Learning and Individual Differences 91 (2021) 102058

Contents lists available at ScienceDirect

Learning and Individual Differences

journal homepage: www.elsevier.com/locate/lindif

Breadth and depth of strategic processing during text comprehension

Natalia Latini, Ivar Bråten *, Ymkje E. Haverkamp

University of Oslo, Norway

ARTICLE INFO

Keywords:
Text comprehension
Strategic text processing
Verbal protocol analysis

ABSTRACT

In this study, 58 Norwegian undergraduates read 10 paragraphs on a relatively unfamiliar topic. Verbal protocol analysis was used to assess strategic text processing at different levels of depth, and post-reading written reports on the topic were used to assess text comprehension. Findings indicated that irrelevant processing was negatively and a combination of surface- and deeper-level strategies was positively related to comprehension performance, but that only irrelevant processing was a unique (negative) predictor of performance after individual differences in reading comprehension skills and prior topic knowledge had been controlled for. Finally, a combination of surface- and deeper-level strategies in the absence of irrelevant prosessing was found to mediate the effect on prior topic knowledge on comprehension performance. Taken together, these findings highlight the potential value of combining strategies at different levels of depth into a broad strategic approach for readers who lack competence or expertise in an area. As such, they may have educational as well as theoretical implications that are discussed in the article.

1. Introduction

Strategic text processing involves effortful behavioral, cognitive, and metacognitive activities intentionally performed to improve some aspect of text-based learning or comprehension (Afflerbach et al., 2008; Bråten et al., 2020; Graesser, 2007). In several prominent theories of text comprehension, such as the constructivist framework of Graesser and colleagues (Graesser, 2007; Graesser et al., 1994) and the landscape model of van den Broek and colleagues (van den Broek, 2010; van den Broek et al., 1999), strategic text processing plays an important role in creating a coherent mental representation of textual content when automatic, bottom-up processes cannot do the job. There is also ample evidence, both correlational and experimental, that strategic text processing is linked to better comprehension performance (Cho & Afflerbach, 2017; McNamara, 2007; Parris & Headley, 2015; Pressley & Harris, 2006).

In particular, using deeper-level strategies aimed at transforming textual information, for example, by generating inferences that involve cross-text connections and connections between text and prior knowledge, has been considered to play a vital role in constructing coherence during reading (Beker et al., 2017; Graesser, 2007; Magliano et al., 2007). Accordingly, research within the Direct and Inferential Mediation Model of reading comprehension by Cromley and colleagues (Cromley et al., 2010; Cromley & Azevedo, 2007) and the Inferential Mediation Model of Magliano and colleagues (Kopatich et al., 2019; Magliano et al., 2020) has indicated that such inferences not only influence text comprehension directly, but also may mediate the effects of other cognitive resources, such as vocabulary and prior topic knowledge, on comprehension performance.

In comparison, surface-level strategies, such as rereading, rehearsing, and paraphrasing textual information without transforming what is already given in the text, have been considered less valuable, with such processing typically deemed more appropriate for retention and reproduction purposes than for constructing coherent understanding of textual information (Beker et al., 2017; Magliano & Millis, 2003). To what extent strategic text processing at different levels of depth is related to performance may depend on not only contextual (i.e., how performance is assessed) but also individual factors, however.

1.1. Is deeper always better?

Recently, Dinsmore and Hattan (2020) performed a review of 15 previous review studies of levels of strategic processing and how different levels (i.e., deeper vs. surface-level) relate to performance. In addition to demonstrating that levels of processing were not consistently defined in these reviews (if at all), Dinsmore and Hattan (2020) found it difficult to conclude regarding the relationships between strategies at different levels of processing and performance, positing that "the degree

* Corresponding author at: Department of Education, University of Oslo, P.O. Box 1092, Blindern, NO-0317 Oslo, Norway.
E-mail address: ivar.braten@ped.uio.no (I. Bråten).

