Relations between Component Reading Skills, Inferences, and Comprehension Performance in Community College Readers

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Abstract

This study was conducted to understand the reading challenges of underprepared college students. A sample of the participants were enrolled in supplemental literacy programs because they were deemed not ready for reading and writing in college. Community college participants completed a series of measures that assessed foundational skills for reading, bridging and elaborative inferences processes, a comprehension measure that reflected close comprehension of a text, and a scenario-based assessment that involved problem solving with texts. Results suggest that bridging inferences were predictive of performance on measures of close comprehension, whereas elaborative inferences were predictive of performance on the scenario-based assessment. In terms of enrollment in supplemental literacy programs, variability in foundational skills and inferencing did not differ as a function of enrollment in these programs. However, underprepared students in this sample had greater difficulty engaging in complex literacy tasks that involved the application of information when compared to better-prepared students.

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Introduction

There is a concerning number of first-year students entering college in the United States who are underprepared to meet reading expectations (ACT, 2006; Baer, Cook, & Baldi, 2006; NAEP, 2015). Given the important role of reading across academic disciplines (Shanahan & Shanahan, 2008, 2012; Goldman et al., 2016), these students often struggle to successfully complete coursework and, consequently, have poor graduation rates (Bailey, Jeong, & Cho, 2010). Importantly, this problem may be more pronounced in open access institutions where a large percentage of students may be required to take supplemental courses intended to remediate literacy deficiencies (Bailey, 2009). With so many readers struggling to meet the literacy demands in their courses, understanding the exact nature of the issues faced by post-secondary students is of critical importance.

Why is it that so many students are underprepared as academic readers? One possibility is that struggling postsecondary readers have deficiencies in the basic component skills necessary to comprehend a text. It is well documented that reading is supported by lower-level skills involved in processing at the word level (e.g., decoding, word recognition) as well as the sentence level (e.g., syntactic assignment; McNamara & Magliano, 2009; Perfetti & Stafurra, 2014). While students are often assumed to be proficient in foundational skills such as decoding and word recognition after 5th grade, this is often not the case (e.g., Wang, Sabatini, O'Reilly, & Weeks, 2019). Another possibility is that they struggle with the ability to generate the inferences that are necessary for comprehension. It has been shown that a subset of children learning to read

become relatively proficient in the foundational skills that support reading, but still struggle with inference processes (e.g., Cain & Oakhill, 1999; McMaster et al., 2012).

Yet another possible reason postsecondary students struggle may be related to the nature of the reading activities they face in an academic setting. Reading in an academic context involves reading to achieve a specific purpose, goal, or task and may involve multiple-document integration (Britt, Rouet, & Durik, 2018; OECD, 2018; Snow, 2002). For example, college students may be asked to read to prepare for a test, write an argumentative paper, or lead a class discussion (McCrudden & Schraw, 2007). Student's ability to engage with text to solve the complex problems they encounter is of great importance for academic and career success (Britt et al., 2018). But, as will be discussed below, not all reading tasks require the same kinds of processing. As such, understanding why some students are not ready to read for college requires an exploration of tasks that vary in the extent that they require close comprehension or using the texts to solve complex problems.

In the current study, we aimed to investigate the reading challenges faced by postsecondary students and whether or not these challenges are specific to different types of literacy tasks. We were specifically interested in understanding the relationship between foundational skills, inference generation, and performance on literacy tasks that vary in the extent they require reasoning beyond the text to solve complex problems. This study involved a diverse sample of U.S. college students who varied in reading proficiency (i.e., some students in the sample were designated as not being ready for college literacy expectations based on institutional placement exams). As such, we were additionally interested in the extent to which enrollment in a supplemental literacy program accounted for variance in inference processes and performance on different literacy tasks.

Foundational Skills and Inferences

In the present study, we used the term *foundational component skills* to describe the lower-level skills and processes that can be separated and examined independently from higher-level reading skills (e.g., inference generation) and comprehension more generally (Perfetti & Adlof, 2012; Sabatini, Bruce, & Steinberg, 2013; Sabatini et al., 2014). These skills support basic comprehension and range from word-level processes involved in recognizing and accessing the meaning of words (e.g., decoding, word recognition; Sabatini, Sawaki, Shore, Hollis, & Scarborough, 2010) to sentence-level processes involved in accurately representing words in their context (e.g., syntactic assignment; Traxler & Gernsbacher, 2011). In the context of a postsecondary population, foundational component skills are predominantly related to one's ability to generate high-quality, lexical representations (automatized word recognition, morphological knowledge, and a broad vocabulary) and to engage syntactic processing skills to facilitate comprehension processes (Perfetti, Wlotko, & Hart, 2005). In other words, these skills allow a reader to process words and accurately represent sentences.

In addition to understanding words and sentences, readers must also understand the relations between sentences and how information in the text relates to existing knowledge (Cain & Oakhill, 2007; Graesser, Singer, & Trabasso, 1994; McNamara & Magliano, 2009). At least two types of inference processes are commonly considered to be essential by major theories of comprehension: bridging inferences, which involve establishing how sentences relate to one's mental model for the prior discourse, and elaborative inferences, which involve bringing in relevant background knowledge and relating it to discourse content (McNamara & Magliano, 2009). Establishing intra-textual connections is critical for constructing a coherent model (Graesser, McNamara, & Louwerse, 2003; McNamara, Kintsch, Songer, & Kintsch, 1996). Moreover, the extent to which readers make strong connections among discourse constituents

and relate them to prior knowledge is strongly related to comprehension outcomes (e.g., Magliano, Trabasso, & Graesser, 1994; McNamara, 2007; Nokes & Dole, 2004). It is important to acknowledge that in the context of processing narrative texts, some have construed elaborative inferences as not necessary for comprehension (Singer, 1988). In the context of learning from expository texts, elaboration more broadly refers to using prior knowledge constructively to derive meaning (McNamara, 2004). Moreover, the distinction between bridging and elaboration may not be discrete when it comes to establishing coherence. Specifically, there are times when establishing causal connections between discourse constituents requires using general knowledge to infer missing events (e.g., Clark, 1977; Long, Golding, & Graesser, 1992), and as such some elaborative (i.e., knowledge-based) inferences may be important for establishing coherence (Graesser, Singer, & Trabasso, 1994; Graesser, McNamara, Louwerse, & Cai, 2004). However, elaboration in the context of learning from expository texts is not restricted to establishing coherence (McNamara, 2004).

