Summer 8-8-2023

Are All Types of Knowledge Types Created Equal? Exploring the Effects of Different Types of Knowledge on Skilled and Less-Skilled Expository Text Comprehension

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ACCEPTANCE

This dissertation, ARE ALL KNOWLEDGE TYPES CREATED EQUAL? EXPLORING THE EFFECTS OF DIFFERENT TYPES OF KNOWELDGE ON SKILLED AND LESS-SKILLED EXPOSITORY TEXT COMPREHENSION, by AMANDA C. DAHL, was prepared under the direction of the candidate's Dissertation Advisory Committee. It is accepted by the committee members in partial fulfillment of the requirements for the degree, Doctor of Philosophy, in the College of Education & Human Development, Georgia State University.

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Dahl, A.C., Carlson, S. E., Renken, M. & Reynolds, E. (2020). *Exploring deep and referential cohesion and its effects on adolescent readers' comprehension processing* (No. 3827). EasyChair. https://easychair.org/publications/preprint/Ncqm

Ness-Maddox, H., **Dahl, A.C.,** Reynolds, E., Carlson, S. E., Seipel, B., Clinton-Lisell, V., & Davison, M. L. (2020). *Exploring the differences between college students' think-aloud responses for narrative and expository texts* (No. 3825). EasyChair. https://easychair.org/publications/preprint/RmQ5

Dahl, A.C., Carlson, S.E., Seipel, B., Ness-Maddox, H., Davison, M. L., Cliton Lisell, V., & Kennedy, P. (Invited for resubmission, December 2022). *The effects of text coherence and genre on item statistics in a reading comprehension assessment for college students.* Discourse Processes.

Clinton-Lisell, V., Taylor, T., Carlson, S. E., Davison, M. L., Ness-Maddox, H., **Dahl, A.C.,** & Seipel, B. (Under review, resubmitted May 2022). *Developing and validating a reading comprehension assessment for college students.* Journal of Psycholinguistic Research.

Clinton-Lisell, V., Carlson, S.E., Ness-Maddox, H., **Dahl, A.C.,** Taylor, T., Davison, M. & Seipel, B. (Under review). *Identifying clusters of less-skilled college student readers based on cognitive processes.* Journal of College Reading and Learning.

PRESENTATIONS:

Dahl, A.C., Carlson, S.E., & McCarthy, K.S. (August, 2021). *Using verbal protocols in text and discourse research: Reflecting on the past and thinking aloud about the future.* [Roundtable]. Society for Text and Discourse [virtual due to Covid-19]

Dahl, A.C., Seipel, B., Carlson, S.E., Clinton Lisell, V., & Ness-Maddox, H. (July, 2021). *Improving on the elusive reliability of elaboration: MOCCA-College response types.* In G. Biancarosa (Chair), Classifying Less Skilled Comprehenders. [Symposium]. Annual conference for the Society for the Scientific Study of Reading, Lancaster University, UK. [virtual due to Covid-19]

Carlson, S. E., **Dahl, A.C.,** Ness-Maddox, H., Kennedy, P., Seipel, B., Clinton-Lisell, V., & Davison, M. L. (August, 2021). *How does text cohesion explain causal processing? Findings from an exploratory examination of MOCCA-College response patterns.* In B. Seipel (Chair), MOCCA-College Year 2 Results and Related Projects. [Symposium]. Society for Text and Discourse [virtual due to Covid-19].

ARE ALL KNOWLEDGE TYPES CREATED EQUAL? EXPLORING THE EFFECTS OF DIFFERENT TYPES OF KNOWELDGE ON SKILLED AND LESS-SKILLED EXPOSITORY TEXT COMPREHENSION

by

AMANDA C. DAHL

Under the Direction of Sarah E. Carlson, Ph.D.

ABSTRACT

Comprehension of expository texts is essential for middle school students to be proficient learners. Different types of knowledge such as content, text structure, and linguistic knowledge are also needed to comprehend expository text. However, it is unknown whether and how different types of knowledge influence middle school readers' comprehension of expository texts. The purpose of this dissertation was to better understand how content, text structure, and linguistic knowledge contribute skilled and less-skilled middle school readers' online (during) and offline (after) comprehension of simple and complex expository text. A review of the current literature on the effects of content, text structure, and linguistic knowledge on middle schoolers' expository comprehension is presented, as well as findings from an independent study with a sample of 50 participants who completed different knowledge assessments, and a think-aloud (during) and recall task (after) reading one simple and one complex expository text. Mixed effects models were used to determine the effects of content, text structure, and linguistic

knowledge, reader skill, and text complexity on middle school readers' expository comprehension processes and products. Results indicated that content, text structure, and linguistic knowledge support the generation of expository comprehension processes and products for middle school readers in different ways. Overall, content knowledge, reader skill, and text complexity significantly impacted the types of processes generated during reading. Content, text structure, and linguistic knowledge also significantly influenced the types of products developed after reading. These findings suggest that knowledge types, reader skill, and text complexity matter for middle school readers' expository comprehension; however, these contributions differ depending on the level of processing and development of representation and when these contributions are applied (during, after reading). Implications for theory and practice are discussed.

INDEX WORDS: expository comprehension, middle school, content knowledge, text structure knowledge, linguistic knowledge, reader skill, text complexity

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A Dissertation

Presented in Partial Fulfillment of Requirements for the

Degree of

Doctor of Philosophy

in

Educational Psychology

in

the Department of Learning Sciences

in the College of Education & Human Development

Georgia State University

Atlanta, GA
2023

DEDICATION

This dissertation is dedicated to my family. Josh, you have been a constant source of encouragement and support. Thank you for selflessly championing my dreams; I would not have been able to do this without you. Everett and Frances, you two are everything. Know that starting over or learning something new is worth the discomfort and the growing pains. Mom, thank you for nudging me toward a career in education and being my first, best teacher. Dad, thank you for showing me the value of hard work and your unconditional support. Carol and Alan, thank you for enthusiastically cheering me on and always offering your help. Love you always.

I also dedicate this work to my former students and their families, who inspire me beyond measure. I hope that this dissertation reflects the hope and joy that you all instilled in me as your teacher.

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to my advisor, Dr. Sarah Carlson. Sarah, I cannot thank you enough for all that you have done for me. As an unexpected "bonus student", you supported me and offered your mentorship without any hesitation, for which I have always been so grateful for. Your advice and guidance have truly been invaluable. Thank you for all the time you have dedicated to this dissertation, but also to my development as a scholar over the past five years.

Many thanks to my committee members – Drs. Scott Crossley, Kathryn McCarthy, and Jessica Scott who provided advice, feedback, and encouragement throughout this study. I am so lucky to have each of you as a mentor and I look forward to future collaborations together.

Finally, thank you to Heather Ness-Maddox, Ellie Hong, Eleanor Fang, Meghan Tadeo, and Anybel Guzman. I cherish your friendship and your generosity. Thank you for your help in making this dissertation happen and for your constant encouragement and support.

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CHAPTER 1
INTRODUCTION TO THE STUDY

Academic success becomes increasingly synonymous with reading proficiency throughout a child's education. Academic success in middle school is particularly dependent on reading proficiency because all aspects of their school day are text-rich – text is used to teach content, access classroom activities, and measure progress on formative and standardized assessments. This emphasis on text extends across all content areas: language arts, science, history, and even math, and as such, children need to proficiently comprehend text to access classroom curricula and learn. Therefore, it is difficult to overstate the importance of understanding how middle school students proficiently comprehend text for sustaining and improving academic outcomes, especially in the context of middle school readers whose success is directly linked to reading comprehension (Lee & Spratley, 2010; Snow, 2002).

The significance of the relationship between middle school students' reading proficiency and academic outcomes is particularly evident with *expository* text (sometimes referred to as informational text, but expository will be used of the purposes of this dissertation). Expository texts are one of the primary sources of text that middle school students are required to understand. Expository texts are written to teach or instruct a reader about certain concepts. As such, expository texts are frequently used resources in classrooms, particularly in content area classes such as history and science, for instruction and learning (i.e., middle school) (Goldman & Bisanz, 2002; Lee & Spratley, 2010). Accordingly, national and state literacy standards, such as the Common Core State Standards (CCSS), prioritize comprehension of expository texts (e.g., CCSS.ELA-Literacy.RI.7.1) as a critical skill for middle school readers.

Comprehension of Expository Text

Reading comprehension is a dynamic and complex construct dependent upon the coordination of several cognitive processes (e.g., thoughts, strategies) that take place during reading to support proficient comprehension (Rapp et al., 2007). These processes include lower-level decoding processes that require the processing of phonemes, syllables, and words, as well as higher-level processes such as inferences to connect text information with previous text or prior knowledge (Graesser et al., 2003). Low level processes and basic reading skills are foundational to reading and contribute to the understanding of individual words or sentences. High level processes, on the other hand, center on accessing meaning throughout the text (Rapp et al., 2007). Readers who cannot sufficiently read words are unable to access meaning in a text and likewise, readers who may be able to decode or read words, yet do not understand word meanings or text events will also fail to comprehend what is read. Thus, proficient comprehension requires the synchronization of both low- and high-level reading skills.

Proficiency with low-and high-level reading skills is particularly important for comprehension of expository text. Although expository texts are ubiquitous and essential for learning, comprehension and learning can be thwarted due to features inherent within expository text (Goldman, 2012). Expository texts have been found to be more difficult to comprehend than narrative texts in research studies (Best et al., 2005; Graesser et al., 2011) as well as when embedded in multiple-choice reading comprehension assessments (Eason et al., 2012). Other evidence indicates that expository texts are also read slower and are harder to recall when asked (e.g., Haberlandt & Graesser, 1985; Graesser et al., 1980).

Another reason that expository texts are generally more difficult to comprehend is that they can vary in their degree of complexity (e.g., Dahl et al., 2021; Graesser et al., 2011). Expository text features, such as unique vocabulary and complex syntax, vary within individual

texts and research indicates that students engage with texts differently (i.e., generate more or fewer high-level processes like inferences) due to features of text complexity (e.g., Dahl et al., 2021; McNamara et al., 1996). Additionally, national and state reading standards expect middle school students to read increasingly complex expository text to prepare for college and career-level reading (e.g., CCSS; CCSS.ELA-Literacy.RI.7.10). Consequently, students need to be adept at comprehending expository text with simple and/or complex text features. However, research comparing students' comprehension of simple and complex expository text is limited particularly in the context of skilled and less-skilled middle school readers (Dahl et al., 2021).

Comprehension of expository text poses challenges for all readers and these hurdles are especially relevant for less-skilled readers. Lack of reading skill (whether lacking due to low- and/or high-level reading skills) coupled with complex vocabulary, syntax, and other features in expository text exacerbates comprehension deficits between skilled and less-skilled middle school readers (e.g., Fang, 2006; James et al., 2021; Lee & Spratley, 2010). As such, less-skilled readers are more likely to need additional support to comprehend expository text (e.g., Best et al. 2005). Thus, it is critical to understand the optimal conditions for readers to comprehend and learn from expository text regardless of skill level and help pave the way to further understand how best to intervene with less-skilled readers.

Theoretical Foundations of Knowledge and Expository Comprehension

In addition to expository text features and reading skill, research indicates that prior knowledge is also closely associated with expository comprehension performance (e.g., Britton et al., 1982; Dochy et al., 1999; Eason et al., 2012; Goldman & Bisanz, 2002; James et al., 2021; Meyer & Rice, 1982). Prior knowledge, or all the knowledge in one's memory, is one of the largest determinants of a readers' potential to comprehend a given expository text (Dochy et al.,

1999; McCarthy & McNamara, 2021). One type of prior knowledge, content knowledge (i.e., knowledge of the content or concepts within a text) has been found to have a positive association with middle school readers' expository comprehension; readers with more prior content knowledge are more likely to understand what they read. In fact, the effect of prior content knowledge on expository text comprehension may be greater than the effect of other reading and cognitive skills for middle school readers (e.g., Ahmed et al., 2016; Elleman et al., 2022; Kulesz et al., 2016). Due to the highly predictive power of prior knowledge, it is critical to understand how other types of prior knowledge may contribute to middle school readers' expository comprehension.

The Reading Systems Framework (RSF; Perfetti & Stafura, 2014) acts as framework for understanding the ways that readers comprehend text using three types of knowledge (Perfetti & Stafura, 2014). The RSF operates on the assumption that readers use general knowledge (i.e., knowledge about the features of text, text structure, and the world), linguistic knowledge (i.e., knowledge of language), and orthographic knowledge (i.e., knowledge of written letters and their corresponding phonemes) to comprehend text. Correlational and intervention studies highlight the contributions of two types of prior knowledge from the RSF relevant to middle school readers' expository comprehension: text structure knowledge and linguistic knowledge. Knowledge of expository text structures (i.e., descriptive, cause/effect, problem/solution, sequence, and compare/contrast) helps readers infer the organizational structure of a text (Meyer & Ray, 2011; Meyer & Rice, 1982; McNamara & Magliano, 2009). In addition, pre-existing knowledge of these structures facilitates top-down retrieval and makes it easier to comprehend expository texts (Britton et al., 1982; Pyle et al., 2017). Thus, text structure knowledge is another

type of prior knowledge that has been found to contribute to middle schoolers' expository comprehension.

Linguistic knowledge, or knowledge of the forms of language (e.g., semantic, syntactic) is another source of knowledge posited as important for middle school readers' comprehension of expository text (Goodwin et al. 2020; James et al., 2021; Perfetti & Stafura, 2014; Nagy & Townsend, 2012). For example, expository texts are written using more complex syntax than traditionally observed in other texts (Scott & Windsor, 2009). Reading texts with complex syntax is taxing because sentence structures are longer, less familiar, and likely more difficult to segment (Scott & Koonce, 2014). Despite the complex language used in expository text, linguistic knowledge has been found to positively affect expository comprehension in upper elementary and middle school readers (e.g., Eason et al., 2012; Scott & Balthazar, 2010).

Although content knowledge, text structure knowledge, and linguistic knowledge have been found to support expository comprehension performance, more research is needed to explain how these sources of knowledge contribute to middle school readers' expository comprehension in varying conditions, including with skilled and less-skilled readers as well as in the context of simple and complex expository text. Drawing upon the assumption that knowledge is pivotal for explaining middle schoolers' expository text comprehension performance, the following study seeks to explore how three aspects of prior knowledge (i.e., content, text structure, and linguistic) support middle school readers' expository text comprehension and learning. Although existing research has illustrated the vital importance of prior knowledge for expository comprehension, little work has investigated how specific types of prior knowledge that are particularly relevant to expository text comprehension (i.e., content, text structure, linguistic knowledge) simultaneously or separately contribute to expository comprehension

performance (McCarthy & McNamara, 2021). Moreover, the relationship between multiple knowledge types and expository comprehension is particularly understudied in middle school students, whose reading skill may alleviate or exacerbate the effects of knowledge on their expository text comprehension reading performance (e.g., Adams et al., 1995; Elbro & Buch-Iversen, 2013). Because middle school students' academic success is inextricably linked to their comprehension of expository text, it is critical to determine how the effects of prior knowledge and reader skill do or do not contribute to students' outcomes. Finally, there is scant research explaining how content, text structure, and linguistic knowledge contribute to comprehension of simple and complex expository text. Thus, it is critical to evaluate how different types of knowledge including content, text structure, and linguistic knowledge, may influence the extent to which skilled and less-skilled middle school readers develop coherent representations of expository text. Conducting such research could enhance our understanding of how middle school students' knowledge is associated with reader skill and expository text complexity to facilitate expository comprehension and thereby, inform theory, support instruction, and improve students' academic outcomes.

Theoretical Foundation of Processes and Products of Expository Comprehension

In addition to prior knowledge, reader skill, and text complexity, another important aspect of expository comprehension is how comprehension performance is measured. Reading researchers have developed two methods for understanding readers' comprehension of text: comprehension *processes* and *products*. The latter, comprehension products, is the most commonly used method for measuring comprehension performance. Comprehension products are "what" readers learn and includes the text representation in memory after reading has ended. Multiple-choice tests and recall tasks, for instance, are common examples of methods used to

examine comprehension products. Comprehension processes, on the other hand, are the cognitive thought patterns readers engage in during the act of reading while the mental representation is being constructed (van den Broek & Helder, 2017). Comprehension processes are "how" readers develop their products or mental representations of text.

Several theories of text comprehension have been developed to explain the process of how readers generate comprehension processes and products to facilitate successful comprehension. For instance, the Construction Integration model (CI; Kintsch, 1988;1998) states that readers build (i.e., construct) a mental representation, or *product* of text that is created from readers generating different types of comprehension *processes* (e.g., inferences) during reading (McNamara & Magliano, 2009). Cognitive processes are generated and updated by readers during reading or "online" (Graesser et al., 1994; Kintsch, 1988) to build coherent mental representations of the text. This mental representation, or *product*, is the reader's understanding or memory of the text after reading that happens "offline" (Graesser et al., 1994).

According to the CI model, a reader's product or mental representation of text can be categorized into three levels in memory: the *surface structure*, the *textbase*, and the *situation model* (Kintsch, 1988; 1998; van Dijk & Kintsch, 1983). The *surface structure* represents the actual words, phrases, and syntactic structure a reader remembers from the text (Fletcher & Chrysler, 1990). Although the CI model assumes that the processes involved with the construction of the surface level text representation (e.g., syntactic parsing) are in place prior to the onset of the model (McNamara & Magliano, 2009), there is little mention of the surface structure in works by Kintsch (1988; 1998). Despite this preexisting assumption that surface level representations bare little impact on comprehension, later research supports the notion that the surface level representation may underpin the processes readers need to successfully

comprehend text and warrants further examination (Graesser et al., 1994; Fletcher & Chrysler, 1990; Gillam et al., 2009; Kucer, 2009; Yeari & Lantin, 2021).

The *textbase* refers to the explicit ideas presented in the text that readers store in memory via their textbase representation (e.g., propositions like main idea, subject/predicate or idea units that represent explicit meaning in a text). Comprehension of the textbase is important because it is the semantic underpinning of the text (Kintsch, 2019). Readers generate processes, such as textbase inferences, that connect explicit ideas across a text to develop a textbase representation. Previous research has found that the generation of textbase inferences while reading helps to establish coherent text representations (e.g., Cain & Oakhill, 1999; Graesser & Clark, 1985; Kintsch, 1988; McNamara, 2007).

The final and third representation of the CI model is the *situation model* and includes memory of explicit information from the surface structure and textbase representations (i.e., words, lexical and syntactic information; text meaning), integrated with a reader's prior knowledge (Kintsch, 1988; 1998). Because the CI model was developed to help support an understanding of the types of text representations developed in memory, it generally assumes the processes readers use during reading without explicitly outlining which processes are used at each level. However, research that followed the development of the CI model has worked to identify the types of processes that skilled and less-skilled readers use during reading to help understand how readers develop surface, textbase, and situation model representations of text (e.g., Carlson et al., 2014, 2022; McMaster et al., 2012). For instance, readers develop situation model representations of text by accessing explicit *and* implicit information in a text as well as prior knowledge. Comprehension processes associated with the situation model include elaborative or knowledge-based inferences (inferences that integrate prior knowledge with

information stated in the text). The generation of knowledge-based inferences in upper elementary and middle school readers has been associated with more coherent text representations developed after reading (Cain & Oakhill, 2006; Carlson et al., 2014, 2022; McMaster et al., 2012; Rapp et al., 2007; van den Broek et al., 2006). Additionally, situation model comprehension has been previously found to be indicative of successful learning (Otero et al., 2002).

Although, previous research has identified that situation model text representations are related to proficient expository text comprehension (e.g., Otero et al., 2002), the CI model does not explain what aspects of knowledge support such comprehension outcomes and whether the contributions of knowledge differ across each level of representation. Kintsch (1988) defines knowledge in the CI model as general knowledge about all aspects of words, syntax, and the world at large; it is these sources of knowledge that guide readers toward extracting meaningful representations from discourse. While reading, individual words and propositions activate relevant knowledge, and the strength of these interconnections is what determines what knowledge is integrated with the text. As such, knowledge generally plays a principal role for the construction of coherent text representations in the CI model; however, specific types of knowledge (i.e., content, text structure, linguistic) and individual differences (i.e., comprehension skill) within those knowledge stores are assumed to be important for comprehension, yet they are not directly explained in the CI model (McNamara & Magliano, 2009).

The current study seeks to expand upon the CI model to understand how individual differences (i.e., prior knowledge, reader skill), and aspects of expository text (i.e., complexity), contribute to the processes and products middle school readers generate to comprehend

expository text (e.g., Best et al., 2005; Dahl et al., 2021; Kintsch, 1988;1998). The current study is designed to expand this line of research in several ways. First, the current study addresses how content, text structure, and linguistic knowledge influence how skilled and less-skilled middle school readers generate comprehension processes and products of surface level, textbase, and situation model levels of expository comprehension. This is important because prior knowledge is a well-known predictor of comprehension performance and although the multidimensionality of the construct is increasingly being addressed, studies rarely examine more than one knowledge type in an individual study (McCarthy & McNamara, 2021). Moreover, an investigation of the relationship between prior knowledge and the comprehension processes and products skilled and less-skilled middle school readers generate is theoretically and empirically important because (a) the current study will expand upon assumptions in the CI model to explain how three types of knowledge contribute to expository comprehension across all three levels of the CI model (surface, textbase, situation model) and such comparisons are rare within the literature (Kintsch, 1988; 1999; McNamara & Magliano, 2009) and (b) the processes and products generated by skilled and less-skilled middle school readers may differ from what is proposed in the CI model as appropriate for typical adult readers (Kintsch, 1988; 1998). Thus, the current study will expand upon the CI model to determine whether different types of knowledge contribute to the development of comprehension processes and products across surface, textbase, and situation model representations of expository text.

In addition to the effects of knowledge on comprehension processes and products, this study addresses the extent to which knowledge differentially contributes to skilled and less-skilled middle school readers' comprehension when reading simple and complex expository text. Comprehension of expository text presents challenges for middle school readers due to the

complex vocabulary, text structures, and syntax embedded within the text; however, little research has been conducted to examine how text complexity may augment or hinder middle school reader's expository comprehension (Dahl et al., 2021). Moreover, there is a demand for research that explains how skilled and less-skilled readers comprehend complex expository text because national and state standards prioritize comprehension of complex text to prepare students for college and career-level reading (CCSS; CSSS.ELA-Literacy.RI.7.10).

Consequently, the current study seeks to understand how aspects relevant to the reader (i.e., knowledge, skill) and expository text (i.e., complexity) contribute to the generation of comprehension processes and products. Therefore, the findings of this work may help explain how skilled and less-skilled middle school readers leverage content, text structure, and linguistic knowledge to comprehend simple and complex expository texts, thus facilitating theoretical and practical applications for how to support middle school readers' expository comprehension.

CHAPTER II
MIDDLE SCHOOLERS' KNOWLEDGE AND EXPOSITORY TEXT COMPREHENSION: A REVIEW OF THE LITERATURE

Evidence from theoretical and empirical research indicates that the amount and quality of a reader's prior knowledge is a significant predictor of text comprehension outcomes (e.g., Dochy et al. 1999; McCarthy & McNamara, 2021). Yet, little is known about how several types of knowledge predict expository text comprehension outcomes for skilled and less-skilled middle school readers. Three types of knowledge that help support comprehension of expository text will be reviewed for this study: content, text structure, and linguistic. Knowledge of content within expository texts, text structures, and linguistic features have been individually found to affect comprehension (e.g., Best et al., 2008; Hebert et al., 2018; Scott & Balthazar, 2010). For instance, content knowledge is a well- known predictor of successful expository comprehension (e.g., Dochy et al., 1999; McCarthy & McNamara, 2021), findings from meta-analyses indicate that text structure knowledge favorably improves expository comprehension performance (e.g., Pyle et al., 2017), and linguistic knowledge is associated with good performance on reading comprehension assessments (e.g., Eason et al., 2012). However, these aspects of knowledge have not been typically examined together, nor are they studied in the context of comparing how skilled and less-skilled middle school readers generate online processes and offline products while reading expository text. Additionally, there is little work examining how prior knowledge may differentially affect students' expository text comprehension in the context of reading simple and complex text (Dahl et al., 2021). Although examining the individual contributions of content, text structure, and linguistic knowledge to comprehension performance are important, the development of comprehension processes and products is sensitive to the resources available to the reader (e.g., knowledge) (Schroeder, 2011). Consequently, these aspects of knowledge

may have individual and overlapping contributions to expository text comprehension for skilled and less-skilled middle school readers.

Review of the Literature

To study how the existing literature discusses the individual and overlapping effects of content, text structure, and linguistic knowledge on skilled and less-skilled middle school readers' comprehension of simple and complex expository text, I conducted a thorough literature review. In the following literature review, I examine studies that focus on the relationship between content, text structure, and/or linguistic knowledge and expository text comprehension outcomes in middle school readers. Although many studies acknowledge the importance of these knowledge types for expository text comprehension outcomes, this review was conducted to understand the extent to which content, text structure, and linguistic knowledge influence skilled and less-skilled middle school readers' comprehension of simple and complex expository text. It is important to understand how individual or overlapping effects of content, text structure, and linguistic knowledge contribute to middle school readers' expository comprehension performance.

As a secondary goal of this review, I examine the extent to which the contributions of content, text structure, and linguistic knowledge differ for skilled and less-skilled middle school readers. As previously discussed, differences in reader skill are often exacerbated when students read expository text (e.g., Best et al., 2005). For instance, less-skilled readers often generate low-level processes (e.g., repetition, paraphrases) while reading or perform more poorly on multiple-choice assessments after reading expository text than their peers with more reading skill (e.g., Gillam et al., 2009). However, different sources of knowledge including content, text structure, and linguistic knowledge have been found to increase reading scores in less-skilled readers (e.g.,

Elbro & Buch-Iversen, 2013) and accordingly, these types of knowledge may be a means to bolster expository comprehension in less-skilled readers. However, it remains to be seen whether individual or overlapping contributions of content, text structure, and linguistic knowledge are beneficial for improving less-skilled middle school readers expository comprehension.

As a final goal of this review, I examine the extent to which the contributions of content, text structure, and linguistic knowledge differ when middle school students read simple and complex expository text. Middle school students are tasked with understanding expository text with varying degrees of difficulty and complexity, although the effects of prior knowledge on expository comprehension are well-known (e.g., McCarthy & McNamara, 2021), less is understood about how the effects of multiple knowledge types may alter how students understand texts with varying levels of complexity. It is critical to understand the effects of different knowledge types on simple and complex expository text because middle school readers need to proficiently read both text types as evidenced by national and state standards that require comprehension of several types of text. Moreover, future research and interventions can leverage knowledge to scaffold students' comprehension of simple and complex expository text.

Scope of the Review

To begin, I outline the scope of the review and clarify any underlying assumptions regarding the constructs examined within the extant literature. Theoretical frameworks and models developed to understand how readers construct meaning from text indicate that prior knowledge is necessary for helping readers to establish a coherent mental representation of text (Kintsch, 1988; 1998; Perfetti & Stafura, 2014). However, much of this theoretical work does not delineate what types of knowledge are necessary for this to occur, nor does it explain how prior knowledge may be more or less imperative for readers with varying skill and when reading texts with varying complexity. More recent theoretical work, such as the Multidimensional

Knowledge Framework, (McCarthy & McNamara, 2021) has illustrated the multidimensional nature of prior knowledge and identified the need for more empirical work that tests how different dimensions or aspects of knowledge affect comprehension in varying populations and contexts. Because these theoretical frameworks use comprehensive definitions of knowledge, there is great variation in the literature regarding what constitutes prior knowledge. For the purposes of this review and the extant study, I define prior knowledge as all the information in one's memory (McCarthy & McNamara, 2021). The focus of this review was to understand the contributions of prior knowledge germane to expository text comprehension. Thus, this review focuses on content, text structure, and linguistic knowledge due to the theoretical and empirical evidence demonstrating how these aspects of prior knowledge are particularly important for improving the processes and products associated with expository text comprehension (e.g., Best et al., 2008; Hebert et al., 2018; Scott & Balthazar, 2010).

The terminology for readers who struggle with reading comprehension can also be conflicting within the extant literature. For example, some studies refer to these readers as less-skilled readers, struggling readers, or poor comprehenders. To accommodate the different nomenclature used to describe the constructs of interest to this review, I chose inclusive and general terminology, rather than specific terms to oversample studies related to the scope of the review during the search process. For instance, I opted to identify students using the term "reader" rather than "comprehender" in the review because it is the more general and inclusive term. Similarly, the terms used to explain how difficult a given text is to read varies including text complexity, text features, or readability. As such, I looked for any relevant terminology that addressed text difficulty or complexity and included such language in the scope of my review.

Using this approach ensured that the review is as comprehensive as possible. The following description of my search methods for the review further details this process.

Search Methods for this Review

I searched for literature within the APA PsychInfo and ERIC databases using the following search terms: (Middle School OR adolescent) AND ("reading comprehen*" OR "reading skills" OR "reading disab*) AND (Prior Knowledge OR content Knowledge OR background knowledge) AND (“text structure”) AND (vocab* AND language OR linguistic knowledge OR proficiency) AND (synta* OR grammar AND language OR linguistic knowledge OR proficiency) AND (morph* AND language OR linguistic knowledge OR proficiency) to identify studies that align with the goals of this review. These search terms originated from my interest in identifying existing peer-reviewed literature that addresses the effects of content, text structure, and linguistic knowledge on expository text comprehension outcomes for middle school students with different comprehension skills. I included manuscripts written in English that were obtained from peer-reviewed journals. Use of these search terms and specifications resulted in the identification of 157 studies.

Next, I applied a search criterion to the 157 identified studies. My inclusion criteria stated that: (a) the sample must include students in grades 5-8 (i.e., this provided a criterion for adolescent or middle school students), (b) the dependent variable must measure expository text comprehension outcomes, and (c) the independent variable(s) and/or targeted intervention construct must be content, text structure, and/or linguistic knowledge. Thus, I eliminated studies that did not meet these inclusion criteria and I identified 23 articles for thorough review.

As such, the remainder of this chapter reviews the 23 identified studies that are aligned with my aforementioned search criteria. The studies are categorized by their focal knowledge type(s). Most of the studies reviewed here investigated the effects of one type of knowledge (i.e.,

content, text structure, or linguistic) on expository comprehension outcomes (*n* = 18); however, five studies investigated the effects of two knowledge types on expository text comprehension outcomes. The primary aim of this review was to understand how content, text structure, and linguistic knowledge contribute to expository comprehension outcomes for all middle school students, so I initially review all relevant studies regardless of the participants' reader skill level. Then, I discuss studies that investigate how two types of knowledge concurrently influence middle schoolers' expository text comprehension performance including the following comparisons: linguistic and text structure knowledge and linguistic and content knowledge.

