RESEARCH STATEMENT

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My research program stems from guidance provided by three mentors during my graduate studies and postdoctoral fellowship. While obtaining my Master's degree, I worked with Marilyn Turner who conducted research investigating the relationship between working memory capacity and reading comprehension. During my doctoral studies, I worked with Alice Healy on research regarding the long-term retention advantages of generating, or self-producing information (i.e., the generation effect). My postdoctoral fellowship with Walter Kintsch involved investigations of the effects of text coherence and prior domain knowledge on text comprehension. These somewhat diverse roots have collectively provided the impetus for my current research program. Working with very different mentors prepared me for both a rigorous experimental study of learning and memory, as well as the basic and applied study of text comprehension processes.

My current research interests include theoretical and applied aspects of memory, knowledge and skill acquisition, and text comprehension, as well as individual differences influencing each of these processes. The overarching goal of my research program is to contribute to our understanding of knowledge and skills, and specifically (a) how knowledge and skills are most effectively acquired, (b) the defining characteristics of skilled individuals, and (c) the representation of knowledge and skills in memory. I have explored these issues in relation to a number of empirical topics, including: arithmetic problem solving skills (McNamara, 1995; McNamara, Eischeid, & Hayes, 1997), computer programming skills (e.g., Doane, McNamara, Kintsch, Polson, & Clawson, 1992; Doane, Sohn, McNamara, & Adams, 2000), the generation effect (McNamara, 1995; McNamara & Healy, 1995a; McNamara & Healy, 1995b; McNamara & Healy, in press), and text comprehension (McNamara, 1997; McNamara, in press-a; McNamara, in press-b; McNamara, submitted; McNamara & Kintsch, 1996a; McNamara & Kintsch, 1996b; McNamara, Kintsch, Songer, & Kintsch, 1996; McNamara & Scott, 1999; McNamara & Scott, submitted; Shapiro & McNamara, in press). In this review, I will concentrate on my two principle research areas, the generation effect and text comprehension.

The Generation Effect

The generation effect refers to a robust retention advantage found for material that is self-generated compared to material that is simply copied or read. In a typical generation paradigm, participants are shown related word pairs in either a *read* or *generate* condition. In the read condition, both words are displayed (e.g., short - tall), whereas in the generate condition, only the cue word and a portion of the target word are displayed (e.g., short - t_ _ _) and the participant generates the target word (i.e., tall). The participant's memory for the target words is then tested. Typical investigations of the generation effect have tested participants' *episodic memory*, which in a laboratory setting is most often the occurrence of a list of words or items. As a graduate student, I observed that these conditions are quite different from those found in educational settings, where the knowledge or skill must be learned and then recalled after extended periods. This lack of correspondence between conditions of laboratory experiments and natural learning settings (other than last minute "cramming" for an exam) prompted me to explore the generalization of the generation effect to skill and knowledge acquisition.

I set out to accomplish this goal by investigating arithmetic skill acquisition. I turned to arithmetic as a domain because recent evidence had demonstrated a generation effect for the answers to simple multiplication problems using the typical episodic memory paradigm. In this paradigm, a participant was shown a set of problems, for which the answers were either presented with the problem (i.e., read condition) or were generated by the participant. The participant was later asked to recall all of the answers to the problems presented during the learning session. For example, if participants had generated (solved) or read the problems '2 x 3 = 6', and '5 x 6 = 30', they would then recall the numbers '6' and '30'. This paradigm provided a unique opportunity to directly examine both episodic memory and skill acquisition. To examine skill acquisition, rather than observing recall for the set of answers, the dependent variable is the speed and accuracy for solving the problems.

The theoretical basis for my research was the procedural reinstatement account of learning and retention (e.g., Healy et al., 1993). The procedural account predicts quite different results for the effects of generating using skill acquisition tasks as compared to episodic memory tasks. The primary theoretical premise of this account is that cognitive procedures constitute the essence of a skill. Cognitive procedures are considered thought processes, mental operations, strategies, or heuristics. For multiplication problems, the cognitive procedures are the operations used to solve the problem. The procedural account predicts that skill acquisition and retention will benefit from a training procedure if cognitive procedures are developed or modified during training. In contrast, with episodic memory tasks, the critical factor leading to improved memory is that the participants engage in cognitive procedures that connect the target item to information already available in memory. Regardless of task, retention performance is improved when the cognitive procedures that were used during encoding (or learning) are relevant to, and thus used during the retention test (i.e., procedural reinstatement).

