Self-Explaining Science Texts: Strategies, Knowledge, and Reading Skill

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Abstract: Self-explanation refers to explaining text to oneself while reading. We examined the quality of middle-school students' self-explanations of a science text which were collected while they were engaged with iSTART, an interactive computer program that teaches reading strategies. Our analysis included an examination of how the quality of paraphrases (i.e., restating the sentence) and elaborations (i.e., drawing on prior knowledge) were mediated by individual difference measures (reading comprehension skill and prior science knowledge) and sentence difficulty (based on information density). Reading comprehension skill was an important determinant in the production of paraphrases and elaborations. In addition, reading skill affected the quality of self-explanations produced; that is, skilled readers produced better quality elaborations (e.g., elaborations that helped build a global understanding of the text). Prior knowledge was also important, with high-knowledge students providing more 'distant' paraphrases. Finally, the production of elaborations and paraphrases was influenced by sentence difficulty. Fewer accurate elaborations were produced for the more difficult sentences. Implications for individual differences and sentence difficulty in the production of self-explanations are discussed.

Introduction

Previous research has shown that actively processing difficult texts improves comprehension (Chi, de Leeuw, Chiu, & LaVancher, 1994; Einstein, McDaniel, Owen & Cote, 1990). Further, there is evidence that explaining the text while reading, is an effective way of promoting active processing of the text, and thus, facilitating comprehension of the texts (e.g., Chi & Bassok, 1989). This is because self-explaining a text involves cognitive processes necessary for the deeper processing of the texts. These processes include monitoring of comprehension, linking separate ideas in the text, and relating the ideas to pre-existing knowledge. As a result, readers who explain text while reading understand more about the text and construct better mental models of the content (e.g., Chi & VanLehn, 1991).

Building on these theoretical foundations, McNamara and Scott (1999) developed a reading strategy intervention called Self-Explanation Reading Training (SERT). SERT aims to improve the quality of self-explanations, and hence, to promote active reading. SERT does this by teaching the importance of using reading strategies (e.g., paraphrasing and elaboration) and training students to these strategies while self-explaining a text. Teaching these strategies generally improves the quality of students' self-explanations and facilitates reading comprehension (McNamara, submitted; McNamara & Scott, 1999). However, we do not have a detailed understanding of the ways in which different types of individuals benefit from using different SERT strategies in different reading situations.

Whereas particular reader characteristics (e.g., prior knowledge) may help students self-explain sentences (e.g., make inferences about the meanings of unknown words), it is possible that reader attributes effectively facilitate text comprehension in one type of sentence, but not others. This is because the type of problems that readers need to solve to understand the sentence would differ as a function of sentence characteristics. These include information density, syntactic complexity, word frequency, and the cohesion with preceding sentences (McNamara, 2001; McNamara, Lowerse, & Graesser, 2002). Consistent with this argument, evidence indicates that text comprehension is mediated by complex interactions between individual differences

(e.g., prior knowledge, reading skill) and text-related factors (McNamara & Kintsch, 1996, O'Reilly & McNamara, 2002).

Given that individual difference factors and sentence characteristics are important for reading comprehension, we expect that they also affect reading strategy use while self-explaining texts. The present paper examines the effects of individual differences and text-related factors on students' use of reading strategies while self-explaining expository texts. We focus on two measures of individual differences: level of prior knowledge and reading comprehension ability, and on one sentence characteristic: sentence difficulty, which is operationalized by the information density of individual sentences.

Self-explanation protocols analyzed in this investigation were collected during computerized reading strategy training, in which students typed their self-explanations to exposi tory texts. The computerized trainer, called iSTART (Interactive Strategy Trainer for Active Reading and Thinking), is an automated SERT training program developed by McNamara, Levinstein and Boonthum (2003). iSTART was found to be an effective trainer in teaching reading strategies, with its teaching performance matching human training (O'Reilly, McNamara, & Sinclair, 2004). This study does not examine the effectiveness of training, but rather focuses on how the explanations to sentences that are generated during training vary in quality as a function of readers' aptitudes and sentence difficulty.

Method

Participants

The sample consisted of 42 eighth and ninth grade children from an east coast suburban school. The students were enrolled in a learning program, called Learning Bridge, designed to motivate students from under-privileged backgrounds.