Struggling readers may have issues with word, sentence, or inference processes (Adlof, Catts, & Little, 2006; Cain & Oakhill, 2007; Perfetti & Hart, 2002; Perfetti & Stafura, 2014), although most research on detecting the challenges with these aspects of reading focus on younger readers (e.g., Adlof, et al., 2006; Cain Oakhill, & Lemmon, 2004; Cain & Oakhill, 2014; Currie & Cain, 2015). Perfetti has conceptualized these aspects of reading as “pressure points” such that challenges in these components can have catastrophic consequences on the fidelity of other processes (Perfetti & Hart, 2002; Perfetti & Stafura, 2014).

Deficits in decoding have been shown to limit comprehension for middle and high-school students (Wang et al., 2019). Thus, deficiencies in foundational component skills may constrain higher-level reading processes (Sabatini et al., 2014; Wang et al., 2019). Moreover, important inference processes in college readers have been shown to rely on success at lower-level

processing and appear to partially mediate the relation between component reading skills and comprehension (Kopatich, Magliano, Millis, Parker, & Ray, 2019). This demonstrates that deficits in component reading skills may be impactful at multiple levels. In the present study, we assess the extent to which different foundational component skills relate to inference processes and comprehension generally in a U.S. college population. Additionally, we assess the extent to which enrollment in a supplemental program was correlated with challenges associated with foundational skills and inference generation.

Reading in an Academic Context

Reading is a goal directed activity, and those goals have a profound impact on reader strategies and behaviors (e.g., Britt et al., 2018; McCrudden & Schraw, 2007; OECD, 2018; Snow, 2002). When engaging with a text, readers derive goals and subgoals based on the reading context, their abilities, and the activity they are asked (or choose) to engage in (Rouet, Britt, & Durik, 2017). With goals in place, reading becomes a problem-solving activity (Britt et al., 2018; Rouet et al., 2017). Readers use their goals to make decisions about what to read (i.e., resources) and how closely to read it, monitoring their progress toward the completion of their goal (e.g., Cerdán, Vidal-Abarca, Martínez, Gilabert, & Gil, 2009; Rouet et al., 2017; Vidal-Abarca, Mañá, & Gil, 2010).

In an academic setting, students engage with text to achieve a variety of goals. For example, students may be asked to read to prepare for class, write an essay, or complete a class project (McCrudden & Schraw, 2007). No matter the case, reading is a goal-directed, purposeful activity. Importantly, as the nature of the reading activities varies, the strategies a student employs may vary along with the relative importance of different comprehension processes (McCrudden, Magliano, & Schraw, 2010).

The skills and cognitive processes involved in academic reading often extend beyond

those involved in the comprehension of a single passage of text (Britt & Gabrys, 2000; Goldman, 2004; Leu, Kinzer, Coiro, & Cammack, 2004; Rouet, 2006; Sabatini et al., 2014). Consider first the context and processes involved in reading a single text. With respect to processes, reading a single passage involves engaging lower and higher-level reading processes to construct a mental model for the text (McNamara & Magliano, 2009). This mental model is likely to reflect the author's intended purpose for writing the text, given readers often read to understand (i.e., close comprehension). Although readers are representing and connecting content, these processes are happening within a single document. In terms of the reading context, a single passage is typically presented in isolation and is written by a single author or collection of authors with the same goal. The reader likely assumes the passage is directly related to the task at hand, which is often provided by an instructor, or—in a research study—by an experimenter. Moreover, the need to evaluate source information and credibility may be less important, assuming a credible source is provided.

Reading tasks may require one to do more than comprehend the text(s). While a reader must certainly engage lower and higher-level reading processes to construct mental models for the text, they must do so selectively, in accordance with their overarching reading goal (Graesser et al., 1994). In the context of reading multiple texts to solve a problem, readers use their goals to engage in relevancy processing, building mental models for parts of the texts that help them reach their reading goal (McCrudden et al., 2010; McCrudden & Schraw, 2007). Thus, selecting what to read and how to read it is an additional task that is not typically afforded when reading a single text. In addition to deciding what and how to read, the reader must also evaluate source information and integrate information both within and across documents (Rouet & Britt, 2011; McCrudden, Stenseth, Bråten, and Strømsø, 2016). All this must be done while the reader maintains and monitors goal progress.

One important thing to consider is the extent to which the relative importance of various reading skills and processes varies depending on the nature of the literacy activity. Given that reading in an academic context can require close comprehension and the need to reason with and beyond the texts, both foundational component skills and inferencing are likely to support both literacy activities to some extent. The question, then, may not be if these individual skills relate, but how and to what extent they relate. In the present study, we seek to explore the relative extent to which foundational skills and inferencing support comprehension in a task that reflects basic, close comprehension of a single text and a task that reflects problem solving with text that extends beyond close comprehension.

Supplemental Literacy Programs

A large percentage of U.S. students arrive at college underprepared to meet the demands required in their courses (e.g., Bailey, 2009; Holschuh & Paulson, 2013; NAEP, 2015). It has been estimated that approximately 75% of community college students are "non-proficient" when it comes to engaging with college reading tasks (American Institute for Research, 2006). With such a large population of struggling readers, institutions devote large amounts of money to supplemental literacy programs (sometimes referred to as developmental programs or more recently, college success programs) designed to foster essential reading skills (e.g., Crisp & Delgado, 2013).

