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# Self-Explanation Reading Training: Effects for Low-Knowledge Readers

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## Abstract

This study examined the effects of self-explanation reading strategy training (SERT) and Preview training on high-school students' comprehension of a science text. The students (n=136) were from a middle to lower SES, inner-city Virginia high school. They were assessed in terms of their science knowledge and reading skill. Nine biology classes were then randomly assigned to SERT, Preview, or Control conditions. Science comprehension was assessed both immediately after training and after a one-week interval. The results indicated that after the one-week retention interval, SERT participants outperformed both Preview and Control participants on passage comprehension. This comprehension advantage was particularly enhanced for low-knowledge readers. This result replicates with high-school student findings reported by McNamara (in press) with college students.

## Introduction

Many high-school students encounter difficulties comprehending their textbooks, particularly those covering scientific material (Bowen, 1999; Snow, 2002). Problems with comprehension can occur for a variety of reasons. One source of difficulty occurs from text specific factors, such as text cohesion (Beck, McKeown & Gromoll, 1989; McNamara, Kintsch, Songer, & Kintsch, 1996). Another source of problems stems from the reader's aptitudes. Of course, efficient decoding abilities are necessary for the reader to understand the words in the sentences (e.g., Perfetti, 1985). However, comprehension difficulties also occur even for readers who understand the words. These comprehension problems can emerge from the inability to draw inferences (e.g., Long, Oppy, & Seely, 1994) and the failure to apply other higher-level reading skills, such as meta-cognitive reading strategies (Cornoldi & Oakhill, 1996).

The recent RAND report on *Reading for Understanding* (Snow, 2002) documents the pressing need to improve reading comprehension. The RAND report also provides a useful heuristic for conceptualizing reading comprehension, which includes four interactive components: Characteristics of the text,

the reader, the comprehension activities, and the socio-cultural context. Accordingly, these factors rarely operate in isolation, and as such, potential interactions between attributes associated with these factors need to be considered in order to develop a more complete understanding of reading comprehension processes.

In terms of text characteristics, research has shown that the structure of the text plays a major role in comprehension. For example, in an analysis of the cohesion of social studies texts, Beck et al. (1989) found that many texts have structures that are far from optimal in terms of promoting deep comprehension. Texts often present too much information with too little detail, contain loose unconnected statements, and have poor integration with previous sections. Overall, the manner in which many informational texts are written present challenges for comprehension.

The knowledge and skills readers bring into the reading situation play an important role in the comprehension of informational texts (McNamara & Kintsch, 1996; Voss & Silfies, 1996). For example, Voss and Silfies found that prior knowledge helps the reader spell out causal links between concepts, whereas reading skill contributes to a better textbase understanding. Indeed, other research has shown that conceptual gaps in text are most easily repaired with domain knowledge (McNamara et al, 1996; cf. McNamara, in press).

Comprehension activities, or the use of higher level reading strategies, also have a major impact on learning (Pressley, Wood, Woloshyn, Martin, King, & Menke, 1992). For example, Chi, De Leeuw, Chiu, and LaVancher (1994) have found positive learning gains for a technique called self-explanation. Students who were asked to explain what they learned from a biology text made more inferences, integrated more information across topics, and developed a deeper understanding of the text than did Control students.

Similarly, McNamara (in press; McNamara & Scott, 1999) developed a comprehensive reading strategy intervention called self-explanation reading strategy training (SERT). SERT helps improve comprehension by encouraging students to make use of various reading

strategies to build connections between the reader's knowledge and the text. It teaches students to use active reading techniques including comprehension monitoring, logic and common sense, elaboration, paraphrasing, bridging inferences, and prediction to improve their ability to explain a text and understand it at a deeper level. McNamara (in press) found that college students who were trained to use SERT outperformed controls on measures of text comprehension. This improvement was especially enhanced for low-knowledge readers on text-based questions (assessing knowledge of information explicitly stated in the text).

While the effects of SERT have been beneficial in improving comprehension with college students, the effects of SERT training on high-school students has not been tested. Examining the influence of learning strategies is especially important in high-school populations because there is a dearth of strategic reading interventions being taught and used in classrooms (Cox, 1997, Garner, 1990). Moreover, in comparison to other countries, students in the United States are falling behind students in other countries on measures of reading comprehension (Snow, 2002).