After addressing the general effects of content, text structure, and linguistic knowledge on middle school readers' comprehension of expository text, I address the secondary aim of this review which was to understand whether these effects differ for skilled and less-skilled middle school readers. That is, I review which of the 23 studies identified within this review explicitly include participants identified as having lower reading skill (*n* =11). I summarize these findings to ascertain whether content, text structure, and/or linguistic knowledge differentially affect skilled and less-skilled middle school readers' expository comprehension.

Finally, I focus on the third aim of this review which was to explain whether the existing literature studies how content, text structure, and linguistic knowledge contribute to middle school readers comprehension of simple and complex expository text. I investigated whether any of the 23 studies included in the review use text materials with different levels of readability or complexity and I summarize these findings to determine if the effects of content, text structure and/or linguistic knowledge differ when middle school students read simple and complex expository text. I identified one study that fits these criteria. I conclude with a general discussion

regarding possible explanations for the findings of the review, as well as limitations and implications for future research and practice.

Contributions of Content, Text Structure, and Linguistic Knowledge on Expository Comprehension

Contributions of Content Knowledge on Expository Comprehension

As stated previously, several theories position knowledge as a key component affecting how readers construct meaning from text. Consider a middle school student who reads a text about how to play and win a baseball game. This reader happens to be a baseball player and can quickly understand the words and concepts within the text because they have a lot of knowledge about baseball. Due to this knowledge, the reader can also generate connections between their personal experiences, knowledge about baseball, and information within the text. Therefore, this student is likely to construct a strong coherent representation of a text on the topic of baseball. The same student is now reading about plate tectonics and is not familiar with geological science or plate tectonics and has no experience with the concepts or vocabulary. Now, the student is likely to struggle with understanding the words and sentences within the text and consequently, may struggle with developing a coherent mental representation of what is read. Although simple examples, these illustrations demonstrate that knowledge is the linchpin that allows readers to access information in the text and integrate this information with their prior knowledge to foster coherent text representations.

In accordance with theories and frameworks that highlight the role of knowledge as a primary contributor to comprehension (e.g., Kintsch, 1988; McCarthy & McNamara, 2021; Perfetti & Stafura, 2014), many of the studies included in this review investigate how content knowledge affects expository outcomes in middle school readers (see Table 2.1 for a comparison of each study). As previously stated, content knowledge can be referred to using several terms

(e.g., topic knowledge) so any study that measured participants' knowledge of content or concepts that aligned to texts within an outcome measure (dependent variable) were included in this section of the review.

Table 2.1

Studies Investigating the Effects of Content Knowledge

Study	Number of Participants (Grade Level)	Reader Skill	Knowledge Assessment(s)	Outcome	Text Content Area (Difficulty level)	Findings
Ahmed et al. (2016)	1196 (7-12)	Not stated	Gates MacGinitie background knowledge test; multiple-choice questions related to world knowledge	Gates MacGinitie Reading Test; Texas Assessment of Knowledge and Skills	Mixed on assessment (not stated)	DIME model accounted for almost all of the variance in RC. Knowledge and inferencing made direct contributions to reading comprehension.
Barth & Elleman (2017)	66 (6-8)	Less-skilled	Researcher-developed content knowledge assessment (see Elleman et al., 2015)	Wechsler Individual Achievement Test-III; Qualitative Reading Inventory-5	Social Studies (~850 Lexile)	Significant effects on the intervention were found for content knowledge on the WIAT-III. They did not find significant effects for inferencing.
Bråten et al. (2017)	130 (6)	Not stated	Researcher-developed measure of content knowledge	Researcher developed (Multiple-choice; literal and inferential	Social Studies (Bjornsson's readability score of 32 – below the typical score of 42)	Participants in the prior knowledge activation condition did better than the control group.
Carr & Thompson (1996)	48 (7- 8)	Less-skilled	Researcher-developed measure of content knowledge	Inferential Reading Comprehension Test; Recall task	Social Studies (not described)	Students with more knowledge correctly answered more inference questions. Children with LD could answer inference questions if familiar with topic but not as efficiently
Elleman et al. (2022)	254 (5)	Not stated	Researcher-developed measure with passage-specific	Researcher-developed measure with 3 literal and 3	Social Studies (Flesh-Kincaid = 4.7 to 5.6; Lexile = 410 to 1,000)	Knowledge explained item level variance in comprehension

			topic familiarity questions	inferential comprehension questions		better than other reading skills and working memory
Hattan (2019)	143 (5-6)	Not stated	Researcher-developed measure of prior topic knowledge	Researcher-developed assessment with multiple-choice and constructed response questions	Social Studies (Flesh-Kincaid = 6.5)	Students with higher content knowledge and relational reasoning ability earned higher comprehension scores. Students in the RR group outperformed KWL and control group.
Swanson et al. 2015	130 (6-8)	Less-skilled	Assessment of Social Studies Knowledge and Comprehension (ASK)	Assessment of Social Studies Knowledge and Comprehension (ASK); Gates MacGinitie Reading Test	Social Studies (Lexile range = 1090-1140)	Significant effects for knowledge acquisition (p =.03), and reading comprehension (p =.01) on the ASK; not on the GMRT
Tarchi (2017)	147 (7)	Not stated	Researcher-developed measure with 10 multiple-choice items	Researcher-developed measure with multiple-choice questions; Free recall task	Social Studies (Not Stated)	Content knowledge and inference skill explained variance in the comprehension measures. Content knowledge, inference skill, metacognition, and topic interest explained variance in free recall.
Vaughn et al. (2019)	690 (8)	Less-skilled	Assessment of Social Studies Knowledge and Comprehension (ASK)	Modified Assessment of Social Studies Knowledge and Comprehension (MASK); Gates MacGinitie Reading Test	Mixed in Assessment (Lexile for MASK = 1090-1140)	ASK scores affected MASK performance for students in the PACT intervention. Effects of PACT lessened if there were high proportions of struggling readers in the class. No effects on Gates MacGinitie Reading Test.
Wolfe & Goldman (2005)	44 (6)	Not stated	Researcher-developed measure with open-ended questions	Think-aloud task	Social Studies (~5th grade level texts)	Content knowledge did not predict processing. Generated

	elaborations and paraphrases most.

In a first example, Ahmed and colleagues (2016) used two standardized reading comprehension outcome measures, the Gates MacGinitie Reading Test Passage Comprehension subtest (GMRT; MacGinitie et al., 2000) and the Texas Assessment of Knowledge and Skills (TAKS) to test the utility of using the Direct and Inferential Mediational (DIME) Model with middle and secondary readers. Both standardized measures included short expository and narrative texts that middle schoolers might read for schoolwork or recreation. Ahmed et al. assessed content knowledge using the Gates MacGinitie background knowledge test that includes multiple-choice questions that measure world knowledge. Although Ahmed and colleagues operationalize "world knowledge" rather than content knowledge, the term content knowledge applies here because the knowledge assessed in the GMRT background knowledge test is associated with the content in the GMRT Passage Comprehension subtest. In addition to measuring prior knowledge and reading comprehension, other components of reading, such as inferencing, are included in the DIME model and hence inference skill was measured using the Bridge-It assessment. Using structural equation modeling Ahmed et al. found that the DIME model accounted for almost all the variance in adolescents' reading comprehension with world (i.e., content) knowledge making a direct contribution to reading comprehension. Knowledge also mediated the relationship between inferencing and comprehension. Thus, students with strong content knowledge generated more inferences which allows readers to better comprehend the texts that are read (Ahmed et al.,). These findings demonstrate the importance of content knowledge for influencing expository text comprehension, but also for mediating other important components of comprehension, such as inferencing. The significant relationship between content knowledge and inferencing is worth highlighting here because frameworks of comprehension,

such as the CI model, emphasize that prior knowledge and inferencing drives situation model representations of text (e.g., Kintsch, 1988) and the DIME model supports this supposition.

An important consideration related to Ahmed et al.'s (2016) findings is that the methods used in their study do not explain how content knowledge, specifically, contributed to the quantity or quality of comprehension processes readers generated while they read each text. Instead, Ahmed and colleagues used offline, standardized comprehension measures to understand how several components of reading contributed to students' mental representation of text after the text was read (i.e., products). Therefore, future research could explore how components of reading, including content knowledge and other types of knowledge including text structure and linguistic knowledge, affect how readers develop mental representations of text during reading through methodological approaches such as eye-tracking or think-aloud studies.

The work of Bråten et al. (2017) expands upon Ahmed et al.'s (2016) findings to highlight how instruction related to content knowledge can support expository comprehension in middle school readers. Bråten et al. implemented an intervention where some students received content knowledge activation instruction and other students received typical instruction in a control group. The knowledge activation instruction included a teacher facilitated discussion where students reflected on life in Norway in the mid-1800's. After this instruction, participants read one historical text adapted from preexisting secondary school textbooks about students emigrating from Norway in the mid-1800's to the United States. Participants in the prior knowledge activation condition performed significantly better on a measure of expository text comprehension than students in the control group. The measure in Bråten et al. was a multiple-choice measure with nine items and of those nine items, some inferential questions were included. Thus, Bråten and colleagues demonstrated that instruction focusing on content

knowledge can enhance middle schoolers' expository text comprehension performance particularly on multiple-choice measures. However, the effects of cognitive predictors, such as content knowledge, on reading comprehension may depend on the outcome measure(s) used in the study (Cutting & Scarborough, 2006) and multiple-choice tests cannot explain how readers arrived at their answers nor can they elucidate whether readers have coherent representations of text, like constructed response or free recall tasks.

Other studies use constructed responses and free recall tasks in addition to multiple-choice tests to study the effects of content knowledge on middle schoolers' text comprehension. Tarchi (2017) for example, used generalized linear modeling to explore whether content knowledge, inference skill, topic interest, and motivation influenced seventh graders' performance on a multiple-choice reading comprehension assessment and free recall task. Tarchi found that content knowledge and inference skill explained variance on a multiple-choice comprehension measure, but only on the inferential items. This finding adds to the body of literature purporting the importance of content knowledge and inference skill on comprehension outcomes (e.g., Ahmed et al., 2016); however, Tarchi's results also emphasize the importance of using measures that tap into textbase and situation model level comprehension (i.e., measures that require inference generation).

Tarchi also found that content knowledge, inference skill, metacognition, and topic interest explained variance on students' free recall performance. Thus, students used more cognitive resources including metacognitive skills, in the recall task than the multiple-choice questions. In this recall task, students were prompted with a question related to the main idea of the text and asked to write what they remembered about the text. Recall tasks require students to rely on their own mental model of a text without prompting that is provided in multiple-choice

questions. In multiple-choice tests, readers can use words in the question to update their text representation and re-establish their situation model as they answer questions (Tarchi, 2017). Therefore, free recall demands that readers use more cognitive resources to explain their mental representation of a text. In addition to recall tasks, other methodologies such as eye-tracking, and think-aloud tasks, could be utilized in future research to explain how these different types of knowledge influence the development of readers' text representations while they are reading.

One study found within this review explored the contributions of content knowledge on middle school readers' comprehension processing via a think-aloud task. Wolfe and Goldman (2005) had 44 sixth grade students complete a researcher-developed content knowledge assessment and then read two social studies texts while completing a think-aloud protocol. Students read the text and after each sentence said whatever they were thinking out loud. Students generated elaborations and paraphrases the most while reading the social studies texts; however, stepwise multiple regression analyses indicated that content knowledge did not predict students' think-aloud responses. Although participants had recently completed a 6- to 8-week unit on the Roman Empire two months prior to participating in the study, participants recalled an average of 4.16 clauses related to the topic (the Fall of Rome) in an open-ended prior knowledge measure. Accordingly, Wolfe and Goldman posited that students might not have had enough knowledge to successfully integrate it into their think-alouds and that is potentially why they did not find an effect of content knowledge on students' comprehension processing. Nonetheless, few studies have investigated the effects of content knowledge on comprehension processing and more research needs to be conducted to understand the extent to which content knowledge and other knowledge types, contribute to comprehension processing in middle school readers.

Contributions of Text Structure Knowledge on Expository Comprehension

Of the 23 studies reviewed here, two focused on text structure knowledge and its influences on expository text comprehension (Meneses et al., 2018; Meyer et al., 2010). Several meta-analyses have been conducted to investigate the effects of text structure knowledge on elementary students' expository comprehension (e.g., Hebert et al., 2016; Pyle et al., 2017) and found that readers with more text structure knowledge were better able to summarize text information and performed better on multiple-choice comprehension assessments. Nonetheless, little empirical work was identified in this review pertaining to middle school readers and thus, it is less clear how text structure knowledge middle supports middle school readers' expository comprehension. One of the two studies is reported here (Meyer et al., 2010) and the other is reported in the *Contributions of Text Structure Knowledge and Reader Skill on Expository Comprehension* section of this review because the sample in the latter manuscript includes skilled and less-skilled readers. See Table 2.2 for a comparison of these studies and their findings.

Table 2.2

Studies Investigating the Effects of Text Structure Knowledge

Study	Number of Participants (Grade Level)	Reader Skill	Knowledge Assessment(s)	Reading Assessment(s)	Text Content Area (Difficulty Level)	Findings
Meneses et al. (2018)	160 (5)	Not stated	Participants read texts with implicit or explicit text structure as a manipulation in the study	Researcher-developed RC measure	Science (Mean sentence length = 15.9 and 16.1).	Texts with explicit structures only benefitted the low skilled group
Meyer et al. (2010)	111 (5 & 7)	Not stated	Researcher-developed measure of text structure strategy knowledge	Gray Silent Reading Test	Mixed on Assessment (Lexile ranged from Grades 2-6)	Students performed better on text structure measure and RC measure when provided

	elaborative feedback while learning text structures

Meyer and colleagues (2010) implemented a computer-based intervention that taught students expository text structures. One hundred eleven fifth and seventh grade students completed a text structure pretest, participated in the intervention, and completed a text structure posttest four months after the intervention ended. Texts within the intervention varied in topic and their readability ranged from Grade 2 to 6. Although texts with variable readability were used in this study, Meyer et al. did not examine how using these texts may have affected students' performance within the intervention. The outcome measures were the Gray Silent Reading Test and an experimenter designed measure of text structure knowledge. Findings indicated that students performed better on the text structure measure and the reading comprehension measure when they had been given elaborative feedback while learning text structures in the intervention. These gains were maintained four months post intervention. The study also targeted 32 of the participants who did not know the problem-solution structure at the onset of the intervention according to their pretest performance. This group of 32 participants were eventually competent with the problem-solution structure based on their posttest performance. These study results suggest that students can learn expository text structures and when they do, this knowledge can have positive effects on reading comprehension outcomes. Although this relationship is important for understanding whether text structure knowledge can improve students' expository comprehension, these results do not indicate whether text structure knowledge supports students' development of comprehension processes as they read and therefore, their coherent mental representation of expository text. Future research utilizing online

methods, such as eye-tracking or think-aloud tasks could fill this gap to explain whether and how text structure knowledge may support expository comprehension while students read.

Contributions of Linguistic Knowledge on Expository Comprehension

Six studies within this review focused on the effects of linguistic knowledge on the text comprehension outcomes of middle school readers (see Table 2.3 for a comparison of all of the reviewed studies that pertain to linguistic knowledge). Three of these six studies did not differentiate between skilled and less skilled readers and those three studies are presented here. Each of these studies measured linguistic knowledge using a battery of assessments that tap into semantic and syntactic knowledge at the word and/or sentence level using short texts that were embedded within an assessment. Thus, within this sample of three studies, comprehension is measured in the context of assessments and not texts that are not naturally occurring in middle school classrooms. For example, Eason et al. (2012) explored the relationship between readers' linguistic knowledge, text types, and question types within a standardized reading comprehension assessment, the Stanford Diagnostic Reading Test – Fourth Edition (SDRT; Karlsen & Gardner, 1995). The SDRT includes narrative and expository texts with a mean Flesch Reading Ease of 72.91. Students read each SDRT item and answered multiple-choice literal and inferential questions after reading. Eason and colleagues measured students' syntactic knowledge using the Test of Language Development receptive grammar and grammatic comprehension subtests and the Peabody Picture Vocabulary Test-III to measure semantic knowledge. Hierarchical regression modeling indicated that semantic awareness contributed the most to students' performance beyond the other linguistic variables (e.g., syntax/grammar) after reading narrative, expository, and functional passages. Semantic awareness, or the ability identify words that are related to one another, contributed the most to all question types within the SDRT – including literal questions and questions that require inferencing. As such, Eason et

al.'s findings highlight the importance of linguistic knowledge but particularly semantic (i.e., vocabulary) knowledge for students' performance on standardized measures of reading comprehension such as the SDRT. However, these findings neglect other aspects of linguistic knowledge, including morphology, and they do not explain how linguistic knowledge might contribute to comprehension outcomes for tasks that require the allocation of more cognitive resources, such as think-aloud tasks or recall. Conducting this work using longer, natural texts would be especially meaningful because Eason and colleagues' study used short, artificial texts which offers little generalization for how linguistic knowledge may affect expository text comprehension outcomes for students reading texts that might be more typically read in the classroom.

In two studies Goodwin and colleagues (2020; 2022) explored the influence of other aspects of linguistic knowledge including vocabulary, morphology, and syntax knowledge, on middle schoolers' performance on a computer adaptive assessment of reading comprehension, the Measures of Academic Progress (MAP). Goodwin et al. (2020) indicated that vocabulary, morphology, and syntax knowledge significantly contributed to middle schoolers' reading comprehension performance on the MAP test. As an extension of what Goodwin and colleagues found in their 2020 study, Goodwin et al. (2022) focused on the relationship between morphological skills and reading comprehension for a subset of eighth graders with poor vocabulary skills. Findings determined that four subsets of morphological skill can support standardized reading comprehension for middle grade readers. Thus, the work of Goodwin and colleagues demonstrates that linguistic knowledge and particularly morphological knowledge, is associated with middle schoolers' good performance on standardized measures of reading comprehension. However, in the studies reviewed here, linguistic knowledge is measured by

assessing individual components of language proficiency (e.g., receptive vocabulary, grammar) at the word or sentence level and as such, there is little knowledge regarding the extent to which discourse-level linguistic knowledge may or may not contribute to text comprehension outcomes. Studies that measure discourse-level linguistic knowledge use stimuli that is at least a paragraph in length and may be able to examine the multiplicative effects of syntax, semantics, and morphology in comprehension performance rather than the individual contributions of each language component. Future studies should examine how discourse-level linguistic knowledge contributes to expository comprehension particularly in the context of naturalistic text to better understand the role of linguistic knowledge in situations that are relevant to middle school readers.

Table 2.3

Studies Investigating the Effects of Linguistic Knowledge

Study	Number of Participants (Grade Level)	Reader Skill	Knowledge Assessment(s)	Reading Assessment(s)	Text Content Area (Difficulty Level)	Findings
Eason et al. (2012)	126 (5-8)	Not stated	Test of Language Development (syntax); Peabody Picture Vocabulary Test-III (semantics)	Stanford Diagnostic Reading Test	Mixed on assessment (Flesch Reading Ease Mean = 72.91)	Regression model accounted for 38-49% of variance. semantic awareness contributed the most of out of the language measures
Goodwin et al. (2022)	1027 (5-8)	Not stated	Gamified computer adaptive assessment of morphology, vocabulary, and syntax	Measures of Academic Progress testing	Mixed on Assessment (not stated)	Vocabulary, morphology and syntax explained 62% of variance in reading comprehension
Goodwin et al. (2020)	184 (5-8)	Not stated	Gamified computer adaptive assessment of morphology,	Measures of Academic Progress testing	Mixed on Assessment (not stated)	Morphological skills can support reading comprehension for different types of

			vocabulary, and syntax			readers. Children with low vocabulary struggled to apply semantic information in morphemes
Proctor et al. (2020)	538 (6-8)	Less-skilled	RAPID computer administered measure from Lexia Learning (measured morphology and syntax)	RAPID computer administered measures from Lexia Learning (measured reading comprehension)	Mixed on Assessment (Not Stated)	Morphology, syntax, and orthography independently predicted reading comprehension outcomes
Trapman et al. (2017)	50 (7)	Less-skilled	Researcher-developed measure of grammatical knowledge and receptive vocabulary	SALSA Literacy Test	Mixed in Assessment (Not Stated)	Linguistic and metacognitive knowledge explained the level of reading comprehension skill
Trapman et al. (2014)	60 (7)	Less-skilled	Researcher-developed measure of grammatical knowledge and receptive vocabulary	Researcher-developed measure of reading comprehension	Mixed in Assessment (Not Stated)	Linguistic knowledge was more important for explaining reading comprehension in bilinguals than for monolinguals

Contributions of Two Knowledge Types on Expository Comprehension

Of the 23 studies reviewed, 5 studies included more than one knowledge type in their analyses (see Table 2.4 for a comparison of relevant studies). What follows is a review of the studies that compared linguistic knowledge and text structure knowledge and linguistic knowledge and content knowledge. One study compared the effects of content knowledge and text structure knowledge and distinguished between skilled and less-skilled readers and will be explained in the *Contributions of Two Knowledge Types and Reader Skill on Expository Comprehension* section later in this review. Although zero studies found in this review

simultaneously investigated how content, text structure, and linguistic knowledge influence middle schoolers' comprehension outcomes, the handful of studies that do compare two knowledge types offer insight into the extent to which these variables influence comprehension within the same analyses.

Table 2.4

Studies Investigating the Effects of Two Knowledge Types

Study	Number of Participants (Grade Level)	Reader Skill	Knowledge Assessment(s)	Reading Assessment(s)	Text Content Area (Difficulty Level)	Findings
Welie et al. (2018)	151 (8)	Not stated	**Linguistic Knowledge:** Researcher-created measures of academic vocabulary and knowledge of connectives **Text Structure Knowledge:** Researcher created measure with reading and summarizing expository texts	Researcher-developed measure of reading comprehension	Mixed Topics (Not stated)	Text structure knowledge had predictive value in models that did not use knowledge of connectives and metacognition and control variables.
Marron (2019)	40 (5)	Not stated	**Linguistic Knowledge:** Test of Narrative Language **Content Knowledge:** Concept questions on the Qualitative Reading Inventory	Qualitative Reading Inventory- 5	Mixed on Assessment (Not stated)	Regression model with content and linguistic knowledge explained 18.9% of the variance in expository text comprehension but individual predictor variables were not significant.
Davis et al. (2017)	83(7)	Not stated	**Linguistic Knowledge:** Peabody Picture Vocabulary Test, Clinical Evaluation of	Sentence and inference verification task; Think-aloud task	Science (Not stated)	Multiple Regression; English proficiency was the strongest predictor. Content knowledge was not

			Language Fundamentals - 4 **Content Knowledge:** Researcher-developed measure where students judged statements as accurate or inaccurate			related to comprehension.
Garcia et al. (2015)	Study 1: 114 (6)	Less-skilled	**Text Structure Knowledge:** Researcher-developed measure of organizational signals **Content Knowledge:** Researcher-developed measure with open-ended questions	Spanish Evaluation of Reading Processes for Secondary Education Students	Mixed on assessment (Not stated)	After controlling for prior knowledge, hierarchical regression indicated that text structure knowledge affected reading comprehension
Garcia et al. (2015)	Study 2: 154 (6-7)	More skilled	**Text Structure Knowledge:** Researcher-developed measure of organizational signal knowledge **Content Knowledge:** Researcher-developed measure with open ended questions	Spanish Evaluation of Reading Processes for Secondary Education Students	Mixed on assessment (Not stated)	Text structure knowledge separately made a significant contribution to RC over and above content knowledge. Similar findings for low and high skilled readers but the impact was higher for the skilled group

Contributions of Linguistic Knowledge & Text Structure Knowledge on Expository Comprehension

Welie et al. (2018) investigated whether eighth graders' knowledge of text structures (i.e., organizational signals) had unique predictive value above the variance accounted for by linguistic knowledge. Participants completed a battery of linguistic knowledge measures that assessed academic vocabulary and knowledge of connectives as well as a text structure knowledge measure. The researcher-developed text structure knowledge measure tasked students with reading 15 short expository texts and summarizing the texts after reading them. Text comprehension was assessed using a researcher-developed assessment with five expository texts and 35 associated multiple-choice questions. Multilevel regression analysis revealed that text structure knowledge was predictive only when knowledge of connectives (e.g., and, therefore) was not used as control variables in the model; therefore, middle school readers need some modicum of linguistic knowledge (e.g., knowledge of connectives) and metacognitive skills to be able to apply text structure knowledge and thereby impact expository comprehension. The effects of text structure knowledge did not depend on language background or language proficiency. Although these conclusions are limited due to the insufficient number of studies that compare linguistic and text structure knowledge within the literature, these findings indicate that linguistic knowledge may be a prerequisite for students to engage in higher level comprehension processes. Welie and colleagues found that middle school readers need some degree of linguistic knowledge to apply their text structure knowledge on a multiple-choice measure; however, the contributions of linguistic and text structure knowledge may change when readers integrate these types of knowledge with text while reading or when completing a more generative task, like a recall task (Tarchi, 2017). More work is needed to compare the effects of text structure and linguistic knowledge particularly in the context of online and offline measures of expository comprehension.

Contributions of Linguistic Knowledge and Content Knowledge on Expository Comprehension

Two studies within this review compared the effects of linguistic and content knowledge on middle schoolers' text comprehension performance. Marron (2019) compared the effects of fifth graders' linguistic knowledge and content knowledge on their expository text comprehension. Linguistic knowledge was assessed using the Test of Narrative Language (TNL; Gillam & Pearson, 2004) whereas content knowledge was assessed using the QRI-5 concept questions. Participants then completed the QRI-5 wherein students read several expository passages modeled after text in science and social studies textbooks. Then students answered eight comprehension questions associated with each passage. Results demonstrated a significant, positive relationship between students' performance on the TNL and the QRI-5 (Spearman's Rho = .35); however, the relationship between content knowledge and QRI-5 performance was slightly higher (Spearman's Rho = .47). Further regression analyses indicated that content and linguistic knowledge together explained 18.9% of the variance in expository text comprehension; however, the individual predictor variables were not significant. Therefore, it appears that linguistic knowledge associated with narrative language and content knowledge collectively contribute to expository text comprehension. However, linguistic knowledge was measured in this study using an assessment of narrative language and the effects of these variables might be larger in an assessment of linguistic knowledge related to *expository* language knowledge rather than language knowledge pertaining to narrative language. Future research could focus on language knowledge that is specifically relevant to expository text.

In a mixed methods study, Davis et al. (2017) compared the effects of monolingual and bilingual seventh graders' linguistic and content knowledge in a sentence verification and think-

aloud task. Linguistic knowledge was assessed using a combination of subtests from the PPVT-4 and Clinical Evaluation of Language Fundamentals – 4 (CELF-4; Semel et al., 2003) to tap into semantic, morphological, and syntactic knowledge. Content knowledge was measured using a researcher-developed assessment testing student's knowledge related to the science texts read during a think-aloud task. The measures used in this study are informative because think-aloud tasks address online comprehension processes and sentence verification tasks tap into offline situation model products. Regression analyses indicated that linguistic knowledge was the strongest predictor of performance on the sentence verification task ($\beta = 0.48$) followed by content knowledge ($\beta = 0.24$). The think-aloud task focused on 10 bilingual students within the sample and qualitative evaluations of think-aloud protocols indicated that students demonstrated emergent processes of disciplinary reading in the think-aloud. In sum, although linguistic and content knowledge were significant contributors to expository text comprehension outcomes, linguistic knowledge explained the largest share of variance. Davis et al. conducted a qualitative analysis of the students' think-aloud protocols and future work might corroborate whether linguistic knowledge contributes to expository comprehension processing more than content knowledge using quantitative approaches.

Taken together these studies suggest that students' linguistic knowledge and content knowledge can positively influence expository text comprehension outcomes for middle school readers. However, the number of studies that have made direct comparisons of the contributions of linguistic and content knowledge is extremely small and as such, more research is needed to understand the extent to which these knowledge types collectively influence middle school readers' expository text comprehension.

Contributions of Knowledge and Reader Skill on Expository Comprehension

A secondary goal of this review was to provide insight into how different knowledge types affect expository text comprehension outcomes for readers with varying skill levels. Many studies included in this review did not specify participants' reading ability; however, several studies differentiated between skilled and less-skilled readers in their work (n = 11). As such, some conclusions can be drawn about how these knowledge types may differentially influence comprehension outcomes for skilled and less-skilled middle school readers.

Contributions of Content Knowledge and Reader Skill on Expository Comprehension

As described earlier, studies that investigated the effects of content knowledge on expository comprehension but did not explore reader skill, found that the effects of content knowledge differed depending on how comprehension was measured (i.e., multiple-choice, recall). More specifically, the findings shared within this review thus far suggest that content knowledge is particularly important for supporting inferencing and expository comprehension performance on inference questions and recall tasks (e.g., Tarchi, 2017). Here I explore whether similar results were found in studies that identified skilled and less-skilled readers within their sample.

To start this comparison, two studies investigated the effects of the Promoting Acceleration Comprehension and Content through Text (PACT) intervention (Swanson et al., 2015; Vaughn et al., 2019). This intervention seeks to improve adolescents' reading comprehension through instruction that targets cognitive processes, motivation, and engagement and content knowledge is one of the primary targets within this intervention. Content knowledge is gained through reading primary and secondary sources related to historical events studied within the intervention. All participating students completed a researcher-developed multiple-choice content knowledge assessment, the Modified Assessment of Social Studies Knowledge

and Comprehension (MASK). The MASK measure was used for students with markedly lower reading skill (Vaughn et al.,). These assessments measure social studies content knowledge as well as the student's ability to comprehend social studies texts. Therefore, the MASK was used as pre and posttest to assess student's growth in content knowledge and comprehension. Participants also completed a standardized reading comprehension outcome measure, the GMRT, to determine whether content knowledge within these interventions affected performance on a generalized reading comprehension measure.

