned mechanisms and schemas (Craik & Bialystok, 2007) come at a cost to specificity, such that encoding becomes more generalized with age (McGinnis, 2009). Indeed, several studies analyzing single word encoding and recall have reported that older adults encode information more generally than young adults and that retrieval failures result from less distinctive processing at the time of encoding (e.g., Mantyla & Backman, 1990; Mantyla & Craik, 1993; Rabinowitz, Craik, & Ackerman, 1982).

Levels of Processing: Depth and Elaboration of Encoding

According to Craik and Lockhart's "Levels of Processing" theory (1972), the amount of information retained from a task is moderated by the quality of depth of its encoding; deeper semantic or cognitive processing is associated with stronger and more durable retention of information (Craik & Lockhart, 1972). Depth is defined as the type of processing (e.g., semantic processing is deep, phonemic processing is shallow) and elaboration is defined as the degree of enrichment that information is given during encoding (Craik, 2002). Asking a person to judge whether a word belongs to a particular category is an example of deep encoding and asking a person to assess whether a word rhymes with another word is an example of shallow encoding. Older adults' deficits in memory performance have been attributed to insufficient encoding (Friedman, Nessler, & Johnson, 2007; Kausler, 1994). More specifically, older adults are less likely to use deep and elaborate encoding skills during learning (Craik & Jennings, 1992; Perfect & Dasgupta, 1997; Perfect, Williams, & Anderton-Brown, 1995) and are more likely to experience breakdowns in the self-initiation of the processing essential for encoding than young adults (Craik & Jennings, 1992). Neurological evidence suggests that decreases in activation of the left inferior prefrontal cortex may be the cause of older adults' failures to spontaneously use processes which would enrich encoding (Friedman, et al., 2007; Nessler, et al., 2006).

The medial-temporal lobes (MTL) and the lateral prefrontal cortex (PFC) are anatomically distinct but highly functionally connected regions that are recruited during the encoding of verbal materials (W. M. Kelley, et al., 1998; Otten, Henson, & Rugg, 2001; Reber, et al., 2002). The MTL region supports the binding and consolidation of memory while the PFC plays an executive role, directing attention and organizing the information to optimize encoding (Werkle-Bergner, Müller, Li, & Lindenberger, 2006). Both the MTL and the PFC regions experience age-related neuroanatomical changes (Raz & Rodrigue, 2006) where poor memory is directly associated with volumetric reductions in the hippocampal regions and indirectly associated with shrinkage in the prefrontal regions affecting executive control (Head, Rodrigue, Kennedy, & Raz, 2008).

These neuroanatomical changes do not necessarily represent an irreversible loss of frontal activity but in some cases may signify a tendency to under-recruit frontal activation that is nonetheless reversible depending on the depth of the encoding task (Logan, Sanders, Snyder, Morris, & Buckner, 2002; Nessler, et al., 2006). For example, using functional magnetic resonance imaging (fMRI), Logan et al. (2002) observed under-recruitment of frontal regions when older adults used their own methods to encode words during a learning task; however, when these same individuals were instructed to use a deep encoding method (judging whether a word was abstract or concrete), the effect of under-recruitment was reversed. Similarly, Nessler and colleagues' (2006) event-related potential (ERP) study observed that older adults under-recruited prefrontal areas during self-initiated encoding but their memory performance improved when instructed to use deep semantic encoding during training.

The above neuroimaging studies reinforce the "environmental support" hypothesis which maintains that older adults do not spontaneously engage in attentionally-demanding deeper processing during study but are capable of deeper processing when directed to use a strategy (Craik, 1990). Behavioral studies have also demonstrated that older adults have improved recall for single words when given training instructions that engage depth of encoding (Bissig & Lustig, 2007; Froger, et al., 2008; Lustig & Flegal, 2008; Sauzéon, N'Kaoua, Lespinet, Guillem, & Claverie, 2000). Most of the literature on depth and elaboration of encoding has targeted the single word recall. Studies employing depth and elaboration of processing techniques in older adults at the reading passage level are few, and these have yielded inconsistent results (Dixon & von Eye, 1984; Holland & Rabbitt, 1992; Luszcz, 1993; McDaniel, et al., 1989; Simon, Dixon, Nowak, & Hultsch, 1982).

McDaniel et al. (1989) induced elaborative processing in young and older adults by manipulating text passages such that letters were missing from some of the idea units. Though young adults recalled more information overall, both young and older adults recalled significantly more idea units from the deleted condition than from the intact condition on a cued recall test. According to the authors, the elaborate encoding as demonstrated in the letter deletion manipulation afforded older adults a more extensive analysis of the text, thus strengthening retrieval (McDaniel, et al., 1989). In contrast, others have found that letter deletion interfered with recall in older adults (Holland & Rabbitt, 1992; Luszcz, 1993). Holland and Rabbit (1992) found that sentence unscrambling, a task that encourages relational processing, promoted deeper encoding and enhanced recall in older adults.

Other studies have found that older adults do not benefit from deep encoding tasks or only receive a mild advantage over shallow tasks during text level study. Simon et al. (1982) examined the effect of shallow, deep, and intentional encoding on text recall in young, middle aged and older adults. The shallow encoding method entailed reading and circling spelling errors. The two deep tasks involved: 1) rating the interest, organization, readability, and how true-to-life the story was on a 5-point scale; and 2) giving written advice to the story's family members. The shallow and deep tasks were incidental, that is, participants were specifically told they were not required to recall the text. The final task was an intentional learning task where participants were instructed to read and learn the story, knowing that they would be tested on their recall. Simon et al.

reported that young adults benefitted similarly from the deep encoding tasks and the intentional learning condition. Middle aged and older adults, however, received no additional advantage from the deep tasks compared to the shallow task. Moreover, the intentional learning task resulted in superior recall compared to both to the incidental deep tasks and the shallow task. Using the same learning conditions as Simon et al. (1982), Dixon and von Eye (1984) reported that older adults retained slightly more information from the deep tasks compared to the shallow tasks but, similar to Simon et al. (1982), these incidental tasks were inferior compared with the superior retention obtained from the intentional learning condition in which participants were instructed to read and learn the story. Older adults performed similarly to young adults across all conditions but had poorer recall overall.

The inconsistencies across these studies may be attributed to the differences in the task instructions given to participants (intentional verses incidental) and the nature of the deep encoding tasks. Simon et al. (1982) and Dixon and von Eye (1984) reported that intentional learning was superior to incidental learning but these authors did not include an intentional deep encoding task as a comparison. McDaniel et al. (1989) found older adults profited from the deep encoding task in their study, however, the participants understood that their comprehension of the material would be tested after study. It is possible that older adults only benefit from deep encoding during passage study if the task additionally requires intentional learning. Alternatively, the type of deep encoding tasks used in the Simon et al. (1982) and Dixon and von Eye (1984) studies may not have been the most effective to induce deep encoding in older adults. According to Craik and Lockhart (1972), how deep one is able to encode is dependent on the type of material to be processed and the type of processing task. The deep tasks used in these studies may not have encouraged older adults to engage actively enough with the actual text. Older adults are known to process text meaning more generally than young adults (McGinnis, 2009); consequently, tasks such as rating the text and giving advice to family members in the text may have encouraged more general rather than specific processing. Furthermore, tasks such as these may have diverted attention to information beyond the text, instead of highlighting the text-specific ideas to be recalled. Providing methods that encourage the reader to interact with the text can stimulate active processing, which improves memory and learning (Kintsch, 1994).

Retrieval Practice: The Testing Effect, 3-R Training, and ARCS Training

One promising method proposed to enable deeper processing during encoding is the practice of retrieval itself. Retrieval is a critical component of learning (Karpicke & Roediger III, 2008). According to Brown and Craik (2000), "an act of retrieval is likely to be more effective as a second encoding to the extent that the retrieval processes involve deeper, semantic processing operations" (p. 103). Older adults benefit from retrieval practice (Bishara & Jacoby, 2008; Rabinowitz & Craik, 1986; van Dijk & Kintsch, 1983). For example, Bishara and Jacoby (2008) showed that for young and older adults, studying words once and retrieving them twice increased memory for those words more than simply studying them three times without recall practice.

The Testing Effect. The phenomenon that recall practice improves long-term retention more than studying (rereading) is a robust finding known in the young adult literature as "the testing effect" (Roediger III & Karpicke, 2006a). The testing effect has been demonstrated in young adults using expository reading passages (Glover, 1989; Roediger III & Karpicke, 2006b). Roediger & Karpicke (2006b) showed that on immediate testing, participants who had restudied text passages outperformed those who had studied fewer times but had received more testing. This effect was reversed, however, after a one-day and one-week delay; those in the repeated testing group retained more information from the text passages after a delay than those in the repeated study group.

3-R Training. In line with the principles of the testing effect, McDaniel and colleagues (2009) used a Read-Recite-Review (3-R) training method to test the immediate and delayed retention of expository text information in young adults. The 3-R method is a shortened version of “survey, question, read, recite, review” (SQ3R) (Robinson, 1946) that requires the participant to read the entire passage, recite the passage from memory, then read the passage again as a way of receiving feedback. McDaniel et al. reported that compared with rereading and note-taking study methods, the 3-R training was the most efficient method for improving immediate and delayed retention of text on free recall (experiment 1 and 2) and multiple choice testing (experiment 2). Although the benefits of note taking are comparable to the 3-R method, the 3-R method required less time. Compared with rereading alone, the authors suggested that recall practice may engage deeper learning (McDaniel, et al., 2009).

ARCS Training. In older adults, the immediate and long-term effects of text retrieval have not, to this author’s knowledge, been examined. While certain memory training techniques use whole passage recall or summary as one part of their training protocols (Meyer & Poon, 2001; Schmidt, Berg, & Deelman, 2000), these studies do not specifically examine the effects of text retrieval on passage retention. Attentive Reading and Constrained Summarization (ARCS) (Rogalski & Edmonds, 2008), a discourse treatment that also uses summarization as part of its protocol, has demonstrated increased lexical retrieval over the long term in a gentleman with primary progressive aphasia. The original training involves reading and summarizing small units of language (two to three sentences) under a number of constraints. The participant attentively reads several sentences of a text with the intention to summarize them from memory, then during summarization the participant is constrained from using any non-specific language (i.e., pronouns or words such as "thing" or "stuff") or from adding opinion. These constraints were used to promote specific language use and topic maintenance. Similar to other training methods (i.e., Meyer & Poon, 2001; Schmidt, et al., 2000), the ARCS treatment included but did not specifically test the effect of summarization on short- and long-term text recall.

The Present Research Study

The current study examined more closely the role of summarization, as used in the ARCS treatment (Rogalski & Edmonds, 2008) as a deeper and more elaborate means of encoding to improve delayed text-based retention in older adults. "Read Attentively, Summarize, Review" (RASR), is a studying technique that incorporates attentive reading and summarization from the ARCS treatment and review from the 3-R method (McDaniel, et al., 2009). The major components of RASR are outlined below.

Read Attentively. Attentive reading with the intent to summarize is a component of the ARCS treatment that encourages an individual to heighten focus on the material that is to be recalled. Older adults, it has been shown, are less likely to self-initiate the processing necessary for encoding (Craik & Jennings, 1992); accordingly, knowing they will have to recall information from memory may encourage them to pay more attention during the initial reading.

Summarize. The act of retrieval reinstates the mental operations used at encoding (Craik, 1990) thus promoting deeper semantic processing (S. C. Brown & Craik, 2000). Summarization requires attending to the essential elements of the text and ignoring the nonessential elements (Adams, 1991; Ulatowska & Chapman, 1994) and encourages participants to use their own words and phrasing, engaging activation of semantically associated concepts (elaboration) which potentially strengthen retrieval.

Review. In addition to attentive reading and summarization, RASR incorporates review from the 3-R method (McDaniel, et al., 2009). Review provides immediate feedback, which is effective in strengthening information retention (McDaniel & Fisher, 1991; McDaniel, Roediger III, & McDermott, 2007), particularly if responses were previously incorrect (Pashler, Cepeda, Wixted, & Rohrer, 2005).