Although supplemental literacy programs appear useful in theory, research has called into question their efficacy (Bailey, 2009; Hodara & Jaggars, 2014; Jaggars & Stacey, 2014). These programs often take a "reading and study strategies" approach that involves introducing students to a variety of strategies intended to make them more active readers. However, the strategies that are emphasized are often generic and not aligned with the reading and writing literacy expectations of early credit bearing courses (Armstrong, Stahl, & Kantner, 2016; Stahl &

Armstrong, 2018), which may be one reason why these programs do not demonstrate the intended outcomes. However, much of this research is conducted with a policy lens, rather than one that focuses on how aspects of college level reading may be indicative of college success. More research is needed to understand the strengths and challenges of underprepared college readers, which may help refine approaches that better meet the needs of underprepared students. Understanding where and why students enrolled in mandatory supplementary reading courses struggle may allow institutions to improve supplemental reading courses and improve student outcomes.

Overview of the Current Study

At the outset of this article, we discussed the alarming number of students who are not ready to read for college (e.g., NAEP, 2015). We contend that understanding this problem requires research on the relationships between the foundational skills (word and sentence), inferences (bridging and elaborative), and tasks that reflect different literacy situations that may arise in college. To this end, this study involved a sample of U.S. community college students. Community colleges are open access, which means that students can enroll regardless of performance on placement test scores. Typically, the institutions have supplemental programs for students who are not deemed ready to meet the literacy demands (reading and writing) of the credit bearing courses. As will be described below, our sample had a substantial number of students enrolled in a supplemental literacy program, and as such were not deemed ready for college with respect to literacy skills. We administered assessments that provided an indication of proficiencies in foundational components of reading, and in particular the word and sentence components. Additionally, we administered an assessment of inferencing as well as comprehension assessments that differed in the extent to which they assessed close

comprehension of a single text or complex problem solving involving multiple texts. The nature of the sample and the assessments enabled the exploration of the following research questions:

1.) How do foundational component skills influence inference processes in postsecondary students?
2.) How do foundational component skills and inferencing relate to performance on tasks that vary in the extent that they require solving complex problems?
3.) To what extent does enrollment in a supplemental literacy program account for variance in inferencing and performance on these two types of comprehension assessments?

Method

Participants

A total of 264 students from a community college district in the South-Central United States participated in at least one of the two study sessions. Participants were compensated with gift cards from "Giftcertificates.com" for their participation in the study ($25 for completing session 1 and an additional $35 for completing session 2). Of the 264 students, 185 were enrolled in supplemental literacy courses[1]. See Table 1 for demographics.

Measures

Study Aid and Reading Assessment (SARA; Sabatini, Bruce, Steinberg, & Weeks, 2015; Sabatini et al., 2019). SARA is a web-based measure comprised of a series of subtests intended to measure foundational component reading skills including decoding/word recognition, vocabulary, morphology, and sentence processing. Each of the subscales has been shown to have good reliability (all Cronbach's α's > .80) and there is evidence of concurrent validity given its

[1] Data was collected as part of an ongoing study investigating factors that contribute to successful academic literacy. Access to the institutional data used to place students in supplemental literacy programs (i.e., mandatory Accuplacer tests scores) was not granted.

ability in predicting state test scores (O'Reilly et al., 2012; Sabatini et al., 2013; Sabatini et al., 2015).

Decoding/word recognition. Participants determined whether a stimulus was a word, non-word, or pseudo-homophone (52 items; α = .89).

Vocabulary. Participants selected the appropriate synonym or topically related words to match a target word (35 items; α = .86).

Morphology. Participants read sentences and filled in the blank with the morphologically correct word (37 items; α = .91).

Sentence Processing. Participants read sentences and filled in the blank with the appropriate word (24 items; α = .84).

Reading Comprehension. Participants read short passages and answered multiple-choice questions. Importantly, this served as our measure of basic comprehension. These questions involved locating key ideas and details as well as drawing inferences across portions of a single text (19 items; α = .80).

Reading Strategies Assessment Tool (RSAT; Magliano, Millis, The RSAT Development Team, Levinstein, & Boonthum, 2011). RSAT is a computer-based assessment tool designed to measure the extent to which readers naturally engage in two types of inference processes: bridging and elaboration. Students read texts presented one sentence at a time on a computer screen at their own pace. At target locations, a prompt appears asking, "What are you thinking now?" Participants are instructed to "think-aloud" by typing their thoughts into a textbox below the prompt.

RSAT scores verbal protocols using computational algorithms. Computational algorithms rely on key word matching and are designed to assess the extent to which content words from participant's protocols overlaps with content words from the text. Content words that overlap

with content words found in the prior text (but not content words from the sentence read immediately prior to the prompt) are used to generate a bridging score, whereas, content words that do not overlap with content words in the text are used to generate an elaboration score. Scores are based on aggregating the bridging and elaboration scores for the sentences in which they produced typed responses.

There is evidence suggesting that RSAT scores are reliable and valid (Magliano et al., 2011). Moreover, RSAT scores are correlated with human judgments of these same processes (r = .74 for bridging and r = .48 for elaboration) and are also correlated with other measures of comprehension such as the ACT and the Gates-McGinitie (r's ranging from .51-.55; Gilliam, Magliano, Millis, Levinstein & Boonthum, 2007; Magliano et al., 2011). Finally, the test-retest reliability of the RSAT scores is high, particularly when considering the fact that it is an open-ended assessment (r's = .79 for bridging and elaboration scores).

In the present study, participants read one history text ("Louis XVI and the French Revolution", 19 sentences) and produced verbal protocols at 6 locations, and one science text ("The Power of Erosion", 22 sentences) in which they produced protocols at 7 locations. Texts were presented in a random order and participants were given one practice text before completing the measure. For the practice text, participants were given feedback when their responses were less than five words (i.e., "We are interested in your thoughts about the texts. In your responses to the prompts, please tell us more about your understanding of what you are reading.").

