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# Effects of Prior Knowledge on Comprehending Text About Learning Strategies

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Good knowledge and skills in using different learning strategies is important for learning with understanding and even more critical during distance learning. Findings indicate that students tend to use and value ineffective learning strategies, thus there is need to educate students. This study aimed to analyze the possibility of using refutation text on learning strategies that students can study independently. The study examined how reported use of learning strategies and preexisting beliefs about the effectiveness of rehearsal and comprehension-oriented strategies relate to the comprehension of text about learning strategies, and how text comprehension is related to later use of strategies and the completion of learning tasks. Participants included 2,706 students from primary school (Grades 3 and 4) and 3,782 students from the end of middle school (Grade 9) across Estonia. Students' learning strategies and learning outcomes were assessed *via* a web-based word list memorization task with follow-up questions. Students were asked to read a written text that was specifically developed to explain the advantages of abstract grouping. Text comprehension was assessed using multiple-choice questions. SEM models were used to answer the research questions. At both school levels, valuing comprehension-oriented learning strategies enhanced text comprehension, suggesting that prior beliefs are important to fully understand written text. In addition, student beliefs and text comprehension also increased use of more advanced strategies. However, students who used comprehension-oriented strategies showed ambiguous improvements in word memorization performance. These findings emphasize that reading about complex topics may be a starting point for learning, but should be followed up with additional discussions, examples, demonstrations, and practice.

**Keywords: comprehension-oriented learning strategies, rehearsal, refutation text, word memorizing, school—aged children**

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## INTRODUCTION

It is widely acknowledged that good self-regulation skills are related to higher achievement, thus many scientists suggest that it is important to help students become self-regulated learners (Vandevelde et al., 2012; Bjork et al., 2013; Dent and Koenka, 2016; Dinsmore and Hattan, 2020). One way learners regulate their cognition is by selecting and applying cognitive learning strategies (henceforth LS)—goal-oriented activities for acquiring, organizing, and transforming

information (Weinstein et al., 2011; Dunlosky et al., 2013; Dent and Koenka, 2016; Dinsmore and Hattan, 2020). Specifically, comprehension-oriented (henceforth COr) strategies like elaboration, visualization, and categorization support learning through understanding and flexible use of learned knowledge later on (Dignath et al., 2008; Weinstein et al., 2011; Dent and Koenka, 2016). The importance of supporting knowledge and use of COrLS has been emphasized by international councils and school curricula (e.g., Council of the European Union, 2018; Estonian Government, 2020). However, findings indicate that many students tend to use and value ineffective LS like simple rehearsal, even in middle school (e.g., Bjork et al., 2013; Dunlosky et al., 2013; Daugherty and Ofen, 2015; Kikas and Jõgi, 2016; Kikas et al., 2020).

As a result, it seems highly worthwhile to teach students about different COrLS and to provide metacognitive knowledge about their effectiveness. One way to accomplish this is through the use of materials that students can study independently. This method seems especially appropriate today, as the COVID-19 pandemic has increased the need for independent learning from the earliest grades (European Commission, 2021). However, when learning new material independently, prior knowledge and beliefs have been shown to guide students' interpretation, understanding, and memory (e.g., Shtulman and Valcarcel, 2012; Van Moort et al., 2020). According to prior research, the first LS children start to use is rehearsal (Ornstein et al., 2010; Schleepen and Jonkman, 2012), and most children have experienced its value at some point. Strong beliefs in the value of rehearsal may guide students to misinterpret texts or misunderstand teachers' discussions about new strategies, including COrLS (Lawson et al., 2019). Studies in areas with strong prior misbeliefs and misconceptions have shown their influence on text comprehension (Diakidoy et al., 2003; Kendeou and van den Broek, 2005, 2007). These findings have directed educators to design specific refutation texts which help students suppress old beliefs and achieve proper understanding (see reviews from Tippett, 2010; Zengilowski et al., 2021).

At present, the authors are not aware of any studies that have examined how students' beliefs in the value of different LS guide their understanding of texts about learning and LS, or how this understanding further guides students to select and apply different LS. In addition, few studies have examined the role of prior knowledge and beliefs in applying LS and on learning outcomes (for exceptions, see Daugherty and Ofen, 2015; Lawson et al., 2019). A better understanding is needed in order to plan teaching and develop reliable learning materials for LS. As skills in using COrLS develop with age and schooling, studies should also include different age groups.

This study aimed to examine how reported use of COrLS and preexisting beliefs about the effectiveness of rehearsal and COrLS relate to the comprehension of a specifically developed LS-related refutation text, and how text comprehension is related to later use of COrLS and the completion of learning tasks. The study was carried out in Estonia at two school levels [primary school (Grades 3/4) and middle school (Grade 9)] to examine possible effects of education level. Students' LS and learning outcomes were assessed *via* a word list memorization task with follow-up questions (Kikas and Jõgi, 2016; Kikas et al., 2020, 2021).

## Rehearsal and comprehension-oriented learning strategies

Learning strategies have been shown to play an important role in memorizing and understanding learned material (Glogger-Frey et al., 2018), including in tasks that require reading and text comprehension (Afflerbach et al., 2020). In this study, we examined rehearsal along with two types of COr strategies: perceptual-based and abstract grouping strategies. In prior experimental studies, the terms "memory strategies" or "memorization strategies" have also been used instead of LS (Ornstein et al., 2010; Yu et al., 2018).

Studies have shown that the easiest LS for most children is rehearsal, or repeating information in order to memorize it. It is a passive method of processing information that does not involve transforming knowledge or moving beyond what is learned (Duncan and McKeachie, 2005; Weinstein et al., 2011). Younger children tend to begin using rehearsal spontaneously without specific metacognitive awareness (Ornstein et al., 2010; Schleepen and Jonkman, 2012). Rehearsal has been shown to be quite effective in the short-term (e.g., for next-day testing) and is widely used and valued by students (Duncan and McKeachie, 2005; Weinstein et al., 2011; Soderstrom and Bjork, 2015).

Through COrLS, a learner tries to find associations between old and new information through analysis, elaboration, reorganization, summarization, visualization, and grouping (Duncan and McKeachie, 2005; Weinstein et al., 2011; Glogger-Frey et al., 2018; Dinsmore and Hattan, 2020). Compared to rehearsal, these LS are more time consuming and cognitively demanding, but they also enhance the probability that information will be understood and can be used flexibly later on (Weinstein et al., 2011). For instance, when using elaboration to learn new information, learners may integrate this new information into a broader framework of interrelated concepts in semantic and episodic memory (cf. Bjork et al., 2013; Takashima et al., 2017). This, in turn, can result in improved retention and later recall (e.g., Belacchi et al., 2011). COrLS can also support text comprehension. For instance, Afflerbach and colleagues (2020) refer to constructively responsive reading strategies that include visualization, summarization, relating important parts of text to prior knowledge, and so on.

Grouping is a LS that presumes at least some knowledge of the learned material and requires good working memory capacity (Conklin et al., 2007; Schleepen and Jonkman, 2012). Depending on prior knowledge and reasoning ability, a learner may elaborate and group newly learned material according to perceptual features and personal experiences or abstract features and underlying structure. Examples of perceptual elaboration and grouping include drawings, models (Tippett, 2010; Wammes et al., 2018), and elaboration of new knowledge with personal experiences (cf. Bjork et al., 2013; Takashima et al., 2017).

Abstract grouping is considered the most demanding LS in terms of cognitive working memory load, prior knowledge, and

thinking skills (Schleepen and Jonkman, 2012). While perceptual grouping mostly involves using everyday knowledge to organize studied material, for successful use of abstract grouping, students must operate with verbally mediated, abstract information—in other words, students must find patterns and structure in learning material. The specific supportive effect of abstract categorization has been shown in learning complex topics (for math, see Hardiman et al., 1989; Kikas et al., 2020; for reading, see Kikas and Jõgi, 2016).