Focus on the Paragraph. RASR requires participants to focus reading, summarizing and reviewing on paragraph segments of text. Dissecting passages into paragraph-by-paragraph study is not new. In young adults, Del Giorno, Jenkins, and Barker Bausell (1974) compared covert paragraph recitation and review to a rereading study technique and found paragraph recitation to be a superior method for remembering information on immediate and delayed cued recall tests. A subsequent study by Orlando and Hayward (1977), compared three study methods in college students: 1) reading and rereading, 2) paragraph reading, covert recitation, reviewing, and 3) paragraph reading, written recitation, reviewing. The authors reported that both the covert and note-taking recitation methods resulted in better immediate short-answer testing than rereading, but on delayed testing one week later, no significant differences were found between the groups though a comparable trend in means was noted.

Although the limited research on paragraph segmentation in young adults is not entirely supported, there is evidence to suggest that in older adults, focusing attention and summarizing at the paragraph level would be a deeper and more effective method of studying than whole passage study. Reductions in attentional resources are part of normal aging (Craik & Byrd, 1982). This already limited processing capacity is further taxed when older adults are required to retrieve information from memory (Whiting & Smith, 1997). Focusing attention and summarizing at the paragraph instead of the passage level is expected to mitigate some of the resource challenges that older adults might encounter with whole passage summary and highlight more specific, text-based encoding of information. In RASR, the amount of information to be studied differs from the ARCS and the 3-R requirements. ARCS was initially used with an individual with a progressive neurogenic disorder who had difficulty maintaining attention beyond three sentences. A 3-sentence summarization maximum would not be challenging enough for a healthy older adult population and could lead to more rote recital of the information. Conversely, the 3-R training method requires that participants recall whole passages. Whole passage study may encourage less detail processing and more gist processing in older adults, who are known to process information more generally (McGinnis, 2009).

The RASR training method combines elements from the published training techniques, ARCS and 3-R, to examine the effect of depth and elaboration of encoding on long-term retention of text detail in older adults. Unlike most studies examining depth and elaboration of encoding in older adults (Bissig & Lustig, 2007; Froger, et al., 2008; Lustig & Flegal, 2008; Sauzéon, et al., 2000) the current study used text passages rather than single words as study materials. Whereas prior studies assessing text retention in older (Dixon & von Eye, 1984; Simon, et al., 1982) and younger adults (McDaniel, et al., 2009; McDaniel, et al., 2007; Orlando & Hayward, 1977; Roediger III & Karpicke, 2006b), did not standardize the materials to be studied, the passages in the current study were created specifically for the experiment. These passages were closely matched on several criteria including number of words, sentences, paragraphs, propositions (idea units), passives, as well as coherence, level of interest and familiarity (see Chapter 3: Standardization of Stimuli).

Another distinction about the current study compared to past studies (i.e., Dixon & von Eye, 1984; Simon, et al., 1982), is that the deep and shallow study techniques were closely matched. Since RASR involves attentive reading at the paragraph level, it was compared to Read-And-Reread-Attentively (RARA), which instructs participants to read each paragraph three times aloud while paying attention to the details, as though they would be asked to recall the information later on. Whereas RASR requires two readings of the paragraph ("attentive reading" and "review reading") separated by a paragraph summary, RARA entails three successive readings of the paragraph or "massed practice" of the material. Massed practice is known to increase immediate retention but not delayed (Balota, Duchek, & Paullin, 1989). In Roediger and Karpicke's (2006b) comparison of repeated testing verses repeated reading in younger adults, the authors found that repeated reading enhanced short-term recall for expository text passages but repeated testing ensured better long-term retention. Both the RASR and the RARA groups were required to perform all tasks aloud to confirm that they were using the intended technique and were encouraged to study the passages as though they would be tested on them immediately after studying (intentional learning).

Research Aims and Predictions

In summary, older adults have difficulty remembering detailed information from what they have read but their gist memory remains intact. One theory proposes that due to age-related declines in processing resources (Craik, et al., 1983) older adults compensate by relying on more generalized encoding (McGinnis & Zelinski, 2003) that can be more inefficient, especially when recall of specific detail is critical (Nessler, et al., 2006). The Levels of Processing framework (Craik & Lockhart, 1972) maintains that deeper and more elaborate encoding of information results in better long-term retention. Neuroimaging and behavioral studies have shown that older adults do not spontaneously engage in processing that promotes long-term retention of information but are capable of deeper encoding when instructed to use specific strategies (Logan, et al., 2002; Nessler, et al., 2006). Practicing retrieval is one strategy for enhancing encoding and strengthening long-term memory. In younger adults, retrieval practice in the form of recall tests after study (the testing effect) (Roediger III & Karpicke, 2006a, 2006b), or during study (3-R Training) (McDaniel, et al., 2009) yielded greater delayed recall of information than studying alone. Accordingly, older adults would benefit from a structured training program that emphasizes deep and elaborate encoding and incorporates retrieval practice during and after study. Considering these points, the current study had three aims:

Aim 1. The first aim examined the effects of a deep verses a shallow study technique on immediate (3 minute) and delayed (24-hour) text recall in older adults. Read-Attentively-Summarize-Review (RASR), a deeper more elaborate way of encoding text emphasizing attention, summarization and review at the paragraph level was compared to Read-And-Reread-Attentively (RARA), a shallower method of encoding involving rereading at the paragraph level. In accordance with the depth of processing framework (Craik & Lockhart, 1972), the author predicted that depth and elaboration of encoding in RASR would result in greater delayed (24 hour) retention of details than rereading alone (RARA). Since massed practice results in greater short-term than long-term retention (Balota, et al., 1989; Roediger III & Karpicke, 2006b), the author predicted that the RARA group would outperform the RASR group on immediate (3 minute) recall testing but would perform more poorly than the RASR group on delayed (24 hour) testing.

Aim 2. The second aim examined the influence of immediate testing (3 minute) after study on delayed (24-hour) recall of information. Since testing is known to improve performance more than studying alone (the testing effect) (Roediger III & Karpicke, 2006a), the author predicted that studying plus testing would result in better delayed recall of information than studying without testing. Moreover, since RASR involves deeper and more elaborate encoding, the author predicted that the RASR group would recall more information than the RARA group in both conditions: studying plus testing and studying without testing.

Aim 3. The third aim assessed the influence of encoding depth and elaboration, studying plus testing, and studying without testing on delayed (24-hour) recognition memory. The author predicted that the deeper and more elaborate encoding group, RASR, would outperform the RARA group on delayed multiple choice recognition testing. Additionally, the author predicted that both groups would recognize the most information from the studying plus recall testing condition, followed by studying without testing, followed by the single reading (unstudied passages) condition.

CHAPTER 3
STANDARDIZATION OF STIMULI

Background

Memory for text in older adults is facilitated by content familiarity (Hartley, 1993), narrative genre, and reductions in idea density (Stine & Wingfield, 1990a, 1990b). Level of interest in text materials is also a well-established factor in maintaining attention during learning. Thus, when examining learning and text retention in older adults, it is critical that the text stimuli not be confounded by factors that could influence memory. Past studies examining depth of processing in older adults have used narrative passages (Dixon & von Eye, 1984; McDaniel, et al., 1989); however, narratives have a familiar organizational structure that supports integration with world knowledge (Adams, et al., 1990; Tun, 1989) which could influence memory. In young adults, text memory studies have used expository passages from English as a Foreign Language test-preparation books (e.g., McDaniel, et al., 2009; Roediger III & Karpicke, 2006b). The two passages used in these studies contained a similar number of idea units but were not closely matched in length nor were they explicitly matched on any of a number of linguistic variables (e.g., number of sentences, number of idea units per sentence, grammatical complexity etc.). To avoid potential confounds introduced by linguistic factors or content factors such as familiarity, genre, complexity, or interest, a set of reading passages was constructed specifically for the current study then rated for similarity by individuals not participating in the experimental study.

Method

Participants

Twenty participants between 18-70 years old volunteered to rate six passages on a number of criteria. All participants initialed an online consent form. No health or demographic information was collected and responses were anonymous. This survey was approved by the University of Florida Institutional Review Board for social and behavioral research (IRB-02).

Materials

Six passages about unusual animals were created: Raccoon Dog, Velvet Worm, Pistol Shrimp, Bearded Vulture, Portia Spider, and Vampire Squid. Information about the animals was obtained from Google and Wikipedia online searches. Materials were designed to be similar in the number of words, characters, paragraphs, sentences, sentences per paragraph, words per sentence, and characters per word, as well as percentage of passives, Flesch reading ease, and Flesch-Kincaid grade level (obtained in Microsoft Word). They were also similar in number of propositions (idea units), as defined by Turner and Greene (1977) and propositional density, defined as the total number of words divided by the number of propositions (Snowdon, et al., 1996). Propositions and propositional density were obtained automatically using the Computerized Propositional Idea Density Rater, third major version (CPIDR 3) (C. Brown, Snodgrass, Kemper, Herman, & Covington, 2008). CPIDR 3 has demonstrated validity against Turner and Greene's (1977) operational definition of proposition, and against human raters. For means and standard deviations of the above features for all six reading passages, see Table 3-1.

Procedure

Participants used an online survey tool called “Survey Monkey” to rate the six animal passages on a 5-point scale. For each passage, participants were asked the following questions:

- How interesting do you find this passage?
- Before reading this passage, how familiar were you with this animal?
- How complex is this passage in terms of its language?
- How difficult is this passage in terms of understanding its content?
- How coherent is this passage in terms of its “flow” of ideas?

Additionally, participants were asked to rate each animal in comparison to the others given three choices: less interesting than the others, about as interesting as the others, or more interesting than the others.

Results

Of the six passages rated in the online survey, participants rated the Raccoon Dog, the Pistol Shrimp, and the Velvet Worm most similarly. Results of survey ratings are summarized in Table 3-2. Features of the final three passages are summarized in Table 3-3. The final Raccoon Dog, Pistol Shrimp, and Velvet Worm passages are found in Appendices A, B, and C, respectively.

Conclusion

Based on results from survey ratings, the Raccoon Dog, the Pistol Shrimp, and the Velvet Worm passages were chosen as the final experimental stimuli. These passages were rated similarly in terms of interest, familiarity, complexity, comprehension, and coherence. Passages were also similar in number of words, characters, paragraphs, sentences, sentences per paragraph, words per sentence, characters per word, percentage of passives, reading ease, grade level, propositions and propositional density.