https://doi.org/10.1016/j.lindif.2021.102058
Received 28 December 2020; Received in revised form 9 July 2021; Accepted 10 August 2021
Available online 20 August 2021

to which these strategies are better or worse is … conditional …" (p. 41). As noted above, one such condition is the way performance is assessed, that is, in terms of coherent understanding or in terms of retention or reproduction of text information. Moreover, Dinsmore and Hattan (2020) suggested that individual differences in competence, specifically in prior domain knowledge, may determine the effectivity of different levels of processing, with efforts to use deeper-level strategies when prior knowledge is low potentially hindering rather that helping with regard to comprehension performance (e.g., because it leads to incorrect inferences). Thus, in accordance with the model of domain learning (Alexander, 1997, 2005), readers could probably profit from the use of surface-level strategies to gain foundational understanding, or from a mix of surface-level and deeper strategies, unless they have high competence or expertise in a domain (which is characterized by high prior knowledge). In the same vein, reading researchers have suggested that paraphrasing may indicate efforts to comprehend and play an important role in text comprehension, especially when combined with other, deeper-level strategies (Coté et al., 1998; van den Broek et al., 2001). For example, in a study of US undergraduates' argument writing from multiple texts, Du and List (2020) recently found that the quality of the written products was predicted not only by deeper-level (evaluation and elaboration) but also by surface-level strategies (restating). In that study, participants' strategic processing was assessed by a procedure in which they typed information about their strategy use at intermittent points during reading.

1.2. Measuring strategic processing through verbal protocol analysis

In their review of reviews, Dinsmore and Hattan (2020) also raised the issue of how strategies at different levels of processing have been measured, with most previous research in this area relying on offline self-report inventories. In the present study, we therefore measured strategies at different levels of processing by means of verbal protocol analysis and related those levels to comprehension performance. Because our participants could be expected to have rather limited background knowledge about the topic of the text, we were particularly interested in whether a *combination* of surface- and deeper-level strategies would be more strongly linked to performance than were either surface-level or deeper-level strategies alone.

Verbal protocol analysis involves having readers think aloud as they read to create a verbal protocol that subsequently can be analyzed by the researchers (Cho et al., 2020; Ericsson & Simon, 1993). Typically, readers are instructed to verbalize all thoughts related to reading that are accessible in working memory, with such thoughts considered to represent effortful meaning making activities that can be analyzed in terms of strategic text processing (Cho et al., 2020; Pressley & Afflerbach, 1995; Trabasso & Magliano, 1996). When readers are asked to verbalize their thoughts whenever they come to mind during reading, a concurrent verbal protocol becomes available; however, when readers are asked to think aloud after the reading of a particular segment of text (e.g., a sentence or paragraph), researchers work with a retrospective verbal protocol in analyzing strategic text processing (Ericsson & Simon, 1993; Pressley & Afflerbach, 1995; Trabasso & Magliano, 1996). In the latter case, it is important that processing has occurred so recently that the products of that processing remain in working memory. Accordingly, Ericsson and Simon (1993) concluded that the closer in time to reading individuals verbalized their thoughts, the more likely traces of that processing would remain in working memory and could be reported (see also, Pressley & Afflerbach, 1995). Ericsson and Simon (1993) also reported that there were few differences between verbal protocols based on concurrent and retrospective verbalization when retrospective reporting was done immediately after a few sentences or a short paragraph was read. This is supported by Pressley and Afflerbach (1995), who claimed that

> …it may simply be impossible to report what one is doing with respect to what is being read right at this instance. If that is so, there should be very little difference between what researchers claim are concurrent and what they view as briefly retrospective reports (p. 130).

Coding systems used in analyzing verbal protocols have focused on different types of inferences (e.g., backward, forward, and elaborative inferences) that can support the construction of a coherent mental representation and, as such, reflect deeper-level text processing strategies (e.g., James & Goldman, 2020; Kendeou & van den Broek, 2007; Kopatich et al., 2019; Linderholm & van den Broek, 2002; Magliano et al., 2020; Trabasso & Magliano, 1996; van den Broek et al., 1993; van den Broek et al., 2001). Moreover, these systems have typically included categories reflecting metacognitive processing (e.g., monitoring of own understanding) and evaluation of different aspects of the text (e.g., the believability of text content), as well as surface-level processing such as associations, text repetitions, and paraphrases (e.g., Coté et al., 1998; James & Goldman, 2020; Kendeou & van den Broek, 2007; Linderholm & van den Broek, 2002).