Most students are able to use different LS beginning in lower middle school (age 9–10; see Crone and Steinbeis, 2017). Children often begin using COrLS more widely during elementary and middle school (Schneider et al., 2004; Best et al., 2009; Shing and Lindenberger, 2011; Schleepen and Jonkman, 2012; Daugherty and Ofen, 2015). Spontaneous use of COrLS usually does not begin until mid to late childhood, when children still benefit less from COrLS than adolescents and young adults (Clerc et al., 2014). The use of COrLS—and abstract grouping, in particular—is related to structural and functional changes in the prefrontal cortex (Yu et al., 2018) which take time to develop. Findings indicate that, between kindergarten and middle school, students learn more about memory functioning and the usefulness of LS (Fritz et al., 2010; Schneider, 2008). However, students tend to experience utilization deficiency—i.e., although strategies are used correctly, student performance is not always good (Clerc et al., 2014). In addition, young children often have difficulty evaluating memory function and performance (Clerc et al., 2014) and tend to have misbeliefs about the effectiveness of different strategies. For instance, Daugherty and Ofen (2015) studied beliefs about the effectiveness of rehearsal and COrLS (shallow and deep encoding, respectively) and found that, while adolescents and adults preferred COrLS, children were equally likely to choose rehearsal or COrLS. The authors further discovered that COrLS ratings increased with age and accounted for better associative recognition.

In summary, while rehearsal strategies may be effective for short-term learning, COrLS support long-term retention of material and learning with understanding. Skills in using COrLS develop with age and school years, and young students often use rehearsal due to limited knowledge and underdeveloped cognitive abilities. COrLS specifically lead to comprehension of material, learning with understanding, and the ability to later access learned material. To the best of our knowledge, no published study has examined the possibility that beliefs in the effectiveness of LS and their effects on learning (including text comprehension) may differ between age groups. Thus, our study aims to fill this gap by using two groups: students in primary school (Grade3/4) and middle school (Grade 9).

## Assessing Learning Strategies

Learning strategies are usually assessed *via* self-report questionnaires (Weinstein et al., 2011). However, students may use different strategies in different contexts and tasks. Such questionnaires usually include broadly worded items that presume the ability to be generalized across times and conditions (Richardson, 2004). In addition, it has been shown that retrospective accounts may introduce potential memory failure and distortions (Veenman, 2011). Therefore, researchers have suggested using task-specific strategy inventories, where questions refer to recently completed learning tasks (Samuelstuen and Bråten, 2007). One possibility is to use a word list memorization task with follow-up questions (Kikas and Jõgi, 2016; Kikas et al., 2020, 2021).

Word memorization tasks have been widely used in experimental studies about memory strategies (Bjorklund et al., 1992; DeMarie et al., 2004; Yu et al., 2018). In some studies, words have been presented sequentially (Yu et al., 2018), while in others, children see words or objects simultaneously (Gaskill and Murphy, 2004). When a person is given a short period of time to remember a list of words, the person may use simple rehearsal or try to elaborate and categorize words in some way. Categorization strategies have been shown to support learning word lists (Gaskill and Murphy, 2004; Ornstein et al., 2010). Most young children do not spontaneously organize to-be-remembered items semantically, but they are capable of such organization if given specific instructions to that effect (Gaskill and Murphy, 2004). With age and experience, children's organizational strategies become increasingly effective (Ornstein et al., 2010; Grammer et al., 2011).

Prior researchers have used word-memorization tasks which included reflection questions about the use and efficacy of various LS (Kikas and Jõgi, 2016; Kikas et al., 2020, 2021). In these studies, words were shown simultaneously and could be easily visualized and categorized into abstract or perceptually based groups, but students were not given any suggestion that such categorization was possible. Results of these studies have shown that, until the end of middle school, the vast majority of students use and perceive rehearsal to be more effective than COrLS. Some studies have also shown that LS are related to academic skills. Namely, reported use of abstract categorization in a word-memorization task was related to higher math calculation and problem-solving skills (Kikas et al., 2020), and reported use of COrLS was related to better math and reading skills (Kikas and Jõgi, 2016).

## Text comprehension and the role of prior knowledge and beliefs in this process

Several models of reading comprehension define text comprehension as a multifaceted process of forming coherent mental representations of presented information (e.g., Kintsch, 2013). Constructing mental representations requires readers to identify semantic connections between various elements of the message and their prior knowledge (van den Broek and Kendeou, 2008). These connections are readily identified if the reader's background knowledge has strong prior associations to the concepts covered in the text. In contrast, text comprehension becomes difficult when a reader's prior knowledge and beliefs do not support the creation of mental representations. For example, O'Reilly and McNamara (2007) showed that, when there is a conflict between prior knowledge and textual information, readers may fail to draw the necessary inferences to connect ideas in the text. Studies have also found that readers who have scientific misconceptions produce more invalid inferences and

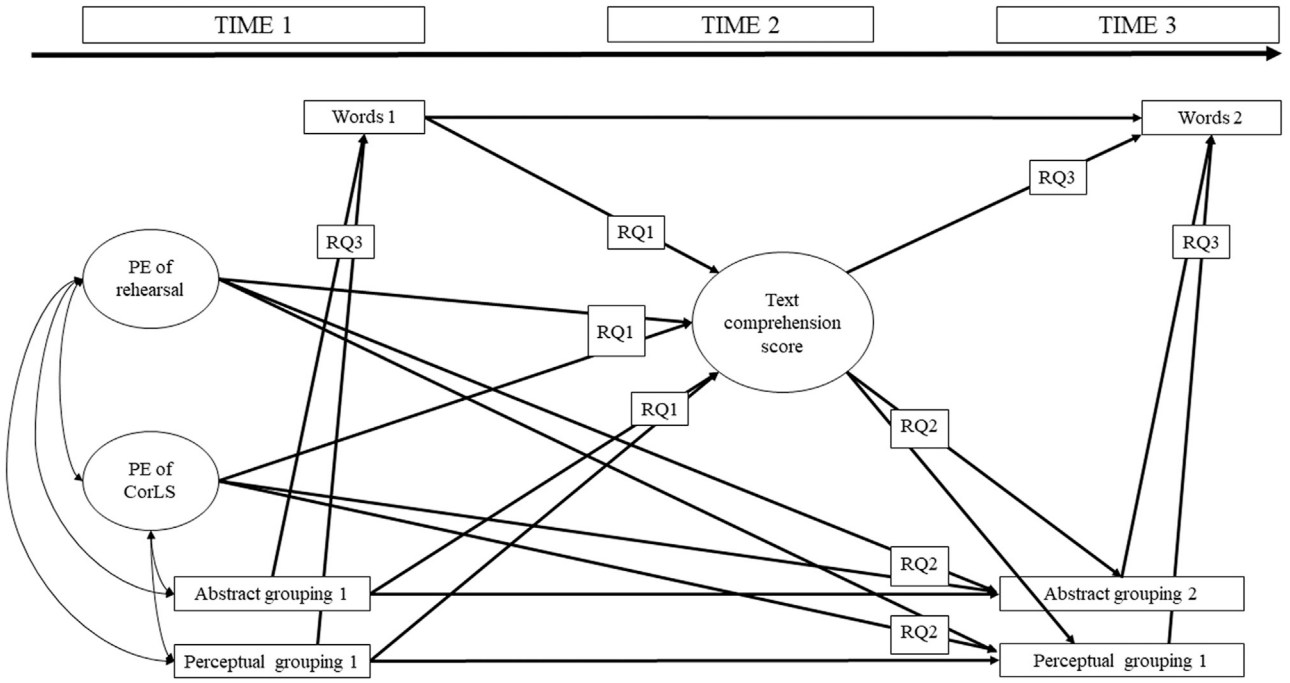


**FIGURE 1 |** Theoretical model and study design.

recall less information than students who do not have prior misconceptions (Diakidoy et al., 2003; Kendeou and van den Broek, 2005, 2007). Thus, in cases of insufficient or incompatible prior knowledge, a reader may fail to recognize semantic connections in the text, thereby hindering meaningful learning.