Table 3-1. Means and standard deviations (SD) of features for all six reading passages

Feature	Mean	SD	Minimum	Maximum
Words	256.83	3.71	250	260
Characters	1171	19.61	1141	1197
Paragraphs	3	0	3	3
Sentences	21.83	1.33	21	24
Sentences/paragraph	7.27	.43	7	8
Words/sentence	11.77	.70	10.7	12.4
Characters/word	4.38	.12	4.2	4.5
Percentage of passives	8.67	.52	8	9
Flesch reading ease	68.4	1.45	66.7	70.9
Flesch-Kincaid grade level	6.58	.16	6.4	6.8
Propositions	124.50	1.38	123	126
Propositional density*	.48	.01	.47	.49

Table 3-2. Online survey results for final three passages by percentage of participants

Dimensions	Raccoon Dog	Pistol Shrimp	Velvet Worm
Interesting or very interesting	60	65	60
Unfamiliar or very unfamiliar	100	100	100
Clear or very clear language	75	80	75
Easy or very easy to understand content	80	80	95
Coherent or very coherent flow of ideas	90	85	80
Less interesting than the others	31	26	21
About as interesting as the others	53	58	68
More interesting than the others	16	16	11

Table 3-3. Final three passage features

Features	Raccoon Dog	Pistol Shrimp	Velvet Worm
Words	258	265	251
Characters	1216	1266	1183
Paragraphs	3	3	3
Sentences	25	26	21
Sentences/paragraph	8.6	8.6	7
Words/sentence	10.3	10.1	11.9
Characters/Word	4.5	4.6	4.5
Percentage of passives	16	11	14
Flesch reading ease	74	71	71.6
Flesch-Kincaid grade level	5.4	5.8	6.2
Propositions	124	123	124
Propositional density	.48	.46	.49

CHAPTER 4
EXPERIMENTAL METHODS

Participants

Participants included 48 native English speaking healthy older adults (17 male) recruited from the Gainesville Florida and Asheville North Carolina regions. All potential participants were initially interviewed by phone and met strict inclusion and exclusion criteria to determine eligibility for the memory study. Since the purpose of the study was to compare the effects of two different memory training techniques and since the participants would be randomized to two different groups, it was necessary to enforce age and education restrictions to ensure both groups would be similarly matched. Participants were included if they were between 60 – 75 years old. Adults older than 75 years were not included due to expected declines in verbal comprehension after this age (Baltes & Mayer, 1999). Similarly, a minimum of 16 years of education was required in order to reduce potential variability between groups, as lower levels of education can increase the rate of memory decline in older adults (Stern, 2009). Participants were excluded if they had a history of a reading disorder, neurologic or psychiatric illness, and were taking medications affecting memory. Additionally, eligible participants had normal or corrected vision and hearing and scored within age-matched normal limits (minimum 20/39) on the Modified Telephone Interview for Cognitive Status (TICS-M) (de Jager, Budge, & Clarke, 2003), a brief cognitive screen which assesses orientation, memory, attention/calculation, and language. Further, in order for participants' data to be used in the analysis, they needed to score 26/30 or higher on the Montreal Cognitive Assessment (MoCA). The MoCA, a more involved cognitive screen than the TICS-M, was used as a post-hoc measure of general cognitive functioning.

Eligible participants were consented then randomly assigned to the Read-Attentively-Summarize-Review (RASR) or the Read-And-Reread-Attentively (RARA) group. Forty-four participants met all of the inclusion criteria and completed the entire study; three did not complete the study and one did not pass the post-hoc cognitive screen. The final RASR group included 23 older adults (3 left-handed, 6 male) and the final RARA group included 21 older adults (1 left-handed, 11 male). All participants received payment of $15 for their time, whether or not they completed the study. This study was supported by a College of Public Health and Health Professions graduate research grant and was approved by the University of Florida Internal Review Board for social and behavioral research (UFIRB 02).

Demographic, cognitive and ability data for the RASR and RARA groups are found in Table 4-1. Two-tailed t-tests revealed no significant differences between groups in age (RASR: M = 65.87, SD = 4.08; RARA: M = 66.71, SD = 2.80) or education (RASR: M = 18.35, SD = 2.39; RARA: M = 18.76, SD = 2.23). Groups also did not differ significantly on cognitive and ability measures (see below), including cognitive screening (MoCA), Trails A, Trails B, Digit Symbol Substitution, Digit Symbol Copy time, vocabulary, Digits Forwards or Digits Backwards. The RASR group scored significantly higher than the RARA group on Digit Ordering [$t(42) = 2.12$, $p = .04$].

Ratings of physical and psychosocial health are found in Table 4-2. Two-tailed t-tests showed that participants in the RASR group did not differ significantly from those in the RARA group on ratings of general and recent physical health, emotional health, or sleep.

Cognitive and Ability Measures

Montreal Cognitive Assessment. The Montreal Cognitive Assessment (MoCA) (Nasreddine, et al., 2005) is a brief 30 question screen that is a sensitive tool for screening mild cognitive impairment among older adults. The MoCA assesses visuospatial/executive function (e.g., drawing and copying), picture naming, memory (word reading and delayed recall), attention (e.g., read letters and tap with hand at each letter "A"), language (e.g., phrase repetition), abstraction (e.g., similarities between banana and orange = fruit), and orientation (e.g., date, month).

WAIS Vocabulary Test. The Wechsler Adult Intelligence Scale (WAIS) (Wechsler, 1999) vocabulary subtest assesses participants' ability to provide verbal definitions for words of increasing difficulty.

Symbol Digit Modalities Test. The Symbol Digit Modalities Test (SDMT) (Wechsler, 1987) assesses attention and processing speed using two tasks: 1) The Digit Symbol Substitution task requires participants to draw abstract symbols that correspond to numbers presented in a coding key. Participants are given 90 seconds to draw as many symbols as possible. 2) The Digit Symbol Copy task requires that participants copy symbols presented in an upper panel to a lower panel. The outcome measure is the timed completion of the 100 symbols to be copied.

Trail Making Test. Trail Making Test Part A and Part B (Reitan & Wolfson, 1985) is considered a processing speed and attention measure. Participants draw lines sequentially between numbers and letters as quickly as they can. For Part A they draw a line connecting 1 to 2, 2 to 3 and so on until reaching number 25. For Part B they draw a line connecting 1 to A, 2 to B and so on until reaching number 25.

Digit Span. Digit Span Forward and Digit Span Backward (Wechsler, 1987) are tests of working memory ability. Digits Forward tests participants' ability to hear then repeat lists of up to 9 numbers in the same order in which they are given. Digits Backward requires participants to hear then repeat lists of up to 8 numbers in reverse order.

Digit Ordering. Digit Ordering is also a working memory test (Hoppe, Muller, Werheid, Thone, & von Cramon, 2000). Participants hear numbers between 1 and10 that are out of numerical order and are asked to order them from least to greatest.

Materials

Reading Passages. Reading passages were designed expressly for the experimental study (see Chapter 3 and Appendices A, B, and C). An initial propositional count was obtained for each passage using a computer program called "Computerized Propositional Idea Density Rater" (CPIDR) (C. Brown, et al., 2008). Propositions were then checked by the author and all nonessential propositions were removed. A proposition was considered nonessential if the meaning of the text could be understood without it. For example, in the line "These claws help it climb trees so *that* it can hunt birds," the word "that" is not an essential element of the text. Propositions were also added in cases where CPIDR had made an error. Corrections resulted in a final propositional count of 105 propositions per passage against which all participants' recalled information was examined. Of the three final passages, one passage was used as the control (single reading) passage and the two others were used as the study passages.

Multiple Choice. A set of 6 multiple choice questions with 4 alternative choices was devised for each of the three passages. The six questions pertained to six categories of detail. The same categories were used for each of the passages. Categories included one place detail (e.g., “The Raccoon Dog can be found in: China”), one size detail (e.g., “The Pistol Shrimp is about: 2 inches long”), one coloring detail (e.g., The Velvet Worm’s coloring is: orange and brown.”), two behavior details (e.g., “Raccoon Dogs are: monogamous”), and one detail that included a number unrelated to the animal’s size (e.g., Pistol Shrimp live together in colonies of about: 30 members”). Four of the questions included one foil each that was closely associated with the correct answer (e.g., “orange and black” was the foil for the Velvet Worm’s coloring “orange and brown”). One of the questions included a foil that was taken directly from the passage but was not true. For example, the statement “The Pistol Shrimp uses its antennae to:” was presented with two choices: the correct answer “taste and touch” and the foil “stun its prey.” According to the passage, the Pistol Shrimp used its claw, not its antennae, to stun its prey. Finally, one of the questions contained two foils from other passages. For example, the statement “Velvet Worms are:” was presented with the correct answer, “secretive animals,” along with the foil from the Pistol Shrimp passage, “social animals,” and the foil from the Raccoon Dog passage, “monogamous.” Order of the four alternative choices was randomized using an online random number generator. Multiple choice tests are found in Appendices A, B, and C.

Procedure

Session 1, Day 1

All participants individually completed two one-hour sessions, 24 hours apart. During the first session, participants were told that they were taking part in an experiment examining how different study techniques affect memory for reading passages. The examiner explained that during the first session they would see three passages about unusual animals. They would be asked to read one passage a single time and study the two other passages using a particular technique. They would also be tested on their recall of information from two of the passages. During the recall test, participants were encouraged to remember as much detail about the passages as they could without regard to the order. Participants were always given the control passage first, followed by an immediate recall test. The order of testing for the two study passages, however, was counter-balanced across participants. That is, roughly half of the participants in each group were tested following the second passage, and half were tested following the third. The order in which the participant read the Raccoon Dog, Pistol Shrimp, or Velvet Worm passages was also counter-balanced. Participant responses were recorded using a Marantz digital recorder.

Passage 1

Participants were instructed to read the first passage aloud at their own pace. They were told that after reading, they would be given some math problems for three minutes, and would then be asked to recall, verbally, as much detail as they could remember from the passage.

Passage 2

Participants were instructed on how to study the next two passages. The examiner read a script of detailed instructions about the training technique including examples to ensure that participants understood how to perform the task. The scripts for the RASR and RARA groups respectively, are presented below:

Read-Attentively-Summarize-Review (RASR)

> One way of studying information is by summarizing it in your own words. The technique you will be using to study these next two passages is called "Read Attentively, Summarize, Review." First read through the passage one

time aloud at your own pace. Then, read the first paragraph aloud at your own pace. While you are reading, keep in mind that I will ask you to give me a summary of this paragraph from memory. When summarizing, try to use your own phrasing and do not worry about the order of the information. If you cannot remember a particular word, use a phrase to describe the word. For example, if you cannot remember “Boston” you might say “A city in the northeast United States.” When you have finished summarizing the first paragraph, reread the first paragraph to check that you have summarized the information correctly. Continue with the second and third paragraph in the same manner: read attentively, summarize in your own words, then review. After, I may have you complete some math exercises then test your recall.

Read-And-Reread-Attentively (RARA)

One way of studying information is by rereading it. The technique you will be using to study these next two passages is called “Reading and Rereading Attentively” or “RARA.” First read through the passage one time aloud at your own pace. Then, read the first paragraph aloud at your own pace. Read it again two more times, each time paying attention to all of the details in the paragraph. Read it as though I will ask you to recall these details later on. When you have finished reading the first paragraph, continue to study each paragraph of the passage, reading it three times while paying attention to the details. When you are finished I may have you complete some math exercises then test your recall.

Participants were given a sheet of paper with an abbreviated version of the instructions so they could refer to it during the study period. After they had studied the passage, roughly half of the participants were given an immediate test after a 3-minute interval.

Passage 3

Participants studied the third passage in the same manner as the second. If participants did not take the oral recall test after the second passage, they took it after the third passage following a 3-minute interval. At the close of Session 1, participants were asked to try not to discuss the study with anyone and to refrain from looking up more information about the animals in the passages they had studied. They were told that during Session 2 of the study, they would perform some naming, memory, language, and drawing tasks. The examiner then said that she could not presently answer any questions about the study, but after the completion of Session 2 she would be happy to discuss the study and answer any questions then.

Session 2, Day 2

At the beginning of Session 2, participants were asked to recall orally as much detail as they could remember from all three passages: the control passage that was read a single time (single reading condition), the study passage that was tested (study condition) and the study passage that was not tested (study-no-immediate-test condition). They were given multiple choice questions based on each passage, then were tested on the cognitive and ability measures. Finally, participants completed a follow-up questionnaire where they rated each of the three animal passages on level of interest and familiarity. They also rated their quality of physical health, emotional health, and sleep, in general and with regard to the past two days during which they participated in the experiment. After, they were debriefed about the study's purpose and the examiner answered any remaining questions.

Data Preparation and Statistical Analyses

To calculate the amount of time each participant spent studying each passage, recordings from the study sessions were uploaded into Audacity, an audio editor. A research assistant edited out all instances where the examiner could be heard speaking during the study session so the final time recorded was based on participant speaking time alone.