Global Integrated Scenario-Based Assessment (GISA; Sabatini et al., 2019). The present study used GISA to assess a complex literacy task that requires students to reason with and beyond the texts. GISA is a web-based assessment designed to measure various aspects of reading comprehension. The higher-level comprehension dimensions assessed are theoretically

grounded and include the ability to evaluate, integrate, extrapolate, and synthesize information to achieve a reading goal (see Bennett, 2011; O'Reilly & Sabatini, 2013; O'Reilly & Sheehan, 2009; Sabatini et al., 2013; Sabatini, O'Reilly, Wang, & Dreier, 2018). In GISA, participants are placed within an enriched reading scenario and are asked to use multiple texts to solve a specific problem. In the form used in the current study, participants are told that there is some debate as to the identity of the person depicted in Da Vinci's famous Mona Lisa painting. Their task is to read various historical accounts in order to update a wiki page. Participants interact with various simulated agents including a professor and classmates throughout the assessment, which takes approximately 45 minutes to complete.

GISA differs from traditional assessments of comprehension in a number of ways. First, GISA provides students with an enriched reading context. Participants interact with various simulated agents including a professor and classmates in a simulated academic setting. Second, while traditional comprehension assessments have no explicit overarching goal, the GISA provides participants with a goal that spans the length of the assessment. Each task a participant completes is related and in service of a culminating final goal. Third, given an overarching goal, texts are topically and causally related. This is in contrast to the isolated texts presented in typical traditional assessments. Lastly, one final difference is in regard to the items participants complete. Participants answer multiple-choice questions, summarize information, evaluate sources, select appropriate synonyms and paraphrases, etc. Thus, GISA provides students with an enhanced reading context, giving them multiple sources and materials to achieve a specific goal. Importantly, many items in GISA require the test taker to reason with and beyond the texts, whereas the items on SARA Comprehension are restricted to locating, paragraphing, and lower-level inferences that are indicative of close comprehension.

Specifically, GISA queries students regarding their relevant background knowledge, asks them to identify key ideas, identify accurate paraphrases and summaries, identify evidence to support a theory, infer author intent and purpose, not only within single texts, but in reasoning across texts. Students also identify contradictions across sources, infer author's emotional states or preferences, motives, reasons/evidence supporting source/credibility, and identify problems/faults with a theory. Other tasks require students to infer author's rhetorical reasons for including particular information, examine opinions, sarcasm, infer author's attitudes on issues, or evaluate evidence for a claim/position, identify relevant source information in digital genres and contexts. All tasks are done in service of a larger goal of evaluating the credibility of sources for inclusion in a digital website.

GISA has been shown to be reliable, having good internal consistency and test-retest reliability in elementary, middle school, and high school populations (Cronbach's $\alpha > .80$; O'Reilly, Weeks, Sabatini, Halderman, & Steinberg, 2014; $r = .87$; Sabatini, O'Reilly, Halderman, & Bruce, 2014, respectively). Moreover, GISA has been shown to correlate with other measures of comprehension and with measures of deep understanding (O'Reilly et al., 2014; LaRusso et al., 2016). In the current study, the sample-specific reliability was good (27 items; $\alpha = .86$). See Sabatini, O'Reilly, Weeks, & Wang (2019) for more details on the properties of the forms and the vertical scale.

Given the moderate correlation between SARA Comprehension and GISA ($r = .65$), a disattenuated correlation was computed to evaluate the extent to which the measures differ after accounting for measurement error. When values are greater than .9, one can argue that the assessments measure essentially the same construct; however, when values are less than .9, the measures likely provide unique information (Lyrén, 2009; McPeek, Altman, Wallmark, &

Wingersky, 1976). In the present study, the disattenuated coefficient was $r = .78$, suggesting that SARA Comprehension and GISA assessed different aspects of reading literacy.

Table 1 *Demographic Data for Sample Used in Present Study*

Demographic Variable	Number of Cases	Percentage of Sample
Sex		
Male	62	23%
Female	87	33%
Missing	115	44%
Race		
White	35	13%
Black	40	15%
Asian	46	17%
Hispanic/Latino	25	10%
Native American	2	1%
Missing	115	44%
English as a Second Language (ESL)		
ESL	73	28%
Non-ESL	76	29%
Missing	115	44%
First-Generation College Student		
First-Generation College Student	87	33%
Not First-Generation College Student	60	23%
Missing	115	44%
Supplemental Literacy		
Enrolled in Supplemental Literacy Courses	185	70%
Not Enrolled in Supplemental Literacy Courses	79	30%

Procedure

The present study consisted of two sessions. All participants completed session one in a computer lab with trained study administrators. During the first session, participants completed the SARA followed by RSAT. This session took between 60-90 minutes to complete. Some participants completed Session 1 during class time while others completed it outside of class time. After completing Session 1, participants were given instructions on how to complete Session 2, which occurred outside of class and was self-administered. In the second session, participants completed the GISA along a demographic survey and other self-report assessments not used in the current study. All measures for both sessions were accessed via web-links with instructions for each measure provided on the websites.

Results

A large percentage of participants were missing data for at least one of the measures used in the current study (44%). This high attrition rate was, in large part, due to participants' failure to complete Session 2 of the study (which contained GISA). All analyses were originally run using listwise deletion (i.e., complete case analysis). That is, if a participant had missing data for any measure in an analysis, their data was excluded from that analysis (Peugh & Enders, 2004). However, given our interest in comparing how foundational component skills related to the two comprehension measures (SARA and GISA) in RQ2 and RQ3, listwise deletion was problematic because of the large discrepancy in sample sizes (n = 256, 154 for SARA Comp and GISA, respectively). Therefore, for RQ2 and RQ3, we reduced the sample to include only participants that had data for all three measures (RSAT, SARA, and GISA). In addition, one participant was an extreme outlier on multiple measures (3-7 *SD*s above the mean) and was, therefore, excluded from all analyses. Thus, for RQ1 (examining relations between foundational component skills and inferencing), a sample of 245 students was used for the analyses. For RQ2 and RQ3

(examining relations between inferencing, supplemental enrolment status, and two different comprehension measures), a sample of 146 students was used for the analyses.[2] Descriptive statistics for SARA subscales, RSAT, and GISA are listed in Table 2 and bivariate correlations between measures are shown in Tables 3 and 4. Variance inflation factors for all analyses were all below 4, indicating minimal concern of multicollinearity. Normal P-P plots suggested that the assumption of normality was met for all analyses. Residual scatterplots also suggested that the assumption of homoscedasticity was met for all analyses.