Specific *refutation texts* have been used to support conceptual change in students with insufficient or incompatible prior beliefs. A refutation text 1) introduces a common theory, belief, or idea; 2) refutes it; and 3) offers an alternative theory, belief, or idea that is shown to be more satisfactory (Hynd, 2001; Tippett, 2010; Lem et al., 2017). Refutation texts usually include a single misconception stated in one sentence, with a single refutation statement presented in the following sentence (e.g., Broughton et al., 2010). A growing body of studies have found a positive effect of refutation texts on conceptual change-oriented learning, but there are also exceptions (for reviews, see Tippett, 2010; Zengilowski et al., 2021). Empirical studies have shown that refutation texts increase the likelihood that readers co-activate incorrect prior knowledge and correct scientific conceptions depicted in the text. This co-activation may help readers detect inconsistencies between prior knowledge and scientifically correct knowledge. This ultimately guides the reader toward proper scientific understanding (see van den Broek and Kendeou, 2017). The effects of refutation texts have been explored in different areas like science, mathematics, and psychology (e.g., Braasch et al., 2013; Beker et al., 2019; van Hoof et al., 2021). A full understanding of COr strategies may require conceptual change, thus refutation texts may be valuable to teachers and students alike.

Ongoing research suggests that reading involves not only the construction of mental representations of presented information, but also the *use* of the meaning that is constructed (see Afflerbach et al., 2020). Thus, readers are expected to do something with the meaning that they construct—e.g., to apply what they learn from the text to solve problems. The current study examines the effect of comprehension of a refutation text about ineffective and effective learning strategies for memorizing information on COrLS use in a word-memorization task among primary and middle school students.

## The current study

The present study was carried out in Estonia, where children start school at age seven and comprehensive school lasts 9 years. As the Estonian orthography is transparent, reading acquisition is relatively easy for children: by the end of first grade, the majority of children in Estonia are rather fluent readers at the word level (Soodla et al., 2015). According to the Estonian National Curriculum for basic schools, students are expected to read fluently and comprehend different types of texts by the end of third grade (Estonian Government, 2020). Thus, it was assumed that participants in the current study (students from Grades 3, 4, and 9) would be able to read and comprehend all written text and tasks used in the study.

The aim of this study was to examine prior beliefs about the effectiveness of rehearsal and COrLS, as well as reported use of COrLS as it relates to the comprehension of refutation text and later use of COrLS. **Figure 1** presents the theoretical model, including the study design and variables. Students at two school levels (Grades 3/4 and 9) were asked to memorize different word lists twice, at Time 1 and Time 3 (cf. Kikas and Jõgi, 2016). In the time period between the memorization tasks (Time 2), students

were asked to read a refutation text related to LS and learning words. At no point were students given hints or suggestions about the possibility of using LS to memorize words. Students who used rehearsal formed a reference group, while those who used COrLS were divided into two groups: perceptual grouping and abstract grouping. Analyses were carried out separately for each school level. Research questions and hypotheses were as follows.

First, what effects do perceived effectiveness of rehearsal and COrLS, use of COrLS in Word Memorization Task 1, and word memorization performance have on text comprehension? We expected that stronger beliefs in the efficacy of COrLS and use of COrLS would relate to better text comprehension, while stronger beliefs in the efficacy of rehearsal would relate to poorer text comprehension. These hypotheses were based on prior studies which showed positive effects of correct knowledge and negative effects of misconceptions on text comprehension (Diakidoy et al., 2003; Kendeou and van den Broek, 2005, 2007). We also hypothesized that better word memorization performance would relate to better text comprehension.

Second, what effects do beliefs in the effectiveness of rehearsal and COrLS, use of COrLS in Word Memorization Task 1, and text comprehension have on COrLS use in Word Memorization Task 2? We expected that students who placed a higher value on COrLS and lower value on rehearsal would tend to use COrLS in Task 2. We also expected that students with better text comprehension would report using COrLS because the text explained the advantages of these strategies.

Third, how is word memorization performance related to COrLS use (Task 1 and 2) and text comprehension (Task 2)? We expected that students who reported using COrLS would show better performance on both word-memorization tasks. Earlier studies have shown that categorization strategies support learning word lists in different age groups (Gaskill and Murphy, 2004; Ornstein et al., 2010; Kikas and Jõgi, 2016; Kikas et al., 2020, 2021). Still, these relationships may be weak due to utilization deficiency (Bjorklund et al., 1997; Clerc et al., 2014). We also expected that students with better text comprehension would show better performance in Task 2 as the text describes how to remember words.

For each research question, we also examined if relations were similar at both grade levels. We did not formulate grade-related hypotheses.

# METHODS

This study used two data sources. First, data for Grades 3/4 came from students who completed a web-based learning to learn competence test. Learning to learn is one of eight key competences emphasized in the Estonian National Curriculum for basic schools (Estonian Government, 2020). The tool for Grades 2–6 is available on the Examinations Information System website (https://eis.ekk.edu.ee/eis) and may be freely used by teachers for learning-oriented assessment of learning to learn competence (see Zeng et al., 2018). An exhaustive manual provides descriptions of the background of the constructs as well as guidelines for carrying out the tests and interpreting the results. Although its usage is not compulsory, many teachers use it.

Second, data for Grade 9 came from a background survey related to the upper middle-school Estonian Language Exam. Background surveys of basic school state examinations aim to assess students' learning to learn-related competence (motivation, beliefs, learning strategies) and have been carried out in Estonia since 2016. Schools were invited to participate through the Estonian Ministry of Education and Research. Participation is voluntary, but the majority of schools participate as teachers get feedback on their students' learning to learn competence.

## Sample and Procedure

The younger sample included 2,706 students (1,672 from Grade 3 and 1,034 from Grade 4; mean age 10.05; 50% boys), and the older sample included 3,782 students from Grade 9 (mean age 15.64; 49% boys). Students from Grades 3 and 4 studied in 67 Estonian-language schools in different parts of Estonia; students in Grade 9 studied in 199 Estonian-language schools in different parts of Estonia. Of these schools, 29 were the same for Grades 3/4 and Grade 9. Both samples included schools of various sizes from both urban and rural areas. Tests were conducted in Estonian, as this was the language of instruction for all schools as well as the native language of the large majority of students. Russian-language tests were also available for all students. Russian-language tests were mainly used in Russian-language schools but were also used by some students who spoke Russian at home. Data from Russian-language tests were not used in this study.

Testing sessions in Grades 3 and 4 took place in teacher-supervised computer labs during a regular school day. The test battery for assessing learning to learn competence included questions and tasks for assessing learning motivation, self-efficacy, and math/reading strategies. Students took up to 45 min to complete the entire test battery. Data were collected from students in Grades 3/4 who had completed tests from May 2017 until May 2019. All students had permission from their parents or guardians to participate in the study.