PACT study results are similar across the two studies. Swanson et al. (2015) found that the PACT intervention led to significant improvements in knowledge acquisition and reading comprehension on the MASK assessment for middle school students in grades six throughout; however, these effects were not found on the GMRT. In a later PACT study, Vaughn et al. (2019) found that performance on the MASK measure predicted performance on the MASK reading comprehension assessment at the conclusion of the intervention; however, these effects lessened if the intervention was delivered in a class with a high proportion of struggling readers. Vaughn and colleagues found no effects for the GMRT. Therefore, content knowledge appears to influence middle school readers' performance on multiple-choice tests of reading comprehension. However, the effects of knowledge were stronger for students in classes with a higher proportion of skilled readers. Results from Swanson et al. and Vaughn et al. do not clarify whether less-skilled readers can leverage content knowledge to answer inferential comprehension questions or to recall text information because comprehension was measured using tests with multiple-choice items. To better understand how less-skilled readers use their content knowledge to generate inferences and situation model representations of expository text

more research using alternative methodological approaches, such as think-aloud and recall tasks may be warranted.

Barth and Elleman (2017) conducted an intervention for struggling middle school readers to boost students' reading comprehension outcomes. Barth and Elleman also used a combination of standardized and researcher-developed measures to examine the effects of their intervention. The intervention targeted activation of prior knowledge, attending to character perspectives, and answering inference questions while reading narrative and expository text. Participants completed a researcher developed content knowledge assessment (Elleman et al., 2015), the Wechsler Individual Achievement Test -III Reading Comprehension subtest (WIAT-III; Wechsler, 2009), and Qualitative Reading Inventory-5 (QRI-5; Leslie & Caldwell, 2011). The WIAT-III is a standardized measure of reading comprehension wherein students complete reading tasks that they might encounter in their school or home lives (e.g., narratives, informational text, advertisements, how-to passages) and answer questions related to the text. Questions on the WIAT-III can be literal or inferential and can be several types of questions (i.e., open-ended, multiple-choice). The QRI-5 is an informal reading inventory. Students read two passages associated with ancient Egypt, answered related inferential comprehension questions, and completed an unaided written retell of the passage. The effects of content knowledge were mixed across the assessments which align with previous findings shared in this review. Significant treatment effects were found for content knowledge on the WIAT-III, but not the QRI-5. These findings suggest that the multiple strategies taught within the intervention (e.g., activating background knowledge, attending to character perspectives) supported performance improvement on a reading comprehension measure that included literal and inferential questions. However, the intervention did not produce significant effects on students' inference generation

or retell on the QRI-5. These findings reiterate that content knowledge supports students' performance on outcome measures that use multiple-choice questions. However, due to the nature of the intervention which taught several comprehension strategies that were not always related to content knowledge (e.g., perspective taking), it is difficult to tease out how much content knowledge contributed to Barth and Elleman's findings. Thus, more work needs to be conducted to understand how content knowledge influences less-skilled readers' performance on inference-focused tasks or retell tasks.

Carr and Thompson (1996) used the Inferential Reading Comprehension Test (IRCT; Andersson, 1993) and a recall task to examine the extent to which content knowledge and reader skill contribute to situation model representations of expository text. Carr and Thompson compared the reading abilities of three groups of students: eighth graders with diagnosed learning disabilities, eighth graders without learning disabilities, and fifth graders without learning disabilities. Students completed a content knowledge pre-test, read 16 expository texts, answered related inferential questions, and a completed recall task. The 16 expository texts used in this study were obtained from the IRCT and written at a fourth-grade readability level per the Dale-O'Rourke Living Word Vocabulary. MANOVA analyses revealed that students with more content knowledge correctly answered more inference questions. Additionally, children with learning differences were able to answer inference questions when they had more content knowledge, but less efficiently than their typical peers. This aligns with findings from Ahmed et al. (2016) suggesting that students with more content knowledge may generate more inferences and thus, generate stronger situation model comprehension. Carr and Thompson also demonstrate that although content knowledge supports inferencing and expository comprehension for all readers, less-skilled readers' mental representations are likely to be less

efficient or less coherent that their peers (e.g., Vaughn et al., 2019). In sum, it appears that content knowledge benefits skilled and less-skilled readers' expository comprehension, however, this effect may be strongest for skilled readers.

The Contributions of Linguistic Knowledge and Reader Skill on Expository Comprehension

Several studies also investigated the contributions of linguistic knowledge and reader skill on expository outcomes in skilled or less-skilled middle school readers (Proctor et al., 2020; Trapman et al., 2014; 2017). In 2014, Trapman et al. (2014) compared the linguistic knowledge of monolingual and bilingual seventh graders to ascertain whether the effects of linguistic knowledge on expository comprehension differ amongst mono- and bilingual students. In this study, grammatical knowledge and receptive vocabulary served as linguistic knowledge and the constructs were measured using two researcher-developed tests. Reading comprehension was assessed with a researcher-developed measure including expository and narrative items. Trapman et al. (2014) determined that linguistic knowledge was more important for explaining reading comprehension in the bilingual group than the monolingual group of middle schoolers. Linguistic knowledge was also found to be an important factor for reading comprehension in the lowest achieving readers within the sample. Thus, Trapman et al.'s findings suggest that linguistic knowledge might be a prerequisite for low achieving students, such as bilingual or low struggling readers, to engage in higher level comprehension skills. However, these findings echo the work conducted by Eason et al. (2012) and Goodwin et al. (2020) in that linguistic knowledge and reader skill are examined in the context of assessments with short, nonnatural texts and as such, it is unclear how middle schoolers with varying reader skills' linguistic knowledge might contribute to other comprehension skills that may necessitate the coordination of additional cognitive resources or knowledge types.

In a more recent study, by Trapman and colleagues, Trapman et al. (2017) conducted a longitudinal study to investigate how linguistic knowledge, metacognitive knowledge, and reading fluency affect the level and growth of reading comprehension skill in low achieving Dutch middle school students. Participants' reading comprehension was assessed using the SALSA Literacy Test (SALT; Van Steensel et al., 2013) that consists of nine texts with differing genres and 65 associated multiple-choice and open-ended questions. The linguistic knowledge assessments were comprised of two researcher-developed measures of grammatical knowledge and receptive vocabulary. Their results demonstrated that the primary predictors of students' reading comprehension proficiency across middle school years were explained by linguistic knowledge. In all, Trapman and colleagues determined that linguistic knowledge explained less-skilled readers' proficiency, whereas, reading fluency did not have an important role in explaining reading comprehension proficiency level. The work of Trapman and colleagues elucidates the importance of linguistic knowledge for expository comprehension for less-skilled readers. The 2017 study in particular highlights how linguistic knowledge matters for students' comprehension performance on multiple-choice *and* open-ended questions which points to linguistic knowledge supporting expository comprehension in tasks that may require more inferencing, such as in answering open-ended questions. Additionally, due to the longitudinal nature of the study it is significant that linguistic knowledge predicts expository comprehension across all the middle school years.

Proctor et al. (2020) used an approach similar to Trapman et al. (2014) and explored whether orthographic and linguistic knowledge predicted reading and writing skills in low achieving middle grade readers in grades six through eight. Orthography, morphology, syntax, and reading comprehension were measured using subtests within a computer-adaptive

assessment, the RAPID, which is a test developed by Lexia Learning (see Foorman et al., 2012). The reading comprehension component of the RAPID includes narrative and expository text materials and utilizes fill-in-the-blank and multiple-choice question types. Structural equation modeling demonstrated that underperforming middle schoolers' morphology and syntax proficiency independently predicted reading and writing performance on the Lexia Learning assessment. Moreover, linguistic knowledge was more associated with reading than writing in this study. The authors recommended that more studies focus on other aspects of linguistic knowledge beyond vocabulary, such as syntax and morphology. This recommendation aligns with findings described previously wherein there is a clear association between linguistic knowledge and expository comprehension outcomes for skilled and less-skilled readers (e.g., Eason et al., 2012; Proctor et al., 2020); however, the extent of this literature focuses on knowledge of components in language (e.g., semantics, syntax, morphology) rather than discourse-level language knowledge. Consequently, more research is needed to determine if these findings would be replicated in a measure of discourse-level linguistic knowledge.

Contributions of Text Structure Knowledge and Reader Skill on Expository Comprehension

One study found in this review explored the effects of text structure knowledge on expository comprehension for less-skilled middle school readers. In Meneses et al. (2018) 160 fifth grade students were assigned to read science texts with implicit or explicit text structures (i.e., use of explicit signal words). After reading, participants answered literal, deep, and critical questions in a researcher-developed assessment. Analysis of variance analyses indicated that the texts with explicit structures supported comprehension for the less-skilled readers but did not support comprehension for the high-skilled readers within the sample. These findings suggest that less-skilled readers may need additional instruction on text structures to support comprehension of expository texts with implicit text structures. As stated previously, there is

ample evidence that text structure knowledge improves skilled and less-skilled elementary readers' performance on offline comprehension measures including multiple-choice tests and recall tasks (e.g., Pyle et al., 2017). More empirical research is needed to determine if the effects of text structure knowledge on expository comprehension are significant for skilled and less-skilled readers across different reading contexts, especially online measures of text comprehension such as think-aloud tasks.

Contributions of Two Knowledge Types and Reader Skill on Expository Comprehension

One of the studies in the review included more than one knowledge type and identified middle school less-skilled readers in their analyses. What follows is a review of the study that compared the contributions of content knowledge, text structure knowledge, and reader skill. Although the number of studies comparing more than one knowledge type are relatively few, it is important to explore their findings to support the development of future studies that compare the multiplicative effects of several types of prior knowledge on expository comprehension outcomes for skilled and less-skilled readers.

Contributions of Content Knowledge, Text Structure Knowledge, and Reader Skill on Expository Comprehension

One study compared the contributions of content knowledge, text structure knowledge, and reader skill on expository comprehension within the same manuscript across two experiments (Garcia et al. 2015). In experiment 1, Garcia and colleagues investigated how less-skilled readers' text structure knowledge (i.e., knowledge of organizational signals) and content knowledge influenced their performance on the reading comprehension subtest of the Spanish Evaluation of Reading Processes for Secondary Education Students (PROLEC-SE). The PROLEC-SE is a standardized measure of expository text comprehension wherein students read

two expository texts and answer 10 associated open-ended questions. Findings indicated that after controlling for content knowledge; knowledge of organizational signals made a significant contribution to student's reading comprehension. Thus, text structure knowledge can help less-skilled readers understand what they read to answer open-ended comprehension questions. As explained previously, measures that include open-ended questions like the PROLEC-SE may require readers to generate more inferences and/or be more reliant on their situation model representations. Accordingly, these findings are significant because they point to text structure knowledge supporting less skilled readers' development of situation model text representations; however, future research using recall tasks might be able to further test this claim.

In their second experiment, Garcia et al. (2015) used the same materials and procedures to investigate whether text structure knowledge affected skilled readers' expository text comprehension performance. The findings in experiment 2 indicated that knowledge of organizational signals separately made a significant contribution to reading comprehension over and above content knowledge. Consequently, Garcia and colleagues' work suggests that skilled and less-skilled readers' knowledge of text structures influenced their comprehension outcomes; however, the effects of text structure knowledge were higher for the skilled readers. Garcia et al.'s findings demonstrate a positive relationship between text structure knowledge and expository comprehension, but it appears that these effects tend to be stronger for skilled readers than less-skilled readers. Future work should explore whether these effects for skilled and less-skilled readers differ when other types of knowledge related to expository comprehension, like linguistic knowledge, are added to the study design.

Contributions of Knowledge and Text Complexity on Expository Comprehension

A third, and final goal of this review is to provide insight into how different knowledge types affect expository text comprehension outcomes when middle school students read texts

with different degrees of complexity. One of the 23 studies included in this review investigated how features of text impact expository comprehension (Elleman et al., 2022). Interestingly, this study also included a higher number of less-skilled readers. Although 10 of the reviewed studies indicated some degree of difficulty or readability of the text materials used in the study, these levels did not vary by complexity as they were matched to the participants' reading ability and thus, the complexity of these texts was below or on-grade level. As another example, Meyer et al. (2010) used texts within their intervention with a wide range of readability (i.e., Lexile grade range between 2 and 6), but Meyer et al.'s analyses does not compare students' performance based on text readability. What follows is a review of one study that statistically investigated whether expository text features contributed to middle school readers' expository comprehension.

The Contributions of Knowledge, Reader Skill, and Text Complexity on Expository Comprehension

Elleman and colleagues (2022) used text features as a random effect in their study investigating how several knowledge types including content knowledge, general knowledge, and vocabulary knowledge predicted reading and listening comprehension in fifth grade readers. Elleman et al. purposefully oversampled less-skilled readers which resulted in a sample of students with lower average passage comprehension scores. The sample also included students with typical and above average reading skill. Content knowledge was assessed using a researcher-developed measure of passage-specific topic familiarity prior to reading and listening to four passages from the fifth-grade level of the QRI-3. The four passages from the QRI-3 varied in Lexile Level from 410 to 1,000. The texts also ranged in Flesh Kincaid Grade Level from 4.7 to 5.6. Coh-Metrix (McNamara et al., 2014), a text analysis tool, was also used to

measure text complexity. Coh-Metrix determined that one of the four passages, although rated easier by Lexile and Flesh-Kincaid, was more complex because of less concrete words and cohesion when compared to the other passages. Notably, the passage identified as more complex by Coh-Metrix was one of the texts read aloud to the participants. After reading and listening to two passages, students answered literal and inferential questions to determine their comprehension of the passages.

Mixed-effects modeling indicated that passage-specific familiarity (i.e., content knowledge) predicted the probability that students would answer a question correctly about a passage. Moreover, literal questions were easier to answer than inferential questions which supports research conducted with samples that do not oversample less-skilled readers (e.g., Tarchi, 2017). Results also indicated when all sources of knowledge (content knowledge, academic knowledge, and vocabulary) were included in Elleman et al.'s model, the knowledge variables impacted expository comprehension more than general reading ability or working memory. Therefore, it appears that content knowledge may be more predictive of middle school readers' ability to answer multiple-choice comprehension questions than general reading ability. However, this finding has not been tested in studies that examine online and offline measures of comprehension, such as think-aloud and recall tasks. To be able to confirm whether content knowledge is more predictive of expository comprehension than general reading ability, research needs to be conducted.

Regarding text complexity, features of each passage (i.e., complexity) significantly contributed to students' performance on the QRI multiple-choice questions. Interestingly, passage features were significant for the texts that the students read and not the texts that students listened to; thus, it appears that text complexity may be particularly important for

reading when compared to listening to expository text. Elleman et al. (2022) do not compare the effects on expository comprehension when reading simple and complex texts because all the texts in their study were identified as being around the same level of complexity by Lexile and Coh-Metrix. However, their findings do reiterate the importance of conducting more research to discover how text complexity may influence middle school readers' expository comprehension especially in text that is read rather than listened to. Taken together, Elleman et al.'s findings demonstrate that content knowledge may be particularly important for comprehension of expository text and answering associated inferential multiple-choice questions. These findings also indicate that content knowledge may predict students' performance above general reading ability. Also, although Elleman and colleagues found that text features significantly impact expository comprehension, more research is needed to compare whether these effects manifest differently across simple and complex text.

Summary of Findings for Contributions of Knowledge on Expository Comprehension

There are several important findings of this review worthy of attention. First, there is substantial evidence indicating a positive relationship between content, text structure, and/or linguistic knowledge and expository comprehension outcomes in middle school readers. Several studies indicated that students with more content knowledge demonstrated stronger performance on multiple-choice and recall measures of expository text comprehension (e.g., Ahmed, 2016; Tarchi, 2017). Similarly, a text structure intervention study demonstrated that when students learn expository text structures, their performance improves on multiple-choice measures of reading comprehension (Meyer et al., 2010). Finally, studies focusing on several components of linguistic knowledge (e.g., semantics, morphology, syntax) revealed that linguistic knowledge influences students' performance on standardized reading comprehension assessments and moreover, semantic knowledge may be particularly important for contributing to these outcomes

(e.g., Eason et al., 2012). Thus, the findings from this review illustrate that content, text structure, and linguistic knowledge independently influence middle school readers' expository comprehension performance.

Although the majority of literature reviewed here investigates the contributions of one knowledge type, some studies compared the effects of two knowledge types on expository text comprehension outcomes. Findings from these studies revealed that linguistic knowledge may be a necessary bridge to higher-level comprehension processes (Welie et al., 2018) and linguistic knowledge may potentially contribute more variance to expository text comprehension than content knowledge (Davis et al., 2017). Nevertheless, this small sample of studies suggests that more work is needed to compare the contributions of these knowledge types to better understand how they differentially affect expository text comprehension outcomes for middle school readers.

Summary of Findings for Contributions of Knowledge and Reader Skill on Expository Comprehension

The findings of this review also provide insight into how different knowledge types affect expository text comprehension outcomes for readers with varying skill levels. Many of the studies in this review did not specify their participants reading ability (n = 12); however, several studies differentiated reader skill within their samples (n = 11). As such, some conclusions can be drawn about how content, text structure, and linguistic knowledge differentially influence comprehension outcomes for skilled and less-skilled middle school readers.

Although prior knowledge contributes to less-skilled readers' expository text comprehension outcomes (e.g., Swanson et al., 2015; Trapman, 2014) research explained in this review indicates that these effects may be more pronounced for skilled readers than less-skilled

readers (Carr & Thompson, 1996; Garcia, 2015; Vaughn, 2019. For example, Vaughn et al. (2019) determined that the effects of content knowledge on expository comprehension were lessened when classrooms had a higher proportion of struggling readers. Similarly, the work of Garcia and colleagues (2015) indicated that the contributions of text structure knowledge on expository comprehension were much greater for skilled readers than less-skilled readers. As such, future research is warranted that can compare the contributions of several knowledge types in one study to determine whether this trend of declining effects of knowledge for less-skilled readers continues if several types of knowledge are compared simultaneously.

Summary of Findings for Contributions of Knowledge and Text Complexity on Expository Comprehension

Although only one study examined the contributions of knowledge and text complexity, some pertinent findings can be shared, nonetheless. Elleman et al. (2022) found that passage features significantly predicted students' expository comprehension for texts that students read to themselves rather than texts read aloud by an experimenter. However, the texts read in Elleman et al. were identified as similar levels of complexity by Lexile and Coh-Metrix and accordingly, more research needs to be conducted to understand how text complexity effects would be amplified in a study where middle school students read simple and complex expository text. This work is practically significant because state and national standards advocate for students to read complex text to be prepared for college and career reading.

General Discussion from the Literature Review

The primary goal of this literature review was to understand how content, text structure, and linguistic knowledge contribute to expository text comprehension outcomes in middle school readers. A secondary goal of this review includes understanding how the contributions of these

knowledge types might differ for skilled and less-skilled readers and third, how they might differ when reading simple and complex texts. In doing so, I highlighted empirical evidence that explains how content, text structure, and linguistic knowledge contribute to expository text comprehension outcomes, particularly for skilled and less-skilled middle school readers reading simple and complex text. This search yielded 23 research studies that met the inclusion criteria for the literature search. The reviewed studies demonstrated that all three types of knowledge have the potential to positively influence middle school readers' expository text comprehension outcomes; however, the limited number of studies that compare the overlapping contributions of content, text structure, and linguistic knowledge and comprehension for middle school readers affect the conclusions that can be drawn from this review.

The Relationship between Knowledge, Inferencing, and Comprehension Outcomes

A focal conclusion of this review relates to the relationship between knowledge, inferencing, and comprehension outcomes. Models and frameworks of comprehension posit a relationship between knowledge, inferencing, and comprehension performance (e.g., Kintsch, 1988; McNamara & Magliano, 2009). More specifically, inferences are generated as readers integrate prior knowledge with text information to fill gaps in the text as they read which in turn facilitates situation model representations that are indicative of proficient comprehension (Kintsch, 1988; van den Broek, 1999). The relationship between knowledge, inferencing, and comprehension performance is empirically supported (e.g., Cain et al., 2001), yet only one of the knowledge types explored within this review repeatedly focused on inference generation. Studies that investigated the contributions of content knowledge included inference skill as a primary variable of interest (e.g., Ahmed et al., 2016) or intentionally chose comprehension outcome measures that tap into inference generation or situation model construction such as think-aloud or recall tasks (e.g., Barth & Elleman, 2017; Davis et al., 2017; Tarchi, 2017; Wolfe & Goldman,

2005). Think-aloud and recall tasks have been touted in previous research as a means for examining readers' comprehension processes during reading (i.e., think-aloud) as well as readers' eventual mental representation of a text after reading has ended (i.e., recall) (e.g., Carlson et al., 2014; 2022; Laing & Kamhi, 2002; McMaster et al., 2015).Wolfe and Goldman (2005), for instance, conducted a think-aloud task with sixth graders and found that students' content knowledge did not predict their comprehension process use (i.e., inference generation); however, students lack of relevant content knowledge may have prevented them from integrating such knowledge into their think-aloud protocols. Think-aloud and recall tasks were not consistently used across the content knowledge studies and accordingly, it is not possible to draw strong conclusions regarding the contributions of content knowledge to students' inference generation while reading (i.e., think-aloud) and students' text representations after reading is over (i.e., recall). Additional research that includes both think-aloud and recall tasks would be useful in further explaining how content knowledge supports inferencing and thus comprehension performance, during and after reading expository text.

Also significant, none of the studies that primarily studied text structure or linguistic knowledge used inference skill as a comparison variable in the studies, nor did they use methodological approaches that allow for conclusions to be drawn about the relationship between linguistic knowledge, text structure knowledge, inferencing, and comprehension performance. Future research should study linguistic and text structure knowledge using methodological approaches that can illuminate the extent to which these knowledge-types support comprehension process generation while reading (e.g., think-aloud task) and building coherent mental representations of text after reading is over (e.g., recall). Findings from these studies could potentially corroborate assumptions from theories of comprehension regarding the

role of knowledge in supporting the development of comprehension processes, like inferencing, and comprehension products recalled after reading is over (Kintsch, 1988; Perfetti & Stafura, 2014).

Discourse-level Language and Expository Comprehension

Another conclusion of this review was the tendency for linguistic knowledge to be studied as individual components of language such as syntax, semantics, or morphology rather than discourse-level linguistic knowledge. That is, linguistic knowledge is not often measured using stimuli that is the length of a paragraph (or longer). All the studies included in this review that investigated the contributions of linguistic knowledge on expository comprehension did so using separate measures for each component of linguistic knowledge (e.g., Eason et al., 2012; Goodwin et al., 2020; Trapman 2014, 2017; Proctor, 2020). Though these individual contributions of linguistic knowledge are important to understand, this review indicates that there is a paucity of research investigating the extent to which knowledge necessary to parse and use language beyond the sentence level relates to expository comprehension. Perfetti and Strafura (2014) theorize that linguistic knowledge is associated with proficient comprehension; however, the findings of this review indicate that this relationship, thus far, has not been empirically tested when linguistic knowledge is operationalized at a discourse-level across all components of language. Relatedly, most of the studies included in this review investigated the effects of linguistic knowledge in the context of standardized reading assessments which often use short texts rather than naturalistic texts middle school students might read in the classroom. Thus, the conclusions of this review pertaining to linguistic knowledge are limited to exploring the contributions of separate components of language on students' expository comprehension of short texts in assessments. Future work might examine how discourse-level language does or does not predict comprehension of longer, natural expository text.

Lack of Variety in Text Materials and Text Complexity

Quite a few conclusions can be drawn about the ways that text materials affected the findings within this review. For instance, most of the studies included in this review used texts that focused on social studies topics or myriad text topics within an assessment. Only two of the studies reviewed included science texts and more specifically, all the studies that measured the effects of content knowledge on expository text comprehension used social studies texts. Therefore, this review indicates that the effects of content, text structure and linguistic knowledge in the context of science texts and other content-focused expository texts are understudied in this population.

Additionally, none of the studies included in this review analyzed whether the effects of content, text structure, and/or linguistic knowledge differed when reading simple and complex texts. This is an interesting gap in the literature because national and state standards such as the Common Core State Standards (National Governors Association Center for Best Practices, Council of Chief State School Officers, 2010), prioritize reading texts with different levels of complexity and there is previous empirical research documenting that features of text complexity (e.g., cohesion) can interact with individual differences (e.g., prior knowledge) and impact comprehension performance (Ozuru et al., 2009). As such, more research is necessary to explore the ways that knowledge affects how middle school readers comprehend simple and complex expository text.

Limitations of the Literature Review

This review has several limitations. First, several synonymous terms are used within the literature to refer to the constructs studied in this review. For instance, the individual components of language (e.g., syntax) can refer to linguistic knowledge or content knowledge is sometimes

referred to as prior knowledge or myriad other terms (see McCarthy & McNamara, 2021 for a review). Text structure knowledge is also operationalized in studies using several terms including organizational signals. Thus, this review is limited by my search terms and using other search terms may have yielded different results.

Additionally, the conclusions of this review are limited by the selected parameters and inclusion criteria. I focused on the effects of content, text structure, and linguistic knowledge on middle school readers' expository text comprehension outcomes. As such, I included studies that had participants in grades five through eight and I did not review studies focusing on elementary or secondary readers or adults. Also, I narrowed this review to include published manuscripts and as such, this review is biased to findings that are accessible in peer-reviewed manuscripts. I did not include work from unpublished or published dissertations or other publications and that is another limitation of this review.

Implications for Research

There are several significant implications for researchers that were borne from this review. First, there is no current literature that compares the effects of more than two types of knowledge on middle school students' expository text comprehension outcomes. Thus, more research is needed to understand how content, text structure, and linguistic knowledge affect student performance within the same analyses.

Additionally, most of the research investigating the effects of knowledge on expository text comprehension focuses on comprehension products particularly using multiple-choice questions to measure students' comprehension performance. Because so many studies indicate a positive relationship between knowledge and expository text comprehension outcomes, it can be assumed that knowledge will also affect how readers generate comprehension processes while reading; however, empirical evidence is not currently available to support this claim based on the

findings in this review. Only two studies looked at comprehension process generation while reading (Davis et al., 2017; Wolfe and Goldman, 2005). Davis et al. (2017) conducted a qualitative analysis of students' process generation and Wolfe and Goldman's assumed that students' deficient content knowledge is why content knowledge did not predict students' comprehension processing. Although the findings from both studies are informative, too few studies examine how content, text structure, and linguistic knowledge contribute to comprehension processes and even fewer studies examine the contributions of knowledge to comprehension processes *and* products. Thus, more research is needed to understand how different knowledge types may support or hinder the generation of middle school readers' comprehension processes during and products after reading expository text.

Additionally, future research is warranted that examines the extent to which discourse-level language (i.e., language that is paragraph length or longer) language contributes to middle school readers' expository comprehension processes and products. As evidenced in this review, there is a dearth of research that investigates how discourse-level linguistic knowledge contributes to expository comprehension in middle school readers, particularly in the context of naturalistic text that students might read throughout their school day. Conducing such research would help to bridge between theoretical frameworks that focus on language components' influence on text comprehension (e.g., Perfetti, 2007) and other frameworks that highlight discourse-level text comprehension (e.g., Kintsch, 1988). Moreover, this research would also offer practical significance for explaining how linguistic knowledge contributes to expository comprehension using texts that middle school readers are exposed to everyday in the classroom.

Finally, the findings of this review indicated that more research needs to be conducted using a variety of text topics and text complexity. Much of the research within this review

suggests that social studies content knowledge affects middle schoolers' performance on proximal measures of expository text comprehension; however, science texts, another common type of expository text read in middle school, are studied less often with this population. As such, more research using myriad text topics, including science, is warranted. Also related to text materials in research, more work needs to be conducted that compares how students' knowledge contributes differentially to comprehension of simple and complex expository text. Little is known about how content, text structure, and linguistic knowledge may influence how and what students comprehend during and after reading simple and complex expository text. Future research that examines this relationship could help inform theoretical frameworks of text comprehension by clarifying how and when middle school readers leverage prior knowledge to comprehend expository text.

Implications for Practice

There are several implications for practicing educators based on the findings in this review. One primary implication was that individual differences, including differences in content, text structure, and linguistic knowledge, are critical for considering how students will comprehend expository text. The findings of this review purport that readers with more content, text structure, and linguistic knowledge are likely to have strong expository text comprehension outcomes. As such, practitioners should be aware of the effects of individual differences on student performance and that knowledge in these areas can be nurtured to improve student outcomes.

Secondly, practitioners should also be aware that other contextual factors related to assessment and text materials may affect the relationship between content, text structure, and linguistic knowledge and expository comprehension. The effects of knowledge may be amplified depending on the type of outcome measure practitioners used to assess expository

comprehension (Cutting & Scarborough, 2006). For instance, students' content knowledge may be more important on measures that require additional cognitive resources, such as tests with open-ended questions rather than multiple-choice measures. Therefore, to the extent that it is possible, teachers may want to strategically choose assessments based on their students' level of prior knowledge and the type(s) of questions on a given reading comprehension assessment.

Also, practitioners may want to pay close attention to the relationship between prior knowledge and reader skill for their students. Less-skilled readers can leverage different knowledge types to support their expository comprehension (e.g., Carr & Thompson, 1996), but to a lesser extent than their peers with more reading skill. It is important for practitioners to consider these implications because student performance is dependent upon a complex interaction between individual differences and text factors (e.g., Snow, 2002) and with these considerations teachers can strategically support middle school readers' expository comprehension. Based on the limitations in the literature highlighted by this review and the need for additional research into the effects of content, text structure, and linguistic knowledge on skilled and less-skilled middle school readers' comprehension of simple and complex science texts, I conducted the following study.

Overview of the Study

Study Purpose

The purpose of this study was to examine how content, text structure, and linguistic knowledge contribute to middle school readers' comprehension processes and products of expository text. To further examine these effects, a secondary purpose of the study was to understand how these contributions may differ for skilled and less-skilled readers. A final, third purpose of this study was to examine whether the contributions of content, text structure, and

linguistic knowledge differed when middle school students read a simple and a complex expository text. Addressing these goals could lead to a better understanding of how to leverage content, text structure, and linguistic knowledge to support expository text comprehension for readers with varied comprehension skills and in myriad contexts.

This study provides significant practical and theoretical contributions to the field. Practically, middle school reading necessitates that students can strategically utilize prior knowledge to comprehend expository text (Snow, 2002). As such, the current study seeks to understand the relationships between these variables in real-world contexts. Understanding how content, text structure, and linguistic knowledge affect comprehension processes and products in middle school readers is important, but equally important is understanding how these effects change for readers depending on their skill level and depending on the complexity of a given text. These are legitimate considerations pertaining to everyday middle school classrooms that are worthy of investigation.