The purpose of this study was to examine the effect of SERT training on high-school students' ability to comprehend science texts. We compared students' comprehension of science texts after they had received either SERT training, Preview training, or a reading Control condition. Previewing is a reading strategy designed to help students better comprehend texts by encouraging them to preview various subsections of the text before they read. This strategy training is based on, and includes the K-W-L instructional technique developed by Ogle (1986). The use of preview techniques is relatively common and has been associated with comprehension gains (Johnston & Allington, 1991).

Our goal was to examine whether SERT or Preview training helped students to better understand the science passages in comparison to the Control condition. First, we predicted that students trained with SERT and Previewing would outperform students in the reading Control group who did not receive reading strategy training. We expected both types of interventions to facilitate students' science text comprehension. However, we expected the benefits of SERT and Previewing to depend on the students' level of prior knowledge. This prediction arises from the way in which each technique encourages the use of prior knowledge. Previewing focuses on the activation of relevant prior knowledge before reading the text to provide a mental schema of the contents. While prior research has clearly shown the benefits of schemas to improve comprehension, we doubt that they will be particularly useful if the student has little prior

knowledge about the topic. As such, we expect the benefits of previewing to depend largely on the amount of prior knowledge the student has about the text topic, primarily benefiting relatively high-knowledge students. In contrast, SERT encourages students to actively process texts (e.g., elaborate and link information contained in the text). The student learns to use whatever knowledge available, including logic and general knowledge, to make sense of the text. Our previous research demonstrated that SERT was primarily beneficial to low-knowledge students (McNamara, in press). We expect similar results here.

## Method

Nine biology classrooms within an inner-city school were randomly assigned to one of three conditions: SERT, Preview, or Control. Students in the three SERT classrooms were provided training on how to self-explain text using five reading sub-strategies. Preview participants were taught how to preview the text before they read it. Control classrooms were simply asked to read the text. After reading, they were asked to focus on any strategies they used to help them better remember the text. Comprehension was assessed using two science passages taken from school science texts. The passages differed in topic and length, which allowed us to examine whether the strategies were used across different science texts. We used both text-based and bridging-inference questions to assess students' comprehension of the science passages.

## Participants

The sample consisted of 136 ninth and tenth-grade biology classes. Students were of mixed gender and ethnicity. The high school was located in an inner city region of Norfolk, Virginia.

## Materials

Student aptitudes were measured with two tests; a modified version of the Gates-MacGinitie Reading Skill Test and a Prior Knowledge Test. The Gates-MacGinitie test is a standardized reading comprehension test, designed for grades 10-12. The test consisted of 40 multiple-choice questions designed to assess student comprehension on several short text passages (Cronbach's Alpha  $\alpha=.91$ ). Due to time constraints, the vocabulary section of the test was not administered, and the time limit for the comprehension question section was reduced to 15 minutes. The prior knowledge test consisted of 35 multiple-choice items which tap knowledge of different science domains including biology, scientific methods, mathematics, earth science, physics, mathematics, and chemistry (Cronbach's Alpha  $\alpha=.74$ ).

To examine immediate and long-term retention, there were two comprehension testing sessions; one immediately following training, and again one week after training. A text on viruses, describing the structure, and reproduction of viruses as well as some examples of viruses and how they relate to disease, was used during the immediate test. The passage was 1216 words in length with a Flesch Reading Ease of 45.1 and Flesch-Kincaid Grade level of 10.6. One week later, we administered a text about earthquakes, which described the causes of earthquakes and the conditions under which they occur. The earthquake text was 749 words in length with a Flesch Reading Ease of 65.1 and Flesch-Kincaid Grade level of 7.5. In an ideal laboratory setting, the order of the texts would be counterbalanced between testing sessions. However, this was not possible due to logistical constraints (e.g., high rates of absenteeism and movement of students between classes).

Reading comprehension was assessed with a set of 8 open-ended and 8 multiple-choice questions; half were text-based and half were bridging-inference questions. For each comprehension assessment, students were asked to indicate whether they had finished reading and, if not, how far they had read.

Self-Explanation Reading Training (SERT) was delivered in three main phases; introduction, demonstration, and practice (see McNamara, in press). During the introduction phase, participants were provided with a description and examples of self-explanation. The instructor defined and provided examples for five reading strategies: comprehension monitoring, paraphrasing, elaboration/logic and common sense, prediction, and bridging.