Design and Materials

Individual differences were measured with two tests; a modified version of the Gates-MacGinitie Reading Skill Test and a Prior Knowledge Test. The Gates-MacGinite 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 α=.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 α=.81).

The iSTART system (see McNamara et al., 2003), in which the self-explanations were collected, consists of three phases. First, the Introduction provides information about self-explanation and five reading strategies (comprehension monitoring, paraphrasing, prediction, elaboration and bridging). The Demonstration provides examples of the self-explanation strategies taught in the introduction. Finally, during the Practice phase, students' type self-explanations to science texts.

In the practice section, students are presented with science texts one sentence at a time on the computer screen. For each sentence, they are asked to type a self-explanation. The quality of the self-explanation is assessed by iSTART, and students are provided feedback, presented by the pedagogical agent, Merlin. The feedback is essentially based on the degree of argument overlap between the students' self-explanation and the target sentence. The program is designed so that it encourages students to use information that is not in the target sentence (e.g., elaboration based on commonsense and previous sections of the text). For example, Merlin might respond with "Try adding some more information that explains what the sentence means" if a students' self-explanation tends to have large overlap with only current sentence. Thus, feedback differs for each user, depending on the quality of self-explanations produced. The self explanations analyzed in this paper are the final versions that a given student provided for a given sentence. Thus, they have been affected by the feedback of the system. For example, students providing poor self-explanations were prompted to supply more information. Thus, the final self-explanations reflect better quality protocols than would otherwise have been provided under spontaneous circumstances. However, it should be noted that, as the example indicates, the system tends to reduce potential differences between high and low quality self explanations produced by skilled and less skilled

readers or for easy and difficult sentences rather than magnifying these differences. In this sense, we are confident that the effects of individual difference and the sentence difficulty reported in this paper are not solely artifacts of the system's feedback.

Students self-explained two texts in the practice phase. The texts were entitled "Stages of Thunderstorm Development" and "Origin of Coal." The present analysis focuses on self explanations for the thunderstorm text. The thunderstorm text, comprising 13 sentences and 197 words, was extracted from a school textbook. It has a Flesch Kincaid Grade level of 9.364.

Procedure

Individual difference measures were collected shortly before iSTART training. Students completed the prior knowledge test first, followed by the Gates-MacGinite reading test. They were given 15 minutes to complete each assessment.

Coding

Students typed their self-explanations, which were automatically recorded in the database of the iSTART program. Two independent coders analyzed the self-explanations in terms of the following seven dimensions: 1) presence of comprehension monitoring; 2) presence of paraphrasing (none, topic identification, repetition, and paraphrasing); 4) distance of paraphrasing from the target sentence; 3) accuracy of the paraphrasing; 4) presence of elaborations; 5) source of the information used in elaborations; 6) how an elaboration contributes to the comprehension of the text; and 7) accuracy of elaboration.

Coding of comprehension monitoring was based on whether self-explanations incorporated the monitoring of students' understanding. Explanations were categorized as either containing or not containing evidence of comprehension monitoring (e.g., 'I don't understand X'; 'I understand Y'). The presence of paraphrasing was judged based on the nature of a statement referring to the target sentence. An explanation was categorized as containing one of the following: 1) a paraphrase that was a restatement of the sentence using different words, 2) a repetition of the sentence that was lexically too similar to the target sentence, 3) a simple topic identification (e.g., 'this is about storms'), and 4) no paraphrase, repetition, or topic identification. Note that explanations given the fourth category might include an elaboration or comprehension monitoring. The primary goal of this classification was to identify successful paraphrases (i.e., as opposed to mere repetition or topic identification). If the explanation was categorized as a paraphrase, the paraphrase was further coded for *accuracy* and *distance* from the target sentences. *Accuracy* had three levels (inaccurate, partially accurate, and accurate); and *distance* had two levels (distant and close). Close paraphrases were closely aligned to the original sentence in terms of sentence structure and/or content words. Distant paraphrases contained the same semantic content as the target sentence but did not have the same sentence structure or content words. Distance coding was intended to capture depth of processing involved in the paraphrasing.