Table 2 *Descriptive Statistics for Measures Used in the Present Study*

Measure	Potential Score Range	*N*	Mean	*SD*
Word Recognition & Decoding	0-50	264	33.12	10.46
Vocabulary	0-38	264	24.56	6.91
Morphology	0-32	264	24.92	8.80
Sentence. Processing	0-26	260	18.12	4.82
Bridging	0—	253	1.80	1.21
Elaboration	0—	253	2.68	1.74
SARA Comprehension	0-22	256	11.66	4.26
GISA	0-27	154	15.32	6.04

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[2] Results using listwise deletion for RQ2 and RQ3 (n = 245, 154 for SARA Comp and GISA, respectively) revealed the same pattern and significance of results, except that word recognition and decoding was significant (p = .03) rather than marginal.

Table 3 *Correlation Matrix for Measures Used in the Present Study Using the Reduced Dataset (n = 146).*

	1. Word Recognition and Decoding	2. Vocabulary	3. Morphology	4. Sentence Processing	5. Bridging	6. Elaboration	7. SARA Reading Comp	8. GISA
1. Word Recognition and Decoding	---	.81***	.75***	.63***	.23**	.48***	.70***	.53***
2. Vocabulary	.81***	---	.73***	.62***	.18*	.41***	.70***	.59***
3. Morphology	.75***	.73***	---	.73***	.29***	.47***	.68***	.52***
4. Sentence Processing	.63***	.62***	.73***	---	.33***	.39***	.70***	.54***
5. Bridging	.23**	.18*	.29***	.33***	---	.34***	.35***	.21*
6. Elaboration	.48***	.41***	.47***	.39***	.34***	---	.43***	.51***
7. SARA Reading Comp	.70***	.70***	.68***	.70***	.35***	.43***	---	.67***
8. GISA	.53***	.59***	.52***	.54***	.21*	.51***	.67***	---

*$p < .05$, **$p < .01$, ***$p < .001$

Table 4 *Correlation Matrix for Measures Used in the Present Study Using Pairwise Deletion (number of cases used indicated in parentheses).*

	1. Word Recognition and Decoding	2. Vocabulary	3. Morphology	4. Sentence Processing	5. Bridging	6. Elaboration	7. SARA Reading Comp	8. GISA
1. Word Recognition and Decoding	---	.72*** (263)	.70*** (263)	.60*** (259)	.16* (252)	.46*** (252)	.59*** (255)	.52*** (153)
2. Vocabulary	.72*** (263)	---	.71*** (263)	.59*** (259)	.13* (252)	.43*** (252)	.62*** (255)	.60*** (153)
3. Morphology	.70*** (263)	.71*** (263)	---	.71*** (259)	.20** (252)	.45*** (252)	.62*** (255)	.52*** (153)
4. Sentence Processing	.60*** (259)	.59*** (259)	.71*** (259)	---	.24*** (248)	.34*** (248)	.62*** (255)	.55*** (153)
5. Bridging	.16* (252)	.13* (252)	.20** (252)	.24*** (248)	---	.32*** (252)	.29*** (245)	.21* (146)
6. Elaboration	.46*** (252)	.43*** (252)	.45*** (252)	.34*** (248)	.32*** (252)	---	.39*** (245)	.51*** (146)
7. SARA Reading Comp	.59*** (255)	.62*** (255)	.62*** (255)	.62*** (255)	.29*** (245)	.39*** (245)	---	.65*** (153)
8. GISA	.52*** (153)	.60*** (153)	.52*** (153)	.55*** (153)	.21* (146)	.51*** (146)	.65*** (153)	---

*$p < .05$, **$p < .01$, ***$p < .001$

RQ1: How do foundational component skills influence inference processes in college students?

To assess the extent to which foundational component skills were predictive of variance in inference processes, two hierarchical, linear multiple regression analyses were conducted with SARA subtest scores as predictors and bridging and elaboration scores as outcome variables. All SARA subtest scores were entered in the first step, followed by supplemental enrollment status in the second step (see research question 3). Results indicated that SARA subtests accounted for approximately 10% of the variance in bridging and 24% of the variance in elaboration. In terms of the predictors, sentence processing was the only significant predictor of bridging (see Table 5). For elaboration, both decoding/word recognition and morphology were significant predictors (see Table 6). No other predictors were statistically significant.

RQ2: How do foundational component skills and inferencing relate to basic comprehension and task-oriented reading?

To assess the extent that foundational component skills and inferencing accounted for variance in the two comprehension measures, two hierarchical, multiple regression analyses were conducted with SARA comprehension and GISA scores as outcome variables (see Table 7 for the regression predicting SARA and Table 8 for the regression predicting GISA). The SARA subtest scores were entered in the first step, followed by bridging and elaboration scores in the second, and supplemental enrollment status in a third. Adding inferencing to the models explained marginally more variance in SARA comprehension, F (2, 139) = 2.94, p = .056, and significantly more variance in GISA, F(2, 139) = 8.68, p < .001. Together, foundational component skills and inferencing accounted for approximately 64% of the variance in SARA comprehension scores (R^2 = .64) and 47% of the variance in GISA scores (R^2 = .47). Results indicated that decoding/word recognition, vocabulary, and sentence processing were all found to be significant predictors of SARA comprehension scores (see Table 5). Bridging accounted for significant

variance beyond word and sentence-level foundational component skills. In terms of GISA, both vocabulary and sentence processing were significant predictors. In contrast with SARA comprehension, elaboration, rather than bridging, significantly accounted for additional unique variance in GISA

Table 5 *Summary of the Results of the Regression Analysis Predicting Bridging*.