The study also contributes to theoretical knowledge. Reading comprehension frameworks purport that prior knowledge supports expository comprehension during reading and after reading (e.g., Kintsch, 1988; Perfetti & Stafura, 2014); however, the current study will expand this notion to determine whether three knowledge types (content, text structure, linguistic) confirm this assertion in general, and specifically in relation to skilled and less-skilled middle school readers' understanding of simple and complex text. The current study advances this line of work further by investigating the contributions of different types of knowledge, reader skill, and text type across all three levels of text representation in Kintsch's CI model. What follows is a more detailed explanation of the practical and theoretical significance of the study.

Significance of the Study

First, the current study extends the field's understanding of prior knowledge. Although prior knowledge is a well-known predictor of text comprehension (e.g., Dochy et al., 1999); there is limited research indicating how knowledge germane to expository text (i.e., content, text structure, linguistic) is associated with comprehension processing and products of expository text. Research indicates that expository texts are more difficult to comprehend than narrative texts due to unfamiliar content, text structures, and linguistic features (Fang, 2006, McCarthy & McNamara, 2021; Meyer & Ray, 2011). Knowledge of expository text content, text structures, and linguistic features have individually been found to predict comprehension performance (e.g., Best et al., 2005; Hebert et al., 2018; James et al., 2021; Scott & Balthazar, 2010); however, these aspects of knowledge have not been typically examined together, nor are they studied in the context of comprehension processes and products across surface-level, textbase, and situation model text representations that readers develop after reading. Although isolated examinations of the contributions of content knowledge, text structure knowledge, and linguistic knowledge to expository comprehension are important, it is equally critical to compare these aspects of knowledge alongside each other in the context of skilled and less-skilled readers and simple and complex expository text. A simultaneous comparison of content, text structure, and linguistic knowledge across all three text representations allows for the potential to pinpoint when *and* how different types of prior knowledge support middle school readers' expository comprehension. Doing such work can further the fields' understanding of prior knowledge and thereby improve expository comprehension performance in middle school readers.

Additionally, this dissertation provides significant contributions for the relationship between knowledge, reader skill, and expository comprehension processes and products in middle school readers. Previous think-aloud research has identified that children and adolescents

tend to engage in more surface level processes (e.g., repetition) when reading expository text (e.g., Dahl et al., 2021; Gillam et al., 2009) and this may be related to the amount and type of content, text structure, and linguistic knowledge that skilled and less-skilled readers need to adequately process expository text. Moreover, the ability to recall important information from expository text has also been linked to the amount and quality of college readers' prior knowledge (e.g., Kendeou & van den Broek, 2007). However, much of the research related to middle school readers' prior knowledge and expository comprehension products has been conducted with multiple-choice assessments rather than recall. Thus, this study will fill this gap in the literature to address whether content, text structure, or linguistic knowledge influences the information that middle school readers recall after reading a simple and a complex expository text. This may further discern how middle school students leverage prior knowledge to comprehend expository text thus, furthering researchers and educators' insight into the ways that future instruction can strategically utilize prior knowledge to support comprehension in a manner that is relevant for the reader, the text, and the educational context (Snow, 2002).

This study also offers insight into the relationship between knowledge, text complexity, and middle school readers' generation of comprehension processes and products. Although research has prioritized text complexity as an important component of expository comprehension (e.g., Graesser et al., 2004, Spencer et al., 2019), little research has evaluated how text complexity affects the comprehension processes and products middle school readers generate while reading expository text (Dahl et al., 2021). Addressing this gap in the research is a welcome addition to the literature because middle school text is written with different levels of complexity, yet there is little empirical research to explain how prior knowledge and reader skill may affect middle school readers' comprehension of simple and complex expository text.

Finally, the current study addresses gaps in theories of comprehension such as Kintsch's CI model (Kintsch, 1988; 1998). An investigation of the processes and products skilled and less skilled middle school readers generate is theoretically and empirically important for several reasons. First, comparisons across all three levels of the CI model (surface, textbase, situation model) are rare within the literature (Kintsch, 1988; 1999; McNamara & Magliano, 2009). Theories of text comprehension posit that textbase and situation levels are the most important for comprehension (e.g., Kintsch, 1988; 1999; Zwaan et al., 1995) because these levels are associated with higher-level comprehension processes like inferences (e.g, Kintsch, 1998; Zwaan & Radvansky, 1998). In addition, previous research has indicated that skilled readers are more likely to be proficient at textbase and situation model producing processes and products (Carlson et al., 2014; Garcia et al., 2015; McMaster et al., 2015). Despite this, there is evidence that surface level processes and products may also be important for successful comprehension (Fletcher & Chrysler, 1990; Graesser et al., 1994; Kucer, 2009; Yeari & Lantin, 2021). Such research has suggested that surface level processes and products may support textbase and situation model processing and consequently, this may be an area to investigate between skilled and less-skilled readers. That is, understanding less-skilled readers' surface level comprehension could provide a deeper understanding of all three levels of text representation described in the CI model; nonetheless more research understanding surface level comprehension is needed to determine the validity of this claim.

To address the aforementioned gaps in the literature and in theory, the following research questions were developed:

Research Questions

(1) To what extent do different types of knowledge (content, text structure, linguistic) influence middle schoolers' generation of surface level, textbase, and situation model processes while reading expository texts?

    a. How does this vary by comprehension skill?

    b. How does this vary by text complexity?

(2) To what extent do different types of knowledge (content, text structure, linguistic) influence middle schoolers' generation of surface level, textbase, and situation model products after reading expository texts?

    a. How does this vary by comprehension skill?

    b. How does this vary by text complexity?

CHAPTER III
METHOD

Research Design

The goal of this study was to understand the ways that different types of knowledge (i.e., content, text structure, linguistic) influence the surface level, textbase, and situation model processes and products of simple and complex expository text comprehension generated by skilled and less skilled middle school readers. Linear mixed effects models were used to address the goals of this study. Mixed effects models are an appropriate method of analysis because the method can use continuous variables as independent variables while also capturing variance at the subject and item (i.e., idea unit) levels (Brown, 2021; Richter, 2006). Other methods, such as repeated measures analysis of variance, have the potential to reduce statistical power and neglect information about the variability within participants or items (Brown, 2021; Barr, 2008); thus, mixed effects models are appropriate for this study given the reasons stated above.

Every participant read one simple and one complex expository text and accordingly, this study is a within subjects crossed design. The following served as independent variables or fixed effects: reader skill, the scores earned on the measures of knowledge (content, text structure, morphological knowledge, sentence repetition), and the simple and complex expository texts. The processes and products generated during the think-aloud and recall tasks operated as the outcome measures or dependent variables. Subject effects served as a random effect to account for variability across participants and items (i.e., idea units) in the extent to which they are affected by the predictors of interest (Brown, 2021). Mixed effects models allow for the opportunity to explore the individual contributions of each knowledge type on surface level, textbase, and situation model processes and products while accounting for participant variability.

Power

Sample size was determined using G*power, a program that estimates sample sizes and effect sizes based on alpha levels and power values (Erdfelder et al., 1996). Although the chosen statistical procedure, mixed effects models (see *Data Analysis* below), does not have an equivalent test in the G*power program, statistical procedures similar to mixed effects models can be used within G*power to estimate an appropriate sample size. Thus, I conducted a power analysis for multiple linear regression because mixed effects analysis is an extension of multiple linear regression (Brown, 2021; Richter, 2006). I conducted an f-test for linear multiple regression: fixed model: where the input parameters were effect size f^2 (i.e., 0.15); α error probability (i.e., α = 0.05); power 1-β error probability (i.e., power = 0.80); number of predictors (i.e., = 3; knowledge assessments). This calculation estimated a sample size of $N = 77$. I then consulted the extant literature for studies using think-aloud and recall tasks for greater clarity on which sample size to pursue. Previous expository text comprehension studies involving think-aloud and recall tasks have been conducted with sample sizes ranging from approximately 40 to over 80 participants (e.g., Kendeou & van den Broek, 2007; Martin & Myers, 2019; Tilstra & McMaster, 2013; Yeari & Lantin, 2021). Thus, I planned to recruit between 40 and 80 participants.

Participants/Setting

Fifty seventh grade students from middle schools in the Western and Southeastern United States participated in the study (M_{age} = 13 years, 0 months, SD_{age} = .57; 38% female, 62% male) following institutional review board approval. Students attended one private school in the southeast ($n = 7$), one private school in the west ($n = 3$) and three public schools in the west ($n = 40$). Table 3.1 depicts participants' demographic information. Participants' school or district did not provide students' socioeconomic status or other demographic data. Also, the school or

district did not provide information pertaining to participants' main and first language use, visual and hearing abilities or specific information related to any relevant developmental disabilities, speech and language disabilities, or learning disabilities.

Table 3.1

Demographic Information

Category	Frequency	Percentage
Gender		
Male	31	62%
Female	19	38%
Racial Identity		
Asian	0	0%
Black	0	0%
White	46	92%
More than one	4	0.8%
Ethnicity		
Hispanic	7	14%
Non-Hispanic	43	86%

Note. *N*=50

School or district administrators provided participants' scores on standardized reading measures to identify students' comprehension skill. Participants' comprehension skill was identified through curriculum-based measures (CBM) provided by each school site. CBM scores on one reading measure were the only data received by participant schools, and thus, were used as proxy for comprehension skill. The goal of this study was to understand how knowledge influences the cognitive processes and products of skilled and less-skilled readers' and simple/complex texts and as such, participants who demonstrated inadequate word reading skills (e.g., could not fluently read text materials and thus could not access meaning within the text) during study activities were excluded from analyses.

Parents received recruitment materials for the study from school administrators via email and participants' guardians consented for their child's participation in a Qualtrics survey. Then

parents signed up for days and times to participate in the study and received a Zoom meeting link. Participants provided informed assent prior to the start of the study tasks. Data collection occurred after-school hours or on weekends in the participants' home or another quiet location of the participants' choosing (e.g., school classroom). School administrators received a $50 e-gift card for their work collecting students' demographic information, reading scores, and help with coordinating the study. Participants received compensation of pencils and/or pens for participating in the study. In addition, parents of participants received a $15 e-gift card when their child completed the study.

Materials

Expository Texts

Four expository texts obtained from open-source middle school textbooks available from the Utah Education Network (UEN), were used in the study. The UEN is a partnership with the Utah State Board of Education and the Utah System of Higher Education and shares open access textbooks that are aligned with the Utah Core Standards. Consequently, the texts used in the study should be equivalent to texts routinely read by middle school students. The texts were semi-randomized such that every other participant read a different complex and simple text. Thus, although four texts were prepared and used in the study, each participant read two out of the four texts. To control for any potential order effects, texts were counterbalanced; half the participants read a simple text first whereas the other half read a complex text first.

The topic of each text was earthquakes, their causes, and their effects. Science texts were selected for the study because science texts are notorious for using complex concepts and linguistic features (Fang, 2006) which have been found to influence text comprehension outcomes in elementary and middle school students (e.g., Best et al., 2005). Earthquakes are also

of interest to the participants and similar topics are used for instruction in middle school classrooms as evidenced by the Next Generation Science Standards (e.g., M.S. ESS-3-2; NGSS, Lead States, 2013). The topic of the texts was held constant to measure knowledge related to one particular topic associated with a content area, rather than confounding the results with outside knowledge from other topics or content areas (to the best of my ability).

Text Complexity

Two of the four texts were considered simpler, whereas the two other texts were more complex. To evaluate text complexity of each text, I used the Automated Readability Tool for English (ARTE; Choi & Crossley, 2022) to ensure that the texts identified as simple were written with text features that are generally easier to comprehend. ARTE is a text analysis tool that automatically calculates the readability of single or multiple texts using several readability formulas including Flesch-Kincaid Grade Level (1975), Automated Readability Index (1975), SMOG (1969), New Dale-Chall (1995), and Coh-Metrix L2 Reading Index (2008). Each readability formula calculates text difficulty using varied indices (e.g., number of difficult words, number of syllables per word, polysyllabic words) and ARTE provides side-by-side comparisons across several readability tools to get a comprehensive sense of how complex a given text may be to read. For this study, Flesch-Kincaid Grade Level, Automated Readability Index, SMOG, and New-Dale Chall, and Coh-Metrix L2 Reading Index readability formulas were used to analyze the text materials and assign text complexity. Flesch-Kincaid Grade Level, Automated Readability Index, SMOG, and New-Dale Chall provide an approximate *grade level* that is appropriate for reading a given text. I compared the grade-levels obtained from ARTE for each of the texts used in the study to confirm that the texts titled, “Surface Pressure” and “Seismic

Waves and Earthquakes" are simpler than the texts titled "Preventing Damage from Earthquakes" and "Predicting Earthquakes" (see Table 3.2 for this comparison).

I also looked at the Coh-Metrix L2 Reading Index to determine the level of cohesion in each text. The simple texts' cohesion range was 0.33 – 0.39 whereas the complex texts' cohesion was lower and ranged between 0.19 – 0.27. Texts with less cohesion have been identified as more challenging text and therefore, the complex texts in the study appear to be less cohesive and are likely to be more difficult to read (McNamara et al., 2014). Although no text is simple for all readers in all contexts, these comparisons give credence to the statement that two of the texts ("Surface Pressure" and "Seismic Waves and Earthquakes") are generally easier to comprehend than the more complex texts.

Table 3.2

ARTE Text Complexity Comparison

	Surface Pressure	Seismic Waves and Earthquakes	Preventing Damage from Earthquakes	Predicting Earthquakes
Text Type	Simple	Simple	Complex	Complex
Word Count	246	227	236	265
Sentence Length	19	17	17	19
Flesch-Kincaid	6.24	6.36	7.72	8.27
Automated Readability Index	7.93	8.45	9.51	9.78
SMOG	8	9	9	10
New Dale-Chall	7.77	7.96	8.47	8.97

Comparing middle schooler's performance when reading simple and complex texts has been used in other think-aloud studies (e.g., Coté et al., 1998) and is relevant for the current study because previous research indicates that the effects of knowledge on comprehension may vary depending on the simplicity or complexity of expository text features (e.g., McNamara et

al., 1996). Moreover, middle school students encounter a wide range of expository texts with varying degrees of difficulty and consequently, it is practically important to explore the contributions of knowledge in simple and complex expository texts. Text material was displayed on computer screens using PowerPoint and typed using size 14 Times New Roman font. The texts are presented in Appendix A.

Measures

Measures of Knowledge

A battery of three knowledge tests were administered to each participant. These tests measure several types of knowledge associated with general comprehension performance (e.g., Perfetti & Stafura, 2014) as well as expository text comprehension (e.g., Best et al., 2005.) More specifically, content knowledge, text structure knowledge, and linguistic knowledge were assessed to ascertain whether and the extent to which these types of knowledge contribute to the generation of comprehension processes and development of comprehension products during a think-aloud and recall task with simple and complex expository texts.

Content Knowledge. Content knowledge was assessed with a researcher-developed measure to investigate participants' content knowledge related to the topic chosen for the texts (e.g., knowledge of earthquakes). Participants completed a 10-item multiple-choice measure centered on the topic of the two experimental texts. The measure included 10 multiple-choice questions relating to earthquakes because that is the topic of the texts that participants read during the experiment. Participants completed the content knowledge measure in approximately 15 minutes. I developed the content knowledge assessment and this measure showed weak reliability (McDonald'$\omega = 0.5$). Although reliability for the content knowledge measure is poor,

there are a small number of items (10) on this measure and adding more items might improve reliability in the future. See Appendix B for Content Knowledge assessment items.

Identifying Structures. To measure text structure knowledge, participants completed part of the *Identifying Structures* measure, in which readers identify the text structure of short, expository texts (Hebert et al., 2018). The authors of this assessment granted me permission to use this test in the study. Test items are in a multiple-choice format. Participants read 15 short expository texts and choose between one of five expository text structure subtypes (e.g., descriptive, problem/solution, sequence) to select the structure that best matches each text (e.g., Meyer et al., 1980). Each of the text structure subtypes was equally represented in the test items (each subtype was represented three times in the text battery). Test items were at an appropriate reading-level for middle grade students (i.e., Lexile). Completion of the Identifying Structures measure took approximately 20 minutes. To my knowledge, validity and reliability data regarding the *Identifying Structures* measure has not been published though it has been used in previous research (Hebert et al., 2018). In the current study, the reliability of the text structure measure was approaching an acceptable value (McDonald'ω = 0.69). See Appendix C for test items.

C-test. Participants completed a c-test to measure linguistic knowledge. C-tests measure general language proficiency and assess linguistic knowledge in the study (Eckes & Grotjahn, 2006). A c-test is a maze task that taps into vocabulary, syntax, morphology, and spelling (e.g., Eckes & Grotjahn, 2006). In a c-test students see one paragraph and after the first few sentences, the second half of words are intermittently omitted. Participants fill in these blanks so that the story is complete and makes sense. The c-test used in this study have been used in previous research with children ages 10-12 (Trakulphadetkrai et al., 2017). Students had five minutes to

complete each c-test and five total c-tests were used in the linguistic knowledge measure. There are 20 items in each c-test with 100 total items across all five c-tests. To my knowledge, validity and reliability data regarding the c-test measure has not been published; however, in the current sample, the c-test indicated strong reliability (Kuder-Richardson Formula 20 = 0.94). C-test items are presented in Appendix D.

Measures of Text Comprehension

Participants completed two tasks to measure their comprehension of the science texts – think-aloud and recall tasks. The think-aloud task measured the types of comprehension processes the participants generated *during* reading whereas the recall task revealed the information the participants remembered and recalled *after* reading ended.

Think-Aloud Task. A think-aloud task was employed in this study to gain access to the reading comprehension processes (i.e., surface level, textbase, situation model processes) participants generated during reading of expository texts (e.g., Coté & Goldman, 1999; Ericsson & Simon, 1999, Wolfe & Goldman, 2005). The think-aloud protocol used in this study was modeled after previous research (e.g., Carlson et al., 2014; Dahl et al., 2021). In a think-aloud, a text is typically presented to the participant sentence-by-sentence and the participant responds aloud with whatever thoughts come to mind at the time. Participants were instructed to say whatever they are thinking because there are no right or wrong responses. Verbal responses were recorded for later transcription and coding (see Procedures section for further detail). Participants completed the think-aloud task in about thirty minutes.

Recall. A recall task was conducted to examine readers' memory for the text after reading ended (i.e., comprehension products for surface level, textbase, situation model levels). Recall tasks have been used to examine whether a reader has remembered important text events

that build coherent mental representations of the text (e.g., Trabasso & van den Broek, 1985). Moreover, recall tasks have been found to be moderately correlated with measures of reading comprehension (e.g., Marcotte & Hintze, 2009; Reed & Vaughn, 2012). To complete the recall task, participants were instructed to say everything that they remember about or related to the previously read text. Recall responses were recorded for later transcription and coding (see Procedures section for further detail). Participants completed the recall task in about 5 minutes.

Procedures

Recruitment

Participants were recruited from middle schools across the United States. I provided school administrators with recruitment materials and consent forms and then school administrators electronically sent this information to families (using Qualtrics). Upon granting consent, parents completed a Qualtrics survey and provided their contact information for scheduling forthcoming virtual study sessions. Standardized reading scores from the current year for students whose families signed consent forms were then requested from school administrators. Prior to engaging in any study activity, all participants competed an informed assent.

Assigning Reader Skill

School or district administrators provided participants' scores on standardized reading measures to identify reader skill. Due to scheduling constraints, school administrates provided me this data during or shortly after data collection. Thus, reader skill was assigned after data collection ended. After I received participants' standardized reading scores, I transformed the scores to z-scores to equitably compare reader skill. I transformed participants' reading scores to z-scores for two reasons. First, z-scores enable the opportunity to use reading skill as a

continuous variable whereas relying on percentiles would force me to use reading skill as a categorical variable. Second, transforming the scores to z-scores accounts for differences between the study sample and the population, therefore, offering a more accurate representation of the current samples' reading ability. See Table 4.1 in the *Results* chapter for descriptive statistics of reading skill.

Most of the school sites used Easy CBM (Alonzo et al., 2006) to measure reading skill; however, one school site used the Kaufman Test of Educational Achievement (KTEA; Kaufman & Kaufman, 1998) to measure students' reading skill. Schools therefore provided one reading measure and these scores were used as proxy for comprehension skill. Although my research questions focus on comprehension skill, I opted to use the broader term of "reader skill" instead because the conclusions I can draw regarding reading comprehension skill are limited given that I was provided only one measure of reading performance per student. Because the goal of this study was to understand the cognitive processes and products of skilled and less skilled readers, students who could not decode or read words during study activities were excluded from analyses.

Knowledge Measures

Participants were seen for two sessions during the spring semester 2022 through the fall semester 2022. Each session was one to two weeks apart from one another depending on each family's availability. In one session the knowledge measures were administered and, in another session, think-aloud and recall tasks occurred. Both sessions were counterbalanced such that half of the participants completed the knowledge measures first and the other half completed the think-aloud and recall tasks first. Each meeting was video recorded so that the experimenter could confirm that all the scores were reliably transcribed. Before proceeding the experimenter

confirmed that the participant's camera and microphone were operational. The task was shared on the experimenter's screen using PowerPoint. Participants did not have control of PowerPoint.

Content Knowledge. The experimenter introduced the content knowledge task and said, "this is a multiple-choice test to see how much you already know about earthquakes. You may know some of these answers and others might be unfamiliar to you. That is okay because I want to understand how much you already know about the topic and what else you could learn about earthquakes. I will read each question out loud to you. Then tell me your answer to the multiple-choice question out loud." The multiple-choice questions were presented on the screen for the participant one question at a time, and the participant said their answer out loud for each of the 10 questions. Their responses were recorded for later scoring (see *Scoring* procedures below).

Text Structure Knowledge. The text structure knowledge measure was introduced by saying "You will be reading several short passages and answering related multiple-choice questions about how each text is written or structured. I will read each text out loud. Then tell me your answer to the multiple-choice question out loud." Next the experimenter modeled an example item. Participants answered the corresponding multiple-choice questions out loud (see Appendix B). Their responses will be recorded for later scoring (see *Scoring* procedures below).

Linguistic Knowledge. The experimenter explained the c-test by calling it a "language puzzle" and saying to students, "You will see a short story on the screen. Some words in the story are not complete because some letters are missing. You will read the story out loud and complete the missing words as you read so that the story makes sense." The experimenter then read an example sentence out loud to the student and verified that the student understood the task. Participants' responses were recorded for later scoring (see *Scoring* procedures below).

Measures of Text Comprehension

Think-Aloud Task.

Another session involved think-aloud and recall tasks. The four possible expository texts were counterbalanced and semi-randomized. That is, half of the participants read a complex text first and the other half read a simple text first. The texts were also semi-randomized so that out of the four available texts, participants were randomly assigned to one of two simple texts and one of two complex texts (see Table 3.3).

Table 3.3.

Text Order Presentation

Participant	Presentation of Texts	
	Text 1	Text 2
1	Simple Text A	Complex Text C
2	Complex Text C	Simple Text B
3	Simple Text B	Complex Text D
4	Complex Text D	Simple Text A
5	Simple Text A	Complex Text D
6	Complex Text D	Simple Text B
7	Simple Text B	Complex Text C
8	Complex Text C	Simple Text A

Note. Texts repeated this order of presentation every eight participants.

The experimenter and participant logged into the same Zoom meeting. The study occurred in a quiet place of the participant's choosing after-school or on the weekend. The experimenter shared her screen to display the think-aloud task. The experimenter modeled how to complete the think aloud while reading using a brief text (e.g., Goldman & Varnhagen, 1986, Suh & Trabasso, 1993). After the participant read a sentence out loud, they said whatever came

to mind. They continued talking about each sentence until they were done and then did the same with the following sentences. The experimenter moved to a new slide after the participant read and thought out loud for each sentence. At the end of the text, there were two yes/no questions to assess basic understanding or reading of the passage. Each session and the verbal think-aloud responses were recorded for later transcription and coding (see *Scoring* procedures below).

Recall.

Participants were required to recall each text after thinking aloud. Prior to recalling, a distracter task was administered immediately after each think-aloud (e.g., simple multiplication problems). The math problems were presented on the screen via PowerPoint. Distracter tasks have typically been used in reading research as a method to offset any recency effects that could take place during recall (e.g., van den Broek, et al., 2001). After the distracter task, the experimenter asked the participant to recall as much information as he/she/they could remember from the text that was just read. The experimenter told the participant that they can share whatever they remember related to the text, including the main idea or details of the text, information that was said in the text or any other information related to the passage. Recalls were recorded for later transcription and scoring/coding (see *Scoring* procedures below).

Scoring Procedures

Measures of Knowledge

Content Knowledge. Participant responses were scored for the number of correct or incorrect answers on the content knowledge multiple-choice questions and totaled out of 10 items.

Identifying Structures. Each of the multiple-choice questions on the text structure knowledge measure were scored as correct or incorrect and totaled out of 15 items.

C-test. Each of the five c-tests included 20 items and thus, each item was scored as either correct or incorrect and totaled for a total score out of 100 total items.

Measures of Text Comprehension

Think-Aloud Task. All think-aloud sessions were recorded and transcribed for coding of the cognitive processes that readers generated at the surface, textbase, and situation model levels during reading. After transcription, the think-aloud protocols were parsed into idea units (i.e., generally subject/verb phrases) and then coded. The coding scheme was influenced by previous think-aloud research with children (e.g., Carlson et al., 2014, 2022; Dahl et al., 2021; McMaster et al., 2012). Although each of the codes have been used in previous research, the codes used in the current study have been tailored to the current study design to align with Kintsch's CI model (1988). That is, *surface* level codes are indicative of processes that repeat words or word order within a text, *textbase* level codes reflect processes that focus on information explicit in the text and connections made between explicit text information, and *situation model* level codes reflect processes that integrate prior knowledge with information in the text.

Thus, the following codes were used in the current study: text repetitions (surface level); paraphrases, connecting inferences, text focused evaluations, text focused metacognitive comments (all textbase level); and, associations, elaborative inferences, knowledge focused evaluations, and knowledge focused metacognitive comments (all situation model level). See the think-aloud levels and codes in Table 3.4 and their corresponding definitions and examples.

Coding occurred in two phases. In the first phase, think-aloud protocols were coded for processes (see codes in Table 3.4 for definitions). The second phase involved further categorizing these codes as surface level, textbase, or situation model processes (Linderholm &

van den Broek, 2002; Pressley & Afflerbach, 1995). For example, words that are repeated after a line of text in a think-aloud protocol were first coded at text repetition (TR). Next, TR codes were categorized as surface level processes. Table 3.4 identifies the definitions of each code, and how these codes will be assigned to each level of representation.

Table 3.4

Coding Process Use in Think-Alouds

Level	Codes	Definition	Example
	Non or Lack of Response (NR)	Participant does not say anything or says too little to warrant coding the response	**Response:** Nothing to say
Surface	Text repetitions (TR)	Repeated words or phrases from the text	**Text:** More sturdy structures are much more expensive to build. **Response:** More sturdy structures more expensive
Textbase	Paraphrases (PAR)	Restates the current sentence using words or word order identical or very similar to the current text	**Text:** Where an earthquake will occur is the easiest feature to predict. **Response:** It's that it's easiest to know where the earthquake is about to happen.
	Connecting inferences (CI)	Explains the current sentence by connecting its meaning with previously read text (local and global)	**Text:** After a while, pressure builds up and the rocks break. **Response:** So that's like what they said in the first couple of sentences where stress builds up and then they either break

			or like change shape.
	Text-focused evaluations (TE)	Opinions about text information or content	**Response:** Well, that seems like a really big stretched sentence
	Text-focused metacognitive comments (TMC)	Metacognitive comments focused on understanding or agreeing about text information or content	**Text:** The relative arrival times of P-waves and S-waves also decreases just before an earthquake occurs. **Response:** I don't know what those waves are.
Situation Model	Associations (ASS)	Concepts from background knowledge brought to mind by the text	**Text:** Compression is stress that squeezes rock until it folds or breaks. **Response:** I've never seen a trash compactor in action.
	Elaborative inferences (EI)	Explains the current sentence by connecting its meaning to background knowledge	**Text:** These communities can implement building codes to make structures earthquake safe. **Response:** You mean like those towers that are like wobbly, but they never fall down.
	Knowledge-focused evaluations (KE)	Opinions about outside background knowledge	**Text:** A good prediction must be accurate as to where an earthquake will occur, when it will occur, and at what magnitude it will be so that people can evacuate.

		Response: Everyone wants to be in the earthquake, so they have a story to tell their friends even if it gives them the risk of dying.
Knowledge-focused metacognitive comments (KMC)	Metacognitive comments focused on outside background knowledge (i.e., not directly related to text information)	**Response:** I know a lot about tornadoes.

Think-Aloud Coding Reliability. Two triad pairs of trained graduate student researchers coded 20% of the total think-aloud protocols in common. After receiving training on the process and the coding scheme, two groups of three experimenters coded the think-aloud protocols. Coders independently coded the think-aloud protocols and then met to discuss in common and discrepancies in coding. Interrater reliability was calculated using Fleiss' kappa, which calculates interrater reliability among three or more raters. Raters demonstrated strong reliability in both pairs, kappa = .87 and .90 (Fleiss, 1971). All the experimenters coded the remaining think-aloud protocols. Discrepancies were resolved via group discussion.

Recall. The recalls were also transcribed, parsed into idea units (i.e., generally subject/verb phrases), and coded for the amount and quality of information remembered from each text. The recall coding scheme was based on previous research that assessed recall quality (e.g., Kendeou & van den Broek, 2007; Linderholm & van den Broek, 2002; McMaster et al., 2012). Although each of the codes have been used in previous research, the codes used in the current study have been tailored to the current study design to align with Kintsch's CI model

(1988). That is, *surface* level codes are indicative of recall responses that repeat words or word order from a text, *textbase* level codes reflect responses that include information explicit in the text and connections made between explicit text information, and *situation model* level codes reflect recall responses that integrate prior knowledge with information in the text.

Thus, the following codes were used to code recall protocols: *verbatim* (i.e., identical recall of text), *conservative* (i.e., nearly literal recall of text), gist (i.e., recalls information synonymous with the gist of text; highly constrained by the text), and *knowledge-connecting* (i.e., the clause includes connections to prior knowledge not directly stated in the text) (see Table 3.5).