In Grade 9, schools were invited to participate in a study regarding background factors related to learning the Estonian language and studying literature. Participation was voluntary; all student participants were granted permission from their parents or guardians prior to participating in the study. Each school and class was allowed to select the most suitable time during the month of May (2019) to complete the online questionnaire. Testing was supervised by subject teachers and took place in computer labs during a regular school day. The test battery included questionnaires for assessing reading-related learning motivation, self-efficacy, reading strategies, and so on. Completion of the test battery took up to 45 min.

In both versions of the test battery, the first word-memorization task (Task 1) was given at the beginning of the test battery (Time 1), and the second word-memorization task (Task 2) was given at the end of the test battery (Time 3). The refutation text was provided in the time period between the two word-memorization tasks (Time 2; see **Figure 1**). An identical

sequence of measures was implemented at both school levels. In addition to the word-memorization task, each test included several other tasks that differed between Grades 3/4 and 9 but did not apply to the current study.

## Measures

The Word List Memorization Task was used for assessing reported strategy use and perceived strategy effectiveness (see Kikas and Jõgi, 2016; Kikas et al., 2021). First, students were asked to memorize 21 Estonian nouns in Grades 3/4 and 24 Estonian nouns in Grade 9. All words were displayed together at the same time on a computer screen in a random arrangement. Words were four to seven letters long and commonly used in everyday language. Words came from three broad, well-known categories (e.g., in Task 1 plants, furniture, animals). Students were neither informed about the categories nor about the possibility to categorize words in any way. Students had 90 s to memorize the words, after which the words disappeared from the screen. Students were then asked to choose the memorized words from a list of 35 words in Grades 3/4, and from a list of 48 words in Grade 9. Students were allowed to choose up to 21 words in Grades 3/4 and up to 24 words in Grade 9. The number of words was different in Grades 3/4 and Grade 9 due to differences in the computer interface for each school level. The task was presented twice: once at the beginning of the test (Time 1; Task 1) and again at the end of the test (Time 3, Task 2). The words to be memorized in the second task were different from those in the first task. Word memorization performance scores (Words 1 and Words 2) were used in subsequent analyses and were composed of the sum of marked learned words plus unmarked additional words (maximum of 35 in Grades 3/4; maximum of 48 in Grade 9).

After completing both memorization tasks (Time 1 and Time 3), students were shown six specific learning strategies and asked to choose the strategy they had used to memorize the words. Students could only choose one strategy. Strategy options were selected from earlier studies which included an open question on strategy use (Kikas and Jõgi, 2016). Two of the strategies tapped rehearsal ("I repeated the words several times in my mind"; "I read the words several times"), three strategies dealt with perceptual grouping ("I formed sentences from the words and memorized those"; "I visualized objects according to the words and memorized those visualizations"; "I grouped the words by first letter and memorized them as groups"), and one strategy was related to abstract grouping ("I grouped the words by their meaning and memorized as groups"). If a student could not find the appropriate description from the list, they were also given the opportunity to describe their strategy using their own words. When possible, researchers categorized these answers into one of the six examined strategies and included them in subsequent analyses. Responses that wrote something else, did not answer the question, or merely copied the words were treated as missing data. According to these answers, three groups of students were formed according to strategy use: rehearsal, perceptual grouping, and abstract grouping. Two dummy-coded indicators were used in subsequent analyses: perceptual grouping (1—used; 0—did not use) and abstract grouping (1—used; 0—did not use). Students who stated using rehearsal formed a reference group.

Beliefs about strategy effectiveness (perceived effectiveness on LS). After the first memorization task (Time 1, Task 1), students were asked to evaluate the effectiveness of each strategy for memorizing target words. The same six strategies were shown again. Students evaluated each strategy on a five-point Likert-type scale (1—very bad [. . .] 5—very good). Multi-group confirmatory factor analysis (i.e., measurement invariance testing) was carried out to see whether the two strategies that described rehearsal and the four that described COrLS converged into two distinct factors at both school levels. Results confirmed scalar invariance (see **Appendix**). According to these analyses, two latent scores were used: Perceived effectiveness of rehearsal and Perceived effectiveness of COrLS. Internal reliabilities of the scales were acceptable at both school levels (for Perceived effectiveness of rehearsal, Cronbach's $\alpha$ = 0.560 and 0.750 for Grades 3/4 and Grade 9, respectively; for Perceived effectiveness of *COrLS*, Cronbach's $\alpha$ = 0.807 and 0.724 for Grades 3/4 and Grade 9, respectively).

A Text comprehension task was used for assessing text comprehension. In the time period between the two word-memorization tasks (Time 2), students were asked to read a refutation text that explained the most effective ways to memorize words. In Grades 3/4, the text was composed of 273 words (27 sentences), and in Grade 9, the text was composed of 325 words (33 sentences). The difficulty levels of the texts were similar in Grades 3/4 and 9: the mean number of letters per word was 6.05 ($SD$ = 6.72) and 5.94 ($SD$ = 6.67), respectively, $t$ 591) = 0.20, $p$ = 0.84. Refutation texts were also similar in terms of sentence length: in Grades 3/4, the mean number of words per sentence was 9.41 ($SD$ = 4.16), and in Grade 9, the mean number of words per sentence was 9.56 ($SD$ = 4.42), $t$ (61) = −0.13, $p$ = 0.89. Thus, the texts were similar in terms of both lexical difficulty and syntactic complexity.

The content of both texts was also very similar. Both texts first discussed commonly used but relatively ineffective strategies for memorizing information (i.e., rehearsal). Next, alternative strategies were described, along with explanations about why these strategies are more effective for learning. The texts explained that, although some people use rehearsal to memorize words, this strategy is not an effective way to learn a large number of words in a short period of time. The text described how perceptual and abstract grouping are more effective by categorizing words and creating connections between previous knowledge and target words. The text also stated that abstract grouping is the best overall way to learn words. Finally, the text provided a concrete example of how to categorize words in abstract groups. Students had unlimited time to read the text but could not proceed to the next task until a minimum of two minutes had elapsed.

After reading the text, five multiple-choice questions about the text were displayed on the computer. Each question included four answer choices as well as a fifth "I don't know" option. The latter option was added to reduce the probability of students choosing right answers by chance. Each question only had one correct answer. Students could not refer to the text while answering the questions. Questions assessed students' ability to understand and integrate information presented in the text. As an example, one

**TABLE 1 |** Descriptives of All Study Variables for Grades 3/4 and 9.

| Variables | Grades 3/4 | | | | | Grade 9 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | *n* | *M* | *SD* | *Min* | *Max* | *n* | *M* | *SD* | *Min* | *Max* |
| Words Task1 | 2,706 | 25.58 | 5.01 | 4 | 35 | 3,782 | 39.00 | 6.17 | 19 | 48 |
| Words Task2 | 2,675 | 25.97 | 5.47 | 3 | 35 | 3,782 | 38.43 | 7.09 | 16 | 48 |
| Strategy: Perceptual grouping Task1 | 2,626 | 0.11 | 0.32 | 0 | 1 | 3,782 | 0.13 | 0.34 | 0 | 1 |
| Strategy: Perceptual grouping Task2 | 2,617 | 0.32 | 0.47 | 0 | 1 | 3,782 | 0.23 | 0.42 | 0 | 1 |
| Strategy: Abstract grouping Task1 | 2,626 | 0.03 | 0.18 | 0 | 1 | 3,782 | 0.12 | 0.32 | 0 | 1 |
| Strategy: Abstract grouping Task2 | 2,617 | 0.07 | 0.25 | 0 | 1 | 3,782 | 0.25 | 0.44 | 0 | 1 |
| Text comprehension | 2,696 | 0.35 | 0.26 | 0 | 1 | 3,782 | 0.64 | 0.28 | 0 | 1 |
| Perceived effectiveness of rehearsal | 2,706 | 4.28 | 0.83 | 1 | 5 | 3,782 | 3.78 | 0.82 | 1 | 5 |
| Perceived effectiveness of COrLS | 2,706 | 2.57 | 0.97 | 1 | 5 | 3,782 | 3.01 | 0.79 | 1 | 5 |