Measure	*B*	*SE*	ΔR^2
Word Recognition & Decoding	.01	.01	.10
Vocab.	-.01	.02	
Morphology	.01	.02	
Sentence Processing	.05*	.02	
Supplemental Literacy Enrollment	.08	.17	.00

*$p < .05$, **$p < .01$; note: ΔR^2 refers to adjusted R^2 values

Table 6 *Summary of the Results of the Regression Analysis Predicting Elaboration*

Measure	*B*	*SE*	ΔR^2
Word Recognition & Decoding	.04*	.02	.24
Vocab.	.03	.02	
Morphology	.04*	.02	
Sentence Processing	-.01	.03	
Supplemental Literacy Enrollment	.07	.22	.00

RQ2: How do foundational component skills and inferencing relate to basic comprehension and task-oriented reading?

To assess the extent that foundational component skills and inferencing accounted for variance in the two comprehension measures, two hierarchical, multiple regression analyses were conducted with SARA comprehension and GISA scores as outcome variables (see Table 7 for the regression predicting SARA and Table 8 for the regression predicting GISA). The SARA subtest scores were entered in the first step, followed by bridging and elaboration scores in the second, and supplemental enrollment status in a third. Adding inferencing to the models explained marginally more variance in SARA comprehension, F (2, 139) = 2.94, p = .056, and significantly more variance in GISA, F(2, 139) = 8.68, p < .001. Together, foundational component skills and inferencing accounted for approximately 64% of the variance in SARA comprehension scores (R^2 = .64) and 47% of the variance in GISA scores (R^2 = .47). Results indicated that decoding/word recognition, vocabulary, and sentence processing were all found to be significant predictors of SARA comprehension scores (see Table 5). Bridging accounted for significant variance beyond word and sentence-level foundational component skills. In terms of GISA, both vocabulary and sentence processing were significant predictors. In contrast with SARA comprehension, elaboration, rather than bridging, significantly accounted for additional unique variance in GISA.

RQ3: To what extent does enrollment in a supplemental literacy program account for variance in inferencing, basic comprehension, and task-oriented reading?

As described above, to examine whether enrollment in a supplemental literacy program accounted for unique variance in inference processes and the two comprehension assessments, supplemental enrollment status was added as a final predictor in the models described above (see Tables 7 and 8). Enrollment status was not a significant predictor of bridging and adding it to the model did not significantly improve model fit, F(1, 140) = .22, p = .64. Similarly, enrollment

status was not a significant predictor of elaboration and adding it to the model did not improve model fit, $F(1, 140) = .29$, $p = .59$.

Enrollment status was also a non-significant predictor of SARA comprehension scores and did not significantly improve model fit, $F(1, 138) = 1.71$, $p = .19$. Interestingly, enrollment status was a significant negative predictor of GISA scores and significantly improved model fit, $F(1, 138) = 5.94$, $p = .02$. Together, foundational component skills, inferencing, and enrollment status accounted for a total of 63% of the variance in SARA comprehension scores and 46% of the variance in GISA scores ($R^2 = .63$, $R^2 = .46$, respectively).

Table 7 *Summary of the Results of the Regression Analyses Predicting the SARA Traditional Comprehension Assessment.*

Measure	*B*	*SE*	ΔR^2
Word Recognition & Decoding	.08†	.04	.62
Vocabulary	.16**	.06	
Morphology	.02	.04	
Sentence Processing	.30**	.07	
Bridging	.44*	.20	.01
Elaboration	.10	.15	
Supplemental Literacy Enrollment	-.66	.51	.00

†$p < .10$, *$p < .05$, **$p < .01$; note: ΔR^2 refers to adjusted R^2 values

Table 8 *Summary of the results of the Regression Analyses Predicting the GISA Scenario-Based Assessment*

Measure	*B*	*SE*	ΔR^2
Word Recognition & Decoding	-.03	.07	.38
Vocabulary	.29**	.09	
Morphology	-.01	.07	
Sentence Processing	.32**	.11	
Bridging	-.12	.33	.06
Elaboration	1.07**	.22	
Supplemental Literacy Enrollment	-2.07*	.85	.02

Discussion

The present study explored the extent to which foundational component skills (at the word and sentence levels) and inference processes related to each other and to different types of literacy tasks in postsecondary readers. Moreover, given the high number of students enrolled in supplemental literacy programs, the current study explored the extent to which enrollment in these courses mattered in terms of inferencing and performance on different literacy tasks. Findings will be discussed in terms of the three research questions that were posed.

With respect to the first research question**,** variability in foundational component skills appeared to be differentially related to variability in the bridging and elaborative inference scores. Results indicated that sentence-level processes (i.e., sentence processing) were a significant predictor of bridging scores, whereas word-level processes (i.e., word recognition/decoding and morphology) were significant predictors of elaboration. While these results are consistent with prior research suggesting that inference processes rely on success at

lower-level processing (Cain & Oakhill, 2007; Kopatich et al., 2019), the fact that different aspects of foundational skills are differentially related to bridging and elaborative inferences extends those findings. Bridging is the process of establishing how content in the current sentence is related to content in previous sentences in the discourse context (e.g., Graesser et al., 1994; Singer, 1988). Given that bridging functions to connect sentences across the discourse, one might expect the accuracy at which one is able to represent sentences to be related to the frequency of generating bridging inferences.

In contrast, elaborative inferences involve drawing on prior knowledge external to the text and connecting it to text content (McNamara, 2004). Theories of language processing (Elman, 1990) and knowledge activation in the context of discourse processing (Myers & O'Brien, 1998; Perfetti & Hart, 2002; Perfetti & Stafura, 2014) assume that words serve as retrieval cues for knowledge activation. Thus, a first step of elaboration is accurately accessing the meaning of words in their context (Cain, Oakhill, & Lemmon, 2004; Perfetti & Stafura, 2014). The present study is consistent with those perspectives, in that proficiency in word recognition and breadth of vocabulary knowledge was significantly related to one's propensity to produce content external to the text in the context of RSAT. One would expect that less knowledge would be activated if the semantic networks associated with the lexicon were relatively depleted, which would also impact one's ability to recognize words.