1.3. The present study

In the present study, we built on the referenced work on strategic text processing, comprehension, and verbal protocol analysis in examining relationships between different types of strategic processing and text comprehension when undergraduates read an informational text on the topic of phobias. To assess participants' strategic text processing, we asked them to think aloud immediately after having read each of 10 paragraphs, and to assess their text comprehension, we asked them to write a report on the topic in question based on their mental representation of the text content (i.e., without the text available). Specifically, these three research questions guided our investigation:

1. Is a combination of strategies at different levels of depth more strongly related to comprehension performance than are deeper-level strategies?
2. Does a mix of surface- and deeper-level strategies uniquely predict comprehension performance?
3. Does a mix of surface- and deeper-level strategies mediate the effect of prior knowledge on comprehension performance?

Prior research has indicated that deeper-level strategies are more strongly related to comprehension performance than are surface-level strategies and also contribute uniquely to comprehension (e.g., Kopatich et al., 2019; Magliano & Millis, 2003; Millis et al., 2006). Further, prior research has found that deeper-level strategies may mediate the effect of prior knowledge on comprehension performance (e.g., Cromley & Azevedo, 2007). What has been underfocused in this line of research, however, is the possibility that a combination of surface- and deeper-level strategies may actually be a better option, at least when students possess rather modest prior knowledge about the domain or topic in question.

Thus, to address the first research question, we compared the strength of the relationship between deeper-level strategies, as revealed by inferences assumed to support mental model construction (e.g., backward, forward, and elaborative inferences; van den Broek et al., 1993), and comprehension performance with the strength of the relationship between a combination of strategies at different levels of processing and comprehension performance. Given that our participants could not be assumed to have reached a stage of competence or expertise in the domain (Alexander, 1997, 2005), we considered it likely that a mix of surface-level and deeper (including metacognitive) strategies would be more strongly related to comprehension performance, as suggested by Dinsmore and Hattan (2020). Accordingly, with respect to the second research question, we expected that a mix of strategies would

uniquely predict comprehension performance when other relevant cognitive resources were controlled for. However, although prior knowledge might generally be limited, participants' prior knowledge could still vary considerably. Regarding the third research question, we therefore entertained the possibility that such variation in participants' prior knowledge about the topic of the text might indirectly affect their comprehension performance through their combined use of surface- and deeper-level strategies.

In addition to participants' prior knowledge about the topic of phobias, we assessed their basic reading comprehension skills. Both theses individual difference variables are likely to influence text processing as well as comprehension performance (e.g., Cromley et al., 2010; Cromley & Azevedo, 2007; Kopatich et al., 2019), and they should therefore be controlled for when examining unique relationships between different types of strategic processing and comprehension performance.

2. Method

2.1. Participants

The sample consisted of 58 undergraduates in educational sciences and humanities at a large public university in southeast Norway. Most participants (77.6%) were enrolled in the first year of a bachelor program, and 17.2% and 3.4%, respectively, were enrolled in the second and third year (one participant was at master level). All participants had completed college preparatory programs in high school. Their mean age was 22.05 years ($SD = 3.05$) and 75.9% were female. Most participants (87.9%) had Norwegian as their first language, and the rest were bilingual. These participants were also included in a study by Latini and Bråten (2021). In that study, 116 students were randomly assigned to four conditions in a 2 (think aloud vs. no think aloud) × 2 (digital vs. print) between-subjects design to examine whether there were differences in strategic text processing and comprehension performance between students reading digital versus printed text. The participants in the present study were the ones who were instructed to think aloud in the Latini and Bråten (2021) study, half of them reading digital text and half of them reading printed text. Since there were no differences in strategic text processing or comprehension performance across reading mediums, these 58 students were collapsed into a single group for the statistical analyses in the present study.[1] Most importantly, all research questions, analyses, and findings regarding relationships between different categories of strategic text processing and comprehension performance, as well as regarding the mediated effect of prior knowledge, are unique to this study.

We recruited participants in regular lectures and those who volunteered received a gift card worth NOK 200 (approx. USD 20) after the data collection. Collection and handling of all data met the requirements of the Personal Data Registers Act and were approved by the Norwegian Social Science Data Services.