A research assistant, blinded to the study group, transcribed verbatim the oral recall tests from the immediate and delayed retention intervals. The author, also blinded to the study group, analyzed all recall transcripts against the 105 essential propositions in each original passage. Propositions were scored as correct if they included the gist of the original text's propositions (Turner & Greene, 1977). For example, "The Raccoon Dog mates for life" was accepted for "The Raccoon Dog is monogamous." Errors were coded and analyzed separately. Approximately one month after coding, the first author and a research assistant trained in propositional analysis, re-analyzed a randomized 20% of all transcripts. Based on point-to-point comparisons, intra-rater reliability was 95.24% and inter-rater reliability was 90.91%.

Mixed model repeated measures ANOVAs were performed to analyze the between group differences in 1) the number of propositions recalled immediately and after a 24 hour delay, 2) the number of propositions recalled after a delay if participants had received an immediate test after study, and 3) the number of correct answers to multiple choice questions. Statistically significant results are reported along with effect sizes (partial eta squared).

Table 4-1. Participant demographic cognitive and ability data

	RASR $n = 23$		RARA $n = 21$			
	Mean	SD	Mean	SD	*t*	*p*
Age	65.87	4.08	66.71	2.80	.81	.43
Education	18.35	2.39	18.76	2.23	.59	.56
MoCA	27.96	1.40	28.43	1.40	1.12	.27
Trails A (secs)	30.51	9.55	30.28	5.24	.10	.92
Trails B (secs)	63.57	26.09	68.43	24.26	.64	.53
Digit Symbol Substitution Correct	56.87	8.96	57.05	11.40	.06	.95
Digit Symbol Copy Time (secs)	69.57	12.99	68.56	13.16	.26	.80
WAIS Vocabulary (70)	63.96	3.07	62.67	3.68	1.27	.21
Digits Forwards	8.13	2.16	7.95	2.44	.26	.80
Digits Backwards	7.26	2.09	6.71	2.19	.85	.40
Digit Order	17.39	1.99	15.71	3.18	2.12	.04

Table 4-2. Participant self-ratings of general and recent health and psychosocial status

	RASR $n = 23$		RARA $n = 21$			
	Mean	SD	Mean	SD	*t*	*p*
General Physical Health	4.35	.78	4.29	.64	.29	.76
Recent Physical Health	4.26	.86	4.29	.64	.11	.91
General Emotional Health	4.57	.59	4.62	.59	.30	.76
Recent Emotional Health	4.52	.59	4.48	.68	.24	.81
General Sleep Quality	3.65	1.03	3.81	.93	.53	.60
Recent Sleep Quality	3.57	1.24	3.57	1.21	.02	.99

Ratings are based on a 5-point scale, 1 = very poor and 5 = very good. Recent = during Day 1 and 2 of the experiment.

CHAPTER 5
RESULTS

All tests were conducted using an alpha level (two-tailed) of .05.

Group Comparisons of Passage Stimuli and Study Time

Participant ratings of passage stimuli are found in Table 5-1. Participants in both groups were nearly equivalent in their ratings of the Raccoon Dog, Pistol Shrimp, and Velvet Worm passages, as indicated by two-tailed t-tests. On average, participants rated the passages as “interesting” (4 on a 5-point scale) and “very unfamiliar” (1 on a 5-point scale).

Study time for each group was analyzed using a two-tailed t-test. Groups differed significantly [$t(42) = 3.13$, $p < .01$]. The RASR group (M = 483.96 secs, SD = 92.83 secs) spent an average of 1.21 more minutes studying each passage than the RARA group (M = 411.64 secs, SD = 53.27 secs).

Experimental Study Analyses

Analysis 1: Effect of Study Technique on Immediate and Delayed Recall of Propositions

As a reminder, on the first day of the experiment, participants read one passage a single time and were tested on their immediate recall of it. They then studied two passages but were only tested on their immediate recall of one of those passages. On the second day, 24 hours later, participants recalled all three passages. Analysis 1 compared the immediate and delayed recall of the single reading passage to the immediate and delayed recall of one of the passages (the passage that did not receive an immediate test was examined in Analysis 2). The dependent variable was number of propositions recalled by the participant. The total number of propositions available for recall was 105. The three independent variables were group (RASR or RARA), retention interval (immediate: 3 minutes later; or delayed: 24 hours later), and passage condition (single reading or study).

To examine the effect of studying technique on retention of propositions across time, the author used a 2 group (RASR or RARA) by 2 passage condition (single reading or study) by 2 retention interval (immediate or delayed) repeated measures analysis of variance (ANOVA). Means and standard deviations are found in Table 5-2. There were significant main effects of group [$F(1, 42) = 4.38$, $p = .04$, partial $\eta^2 = .09$] and passage condition [$F(1, 42) = 161.60$, $p < .0001$, partial $\eta^2 = .79$] qualified by a group by passage condition interaction [$F(1, 42) = 9.52$, $p < .01$, partial $\eta^2 = .19$] indicating that groups did not differ by the number of propositions recalled after reading a passage a single time, but the RASR group's retention (immediate and delayed) of propositions was superior to the RARA group's for passages they had studied (see Figure 5-1). On closer inspection of the interaction, between-group t-tests verified that the groups did not differ significantly from each other on propositional recall for immediate single reading passages [$t(42) = .98$, $p = .33$] or delayed single reading passages [$t(42) = .19$, $p = .85$]. On studied passages, however, the RASR group immediately recalled approximately 13.66 more propositions than the RARA group [$t(42) = 2.90$, $p < .01$] and recalled an average of 9.71 more propositions than the RARA group after a delay [$t(42) = 2.19$, $p = .03$].

A main effect of retention interval was also found [$F(1, 42) = 145.23$, $p < .0001$, partial $\eta^2 = .78$] and this too was qualified by a retention interval by passage condition interaction [$F(1, 42) = 6.16$, $p = .02$, partial $\eta^2 = .13$]. Not surprisingly, both groups recalled more propositions after immediate testing than after delayed testing and recalled more after studying than after a single reading. There was no interaction between retention interval and group [$F(1, 42) = 1.49$, $p = .23$, partial $\eta^2 = .03$] nor was there an interaction among retention interval, passage condition, and group [$F(1, 49) = .17$, $p = .68$, partial $\eta^2 < .01$]. In sum, contrary to the prediction that the repeated rereading technique of the RARA group would result in greater immediate recall due to a mass practice effect, findings indicated that the RASR group outperformed the RARA group both immediately and after a 24 hour delay on studied passages.

Analysis 2: Effect of Immediate Recall Test on Delayed Recall of Propositions

As noted above, participants studied two passages on the first day, received immediate testing on only one of those passages but recalled both after a 24 hour delay. Analysis 2 compared the delayed recall of the studied passage that received immediate testing (the delayed “study” condition in Analysis 1) to the studied passage that did not. The dependent variable was number of propositions recalled (out of 105 total) by the participant after a delay. The two independent variables were group (RASR or RARA) and testing condition (study-plus-test or study-no-test).

To examine the effect of immediate recall testing after study on propositions recalled after a delay, a 2 group (RASR or RARA) by 2 testing condition (study-plus-test or study-no-test) repeated measures ANOVA was performed. Means and standard deviations are found in Table 5-3. The author found a significant main effect of testing condition [$F(1, 42) = 9.56$, $p < .01$, partial $\eta^2 = .19$], that is, regardless of whether participants studied using the RASR or the RARA method, they remembered more propositions if they had been testing previously on their recall (see Figure 5-2). No between-groups main effect was found [$F(1, 42) = 2.72$, $p = .11$, partial $\eta^2 = .06$] nor was there an interaction between testing condition and group [$F(1, 42) = 1.37$, $p = .25$, partial $\eta^2 = .03$]. Thus, the RASR group did not retain more propositions than the RARA group after a 24 hour delay if they had not received testing after study.

Analysis 3: Effects of Studying Technique and Immediate Recall Testing on Delayed Recognition Testing

On the second day of the experiment, participants completed a 6-question, 4-choice multiple choice test for each of the three passages: the single reading passage, the passage they had studied plus received recall testing, and the passage they had studied but had not received recall testing. The dependent variable was the number of correct answers (out of 6) and the independent variables were group (RASR or RARA) and passage condition (single reading, study-plus-test, or study-no-test).

To examine the effect of study technique and influence of immediate recall testing on delayed recognition memory, a 2 group (RASR or RARA) by 3 condition (single reading or study-plus-test or study-no-test) repeated measures ANOVA was performed. Means and standard deviations are found in Table 5-4. The author found a significant main effect for passage condition [$F(1, 42) = 21.23$, $p < .0001$, partial $\eta^2 = .34$]. On closer inspection, within group paired samples *t*-tests confirmed that both groups recognized significantly more information from the study-plus-test passage than the single reading passage [RASR: paired $t(22) = 5.41$, $p < .0001$; RARA: paired $t(20) = 2.26$, $p = .04$]. Both groups also recognized more information from the study-no-test passage than the single reading passage [RASR: paired $t(22) = 4.54$, $p < .0001$; RARA: paired $t(20) = 2.25$, $p = .04$]. No differences in recognition were found between the study-plus-test and study-no-test passages [RASR: paired $t(22) = 1.42$, $p = .17$; RARA: paired $t(20) = .41$, $p = .69$]. No between groups main effect was found [$F(1, 42) = .07$, $p = .80$, partial $\eta^2 < .01$], nor was there a condition by group interaction [$F(1, 42) = 1.63$, p

= .21, partial η^2 = .04]. Therefore, the RASR group did not outperform the RARA group on multiple choice testing and neither group received any added benefit from receiving a recall test after studying. In sum, performance on multiple choice testing was dependent on whether or not the groups had studied the passages.

Post-Hoc Examination of Errors

Analyses 1 and 2 were based on the number of correct propositions recalled. During recall of the passages, however, participants produced a number of errors. Although no a priori predictions were made regarding errors, a preliminary analysis of errors yielded results that deserve mention. Three types of errors were coded, 1) incorrect information errors (e.g., recalling incorrectly that the Raccoon Dog had 7 pups instead of 5 pups), 2) intrusion errors (recalling information related to the other passages), and 3) commission errors (adding information that was not included in the original passage). The following two analyses paralleled analyses 1 and 2 above except the dependent variables for both were the total number of errors recalled.

Analysis 1: Effect of Study Technique on Immediate and Delayed Recall of Errors

Due to violations of Levene's test of equality of error variances, errors were transformed into square roots then analyzed with a 2 group (RASR or RARA) by 2 passage condition (single reading or study) by 2 retention interval (immediate or delayed) repeated measures ANOVA. The uncorrected error means and standard deviations are found in Table 5-5. A main effect of retention interval was found [$F(1, 42) = 9.00$, $p < .01$, partial η^2 = .18] qualified by a retention interval by passage condition interaction [$F(1, 42) = 6.18$, $p = .02$, partial η^2 = .13]. In the condition where the passage was only read a single time, both groups produced substantially fewer errors on immediate testing and more errors on delayed testing. The low error production on immediate testing is most likely due to an order effect; since the single reading passage was always the first passage recalled and therefore less likely to be affected by intrusion errors from the other passages. For the passages participants had studied, however, there was little change in the number of errors produced during immediate or delayed testing (see Figure 5-3). There was no main effect of group [$F(1, 42) = 2.18$, $p = .15$, partial $\eta^2 = .05$]; no retention interval by group interaction [$F(1, 42) = .46$, $p = .50$, partial $\eta^2 = .01$], no main effect of passage condition [$F(1, 42) = .02$, $p = .90$, partial $\eta^2 < .0001$], no condition by group interaction [$F(1, 42) = .14$, $p = .72$, partial $\eta^2 < .01$], and no retention interval by condition by group interaction [$F(1, 42) = .17$, $p = .69$, partial $\eta^2 < .01$]. Therefore, the RASR and RARA groups did not differ from each other in terms of the number of errors recalled. Instead both groups appeared to have benefitted from studying as the number of errors recalled from studied passages did not increase after a 24 hour delay.