Table 3.5

Coding Comprehension Products in Recall

Level	Codes	Definition	Example
Surface	Verbatim (V)	Verbatim recall for the actual words, phrases, and syntax in the text	I think surface pressure
Textbase	Conservative (C)	Idea unit is close to the gist (similar to a paraphrase) of the original text and uses similar words and/or word order	There are three different types of seismic waves on there.
	Gist (G)	Recalls information that is synonymous to text information, highly constrained to information in the text	And then they have a seismograph. It's basically this thing with a big string with a weight on it.
Situation Model	Knowledge-connecting (K)	Recalls information in the text that is also integrated with the reader's background knowledge	Yeah, I remember thunderstorms. The passage I read was about predicting storms.

Coding occurred in two phases. In the first phase, recall protocols were coded for products (see codes in Table 3.5 for definitions). The second phase involved further categorizing these codes as surface level, textbase, or situation model processes (Linderholm & van den Broek, 2002; Pressley & Afflerbach, 1995). Table 3.5 identifies the definitions of each code, and how these codes will be assigned to each level of representation.

Recall Coding Reliability. Two triad pairs of trained graduate student researchers also coded 20% of the recall responses in common. After receiving training on the process and the coding scheme, two groups of three experimenters coded the recall responses separately and then met to discuss in common and discrepancies in coding. Interrater reliability was calculated using Fleiss' kappa, which calculates interrater reliability among three or more raters. Raters demonstrated strong reliability in both pairs, kappa = .86 and .94 (Fleiss, 1971). All the experimenters coded the remaining recall responses and discrepancies were resolved via group discussion.

Data Analyses

Data Entry and Computation

After coding the think-aloud and recall protocols, participant scores were calculated for each independent and outcome variable. For the knowledge measures, raw scores were transformed to z-scores to ensure that scores were comparable in the analyses. For the online processing scores, I totaled the number of each process generated in a participant's think-aloud protocol (e.g., total number of elaborative inferences). Then, the surface-level processes (i.e., text repetitions), the textbase processes (i.e., paraphrases, text-focused metacognitive comments, evaluations), and the situation model processes (i.e., associations, elaborative inferences, knowledge focused metacognitive comments, evaluations) were totaled. Finally, I converted

these totals to proportions because the four texts were not the same length, and the number of comprehension processes were not equitably distributed across the texts. For instance, the mean number of surface level processes generated while reading “Predicting Earthquakes” was divided by 19 (the total number of lines in the text); whereas, the mean number of surface level processes generated while reading “Preventing Damage from Earthquakes” was divided by 17 (the total number of lines in the text). The same processes were used to calculate a proportion score for surface, textbase, and situation model recall responses to determine scores for the offline comprehension products.

Descriptive Statistics

Descriptive statistics included measures of normal distribution, including skewness and kurtosis, as well as means and standard deviations. Correlational analyses were calculated among the variables to test assumptions of linear mixed effects (see *Analytic Approach* below) and describe the relationship among the dependent variables.

Analytic Approach

Linear mixed effects models were used to address the goals of this study to account for individual differences at the participant level. Moreover, linear mixed effects models can handle analyses in which the predictors and outcome variables are continuous variables (Meteyard & Davies, 2020). Every participant read one simple and one complex expository text and accordingly, this study is a within subjects design. The following served as independent variables or fixed effects: scores earned on the measures of knowledge (content, text structure, linguistic), reader skill, and the simple/complex expository texts. Reader skill was a continuous predictor that was a z-score based on students’ scores from a standardized curriculum-based assessment of

reading comprehension skill. All the knowledge measures were continuous predictors, and the text type is a factor with two levels (simple, complex). Because most of these variables were on arbitrary scales, all the fixed effects' raw scores, excluding text type (simple, complex), were converted to z-scores to facilitate comparison across variables. The simple and complex expository text variable was categorical and therefore, it was not converted to a z-score. Interaction effects among all the independent variables were also included to fully examine the relationship between the variables of interest and their effects on middle school readers' expository comprehension. Previous research indicates mixed findings on the extent to which knowledge may or may not interact with text complexity and reader skill (e.g., Cain et al., 2004; McNamara et al., 1996; Spencer et al., 2019), and thus, the current study also examined whether any interactions were present among the independent variables. The processes and products generated during the think-aloud and recall tasks operated as dependent variables to answer both research questions.

Model Building

All models were fit in R using package lme4 (Bates et al., 2015). I adopted a model approach in which I tested a series of models for each dependent variable (think-aloud: surface, textbase, situation model processes; recall: surface, textbase, situation model products). For each model there were 42 participants across 84 observations (two texts per participant). A baseline model (m0) included participant random intercepts to account for variability across participants in the extent to which they are affected by the predictors of interest (Brown, 2021). I also examined whether including a random slope for text type over participants would fit the data in a null model to prevent the inflation of Type 1 error rates (Barr et al., 2013; Matuscheck et al.,

2017). However, a random slope for text type did not fit the data for any of the models and therefore, a random slope for text type was not used in any of the analyses.

Model 1 included content knowledge, text structure knowledge, and linguistic knowledge as fixed effects and the proportion of think-aloud or recall responses generated at that level (i.e., surface, textbase, situation model) as the dependent variable. Model 2 was fitted with the following fixed effects: content knowledge, text structure knowledge, linguistic knowledge, and reader skill. Model 3 included all the fixed effects from Model 2 and added text type. Content knowledge, text structure knowledge, linguistic knowledge, reader skill, and text type were selected as fixed effects (predictors) to address RQ1 and RQ2. Finally, Model 4, included all the previous fixed effects as well as all associated two-way interaction terms. I developed Model 4 to investigate whether any interactions were present among the independent variables. I did not include any interactions in the Models 1-3 for several reasons. First, the primary interest of this study is understanding how knowledge influences middle school students' comprehension processes and products and although interactions between knowledge, reader skill, and text complexity may be present, including these interactions within each model could overfit the model and thus preclude me from being able to draw conclusions about the effects of knowledge on these dependent variables. Moreover, a small sample size is unlikely to support a model with several predictor variables and interactions and can lead to an increased Type I error rate (Barr et al., 2013). I also chose to limit Model 4 to two-way interactions among all the independent variables. Previous research using mixed effects models has used a similar approach (e.g., McCarthy et al., 2022) and this was done to address some the aforementioned issues related to sample size and potentially overfitting the model.

Significance Testing. For the mixed effects models, I tested significance for the fixed effects using the lmerTest package in R (Kuznetsova et al., 2017) that applies the Sattherthwaite's method to estimate degrees of freedom and generates *p*-values with a $\alpha = 0.05$ criterion for significance. Additionally, I used maximum likelihood when fitting each model in R to account for models with differing fixed effects (Bates et al., 2014). A chi-squared value is generated based on a likelihood ratio test (i.e., the difference between the log-likelihood for Model A and the log-likelihood for Model B). Likelihood ratio tests were conducted to compare the effects in Models 0-3. That is, each model was compared in succession to one another to determine which model best fit the data. AIC values and likelihood ratio test results are presented in the *Results* section, along with coefficients from the models.

Mixed Effects Model Assumptions

Mixed effects models require testing several assumptions to ensure that one can draw correct conclusions from analyses. The first assumption is that the explanatory variables are linearly related to the response. To address this assumption, residuals were plotted against the explanatory variables to indicate if the wrong model has been fitted or if there is some dependence on some other explanatory variable. If this is the case some obvious patterning will be visible in the plot. This assumption was met by all models. A second assumption is that the errors have constant variance. This assumption was met by plotting the residuals to observe whether the presence of visual trends may indicate seasonal patterns or autocorrelation. No patterns were observed and therefore, this assumption was met. The third assumption is the absence of heteroskedasticity. To meet this assumption, the residuals of the model need to generally have a similar amount of deviation from the predicted values. To look at this assumption I looked at the residual plot again. Some homoscedasticity was observed for the

recall response models; however, mixed effects are robust against violations of sphericity and homoscedasticity (Quene & van den Bergh, 2004; 2008). Another assumption of linear mixed effects models is that the errors are normally distributed. A normal probability plot was used to indicate if the normality assumption is valid, however, high non-normality should have been picked up from exploring the data initially (see Tables 4.1 and 4.9 in *Chapter 4*).

CHAPTER IV
RESULTS

Hypotheses

The hypotheses addressing each research question are:

Research Question 1. To what extent do different types of knowledge (content, text structure, linguistic) influence middle schoolers' generation of surface level, textbase, and situation model processes while reading expository texts?

RQ1a. How does this vary by reader skill?

RQ1b. How does this vary by text complexity?

H0: There are no significant contributions of content, text structure, and linguistic knowledge to middle schoolers' generation of surface level, textbase, and situation model processes while reading expository texts. Also, these contributions do not differ as a function of reader skill. Finally, the contributions of content, text structure, and linguistic knowledge do not differ as a function of text complexity.

H1: Main: There are significant contributions of content, text structure and linguistic knowledge to middle schoolers' generation of surface level, textbase, and situation model processes while reading expository texts.

H1: a: The contributions of content, text structure, and linguistic knowledge differ as a function of reader skill.

H1: b: The contributions of content, text structure, and linguistic knowledge also differ as a function of text complexity.

One expectation for this hypothesis is that content, text structure, and linguistic knowledge will have significant contributions to middle schoolers' process generation at surface, textbase, and situation model levels while reading expository texts. More specifically, I anticipate that content knowledge will influence situation model processing. Based on previous findings, content knowledge should positively influence readers' situation model processes so that readers with more content knowledge are better equipped to generate situation model processes (Best et al., 2005; Elbro & Buch-Iversen, 2013). Although it has not been formally tested in research, text structure knowledge is theorized to positively influence readers' comprehension of the textbase (e.g., Kintsch, 1998) and therefore, readers with more text structure knowledge will be more likely to generate textbase level think-aloud responses than readers with less text structure knowledge. Previous research indicates that linguistic knowledge contributes to readers' surface and textbase level process generation (e.g., Gillam et al., 2009; Trapman et al., 2014) and, thus, I anticipate that readers with less linguistic knowledge will be more likely to generate surface and textbase level processes.

Additionally, I expect a negative relationship between reader skill and surface and textbase level processing. Think-aloud studies have highlighted that less-skilled readers tend to generate comprehension processes that do not integrate knowledge (e.g., Carlson et al., 2014; 2022; Coté et al., 1999) and accordingly, I expect that less skilled readers' think-aloud responses will mostly be repetition and paraphrasing (i.e., surface and textbase).

As described in the literature review (*Chapter 2* of this dissertation), there is limited research indicating how prior knowledge (of any type) may differ as a function of text complexity. Previous research findings are mixed on whether types of knowledge, such as

content knowledge, interact with text complexity and influence the extent to which readers generate processes (i.e., situation model level) when reading complex text (e.g., Cain et al., 2004; McNamara et al., 1996; Spencer et al., 2019). Therefore, it was expected that content knowledge will contribute to the generation of situation model processes while reading complex expository text. More specifically, readers with more content knowledge will generate more situation model processes while reading the complex text.

Research Question 2. To what extent do different types of knowledge (content, text structure, linguistic) influence middle schoolers' generation of surface level, textbase, and situation model products after reading expository texts?

RQ2a: How does this vary by reader skill?

RQ2b: How does this vary by text complexity?

H0: There are no significant contributions of either content, text structure, and linguistic knowledge to middle schoolers' generation of surface level, textbase, and situation model products after reading expository texts. Also, these contributions do not differ as a function of reader skill. The contributions of content, text structure, and linguistic knowledge do not differ as a function of text complexity.

H2: Main: There are significant contributions of content, text structure and linguistic knowledge to middle schoolers' generation of surface level, textbase, and situation model products after reading expository texts.

H2: a: The contributions of content, text structure, and linguistic knowledge differ as a function of comprehension skill.

H2: b: The contributions of content, text structure, and linguistic knowledge differ as a function of text complexity.

One expectation for this hypothesis is that content, text structure, and linguistic knowledge will have significant contributions to middle schoolers' recall of expository texts. Previously conducted research indicates that content knowledge contributes to less skilled readers' generation of textbase products after reading expository text (Yeari & Lavie, 2021) as well as skilled readers' generation of situation model products (e.g., Miller & Keenan, 2009). That is, readers with more content knowledge are more likely to include textbase and situation model representations in recall after reading expository text. However, there is also evidence indicating that when the effects of content and text structure knowledge are compared, text structure knowledge affects comprehension more than content knowledge (Garcia, 2015). Therefore, it is expected that content knowledge will contribute to participant's recall responses at the situation model level.

Text structure knowledge has been found to influence readers' generation of textbase products (Cain et al., 2001; Hebert et al., 2018); thus, I anticipate that participants with more text structure knowledge will be more likely to include more textbase responses in their recalls than those with less text structure knowledge. Also, linguistic knowledge has been found to contribute to readers' generation of surface level recall products (Yeari & Lantin, 2021) and I similarly expect that readers with more linguistic knowledge will be less likely to produce recall responses at the surface level than readers with less linguistic knowledge.

Additionally, I anticipate that reader skill will contribute to a positive relationship with situation model recall responses. As stated in the CI model, proficient reading comprehension is related to a readers' ability to integrate knowledge with text information as they develop situation model representations (Kintsch, 1988). A large body of research demonstrates that less-skilled readers struggle with integrating prior knowledge to generate inferences and therefore, perform poorly on offline measures of reading comprehension, such as recall tasks (e.g., Cain et al., 2001; Eason et al., 2012). Based on this theoretical assumption and related empirical evidence, I anticipate that less-skilled readers will be less likely to integrate knowledge into their recall responses. Therefore, readers with more skill will be more likely to include situation model responses in their recall than less-skilled readers.

There is also limited research indicating that the effects of prior knowledge (of any type) may differ as a function of text complexity (see *Chapter 2*). However, research conducted with adults suggests that readers with more prior content knowledge on a given topic remember and learn more information when reading expository text with complex features than readers with less prior content knowledge (e.g., McNamara et al., 2007; Ozuru et al., 2009). However, text complexity has been previously found to be more important for text recall than other cognitive skills including reader skill or content knowledge (Spencer et al., 2019). Therefore, it is expected that text type will contribute to textbase and situation model recall responses, such that readers will recall more textbase information from the simple text and more situation model information from the complex text.

The results are explained in the following fashion. First, I provide descriptive statistics and correlational analyses. Then, I describe the results for the linear mixed effects models

pertaining to the think-aloud responses across the surface, textbase, and situation model. After this I repeat the same process with the recall responses. I start with descriptive statistics and correlational analyses for the recall responses. Finally, I explain the results for the linear mixed effects models pertaining to the recall responses across the surface, textbase, and situation model.

Descriptive Statistics for Think-Aloud Responses

Individual Difference Measures

Reader skill, content knowledge, text structure knowledge, and linguistic knowledge are individual difference variables within the study. Reader skill was calculated after transforming raw scores from curriculum-based reading measures into using z-scores because participants attended different schools and thus, used different reading tests to track reading progress (see *Methods* section for further details on how this was done). The average z-score for reader skill was -0.25 (*SD* = 1.30).

Possible scores on the content knowledge measure range from 0 to 10. The mean score on the content knowledge measure was 3.81 (*SD* = 1.44). Scores on the text structure measure, the knowledge structures test, ranged from 0 to 15 (*M* = 7.86, *SD* = 3.32). (Hebert et al., 2018). Scores on the linguistic knowledge measure, the c-test, ranged from 0 to 100 (*M* = 71.88, *SD* = 16.57) (Trakulphadetkrai et al., 2017). To make equitable comparisons across these assessments, the raw scores were transformed into z-scores.

Missing Data

Of the 50 participants who completed the knowledge assessment, 5 of the participants did not have reading score data and 3 more participants did not complete both think-aloud and

recall sessions. Therefore, data for 42 participants are included in the think-aloud and recall analyses.

Think-Aloud Responses

Descriptive statistics and indicators of normal distribution for think-aloud response variables are listed in Table 4.1. Indicators of a normal distribution or normality were identified as skewedness scores of +/-2 and kurtosis scores of +/-7 (Kline, 2011). The surface level think-aloud responses were outside acceptable levels of normality. Although there are options for log transforming data to correct nonnormality, human coding is imperfect and conducting transformations may not adequately represent or could potentially distort how the participants' performed during the study tasks. Moreover, linear mixed models are robust against violations of normality and homoskedasticity (Quene & van den Bergh, 2004; 2008; Winter, 2013).

Table 4.1

Think-Aloud Responses Descriptive and Distribution Statistics

	M(*SD*)	Skewedness/Kurtosis
Surface	0.05 (0.11)	3.75/15.27
Textbase	0.49 (0.21)	-0.02/-0.86
Situation Model	0.46 (0.22)	0.07/-0.94

Note. $N = 42$. Think-aloud responses were computed into proportions generated across one simple and one complex expository text.

Think-Aloud Correlations

Correlational analyses were conducted to examine any significant associations among the variables of interest and to determine whether any multicollinearity was present among the dependent variables. If there is a strong correlation between independent variables this could indicate that the variables measure the same construct. Moreover, if multicollinearity is present,

it can be difficult to determine which independent variable(s) contributes to the outcomes analyzed in the study.

Correlations. Correlational relationships between the reader skill, knowledge scores and surface, textbase, and situation model processes generated during the think-aloud task are presented in Table 4.2. The focus of the current study is to examine the effects of content, text structure, and linguistic knowledge on middle school readers' comprehension processing and therefore, significant correlations pertaining to this aim are reported here. Correlational analyses indicated that linguistic knowledge significantly negatively correlated with the generation of surface level processes (r = -0.35, $p < 0.05$). Although there are significant correlations amongst the independent variables (content, text structure, linguistic knowledge, reader skill), none of these correlations are > .70 and therefore, there is no indication of multicollinearity among the predictor variables.

Table 4.2

Correlations for Think-Aloud Responses

Variable	1	2	3	4	5	6
1. Reader Skill						
2. Content Knowledge	.52**					
3. Text Structure Knowledge	.46**	.39**				
4. Linguistic Knowledge	.56**	.30	.57**			
5. Surface Level	-.30	.17	-.23	-.35*		
6. Textbase	-.10	-.23	-.17	-.07	-.03	

7. Situation Model	.24	.13	.26	.23	-.46**	-.85**

Note. * indicates $p < 0.05$. ** indicates $p < 0.01$.

Linear Mixed Effects Models for Think-Aloud Responses

To investigate the contributions of content, text structure, and linguistic knowledge on middle school readers' surface, textbase, and situation model processing, several linear mixed effects (LMEs) models were created. Likelihood ratio tests were conducted between a baseline model and Models 1-3 to determine whether adding each variable improved the fit of the model. Likelihood ratio tests were not performed for Model 4 because it did not nest with Model 3 (i.e., too many interactions were added in Model 4 to compare it to Model 3). Significant likelihood ratio tests illustrate whether adding the additional variable improved the model fit compared to the previous model.

Surface Level Think-Aloud Responses

Table 4.3 depicts the (LME) results for surface think-aloud responses. After comparing a baseline model to Model 1(all three knowledge types as fixed effects) ($x^2(3) = 11.51$, $p = 0.01$; AIC = -173.97); coefficients in Model 1 indicated a significant positive relationship between content knowledge ($\beta = 0.04$) and a negative relationship between linguistic knowledge ($\beta = -0.04$) and surface model think-aloud responses. In Model 2, adding reader skill to the model improved model fit ($x^2(1) = 5.20$, $p = 0.02$; AIC = -177.16). Model 2 also indicated a significant relationship between content knowledge ($\beta = 0.06$) and showed a negative relationship between reader skill and surface think-aloud responses ($\beta < -0.03$). Model 3 added text type to the model and improved model fit; thus, a model with content knowledge, text structure knowledge,

linguistic knowledge, reader skill, and text type fit better than one without text type ($x^2(1) = 5.34$, $p = 0.02$; AIC = -180.50). Coefficients in Model 3 showed a positive relationship between content knowledge ($\beta < 0.06$) and text type ($\beta = 0.02$) and a negative relationship with reader skill ($\beta = -0.03$) and surface level think-aloud responses. Therefore, as indicated in Model 3, the best-fitting model, readers with more content knowledge generated more surface level responses and readers made more surface level responses while reading the simple expository text. Also, less-skilled readers generated a greater proportion of surface level think-aloud responses.

Table 4.3

Likelihood Model Tests and Coefficients for Mixed Effects Models Predicting Surface Level Think-Aloud Responses

	Model 1				Model 2				Model 3			
	AIC	BIC	X^2	*p*	AIC	BIC	X^2	*p*	AIC	BIC	X^2	*p*
	-173.97	-159.38	11.51	**0.01****	-177.16	-160.15	5.20	**0.02***	-180.50	-161.05	5.34	**0.02***
Fixed Effects:	β	SE	*t*-value	*p*	β	SE	*t*-value	*p*	β	SE	*t*-value	*p*
Content Knowledge	0.04	0.02	2.42	**0.02***	0.06	0.02	3.32	**0.001****	0.06	0.02	3.32	**0.001****
Text Structure Knowledge	-0.02	0.02	-0.96	0.34	-0.01	0.02	-0.79	0.44	-0.01	0.02	-0.78	0.43
Linguistic Knowledge	-0.04	0.02	-2.30	**0.03***	-0.02	0.02	-1.26	0.21	-0.02	0.02	-1.26	0.21
Reader Skill					-0.03	0.02	-2.35	**0.02***	-0.03	0.01	-2.35	**0.02***
Text Type (Simple)									0.02	0.01	2.38	**0.02***
Random Effect:	Variance:	*SD:*			Variance:	*SD:*			Variance:	*SD:*		
Participant	0.01	0.09			0.01	0.08			0.01	0.08		
Model Fit:												
R^2 Marginal	0.22				0.30				0.31			
R^2 Conditional	0.82				0.82				0.84			

Additionally, Model 4 revealed one significant interaction (see Table 4.4). Coefficients indicated a significant positive relationship between content knowledge and surface level think-aloud responses (β = 0.05). Also, text type predicted surface level processes such that readers generated a higher proportion of surface level processes while reading the simple text (β = 0.02). Model 4 also revealed a negative interaction between content knowledge and linguistic knowledge (β = -0.06) (see Figure 4.1). That is, middle school readers with more content knowledge, but less linguistic knowledge generated a greater proportion of surface level think-aloud responses.

Table 4.4

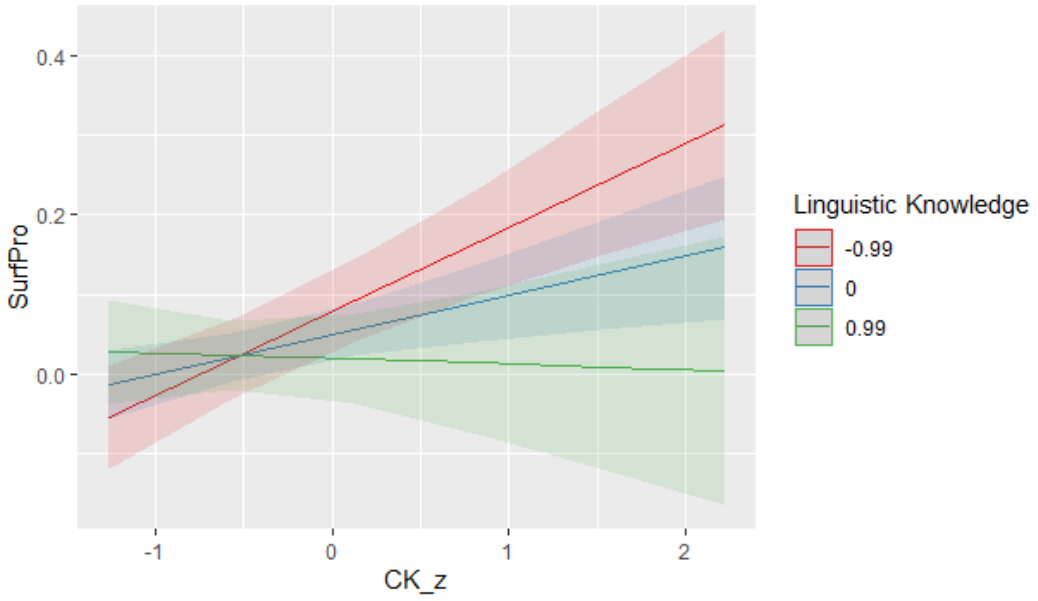
Model Estimates for Model 4 Predicting Surface Level Processing

	β	SE	*t*-value	*p*
Fixed Effects:				
Content Knowledge (CK)	0.05	0.02	2.96	**0.001****
Text Structure Knowledge (TSK)	-0.01	0.02	-0.88	0.92
Linguistic Knowledge (LK)	-0.02	0.02	-1.19	0.23
Reader Skill	-0.02	0.02	-1.73	0.09
Text Type	0.02	0.01	2.33	**0.02***
CK * TSK	-0.01	0.01	-0.29	0.77
CK * LK	-0.06	0.02	-2.73	**0.01***
TSK * LK	-0.01	0.02	-0.75	0.45
CK * Reader Skill	-0.01	0.01	-0.77	0.44
TSK * Reader Skill	0.01	0.02	0.71	0.47
LK * Reader Skill	0.02	0.01	1.69	0.10
CK * Text Type (simple)	-0.01	0.01	-0.28	0.77
TSK * Text Type (simple)	0.01	0.01	0.99	0.32
LK * Text Type (simple)	0.01	0.01	-0.01	0.99
Reader Skill * Text Type (simple)	0.01	0.01	0.43	0.66
Random Effect:	Variance	*SD*		
Participant	0.01	0.05		

Note. * $p < 0.05$. ** $p < 0.01$.

Figure 4.1

Predicted Values of Content and Linguistic Knowledge on Surface Level Think-aloud Responses



Note. CK_z refers to Content Knowledge and SurfPro refers to the proportion of surface level processes

Textbase Think-Aloud Responses

Table 4.5 depicts the model summary for textbase think-aloud responses. Model 1, which included all the knowledge types as fixed effects, did not improve model fit ($x^2(3) = 4.41$, $p = 0.22$; AIC = -23.97) and, nor did Model 2 ($x^2(1) = 0.10$, $p = 0.75$; AIC = -22.07). A likelihood ratio test comparing Model 3 and Model 2, revealed that Model 3 (model with all the predictors) best fit the data ($x^2(1) = 4.32$, $p < .05$; AIC = -24.40). Thus, a model with content knowledge, text structure knowledge, linguistic knowledge, reader skill, and text type best fits the data. Coefficients in Model 3 showed a positive relationship between text type (simple) ($\beta = 0.08$) and textbase think-aloud responses. Therefore, participants, regardless of individual differences in

knowledge and reader skill, generated more textbase responses while reading the simple texts, as compared to the complex texts.

Table 4.5

Likelihood Ratio Tests and Coefficients for Mixed Models Predicting Textbase Think-Aloud Responses

	Model 1				Model 2				Model 3			
	AIC	BIC	X^2	*p*	AIC	BIC	X^2	*p*	AIC	BIC	X^2	*p*
	-23.97	-9.38	4.41	0.22	-22.07	-4.95	0.10	0.75	-24.40	-4.95	4.32	**0.04***
Fixed Effects:	β	SE	*t*-value	*p*	β	SE	*t*-value	*p*	β	SE	*t*-value	*p*
Content Knowledge	-0.04	0.03	-1.57	0.12	-0.05	0.03	-1.56	0.12	-0.05	0.03	-1.56	0.13
Text Structure Knowledge	-0.03	0.03	-0.85	0.40	-0.03	0.03	-0.88	0.38	-0.03	0.03	-0.88	0.38
Linguistic Knowledge	0.01	0.03	0.44	0.67	0.01	0.03	0.27	0.79	0.01	0.03	0.27	0.79
Reader Skill					0.01	0.03	0.32	0.75	0.01	0.03	0.32	0.75
Text Type (Simple)									0.08	0.04	2.13	**0.04***
Random Effect:	Variance:	*SD:*			Variance:	*SD:*			Variance:	*SD:*		
Participant	0.01	0.10			0.01	0.10			0.01	0.11		
Model Fit:												
R^2 Marginal	0.07				0.07				0.10			
R^2 Conditional	0.32				0.32				0.39			

Although Model 4 did not improve model fit, I provide the full model below (Table 4.6). Consistent with Model 3, text complexity predicted textbase think-aloud responses (β = 0.08) indicating that readers generated more textbase think-aloud responses while reading the simple text. There were no other significant effects (see Table 4.6).

Table 4.6

Model Estimates for Model 4 Predicting Textbase Think-Aloud Responses

	β	SE	*t*-value	*p*
Fixed Effects:				
Content Knowledge (CK)	-0.03	0.04	-0.75	0.45
Text Structure Knowledge (TSK)	-0.02	0.04	-0.51	0.61
Linguistic Knowledge (LK)	0.01	0.05	0.27	0.79
Reader Skill	0.00	0.04	0.05	0.96
Text Type	0.08	0.04	2.21	**0.03***
CK * TSK	0.03	0.04	0.85	0.40
CK * LK	0.00	0.05	0.10	0.92
TSK * LK	-0.01	0.04	-0.16	0.87
CK * Reader Skill	0.00	0.03	0.05	0.96
TSK * Reader Skill	-0.00	0.04	-0.02	0.98
LK * Reader Skill	0.02	0.03	0.90	0.37
CK * Text Type (simple)	-0.05	0.04	-1.19	0.24
TSK * Text Type (simple)	-0.02	0.04	-0.54	0.59
LK * Text Type (simple)	0.04	0.05	0.79	0.43
Reader Skill * Text Type (simple)	0.01	0.04	0.34	0.73
Random Effect:	Variance:	*SD:*		
Participant	0.01	0.10		
Fit:				
Marginal R^2	0.17			
Conditional R^2	0.42			

Note. * $p < 0.05$. ** $p < 0.01$.

Situation Model Think-Aloud Responses

Table 4.7 depicts the model summary for situation model think-aloud responses. After comparing a baseline model to Model 1, Model 1 results indicated that the knowledge measures did not significantly contribute to differences in situation model processing ($x^2(3) = 4.89$, $p = 0.18$; AIC = -9.69). Additionally, none of the predictors in Model 2 (knowledge types and reader skill) significantly contributed to situation model processing and Model 2 did not improve model fit ($x^2(1) = 0.72$, $p = 0.40$; AIC = -8.41). Model 3 included all three knowledge types, reader skill, and added text type. Analysis of Model 3 showed that adding text type improved the model fit ($x^2(1) = 7.58$, $p < .01$; AIC = -13.99) and indicated that text type (simple) was a significant negative predictor of situation model process generation ($\beta = -0.10$), such that, readers generated a greater proportion of situation model processes when reading the complex text than when reading the simple text, even when controlling for the contributions of knowledge and reader skill.