Coding of the elaborations was based on whether the self-explanations included any ideas that were not explicitly present in the target sentence. Once a self-explanation was found to contain an elaboration, it was further coded for the *source* of the information, the nature of its *contribution,* and its *accuracy*. The *source* of elaboration was classified into three categories: 1) previous sections of the text, 2) domain specific knowledge, and 3) domain-general knowledge, including personal experience, common sense, and general knowledge. The nature of its *contribution* was also classified into three categories: 1) relevant to the comprehension of neither the current sentence nor the overall text; 2) relevant and contributes to the comprehension of only the target sentence; and 3) relevant and contributes to a global level of comprehension that goes beyond the current sentence (e.g., actively building the large picture depicted by overall text). Finally, elaborations that were classified as relevant to either current sentence or more global level of comprehension were coded for *accuracy*. Accuracy was judged as either accurate or inaccurate, based on the extent to which the self-explanation was scientifically correct. It should be noted that the accuracy of elaborations was coded on two levels (correct or incorrect), as opposed to three levels used in the accuracy of paraphrasing coding (inaccurate, partially accurate or accurate). This is because accuracy of elaborations was based on scientific correctness, as opposed to a 'model sentence'.

As these descriptions indicate, a particular self-explanation can contain all reading strategies varying in their qualities. Reliability of the coding was evaluated using Cohen's Kappa and simple agreement analysis

(when the coding is binary). Reliability between the coders was 85% or above for all coding dimensions. Disagreements were resolved via a discussion between the coders.

Results

As mentioned earlier, our analysis focuses on the influence of two individual differences (prior knowledge and reading comprehension skill) and sentence difficulty. As for the examination of the effects of individual differences, we adopted median split method, dividing students into high and low-knowledge groups, or high and low reading comprehension skill groups, using the median scores. For the sentence difficulty analysis, we classified the 13 sentences of the thunderstorm text into "high difficulty" and "low difficulty" sentences based on the information density of each sentence. Two independent coders' identified the number of distinct concepts contained in each sentence. Both coders classified sentences 1, 2, 3, 4, 5, 10 and 11 as low difficulty sentences (easy sentences) and sentences 6, 7, 8, 9, 12 and 13 as high difficulty sentences (difficult sentences), and thus were in agreement about which sentences were low difficulty and high difficulty.

Several statistical techniques were used to analyze the data. We used analysis of variance (ANOVA) to analyze the frequency of strategy use. We conducted a series 2x2 mixed design ANOVAs, which comprised *sentence difficulty (easy or difficult)* as the within-subjects factor and either *reading comprehension skill (high or low)* or *prior knowledge (high or low)* as the between-subjects factor. However, in addition to the analysis of how often a particular type of self explanation was produced (e.g., accurate paraphrase), we often wanted to analyze how the distribution of different types of self-explanation differed (source of information contained in the elaborations) between different types of students. In such cases, we used Chi-square to capture the difference in the overall frequency distributions.

Our data indicated that students' often attempted to paraphrase (91.0%). Of these attempts, 94% were successful (i.e., not repetitions or topic identifications). Overall, 84% of all self-explanations produced included successful paraphrases. Also, self-explanations quite frequently contained elaborations (41%). However, only 4% of the self-explanations contained comprehension monitoring. Therefore, we focus on the analysis on paraphrasing and elaboration.

Paraphrasing

The analysis indicated proportion of successful paraphrases (as opposed to repetition and topic identification) produced was associated with sentence difficulty and reading skill. Two sets of 2x2 mixed design ANOVAs were performed on the proportion of successful paraphrases. The analysis indicated a marginally significant main effect of sentence difficulty, $F(1, 39) = 3.117$, $MSE = .0079$, $p = .08$, and a main effect of reading comprehension skill, $F(1,39) = 3.722$, $MSE = .015$, $p = .06$. There were no other reliable main effects or interactions. Successful paraphrases are marginally more likely to be produced for easy sentences (M = .95, SD = .08) than difficult sentences (M = .92, SD = .13). They are also marginally more likely to be produced by skilled readers (M = .96, SD = .09) than less skilled readers (M = .91, SD - .12).

While reading comprehension skill was important for the quantity of paraphrases, prior knowledge played a more significant role in the quality of paraphrases produced. Specifically, prior knowledge was associated with the distance of the paraphrase. Two sets of mixed model 2x2 ANOVAs on the frequency of distant paraphrases indicated that distant paraphrases occurred more frequently for high-knowledge students (M = 0.63, SD = 0.22) than low-knowledge students (M = 0.44, SD = 0.24), $F(1, 39) = 7.531$, $MSE = .103$, $p < .01$. Also the main effect of reading comprehension skill approached statistical significance, with more distant paraphrases produced by skilled readers (M = 0.61, SD = 0.29) than by less skilled readers (M = 0.47, SD = 0.24), $F(1, 39) = 3.361$, $MSE = .113$, $p < .08$. Interactions between the sentence difficulty and individual differences were not significant.