Analysis 2: Effect of Immediate Recall Test on Delayed Recall of Errors

Errors were examined using square root transformations submitted to a 2 group (RASR or RARA) by 2 testing condition (study-plus-test or study-no-test) repeated measures ANOVA. The uncorrected error means and standard deviations are found in Table 5-6. The author found no main effect of testing condition [$F(1, 42) = .67$, $p = .42$, partial $\eta^2 = .02$] or group [$F(1, 42) = 1.73$, $p = .20$, partial $\eta^2 = .04$] and no condition by group interaction [$F(1, 42) = .11$, $p = .74$, partial $\eta^2 = < .01$]. Thus, neither study technique nor testing after studying had an influence on the number of errors produced during delayed recall.

Table 5-1. Participant interest and familiarity ratings of passages

	RASR *n* = 23		RARA *n* = 21			
	Mean	SD	Mean	SD	*t*	*p*
Level of Interest						
Raccoon Dog	4.17	1.23	4.29	.85	.35	.73
Pistol Shrimp	4.04	1.22	4.33	1.02	.85	.40
Velvet Worm	4.17	1.11	4.38	.74	.72	.48
Level of Familiarity						
Raccoon Dog	1.09	.29	1.05	.22	.51	.62
Pistol Shrimp	1.13	.34	1.05	.29	.94	.35
Velvet Worm	1.09	.29	1.05	.22	.51	.62

Ratings are based on a 5-point scale, 1 = very uninteresting or very unfamiliar and 5 = very interesting or very familiar

Table 5-2. Group proposition means and standard deviations (SD) for immediate (IMM) recall and delayed (DEL) recall across passage conditions

Passage Condition	Retention Interval	RASR *n* = 23		RARA *n* = 21			
		Mean	SD	Mean	SD	*t**	*p**
Single Reading	IMM	33.13	11.96	30.10	8.06	.98	.33
	DEL	18.48	12.12	17.86	9.17	.19	.85
Study	IMM	61.04	14.98	47.38	16.29	2.90	<.01
	DEL	41.04	12.76	31.33	16.53	2.19	.03

Maximum score = 105; IMM = 3 mins; DEL = 24 hrs

Table 5-3. Group proposition means and standard deviations (SD) for delayed recall (DEL) across testing conditions

Testing Condition	Retention Interval	RASR *n* = 23		RARA *n* = 21			
		Mean	SD	Mean	SD	*t**	*p**
Study-Plus-Test*	DEL	41.04	12.76	31.33	16.53	2.19	.03
Study-No-Test	DEL	31.52	16.12	27.05	18.61	.86	.40

Maximum score = 105; DEL = 24 hrs

*Means and SD are from the delayed recall test of the study condition (Study DEL) in Table 5.2.

Table 5-4. Group means and standard deviations (SD) for delayed multiple choice testing across passage conditions

Passage Condition	Retention Interval	RASR n = 23		RARA n = 21			
		Mean	SD	Mean	SD	t*	p*
Single Reading	DEL	3.74	1.25	4.19	1.37	.58	.26
Study-Plus-Test	DEL	5.22	.90	5.05	1.07	.57	.52
Study-No-Test	DEL	5.00	1.09	4.90	1.04	.30	.77

Maximum score = 6; DEL = 24 hrs

Table 5-5. Group error means and standard deviations (SD) for immediate (IMM) recall and delayed (DEL) recall across passage conditions

Passage Condition	Retention Interval	RASR n = 23		RARA n = 21			
		Mean	SD	Mean	SD	t*	p*
Single Reading	IMM	1.30	1.40	1.95	2.16	1.19	.25
	DEL	4.52	7.88	6.52	10.63	.71	.48
Study	IMM	1.91	1.91	3.33	4.51	1.34	.19
	DEL	2.00	1.86	2.90	3.59	1.06	.29

IMM = 3 mins; DEL = 24 hrs

Table 5-6. Group error means and standard deviations (SD) for delayed (DEL) recall across testing conditions

Passage Condition	Retention Interval	RASR n = 23		RARA n = 21			
		Mean*	SD	Mean	SD	t*	p*
Study-Plus-Test*	DEL	2.00	1.86	2.90	3.59	1.06	.29
Study-No-Test	DEL	2.48	2.73	4.67	5.89	1.56	.13

DEL = 24 hrs

*Means and SD are from the delayed recall test of the study condition (Study DEL) in Table 5-5.

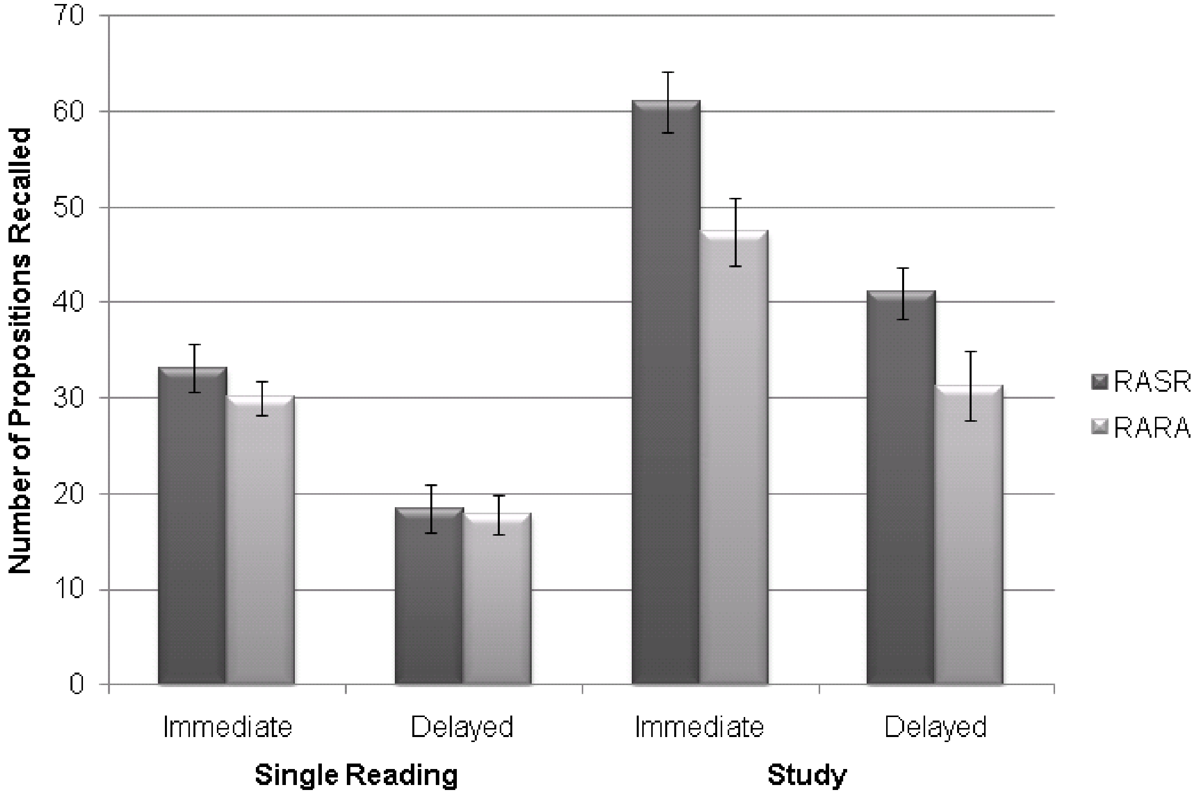

Figure 5-1. Propositions recalled at immediate and delayed retention intervals across single reading and study passage conditions. On paragraphs that were not studied, the two groups did not differ in recall at either time point. However, the RASR study group recalled more propositions at both immediate and delayed time points than the RARA study group. Both groups also remembered more propositions from the study condition than the single reading condition.

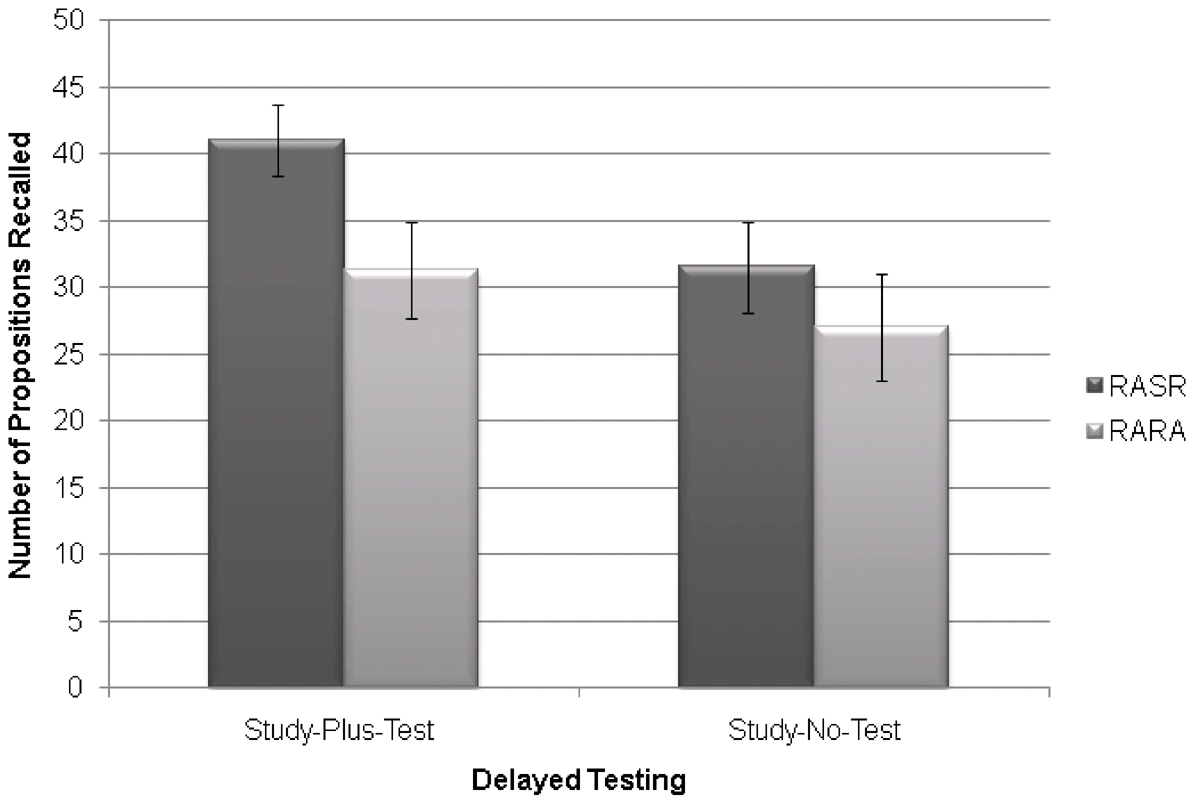

Figure 5-2. Propositions recalled after a delay for studied passages with and without immediate testing. Passages that had been tested immediately after study were recalled better after a delay, regardless of study type.