**TABLE 2 |** Correlations between All Study Variables for Grades 3/4 and 9.

| Grade 3/4 | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Words Task1 | | | | | | | | |
| 2 | Words Task2 | 0.555** | | | | | | | |
| 3 | Strategy: Perceptual grouping Task1 | –0.081** | –0.080** | | | | | | |
| 4 | Strategy: Perceptual grouping Task2 | –0.032 | 0.009 | 0.189** | | | | | |
| 5 | Strategy: Abstract grouping Task1 | 0.075** | 0.064** | –0.068** | –0.029 | | | | |
| 6 | Strategy: Abstract grouping Task2 | 0.114** | 0.165** | –0.018 | –0.184** | 0.329** | | | |
| 7 | Text comprehension | 0.218** | 0.284** | –0.028 | 0.088** | 0.172** | 0.303** | | |
| 8 | Perceived effectiveness of rehearsal | 0.097** | 0.100** | –0.206** | –0.093** | –0.135** | –0.087** | 0.011 | |
| 9 | Perceived effectiveness of COrLS | 0.001 | 0.015 | 0.176** | 0.143** | 0.158** | 0.117** | 0.121** | 0.087** |
| **Grade 9** | | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** |
| 1 | Words Task1 | | | | | | | | |
| 2 | Words Task2 | 0.535** | | | | | | | |
| 3 | Strategy: Perceptual grouping Task1 | 0.066** | 0.023 | | | | | | |
| 4 | Strategy: Perceptual grouping Task2 | 0.017 | 0.057** | 0.288** | | | | | |
| 5 | Strategy: Abstract grouping Task1 | 0.177** | 0.149** | –0.141** | –0.096** | | | | |
| 6 | Strategy: Abstract grouping Task2 | 0.118** | 0.261** | –0.023 | –0.323** | 0.394** | | | |
| 7 | Text comprehension | 0.206** | 0.347** | 0.012 | 0.049** | 0.183** | 0.322** | | |
| 8 | Perceived effectiveness of rehearsal | 0.028 | 0.003 | –0.176** | –0.052** | –0.168** | –0.149** | –0.028 | |
| 9 | Perceived effectiveness of COrLS | 0.088** | 0.110** | 0.156** | 0.096** | 0.208** | 0.196** | 0.178** | –0.131** |

**p < *0.01*.

item was, "Words can be remembered most easily and effectively" with the following choices: 1) if I imagine them in pictures; 2) if I repeat them several times; 3) if I group them according to meaning (correct choice); 4) if I read them several times; or 5) I don't know. Answers were coded as correct 1) or incorrect (0). A latent variable (text comprehension score) was used in subsequent analyses. Internal reliabilities of the scales were acceptable at both school levels (Cronbach's $\alpha$ = 0.62 and 0.77 for Grades 3/4 and Grade 9, respectively).

## Analysis Strategy

Data were analyzed using the M*plus* statistical package (Version 8.3; Muthén and Muthén, 1998–2017). SEM models were used to answer research questions. First, we employed the measurement models for perceived effectiveness of LS and text comprehension. Second, we specified the model presented in **Figure 1**. We estimated two models: one for Grades 3/4 and one for Grade 9. Because of the large sample size, both models were trimmed at the $p < 0.001$ level. Items related to reported strategy use and text comprehension were specified as categorical variables.

A missing data analysis showed that the proportion of missing data for all studied variables ranged from 0 to 1.233%. The data were not missing at random, Little (1988) MCAR test: $\chi^2$ 49) = 289.628, $p \leq 0.001$. We used the standard full-information maximum likelihood (FIML) approach for the missingness. This missing data method uses all data that are available in order to estimate the model without imputing data.

Model fit was examined using five model-fit statistics: chi-square ($\chi^2$), the comparative fit index (*CFI*), the Tucker–Lewis index (*TLI*), the root mean square error of approximation (*RMSEA*), and the standardized root mean square residual (*SRMR*). Non-significant $\chi^2$, *CFI*, and *TLI* values above 0.90, and *RMSEA* and *SRMR* values below 0.10 indicate an acceptable model fit (Hu and Bentler, 1999; Muthén and Muthén, 1998–2017). However, since model-fit statistics can be misleading when dealing with complicated models and large sample sizes, each must be judged individually depending on the model (Kline, 2015).

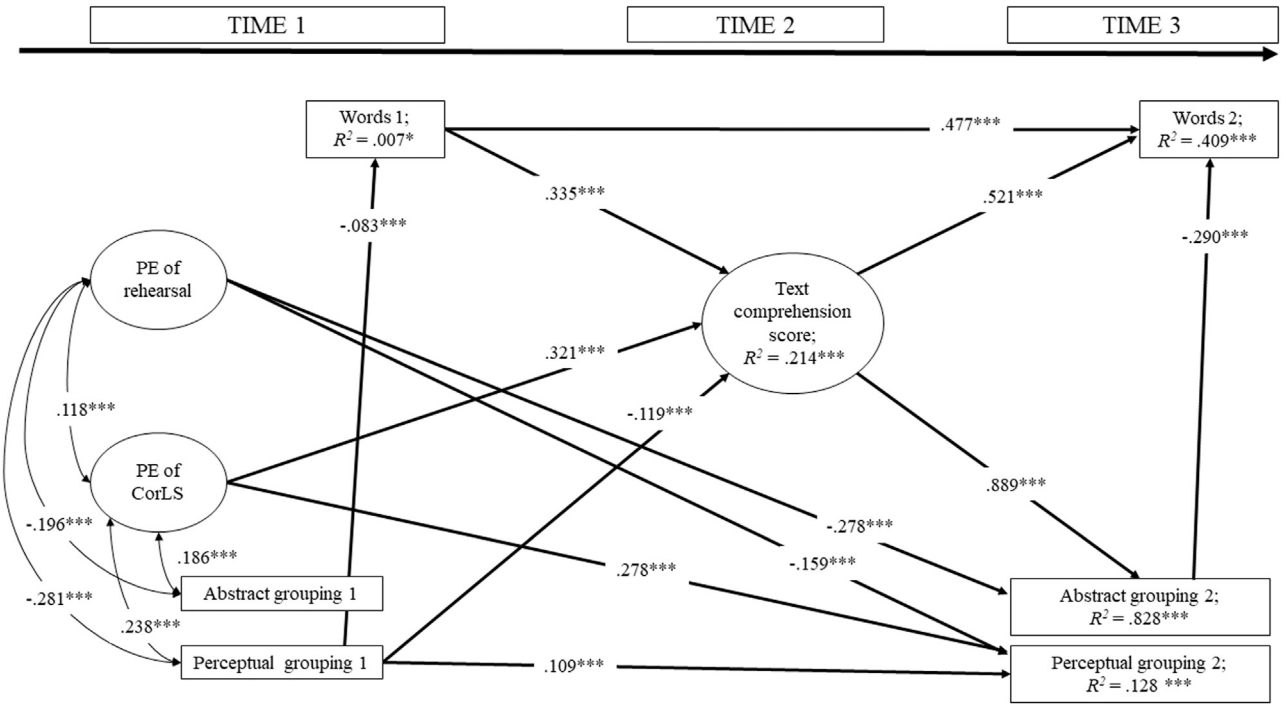


**FIGURE 2 |** Standardized solution of Structural Equation Model in Grades 3/4. Only significant paths and correlations are shown; ***$p < 0.001$.