Results from the present study are consistent with prior research investigating the role of lower-level skills on inference processes. Cain and Oakhill (2011) found that inferencing was related to one's ability to understand the meaning of words in elementary aged students. Additionally, with 10 to 11 year olds, Cain and Oakhill (2014) found that word knowledge was of particular importance to inferences that involved bringing in outside knowledge to fill in missing information (i.e., "global inferences"').

An important distinction is now made between a reader's breadth (number of words known) and depth (amount of knowledge about words) of word knowledge (e.g., Cain & Oakhill, 2014; Oakhill, Cain, & McCarthy, 2015; Perfetti, 2007). Importantly, comprehension ability may vary as a function of the richness of word representations activated (Perfetti, 2007; Perfetti & Hart, 2002). High quality representations contain knowledge about aspects of word forms (e.g., morphological features) in addition to word meanings (e.g., semantics; Perfetti, 2007; Oakhill et al., 2015). In the present study, knowledge of words in the form of morphological processing ability was a significant predictor of elaboration. Thus, poor comprehenders may be less likely to engage the general knowledge necessary to make elaborative inferences due to their lack of rich semantic representations (Cain & Oakhill, 2014; Long, Oppy, & Seely, 1994; Oakhill et al., 2015). SARA's assessments of word knowledge are likely most sensitive to breadth, rather than depth. The results of this study should arguably be replicated with assessments sensitive to depth of word knowledge.

With respect to the second research question, the present study assessed the extent to which foundational component skills and inference processes related to two different types of comprehension assessments: one that reflected close comprehension of a text, and another that reflected problem solving in an academic context. Results indicated that both word and sentence-level processes were significant predictors of performance on the two types of assessments. Specifically, word recognition/decoding, vocabulary, and sentence processing were significant predictors of SARA comprehension and vocabulary and sentence processing were significant predictors of GISA comprehension. Clearly, foundational component skills are necessary for constructing a mental model for text, regardless of variability in task. Foundational component skills may be necessary but not sufficient for text comprehension more broadly (Cain & Oakhill, 2007).

Interestingly, in the present study inference processes appeared to be differentially related to the two comprehension assessments. Whereas bridging was a significant predictor of SARA comprehension scores, elaboration was a significant predictor of GISA scores. As mentioned, bridging involves integrating information across a text and is crucial for establishing coherence (e.g., Allen, Jacovina, & McNamara, 2016; Graesser, Singer, & Trabasso, 1994; McNamara, 2017). The SARA comprehension assessment contained items that specifically targeted or required bridging inferences. While it is known that less-skilled adult readers are able to generate inferences when prompted to do so (Hannon & Daneman, 1998), the present study suggests that one's propensity to spontaneously engage bridging inferences during reading may be related to their ability to do so during an assessment.

Elaboration in the context of RSAT may reflect the extent that readers activate and apply relevant background knowledge, which is presumably important for purposeful reading (Kintsch, 1988; McNamara & Kintsch, 1996; Alexander, 2000, 2003). Given that GISA was intended to require test takers to reason beyond the material found in the texts (e.g., Sabatini et al., 2014), one's ability to activate and apply relevant background knowledge may be of particular importance. Specifically, in regard to evaluating potential contradictions about Da Vinci's model for the Mona Lisa, knowledge of Da Vinci, the Mona Lisa, or art history may have benefited readers. Moreover, while background knowledge of these topics was not strictly necessary, reasoning through multiple sources to construct a historical timeline with various events may be aided by relevant prior knowledge (Sabatini et al., 2014). Thus, while comprehension of a text is necessary for GISA, it may not be sufficient; one's ability to integrate across texts and learn from text content to solve a problem goes beyond aspects of basic comprehension (Kendeou, Rapp, & van den Broek, 2003).

These results may generalize to reading activities that happen in academic contexts. Literacy activities vary across disciplines taught in college courses (Armstrong & Lampi, 2017; Stahl & Armstrong, 2014). Some activities require that students demonstrate close comprehension of texts that they are assigned, and those activities may be relatively more supported by the propensity to generate bridging inferences than elaborative inferences. In contrast, tasks that require problem solving beyond understanding the text(s) may be supported by students' ability and willingness to engage in the elaborative processes that support the task at hand.

These results, however, should be interpreted with caution. One would need to replicate these findings with other assessments associated with close comprehension and purposeful reading. At this juncture, it is best to interpret the present results as suggesting that the relative importance of these processes may differ as a function of the nature of the reading task. Future research should explore the extent to which these effects are specific to the assessments used here or whether they apply more broadly.

Although the Reading Systems Framework (RSF; Perfetti & Stafura, 2014) did not originally guide our research questions, the results associated with Questions 1 and 2 have implications for it. RSF assumes comprehension arises through word-to-text integration, which requires a direct linkage between the systems that support word identification and those that support local discourse level processes (i.e., constructing accurate representations of sentences, and establishing connections between sentences). The results indicating that dimensions associated with word identification in SARA were significant predictors of elaborative inferences and performance on the traditional and the scenario-based assessments is consistent with this perspective.

However, Perfetti and Stafura (2014) assume that word identification should be related to bridging inferences. Moreover, vocabulary and background knowledge are thought to play a role in bridging processes in addition to elaborative processes (e.g., Barnes, Dennis, & Haefele-Kalvaitis, 1996; Barnes, Ahmed, Barth, & Francis, 2015). It may be the case that word identification supports bridging inference indirectly, through the processes that support sentence level semantics. That is, foundational component skills such as decoding and word recognition serve to activate lexical units that support the construction of a sentence level representation. This idea is consistent with the word to text assumption of the RSF and indicates that there may be complex relationships between the sub processes that support reading words and sentences and inference processes. While hierarchical regression modeling was used here, future research with a larger sample size may consider more complex modeling (e.g., structural equation modeling) to test for direct and indirect effects between word, sentence, and inference processes as well as different types of comprehension assessments.