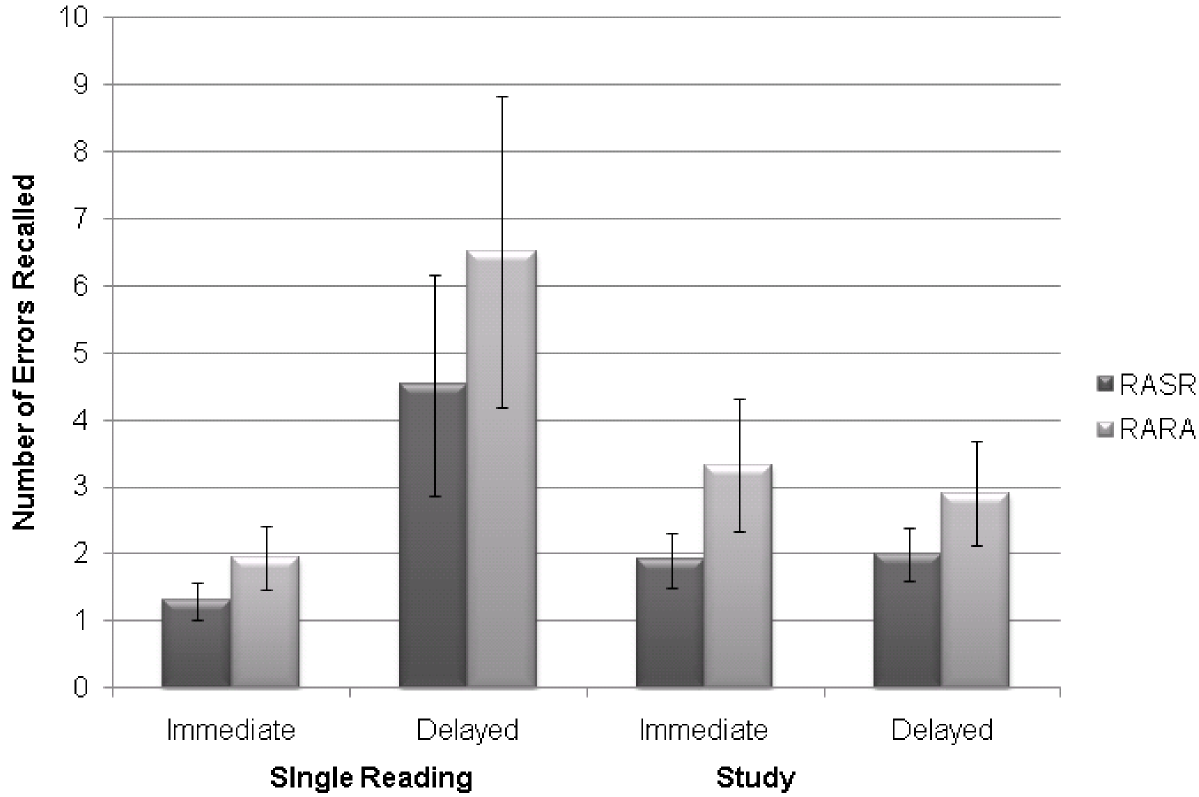

Figure 5-3. Errors recalled at immediate and delayed retention intervals across single reading and study passage conditions. Errors significantly increased from immediate to delayed recall in the single study condition but were maintained in the study condition.

CHAPTER 6
DISCUSSION

The Levels of Processing theory (Craik & Lockhart, 1972) maintains that the more deeply and elaborately information is encoded during learning, the better that information will be retained. One technique proposed to enable deeper processing of text information during encoding is retrieval practice (S. C. Brown & Craik, 2000). Retrieval in the form of testing is the bases for the testing effect, a phenomenon that testing recall after learning increases the likelihood that the information will later be recalled (Carrier & Pashler, 1992; Roediger III & Karpicke, 2006a). The present research examined the effects of depth and elaboration of encoding on text recall in high-functioning older adults by comparing two study techniques: a deep and elaborate study method incorporating retrieval practice in the form of paragraph summaries, and a shallower method requiring repeated readings of paragraphs. Results from primary analyses indicated that 1) the deeper and more elaborate study technique yielded greater immediate and delayed (24 hour) recall of information than the shallow technique; 2) recall testing after study resulted in greater retention of information after a delay than no testing, regardless of the study technique used; and 3) multiple choice testing yielded higher recognition for passages that were studied than for those that were not, irrespective of study technique or the presence of an immediate recall test. A post-hoc analysis of error production during recall tests indicated that the number of errors recalled for passages that were studied did not change from immediate to delayed testing; however, for passages that were not studied, the number of errors increased significantly after 24 hours. Findings are discussed in terms of the Levels of Processing framework, the importance of encoding techniques that incorporate retrieval, and the relevant implications for older adults and for populations with neurogenic disorders.

Effect of Study Technique on Recall

According to the Levels of Processing framework, the author predicted that depth and elaboration of encoding in the Read-Attentively-Summarize-Review (RASR) study technique would result in greater long-term retention of passage recall in older adults compared to a more shallow study technique: Read-And-Reread-Attentively (RARA). Additionally, since massed practice results in better immediate retention (Balota, et al., 1989; Roediger III & Karpicke, 2006b) and since the RARA group had more exposure to the passages than RASR, the author predicted that the RARA group would have greater immediate but poorer delayed recall. Results from free recall testing supported the Levels of Processing framework but did not support predictions about massed practice. Participants using the shallow but massed practice RARA training did not remember more propositions immediately. The current study's findings differ from Roediger and Karpicke's (2006b) who found that massed rereading of expository texts in young adults yielded greater immediate retention but poorer delayed retention. This discrepancy is most likely due to the methodological design differences between the studies. Roediger and Karpicke's participants in the "study study" group (experiment 1) had twice as many opportunities to study the passage (two 7-minute intervals) compared to the "study test" group (one 7-minute interval). In the current study, the RARA group spent approximately 6.86 minutes rereading the text a total of four times (the entire passage was read once followed by three readings of each paragraph). In comparison, the RASR group spent about 8.07 minutes reading the entire passage three times, interspersed with paragraph summaries. It is possible that the RARA group would have needed more time or more exposures to the reading passage to achieve the immediate recall gains reported by Roediger and Karpicke (2006b). The current study's results more closely resemble those reported in McDaniel et al.'s (2009) young adult study. These authors found that the Read-Recite-Review group outperformed the reread-only group on immediate and delayed tests, possibly because both groups had the same number of opportunities to read the text (two).

The immediate and delayed recall results from the first analysis demonstrated that the older adults in the current study benefitted from a memory training technique that involved depth and elaboration of encoding. It is not likely that this finding was due to inherent differences between the groups, as the demographic, cognitive, and ability measures of both groups were nearly equivalent. Since the purpose of this study was to compare two specific training methods, the author required that the participants in the two comparison groups be as similarly matched as possible; thus, participants in the current study met strict age and education restrictions. Consequently, the results of the current study apply to a select group of older adults between the ages of 60 -75 who have a high level of education. Despite the higher education levels of these participants, the group trained in the shallower encoding technique, RARA, did not remember as many propositions as those trained in the deeper technique RASR. Moreover, due to the repeated measures design of the current study, participants' memory performance after training was compared to their baseline performance after reading a passage a single time, thus any improvement in memory is more likely attributed to the training technique than to factors such as education level. Finally, these results are not likely due to difference in the duration of exposure to the study materials. Although the RASR group spent significantly more time studying the passage, the actual time difference was only 1.21 minutes. Past studies have shown that the amount of time spent processing during study was not a good gauge for the depth of processing effect (Craik & Tulving, 1975; Glover, 1989).

The current study's findings contribute to the growing evidence that deep semantic encoding techniques enhance memory in older adults (Bissig & Lustig, 2007; Bunce, 2003; Fay, Isingrini, & Clarys, 2005; Froger, et al., 2008; Lustig & Flegal, 2008; McDaniel, et al., 1989; Taconnat & Isingrini, 2004; but see Kalpouzos et al., 2008). With few exceptions, Levels of Processing studies in older adults have targeted memory for single words. Due to the methodological differences between past studies and ours, direct comparisons are difficult to make. Discussion of the first analysis will focus specifically on text passage memory in older adults, what is meant by "depth and elaboration" of processing, and how the RASR technique might have contributed to the depth and elaboration of text encoding.

Text memory is hierarchically represented by two different levels: the text-based or detail level that is closely tied to the text's original meaning, and the situation model or gist level that is a more generalized, subjective integration of the text-base with associative experience (van Dijk, 1995; van Dijk & Kintsch, 1983). Calvo and Carreiras (1991) claim that higher levels (gist) are easier to retrieve because the information can be inferred; whereas, lower levels (details) are more difficult to access because they cannot be inferentially reconstructed. Similarly, details are considered more attention-demanding because there are fewer opportunities for integration with the text as a whole during learning (Kintsch & van Dijk, 1978). Evidence suggests that older adults do not efficiently allocate attention to the encoding of details in text but rely instead on their intact ability to encode gist (Noh, et al., 2007; Stine-Morrow, et al., 2004). But general level encoding is vague (Koriat & Goldsmith, 1996), prone to error (Tun, Wingfield, Rosen, & Blanchard, 1998), and can even impede subsequent recall (Koutstaal & Cavendish, 2006; Rudoy, Weintraub, & Paller, 2009). Moreover, reliance on gist-processing may only be effective for certain kinds of texts, such as narratives or texts with familiar topics that support situation model construction. When faced with detail-laden and unfamiliar expository texts, breakdowns in memory are more apparent (Hartley, 1993; Stine & Wingfield, 1990a, 1990b; Tun, 1989). To this author's knowledge, the current study is the first text memory study in older adults to have specifically designed closely matched text passages that discourage gist-level processing. The passages used in the current study were unfamiliar, expository, and detail-rich. According to Craik (2002), specific information is best remembered when contextualized within the schematic framework of deep processing. Within this framework, details become meaningful as the relatedness between them is strengthened.

The results of the first analysis suggest that older adults can improve their immediate and delayed memory for challenging passages using a training technique that emphasizes depth and elaboration of encoding. But what exactly is meant by "depth and elaboration"? At the word level, "deep" refers to the type of processing and usually entails making a semantic judgment, such as determining whether or not the target word belongs to a certain category; whereas, shallow processing typically involves making a judgment about the surface features of the word, as in declaring whether or not the target word is in capital letters (Craik & Lockhart, 1972). Elaboration refers to the extensiveness of the encoding or the degree to which the target word is enriched (Craik, 2002). Craik and Lockhart (1972) hypothesized that memory traces are stronger and more durable as a function of how deeply and elaborately content is encoded.

Anderson (1983) explains Levels of Processing in terms of spreading activation models where knowledge is a network of ideas and deep elaborative processing is synonymous with an increase in the number associated pathways among these ideas. According to Anderson, the key to activating the network and consequently strengthening memory is in the retrieval process. Initial retrieval of a concept ("dog"), for example, activates associated concepts ("bone, leash, walk etc") and increases the likelihood that any of these associations can be used to cue retrieval during later recall. Recall after study enhances long-term retention more than studying alone, a phenomenon called the testing effect (Carrier & Pashler, 1992; Roediger III & Karpicke, 2006a). The underlying mechanism supporting the testing effect may be elaborative processing, according to findings from Carpenter's (2009) research examining single word study and retrieval in young adults. Like Anderson (1983), Carpenter suggests that initial retrieval activates an elaborate network of associated concepts, which creates multiple routes to the target that can be activated during later retrieval. Subsequent retention is greatest when fewer cues are provided during initial retrieval; it follows that free recall should be most effective for later retention since, in the absence of cues, it endorses greater elaborate activation of related concepts during initial search (Carpenter, 2009; Carpenter & DeLosh, 2006).

At the text level, Read-Attentively-Summarize-Review (RASR) incorporated free recall into study by encouraging participants to use their own words and phrasing as much as possible. In line with Anderson (1983) and Carpenter (2009), the author suggests that the recall component of RASR provided an extensive search for target information that activated an elaborate network of semantically associated concepts, thus strengthening retention. According to Craik (1990), retrieval acts as a second encoding by reinstating the mental operations used during the initial encoding. A recent review by Danker and Anderson (2010) provides considerable evidence that the brain regions involved in retrieval reactivate a smaller portion of the brain state used during encoding and that more reactivation occurs for content that is recollected than for information that is recognized as familiar. There are documented differences in the way that older adults encode and retrieve information compared to younger adults that may make retrieval practice a particularly effective "secondary encoding" strategy for remembering information in advanced years. During intentional encoding tasks where participants are instructed simply to memorize the material, older adults show under-recruitment of frontal regions in comparison to younger adults (Logan, et al., 2002; Nessler, et al., 2006). During retrieval, particularly when it is effortful such as in free recall, they show increased recruitment of frontal regions (e.g., Logan, et al., 2002; Velanova, Lustig, Jacoby, & Buckner, 2007) which may enhance performance by serving as a compensatory mechanism for age-related declines in these regions (e.g., Cabeza, Anderson, Locantore, & McIntosh, 2002; Rosen, et al., 2002; Velanova, et al., 2007). Research shows that under-recruitment of the frontal regions can be reversed with deep encoding methods (Logan, et al., 2002; Nessler, et al., 2006) and that over-recruitment during retrieval subsides with practice (Velanova, et al., 2007). Together, evidence suggests that studying (practice) is not only important for efficient retrieval of information but that deep elaborate study is important for efficient encoding. If encoding processes are partially reinstated at retrieval (Craik, 1990; Danker & Anderson, 2010), and if older adults can normalize brain activation for encoding and retrieval with deep training methods and practice, then a deep encoding technique that incorporates retrieval practice into study, such as RASR, may be an effective method for strengthening memory in older adults.

