Study Protocol with Statistical Analysis Plan (SAP)

Official Title of the Study: **Knowledge Accessibility and Availability in Forming Knowledge-to-Text Inferences among Middle Grade Readers**

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SCIENTIFIC BACKGROUND:

All major theories of reading comprehension (e.g., Kintsch, 1998; van den Broek et al., 1996) emphasize the importance of inferencing. Recent adolescent-based research shows that inferencing improves across grades 6-12, uniquely accounts for variance in sentence- and passage-level comprehension, and that individual differences in inferencing relate in a principled way to variations in reading comprehension for readers of all abilities (Barth et al., 2015[b]; Barnes et al., 2015). These findings suggest that comprehension requires inferencing and that comprehension fails when readers do not possess relevant knowledge (i.e., availability) or are slow in their retrieval (i.e., accessibility) and integration of knowledge from text or semantic memory during reading (Kendeou, 2015). To date, only one study has examined the effects of knowledge availability and accessibility on inferencing among adolescents. Those results reveal that students will twice as likely use easily accessible knowledge to form inferences than knowledge that takes longer to retrieve (Barnes et al., 1996). But this study did not measure speed of forming inferences, used first grade texts, and excluded less skilled middle grade readers. From the cognitive science literature, few studies have examined the effect of retrieval practice on knowledge availability and inferencing (Butler, 2010; Karpicke & Blunt, 2011; Smith & Karpicke, 2014). Results show that retrieval practice enhances knowledge availability for text content and leads to improved inferencing on near and far transfer tasks. However, these studies – conducted on adult readers – did not measure knowledge accessibility or individual difference factors.

OBJECTIVES:

To extend this limited body of research, this project conducts experimental studies with three objectives:

(1) To conduct experimental studies to determine the extent to which variations in knowledge base availability and accessibility influence the rate and accuracy of forming inferences.

(2) To investigate whether individual difference factors are potential sources of variability in explaining inferencing and reading comprehension.

(3) To conduct experimental studies to determine the extent to which adolescent readers can improve the rate and accuracy of forming inferences through retrieval practice techniques that have well-supported theoretical underpinnings and demonstrated efficacy among adults.

AIMS:

(1) To examine the extent to which knowledge-base availability and accessibility relate to the accuracy and rate of constructing inferences using that knowledge among middle grade readers.

(2) To examine the extent to which retrieval practice (i.e., spaced practice testing) increases knowledge availability and accessibility and improves the accuracy and rate of forming inferences using that knowledge base among middle grade readers.

(3) To integrate investigative research into an undergraduate Honors Research Program by developing an investigative laboratory component that engages undergraduates in conducting applied research.

Barth, Amy Elizabeth

DESIGN:

Study 1:

    Scientific Premise: A reader must supply relevant knowledge and integrate current information from text with that knowledge (Perfetti & Stafura, 2015). But we do not know how accessibility of an available knowledge base relates to knowledge-based inferencing. Further, regardless of how knowledge accessibility relates to knowledge-based inferencing, other factors may affect the accuracy or rate at which adolescent readers form knowledge-based inferences.

    Participants. This study will randomly select 300 students in grades 5-8 (i.e., 160 students per grade). Because of the short duration of the experiment, we estimate 20% attrition. We will replace all students who attrite from the sample within grade to ensure sufficient power. This study excludes students with significant cognitive impairments who participate in the SLCSD Life Skills Class (e.g., severe autism, behavior, cognitive disability) due to task demands. This study includes all genders, races, and socioeconomic status to enhance generalizability of findings and to determine if child-attributes moderate knowledge accessibility and availability.

    Power. General recommendations on sample sizes in structural equation modeling (SEM) suggest minimum samples of 300. This sample size will allow us to detect correlations among constructs larger than 0.05 and regression coefficients in latent variable regressions of 0.05 with over 80% power.

    Method. Participants will complete a four-phase experiment. Procedures represent a modification of those used by Barnes et al. (1996). In Phase 1, students learn a knowledge-base of 18 facts about a pretend planet named Gan. In Phase 2, which occurs after students learn the knowledge base to criterion (perfect recall), students will read and listen to a six-episode text. Immediately after hearing each text section, the computer asks students questions measuring understanding (i.e., literal, coherence inference, and elaborative inference questions). Phase 3 occurs immediately after hearing all text sections and retests retention of the knowledge-base and inference making. One week later, Phase 4 retests the knowledge-base and inference making. Students also take a larger test battery.

    Phase 1: The Knowledge Base. The knowledge base comprises 18 details that relate to the text. Each detail will appear on the computer screen in a block at a rate of 1 item every five seconds. Participants will initiate the presentation of the first detail by pressing the space bar. For each detail, the computer will display the fact in the middle of the tenth row of the monitor; E-Prime (Schneider et al., 2002) will also read the detail to the student. An Immediate Recall Task and a Verbal Recall Task will assess knowledge base acquisition to provide an indication of how easily the students acquired the knowledge-base and will serve to teach the knowledge-base to criterion, as follows.

    Immediate Recall. The computer will ask the participant to recall as many details as he or she can with no time restriction on recall. We will index accessibility by the amount of time taken to recall the knowledge-base and availability by the total number of knowledge-base details correctly recalled.