## RESULTS

**Table 1** presents means and standard deviations for Grades 3/4 and 9. **Table 2** presents correlations among all constructs for Grades 3/4 and 9.

We started by estimating the model for primary school ($n$ = 2,706). The model is presented in **Figure 2**. Model fit was $\chi^2$ [103] = 485.974, $p < 0.001$; *CFI* = 0.911, *TLI* = 0.882, *RMSEA* = 0.039 90% C.I [0.034, 0.040], *SRMR* = 0.111). In relation to the first research question (RQ1), the results showed that better text comprehension was predicted by better word memorization performance in Task 1 ($\beta$ = 0.335, *S.E.* = 0.024, $p < 0.001$) and higher perceived effectiveness of COrLS ($\beta$ = 0.321, *S.E.* = 0.032, $p < 0.001$). Students who reported using perceptual grouping tended to have poorer text comprehension compared with students who reported using rehearsal or abstract grouping ($\beta$ = –0.119, *S.E.* = 0.022, $p < 0.001$).

In relation to the second research question (RQ2), use of abstract grouping in Word Memorization Task 2 was predicted by better text comprehension ($\beta$ = 0.889, *S.E.* = 0.032, $p < 0.001$) and lower perceived effectiveness of rehearsal ($\beta$ = –0.278, *S.E.* = 0.034, $p < 0.001$). Use of perceptual grouping, however, was predicted by lower perceived effectiveness of rehearsal ($\beta$ = –0.159, *S.E.* = 0.034, $p < 0.001$) and higher perceived effectiveness of COrLS ($\beta$ = 0.278, *S.E.* = 0.034, $p < 0.001$). Use of perceptual grouping tended to be stable across both word-memorization tasks ($\beta$ = 0.109, *S.E.* = 0.022, $p < 0.001$).

In relation to the third research question (RQ3), students who reported using perceptual grouping tended to perform lower the first word-memorization task ($\beta$ = –0.083, *S.E.* = 0.017, $p < 0.001$), and students who reported using abstract grouping tended to perform lower in the second task ($\beta$ = –0.290, *S.E.* = 0.082, $p < 0.001$). However, the latter association should be interpreted with caution due to its inconsistency with zero-order correlation in **Table 2** ($r$ = 0.165, $p < 0.01$). We also estimated indirect effects from perceived effectiveness of rehearsal and COrLS (Time 1) to Word Memorization Task 2 (Time 3). One indirect effect from perceived effectiveness of rehearsal *via* using abstract grouping in Task2 to Word Memorizing score in Task 2 was significant ($\beta$ = 0.081, *S.E.* = 0.020, $p < 0.001$). For perceived effectiveness of COrLS, two indirect paths were significant: one indirect path from perceived effectiveness of COrLS to Word Memorization Task 2 *via* text comprehension ($\beta$ = 0.167, *S.E.* = 0.031, $p < 0.001$), and another *via* text comprehension and use of abstract grouping in Task 2 ($\beta$ = –0.083, *S.E.* = 0.025, $p$ = 0.001).

Next, we estimated the model for middle school ($n$ = 3,782). The model is presented in **Figure 3**. Model fit was $\chi^2$ [105] = 1,374.575, $p < 0.001$; *CFI* = 0.867, *TLI* = 0.828, *RMSEA* = 0.057, 90% C.I [0.054, 0.059], *SRMR* = 0.089). In relation to RQ1, results showed that better text comprehension was predicted by use of abstract grouping ($\beta$ = 0.166, *S.E.* = 0.021, $p < 0.001$), higher word memorization scores in Task 1 ($\beta$ = 0.214, *S.E.* = 0.019, $p < 0.001$), and higher perceived effectiveness of COrLS ($\beta$ = 0.231, *S.E.* = 0.024, $p < 0.001$). In relation to RQ2, use of abstract grouping in Word Memorization Task 2 was predicted by better text comprehension ($\beta$ = 0.570, *S.E.* = 0.024, $p < 0.001$), lower perceived effectiveness of rehearsal ($\beta$ = –0.127, *S.E.* = 0.021, $p < 0.001$), and higher perceived effectiveness of COrLS

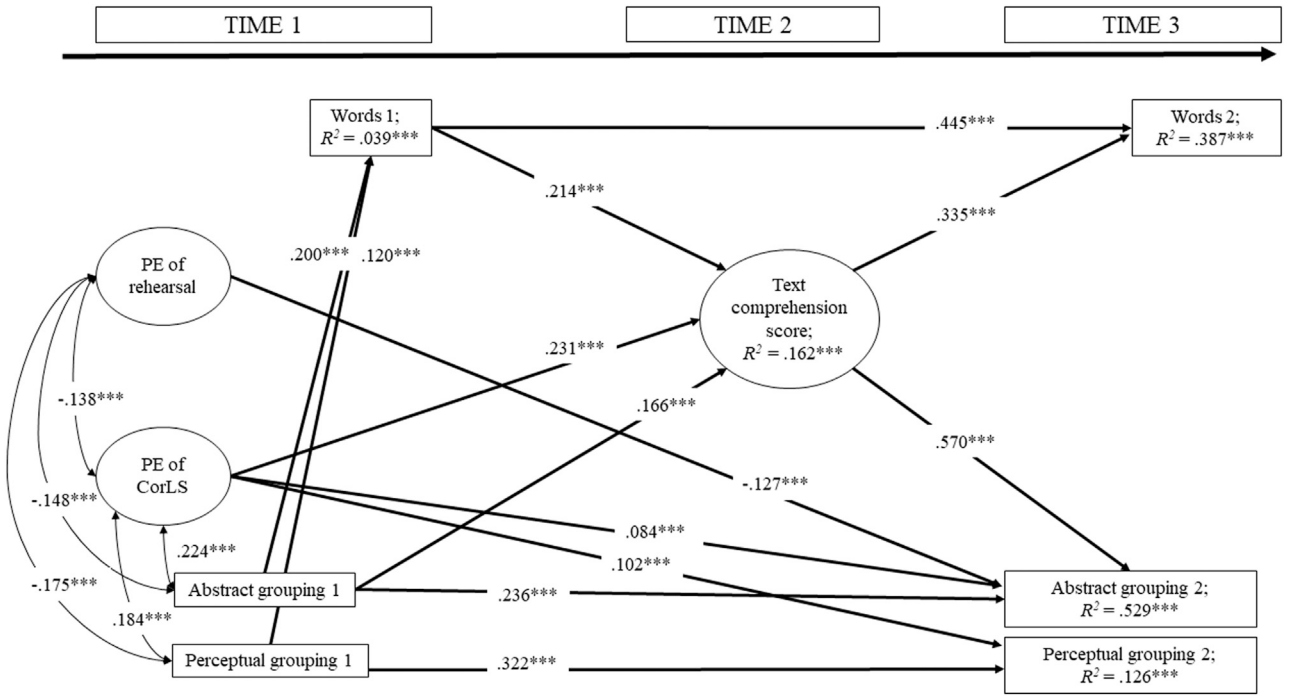


**FIGURE 3 |** Standardized solution of Structural Equation Model in Grade 9. Only significant paths and correlations are shown; ***$p < 0.001$.

($\beta = 0.084$, *S.E.* = 0.023, $p < 0.001$). Reported use of perceptual grouping for Word Memorization Task 2 was predicted by higher perceived effectiveness of COrLS ($\beta = 0.102$, *S.E.* = 0.023, $p < 0.001$). Both grouping strategies—perceptual grouping ($\beta = 0.322$, *S.E.* = 0.019, $p < 0.001$) and abstract grouping ($\beta = 0.236$, *S.E.* = 0.019, $p < 0.001$)—tended to be stable across both word-memorization tasks.