Table 4.7

Likelihood Ratio Tests and Coefficients for Mixed Effects Models Predicting Situation Model Think-Aloud Responses

	Model 1				Model 2				Model 3			
	AIC	BIC	X^2	*p*	AIC	BIC	X^2	*p*	AIC	BIC	X^2	*p*
	-9.69	4.89	4.89	0.18	-8.41	8.61	0.72	0.40	-13.99	5.46	7.58	**0.01****
Fixed Effects:	β	SE	*t*-value	*p*	β	SE	*t*-value	*p*	β	SE	*t*-value	*p*
Content Knowledge	0.00	0.03	0.10	0.92	-0.01	0.03	-0.26	0.80	-0.01	0.03	-0.26	0.79
Text Structure Knowledge	0.04	0.04	1.21	0.23	0.04	0.04	1.13	0.26	0.04	0.04	1.13	0.26
Linguistic Knowledge	0.03	0.03	0.79	0.43	0.01	0.04	0.38	0.71	0.01	0.04	0.38	0.71
Reader Skill					0.03	0.03	0.85	0.40	0.03	0.03	0.85	0.40
Text Type (Simple)									-0.10	0.03	-2.88	**0.01****
Random Effect:	Variance:	*SD:*			Variance:	*SD:*			Variance:	*SD:*		
Participant	0.02	0.14			0.02	0.14			0.02	0.15		
Model Fit:												
R^2 Marginal	0.08				0.09				0.13			
R^2 Conditional	0.45				0.45				0.55			

Note. * $p < 0.05$. ** $p < 0.01$.

Additionally, Model 4, revealed that text type predicted situation model think-aloud responses (β = -0.10). This suggests that all readers generated more situation model think-aloud responses while reading the complex text. However, each of the knowledge types, reader skill, and all associated two-way interactions were not significant (see Table 4.8).

Table 4.8

Model Estimates for Model 4 Predicting Situation Model Think-Aloud Responses

	β	SE	*t*-value	*p*
Fixed Effects:				
Content Knowledge (CK)	-0.02	0.04	-0.38	0.70
Text Structure Knowledge (TSK)	0.02	0.04	0.50	0.62
Linguistic Knowledge (LK)	0.01	0.06	0.20	0.84
Reader Skill	0.03	0.04	0.50	0.56
Text Type	-0.10	0.03	-2.99	**0.00****
CK * TSK	-0.02	0.05	-0.63	0.53
CK * LK	0.05	0.06	0.94	0.35
TSK * LK	0.02	0.04	0.42	0.67
CK * Reader Skill	0.01	0.04	0.25	0.80
TSK * Reader Skill	-0.01	0.04	-0.24	0.80
LK * Reader Skill	-0.04	0.03	-1.42	0.16
CK * Text Type (simple)	0.05	0.04	1.31	0.20
TSK * Text Type (simple)	0.01	0.04	0.25	0.80
LK * Text Type (simple)	-0.04	0.04	-0.81	0.42
Reader Skill * Text Type (simple)	-0.02	0.04	-0.48	0.63
Random Effects:	Variance:	*SD:*		
Participant	0.02	0.14		
Model Fit:				
Marginal R^2	0.21			
Conditional R^2	0.57			

Note. * $p < 0.05$. ** $p < 0.01$.

Descriptive Statistics for Recall Responses

Individual Difference Measures

The descriptive statistics for reader skill and the knowledge measures are the same as those reported previously for think-aloud responses.

Missing Data

Of the 50 participants who completed the knowledge assessment, 5 of those participants did not have reading skill data and 3 additional participants did not complete the think-aloud and recall sessions. Therefore, data for 42 participants are included in the think aloud and recall analyses.

Recall Responses

Descriptive statistics and indicators of normal distribution for recall response variables are listed in Table 4.9. Indicators of a normal distribution or normality were identified as skewedness scores of +/-2 and kurtosis scores of +/-7 (Kline, 2011). The surface level recall responses were outside acceptable levels of normality (see Table 4.9). Although there are options for log transforming data to correct nonnormality, human data is imperfect and conducting data such transformations may not adequately represent how the participants' performed during the study tasks. Moreover, linear mixed models are robust against violations of normality and homoskedasticity (Quene & van den Bergh, 2004; 2008; Winter, 2013).

Table 4.9

Recall Descriptive and Distribution Statistics

	M(*SD*)	Skewedness/Kurtosis
Surface	0.03 (0.08)	3.75/14.95
Textbase	0.75 (0.27)	-1.05/0.48
Situation Model	0.18 (0.22)	1.25/1.21

Note. $N = 42$. Scores are based on proportions of responses generated across one simple and one complex expository text.

Recall Correlations

Correlational analyses were again conducted to examine any significant relationships among the variables of interest and to determine whether any multicollinearity was present among the independent and dependent variables for the recall responses. If there is a strong correlation between variables this could indicate that the variables measure the same construct.

Correlations. Correlational relationships between the knowledge scores, reader skill, and surface, textbase, and situation model products generated during the recall task are listed in Table 4.10. The focus of the current study is to examine the effects of content, text structure, and linguistic knowledge on middle school readers' comprehension products and therefore, significant correlations pertaining to this aim are reported here. Text structure knowledge significantly correlated with textbase recall responses ($r = 0.42$, $p < 0.01$). Additionally, linguistic knowledge significantly correlated with textbase recall responses ($r = 0.34$, $p < 0.05$). As with the think-aloud correlations, there is no evidence of multicollinearity among the independent variables.

Table 4.10
Correlations for Recall Responses

Variable	1	2	3	4	5	6
1. Reader Skill						
2. Content Knowledge	0.52**					
3. Text Structure Knowledge	0.46**	0.39**				
4. Linguistic Knowledge	0.56**	0.30	0.57**			
5. Surface Level	-0.26	-0.13	-0.16	-0.30		

6. Textbase	0.19	-0.04	0.42**	0.34*	-0.19	
7. Situation Model	-0.06	-0.13	-0.01	-0.06	-0.08	-0.66**

Note. * $p < 0.05$. ** $p < 0.01$.

Linear Mixed Effects Models for Recall Responses

Parallel to the think-aloud analyses, I created several LME models to investigate the contributions of content, text structure, and linguistic knowledge on middle school readers' surface, textbase and situation model recall responses. Likelihood ratio tests were also conducted for a baseline model and Models 1-3 to determine whether adding each variable improved the fit of the model. Likelihood ratio tests were not performed for Model 4 because it did not nest with Model 3 (i.e., too many new interactions were added in Model 4 to conduct a likelihood ratio test and compare it to Model 3). Significant likelihood ratio tests indicate whether adding additional variables improved the model fit compared to the previous model.

Surface Recall Responses

Table 4.11 depicts the model summary for surface level recall responses. Model 1 indicated that there were no significant effects found between content, text structure, or linguistic knowledge and surface level products ($x^2(3) = 5.63$, $p = .13$; AIC = -190.63). The addition of reader skill in Model 2 did not improve fit and there were no significant predictors ($x^2(1) = 0.53$, $p = 0.46$; AIC = -189.17). In Model 3 adding text type to the model did not improve fit and again there were no significant predictors ($x^2(1) = 0.90$, $p = 0.34$; AIC = -188.06). Model 4 indicated two significant interactions. The model summary for Model 4 is displayed in Table 4.12.

Table 4.11

Likelihood Ratio Tests and Coefficients for Mixed Effects Models Predicting Surface Level Recall Responses

	Model 1				Model 2				Model 3			
	AIC	BIC	X^2	*p*	AIC	BIC	X^2	*p*	AIC	BIC	X^2	*p*
	-190.63	-176.05	5.63	0.13	-189.17	-172.15	0.53	0.46	-188.06	-168.62	0.90	0.34
Fixed Effects:	β	SE	*t*-value	*p*	β	SE	*t*-value	*p*	β	SE	*t*-value	*p*
Content Knowledge	-0.00	0.01	-0.39	0.70	-0.00	0.01	-0.05	0.96	-0.00	0.01	-0.05	0.96
Text Structure Knowledge	0.00	0.01	0.20	0.85	0.00	0.01	0.27	0.79	0.00	0.01	0.27	0.79
Linguistic Knowledge	0.03	0.01	-2.00	0.05	-0.02	0.01	-1.53	0.13	-0.02	0.01	-1.53	0.13
Reader Skill					0.01	0.01	-0.73	0.46	-0.00	0.01	-0.73	0.47
Text Type (Simple)									-0.01	0.01	-0.95	0.35
Random Effect:	Variance:	*SD:*			Variance:	*SD:*			Variance:	*SD:*		
Participant	0.00	0.06			0.00	0.05			0.00	0.05		
Model Fit:												
Marginal R^2	0.10				0.09				0.11			
Conditional R^2	0.56				0.45				0.57			

Table 4.12

Model Estimates for Model 4 Predicting Surface Level Recall Responses

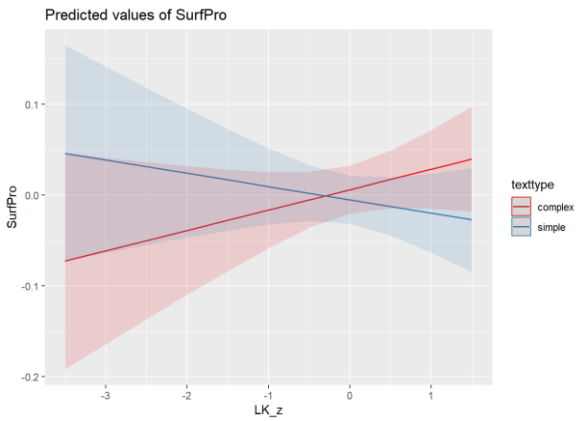
	β	SE	*t*-value	*p*
Fixed Effects:				
Content Knowledge (CK)	-0.01	0.01	-0.78	0.96
Text Structure Knowledge (TSK)	0.00	0.01	0.27	0.43
Linguistic Knowledge (LK)	0.03	0.01	1.52	0.79
Reader Skill	-0.03	0.01	-1.91	0.06
Text Type	-0.00	0.01	-0.37	0.71
CK * TSK	-0.01	0.01	-0.56	0.57
CK * LK	0.01	0.02	1.19	0.24
TSK * LK	0.02	0.01	1.86	0.07
CK * Reader Skill	0.01	0.01	1.09	0.28
TSK * Reader Skill	-0.02	0.01	-1.35	0.18
LK * Reader Skill	0.02	0.01	1.74	0.08
CK * Text Type (simple)	-0.00	0.01	-0.03	0.97
TSK * Text Type (simple)	0.00	0.01	0.29	0.77
LK * Text Type (simple)	-0.04	0.02	-2.59	**0.01 ***
Reader Skill * Text Type (simple)	0.03	0.01	2.49	**0.02***
Random Effect:	Variance:	*SD:*		
Participant	0.001	0.04		
Model Fit:				
Marginal R^2	0.41			
Conditional R^2	0.65			

Note. *$p < .05$, **p <.01.

Model 4 indicated a significant interaction for the effects of linguistic knowledge and text complexity (β = -0.04). As shown in Figure 4.2, linguistic knowledge was positively related to the proportion of surface recall responses in the complex texts. By contrast, linguistic knowledge was negatively related to proportion of surface recall responses in the simple texts.

Figure 4.2

Predicted Values of Linguistic Knowledge and Text Complexity on Surface Level Recall Responses

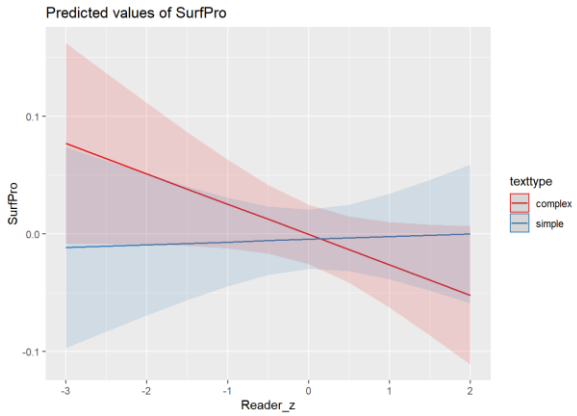


Note. LK_z refers to Linguistic Knowledge and SurfPro refers to the proportion of surface level products

A second interaction between reader skill and text complexity was also found in Model 4 for surface level recall products (β = 0.03) (see Figure 4.3). In the simple texts, there was little effect of reader skill on the proportion of surface recall responses. By contrast, there was a negative relation between reader skill and surface products for the complex texts. That is, as reader skill increased, the proportion of surface level recall responses decreased.

Figure 4.3

Predicted Values of Reader Skill and Text Complexity on Surface Level Think-aloud Responses



Note. Reader_z refers to Reader Skill and SurfPro refers to the proportion of surface level products

Textbase Recall Responses

Table 4.13 depicts the model summary for textbase recall responses. After a comparison between a baseline model and Model 1 ($x^2(3) = 18.96$, $p < .01$, AIC = 6.97), coefficients in Model 1 indicated a significant negative relationship between content knowledge (β = -0.07) and a positive relationship between text structure knowledge (β = 0.11) on textbase recall responses. In Model 2 reader skill was added to the model. Model 2 also indicated a significant negative relationship between content knowledge (β = -0.08) and a positive relationship between text structure knowledge (β = 0.11) on textbase recall responses; however, adding reader skill to Model 2 did not improve the overall fit of the model ($x^2(1) = 0.19$, $p = 0.66$, AIC = 8.77). Model 3 added text type to the model and again, although coefficients revealed significant relationships between content knowledge (β = -0.08) and text structure knowledge (β = 0.11), Model 3 did not significantly improve model fit ($x^2(1) = 2.19$, $p = 0.14$, AIC = 8.58). The findings from Model 1,

the best-fit model, suggest that readers with more content knowledge produced a greater proportion of textbase recall responses than readers with less content knowledge. These results also indicate that students with more text structure knowledge produced a greater proportion of textbase recall responses than students with less text structure knowledge which supports the notion that knowledge of text structures provides an organizational framework for how to recall text information.

Table 4.13

Likelihood Ratio Tests and Coefficients for Mixed Effects Models Predicting Textbase Recall Responses

	Model 1				Model 2				Model 3			
	AIC	BIC	X^2	*p*	AIC	BIC	X^2	*p*	AIC	BIC	X^2	*p*
	6.97	21.55	18.96	**0.002****	8.77	25.79	0.20	0.46	8.58	28.02	2.19	0.14
Fixed Effects:	β	SE	*t*-value	*p*	β	SE	*t*-value	*p*	β	SE	*t*-value	*p*
Content Knowledge	-0.07	0.02	-2.36	**0.02***	-0.08	0.03	-2.34	**0.02***	-0.08	0.03	-2.34	**0.02***
Text Structure Knowledge	0.11	0.03	3.23	**0.002****	0.11	0.04	3.18	**0.002****	0.11	0.04	3.18	**0.002****
Linguistic Knowledge	0.05	0.03	1.48	0.14	0.04	0.04	1.18	0.25	0.04	0.04	1.18	0.25
Reader Skill					0.01	0.03	0.45	0.66	0.01	0.03	0.45	0.66
Text Type (Simple)									0.07	0.05	1.50	0.14
Random Effect:	Variance:	*SD*:			Variance:	*SD:*			Variance:	*SD:*		
Participant	0.01	0.09			0.01	0.09			0.01	0.10		
Model Fit:												
R^2 Marginal	0.25				0.25				0.11			
R^2 Conditional	0.37				0.37				0.57			

Note. **p* < .05, **p <.01.

In Model 4, all the knowledge types, reader skill, text type, and all their two-way interactions indicated that there were no significant interactions (see Table 4.14).

Table 4.14

Model Estimates for Model 4 Predicting Textbase Products

	Estimate	SE	*t*-value	*p*
Fixed Effects:				
Content Knowledge (CK)	-0.05	0.04	-1.24	0.22
Text Structure Knowledge (TSK)	0.07	0.05	1.46	0.15
Linguistic Knowledge (LK)	0.08	0.05	1.34	0.18
Reader Skill	-0.04	0.04	-0.84	0.40
Text Type (simple)	0.07	0.05	1.57	0.12
CK * TSK	-0.02	0.04	-0.39	0.70
CK * LK	0.09	0.05	1.96	0.06
TSK * LK	-0.08	0.04	-1.96	0.06
CK * Reader Skill	-0.03	0.03	-1.05	0.30
TSK * Reader Skill	0.01	0.04	0.36	0.71
LK * Reader Skill	0.00	0.03	0.02	0.99
CK * Text Type (simple)	0.04	0.05	0.65	0.52
TSK * Text Type (simple)	0.01	0.06	0.15	0.88
LK * Text Type (simple)	-0.03	0.06	-0.43	0.67
Reader Skill * Text Type (simple)	0.02	0.05	0.38	0.70
Random Effect:	Variance:	*SD:*		
Participant	0.00	0.06		
Model Fit:				
Marginal R^2	0.36			
Conditional R^2	0.42			

Note. * $p < 0.05$. ** $p < 0.01$.

Situation Model Recall

Table 4.15 depicts the model summary for situation model recall responses. After comparing a baseline model with Model 1, findings indicated that none of the predictors were significant for the situation model recall responses ($x^2(3) = 4.32$, $p = 0.23$, AIC = -8.15). In Model 2 (knowledge types and reader skill) none of the fixed effects predicted situation model recall responses ($x^2(1) = 1.29$, $p = 0.26$, AIC = -7.44). Similarly, there were no significant effects

in Model 3 (knowledge types, reader skill, and text complexity) ($x^2(1) = 0.19$, $p = 0.66$, AIC = -5.63). In Model 4, however, there was one significant negative interaction between text structure knowledge and linguistic knowledge ($\beta = -0.07$) (see Table 4.16).

Table 4.15

Likelihood Ratio Tests and Coefficients for Mixed Effects Models Predicting Situation Model Recall Responses

	Model 1				Model 2				Model 3			
	AIC	BIC	X^2	*p*	AIC	BIC	X^2	*p*	AIC	BIC	X^2	*p*
	-8.15	6.43	4.32	0.23	-7.44	9.57	1.29	0.26	-5.63	13.81	0.19	0.66
Fixed Effects:	β	SE	*t*-value	*p*	β	SE	*t*-value	*p*	β	SE	*t*-value	*p*
Content Knowledge	0.04	0.02	1.47	0.14	0.05	0.03	1.82	0.07	0.05	0.03	1.82	0.07
Text Structure Knowledge	-0.06	0.03	-1.87	0.07	-0.05	0.03	-1.76	0.08	-0.05	0.03	-1.76	0.08
Linguistic Knowledge	0.02	0.03	0.70	0.49	0.03	0.03	1.11	0.27	0.03	0.03	1.11	0.27
Reader Skill					0.01	0.02	-1.14	0.26	-0.02	0.02	-1.14	0.26
Text Type (Simple)									-0.02	0.05	-0.44	0.66
Random Effect:	Variance:	*SD:*			Variance:	*SD:*			Variance:	*SD:*		
Participant	0.00	0.00			0.00	0.00			0.00	0.00		
Model Fit:												
R^2 Marginal	0.05				0.07				0.07			
R^2 Conditional	0.05				0.07				0.07			

Note. *p < .05, **p <.01.

Table 4.16

Model Estimates for Model 4 Predicting Situation Model Products

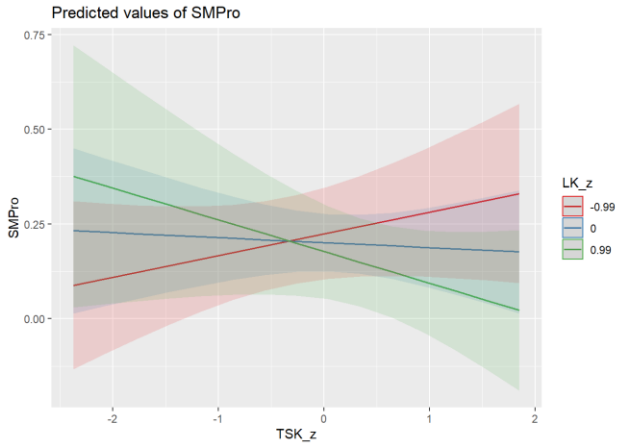
	Estimate	SE	*t*-value	*p*
Fixed Effects:				
Content Knowledge (CK)	0.04	0.04	0.92	0.36
Text Structure Knowledge (TSK)	0.00	0.04	0.07	0.94
Linguistic Knowledge (LK)	-0.02	0.05	-0.45	0.65
Reader Skill	0.02	0.04	0.74	0.46
Text Type	-0.03	0.04	-0.75	0.45
CK * TSK	-0.02	0.04	-0.79	0.43
CK * LK	-0.04	0.03	-0.84	0.40
TSK * LK	-0.07	0.03	-2.07	**0.04***
CK * Reader Skill	0.01	0.03	0.54	0.59
TSK * Reader Skill	0.06	0.03	1.96	0.05
LK * Reader Skill	0.00	0.02	0.15	0.88
CK * Text Type (simple)	0.03	0.05	0.54	0.59
TSK * Text Type (simple)	-0.08	0.05	-1.59	0.12
LK * Text Type (simple)	0.04	0.06	0.84	0.40
Reader Skill * Text Type (simple)	-0.05	0.05	-1.13	0.26
Random Effect:	Variance:	*SE:*		
Participant	0.00	0.00		
Model Fit:				
Marginal R^2	0.21			
Conditional R^2	0.21			

Note. * $p < 0.05$. ** $p < 0.01$.

As displayed in Figure 4.6, the interaction between text structure knowledge and linguistic knowledge indicated that readers with more text structure knowledge but less linguistic knowledge produced a greater proportion of situation model recall responses. On the other hand, readers with less text structure knowledge and more linguistic knowledge produced a greater proportion of situation model recall responses. As depicted in Table 4.15, the R^2 for each of the situation model recall response models suggests a lack of variability in participants' responses. I plan to pursue other methods of analysis (e.g., non-parametics) to further explore these effects.

Figure 4.4

Predicted Values of Text Structure Knowledge and Linguistic Knowledge on Situation Model Recall Responses



Note. TSK_z refers to Text Structure Knowledge, LK_z refers to Linguistic Knowledge and SMPro refers to the proportion of surface level products

CHAPTER V
DISCUSSION

Middle school readers are required to comprehend expository text to demonstrate academic proficiency. To comprehend expository text, readers integrate prior knowledge with text information while reading to develop coherent mental representations of text that can be recalled after reading has concluded (Kintsch, 1998; Kintsch & Van Dijk, 1978). Previous research has been limited in investigating whether different types of prior knowledge, such as content, text structure, and linguistic knowledge differentially contribute to the comprehension processes middle school readers generate while reading, as well as whether these three knowledge types simultaneously influence middle schoolers' recall of expository text. However, this research has indicated that differences in reader skill may forestall or augment the contributions of content, text structure or linguistic knowledge on expository comprehension (e.g., Garcia et al., 2015; Meneses et al., 2018; Swanson et al., 2015). Additionally, text complexity has been associated with prior knowledge and could significantly influence middle school readers' comprehension performance (McNamara et al., 1996; Spencer et al., 2019).

Accordingly, the current study was motivated by theoretical frameworks of text comprehension (e.g., CI Model; Kintsch, 1998) and previously conducted research demonstrating that individual differences (i.e., prior knowledge and reader skill; e.g., Garcia, 2015; Tarchi, 2017) and text features (i.e., text complexity; e.g., Eason et al., 2012; Dahl et al., 2021) are vital for middle school readers' comprehension of expository text. Yet no studies have simultaneously examined the contributions of all these factors on middle school readers' comprehension performance. Considering these gaps, my research questions were: 1) To what extent do different types of knowledge (content, text structure, linguistic) influence middle schoolers' generation of surface level, textbase, and situation model processes while reading

expository texts? 1a) How does this vary by comprehension skill?1b) How does this vary by text complexity? And 2) to what extent do different types of knowledge (content, text structure, linguistic) influence middle schoolers' generation of surface level, textbase, and situation model products after reading expository texts? 2a) How does this vary by comprehension skill? 2b) How does this vary by text complexity?

To answer these research questions, I conducted a study in which middle school students read one simple and one complex expository text. The text materials were identified as simple or complex using the Automated Readability Tool for English (ARTE; Choi & Crossley, 2022). For each text, participants thought aloud while reading, and after reading they recalled the expository text that was just read. Participants also completed three knowledge assessments: a researcher-developed measure of content knowledge, the Identifying Structures test (text structure knowledge; Hebert et al., 2018), and a c-test (linguistic knowledge; Trakulphadetkrai et al., 2017). Participants' comprehension skill was identified through curriculum-based measures (CBM) provided by each school site. As noted, CBM scores were the only data received by participant schools, and thus, were used as proxy for comprehension skill. However, given that the data from only one reading measure was provided, this limits conclusions that can be made about reading comprehension skill level. Thus, the remainder of this discussion will refer to reading skill rather than comprehension skill.

After recording participants' scores on each of the knowledge assessments as well as recording participants' think-aloud and recall responses, I coded their responses based on processes and products identified by the theoretical foundation for this study and previous research conducted with children completing think-aloud and recall tasks (Dahl et al., 2021; Carlson et al., 2014; Kintsch, 1988, 1999; McMaster, 2015). Specifically, responses in the think-

aloud and recall tasks were coded to fit within predetermined surface, textbase, or situation model level responses. In the think-aloud, surface level responses repeated text information word-for-word. Textbase responses explained explicit information from the text and included paraphrases, bridging inferences, and text-focused metacognitive comments. Situation model responses explained explicit information from the text as well as integrated prior knowledge within the response. Situation model responses also included elaborative inferences and knowledge-focused metacognitive comments. For the recall, surface level responses occurred when students recalled verbatim words or phrases from the text. Textbase recall responses paraphrased text information and were gist summaries or were constrained by explicit text information. Finally, situation model recall responses were comments that integrated outside knowledge that was not explicitly stated in the text (see Tables 3.4 and 3.5 for examples).

Based on mixed effects model analyses, tests of within subjects effects for knowledge, reader skill, and text type indicated differences in the extent to which content, text structure, and linguistic knowledge contributed to the generation of surface, textbase, and situation model processes and products during and after reading expository text. In the next sections, I discuss significant findings and findings associated with my hypotheses that are related to students' processing during the think-aloud tasks and products from the recall tasks.

The Influence of Knowledge, Reader Skill, and Text Complexity while Reading Expository Text

For this study, I hypothesized that content, text structure, and linguistic knowledge would significantly contribute to middle schoolers' generation of surface level, textbase, and situation model processes while reading expository texts in different ways. In the following sections, I will

discuss significant findings and findings associated with my hypotheses that are related to students' processes during the think-aloud task.

Considering each of the hypotheses for this study, I begin with discussing the effects of knowledge on surface level processing of expository texts (RQ1). Then, I explain the effects of knowledge on surface level processing of expository text by reader skill (RQ1a) and then text complexity (RQ1b). Thereafter I discuss each of these effects across textbase and situation model processing. For some of the research sub-questions (RQ1a, b), I did not expect that the effects of knowledge would vary by reader skill or text complexity at each level of processing and thus I did not make hypotheses for those sub-questions findings. For the cases where there were no hypotheses and results were insignificant, these results are not discussed (e.g., reader skill and situation model processing). However, all aspects of the sub-questions are addressed in the implications for theoretical and empirical research portions of the discussion.

The Influence of Knowledge during Surface Level Processing of Expository Texts

Based on previous research, I anticipated that there would be a negative association between linguistic knowledge and surface level processing where readers with less linguistic knowledge would be more likely to generate surface level comprehension processes (Gillam et al., 2009). Although the best-fit model did not indicate that linguistic knowledge contributed to surface level processing in general; a previous model (Model 1) did reveal a significant negative association between linguistic knowledge and surface level processing. This finding is discussed further in *the Influence of Knowledge during Surface Level Processing of Expository Text by Reader Skill* section of the discussion below because reader skill appeared to be more relevant for surface level processing than linguistic knowledge.

Additionally, content knowledge was identified as a significant contributor to middle school readers' surface level processing of expository text. Contrary to my hypothesis, analyses at the surface level revealed that readers with more content knowledge were more likely to generate surface level responses in their think aloud. Surface level processes were identified when readers repeated text information verbatim, and I did not hypothesize that content knowledge would contribute to readers' surface level processes. One speculative reason for this finding could be that readers with prior content knowledge had additional exposure to the content words or phrases in the text and as such, these students could quickly and easily repeat text information while they were reading (Priebe et al., 2011). Although this finding was not expected, it extends the fields' knowledge of surface level processes because relatively little empirical work has examined the effects of knowledge on readers' surface level processing. Recent research indicates that surface level processes may be foundational for building coherent mental representations of text (Kucer, 2009; Yeari & Lantin, 2021). The findings explained here suggest that readers with more content knowledge tend to generate more surface level processes and as such, this study offers evidence for understanding how specific knowledge, and in this case, content knowledge, influences middle school readers' surface level processing of expository text.

In addition to content knowledge independently contributing to surface level processing, there was also a significant interaction between content knowledge and linguistic knowledge on surface level processing. This interaction suggests that once readers have a certain threshold of content knowledge, linguistic knowledge may be less imperative for generating surface level processes during a think-aloud task. That is, readers may be able to repeat surface level text information while they are reading due to previous exposure to content, rather than knowledge of

discourse-level language. Consequently, this study supports the idea that content knowledge may be more important than linguistic knowledge for the likelihood that middle school readers will generate surface level processes while reading expository text. Studies that have simultaneously examined the effects of linguistic and content knowledge determined that both knowledge types contributed to expository comprehension generally but did not examine whether these knowledge types relate to surface level processing of expository text (Davis et al., 2017; Marron, 2019). Consequently, this study extends the literature to specify that content knowledge may be more important than linguistic knowledge for middle school readers generation of surface level processes while reading expository text; however, this finding does not take reading skill or other variables into consideration.