    Verbal-Recall Task. Next, the computer will ask each participant 18 questions to assess his or her literal memory for each knowledge-based item, with each question read and presented in middle of the tenth row of the monitor. After completing all 18 questions, the computer will provide the correct answer for each question with only items that the student recalls incorrectly

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presented more than once. Presentation will stop when the participant answers all questions correctly. The computer will time responses to questions from the offset of the question to the onset of the response to provide a measure of accessibility of each knowledge-base item.

Phase 2: Text and Questions. After the Verbal-Recall Task, the computer will present the six-section text, one section at a time. Seven questions asked immediately after each text section assess various aspects of text comprehension (literal questions, coherence inference questions, and elaborative inference questions). The computer will time responses to questions from the offset of the question to the onset of the response to provide a measure of accessibility of each item. When a student answers a question incorrectly or incompletely, the research assistant will use a nonspecific prompt to elicit a fuller response (i.e., tell me more about that).

Phase 3: Retention of the Knowledge Base. After the student completes all text sections and questions, the computer will test memory for the knowledge-base using the Immediate Recall Task and Verbal Recall Task described for Phase 1 with no feedback provided.

Phase 4: Long-Term Retention of the Knowledge Base. One week later, students' retention of the knowledge-base will be tested using the Immediate Recall Task and Verbal Recall Task described for Phase 1. We will also administer additional measures to assess reading comprehension, inferencing, and individual difference factors.

Assessments. Assessments measure the constructs of reading comprehension, inferencing, word reading efficiency, metacognition, working memory, and background knowledge.

Statistical Analysis Plan for Study 1.

Data Analysis. We will screen for missing data and outliers and evaluate the distributional properties of observed variables, making transformations as necessary and appropriate. If possible, we will correlate non-plausible values or list them as missing if not possible, and label extreme data points.

Analytic Approach. We will model the effects of knowledge availability and accessibility on inferencing without dichotomizing the distribution of comprehension. To determine whether reader characteristics (i.e., knowledge availability and accessibility, metacognition, reading comprehension, word reading efficiency, background knowledge, working memory, and grade) make unique contributions to inferencing, we will fit mixed effects explanatory item response models to the trial-by-trial inferencing accuracy and speed data using SAS PROC MIXED with item-level accuracy and reading speeds cross classified between person and items. We will also next people within grade, treating grouping variable for people such as grade and items as fixed factors. If limited variability exists in the accuracy data, we will only model response time data. The sampling plan maximizes power to detect whether variations in knowledge accessibility and availability relate to differences in their rate and accuracy in which students use that knowledge to form inferences. The study has sufficient power to test secondary hypotheses which will examine if accessibility of knowledge affects inferencing with that knowledge more so for less skilled than for skilled comprehenders after controlling for knowledge availability and whether individual difference factors such as working memory, metacognition, and reading fluency relate to differences in the accuracy and rate of forming knowledge-based inferences and comprehension of text.

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Study 2:

Scientific Premise. In the transfer literature, some evidence suggests that conditions of initial learning improve the direction and magnitude of transfer. For example, several studies show that the greater the degree of initial learning, the higher the probability of positive transfer (e.g., Bruce, 1933; see Ellis, 1965) as does increasing the quantity and variability of training question types or problems (see Kimball & Holyoak, 2000). These findings suggest that if a student receives multiple opportunities and ways to access information in memory, it increases retention of the information and accessibility to the information which can improve use of that knowledge on related tasks. To date, no study has evaluated how initial learning conditions designed to enhance knowledge availability and accessibility effect knowledge-based inferencing and comprehension among middle grade less skilled readers.

Participants. Study participants (n – 180) will come from Storm Lake Community School District students in grades 5-8. We anticipate that students will come from diverse socio-economic and ethnic backgrounds.

Power and Design. We estimate the sample associated with an effect size of 0.25, alpha 0.05, and with over 80% power at 136 participants for between group differences, 36 for within group differences, and 180 for the interaction. Randomization will occur within grade, with all qualified students in grade 5 available for randomization because they did not participate in Study 1.

Procedure. Study 2 follows the same procedure as Study 1 with the following changes. After the Verbal-Recall Task, the computer will present the six-section informational text one section at a time with each section approximately 500 words in length. Immediately after studying, the computer reassesses the students' retention of the knowledge base with the Immediate Recall Task and Verbal Recall Task. Next, students will restudy two of the text sections (restudy passages condition), repeatedly take the same test on another two text sections (same test) and repeatedly take different tests on the other two text sections (variable text). Immediately following, students' retention of the knowledge-base will be reassessed with the Immediate Recall and Verbal Recall Tasks.

Assessments. One week later, participants will return to assess their knowledge base retention and inferencing and comprehension of the passages. Study 1 assessments will also be administered.

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Statistical Analysis Plan for Study 2.

       Data analysis. We will screen for missing data and outliers and evaluate the distributional properties of observed variables, making transformations as necessary and appropriate. When possible, we will correct non-plausible values or list them as missing if we cannot correct them and label them extreme data points.

       Analytic approach. Data analysis will use repeated measures analysis of variance models to examine the effect of the experimental condition on knowledge retention. Separate ANOVAS will analyze scores obtained on the question types and the efferent error types by condition. The sampling plan maximizes power to examine Aim 2. The analyses include factors such as socioeconomic, gender, and disability status to determine whether these demographic factors impact inferencing.