Free recall is a top-down, constructive process which necessitates more self-initiated processing (Craik, et al., 1983). Due to age-related declines in cognitive resources, self-initiated tasks such as free recall are particularly challenging for older adults (Craik & McDowd, 1987; Taconnat, Clarys, Vanneste, Bouazzaoui, & Isingrini, 2007; Whiting & Smith, 1997). Consequently, some have argued that optimal memory training in older adults should provide more external support by increasing the number of cues at encoding and retrieval (Taconnat, et al., 2007; Taconnat & Isingrini, 2004). One might reason that rereading should enhance memory since subsequent readings increase external support by re-presenting material that may have been initially missed. Additionally, rereading can build from material that was learned during the first reading, effectually freeing up cognitive resources (Kintsch, 1994; Stine-Morrow, et al., 2004). Indeed, Harris, Rogers, and Qualls (1998) demonstrated that repeated reading increased text processing performance in their older participants on tests of discrimination and recognition. Recognition, however, is not as sensitive an indicator of memory performance in older adults as recall (e.g., Bishara & Jacoby, 2008; Parker, Landau, Whipple, & Schwartz, 2004). Immediate and delayed recall tests from the current study showed that rereading was a less effective way of encoding in comparison to a training technique that incorporated retrieval, in the form of paragraph summaries, into study. One reason could be that the rereading group, RARA, was not allocating enough attention to details during subsequent readings. Stine-Morrow et al. (2004) showed that on a second reading of an expository text, older adults demonstrated decreases in the amount of processing allocated to the text-base (details), whereas young adults did not. Alternatively, the rereading task may not have been challenging enough for the participants in the RARA group to maintain attention during reading.

McNamara and Kintsch (1996) contend that increasing the difficulty of a reading task promotes deeper encoding by preventing the reader from superficially processing the text, provided the reader is processing information relevant to the text and is sufficiently able to execute the demands of extra processing. RASR may have been more challenging than RARA since it required participants to actively engage in processing (recall via paragraph summaries) that was demanding. At the same time, the RASR technique was structured to reduce processing demands during training by limiting the focus to the paragraph level. Other components of RASR may have contributed to making RASR a deeper method of study than RARA such as attention and feedback. It has been demonstrated that participants pay more attention to a task when they know they will be asked to recall it (Chun & Turk-Browne, 2007). Additionally, if the RASR participants missed important details or recalled inaccurate information during their summaries, they were provided with an opportunity to review. Immediate feedback in the form of review has proven beneficial for strengthening memory (McDaniel & Fisher, 1991; McDaniel, et al., 2007; Pashler, et al., 2005).

Results from the first analysis showed that participants using a deeper and more elaborate study technique, incorporating retrieval practice and review, remembered more details from unfamiliar expository passages than those using a rereading technique. Past studies suggest that, due to declines in processing resources, older adults would benefit more from memory training that increases the availability of cues during encoding and retrieval (Taconnat, et al., 2007; Taconnat & Isingrini, 2004). The author suggests that increased cue support may not be challenging enough or elaborate enough to strengthen memory for later recall, at least in older adults with higher levels of education. The author proposes that a more challenging training method with decreased cue support (retrieval through summaries) structured to decrease processing load (constraining study to the paragraph level) may be more beneficial.

Effect of Immediate Testing on Delayed Recall

The second analysis was an examination of the testing effect (Carrier & Pashler, 1992; Roediger III & Karpicke, 2006a), which states that more information is retained long-term if tested after study. In accordance with this hypothesis, the author predicted that studying plus testing would result in better delayed retention of information compared to studying without testing. Since RASR entails deeper and more elaborate encoding, the author predicted the RASR group would recall more information, with and without immediate testing, than the RARA group. Predictions were only partially supported. On delayed recall testing, results supported the testing effect; participants remembered significantly more details from passages they had immediately recalled after studying than from passages they had studied but not immediately recalled. This was true for both groups, regardless of study method.

The testing effect is a well-established finding that has been demonstrated in young adults using educationally relevant materials such as text passages (Karpicke & Roediger III, 2008; McDaniel, et al., 2009; Roediger III & Karpicke, 2006a, 2006b). Findings from the current study contribute to the testing effect evidence by demonstrating that the effect extends to older adults. This is an important finding because it suggests that simply adding a recall component to study, regardless of the study technique, may improve delayed retention of text information in a population that struggles with remembering details (Cohen, 2000; Holland & Rabbitt, 1990).

The second prediction, that the RASR group would outperform the RARA group on delayed testing even in the absence of a test after study, was not supported. One explanation for why RASR paired with testing was more beneficial than without is that the testing condition (free recall) closely matched the study condition (recall through summary). The concept of a positive association between encoding and retrieval type is referred to as the "encoding-specificity principle" (Tulving & Thomson, 1973). Similarly, "transfer-appropriate processing" contends that information is better retained if the retrieval test matches the operations used during encoding (Morris, Bransford, & Franks, 1977). For example, Morris et al. (1977) demonstrated that shallow encoding using rhyme was superior to deep semantic encoding when the retrieval condition used a rhyme recognition task. Transfer-appropriate processing does not necessarily discount the Levels of Processing advantage, on the contrary, the two concepts may be considered complementary (Craik, 2002; Lockhart, 2002). In the example from Morris et al. (1977), participants remembered substantially more when semantic encoding matched semantic retrieval (deep) than when rhyme encoding matched rhyme retrieval (shallow). Deeper encoding was still more beneficial overall than shallow encoding. Craik (2002) contends that “Deeper encoding processes result in encoded traces that are *potentially* very memorable, provided than an appropriate cue is available a the time of retrieval” (p.310). In RASR, the recall test that followed study potentially strengthened retention by providing an appropriate retrieval cue that matched encoding. Though the RARA group also benefitted from immediate recall on delayed testing, they remembered fewer details after a 24 hour delay than the RASR group. Together, these findings suggest that, while recall testing after study is effective, it may be more effective when paired with a study technique that promotes deeper and elaborate encoding.

Recognition Testing

The above findings are in relation to free recall testing which entails actively retrieving information without the benefit of cues. To test the effect of depth of processing and study plus testing on recognition memory, participants were given multiple choice questions after a delay. The author predicted that the RASR group would recognize more information than the RARA group and that both groups would recognize the most information from the study plus testing condition, followed by the study without testing condition, followed by the unstudied (single reading) condition. Predictions were not supported by the results. Regardless of study technique or prior recall testing, both the RASR and RARA groups recognized more details on multiple choice testing if they had studied the passages, than if they had read the passage a single time.

Multiple choice testing is an assessment of recognition memory, a form of memory that remains largely unaffected in normal aging (e.g., Craik & McDowd, 1987; Kalpouzos, et al., 2009; Parker, et al., 2004; Taconnat, et al., 2007; Yonelinas, 2002). Recognition is also a less sensitive test of memory performance in older adults than free recall (e.g., Bishara & Jacoby, 2008; Parker, et al., 2004). Perhaps the multiple choice testing used in the current study was only sensitive enough to discriminate between studied and unstudied passages, but not sensitive enough to distinguish between study techniques or the presence of prior recall testing. Even so, that both groups performed similarly on recognition testing indicated that the material was indeed processed; however, recall testing reflected that it was processed more deeply in the RASR group.

Post-Hoc Examination of Errors

The focus of current study was on the effect of study technique and prior recall testing on the immediate and delayed retention of correct propositions (details). Thus, the free recall analyses (analysis 1 and 2) did not include errors. However, some participants did make errors during their recall tests. These errors were coded and submitted to separate analyses. Since the author did not have any a priori predictions about errors and since errors were not the focus of this experiment, findings will only be briefly discussed here. It should be noted that error production was highly variable; consequently, the error data were transformed into their square roots before they were analyzed. Findings revealed that both groups had similar patterns of error production. On studied passages, the total number of errors did not change from immediate to delayed testing but for the single reading (unstudied) passage, the number of errors significantly increased from immediate to delayed testing. The lower number of errors on the immediate single reading test is most likely explained by an order effect. The single reading passage was always the first passage read and recalled, whereas the order of the two studied passages (study plus testing and study without testing) was counter-balanced. Some of the passages may have been confused with one another because they contained similar ideas. For example, both the Raccoon Dog and the Velvet Worm passage mention “claws”; the dog uses claws to climb trees but the worm uses them to maneuver over rough terrain. If a person had read the Raccoon Dog first then was immediately tested, there would be fewer opportunities for errors than if he or she were trying to recall this passage 24 hours later after having studied the other two.

Evidence suggests that there is an age-related decline in the ability to inhibit related but irrelevant sources of information and as the number of similarities between one source and another increases, so do the number of errors (Radvansky, Zacks, & Hasher, 1996, 2005). Similarly, on studies where several lists must be learned in succession then recalled, older adults are reported to be more susceptible to intrusion errors (errors of interference from prior lists) (Kahana, Dolan, Sauder, & Wingfield, 2005; Kliegl & Lindenberger, 1993). Additionally, older adults are reported to make more errors of commission (adding information that was not previously learned) than young adults during free recall (C. M. Kelley & Sahakyan, 2003). A more complete understanding of error production during recall would require more extensive analysis. Thus, explanation at this point is speculative and should be interpreted with caution. Nonetheless, what is interesting is that the number of errors increased only on passages that were not studied. Presumably, studying positively influences delayed retention of information by limiting further production of errors.

General Discussion

The current research demonstrated that retrieval practice during and following study improved retention of text details in well-educated older adults. The current study compared two study techniques: Read-Attentively-Summarize-Review (RASR) and Read-And-Reread-Attentively (RARA). Participants using RASR, a deep and elaborate encoding method incorporating retrieval through paragraph summaries, retained more details immediately and after a 24 hour delay than those using a re-reading technique. This finding alone would appear to support the Levels of Processing framework: that more information is retained after a delay if it has been semantically encoded (depth) and highly integrated (elaboration) (Craik & Lockhart, 1972). However, the RASR participants did not have better delayed retention unless they had taken a recall test immediately after studying, suggesting that it was most likely the combined effects of study technique plus immediate testing that were responsible for better delayed retention in this group.

Testing after study is known to enhance retention, a phenomenon called the testing effect (Carrier & Pashler, 1992; Roediger III & Karpicke, 2006a). Moreover, the match between type of test and type of encoding, transfer-appropriate processing, is also known to improve retention (Morris, et al., 1977). Since a deeper and more elaborate encoding method has the potential to be strengthened by an appropriate retrieval test, transfer-appropriate processing and the Levels of Processing framework may be considered complementary (Craik, 2002; Lockhart, 2002). Given that the RASR participants engaged in recall practice through summaries during study and were then tested using free recall, the author suggests that transfer-appropriate processing may have partially contributed to the delayed retention benefit in this group. More than transfer-appropriate processing, however, there is something about retrieval practice itself that benefits later retention. Retrieval practice during and after study may be acting as a second encoding (Craik, 1990) wherein depth and elaboration are expressed as the strengthening of an extensive network of associated semantic concepts (Anderson, 1983; Carpenter, 2009).