2.2. Materials

2.2.1. Text

Each participant read one 10-paragraph informational text titled "Phobias," which was based on an encyclopedia on phobias (Milosevic & McCabe, 2015) in addition to diverse popular science articles dealing with this topic. Both the length and the language of these original texts were adapted to form a single text consisting of 1000 words (approx. 100 words per paragraph). On a separate title page, source information (author's name and credentials plus venue and date of publication) was presented in addition to the title. The text was said to be authored by a female psychologist with a common Norwegian name and published in the Journal of the Norwegian Psychological Association in 2019.

The 10 paragraphs of the text were presented on 10 pages (one paragraph per page) and covered three main themes: (1) what phobias are, (2) why phobias occur, and (3) how phobias can be treated. The first theme was covered in the first four paragraphs, with the first paragraph describing fear as a natural response to real threats that can result in fight or flight reactions, the second paragraph discussing phobias in terms of irrational fear that interferes with everyday life, the third paragraph describing the main categories of phobias (i.e., social and specific phobias) and their characteristics, and the fourth paragraph describing and explaining some less familiar phobias (phonophobia and trypophobia). The second theme was covered in the next four paragraphs, with the fifth paragraph discussing genetic causes of phobia and relating them to autonomous nervous system vulnerability and lower levels of an inhibitory neurotransmitter, the sixth paragraph discussing how phobias can be learned through the mechanisms of classical conditioning and observational learning, the seventh paragraph discussing how phobias may have an evolutionary origin and be derived from fears that increased the chances of survival in the distant past, and the eighth paragraph discussing gender difference in the prevalence of phobias and the potential contribution of stereotypical gender roles in this regard. Finally, the third theme was covered in the last two paragraphs, with the ninth paragraph discussing medical treatment by means of sedative drugs or cortisol, and the tenth paragraph discussing psychological treatment in the form of traditional or virtual reality exposure therapy. Half of the participants read the 10 paragraphs printed in a stapled booklet and the other half read them in a PDF file on a tablet (see Participants section).

We used Björnsson's (1968) formula, based on word and sentence length, to compute the readability of the text. This resulted in an average readability estimate of 48.00 ($SD = 9.99$) for the 10 paragraphs, indicating that the difficulty level of the text was comparable to that of information texts from the Norwegian government (Vinje, 1982).

2.2.2. Reading comprehension measure

We used a Norwegian version of a cloze test developed in Danish by Gellert and Elbro (2013) to measure basic reading comprehension skills. This Norwegian version has been validated in several recent studies (e.g., Bråten et al., 2019; Latini et al., 2020). Participants read five narrative and five expository texts that ranged in length from 40 to 330 words and had a total length of 1340 words. The 10 texts had 41 word gaps altogether, with four alternatives provided for each gap, and participants were asked to read the texts and refill as many of these gaps as possible during a period of 10 min. One point was awarded for each correctly refilled gap (i.e., the possible range of scores was 0–41). Of note is that correct refilling of all gaps required some form of inferencing (Gellert & Elbro, 2013). The internal consistence reliability (Cronbach's α) for participants' scores was 0.80.

2.2.3. Prior knowledge measure

We measured prior knowledge about phobias by asking participants to respond in writing to the following open ended questions: (1) what is a phobia?, (2) which types of phobias do you know?, (3) do you know why some people have phobias?, and (4) do you know how phobias can be treated? On the first question, scores were based on the definition of phobias by Milosevic and McCabe (2015), which included four aspects: (1) a phobia is a fear of something, (2) it is irrational, (3) it is intense and enduring, and (4) it is maladaptive. Participants were awarded one point if they included one of these aspects, two points if they included two of these aspects, and three points if they included three or four of these aspects. To receive a score of three on this question, participants had to include the aspect of irrationality, though. On the second question, one

[1] The 58 participants in the present study did not differ from the participants in the previous study who did not think aloud (and were not included in this study) with respect to variables such as gender, age, educational level, language background, reading comprehension skills, prior knowledge, and comprehension performance.