During the demonstration phase, participants watched a video depicting a student reading and self-explaining a text about forest fires. Participants could refer to the accompanying video transcript during viewing. The video was paused at various points, and participants identified and discussed the strategies being used by the student in the video. In the practice phase, the participants worked in pairs to practice self-explanation while reading a chapter from their science textbook. The participants took turns self-explaining, alternating after each paragraph. At the end of each paragraph, the partner who was listening (and not self-explaining) summarized the paragraph.

Preview training was also delivered in the form of three phases. During the introduction, participants were given a description of the basic Preview strategy; a review of subsections in a text that can be previewed (Title, introduction, objectives bold italics, pictures/figures, conclusion and chapter review questions) and strategies for note-taking during reading (questions such as, What I know, What I need to know. What I found out). During demonstration, the instructor

demonstrated the Preview strategies to the class with a text on forest fires. Finally, during practice, the students practiced using the preview techniques on a chapter taken from their textbook.

In the Control condition, participants read the science texts to which trained groups were exposed during training. Participants wrote down strategies they used while reading, but did not discuss the strategies.

## **Design and Procedure**

Each class was randomly assigned to one of the three conditions; SERT, Preview, or Control (three classes were assigned to each condition). Experimental sessions were conducted during students' regular classroom time by two experimenters. Prior to training, students completed the prior knowledge and Gates-McGinitie Reading test. A 15-minute time limit was given for each test. The prior knowledge test was administered first.

SERT and Preview training were conducted during two class periods conducted on consecutive days. Participants were told that the purpose of the study was to learn strategies that would help them to better understand and remember what they read. The total amount of time spent learning the experimental interventions during the two days was approximately the same. The Control condition required one class period. Students in the Control condition were told that the purpose of the training was to find out about the strategies they use when reading their textbooks.

Immediately after training and after a one-week interval, participants were given 30 minutes to read the science passage and answer comprehension questions. In the experimental conditions, the experimenter briefly reviewed the strategies for either SERT or Preview before beginning the comprehension test. For both the virus and earthquakes texts, the students did not have the text available when they answered the questions.

## **Results**

### **Pre-test Scores**

Scores on the pretest measures of prior knowledge and reading skill were examined as a function of condition to ensure that the groups were comparable on these measures. To do this, we conducted two univariate ANOVAs, with condition as the between-subjects factor (SERT, Preview, and Control) and student aptitude scores (either prior knowledge or reading Gates-MacGinitie). There were no reliable differences in prior knowledge scores ( $F(2,135)=0.74$ ,  $MSE=0.017$ ,  $p>0.05$ ) or Gates-MacGinitie scores ( $F(2,134)=0.77$ ,  $MSE=41.192$ ,  $p>0.05$ ) as a function of condition.

To examine the effects of individual differences, we used a median split to divide students into high and low-knowledge groups, or high and low reading comprehension skill groups.

### Effects of Training Condition

To assess the effectiveness of SERT training on students' comprehension of the virus and earthquake texts, we conducted two sets of mixed model ANOVAs. The within-subjects factors were question type (text-based or bridging-inference), question format (multiple-choice or open-ended) and the between-subjects factors condition (SERT, Preview, or Control) and either reading skill (high or low) or prior knowledge (high or low). A combined analysis of reading skill and prior knowledge could not be performed because there were too few participants. To avoid conflating effects of reading skill with prior knowledge, the participants' scores on the prior knowledge measure were entered as covariates in the reading skill analysis, and vice versa, the participants' scores on the reading skill measure were entered as covariates in the prior knowledge analysis.

There were no reliable main or interaction effects of condition on the immediate comprehension test (virus text). In contrast, the earthquake text administered one week later revealed reliable effects of training condition. Therefore, the present analysis focuses on the latter results.