Recall is a more sensitive test of memory performance in older adults than recognition (e.g., Bishara & Jacoby, 2008; Parker, et al., 2004). Recognition testing in the present research revealed that studying, regardless of technique or presence of prior testing, resulted in better delayed recognition on multiple choice testing than not studying. Recognition testing provides more cues to trigger memory. Some suggest that older adults, who experience declines in self-initiated processing, would benefit more from greater cue support at retrieval and encoding (Taconnat, et al., 2007; Taconnat & Isingrini, 2004). The author argues that recognition testing is a more impractical and less ecologically valid method for remembering text information than recall. In older adults, reading is one of the main sources for learning new information (Stanovich, et al., 1995). It would be unrealistic to have multiple choice tests for every new piece of written information that is encountered. Moreover, recognition remains largely unaffected in older adults compared to recall (Craik & McDowd, 1987; Taconnat, et al., 2007; Whiting & Smith, 1997). Engaging in recall during and after study would allow older adults to practice what is most impaired.

The current study's findings have several potential implications for healthy aging. During learning, older adults are less likely to engage in deep and elaborate encoding (Craik & Jennings, 1992; Perfect & Dasgupta, 1997; Perfect, et al., 1995) and this has been attributed to an age-related decline in effortful self-initiated processing (Bryan, Luszcz, & Pointer, 1999; Taconnat, Clarys, Vanneste, & Isingrini, 2006). The current study's results contribute to the evidence that older adults can engage in deeper and more elaborate processing when directed to use a strategy (Craik, 1990; Logan, et al., 2002; Nessler, et al., 2006). Moreover, the strategies used in the current study are not complicated and do not require a great deal of instruction. If older adults have difficulty self-initiating encoding processing, then it would be advantageous for them to engage in activities that are not only good for memory but also easy to implement. Importantly, what the current study demonstrated is that even without a specific studying technique, simply recalling information after study results in greater retention one day later than studying without testing. Older adults might be encouraged not just to read, but to read and then tell someone about it.

From a rehabilitation standpoint, the current study's findings suggest that other populations with resource limitations (such as those with traumatic brain injury, mild cognitive impairment, or early dementia) may also benefit from training techniques that encourage depth and elaboration of processing through recall practice. Some modifications, however, may be necessary. For instance, recall practice is *errorful*. Typically, learning that is *errorless* has been most successful for the rehabilitation of neurogenic populations (e.g., Baddeley & Wilson, 1994; Clare, Wilson, Carter, Roth, & Hodges, 2002; Tailby & Haslam, 2003). There is some evidence that recall through summary can be rehabilitative. RASR was modeled after Attentive Reading and Constrained Summarization (ARCS) (Rogalski & Edmonds, 2008), a treatment that increased lexical retrieval in a gentleman with primary progressive aphasia. ARCS, like

RASR, focused on smaller units of text to help reduce the resource load associated with summarization from memory. Perhaps by reducing the amount of information recalled at one time, a reduction in error production might occur. At the very least, the present research suggests that the therapy techniques currently used in rehabilitation practice may be enhanced by the addition of testing, in the form of free recall, at the end of each session.

One primary caveat to the present research is that the results are based on highly educated older adults under the age of 75. More research is needed to test if the RASR technique would benefit adults of advanced age or lower education levels. Additionally, a young adult comparison group was not included in this study so it would be interesting to examine how young adults, who do not typically have difficulty remembering details, would compare to older adults. With regard to the technique itself, while the RASR group was encouraged to use their own words as much as possible during paragraph recall, some may have used rote recitation more than others. Additionally, since a comparison with whole passage study was not included, it is unclear the degree to which paragraph study benefitted retention. To address these caveats, future research should compare the effects of rote recall verses summary as well as whole passage study to paragraph study. Finally, further investigation into the number and type of errors recalled during testing would enlighten us on the association between studying and error maintenance. Ultimately, the authors has begun to lay the groundwork for future research on the current study’s application to populations with neurogenic disorders.

In conclusion, results of the current research suggest that older adults instructed in deep elaborate study techniques that emphasize recall can improve delayed retention of text details compared to rereading. These findings, while preliminary, provide fertile ground for research in aging and rehabilitation.

APPENDIX A
THE RACCOON DOG PASSAGE

The Raccoon Dog lives in dense forests near water and can be found in China. It's called a Raccoon Dog because it has a black facial mask. The dog has a black and yellow coat and is about 15 pounds. An excellent swimmer, it hunts in streams where it uses its paws to catch fish. Unlike other canines, it has curved claws. These claws help it climb trees so that it can hunt birds. It prefers to hunt in the dark because it's a nocturnal animal.

The Raccoon Dog is the only canine that hibernates in the winter. Hibernation lasts several months but during this time the dog will emerge occasionally to feed. The Raccoon Dog is not an aggressive animal. It doesn't bark like a regular dog; instead, it emits a high-pitched whine. It also prefers to hide or play dead than fight. The Raccoon Dog's main predator is the human. Over-hunting and fur-trapping are threatening the dog's existence. In China, people raise the dogs on farms for their fur.

The Raccoon Dog is monogamous. Mating season begins after the dogs come out of hibernation. The female gives birth to about 5 pups. Both parents assist in raising them. The male brings food to the mother while she nurses. The Raccoon Dog weans her pups later than any other canine. She continues to nurse even after her pups have begun eating solid food. After weaning her pups, the mother Raccoon Dog hunts while the father stays in the den and cares for the pups.

APPENDIX B
THE PISTOL SHRIMP PASSAGE

The Pistol Shrimp can be found in the tropical waters of the Caribbean. It's called a Pistol Shrimp because its claw shoots and sounds like a weapon. It's one of the loudest animals in the sea. It has a large snapping claw that fires a blast of bubbles as loud as a jetfighter. This blast stuns the shrimp's prey and the collapsing bubbles momentarily reach the sun's temperature. The shrimp also has a small pincher claw. If it loses the snapper, the pincher transforms into a new snapper.

The Pistol Shrimp is a little over 2 inches long and is brown and white. It uses its antennae to taste and to touch. The shrimp has poor eyesight. On its own, the Pistol Shrimp is defenseless. Consequently, it has a mutually beneficial relationship with the Goby fish. The shrimp shares its food and its burrow and in return, the fish protects it. When out of its burrow, the shrimp keeps one antenna on the Goby's tail. When predators approach, the Goby flicks its tail in warning.

Pistol Shrimp are social animals. They live together in sponges in colonies of about 30 members. The queen is the largest in the colony. She lives with one male and their offspring which consist of soldiers and workers. The soldiers protect the colony by attacking intruders. The workers care for the young. Newborn shrimp float on the surface of the ocean. As they grow, they change shape and shed their skin several times. After they are finished growing they sink to the bottom.

APPENDIX C
THE VELVET WORM PASSAGE

The Velvet Worm lives in the Amazon rainforest of Peru. It’s called the Velvet Worm because the fine hair on its skin feels like velvet. The worm is about 1.5 inches long and is orange and brown. The Velvet Worm breathes through its skin, which has many tiny holes. Because it’s porous, the Velvet Worm dries out quickly. For this reason, it needs to live in a humid place. Although it’s called a worm, it has feet and retractable claws. The claws help it maneuver over rough terrain.

The Velvet Worm is popular in the exotic pet trade because of its unusual appearance and eating habits. On either side of its mouth are glands that hold sticky slime. It squirts this slime to ensnare prey or to defend itself from predators. People describe the Velvet Worm as a “secretive” animal because it likes to hide. It doesn't like direct sunlight so it’s most active during the night. When the weather is cold, the Velvet Worm shelters in crevices in rocks.

The male Velvet Worm attracts the female with a special scent and sperm packets that he carries on his head like a trophy. The male deposits these packets on the female's body. Under these deposits, the female's skin collapses. This allows the sperm to migrate to her eggs. The female can fertilize her eggs immediately or she can prolong fertilization for several months. She has receptacles close to her eggs where she can store the sperm. This way, she may fertilize her eggs as needed.

APPENDIX D
THE RACCOON DOG MULTIPLE CHOICE TEST

Raccoon Dog

Please circle the most correct response based on the passages that you have read.

1. The Raccoon Dog can be found in:
    a. India
    b. China
    c. Australia
    d. Korea

2. The Raccoon Dog is about:
    a. 18 pounds
    b. 45 pounds
    c. 15 pounds
    d. 10 pounds

3. The Raccoon Dog's coloring is:
    a. black and yellow
    b. orange and red
    c. black and white
    d. black

4. The Raccoon Dog is the only canine that:
    a. doesn't make a good pet
    b. hibernates in the winter
    c. eats berries
    d. hunts in streams

5. Raccoon Dogs are:
    a. secretive animals
    b. monogamous
    c. solitary animals
    d. social animals

6. The female Raccoon Dog gives birth to about:
    a. 5 pups
    b. 7 pups
    c. 10 pups
    d. 2 pups

KEY: Correct answers are in bold and closely associated foils are italicized.

APPENDIX E
THE PISTOL SHRIMP MULTIPLE CHOICE TEST

Pistol Shrimp

Please circle the most correct response based on the passages that you have read.

1. The Pistol Shrimp can be found in the waters of:
    a. The Canary Islands
    b. Japan
    c. Morocco
    d. The Carribbean

2. The Pistol Shrimp is about:
    a. 10 inches long
    b. 1 inch long
    c. 6 inches long
    d. 2 inches long

3. The Pistol Shrimp's coloring is:
    a. brown and tan
    b. brown and white
    c. red and gold
    d. white

4. The Pistol Shrimp uses its antennae to:
    a. communicate with other shrimp
    b. stun its prey
    c. taste and touch
    d. ward off predators

5. Pistol Shrimp are:
    a. social animals
    b. monogamous
    c. solitary animals
    d. secretive animals

6. Pistol Shrimp live together in colonies of about:
    a. 40 members
    b. 30 members
    c. 60 members
    d. 100 members

KEY: Correct answers are in bold and closely associated foils are italicized.

APPENDIX F
THE VELVET WORM MULTIPLE CHOICE TEST

Velvet Worm

Please circle the most correct response based on the passages that you have read.

1. The Velvet Worm can be found in:
    a. Mali
    b. Brazil
    c. Peru
    d. India

2. The Velvet Worm is about:
    a. 2.5 inches long
    b. 1.5 inches long
    c. 5 inches long
    d. 10 inches long

3. The Velvet Worm's coloring is:
    a. orange and brown
    b. tan and white
    c. yellow
    d. orange and black

4. The Velvet Worm is popular in the exotic pet trade because:
    a. of its unusual mating habits
    b. it is inexpensive
    c. of its unusual appearance and eating habits
    d. it gets along well with other animals

5. Velvet Worms are:
    a. secretive animals
    b. social animals
    c. solitary animals
    d. monogamous

6. The Velvet Worm can prolong fertilization of her eggs:
    a. for 8 weeks
    b. for several weeks
    c. for 1 year
    d. for several months

KEY: Correct answers are in bold and closely associated foils are italicized.

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BIOGRAPHICAL SKETCH

Yvonne Rogalski is a Canadian who received a bachelor's degree in General Arts from the University of Waterloo, Ontario, in 1995. After graduating, she spent 5 years in Asia, living, teaching, travelling, and studying. During her time in Taiwan, she met her husband, an American from Gainesville, Florida. Upon returning to North America, Yvonne decided to go back to school to pursue a bachelor's degree in English at the University of Florida. She had planned to get a master's degree in Education; however, after meeting professors and students in Communication Sciences and Disorders, she decided that she wanted to be a speech-language pathologist instead. During her master's program, she met and trained as a clinician under Dr. John Rosenbek, who inspired her to pursue a doctorate and who is currently her primary mentor. While at the University of Florida, Yvonne received her BA in English in 2003, her MA in Communication Sciences and Disorders in 2005, and her PhD in Rehabilitation Science in 2010. Yvonne is looking forward to starting her academic career as an assistant professor in the Department of Speech Language Pathology and Audiology at Ithaca College.