In relation to RQ3, higher word memorization performance in Task 1 was predicted by use of perceptual grouping ($\beta = 0.120$, *S.E.* = 0.025, $p < 0.001$) and abstract grouping ($\beta = 0.200$, *S.E.* = 0.024, $p < 0.001$). Higher word-memorization performance in Task 2 was predicted by better text comprehension ($\beta = 0.335$, *S.E.* = 0.016, $p < 0.001$) and higher word-memorization scores in Task 1 ($\beta = 0.445$, *S.E.* = 0.011, $p < 0.001$). Finally, we estimated indirect effects from perceived effectiveness of rehearsal and COrLS (Time 1) to word memorization in Task 2 (Time 3). None of the indirect paths from perceived effectiveness of rehearsal to word memorization in Task 2 were significant. For perceived effectiveness of COrLS, an indirect path from perceived effectiveness of COrLS to word memorization in Task 2 *via* text comprehension was significant ($\beta = 0.077$, *S.E.* = 0.009, $p < 0.001$).

## DISCUSSION

This study investigated how primary and middle school students' prior beliefs in the effectiveness of rehearsal and COrLS and reported use of COrLS affect comprehension of text about LS and word memorization. We found that valuing COrLS supported text comprehension at both school levels, thereby suggesting the importance of prior beliefs in comprehending text. Student beliefs and text comprehension also played a role in strategy use. However, relations between strategy use and word memorization performance were somewhat less clear.

### Predictors of Text Comprehension

At both school levels, higher evaluations of the effectiveness of COrLS were related to better text comprehension. This may indicate that beliefs or metacognitive knowledge of LS guide students' information processing and interpretations of text by making semantic connections between elements of the text and allowing students to build coherent mental representations and use it afterwards when answering to questions on the text (Afflerbach et al., 2020; van den Broek and Kendeou, 2017). With coherent mental representations, more information can be held in working memory, thereby supporting better interpretation of the text. For students who valued COrLS—specifically abstract categorization—the main idea of the text may have already been known, meaning they only had to remember a few new details. Thus, later recall might have been easier. Students who perceived the efficacy of COrLS lower had to remember more new information, thus difficulties in text comprehension might have occurred due to working memory overload (Schleepen and Jonkman, 2012). Students might have also disagreed with the textual information, leading to difficulties in integrating ideas presented in the text (cf. Diakidoy et al., 2003; Kendeou and van den Broek, 2005, 2007; O'Reilly and McNamara, 2007; Lem et al., 2017). However, valuing rehearsal was not found to inhibit understanding. As rehearsal

can be effective in some cases, there is no need for conceptual change. It is important to note that self-report measures do not provide information about how students felt in their evaluations or why they considered certain methods to be more effective.

Metacognitive knowledge of LS also guides students to apply LS (Clerc et al., 2014; Daugherty and Ofen, 2015). Students who reported using COrLS valued COrLS strategies higher and rehearsal lower. Still, Grade 9 students who used abstract grouping tended to comprehend the text better, while students in Grades 3/4 who used perceptual grouping tended to have even lower text comprehension scores. It should be emphasized that these were self-reports and that students could only mark one strategy. In reality, students may have used multiple strategies. This task of reporting on strategy use might be specifically confusing for younger students.

At both school levels, text comprehension was predicted by better word memorization performance in Task 1. Memorization and task comprehension presume motivation and similar cognitive skills—specifically, attention and working memory. When memorizing words and reading text, students must focus their attention. In addition, when recognizing words and answering multiple-choice questions, students must be capable of shifting between stimuli, differentiating between correct and incorrect stimuli, inhibiting incorrect stimuli, focusing on correct stimuli, and recognizing correct answers. In the present study, some students may have failed to fully read the text or finish the task (for the importance of motivation and effort in learning, see Yen et al., 2004). We may also hypothesize that those with better word-memorization performance used more effective LS. To some extent, word-memorization performance may indicate appropriate strategy use, which itself supports text comprehension. As mentioned before, reading text and making correct deductions has been shown to depend on prior knowledge (Diakidoy et al., 2003; Kendeou and van den Broek, 2005, 2007; Lem et al., 2017; van den Broek and Kendeou, 2017).

## Predictors of Reporting COrLS Use in Word Memorization Task 2

Students with better text comprehension tended to report using abstract grouping in Word Memorization Task 2. This effect was especially high in Grades 3/4. Thus, we may argue that a brief independent reading of a carefully designed refutation text could guide students to search for more effective learning strategies when memorizing words. The text emphasized the advantages of abstract grouping and included specific examples of how to memorize words in distinct categories. Students may have remembered the text and examples when answering questions pertaining to Task 2. However, we only studied reported use, not actual use. Thus, we do not know whether students actually used COrLS or only reported what was described as the best strategy. We may hypothesize that the large effect in Grades 3/4 may be related to younger students' tendency to report what was read in text rather than what they actually did. While many studies have confirmed the effectiveness of refutation texts to enhance conceptual change in science education (Diakidoy et al., 2003; Braasch et al., 2013; Muis et al., 2018; Beker et al., 2019), our study referred to the effectiveness of a refutation text in the area of LS.

Reported use of LS was not very stable over time, specifically among younger students, and effects of LS evaluations—while in the expected direction—were low. Effects were larger in Grades 3/4 than in Grade 9. We expected that younger students, specifically, may have difficulty evaluating their own memory function, ability to learn, and use of learning strategies (Schneider, 2008; Clerc et al., 2014; Fritz et al., 2010). As evaluations were assessed after the first word-memorization task but before reading the refutation text, some students may have changed their beliefs due to information presented in the text.

## COrLS and Learning Outcomes

At both school levels, we found a low but expected positive relationship between reported use of COrLS and success in correct word memorization and text comprehension (see Pearson correlations, **Table 2**; one exception was between perceptual grouping and Task 1 word memorizations scores in Grades 3/4). However, when other factors were taken into account, the effect of reported COrLS use on word-memorization performance was visible only for Grade 9 students in Task 1. In an earlier study that used a similar word-memorization task, seventh-grade students who used COrLS also remembered more words (Kikas and Jõgi, 2016). Moreover, studies have indicated a positive relationship between academic skills and use of COrLS or abstract categorization at the end of middle school (Kikas and Jõgi, 2016; Kikas et al., 2020).

In contrast, the impact of using COrLS on word memorization was negative in Grades 3/4. Younger students may not benefit from using COrLS for several reasons. COrLS require robust content-specific knowledge and strong working memory capacity, and younger children may not be capable of using these strategies effectively (Conklin et al., 2007). Specifically, abstract categorization presumes strong thinking ability. Young students often need hints about categories (Gaskill and Murphy, 2004); without them, these students fail to find groups or waste too much time searching for relations.

In the present study, students were not given any hints before or during the task; abstract categorization was only described in the text. The strong relationship between text comprehension and use of abstract grouping may indicate that students remembered what *should* be done, but were nonetheless incapable of following the suggestions. As a result, students with lower executive functioning or poorer categorization abilities may perform better with simple rehearsal. Negative relations—specifically those between use of abstract grouping and word-memorization outcomes in Task 2—may refer to utilization deficiency. When younger students use COrLS, there may be no benefit in performance or even a decline in performance (Clerc et al., 2014). Even if students value and use abstract grouping, they may waste too much time searching for groups, resulting in insufficient time for memorization. Students in this situation may revert back to rehearsal as an easier and more familiar strategy (cf. Clerc et al., 2014).

Younger children, in specific, tend to have difficulties using new strategies, resulting in declining outcomes (Clerc et al., 2014).