### Reading Skill Analysis

In the first analysis, reading skill was treated as a between-subjects variable, while prior knowledge was included as a covariate. There was a main effect of condition ( $F(2,124)=3.72$ ,  $MSE=0.268$ ,  $p<0.05$ ), indicating that SERT participants ( $M=0.43$ ,  $SD=0.15$ ) outperformed Control ( $M=0.36$ ,  $SD=0.16$ ) and Preview ( $M=0.36$ ,  $SD=0.12$ ) participants (see Figure 1). A post-hoc analysis using Least Significant Difference confirmed this trend showing that SERT participants performed better than Preview ( $p<0.05$ ) and Control participants ( $p<0.05$ ); however, Control and Preview did not differ ( $p>0.05$ ). There was also a main effect of reading skill ( $F(1,124)=11.08$ ,  $MSE=0.798$ ,  $p<0.05$ ), indicating that high reading skill students ( $M=0.43$ ,  $SD=0.15$ ) better understood the earthquake passage than did low reading skill students ( $M=0.34$ ,  $SD=0.13$ ).

Our analysis also showed effects for question format and question type, which were independent of training condition. There was a significant effect for question format ( $F(1,124)=16.86$ ,  $MSE=0.664$ ,  $p<0.05$ ) indicating that more multiple-choice questions ( $M=0.48$ ,  $SD=0.19$ ) were answered correctly than open-ended questions ( $M=0.29$ ,  $SD=0.15$ ). There was also a significant main effect for question type

( $F(1,124)=6.63$ ,  $MSE=0.286$ ,  $p<0.05$ ), indicating that students answered more questions based on the text correctly ( $M=0.46$ ,  $SD=0.18$ ) than questions requiring bridging-inferences ( $M=0.31$ ,  $SD=0.17$ ). No other effects were significant.

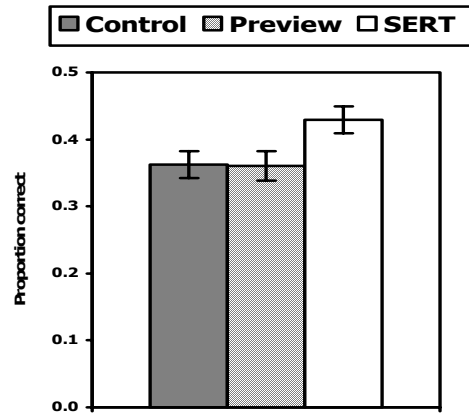


Figure 1. Proportion correct on Earthquakes comprehension test as a function of condition

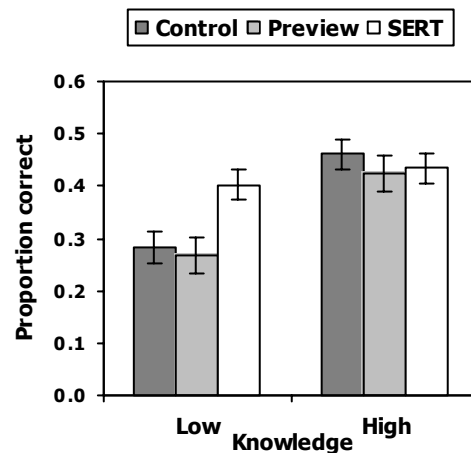


Figure 2. Proportion correct on Earthquakes comprehension test as a function of condition and prior knowledge

### Prior Knowledge Analysis

This section examines how the effects of condition depended on students' prior knowledge by including prior knowledge as a between-subjects variable, and reading skill as a covariate. As reported above, the main effects of condition, question format, and question type were reliable. There was also a main effect of prior knowledge ( $F(1,124)=11.10$ ,  $MSE=0.783$ ,  $p<0.05$ ), indicating that high-knowledge ( $M=0.43$ ,  $SD=0.14$ ) students better understood the passage than did low-knowledge students ( $M=0.34$ ,  $SD=0.13$ ). This main effect was qualified by a significant interaction between knowledge and condition ( $F(2,124)=3.84$ ,  $MSE=0.271$ ,  $p<0.05$ ). A Post hoc Least Significant Difference

analysis indicated for low-knowledge students, SERT participants ( $M=0.43$ ,  $SD=0.15$ ) outperformed Control ( $p<0.05$ ) ( $M=0.30$ ,  $SD=0.16$ ) and Preview ( $p<0.05$ ) participants ( $M=0.30$ ,  $SD=0.12$ ) (see Figure 2). There was no difference between Control and Preview participants ( $p<0.05$ ). In contrast, the effect of condition was not evident for high-knowledge participants ( $F(2,67)=0.41$ ,  $MSE=0.036$ ,  $p>0.05$ ).