Therefore, the procedural account predicts that generating will have an advantage over the read condition for knowledge and skill acquisition only when it results in the development of new and stable cognitive procedures (and the read condition does not), and when those same procedures are reinstated during the test. This prediction was confirmed in two studies that I conducted before beginning my position at O.D.U. (McNamara & Healy, 1995a). For example, we found that for college students, reading and generating equivalently improved response times for solving simple multiplication problems (e.g., 40 x 9). In contrast, generating had a clear advantage over reading for difficult problems (e.g., 14 x 9). Thus, calculating the answers improved multiplication skill for difficult problems for which the participants were forced to develop new cognitive procedures during training. These results were replicated with second-grade children: only those children who had not yet developed cognitive procedures for simple multiplication benefited from generating the answers to problems (McNamara, 1995).

Based on the procedural account, a generation effect in skill acquisition was predicted for difficult and not simple problems. In contrast, with episodic memory tasks, a generation effect is predicted for simple, but not difficult problems. This prediction follows from the assumptions that memory is improved when the encoding task involves the use of cognitive procedures that connect the target item to information already available in memory, and these procedures are reinstated at test. This prediction was confirmed in a recent study (McNamara & Healy, in press). With simple problems, we found that participants tend to retrieve and then "resolve" the problem in order to recall the answers to the simple multiplication problems when tested. This process in effect reinstates the same procedures as used during encoding and hence improves recall in the generate condition as compared to the read condition. In contrast, participants are less likely to

"resolve" a difficult multiplication problem (and thus reinstate the encoding procedures) because difficult problems are more time consuming to solve (see also, McNamara & Healy, 1995b).
My primary goal at this juncture is to further test the procedural account using the more standard stimuli of words, rather than multiplication problems. To do so, I am comparing memory for words and non-words that are generated or read in the context of either concrete words or abstract words. It has been well established that concrete words (e.g., desk) are better recalled than abstract words (e.g., love) due the ease of creating images of the words. In addition, words are more readily recalled than non-words. The goal of this study is to manipulate the likelihood of reinstating at test the cognitive procedures engaged during encoding, much like we have achieved with arithmetic problems.
I investigate the generation effect because I believe the paradigm has the potential to reveal fundamental, important properties of human learning and memory. Moreover, the generation effect embodies the concept of active processing, and the importance of active processing to knowledge and skill acquisition. In sum, active participation in the learning process leads to superior learning and retention as compared to passive perception. By developing an understanding of the parameters of the generation effect as well as a clear explanation of this effect, we will be better able to predict when the generation effect will be useful in terms of leading to enhanced long-term retention.

Reading Comprehension
Reading is a pervasive and important activity in our lives — we read for pleasure, to keep up with current events, and to acquire new knowledge and skills. However, many written materials (particularly instructional textbooks) are poorly written and difficult to understand, and many individuals have difficulty understanding written text. Thus, one important concern is to develop a more complete theoretical understanding of the reading process and to develop successful interventions for less-skilled readers. A large part of my research examines processes related to reading, and specifically, knowledge acquisition from expository texts. I am particularly interested in discovering conditions to improve knowledge acquisition from texts and understanding how this process depends on the readers' individual differences. I am also concerned with better understanding critical aspects of skilled reading performance, and using this theoretical understanding to devise instructional techniques for less-skilled readers.