point was awarded if participants included one or more phobias from one of the following six categories, which commonly figure in the literature on phobias (Milosevic & McCabe, 2015): (1) animals/insects, (2) nature (e.g., heights, water, darkness), (3) blood-injection-injury (e.g., needles, illness), (4) situations (e.g., flying, elevators, driving, small rooms), (5) social phobias, and (6) others. To receive two points, participants had to include phobias from two or three of these categories, and to receive three points, they had to include phobias from four or more categories. On the third question, one point was awarded for including one of the following potential causes of phobias: (1) genetics, (2) learning (including traumatic experiences), (3) evolutionary mechanisms, and (4) gender role stereotypes. To receive two points, participants had to include two of these potential causes, and to receive three points, they had to include three or four of them. Finally, on the fourth question, one point was awarded if participants included one of the three most common ways of treating phobias (i.e., exposure therapy, medication, and conversation based therapy). If participants included two or three of these treatments, two or three points were awarded. The possible range of scores was thus 0–3 on each question and 0–12 on the entire prior knowledge measure.

Two authors scored participants' responses to the four questions. A random selection of 25% of participants' responses was scored independently, resulting in an interrater reliability coefficient (Pearson's *r*) of 0.92. Disagreements were solved in discussion. The scoring of the remaining participants' responses was done by the authors separately.

2.2.4. Text processing

Audio recorded verbal protocols were transcribed and segmented into units of analysis, with a unit of analysis defined as a comment or set of comments on the same phrase, sentence, or group of sentences within a paragraph. Thus, units of analysis varied in length; a unit could be a short comment referring to one phrase or one sentence in a paragraph of the text, or it could be several comments referring to several sentences in a paragraph. In all instances, however, a unit of analysis referred to a distinct idea or theme described in a paragraph. This unit of analysis is consistent with the coarse grain size used by other researchers coding strategic text processing or self-explanation in verbal protocols (e.g., Chi et al., 1994; Coté et al., 1998; Strømsø et al., 2003). The units were coded into one of eight categories of text processing, with this coding system based on prior work by van den Broek and colleagues (e.g., Kendeou & van den Broek, 2007; Linderholm & van den Broek, 2002; van den Broek et al., 2001) and Magliano and colleagues (e.g., Kopatich et al., 2019; Magliano et al., 2020; Trabasso & Magliano, 1996).

The category of *associations* included comments made in response to text content that referred to prior knowledge or experience without facilitating understanding or creating coherence (e.g., "I was thinking about my cousin, because she has phonophobia, so she has stopped visiting our house, it's so funny"). *Paraphrases* involved comments that repeated or reworded text content (e.g., "And then, there are two forms of phobias, social phobia and specific phobia"). *Backward inferences* included comments that connected content in the current paragraph with content in one or more preceding paragraphs (e.g., "I was thinking that this paragraph was about phobias, so it's building on the first paragraph, because in the first paragraph, fear was explained"). *Elaborative inferences* involved comments that connected text content with relevant prior knowledge and experience that facilitated understanding and increased coherence (e.g., "I'm thinking that struggling with social phobias must be worst, because if you need treatment you have to see a human being, so then you must break a barrier you have inside"). *Predictive inferences* were comments that anticipated content in one or more forthcoming paragraphs based on content in the current paragraph (e.g., "…but I reckon that what I'm going to read later is that phobias are not necessarily that rational"). *Monitoring* included comments that involved reflections on one's own thinking about text content or one's own (lack of) understanding or knowledge of text content (e.g., "I haven't really understood this text, but it has something to do with genes, I think"). *Evaluation* included comments that were opinions about or affective responses to text content (e.g., "It was interesting what they said about some people being more vulnerable to phobias in relation to their nervous system"). Finally, comments that did not fit into any of the categories above and did not facilitate understanding or contribute to coherence were coded as *other* (e.g., "And the last one was something about animals"). The entire coding system for the verbal protocols is described and further exemplified in Appendix A.

Two authors coded the verbal protocols. A random selection of 20% of participants' protocols was coded independently, resulting in a substantial interrater reliability (Cohen's Kappa) of 0.70. All disagreements were solved in discussion, and the coding of the remaining participants' verbal protocols was done by the authors separately.