With respect to the third question, the results from the present study indicated that enrollment in a supplemental literacy program was not predictive of inference processing nor was it predictive of performance on the SARA comprehension assessment. It was, however, a significant negative predictive of performance on GISA. While this result may reflect difference in the difficulty of the SARA comprehension and GISA, we argue that the result may have to do with the qualitative difference between the two assessments. As discussed above, the SARA comprehension assessment was intended to assess proficiencies in close comprehension (e.g., identify key ideas, draw inferences), whereas GISA was intended to assess students' ability to use multiple, connected texts to solve a complex problem. While coursework in college may reflect both kinds of literacy activities, the present results suggest that struggling college students may struggle more specifically with coursework that requires complex problem solving that

involves reasoning beyond the text. These processes are the hallmark of disciplinary literacy activities in disciplines such as history and science (Shanahan & Shanahan, 2008; Shanahan et al., 2012). Such challenges would have repercussions on not just academic performance, but any professional or life activity that requires problem solving with text (Britt et al., 2018; Snow, 2002).

Research over the last decade has called into question the effectiveness of supplemental reading courses (as well as developmental education in general; e.g., Bailey, 2009). Several studies suggest that these supplemental reading courses are largely unsuccessful, especially in terms of long-term outcomes such as degree attainment (Bailey, 2009; Hodara & Jaggars, 2014; Jaggars & Stacey, 2014). As such, researchers have called for more rigorous studies investigating supplemental reading programs and the population of students enrolled in them (e.g., Crisp & Delgado, 2013; Lavonier, 2016). What does this study tell us about underprepared college students and the struggles they face? The sample of supplemental students involved in this study displayed the same degree of variability in proficiencies in foundational skills and propensity to bridge as their cohort not in the program. Indeed, the present results are consistent with calls for supplemental support programs to teach literacy skills that represent expectations of credit bearing course (Armstrong et al., 2016; Stahl & Armstrong, 2018). The effectiveness of programs that typically teach generic reading and study strategies has been called into question (e.g., Alliance for Excellent Education, 2006; Bailey et al., 2010; Bettinger & Long, 2005), and it may be the case that courses of this ilk are not targeting the skills actually required to succeed in the first courses that college students experience (Armstrong et al., 2016; Holschuh & Paulson, 2013).

There are limitations to this study that must be considered with respect to the issue of college readiness. For example, it is well documented that prior knowledge has implications on

comprehension outcomes (e.g., Cromely & Azevedo, 2007; Ozuru, Dempsey, & McNamara, 2009; O'Reilly, Wang, & Sabatini, 2019), but the design of this study did not afford an exploration of that issue. Students take a number of courses in college that provide them with their first exposure to a topic (e.g., typically only advanced placement students have access to psychology courses as high school students). This only underscores the need to explore the extent to which variance in prior knowledge is related to how elaborative processes support performance on academic literacy task that require complex problem solving.

Another limitation that warrants consideration is RSAT, which provided the measure of bridging and elaborative inferences. We construe RSAT as reflecting a students' propensity to engage in those processes during reading. It does not provide an assessment of the accuracy, relevancy, and proficiency of bridging and elaborative inferences. While the RSAT scoring system is correlated with human judgments of elaborations that reflect constructive learning processes (Gilliam et al., 2007; Magliano et al., 2011), the scoring system does not distinguish between elaborative processes that are supportive of learning from those that may be less supportive. This study should be replicated with a measure of inference accuracy and the extent that inferences support learning, albeit we know of no standardized measures that directly assess the accuracy of bridging and elaborative inferences as they are conceptualized in theories of comprehension (e.g., Graesser et al., 1994). Until more refined computational algorithms are developed, such a replication would require human coding, which is challenging in the context of a study with relatively large samples.

While not a limitation per se, one unique aspect of GISA is that texts are thematically related, and this reflects a literacy task in which readers need to rely upon multiple documents. It is well documented that multiple documents task reflect unique challenges not necessarily reflected in literacy task that rely on a single texts (Rouet & Britt, 2011). For example, readers

are more likely to need to keep track of sources of the documents, as they may vary in reliability (Bråten, Strømsø, & Britt, 2009). Making connections across documents can present a serious challenge for readers (Blaum, Griffin, Wiley, & Britt, 2017). It may be the case that students enrolled in the supplemental programs struggled with the multiple-documents nature of GISA. However, it is important to note that GISA provides scaffolds to support multiple documents processing that may not be provided in tasks that occur in their coursework. As such, GISA may not be the most appropriate measure to assess strengths and challenges of processing multiple documents, per se. Nonetheless, this research is warranted with struggling college readers who likely need continued literacy support in terms of multiple-document comprehension and discipline-specific reading, which is essential for college and career success (Williamson, 2008; Shanahan & Shanahan, 2008).

This study was conducted in one location. While that may be typical of many studies in discourse comprehension that involve college populations, we contend that future research should involve multiple sites. Colleges and universities attract different populations of students for a variety of reasons, such as admission criteria and socio-economic factors. The institution where this study was conducted is an open access institution, which means that students can be enrolled regardless of their admission scores, albeit they may be referred to supplemental literacy courses. The extent to which these findings extend to four-year institutions should be explored. Moreover, this research was focused specifically on struggling college students in the United States and was based off research suggesting they are underprepared (e.g., NAEP, 2015). The extent to which these results apply to populations outside the United States remains to be explored, however, we suspect that underprepared post-secondary students may generally struggle with literacy tasks that involve problem solving.

We see this study as important as a start to a concerted effort of discourse psychology and related fields to study the issue of college readiness with respect to reading. The theoretical lens and empirical approaches of this community can make substantial contribution to better understand why students struggle in their first college experiences, and what can be done to help them succeed. While there is a plethora of research on individual differences in comprehension that involves college students, we encourage research on students designated as being underprepared to read for college by institutions of higher learning. We hope that the present study serves to motivate more research in discourse psychology on this important issue.

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