The Influence of Knowledge during Surface Level Processing of Expository Text by Reader Skill

Here I explain the effects of knowledge on surface level processing of expository text by reader skill (RQ1a). Reader skill may also be an area related to one's knowledge and processing during reading of expository text. To investigate this relationship, I anticipated that reader skill would contribute to surface level processing in that less-skilled readers would generate more surface level processes. Previous research indicates that less-skilled readers have been found to over rely on processes that repeat or paraphrase text information (i.e., surface level) (Gillam et al., 2009). Analyses revealed that content knowledge and reader skill predicted surface level processes and consequently, readers with more content knowledge and less-skilled readers were more likely to generate surface level processes of expository text. There was no interaction found between content knowledge and less-skilled readers' generation of surface level processes however, and therefore, it appears that content knowledge and reader skill individually contribute

to surface level processing. These findings align with previous research suggesting that less-skilled readers may need support in generating comprehension processes that are more advanced than surface level repetition, such as bridging or elaborative inferences (Cain et al., 2001). In sum, the findings pertaining to reader skill and surface level comprehension processing extend the field because they indicate that content knowledge and reader skill influence middle school readers' surface level processing of expository text.

It is also worthwhile mentioning the relationship between linguistic knowledge and reader skill for surface level processing. Although the best-fit surface level model (Model 3) did not support my hypothesis that readers with less linguistic knowledge would be more likely to generate surface level processes, as mentioned above, Model 1 revealed a significant negative relationship between linguistic knowledge and surface level processing. However, the relationship between linguistic knowledge and surface level processing was no longer significant once reader skill was included as a predictor variable in Model 2. Thus, the findings here suggest that readers with less linguistic knowledge may be more likely to generate surface level processes to some extent, but reader skill is more likely to influence surface level processing than linguistic knowledge. This finding reiterates the importance of considering knowledge in relation to reader skill and other aspects of text comprehension (e.g., text complexity) when evaluating middle schoolers' surface level processing of expository text.

The Influence of Knowledge during Surface Level Processing of Expository Text by Text Complexity

In this section I explain the effects of knowledge on surface level processing of expository text by text complexity (RQ1b). The best-fit surface level processing model (Model 3) indicated that content knowledge continued to significantly affect participants' surface level

processing even after adding reader skill and text complexity to each successive model. Thus, as stated previously, content knowledge appears to be particularly critical for middle school readers' comprehension processes (i.e., surface level) of expository text. The best-fit model for surface level processing also indicated that text complexity predicted the likelihood that participants repeated text information because participants were more likely to generate surface level think-aloud responses while reading the simple text. One potential explanation for this finding is that the simple text included more explicit information and therefore, readers did not need to fill gaps in the text by generating knowledge- or text-based inferences. Therefore, based on this explanation, reading the simple text may have influenced repeating of text information, rather than engage in higher level comprehension processing during the simple text. To my knowledge no research has been conducted investigating the relationship between surface level processing and text complexity, and therefore, this finding contributes to the fields' understanding of how content knowledge and text complexity influence surface level processing of expository text.

The Influence of Knowledge during Textbase Processing of Expository Texts

In this section, I discuss how knowledge influenced readers' processing at the textbase level (RQ1). I expected that linguistic knowledge and text structure knowledge would significantly contribute to students' think-aloud responses at the textbase level (Kintsch, 1988; Trapman et al., 2014). However, analyses at the textbase level revealed that none of the knowledge types predicted middle school readers' textbase processing. Textbase processes occurred when participants' think-aloud responses centered on explicit information found within the text, as in readers generating paraphrases and/or local/global bridging inferences. The current findings at the textbase level were not expected due to theories of comprehension positing that

textbase processes are generated to construct meaning within a text (Kintsch & Rawson, 2008); however, few studies have systematically examined whether multiple types of prior knowledge influence textbase level representations particularly in the context of a think-aloud task (e.g., Kintsch, 1988). One explanation for this null finding could be that middle school readers may not routinely and strategically rely on text structure or linguistic knowledge as they read to develop textbase representations. Perhaps other cognitive resources, like executive function, motivation, or interest-level are more important for developing textbase responses during a think-aloud task. However, this explanation is speculative, and thus, future research might investigate what types of cognitive resources (e.g., motivation, interest) are predictive of textbase processing in middle school readers' expository comprehension.

The Influence of Knowledge during Textbase Processing of Expository Texts by Reader Skill

In this next section, I explain whether the effects of knowledge on textbase processing varied by reader skill (RQ1a). I hypothesized that less-skilled readers would be more likely to generate textbase processes while reading expository text. That is, I expected that reader skill would independently contribute to textbase processing. As previously stated, there were no significant effects of knowledge identified at the textbase level for comprehension processing. There were also no significant effects of reader skill. Think-aloud studies have identified that less-skilled readers tend to generate more textbase level processes, like paraphrases, than more-skilled readers (e.g., Laing & Kamhi, 2002); however, that was not found in the current study. There are a few possibilities for why knowledge and reader skill did not contribute to textbase processing. First, paraphrases, text-based inferences, and text-based metacognitive comments were coded as textbase processes. This was done because all these processes focus on the words in the text rather than integrating outside knowledge. However, previous think-aloud research

has found differences in comprehension process use by reader skill and such studies likely used different coding schemes that employed a more fine-grained approach (e.g., Carlson et al., 2014; Dahl et al., 2021). These studies did not collapse codes at the textbase level and separately investigated each type or process (e.g., Carlson et al., 2014), and therefore, paraphrasing and bridging inferences were not examined as one type of response as in the current study (i.e., textbase level responses). Thus, the current findings may have been different had the codes not been collapsed. For example, inferences generated that focus on information in the text (i.e., bridging inferences) have been found to differentiate between skilled and less-skilled readers' comprehension performance (Laing & Kamhi, 2002). Including text-based inferences and paraphrases as one code as found in the current study, may have eliminated any effects for knowledge or reader skill at the textbase level. Accordingly, although knowledge and reader skill did not contribute to middle school readers' textbase comprehension processes, these null findings have implications for informing theory, such as the CI model, and understanding whether middle school readers use knowledge to generate comprehension processes and develop coherent representations of expository text (Kintsch, 1988).

The Influence of Knowledge during Textbase Processing of Expository Texts by Text Complexity

With respect to RQ1b, regarding the effects of knowledge varied by text complexity, the results indicated that participants generated a greater proportion of textbase processes while reading the simple text. Previous think-aloud research has suggested that middle school readers may be more likely to paraphrase or summarize text information in their think-aloud responses while reading simpler text (Dahl et al., 2021). In the current study, paraphrase responses were coded as textbase processes and therefore, the results found here align with previous research

indicating that simpler expository texts may prompt middle school readers to generate paraphrases and text-focused responses during think-aloud tasks. This finding is notable because the effect of text complexity was significant above the contributions of knowledge and reader skill. Therefore, text complexity plays a significant role in how these students process texts, even when considering their individual differences in knowledge and skill.

The Influence of Knowledge during Situation Model Processing of Expository Text

In this section, I discuss how knowledge influenced readers' processing at the situation model level (RQ1). Regarding situation model processes, my foremost expectation was that readers with more content knowledge would be more likely to generate situation model processes. The best fitting model at the situation model level did not indicate a positive significant association between content knowledge and situation model processes. It was also surprising that neither content, text structure, nor linguistic knowledge contributed to situation model processing since this type of process is reliant on extant knowledge and as such, this finding deviates from Kintsch's CI Model (1988) because the CI model suggests that situation model processes occur as readers integrate prior knowledge and text information to comprehend gaps or implicit information from a text (Kintsch, 1998; Kintsch & Van Dijk, 1978). Participants in the current study did generate inferences and therefore integrated knowledge with text information as evidenced by their situation model think-aloud responses (see Figure 4.1 to compare the number of responses by CI model level); however, it appears that middle school readers may have used cognitive resources, other than content, text structure, or linguistic knowledge to generate inferences in the current study.

Previous research can help to interpret the null findings for situation model processing of expository text. Although relatively few studies have examined how knowledge contributes to

situation model processing in a think- aloud. Wolfe and Goldman (2005) did investigate this relationship in a think-aloud task and similarly found no significant relationship. Wolfe and Goldman rationalized that this could be because students' had too little content knowledge, and therefore, could not integrate their knowledge during a think-aloud task. That conclusion could be possible in the current study as well. Participants' mean score on the content knowledge measure was quite low out of the total possible points (i.e., 3.81 out of 10) and as such, the students in the sample had very limited content knowledge. The content measure used in this study was also researcher developed, and thus, could be further developed and validated in future research. One promising point, however, was that content knowledge was approaching significance in three of the linear mixed effects models at the situation model level. Therefore, future studies with larger sample sizes may help identify the extent to which content knowledge can positively predict situation model processing of expository text in middle school readers.

Middle school readers may also not be used to purposefully talking about and making connections to extant knowledge while completing a think-aloud task. More research is needed to better understand the extent to which middle school readers use prior knowledge to generate situation model processes while reading expository text. For example, future studies might use other constructed response approaches such as self-explanation (e.g., McCarthy & Hinze, 2021). Another approach could test whether there is a relationship between content, text structure, or linguistic knowledge and think-aloud performance when students receive direct training on how to integrate knowledge in a think-aloud task. Conducting such work would elucidate whether and how knowledge can support situation model processing in middle school readers.

The Influence of Knowledge during Situation Model Processing of Expository by Text Complexity

Here I discuss how knowledge contributed to situation model processing in relation to text complexity (RQ1b). I expected that there would be an interaction between content knowledge and text type such that when content knowledge increased, the likelihood that readers generated situation model responses would depend on the type of text being read (e.g., Cain et al., 2004; McNamara et al., 1996; Spencer et al., 2019). In other words, readers with more content knowledge would be more likely to generate situation model responses when reading the complex text. The best fitting model at the situation model level indicated a significant association between text type and situation model processing, although contrary to my hypotheses, there was not an interaction between content knowledge and text type. Instead, students' situation model processing was associated with reading complex expository text. That is, regardless of reader skill, participants were more likely to generate situation model processes while reading the complex text than the simple text. Situation model processes were coded when readers integrated prior knowledge with text information in their response. Although I did not anticipate this finding, there is some precedence for it within the literature. Complex text often lacks cohesion and tends to have more gaps or implicit information within the text (McNamara et al., 2014). Therefore, reading texts with low cohesion requires readers to generate inferences to fill in gaps that are more prevalent in complex text (Graesser et al., 2004) and as stated previously, readers need to integrate extant knowledge to generate gap-filling inferences (Kintsch, 1988; 1999). Thus, in accordance with the findings in the current study, more complex (less cohesive) text prompted readers to generate more situation model inferences due to the greater number of gaps within the text. This finding extends our knowledge of how text complexity contributes to situation model processing in middle school readers. Previous studies have found that text features, like complexity prompt situation model processes (Dahl et al.,

2021); however, the current finding also indicates that this effect remains true for skilled and less-skilled readers and beyond the effects of content, text structure, and linguistic knowledge. Thus, this finding suggests that perhaps middle school readers should be encouraged to read challenging text to stimulate the generation of situation model comprehension processes while reading expository text.

An important caveat of this finding, however, is that the current study did not examine the accuracy of participants' situation model responses in the think-aloud task. This is important because although content knowledge influenced the generation of more situation model processes while reading complex text, this could be detrimental to students' comprehension if inaccurate responses lead to incoherent or inaccurate mental representations of a given text (Karlsson et al., 2018; Kendeou & van den Broek, 2007). In this study responses were coded as situation model responses whenever students explained the text using any type of prior knowledge regardless of accuracy. For example, students could have thought out loud with off-topic or incorrect responses and this occurrence in children's think-alouds has demonstrated the potential to hinder comprehension (e.g., Dahl et al., 2021; Karlsson et al., 2018). As such, future research should continue to compare middle school readers' situation model processing while reading a variety of expository texts with different features of text complexity to understand whether this relationship promotes coherent or incoherent mental representations of text.

Summary of the Influence of Knowledge, Reader Skill, and Text Complexity while Reading Expository Text

Overall, these findings support the notion that some types of knowledge influence middle schoolers' reading comprehension processes at different levels depending on individual differences (reader skill) and text complexity. Specifically, content knowledge, reader skill, and

text complexity were important for surface level processes. Content knowledge may have afforded readers more surface level think-aloud responses because they were already familiar with words and concepts in the text (Priebe et al., 2011). For instance, readers may have been quick to repeat phrases like “plate boundaries” or “small quakes, called foreshocks” out loud while reading because readers with more content knowledge had previous exposure to this terminology. Relatedly, content knowledge may have moderated linguistic knowledge at the surface level due to the greater number or vocabulary terms related to science content than general linguistic knowledge.

Also important, although reader skill was associated with surface level processing, reader skill was not found to be related to textbase or situation model processing. The association between reader skill and surface level processes was expected; however, it was surprising that reader skill did not contribute to situation model processing due to previous research demonstrating that less-skilled readers tend to generate fewer and less efficient processes that necessitate inferencing (i.e., situation model level) than their more-skilled reader peers (e.g., Cain & Oakhill, 1999). Future research that examines whether reader skill is related to the accuracy or quality of middle school readers’ situation model processing could enhance our understanding of the effects of reader skill on middle school readers’ comprehension processing of expository text.

Finally, text complexity appears to be very important for students’ development of all three types of expository text representations (i.e., surface, textbase, situation model). As stated previously, middle school readers were more likely to generate surface level processes while reading simple text and more likely to generate situation model processes while reading complex text. Therefore, students may be encouraged to read complex text to prompt inference generation

and simple text to prompt text repetition or paraphrasing during reading. This finding extends our understanding of text complexity because it suggests that regardless of content, text structure, and linguistic knowledge and reader skill, middle school students may be more likely to generate different types of processes while reading simple or complex expository texts (Dahl et al., 2021).

Altogether these findings are significant because they scratch at the surface of how knowledge contributes to reading comprehension of different types of expository texts. As with much research, however, additional investigation is needed to understand how knowledge contributes to comprehension processing of expository text. Although theories and empirical research assume that knowledge supports readers as they generate comprehension processes (Kintsch, 1988, Zwaan & Radvansky, 1998), the current study provides mixed evidence to support that notion. Theories of reading comprehension, like the CI model, were designed in the image of the proficient adult reader (Kintsch, 1988; McNamara & Magliano, 2009), and as such, perhaps middle school readers may not yet purposefully use their knowledge to support situation model comprehension. Middle school readers may also rely on other cognitive resources, such as interest or motivation, to facilitate inferencing. As such, additional research is needed to better understand how content, text, structure, and linguistic knowledge influence textbase and situation model comprehension processing in middle school readers.

The Influence of Knowledge, Reader Skill, and Text Complexity After Reading Expository Text

For this study, I hypothesized that content, text structure, and linguistic knowledge would significantly contribute to middle schoolers' surface, textbase, and situation model level products after reading expository texts in different ways. In the following sections, I discuss significant

findings and findings associated with my hypotheses that are related to students' products of expository texts.

The Influence of Knowledge on Surface Level Products of Expository Texts

In this section, I begin with discussing the effects of knowledge on surface level products of expository texts (RQ2). Next, I will explain how the effects of knowledge vary by reader skill and text complexity (RQ2a and b). Then, I will explain the effects of knowledge on textbase processing of expository text by text complexity (RQ2b). Then I will discuss the effects of knowledge on situation model products of expository text (RQ2). To conclude, I will explain the effects of knowledge on situation model products of expository text by reader skill (RQ2a) and text complexity (RQ2b). For some of the research sub-questions (RQ2a, b), I did not expect that the effects of knowledge would vary by reader skill or text complexity, and thus I did not make hypotheses for those sub-questions across every level of representation. For some of the research sub-questions, there were instances wherein there were no hypotheses and results were insignificant and therefore, results in these cases are not discussed.

Based on previous research, I anticipated that linguistic knowledge would contribute to surface level recall responses such that readers with less linguistic knowledge would generate more surface level recall responses (Davis et al., 2017; Trapman et al., 2014, 2017). Findings supported this hypothesis in that linguistic knowledge was related to surface level recall responses. That is, readers with more linguistic knowledge produced fewer surface level recall responses. This finding aligns with the Reading Systems Framework which posits that several sources of knowledge, including linguistic knowledge, are related to text comprehension (Perfetti & Stafura, 2014). Surface level recall responses were coded when participants recalled verbatim text information. As such, participants with more linguistic knowledge may have leveraged their

semantic and syntactic knowledge to recall more information than simply repeating information stated in the text (i.e., surface level recall), and therefore, made fewer surface level recall responses. This finding contributes to the field because previous research related to linguistic knowledge has examined whether linguistic knowledge contributes to middle school readers' comprehension of short, artificial texts embedded in assessments (e.g., Eason et al., 2012). The current study revealed that linguistic knowledge can also contribute to middle school readers' surface level recall of an expository text that is more representative of what middle school students read in everyday classrooms. Future research could test whether this relationship would be replicated with other naturalistic texts and other samples of middle school readers.

The Influence of Knowledge on Surface Level Products of Expository Reading by Reader Skill

Now I discuss how the effects of knowledge on middle school readers' surface level products varied by reader skill (RQ2a). Although reader skill was not found to be a significant contributor to surface level products in Models 1-3, Model 4 indicated a significant interaction between reader skill and text complexity. This finding suggests that more skilled readers generated a smaller proportion of surface level recall products than less-skilled readers. Additionally, less-skilled readers generated a significantly greater proportion of surface level recall responses when reading the complex text than reading the simple text. Previous recall studies have found that less-skilled readers remember less text information after reading is over and often the information that they remember is less related to the main ideas presented in the text (Yeari & Lantin, 2021). Thus, this finding supports previous research because less-skilled readers in this sample recalled a greater proportion of surface level text information than more-skilled readers. Moreover, the types of recall responses that less-skilled readers made focused on

repeating text information rather which may or may not have been information that was central to the purpose or meaning of the text.

The Influence of Knowledge on Surface Level Products of Expository Reading by Text Complexity

Relating to RQ2b, the influence of knowledge of surface level products of expository recall by text complexity, two interactions in Model 4 will currently be discussed. As previously mentioned, Model 4 revealed an interaction between reader skill and text complexity such that less-skilled readers recalled more surface level text information after reading the complex text. Accordingly, less-skilled readers repeated text information in their recall responses after reading complex text which supports the notion that text complexity affects middle school readers' ability to remember text information after reading is over. Though previous research has indicated similar effects for text complexity and performance on other measures of expository comprehension after reading is over (Elleman et al., 2022), an effect of text complexity on surface level recall has not been previously identified. Therefore, the current finding reiterates the importance of considering text complexity for its effect on middle school readers' expository recall across surface, textbase, and situation model comprehension products.

A second significant finding in Model 4 revealed an interaction between linguistic knowledge and text complexity on middle school readers' recall of surface level products. That is, readers with more linguistic knowledge recalled more surface level information after reading the complex text. In comparison, readers with less linguistic knowledge recalled more surface level information after reading the simple text. Together, these findings suggest that middle school readers' linguistic knowledge helps them repeat information from an expository text during a recall task. Readers with more linguistic knowledge may be able to apply their linguistic

knowledge to help them repeat information from an expository text that may be written with more advanced vocabulary or complex syntax. To my knowledge, no study has found a relationship between linguistic knowledge and surface level recall of expository text; however, this finding supports theoretical and empirical research highlighting how linguistic knowledge supports middle school readers' performance on measures of expository comprehension products (e.g., Eason et al., 2012; Perfetti & Stafura, 2014).

The Influence of Knowledge on Textbase Products of Expository Reading

Here I share the effects of knowledge on middle school readers' textbase products of expository texts (RQ2). At the textbase level, I expected that text structure knowledge would positively predict textbase recall responses so that readers with more text structure knowledge would be more likely to recall textbase information after reading expository text (Hebert et al., 2018). Analyses of textbase recall responses revealed a significant positive relationship between text structure knowledge and a significant negative relationship between content knowledge on recall responses. There was a positive relationship between text structure knowledge and textbase recall responses indicating that students with more text structure knowledge were more likely to generate textbase recall responses. This finding aligned with my hypotheses as well as previous research conducted with elementary readers which suggests that text structure knowledge helps readers organize their mental representations of expository text and therefore, recall text information (Hebert et al., 2018; Pyle et al., 2017). This finding extends previous research because it specifies that text structure knowledge supports *textbase* level recall. Therefore, this study supports the notion that when middle school readers are familiar with expository text structures, they can easily recall explicit text information because they know the underlying text structure. Previous research has indicated that text structure knowledge predicts

recall performance overall (e.g., Pyle et al., 2017), but this is the first time that research has specifically identified which level of readers' mental representation is supported by text structure knowledge (i.e., textbase).

The second significant knowledge type for textbase products of expository text was content knowledge. I did not expect that readers with less content knowledge would be more likely to generate textbase recall responses. Textbase recall responses were coded when participants explained or paraphrased information from the text but did not integrate any outside knowledge in their responses. A potential explanation for this finding is that readers with less content knowledge may have focused their responses on explicit text information (i.e., textbase responses). Although theories of comprehension and previous research posit that content knowledge positively predicts strong recall performance overall, it is possible that content knowledge is less integral for producing textbase recall responses (Kintsch, 1988; Tarchi, 2017). In relation to the current study, readers with less content knowledge may have focused on explicit or textbase information because they may have had less content knowledge available to integrate in their recall response. Thus, the findings pertaining to the textbase products extend the field to explain that readers with less content knowledge may be more likely to produce textbase products after reading expository text.

The Influence of Knowledge on Textbase Products After Expository Reading by Text Complexity

In this section, I explain findings related to the effects of knowledge on textbase products and how these effects varied due to text complexity (RQ2b). I expected that text complexity would separately contribute to textbase recall independent of the effects of content, text structure, or linguistic knowledge. Specifically, I anticipated that participants would be more

likely to recall textbase information after reading the simple text and less likely to recall textbase information after reading the complex text. Although content and text structure knowledge contributed to textbase recall, there were no significant effects of text complexity on textbase recall. As stated earlier, research has identified that simpler texts are easier to recall (Haberlandt & Graesser, 1985) and perhaps because they tend to have more cohesion (e.g., McNamara et al., 2014). Reading simple, cohesive text eliminates the need to generate inferences (.g., McNamara et al., 2014; McNamara et al., 1996). Thus, I anticipated that readers would recall more textbase information after reading the simpler text. However, it appears that content and text structure knowledge are more predictive of middle school readers' textbase recall than text complexity. For example, middle school readers may leverage text structure knowledge to recall explicit text information and generate gist recall responses regardless of how complex a given text is. Thus, this finding emphasizes the importance of content and text structure knowledge because these sources of knowledge are related to textbase products of expository text regardless of how complex a text may be to read.

The Influence of Knowledge on Situation Model Products After Expository Reading

Next, I describe how knowledge contributed to participants' situation model products (RQ2). At the situation model level, I anticipated that content knowledge would contribute to situation model recall responses (Ahmed et al., 2016; Garcia, 2015; 2017; Tarchi, 2017). However, none of the models at the situation model indicated that content knowledge significantly contributed to middle school readers' situation model recall of expository text. I did not anticipate null results for the situation model level because previous studies have found that content knowledge has contributed to students' offline comprehension of text, such that readers with more content knowledge are more likely to integrate knowledge into their recall responses

(e.g., Tarchi, 2017). Several meta-analyses have also demonstrated positive effects of content and text structure knowledge on comprehension products (e.g., Dochy et al., 1999; Hebert et al., 2018; Pyle et al., 2017). It is worth mentioning that the effects of content knowledge and text structure knowledge were approaching significance in several of the models for situation model products. Thus, it would be valuable to replicate this work with larger sample sizes to determine whether content and text structure knowledge support middle school readers' situation model representations of expository text.

Although content knowledge did not significantly contribute to situation model recall, Model 4 revealed an interaction between linguistic knowledge and text structure knowledge and situation model recall products. Therefore, these knowledge types appear to influence how middle school readers' recall situation model expository text information. The interaction indicates that readers with more linguistic knowledge, but less text structure knowledge generated a greater proportion of situation model recall responses. In contrast, readers with more text structure knowledge, but less linguistic knowledge generated more situation model recall responses. Therefore, these findings suggest that readers benefit from both types of knowledge to integrate prior knowledge into their situation model recall responses and that both knowledge types are not simultaneously needed to do so after reading expository text. To my knowledge, no study has found that linguistic and text structure knowledge support readers' situation model recall of expository text, nevertheless, this finding supports theoretical and empirical research highlighting how linguistic and text structure knowledge supports middle school readers' performance on measures of expository comprehension products (e.g., Eason et al., 2012; Perfetti & Stafura, 2014).

The Influence of Knowledge on Situation Model Products After Expository Reading by Reader Skill

In this section I explain the extent to which the effects of knowledge on situation model products varied by reader skill (RQ2b). I hypothesized that readers with more reading skill would generate more situation model recall responses. However, as stated previously, neither knowledge nor reader skill contributed to situation model products. One potential explanation for this null effect is related to the coding scheme. Situation model products were coded in the current study when students integrated outside knowledge within their recall responses; however, I did not code these responses for accuracy or quality. There is evidence that less-skilled readers may be more likely to produce more inaccurate statements after reading expository text (Karlsson et al., 2018). As such, future research may want to examine whether reader skill contributes to the veracity of students' situation model responses in a recall task. Findings related to the accuracy of middle school readers' situation model products would enhance our understanding of the conditions in which content, text structure, and linguistic knowledge promote *high-quality* situation model recall. Doing so could help educators and researchers know which types of prior knowledge should be fostered to promote accurate recall responses.

The Influence of Knowledge on Situation Model Products After Expository Reading by Text Complexity

Finally, in this section, I describe whether the contributions of knowledge to situation model products varied by text complexity at the situation model level (RQ2b). I expected that text complexity would predict situation model products in the sense that readers would recall more situation model products after reading the complex text. However, as mentioned previously, there were no significant effects of knowledge, reader skill, or text complexity on

situation model products after expository reading. Thus, it appears that middle school readers were able to recall the same amount of situation model products regardless of the text being simple or complex. This finding could relate to the fact that middle school readers do not understand how to incorporate knowledge into their recall of text information. Future research might prompt students to complete an explanatory retrieval task to determine if recall prompts hinder readers from integrating knowledge into their responses or if middle school students need additional training to integrate their prior knowledge into a recall or retrieval task (McCarthy & Hinze, 2021).

Summary of the Influence of Knowledge, Reader Skill, and Text Complexity after Reading Expository Text

The findings revealed from the recall responses reiterate that prior knowledge contributes to middle school readers' comprehension products, albeit the effects of these contributions differ at each level of their mental representation. For instance, students with less linguistic knowledge were more likely to recall surface level or verbatim text information when reading complex text. Similarly, linguistic knowledge supported middle school readers' ability to integrate prior knowledge in their situation model recall responses. Although this association has not been found in previous research, theories of reading comprehension, such as the Reading Systems Framework have highlighted the importance of linguistic knowledge for supporting surface levels of comprehension processes and products (Perfetti & Stafura, 2014). Therefore, the current findings extend the field and reinforce the importance of linguistic knowledge for developing coherent mental representations of expository text, particularly for middle school readers.

Another primary finding from the recall responses is that text structure knowledge enhances middle school readers' recall of expository text. As supported by research conducted with elementary students, it appears that text structure knowledge also contributes to middle school readers' memory for expository text (Hebert et al., 2018; Pyle et al., 2017). Additionally, the current study extends this finding to indicate that text structure knowledge primarily contributes to recall of explicit text information at the textbase level. Thus, this finding has implications for understanding how and when text structure knowledge supports expository comprehension because it appears that text structure knowledge is a significant contributor to middle school readers' textbase recall produced after reading expository text.

It is significant to note that reader skill and text complexity did not have any significant effects on middle school readers' recall of simple or complex expository text. I anticipated that reader skill and text complexity would contribute to the likelihood that participants would recall situation model information. Specifically, I thought that more skilled readers would generate more situation model recall responses and that readers would generate more situation model recall responses after reading the complex text. Although surprising, the insignificant effects of reader skill and text complexity on middle school readers' recall responses was not wholly unwarranted because the current study did not distinguish between accurate and inaccurate recall responses. Moreover, middle school readers may not have experienced integrating their extant knowledge about a topic or text into their recall of a text. Future research is recommended to distinguish whether reader skill or text complexity may have contributed to the likelihood that middle school readers produce situation model responses in a recall task after reading expository text.

Overall Conclusion of Findings

Overall, the contributions of content, text structure, and linguistic knowledge differed across surface, textbase, and situation model level processes and products of expository comprehension. Specifically, content knowledge positively predicted surface level processing. In addition, content knowledge and text structure knowledge significantly contributed to textbase recall. Content knowledge negatively contributed to textbase recall, whereas text structure knowledge positively contributed to textbase recall. There were no contributions of knowledge for situation model processes.

Secondly, there were additional findings indicating that reader skill was negatively associated with surface level processing. This provides information about how less-skilled readers were more likely to generate surface level processes while reading expository text. I expected this result based on previous research indicating that less-skilled readers tend to rely on simpler processes such as repetition or paraphrasing (e.g., Laing & Kamhi, 2002; Yeari & Lavie, 2021). Reader skill did not contribute to participants' recall of expository text. However, as previously stated, future research might continue to examine the extent to which reader skill relates to middle school readers' quality and accuracy of comprehension processes and products of expository comprehension to extend the findings of this dissertation.

Finally, regarding text complexity, analyses indicated that when reading a simple text, middle school readers generated a greater proportion of surface level processes and textbase processes and when reading a complex text middle school readers were generated a greater proportion of situation model processes. This finding adds to growing evidence indicating that text complexity contributes to the types of comprehension processes that middle school readers generate while reading expository text (Dahl et al., 2021) and extends this finding further to

explain that the effect of text complexity remains significant for skilled *and* less-skilled middle school readers.

In summary, although these findings align with previous research indicating that the effects of comprehension predictors may depend on how comprehension is measured (Collins et al., 2017; Cutting & Scarborough, 2006), the current study expands upon this notion to suggest that the effects of comprehension predictors may also depend on *when* comprehension is measured (i.e., during/after reading).

Limitations

Although the findings from this study are supported by and extend previous research, it is also not without its limitations. First, the study's findings are limited due to the nature of the knowledge assessments and the quality of the data. The content knowledge measure and Identifying Structures measure indicated weak to poor internal reliability. Although the Identifying Structures measure indicated less than ideal reliability, it has been used in other published studies, and the findings in the current study align with previous research conducted with elementary readers (e.g., Pyle et al., 2017). The content knowledge measure, however, indicated quite weak reliability which is an important limitation of the study. The poor reliability may be related to the small number of items on the measure (10) and future research should improve upon the content knowledge measure. It appears that the questions on the content knowledge measure may have been too difficult for the sample because the mean score was 3.81 and therefore, revisions could be made to ensure that the items better reflect middle schoolers' knowledge about earthquakes.