Text coherence and prior knowledge

One line of my research examines how learning from texts depends on the text's structure and the reader's prior knowledge (McNamara & Kintsch, 1996; McNamara et al., 1996; McNamara, submitted). This research has demonstrated that low-knowledge readers benefit more from high-coherence text in terms of both memory and understanding, whereas relatively high-knowledge readers develop a better, deeper understanding of the text content with low-coherence and more difficult text. Essentially, a low-coherence text, which has more conceptual gaps, induces the reader to engage in more active processing of the information in the text, and the high-knowledge reader possesses the tools that render this processing beneficial.
In recent studies, I have been concerned with several issues regarding the effects of text coherence and prior knowledge. One issue concerns the assessment of knowledge and learning. For example, Amy Shapiro and I (Shapiro & McNamara, in press) recently examined the ability of Latent Semantic Analysis of written essays and verbal recalls to predict readers' prior

knowledge and learning from text (as indicated by its correlations with other measures of knowledge and learning). Latent Semantic Analysis (LSA) is a computational technique to assess the semantic similarity between units of language (words, phrases, etc). LSA provides a cosine, which indicates the degree of overlap between two or more passages. We found that the cosine between passages read by participants and their recall of the passages highly correlated with experimenter-derived recall scores and other measures of text-based comprehension. LSA was, however, less successful at predicting readers' conceptual understanding of the text (as reflected by essays and conceptual questions) and readers' prior knowledge. These results have important implications for the use of LSA in educational settings.

The second issue regards the theoretical explanation of the interactive effects of text coherence and prior knowledge. It has been assumed that high-knowledge readers make inferences while reading the low-coherence text, which serve to link the textual information with prior knowledge. Prior knowledge provides a schema for understanding the material and the links provide a pathway for retrieving the new information. To further test this assumption, I conducted a study in which participants read either a high or low-coherence text twice, or they read both the high-coherence and low-coherence texts in alternating orders (McNamara, submitted). I assumed that reading the low-coherence text first would force the reader to use prior knowledge to fill in the conceptual gaps. However, using prior knowledge would be unnecessary if the reader were presented with the high-coherence version first. That is, reading the low-coherence version after the high-coherence version was predicted to inhibit active processing. As predicted, high-knowledge readers benefited from the low-coherence text when it was read first, but not when it was read after the high-coherence text. These results further support the assumption that low-coherence text induces active processing of text, which results in the reader making connections between prior knowledge and the text.

The third issue in which I have recently become interested regards the coherence of reading material presented to young readers (7-8 years old). There is currently very little research concerning the effects of text structure and domain familiarity on beginning readers' comprehension. Most basal readers are judged based on their readability as reflected by standard readability formulas, and not by their conceptual coherence. I am currently conducting pilot studies with second grade children to assess the combined effects of text coherence, domain familiarity (i.e., prior knowledge), and reading (i.e., decoding) skill on comprehension. Preliminary results have indicated that for a less familiar, expository passage about whales, coherence benefited only less-skilled readers. For a more familiar, fictional passage about a hippopotamus (*Hippo*), increased coherence benefited less-skilled readers, but had a detrimental effect on comprehension for the skilled readers. These findings parallel those for adult readers, and indicate that young readers better understand passages about familiar domains, and moreover, that increasing the coherence of text is particularly important for passages concerning less familiar concepts.

Reading ability

I am also concerned with theoretical issues regarding the characteristics of skilled individuals, and particularly skilled comprehension. One important question raised by cognitive scientists is why individuals differ in their ability to comprehend texts or discourse. Developing an understanding of why and how people differ in comprehension skill will help us to identify the cognitive processes involved in comprehension, and indicate potential interventions for less-

skilled readers (McNamara, in press-b). One explanation of reading ability assumes that readers with greater working memory capacity are better readers because they are able to process more words and phrases at a time. However, research has also demonstrated that skilled readers are more strategic readers, and that interventions that provide reading strategy instruction improve reading skill. This relationship alludes to the potential importance of strategy use to working memory capacity measures as well. However, many researchers assume that working memory measures reflect a stable characteristic of an individual, and are unaffected by strategy use. I have recently examined this assumption in collaboration with a Master's student Jennifer Scott (McNamara & Scott, submitted). We provided participants with three sessions of strategy training on a short-term memory task, which consisted of reading a list of words and then recalling the words. Strategy training involved creating a story from the words in the list. We then examined whether the benefits of training transferred to performance on a working memory task, which involved reading sentences (with a comprehension task) along with the words. As we had predicted, participants who were given strategy training, in comparison to those who had only performed the short-term memory tasks without strategy training, showed substantial improvements on working memory task scores. We also found that participants who reported using mnemonic strategies before training showed significantly greater working memory capacity scores than less-strategic participants. In sum, strategy use clearly influences working memory task performance. Future research will examine whether strategic readers are also more likely to use strategies when performing working memory tasks. That is, strategic readers may also be strategic memorizers. If this is the case, strategy use may contribute to correlations between working memory capacity and verbal abilities.