## Discussion

Our findings indicate that SERT training helps students comprehend science texts. Specifically, SERT students performed better on the earthquake comprehension assessment than did Preview or Control students. Moreover, our findings also suggest that SERT training is particularly beneficial to facilitating comprehension among low-knowledge students, as evidenced by the finding that low-knowledge students trained with SERT performed better on the earthquake comprehension test than did low-knowledge students in the Preview and Control conditions.

The finding that the effect of SERT training emerged one week after training is encouraging because it suggests that students remember and use the strategies beyond the time of training. We expect that the lack of training effects on the immediate comprehension test is likely due to a fatigue effect following training.

Overall, our findings replicate those of McNamara (in press), which showed that SERT training facilitated readers' comprehension of scientific texts. Most importantly, both McNamara's study and the present results show that low-knowledge students tend to benefit most from SERT training in terms of comprehension gains. This is a very important finding because it suggests that the SERT method may be an effective technique for supporting comprehension among low-knowledge students most at risk from comprehension problems while reading difficult textbooks.

We predicted that SERT and Previewing would have differential effects on comprehension. We predicted that Preview technique would be less effective for low-knowledge students because using the Preview technique requires students to activate their prior knowledge before reading (i.e., when previewing the titles and subtitles). Thus, we expected Previewing to help high-knowledge students and SERT to benefit low knowledge students. Although we confirmed the latter prediction, we did not find benefits for previewing. This result may be because the students were relatively low knowledge overall. Perhaps the benefits of Previewing depend on a greater availability of prior knowledge than possessed by these inner-city high-school students. Indeed, a majority of students may not have sufficient knowledge to make use of previewing (Snow, 2002).

We expected the use of the SERT method to facilitate comprehension because of the manner in which the student engages with the material during the application of the SERT techniques. Specifically, the reader engages in on-line comprehension monitoring, while at the same time applying techniques known to aid comprehension, such as elaboration and bridging (Chi et al, 1994). This on-line method allows the student to process information effectively, which, in turn, supports comprehension. SERT strategies may provide a scaffold by which the student can integrate new information into their existing knowledge schemas, even in the absence of domain knowledge. Conversely, when using the Previewing method, students do not necessarily engage in on-line comprehension monitoring and reading strategy techniques. Rather, the Preview method encourages readers' to use comprehension monitoring prior to reading. A potential problem with this method is that it does not engage the reader as effectively with the text and the information they are reading.

In terms of understanding the reading process, our study supports the view that the comprehension activities used by the reader play a critical role in reading comprehension (e.g., Pressley et al, 1992). That is, students who have better comprehension skills, as reflected in their use of comprehension monitoring practices and utilization of active reading strategies, are likely to make comprehension gains (Chi et al, 1994).

Of course, to understand the links between reading strategy use (e.g., self-explanations) and comprehension, it is necessary to investigate the associations between strategy use and comprehension. For example, McNamara (in press) investigated the links between styles of self-explanation and performance on a science comprehension test. She found a reliable positive correlation between college students' comprehension scores and their use of logic and common sense self-explanations. In a similar vein, O'Reilly, Sinclair, and McNamara (in press) also found correlations between self reported use of individual SERT strategies and comprehension. However, more research is needed in this area to understand more fully the ways in which students use strategies to facilitate comprehension actually support learning gains.

In conclusion, our findings suggest that SERT training is a useful method of reading strategy training, which can be used to enhance comprehension at the high-school level. Indeed, McNamara and colleagues are currently working on integrating the SERT method of teaching into the high-school classroom. McNamara, Levinstein, and Boonthum (in press) have developed an interactive, automated version of SERT training, designed to be integrated into classrooms. The long-term aim is to develop a SERT intervention which is tailored to the needs and level of the student. In its

current form, the automated trainer, iSTART (Interactive Strategy Trainer for Active Reading and Thinking) teaches students the SERT strategies. The program comprises the three basic components used in the tutor delivered training: introduction, demonstration, and practice. During the practice section, in which students practice using the strategies, the iSTART system assesses the quality of the self-explanations and provides feedback to the student to encourage deep processing of the text (McNamara et al., in press).

Several preliminary examinations of the iSTART system have indicated that the computerized version of SERT training is as effective as live SERT training (O'Reilly, Sinclair, & McNamara, in press). Overall, the present findings and those collected from the iSTART studies indicate that SERT is an effective reading strategy intervention, which can be used in the classroom to help students comprehend difficult textbooks.

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