The findings are also limited due to the sample used in the current study. Firstly, although there was intention to examine whether the effects of content, text structure, and linguistic knowledge varied by comprehension skill, the curriculum-based measures (CBM) provided by participants' schools included one reading measure and that precluded me from being able to confidently identify comprehension skill. Therefore, I used CBM scores as a proxy for comprehension skill, and thus, the conclusions of the current study are limited regarding comprehension skill level and instead focus on general reading skill.

Another limitation related to the current sample and reading skill is that most of the readers within the sample that were identified as having less-skill did have lower than average reading skill however, these readers had a good amount of reading skill relative to readers with extremely poor skill. That is, the largest group of less-skilled readers had z-scores between -1.5 and 0 and the skilled readers' z-scores were 0 and above. Less than half of the less-skilled readers had z-scores distributed between -3.00 and -1.50. The reader skill variable was continuous in the current study which meant that analyses considered participants' individual performance on reading measures. If reader skill had been categorical and did not consider score variability, the effects of reader skill would have likely been greater for situation model comprehension. However, using reader skill as a categorical variable puts all the skilled readers into one group and the less-skilled readers into another group and neglects performance variability within the data, therefore providing results that are not aligned with participants' reader skill in the sample. As such, future research might oversample less-skilled readers to get a better sense of how readers with extremely low reading skill might perform on think-aloud and recall tasks.

Another limitation related to data quality pertains to the nonnormality of the surface level data. There was not a normal distribution of surface level think-aloud and recall responses. That is, participants did not generate many surface level think-aloud and recall responses, especially in comparison to the number of textbase and situation model responses readers generated in the study. To my knowledge, previous research has not examined surface level text representations using think-aloud and recall tasks and as such, this current study is a novel attempt to examine this phenomenon. I did not log transform the surface level data because I did not want it to misrepresent or change what students did in the study and the statistical methods used in the study are robust against violations of normality (Quene & van den Bergh, 2004; 2008; Winter, 2013). Moreover, it is informative for future research to understand that even though students generate fewer surface level representations than textbase and situation model representations, content and linguistic knowledge may still be contributing to readers' surface level representations of expository text. Nevertheless, the study's findings pertaining to the surface level should be interpreted with caution and future work should investigate how surface level text representations can be effectively examined to better understand their theoretical and practical implications for expository text comprehension.

One other issue related to data quality that limits the findings of the current study is the lack of participant level variability for situation model recall responses. As indicated by the marginal and conditional R^2 of the mixed effects models, there was little variance among participant responses. Therefore, the findings for situation model comprehension products should be interpreted with caution. To remedy this limitation, I plan to conduct future analyses using alternative methods to determine if the findings hold using other types of analyses that better suit the data (i.e., nonparametric approaches).

Although the coding scheme used in the current study is a limitation, it is also a necessary first step in understanding the effects of knowledge, reader skill, and text complexity in middle school readers' expository comprehension. What limits the coding scheme is the fact that it did not examine whether participants' responses were of high-quality and accurate. Though other think-aloud and recall studies have examined the quality and accuracy of participants' responses (e.g., McCarthy et al., 2021, Kendeou & van den Broek, 2007), I did not do so because it was not a primary goal of the current study. However, the study results make it evident that a natural next step for this line of research is to test how the effects of this study would differ when students' responses are coded for quality and accuracy.

Additionally, there are limitations regarding the methodological approaches used in the study. Although recall tasks have been found to be moderately correlated with school-aged readers' reading comprehension performance on other assessments (e.g., Reed, 2012), the recall task used in the current study is another limitation. Recall tasks are a type of constructed response wherein the researcher is reliant upon whatever participants verbally express aloud. Therefore, the findings reflect what participants say out loud and they are not necessarily a comprehensive representation of participants' surface, textbase, and situation model mental representations of the text after reading is over. For instance, some participants may have a coherent situation model representation of a text, yet they did not verbalize that or reference their prior knowledge during their recall response. Furthermore, recall instructions can limit participants responses. Recall instructions tend to emphasize surface and textbase level representations rather than situation model representations (e.g., Hinze et al., 2013). Recall instructions ask readers to talk about everything that they remember after reading the given text; however, readers do not often elaborate these responses beyond information explicitly stated in

the text. As a result, readers frequently recall surface level and textbase level information from the text during free recall tasks. Other types of constructed responses instruct readers to elaborate beyond the text by having participants explain, argue about/for, or describe information after reading. These elaborative recall tasks may prompt readers to recall surface, textbase, *and* situation model information. Thus, solely relying on free recall responses in the current study is a limitation. Future research might use recall tasks that encourage elaboration, alongside other measures of comprehension products to provide a more comprehensive picture of middle school readers' surface, textbase, and situation model expository comprehension products.

A final limitation in the study concerns text complexity. Although my findings indicate that text complexity was associated with situation model processing, I cannot make claims about what features of text complexity drive this relationship. For example, previous studies have identified that one aspect of text complexity in particular, text cohesion could be related to this phenomenon (e.g., Dahl et al., 2021; McNamara et al., 1996). Texts with less cohesion are more implicit and have more gaps in the text which makes the text more complex and forces readers to generate more inferences. The current study identified the complexity of the texts used in the study using ARTE (Choi & Crossley, 2022), a tool that measures text readability. In addition to lower readability scores, ARTE also identified that the simple texts had more cohesion than the complex texts which supports previous research indicating that text cohesion is associated with situation model representations of expository text (e.g., Dahl et al., 2021; McNamara et al., 1996). However, other aspects of text features that are associated with complexity including syntactic complexity and connectives are not tested in the current study.

Implications for Theoretical Research

This study extends prior research by examining the contributions of content, text structure, and linguistic knowledge on skilled and less-skilled middle school readers' comprehension processes and products of expository text. These findings extend the research in the field of text comprehension by providing evidence that the contributions of knowledge to middle school readers' comprehension vary depending on the level of comprehension (i.e., surface, textbase, situation model) and when comprehension was measured (during/after reading). Importantly, there are several implications of these findings for theoretical research. Next, two important implications are highlighted for how the findings of the current study challenge theories of reading comprehension and suggest that future research is needed to understand how middle school readers develop coherent surface, textbase, and situation model text representations during and after reading.

The Importance of Knowledge on the Construction of Mental Representations of Text After Reading

Many theories of text comprehension posit that successful reading comprehension occurs when readers construct coherent mental representations of text (e.g., Kintsch, 1988; 1998; Zwaan et al., 1995). Kintsch's Construction-Integration Model expands upon this notion to suggest that readers' mental representations can be categorized into three levels: surface, textbase, and situation model (Kintsch, 1988). Surface and textbase level representations support comprehension of information explicitly stated in a text whereas situation model representations help readers generate inferences and understand implicitly stated information in a text. Kintsch and others theorize that prior knowledge is a chief explanation for how readers construct mental representations of text. Moreover, situation model text representations are particularly linked

with prior knowledge because readers integrate prior knowledge with text information to infer implicit events and/or relationships in a text (Kintsch, 1988; Perfetti & Stafura, 2014).

The results of the current study support the stance that prior knowledge contributes to readers' coherent mental representations of text. Content, text structure, and linguistic knowledge contributed to middle school readers' surface and textbase comprehension products in a recall task. Although all three types of prior knowledge contributed to middle school readers' recall responses, it is important to reemphasize that recall tasks tend to prompt surface and textbase representations, rather than situation model representations of text (e.g., Hinze et al., 2013). Therefore, future work utilizing other types of elaborative constructed responses, such as explanatory retrieval might find a stronger effect of prior knowledge on middle school readers' surface, textbase, and situation model comprehension products.

In contrast, content and linguistic knowledge influenced participant's comprehension processes during a think-aloud task, but only for surface level text representations. Thus, prior knowledge appears to be less influential for the construction of middle school readers' mental representations of expository text during reading. This finding deviates from assumptions in theoretical frameworks of text comprehension positioning prior knowledge as essential for situation model comprehension processing. Thus, the current study suggests that middle school readers may be less likely to rely on prior knowledge as they develop mental representations of expository text. One previous think-aloud study similarly found that prior knowledge did not contribute to middle school readers' comprehension processing of expository text (Wolfe & Goldman, 2005), and consequently, there is emerging evidence that middle school readers do not integrate knowledge with text information while reading is happening. However, theoretical frameworks of text comprehension are generally modeled after proficient adult readers

(McNamara & Magliano, 2009) and there may be substantive differences in how school-age and adult readers leverage prior knowledge to develop coherent text representations. Thus, more research evaluating differences between younger readers and adult readers is warranted to help disentangle why the findings from the current study digress from theories of text comprehension and why prior knowledge played a less prevalent role in comprehension processing.

The Importance of Text Complexity for Middle School Readers' Expository Comprehension During Reading

Although prior knowledge was not found to significantly contribute to surface, textbase, and situation model comprehension processing, text complexity did influence middle school readers' expository comprehension processing across all three types of text representations. Moreover, these effects were significant above and beyond the contributions of knowledge and reader skill for textbase and situation model think-aloud responses. This finding suggests that all participants generated different proportions of textbase and situation model processes due to the complexity of the text regardless of participants' reading skill or prior knowledge. This is a noteworthy finding because there is relatively little theoretical research that explicates text complexity as a central component of expository text comprehension processing. Many text comprehension theories focus on components of comprehension related to the individual reader, rather than the situational context, such as the task and the text (e.g., Kim, 2017; Kintsch, 1988; Perfetti & Stafura, 2014). However, some theoretical frameworks, such as the RAND heuristic model and the RESOLV framework, highlight the importance of extenuating contexts that explain comprehension performance beyond individual component skills or knowledge (Pearson et al., 2020; Rouet et al., 2017; Snow, 2002). Though theoretical approaches such as the RAND model and the RESOLV framework emphasize how aspects of the text can enhance or hinder

comprehension performance, text complexity is not explicitly named as a primary determinant of text comprehension. As indicated in the findings of the current study and other recent empirical work, the complexity of a given expository text has the potential to predict the types of comprehension processes middle school readers generate while reading (Dahl et al., 2021). Consequently, more theoretical work is needed to unravel how text complexity specifically plays a role in middle school readers' expository comprehension. Future theoretical models that delineate how text complexity affects expository text comprehension can pave the way for supporting new, effective methods of instruction and improving middle school readers' expository text comprehension outcomes.

Implications for Empirical Research

In addition to theoretical research, there are several opportunities to extend the research findings of the current study to better understand how knowledge supports middle school readers' comprehension processes and products of expository text. In the next section I highlight three such opportunities for future empirical research: further exploration of surface level comprehension processes and products, replication with larger, more diverse samples, and examining response quality and accuracy.

Surface Level Comprehension Processes and Products

The current study supports that content knowledge, reader skill, and text complexity contribute to middle school readers' surface level processing of expository text. In fact, the fixed and random effects in the best fitting model for surface level processing explained 84% of the variance in middle school readers' surface level think-aloud responses. Despite this significant finding, there is a dearth of studies that examine surface level comprehension processes and

products of expository text (McNamara & Magliano, 2009) and future research could investigate other components of reading comprehension, such as decoding skill, to further explain how surface level processes and products support middle school readers' expository comprehension.

Relatedly, future studies might measure middle school readers' surface level processes and determine whether these processes predict surface, textbase, or situation model products of expository text. Such work would support the field's understanding of the role that surface level processing plays in helping middle school readers to develop coherent representations of expository text.

Replication with Larger, More Diverse Samples

This study could be replicated with a larger and more diverse sample. An analysis with 42 participants revealed significant effects for knowledge, reader skill, and text complexity on middle school readers' comprehension processes and products of expository text; however, there were several instances where content and text structure knowledge approached significance in the current analyses and these relationships could be explored further in future research. Replicating this study with a larger sample size might disentangle whether the effects of content and text structure knowledge would be significant in different contexts. Such studies would further the field's understanding of the role of knowledge in skilled and less-skilled middle school readers' comprehension of simple and complex expository text.

Additionally, this study could be replicated with a more diverse sample. Too often educational psychology research is restricted by an overinclusion of individuals from western, educated, industrialized, rich, and democratic backgrounds in empirical research (Kumar et al., 2020). Unfortunately, the current study continues this trend because most families who

consented to participate in the current study were from western, industrialized, and Caucasian backgrounds. Future research could purposefully recruit participants from diverse communities to ensure greater diversity and representation in text comprehension research.

Response Quality and Accuracy

Finally, prior think-aloud research has found that the quality and accuracy of think-aloud and recall responses can affect readers' mental representation of the text (e.g., Kendeou & van den Broek, 2007). Future research could investigate the extent to which content, text structure, and linguistic knowledge contribute to the quality and accuracy of middle school readers' comprehension processes and products of expository text. The coding scheme in the current study did not distinguish textbase or situation model responses based on their quality or accuracy. Other coding schemes have coded constructed responses for their quality and/or accuracy to determine whether comprehension process quality affects comprehension performance (e.g., Carlson et al., 2014; McCarthy et al., 2021). Coding participants' responses based on their quality or veracity may have produced results more in line with the CI model wherein knowledge might positively contribute to more accurate or more advanced situation model responses (Kintsch, 1988; 1998). Thus, such future work would extend the findings of this dissertation to explain whether content, text structure, and linguistic knowledge are associated with high-quality and accurate comprehension processes and products of expository text.

Conclusions

This study provides support for the notion that different types of knowledge contribute to the generation of expository comprehension processes and products for middle school readers. More specifically, content knowledge and linguistic knowledge may be particularly important for

surface level expository comprehension processing. Also, content and text structure knowledge appear to be predictive of recall of expository text. While none of the knowledge types contributed to the generation of comprehension processes at the textbase and situation model levels, text complexity contributed to students' generation of surface, textbase, and situation model comprehension processes. Therefore, the findings reported here suggest that prior knowledge appears to be important for middle school readers' development of their mental representations of expository text after reading has ended whereas text complexity meaningfully contributes to middle school readers' processing of expository text as reading is happening. In conclusion, knowledge types, reader skill, and text complexity matter for middle school readers' expository comprehension; however, these contributions differ depending on the level of representation (surface, textbase, situation model) and when these contributions are applied (during, after reading). These findings inform theoretical and empirical research by identifying how specific reader factors like prior knowledge contribute to expository comprehension after reading and how specific text factors like text complexity contribute to processing of expository text during reading. These specifications add to the field in the service of understanding the optimal conditions for enhancing middle school readers' comprehension of expository text (Pearson et al., 2020; Snow, 2002).

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APPENDICES
Appendix A

Seismic Waves

Every day, worldwide, there are about 8,000 earthquakes. The sudden release of energy causes seismic waves – and it's the seismic waves that make the earth shake. In order to figure out where an earthquake was centered, you need to know where that earthquake began. We know earthquakes begin in rock below the surface. Most earthquakes start in the Lithosphere. The focus is the point beneath Earth's surface where rock that is under stress breaks, triggering an earthquake. The point on the surface directly above the focus is called the epicenter.

There are three categories of seismic waves: P-waves, S-waves, Surface waves. An earthquake sends out two types of waves from its focus: P waves and S waves. When these waves reach Earth's surface at the epicenter, surface waves develop. The instrument that measures seismic wave vibrations is called a seismograph.

Earthquakes are recorded by instruments called seismographs. The recording they make is called a seismogram. The seismograph has a base that sets firmly in the ground, and a heavy weight that hangs free. When an earthquake causes the ground to shake, the base of the seismograph shakes too, but the hanging weight does not. Instead the spring or string that it is hanging from absorbs all the movement. The difference in position between the shaking part of the seismograph and the motionless part is what is recorded.

Surface Pressure

Earthquakes can happen anywhere. They happen most often along plate boundaries or established fault lines. The Earth has three primary earthquake zones: the Circum-Pacific Seismic Belt, the Alpide, the Mid-Atlantic Ridge. An earthquake is the shaking and trembling that results from the movement of rock beneath earth's surface. When Earth's plates move forces are created that squeeze or pull the rock in the crust. Because stress is a force, it adds energy to the rock. The energy is stored in the rock until the rock either breaks or changes shape.

There are three types of stress that occur in the crust. Shearing is stress that pushes a mass of rock in two opposite directions. Tension is stress that pulls on the crust, stretching rock so that it becomes thinner in the middle. Compression is stress that squeezes rock until it folds or breaks. One plate pushing against another can compress rock like a giant trash compactor.

Many earthquakes occur along the edges of oceanic and continental plates. These plates are constantly bumping into each other, pulling away from each other or trying to slide past one another. When two plates run into each other or try to slide past each other, an earthquake occurs.

That's because when the plates rub up against each other, they don't just slide smoothly, they stick a little. They keep pushing against each other but they can't move – they're stuck. After a while, pressure builds up and the rocks break.

Preventing Damage from Earthquakes

Whether we can predict when disasters will happen or not, there are ways we can prepare for them in areas where they are more likely to occur so that we can possiblyreduce the damage to

society. Scientists are developing technologies that will help us predict catastrophic natural disasters and mitigate (reduce) their effects.

In areas where earthquakes are likely, buildings are now designed with features that will help them withstand the earthquake. Skyscrapers and other large structures built on soft ground must be anchored to bedrock, even if it lies hundreds of meters below the ground surface. They are also built to sway with an earthquake wave. The correct building materials must be used. Houses should bend and sway. Wood and steel are better than brick, stone, and adobe, which are brittle and will break. Large buildings can be placed on rollers so that they move with the ground. In a multi-story building, the first story must be well supported. Old buildings may be retrofitted to reinforce their structures.

Why aren't all structures in zones at risk for natural disasters constructed for maximum safety or why don't all homes have storm shelters? Cost, of course. More sturdy structures are much more expensive to build. Storm shelters require land space and money to dig and build another structure. So communities must weigh how great the hazard is, what the cost is, and make an informed decision.

Predicting Earthquakes

Scientists are a long way from being able to predict earthquakes. A good prediction must be accurate as to where an earthquake will occur, when it will occur, and at what magnitude it will be so that people can evacuate. An unnecessary evacuation is expensive and causes people not to believe authorities the next time an evacuation is ordered.

Where an earthquake will occur is the easiest feature to predict. Scientists know that earthquakes take place at plate boundaries and tend to happen where they've occurred before. Earthquake-prone communities should always be prepared for an earthquake. These communities can implement building codes to make structures earthquake safe.

When an earthquake will occur is much more difficult to predict. Since stress on a fault builds up at the same rate over time, earthquakes should occur at regular intervals. But so far scientists cannot predict when quakes will occur even to within a few years.

Signs sometimes come before a large earthquake. Small quakes, called foreshocks, sometimes occur a few seconds to a few weeks before a major quake. However, many earthquakes do not have foreshocks and small earthquakes are not necessarily followed by a large earthquake. Often, the rocks around a fault will dilate as microfractures form. Ground tilting, caused by the buildup of stress in the rocks, may precede a large earthquake, but not always. Water levels in wells fluctuate as water moves into or out of fractures before an earthquake. This is also an uncertain predictor of large earthquakes. The relative arrival times of P-waves and S-waves also decreases just before an earthquake occurs.

Appendix B

Content Knowledge Measure

1. The point beneath Earth's surface where that triggers an earthquake is called the
    a. Epicenter
    b. Fault
    c. Focus
    d. Magnitude

2. The instrument used to measure and record the size and duration of an earthquake is called a(n)
    a. Magnitude scale
    b. Mercalli Scale
    c. Tele Scale
    d. Richter scale

3. An earthquake is most likely to happen in

    a. Florida
    b. North Dakota
    c. California
    d. Antarctica

4. Which description below best describes a fault?

    a. A break in the rocks that make up the Earth's crust
    b. Where two plates come together
    c. Where seismic activity is recorded
    d. A bulge in the Earth's surface

5. The epicenter of an earthquake is

    a. Where two plates collide
    b. The measurement of a fault line
    c. The closest location to the center of an earthquake
    d. What the

6. To stay safe during an earthquake you should
    a. Evacuate
    b. Stand in a doorway
    c. Find higher ground

d. Go to the basement

7. Why do earthquakes cause damaging fires?

a. Magma from the Earth's core can escape through faults
b. Lightning commonly strikes during earthquakes
c. Seismic waves can break gas, water, and electrical lines
d. Tsunamis after an earthquake can cause fires

8. New ocean crust is formed at

a. Divergent boundaries
b. Transform fault boundaries
c. Convergent boundaries
d. Continental volcanic arcs

9. What layers of Earth make up the lithosphere?

a. The crust and lower mantle
b. The continental crust and oceanic crust
c. The upper and lower mantle
d. The crust and upper mantle

10. The San Francisco earthquake of 1906 occurred along which fault?

a. The San Andreas fault
b. The Pacific fault
c. The California fault
d. The San Mateo fault

Appendix C

Identifying Structures

Practice

Eyeglasses have evolved over time. The first eyeglasses were developed in Italy in 1286. They were made by connecting the handles of two magnifying glasses. In 1784, Benjamin Franklin invented bifocals, which allowed people to see objects both far away and close up. In 1888, the first contact lenses were invented. These contact lenses were made of glass. Contact lenses made of soft silicone became popular in the 1980s.

A. Simple Description

B. Cause/Effect

C. Sequence

D. Problem/Solution

E. Compare/Contrast

There are many diseases that can make people sick. Some of them can even be deadly. Our bodies can't always fight them off on their own. Vaccines can protect people from getting deadly diseases. Vaccines help a person's body make something called "antibodies." Antibodies help people develop immunity to a disease. Vaccines are often given to very young children to prevent them from getting diseases early.

A. Simple Description

B. Cause/Effect

C. Sequence

D. Problem/Solution

E. Compare/Contrast

American colonists had a problem. Even though they left their countries to go to a new land, England still governed them. Americans had to pay taxes to England and they could not make their own rules. On July 4th, 1776 the colonists signed the Declaration of Independence and went to war with England. This helped them win the freedom to make their own laws.

A. Simple Description

B. Cause/Effect

C. Sequence

D. Problem/Solution

E. Compare/Contrast

There are two main types of waves: electromagnetic waves and mechanical waves. Microwaves are an example of electromagnetic waves. The waves of the ocean are mechanical waves. They both transfer energy. Electromagnetic waves travel through electrical and magnetic fields. Mechanical waves travel through objects. Electromagnetic waves can travel through a vacuum, like outer space; mechanical waves cannot.

A. Simple Description

B. Cause/Effect

C. Sequence

D. Problem/Solution

E. Compare/Contrast

Banks are a safe place to deposit money. The money that customers deposit can be borrowed by other customers. This is called a loan. Banks charge a percentage, or interest, on a loan. This is one way banks make money. Customers can also store valuables, such as jewelry and important papers, inside a special part of the bank called the vault.

A. Simple Description

B. Cause/Effect

C. Sequence

D. Problem/Solution

E. Compare/Contrast

Extreme temperatures can cause the breakdown of rocks. Hot and cold temperatures cause rocks to expand and contract. This weakens the rocks and eventually they break down. Also, when water seeps into a cracked rock and freezes, it expands. This widens the crack and can even break the rock into pieces.

A. Simple Description

B. Cause/Effect

C. Sequence

D. Problem/Solution

E. Compare/Contrast

Niagara Falls is a natural wonder. It is the largest waterfall by volume in North America. More than 700,000 gallons of water f low over the falls every second during peak f low. The water drops between 70 and 185 feet. The water that flows over Niagara Falls comes from the four Upper Great Lakes: Michigan, Huron, Superior, and Erie. The water flows into the fifth Great Lake, Ontario.

A. Simple Description

B. Cause/Effect

C. Sequence

D. Problem/Solution

E. Compare/Contrast

Making a map is a complex process. First, the mapmaker draws the outline of the land. Then, they add important details like roads, rivers, or mountains. Next, the mapmaker adds a compass rose depicting the cardinal directions. Finally, they add a map title and create a map key to help people understand the map.

A. Simple Description

B. Cause/Effect

C. Sequence

D. Problem/Solution

E. Compare/Contrast

When someone is sick and sneezes, millions of droplets of water and mucus are released into the air. The droplets may contain harmful microorganisms. They can land on surfaces that you touch. To avoid getting sick, you should wash your hands frequently. You can also try to avoid being close to someone who is sick.

A. Simple Description

B. Cause/Effect

C. Sequence

D. Problem/Solution

E. Compare/Contrast

Arizona’s Grand Canyon is millions of years old. Primarily, two factors created this colorful canyon: the movement of tectonic plates and erosion. Shifting tectonic plates caused the earth’s crust to rise and tilt. Water from the Colorado River carried away layers of earth. This water erosion cut deeper and deeper, revealing many layers of canyon rock.

A. Simple Description

B. Cause/Effect

C. Sequence

D. Problem/Solution

E. Compare/Contrast

To power a light bulb with a battery, you need a 9-volt battery, a light bulb, a socket, and two wires. First, screw the light bulb into the socket. Next, wrap one end of each wire around one

connection on the socket. Then, touch one wire to the positive terminal on the battery. Finally, touch the other wire to the negative terminal. The light bulb will light up.

A. Simple Description

B. Cause/Effect

C. Sequence

D. Problem/Solution

E. Compare/Contrast

Human vision relies on light and the brain. First, light reflects off an object. It enters the cornea, a protective outer layer. Next, the iris and pupil control how much light passes into the inner eye. Light continues through the lens before it reaches the retina, where electro-chemical signals are created. These signals travel along the optic nerve to the brain. Finally, the brain interprets what was seen.

A. Simple Description

B. Cause/Effect

C. Sequence

D. Problem/Solution

E. Compare/Contrast

Pioneers in the Great Plains built log cabins or sod houses. Both were small and simple. Pioneers who owned land with trees built log cabins. They cut the logs from the trees on their land. Pioneers who lived on prairie land built sod houses. Sod houses were made from grass and dirt. Sod houses were harder to keep clean than log cabins.

A. Simple Description

B. Cause/Effect

C. Sequence

D. Problem/Solution

E. Compare/Contrast

The Rockies and Cascades are mountain ranges. They both stretch across the border between the United States and Canada. The Rockies extend 3,000 miles. The Cascades do not cover as much distance as the Rockies. They span 700 miles. The peaks of the Rocky Mountains were formed more than 50 million years ago. Some of the peaks in the Cascade Range were formed recently by active volcanoes.

A. Simple Description

B. Cause/Effect

C. Sequence

D. Problem/Solution

E. Compare/Contrast

Desert climates can be very dry and hot. Deserts receive less than ten inches of rain a year. The surface of a desert is covered with rocks and sand. An important characteristic of deserts is that vegetation is sparse. Plants and animals that live in the desert have adapted to survival in dry and hot conditions.

A. Simple Description

B. Cause/Effect

C. Sequence

D. Problem/Solution

E. Compare/Contrast

Bartering is a system in which people trade goods and services. Problems can occur with this system. For example, bartering does not work when one person comes empty-handed. Also, it will not work when one person brings something the other person does not desire. Finally, a person who believes their item has greater value will not want to trade. When bartering does not work, people use money.

A. Simple Description

B. Cause/Effect

C. Sequence

D. Problem/Solution

E. Compare/Contrast

Appendix D

Linguistic Knowledge Measure

The Green Van

He was called Mr Savage. He did odd jobs on the farm. My brothers and I didn't like him. He was unfriendly. He never spoke to us, so we decided to hate him. One afternoon w_____ found his va____ parked by th____ sheds. He wa_____ nowhere to b____ seen. We gues_____ he'd b____ up at th____ house talking t_____ our dad. S____ we threw so_____ mud at th_____ van. At fir____ it was ju____ a bit, a_____ the wheels. So_____ we got carr_____ away and just hur_____ mud at th____ body of th____ van – on the sides, across the front, even onto the roof. Not a word passed between us but an unspoken pact developed. We were going to cover the whole thing.

The Ants and the Grasshopper

It was autumn time. The leaves were frosty and the ground was hard as an axe blade. The ants we_____ busy moving gra_____ of wheat fr_____ their store in_____ the anthill. A grassh_____ happened to ho_____ by. It wa_____ cold and alm_____ starving for i____ had not ha_____a nibble i_____ weeks. It stop_____ and asked th_____ ants if th_____ would share so_____ food. "What we_____ you doing th_____ summer?" ask_____ the ants wh____ had been bu_____ all summer long, storing food for winter. "Why, I was singing all day and night", replied the grasshopper. "Well then," said the ants, "as you kept yourself so busy all summer with singing, you can keep yourself busy all winter by dancing." Then they shut their food store and disappeared into their nest.

How to Hide a Pirate's Treasure

If I was asked to bury treasure, I would identify a place where no one could come across it by accident. This would me_____ finding a pla_____ where peo_____ did not oft_____ go so th_____ no one cou_____ stumble across th_____ loot. The so_____ of place th____ I would lo____ for would b_____ uninhabited, and al_____ a hostile enviro_____. Deserts, moun_____ ranges, icy was_____ and beneath th_____ sea would al____ be on m_____ list because th_____ are inaccessible t_____ most people. Desert islands would also be ideal because there would be little chance of anyone discovering the treasure.

The Stormy Rescue

It must have been about two o'clock that night when Aunt Millie awoke. The rain had finally stopped but it was still dark outside. She had le_____ the window do_____ just in ca_____ the fox ca_____ back. That wa____ what pulled he_____ up out o_____ her sleep – tw_____ short, sharp bar_____. She tugged o_____ her thin cot_____ robe and ma_____ her way downs_____. She flicked o_____ the porch lig_____ and jumped ou_____ through the sid_____ windows. To he_____ amazement, there wa_____ Tom. As she sa_____ later, he just looked like a drowned turkey standing there on the porch, dripping with rain and his face turned down at the edges.

Ali Baba

Ali Baba was a woodcutter, struggling to make a living. He and his wife and children were very poor. Ali Baba was in the forest and he saw a troop of robbers. They were rid_____ past carrying ba____ of silver an____ gold. Being ve_____ frightened he hi_____ behind

some roc_____ on the mounta_____. He saw th____ robbers ride rou_____ the mountain towa_____ a sheer cli_____ face. Then th_____ leader of th_____ robbers, a ta_____ clever man, pau_____ the company an_____shouted at th____ mountainside: Open Sesame!' T_____ Ali Baba's astoni_____ the cliff swu_____ open and the entire troop rode into the huge cavern. The mountain shut behind them. Ali Baba was too scared to move. He stayed hidden behind the rocks. Finally he saw the troops reappear from the mountain. The robbers scattered and rode off through the forest. Ali Baba waited, then he approached the cliff face. 'Open Sesame!' he cried, and stood amazed as the mountainside opened.