Another explanation of reading ability is that skilled readers are better able to suppress irrelevant information. That is, they ignore information that is not relevant. My work with Walter Kintsch prompted me to question the degree to which suppression was the result of ignoring irrelevant information, as opposed to actively processing relevant information. That is, if a reader better understands text that is being actively processed (e.g., McNamara & Kintsch, 1996), how does that reader at the same time ignore, or *turn off*, irrelevant information. My first step was to conduct a simulation of published data showing suppression using Kintsch's construction-integration model (McNamara, 1997). The results of this simulation indicated that active knowledge activation provided a viable alternative as an explanation for suppression. I have since conducted a series of experiments to further examine the role of suppression and knowledge for reading ability. However, preliminary results from these studies have indicated that both suppression and knowledge activation play important roles in reading ability (contrary to the assumption made by my construction-integration model). My future research will be directed toward better understanding the complex interplay between processes underlying reading ability.

Reading strategy training

When I began my position at O.D.U, I obtained funding from the McDonnell Foundation to investigate methods for improving knowledge acquisition from texts, and how those methods depend on the prior skills or domain knowledge of the learner. A large part of my first two years at O.D.U. was devoted to developing a training program to improve readers' active processing of text. One procedure that increases active processing during reading is *self-explanation*, the

process of explaining the text while reading. Research has shown that readers who explain the text to themselves better understand the text. However, some readers are more skilled self-explainers than others. Thus, one goal of this project was to develop an intervention to improve readers' ability to self-explain difficult text. The training involved instruction and practice using self explanation along with reading strategies that focused on the benefits of using logic and prior knowledge to understand the text, predicting what the text would say, making bridging inferences, and monitoring comprehension (McNamara & Scott, 1999; McNamara, 2000).

My first experiment examined the effect of training for middle-school students. However, the children showed no benefits of self-explanation, and no benefits from strategy training. Nevertheless, subsequent work has demonstrated that training was effective for undergraduate college students. Moreover, reading strategy training was most effective for students who had less prior knowledge about the domain of the text. Protocol analyses have supported the assumption that training provided low-knowledge students with strategies that they could use while reading, which effectively compensated for their lack of domain knowledge. These readers instead relied on their common sense and logic to understand the difficult text.

I have recently turned my attention to examining whether strategy training improves not only text comprehension, but also students' exam scores in science courses. Three additional experiments were possible due to additional funding provided by Old Dominion University. The results of these experiments have been overwhelmingly positive. Across five classrooms including almost 1000 students, we have found consistent benefits for a brief two-hour self-explanation and reading strategy training session. Reliable improvements on exam scores for students who received training in comparison to students who did not receive training have ranged between 5 and 14 percent (McNamara, 2000). Hence, the intervention to improve self-explanation skills has been successful both in terms of improving text comprehension and in terms of impacting the students' performance in their science courses.

This research has confirmed that students need and benefit from learning strategies that enable them to read more actively. The effectiveness of this reading strategy training is indeed astounding. A relatively simple two-hour training session has provided increases of up to 14 percent on course exams. Moreover, this benefit has been replicated across five science courses. My future research will address how to identify those students who are most in need of training, how to prolong the benefits of training, and how to provide this training to a larger audience. Ultimately, this training could provide significant and substantial benefits to many struggling students who might otherwise abandon their studies.

In conclusion, my research program is geared toward further developing our theoretical understanding of the learning process, and to use this theoretical basis for developing interventions that improve individuals' ability to acquire new knowledge and skills. My research program is somewhat diverse because I believe that approaching this problem from various perspectives will lead to a more complete understanding of knowledge and skill acquisition. With this approach, I hope to make meaningful theoretical, empirical, and applied contributions to the field of psychology.

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