We also examined how individual differences and/or sentence difficulty influenced the accuracy of the paraphrases. In this analysis, a score of 0, 0.5 and 1.0 was assigned for inaccurate, partially accurate, and accurate paraphrases, respectively. The two sets of 2x2 mixed model ANOVAs on the accuracy scores indicated a main effect of sentence difficulty, $F(1, 39) = 19.486$, $MSE = .0030$, $p < .001$, with greater accuracy for low difficulty sentences (M = .70, SD = 19) than high difficulty sentences (M = .53, SD = .20). There were no other main effects or interactions.

Elaboration

Two sets of 2x2 mixed design ANOVAs were performed on the proportion elaborations contained in the self-explanations. The results showed that there was a marginally significant main effect of sentence difficulty, $F(1,33) = 3.4$, $MSE = .0371$, $p = .07$, and a main effect of reading comprehension skill, $F(1,33) = 6.1$, $MSE = .012$, $p < .05$. More elaborations were produced for easy sentences (M = .44, SD = .30) than difficult sentences (M = .35, SD = .24). Also, more elaborations were produced by skilled readers (M = .49, SD = .05) than less skilled readers (M = .30, SD = .05). There were no other reliable main effects or interactions.

Of the elaborations produced, 66% were based on general knowledge or common sense, 23% were text-based, and 11% were based on scientific knowledge. We used 2x2 ANOVAs to investigate effects of individual differences and sentence difficulty in the production of different types of elaboration. For general knowledge elaborations there were no reliable main effects. However, an interaction between reading skill and sentence difficulty was reliable, $F(1,33) = 5.2$, $MSE = .024$, $p < .05$. A post-hoc t-test indicated that, for less skilled readers, more general knowledge elaborations were produced for easy sentences (M = .26, SD = .24) than difficult sentences (M = .17, SD = .19). For text-based elaborations there was a main effect of sentence difficulty, $F(1,33) = 11.7$, $MSE = 0.009$, $p < 0.01$. More text-based elaborations were produced for easy sentences (M = .13, SD = .17) than difficult sentences (M = .06, SD = .14), There were no other reliable main effects or interactions. Finally, we found no reliable main effects or interactions for scientific elaborations.

In terms of the contribution of elaborations to explaining the target sentences, 68% focused on the current sentence, 11% on a global level of comprehension beyond the current sentence, and 20% were irrelevant. Again, we used 2x2 ANOVAs to examine whether individual difference factors and sentence difficulty influenced the production of each of the current sentence, knowledge building and irrelevant elaborations. For current sentence and irrelevant elaborations, there were no main effects or interactions between individual difference factors or sentence difficulty. However, for knowledge building elaborations there was a main effect of reading comprehension skill, $F(1,33) = 7.6$, $MSE = .002$, $p < 0.01$. Skilled readers were more likely to make knowledge building elaborations (M = .11, SD = .12) than less skilled readers (M = .03, SD = .11). There were no other reliable main effects or interactions.

Thus far, the analysis has considered the source and contribution of elaborations independently. However, the source of information contained in the elaborations and the contribution of elaborations may be interrelated. To investigate the relationship between the source and contribution of elaborations in explaining the target sentences we carried out a distribution analysis. Table 1 presents frequency distribution of irrelevant, relevant to current sentence, and knowledge building elaborations as the function of the source of information used in the elaboration. The table shows a difference in the distribution of elaboration source and contribution, $X^2=6.2$ (2), $p < .05$. In particular, text-based elaborations were more likely to be relevant to either explaining the current sentence or knowledge building. This trend was not affected by individual difference factors (reading comprehension skill and prior knowledge) or sentence difficulty.

Table 1. Relationship between the source and contribution of elaborations

	Irrelevant	Current sentence	Knowledge building
General knowledge and common sense	35 (.23)	109 (.73)	4 (.03)
Text-based	2 (.03)	31 (.59)	19 (.36)
Scientific	8 (.33)	14 (.58)	2 (.08)

Note. Table reports frequencies (with proportions in parentheses).