Because we were interested in the distinction between deeper and surface-level processing strategies in the present study, we recoded the three types of inferences described above into a broader category of *inferences* indicating deeper-level strategies (e.g., Coté et al., 1998; Kendeou & van den Broek, 2007) while we retained the category of *paraphrases* as an indication of surface-level strategies (e.g., Beker et al., 2017; Magliano & Millis, 2003). Moreover, we recoded the comments categorized as monitoring and evaluation, respectively, into the broader category of *monitoring*, indicating evaluations of text content as well as one's own understanding and knowledge of that content (e.g., Coté et al., 1998; Strømsø et al., 2003). The categories associations and other were combined into a broader category of *irrelevant processing*. An estimation of interrater reliability based on independent coding of 20% of the verbal protocols yielded a high Cohen's Kappa of 0.83 for these four categories of text processing. Finally, we created a broad category including a mix of surface-level and deeper strategies by combining the categories of paraphrases, inferences, and monitoring, which might be particularly adaptive for non-expert readers (Alexander, 1997, 2005; Dinsmore & Hattan, 2020). Only the four categories described in this paragraph (i.e., inferences, paraphrases, monitoring, and irrelevant processing), together with the mixed processing category, were used in subsequent statistical analyses.

2.2.5. Comprehension performance

To measure comprehension of the text content, we asked participants to write a report in which they discussed what phobias are, why they occur, and how they are treated. In each of the 10 paragraphs, we identified the main idea and awarded participants 0 or 1 point dependent on whether this main idea was correctly represented in their written products or not. In addition, in each paragraph, we determined how the main idea was further elaborated and awarded participants 0 or 1 point dependent on whether this elaboration was present in their written products or not. For example, in the paragraph defining phobias (i.e., paragraph 2), we identified the main idea as *phobias involve irrational fear* and an elaboration of this idea as *phobias interfere with adaptive functioning*. The scores for each paragraph thus ranged from 0 to 2, and the scores on the entire measure could possibly range from 0 to 20. Only the total scores were used in subsequent statistical analyses, with these reflecting the extent to which participants had represented an elaborated overview of the characteristics, causes, and treatments of phobias, as presented across the 10 paragraphs. The main idea and elaboration we identified in each of the 10 paragraphs as a basis for the scoring system are presented in Appendix B.

Two authors scored the written responses. A random selection of 25% of participants' responses was scored independently, resulting in a high interrater reliability estimate (Cohen's Kappa = 0.93). Also, the two raters' total scores for these responses were highly correlated (Pearson's $r = 0.95$, $p < .01$). All disagreements were solved in discussion, and the scoring of the remaining participants' responses was done by the authors separately.

2.3. Procedure

The first author collected the data in individual 60-min sessions in a quiet room at the university. First, participants received a folder containing a demographic survey, the reading comprehension measure, and the prior knowledge measure and completed these materials in this order. Participants were then given a task in which they practiced thinking aloud as they read a three-paragraph text about schizophrenia. This text was similar to the experimental text in terms of layout, paragraph length, and writing style. Before reading the practice text, participants were given the following oral instruction:

> *In this investigation you will read 10 paragraphs of text, and after each paragraph, you are going to say aloud everything you are thinking about what you are reading. But first you will get a practice task in which you read three paragraphs on another topic. After reading a paragraph silently, you turn the page, and on that page you will be asked to verbalize everything you are thinking about what you are reading. Nothing is right or wrong to say; just say everything you are thinking about what you are reading. If you do not say anything, I will ask you to talk. When you have said everything you are thinking about what you are reading, you turn the page and continue reading silently. Do you understand what you are going to do?*

Participants were reminded to talk if they remained silent for more than three seconds ("Don't forget to think aloud"). After the practice session, participants read the following instruction:

> *You are now going to read a text about phobias in order to write a brief report in which you discuss what phobias are, why they occur, and how they are treated. The text consists of 10 paragraphs, with one paragraph on each page. When you have read a page, you will be asked to say aloud everything you are thinking about what you are reading. You can not look back to the text while thinking aloud.*

Moreover, participants were instructed that they could spend up to 15 min reading the entire text. This time frame was based on piloting of the materials, which indicated that a time limit of 8 min would allow all students to read the entire text, and that the average additional time used to think aloud was approximately 7 min. When participants had read a paragraph and turned the page, only the think-aloud prompt "What are you thinking about what you are reading?" appeared on the next page. After finishing thinking aloud, participants again turned the page to access the next paragraph, and so forth.