The reason Grade 9 students who applied COrLS did not perform better in Word Memorization Task 2 may also be related to utilization deficiency. The task—to identify learned words among numerous distractor words—might impede the recall of associated words because the words were presented in a random order, not in categories. In this case, free recall might have been better for students who used abstract grouping.

## Limitations and Future Directions

Some limitations of this study should be addressed. First, a word-list memorization task is only one way to assess and teach learning strategies, and this task is quite contrived. With the possible exception of learning a foreign language, memorizing words is not the aim of traditional school education. Abstract categorization, however, is related to identifying the underlying structure of new information both in science (Chi et al., 1981) and math (Hardiman et al., 1989; Kikas et al., 2020). In addition, students were given a list of strategies to choose from. Although the strategies were carefully selected based on prior studies, a list of options might still guide students to mark the strategy they thought to be the best rather than the one they actually used. The ability to choose only one strategy may also restrict and incline students' choices. Future research should include other methods of studying learning strategies, such as interviews.

Second, we used computer-based tests that have several advantages over classroom and individual tests, such as standardized coding and immediate feedback. However, computer-based tests have research limitations. When assessing memorization, students were asked to mark memorized words from a provided list; students were not given the option to write the words themselves. Thus, this task assessed recognition of learned words, not recall or reproduction. In addition, since students completed several tasks during the same test battery, some students may have become fatigued and lost motivation during the second word-memorization task. Future research should use open-ended questions which would enable researchers to examine actual strategies.

Third, we did not control for potentially confounding variables like cognitive ability or motivation. We also did not assess student reading ability, which could have impacted both word memorization and text comprehension, especially in Grades 3/4. Future studies should control for confounding factors that may affect the associations we reported.

Fourth, materials were slightly different between Grades 3/4 and Grade 9. Moreover, in addition to difference in the number of learned words, ratios of target words to all words were different (0.6 for the younger group and 0.5 for the older group). This means that students in the younger group had a higher likelihood of choosing by chance. As a result, we analyzed relations in different models and did not make strict comparisons. In addition, while sample sizes in general were large, they varied a lot between grade levels. Future studies could benefit from using identical materials that would enable direct comparison across grades.

Some model fit indices were slightly lower than general recommendations for evaluating model fit (Hu and Bentler, 1999; Muthén and Muthén, 1998–2017). We aimed to control a theoretically driven model, but lower fit indices imply that some relations in the model might be misspecified. This could reflect the aforementioned limitations of the assessment tool.

## Practical Implications and Conclusion

Despite the fact that various COrLS have been shown to be important in learning (Dent and Koenka, 2016; Dignath, et al., 2008; Fiorella and Mayer, 2015) and that Estonian teachers are encouraged to support use of learning strategies (Estonian Government, 2020), our study showed that only a minority of students use COrLS before reading a refutation text (11% of students reported perceptual and 3% abstract grouping in Grades 3/4, and 13% reported perceptual and 12% abstract grouping in Grade 9). In particular, COrLS have advantages over simple rehearsal for long-term retention and comprehension of learned material (Fiorella and Mayer, 2015). When using COrLS, learners form associations between learned materials by integrating information into a broad framework in semantic and episodic memory (Bjork et al., 2013; Takashima et al., 2017) that can later be used in solving complex problems. The vital importance of knowledge about and skills in using LS adaptively for each learning task has been emphasized as a part of learning to learn competence in various political documents (e.g., Council of the European Union, 2018). Thus, the first practical suggestion of our study refers to a need to educate students about learning strategies, to demonstrate how some strategies are more effective than others, and to provide specific information about each strategy. Consider research on developmental peculiarities of memory, learning, and LS (e.g., Schleepen and Jonkman, 2012; Crone and Steinbeis, 2017; Yu et al., 2018), this education and training should be started in primary school. Intervention studies in primary school have already verified this possibility (e.g., Gaskill and Murphy, 2004; Cornoldi et al., 2015; Kikas et al., 2021). Refutation texts have been used for teaching topics where students tend to have incorrect prior knowledge (Tippett, 2010; Zengilowski et al., 2021). We composed a refutation text about learning and LS that students had to read and comprehend independently. Independent reading may be more frequently used at school today due to the COVID-19 pandemic and distance learning. Although we found that more students reported using COrLS in the second word-memorization task after reading the text (32% reported perceptual and 7% abstract grouping in Grades 3/4, and 23% reported perceptual and 25% abstract grouping in Grade 9), reported strategy use was not related to better word memorization. As shown in other academic disciplines (Diakidoy et al., 2003; Kendeou and van den Broek, 2005, 2007), prior beliefs in the effectiveness of COrLS played a role in text comprehension. This suggests that independent reading by itself is not enough for students to learn how learning strategies should be used. Students learned factual knowledge during their reading of the refutation text but could not use this factual knowledge in practice (see utilization deficiency, Clerc et al., 2014). Thus, the second implication of our study is that reading about complex topics may be a starting point, but should be followed up with additional discussions, examples, demonstrations, and practice. Other research has specifically underscored the value of learning about LS in different lessons at school as opposed to extracurricular settings (Hattie et al., 1996).

Practicing strategies in different contexts promotes automatization, reduces cognitive load related to monitoring new strategies, and helps to overcome utilization deficiency (Clerc et al., 2014). Moreover, simply reading may not raise sufficient metacognitive awareness to learn with understanding (see Schneider, 2008; Cornoldi et al., 2015). Both younger and older students benefit from practicing the application of different strategies, seeing their efficacy, and discussing about learning, memory, and why some LS are more effective than others (see Dehn, 2010; Kikas et al., 2021).

Finally, other texts similar to the one used in the present study may be useful in school settings for teaching about learning strategies. As teachers may also lack knowledge about effective LS (e.g., Lawson et al., 2019), these texts may also enhance teachers' knowledge about LS. As text comprehension was affected by prior beliefs, teachers should guide students by providing metacognitive knowledge of why, when, and where to use each learning strategy.

In this study, we investigated the relationships between primary and middle school students' prior beliefs in the effectiveness of rehearsal and COrLS, use of these strategies, comprehension of text about LS, and word memorization. At both school levels, valuing COrLS enhanced text comprehension, suggesting that text-related prior beliefs are important in the comprehension. In addition, student beliefs and text comprehension was related to more advanced strategy use. Finally, findings about associations between strategy use and word memorization were less clear, emphasizing the need for further research.

## DATA AVAILABILITY STATEMENT

The data collected for the current study are not publicly available, but are available from the corresponding author, (EK), upon reasonable request.

## ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the Estonian legislation and institutional requirements. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

## AUTHOR CONTRIBUTIONS

EK: conceptualization, funding acquisition, methodology, writing introduction and discussion. GS: methodology, data analyses, writing the results part. KM: data analyses, writing method part. PS: writing about reading comprehension related topic.

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## APPENDIX

Fit Indices of the Measurement Invariance Models for Beliefs about Strategy Effectiveness.

| | $\chi^2$ | *df* | *p* | $\Delta\chi^2$ | $\Delta df$ | *P* | *RMSEA* | *CFI* | *TLI* | *SRMR* |
|---|---|---|---|---|---|---|---|---|---|---|
| Configural invariance | 78.20 | 6 | 0.00 | | | | 0.06 | 0.99 | 0.94 | 0.01 |
| Metric invariance | 138.20 | 10 | 0.00 | 58.90 | 4 | 0.00 | 0.06 | 0.98 | 0.94 | 0.03 |
| Scalar invariance | 236.72 | 14 | 0.00 | 89.65 | 4 | 0.00 | 0.07 | 0.97 | 0.93 | 0.04 |