Finally, we examined the accuracy of elaborations. The two 2x2 mixed model ANOVAs yielded a main effect of sentence difficulty, $F(1, 39)=8.6$, $MSE = .0098$, $p < 0.01$, and reading comprehension skill, $F(1,39) = 9.2$, $MSE = .037$, $p < .01$. Accurate elaborations were more likely to be produced for easy sentences (M = .22, SD = .03) than difficult sentences (M = .12, SD = .02). Skilled readers tended to produce more accurate elaborations (M = .22, SD = .20) than less skilled readers (M = .12, SD = .15). There were no other reliable main effects or interactions.

Co-occurrence of Paraphrases and Elaborations

The analysis so far has explored the nature of students' paraphrases and elaborations individually. However, they often occur together within a given self explanation. This section explores the relationships between paraphrases and elaborations contained in the self-explanations by examining the co-occurrence of paraphrases and elaborations.

Of the sentences self-explained, 54% contained paraphrasing only, 10% elaboration only and 31% both paraphrasing and elaboration (5% of the sentences contained neither paraphrasing nor elaboration). As will be shown shortly, the combination of paraphrases and elaborations was mediated by individual difference factors (prior knowledge and reading comprehension skill), but not sentence difficulty.

Table 2 shows that the distribution of self-explanations containing paraphrasing and/or elaborations differed for skilled and less skilled readers, X^2: 21.7 (2), $p < .001$. More skilled readers produced a combination of paraphrases and elaborations, and elaborations only, whereas less skilled readers produced more paraphrases only.

A similar distribution pattern emerged for high and low-knowledge students, indicating a difference in the pattern of co-occurrence of paraphrasing and elaboration between high and low-knowledge students, X^2: 6.0 (2), $p < .05$. As the left two columns of Table 2 shows, high-knowledge students produced a combination of paraphrases and elaborations, and elaborations only, whereas low-knowledge students produced more paraphrases only.

Table 2. Co-occurrence of paraphrases and elaborations as a function of individual differences.

Strategies	Low reading skill	High reading skill	Low-knowledge	High-knowledge
Paraphrasing only	162 (.67)	128 (.50)	140 (.62)	150 (.55)
Elaboration only	13 (.05)	39 (.14)	27 (.11)	25 (.09)
Paraphrasing and elaboration	64 (.28)	94 (.36)	59 (.27)	99 (.36)

Note. Table reports frequencies (with proportions in parentheses).

The analysis so far has indicated a difference in the co-occurrence of paraphrasing and elaboration as a function of prior knowledge and reading skill. We further explored the nature of the co-occurrence in more detail by looking into the kinds of paraphrasing and elaborations that co-occurred. Table 3 and Table 4 show the relationship between close and distant paraphrases and the source and contribution of the elaborations.

Chi-square analysis indicated that different types of elaboration tended to co-occur with distant and close paraphrases, X^2: 6.2 (2), $p < .05$. More text-based elaborations co-occurred with distant paraphrases, whereas more general knowledge elaborations co-occurred with close paraphrases.

Table 3. Co-occurrence of close and distant paraphrases and types of elaboration

Elaborations	Close paraphrases	Distant paraphrases
General knowledge	50 (.72)	55 (.56)
Text-based	13 (.19)	36 (.37)
Scientific	6 (.08)	7 (.07)

Note. Table reports frequencies (with proportions in parentheses).

Focusing on the contribution of elaborations, the Chi square analysis again showed that different kinds of elaboration tended to occur with close or distant paraphrases, X^2: 6.1 (2), $p < .05$. Distant paraphrases tended to co-occur with knowledge building elaborations.

Table 4. Co-occurrence of close and distant paraphrases and contribution of elaboration

Elaborations	Close paraphrases	Distant paraphrases
Irrelevant	11 (.15)	20 (.20)
Current sentence	54 (.78)	58 (.59)
Knowledge building	4 (.05)	20 (.20)

Note. Table reports frequencies (with proportions in parentheses).

Overall, the above two Chi-square analyses regarding the co-occurrence of close and distant paraphrase with different kinds of elaborations indicate that the quality elaborations, in particular the text-based and knowledge building elaboration, tend to co-occur with distant as opposed to close paraphrases.