When participants had finished reading the text, they accessed a web based questionnaire by clicking on a Google Chrome window located on the taskbar of a laptop computer. This questionnaire contained the following written task instruction:

> *Based on the text you just read, you are going to write a brief report in which you discuss what phobias are, why they occur, and how they are treated. You can spend as much time as you want on this writing task. It is important that you express yourself as completely and elaborately as you can.*

Below this instruction, participants wrote their report in a separate text entry box with no word limit. The task instruction was visible during writing, but participants could not re-access the text. When finished, they submitted their report to a server by clicking on a "Send" button.

2.4. Data analysis

First, we computed Pearson's correlations to examine bivariate relationships between the categories of strategic processing and comprehension performance. Next, we performed a hierarchical multiple regression analysis to examine the unique contributions of categories of strategic processing to comprehension performance when reading comprehension skills and prior knowledge were controlled for. Finally, we performed bootstrapped mediation to examine whether strategic text processing mediated the effect of prior knowledge on participants' comprehension performance.

3. Results

Table 1 includes descriptive information and zero-order correlations for the individual difference measures, the categories of strategic text processing, and comprehension performance. As can be seen, both reading comprehension skills ($r = 0.31$, $p = .018$) and prior topic knowledge ($r = 0.44$, $p = .001$) were positively and statistically significantly correlated with comprehension performance. Moreover, prior knowledge was positively and statistically significantly correlated with paraphrases ($r = 0.32$, $p = .013$) and mixed processing ($r = 0.40$, $p = .002$). Finally, the category of irrelevant processing was negatively and statistically significantly correlated with comprehension performance ($r = -0.37$, $p = .005$) and the category of mixed processing was positively and statistically significantly correlated with performance ($r = 0.37$, $p = .004$), while the other categories of strategic processing (i.e., paraphrases, inferences, and monitoring) had lower positive and non-significant correlations with performance. As expected, mixed processing was more strongly correlated with comprehension performance than was deeper processing in the form of inferences, with $Z = 1.83$, $p = .034$ (Lenhard & Lenhard, 2014), which is in accordance with the fact that participants, on average, displayed only modest prior knowledge about the topic of phobias.

Of note is that participants' scores were lower on deeper-level (i.e., inferences) than on surface-level strategies (i.e., paraphrases). Still, there was substantial variation within both categories, as indicated by the standard deviations. While a number of participants predominantly used paraphrases, there were also some participants who used more inferences than paraphrases or struck a good balance between the two categories of strategic processing. The fact that prior knowledge was more strongly related to paraphrases and mixed processing strategies than to inferences may suggest that the former categories were better adapted to participants' general level of prior knowledge than was the latter.

Next, we performed a hierarchical multiple regression analysis with comprehension performance as the dependent variable. Reading comprehension skills and prior topic knowledge were entered into the equation in step one. In step two, we included participants' scores on the irrelevant and mixed processing measures, which were the only processing measures that were statistically significantly correlated with performance. The results of this regression analysis are shown in Table 2. Reading comprehension and prior knowledge entered into the equation in step one explained a statistically significant amount of variance in performance, with $R^2 = 0.22$, $F(2, 55) = 7.81$, $p = .001$. In this step, prior knowledge ($\beta = 0.37$, $p = .004$), but not reading comprehension ($\beta = 0.19$, $p = .114$), was a statistically significant unique positive predictor of performance. After step two, with irrelevant and mixed processing also included in the equation, $R^2 = 0.32$, $F_{change}(2, 53) = 3.88$, $p = .027$, with the addition of these variables resulting in a statistically significant 10% increment in the explained variance. In this step, irrelevant processing ($\beta = -0.28$, $p = .033$) was a statistically significant unique negative predictor of comprehension performance. Mixed processing was not a unique predictor of comprehension, however ($\beta = 0.08$, $p = .576$). The reason mixed processing did not contribute uniquely although it had a positive zero-order correlation with comprehension performance, may be its positive correlation with reading comprehension and prior knowledge (see Table 1). Presumably, some of the variance that mixed processing shared with performance had therefore already been accounted for. Of note is that an R^2 of 0.32 can be regarded as a large effect in multiple regression analysis (Cohen, 1988).

Finally, we examined the possibility that strategic text processing mediated the effect of prior knowledge on comprehension performance.

Table 1
Descriptive statistics and zero-order correlations for all measured variables.