Discussion

Overall, our analyses established that prior knowledge (high or low), reading comprehension skill (high or low) and sentence difficulty (low difficulty and high difficulty) played a role in both the production and quality of paraphrases and elaborations. The research is unique in that it has identified ways in which self-explanations differ as a function of reader characteristics and text characteristics. It thus expands our understanding of the ways in which different types of reader interpret sentences in the comprehension process.

At the most general level, although marginal, students with better reading comprehension skill tended to produce paraphrases (as opposed to simple repetition or topic identification) and elaborations more frequently. More importantly, reading skill was associated with the type and accuracy of elaborations. Better comprehenders produced higher quality elaborations; that is, their elaborations contained more knowledge building, sentence linking, and were more accurate. However, the overall analysis indicates that these high quality elaborations were often associated with "easy sentences." This pattern implies that skilled readers are not necessarily good at solving problems associated with the comprehension of the difficult sentences. Rather they are good at actively relating different parts of texts to construct a global representation of the text. Indeed, previous research has shown that reading skill is closely associated with active processing (as opposed to minimalist processing) of the text (O'Reilly & McNamara, 2002).

On the other hand, prior knowledge was found to be important for the production of distant paraphrases. This makes sense because an accurate distant paraphrase requires a better understanding of the situation depicted by the sentence; the resulting paraphrase would become distorted if one attempts to transform the sentence without understanding the situation. This finding appears to be consistent with general consensus that comprehension of a sentence in scientific text is closely associated with prior knowledge of the topic.

It is somewhat surprising that effects of prior knowledge were not detected in other areas of the analysis, such as the production of elaborations. Greater prior knowledge should help students produce elaborations. One possible explanation is that high-knowledge students may not need to elaborate because they understand the sentence. This notion is in accordance with deLeeuw and Chi (2003) who argued that elaborations are often produced when there is a gap between the information depicted by the text and the readers' representation of the situation depicted by the text.

Of course, readers may elaborate not only when they have problems with the current sentence, but also when they have difficulty placing the meaning of the current sentence in the context of the broader text. However, for this to occur, two conditions need to be met. First, the sentence must be sufficiently easy so that readers can comprehend the meaning of individual sentences relatively well. Second, readers' must be active processors (see O'Reilly & McNamara, 2002) to link a given sentence to the previous section of the text. Our data are consistent with this speculation. Text-based elaborations that tend to contribute to knowledge building appear to occur more frequently in easy sentences than difficult sentences. Further they are more likely to co-occur with distant than close paraphrases, indicating many text-based, knowledge building elaborations occur when readers understand the sentence relatively well. Finally, this trend is more pronounced among skilled than less-skilled readers. Taken together, the findings suggest that knowledge building elaborations tend to occur when skilled readers read a sufficiently easy sentence.

Overall, our analyses, regarding the relations between individual difference measures (prior knowledge and reading comprehension skill), sentence characteristics (information density), and the type of self-explanation, provide an insight into how different types of individuals deal with different types of sentences. However, because our research is limited to self-explanations produced under somewhat artificial training conditions, care needs to be taken in generalizing the findings to spontaneous reading conditions in which students are not provided with prompts or hints in connection with their self-explanations. We are currently analyzing written self-explanations that are spontaneously produced outside the iSTART training to examine the quality of self-explanations produced during more natural reading conditions.

Nevertheless, our findings have important implications for educational practice; this is because optimal learning requires the careful matching of student type (knowledge level and reading skill) to text type (text difficulty). Our findings suggest that sentences, or their relation to the other sections of the text, should be challenging enough to introduce some conflict between students' current mental model and the text, which, in turn facilitates the use of elaboration. If sentences are too easy, students do not find it necessary to elaborate; if too difficult, they inhibit access to sources of information needed to elaborate. This notion is in accordance with evidence that high-knowledge, inactive readers benefit most from reading relatively low-cohesion texts (O'Reilly & McNamara, 2002; McNamara, in press). We believe that future research should explore the effect of various text characteristics on the production of quality self-explanations in order to adequately match the reader type to text type at much more fine grained level using various global/local attributes of the texts. We also believe that future versions of iSTART should take into account both reader and text characteristics, and thus train students to self-explain texts using 'optimal' texts (i.e., those that encourage the production of quality self-explanations). The challenge for McNamara and colleagues is to develop a reading strategy trainer that is adaptable to the aptitudes of the student.

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