Variable	1	2	3	4	5	6	7	8
1. Reading comprehension	–							
2. Prior knowledge	0.33*	–						
3. Irrelevant	−0.13	−0.09	–					
4. Paraphrases	0.10	0.32*	−0.45**	–				
5. Inferences	0.17	0.16	−0.02	−0.26	–			
6. Monitoring	0.06	−0.10	0.17	−0.69**	0.44**	–		
7. Mixed processing	0.23	0.40**	−0.45**	0.63**	0.43**	0.05	–	
8. Comprehension performance	0.31*	0.44**	−0.37**	0.25	0.12	0.01	0.37**	–
M	29.59	5.57	3.09	8.62	3.00	5.62	17.24	7.48
SD	5.70	1.57	3.03	8.77	3.14	5.01	7.17	2.96
Skewness	−0.13	0.39	1.74	0.67	1.53	0.67	0.27	0.35

* $p < .05$.
** $p < .01$.

Table 2
Results of multiple regression analysis for variables predicting comprehension performance.

Predictor	*B*	*SE B*	β
Step 1			
Reading comprehension	0.10	0.07	0.19
Prior knowledge	0.70	0.24	0.37**
Step 2			
Reading comprehension	0.08	0.06	0.15
Prior knowledge	0.62	0.24	0.33*
Irrelevant processing	−0.27	0.12	−0.28*
Mixed processing	0.03	0.06	0.08

Note. $R^2 = 0.22$ for Step 1 ($p = .001$), $\Delta R^2 = 0.10$ for Step 2 ($p = .027$).
* $p < .05$.
** $p < .01$.

For this analysis, we created a new strategy variable by subtracting the number of comments categorized as irrelevant processing from the number of comments included in the mixed processing category, thus focusing on a potentially adaptive combination of surface- and deeper-level strategies in the absence of irrelevant processing presumably working in the opposite direction. The assumption that irrelevant processing worked in the opposite direction followed from the preceding correlation and regression analyses. The new variable, which we called mixed relevant processing, was positively correlated with prior knowledge ($r = 0.35$, $p = .007$) as well as with comprehension performance ($r = 0.42$, $p = .001$). Specifically, the indirect effect of prior knowledge on performance via mixed relevant processing was tested using a bootstrap estimation approach with 5000 samples (Preacher & Hayes, 2008). Reading comprehension was included as a covariate in this analysis. The model accounted for a statistically significant portion of the variance, $R^2 = 0.29$, $F(3, 54) = 7.39$, $p = .0003$. The bootstrapped results showed a statistically significant indirect effect of prior knowledge on comprehension performance via mixed relevant processing, with an estimate of 0.165 ($CI_{95\%}$: 0.024–0.412). As can be seen in Fig. 1, the direct effect of prior knowledge on performance remained statistically significant, $B = 0.539$, $SE = 0.240$, $p = .029$, which is consistent with a partial mediation. The covariate of reading comprehension was not a statistically significant predictor, with $B = 0.079$, $SE = 0.063$, $p = .220$.

4. Discussion

The aim of the current study was to investigate the potential role that a combination of surface-level and deeper text processing strategies might play in comprehension performance. To that end, we had undergraduates read a text on a topic of which they had limited prior knowledge, collecting verbal protocol data on their strategic processing and assessing their comprehension performance by means of post-reading written reports on the topic in question. Importantly, this approach also gave us the opportunity to examine how qualitatively different categories of strategic text processing might be differentially associated with readers' comprehension of the text.

Based on the model of domain learning (Alexander, 1997, 2005), we, following Dinsmore and Hattan (2020), considered it likely that a mix of surface- and deeper-level strategies would be more valuable for readers at this level of domain learning than would any of those categories alone. According to this model, readers who lack competence or expertise in a domain will still be dependent on surface-level strategies such as paraphrasing to acquire knowledge and gain basic understanding while gradually developing a repertoire of deeper strategies such as drawing inferences to build coherent understanding (Alexander, 2005). Therefore, breadth rather than depth might be the better strategic approach when encountering informational texts on a relatively unfamiliar topic.

Consistent with this view, our correlation analysis showed that the category of mixed processing was positively and statistically significantly correlated with comprehension performance, whereas neither surface-level (i.e., paraphrases) nor deeper strategies (i.e., inferences)

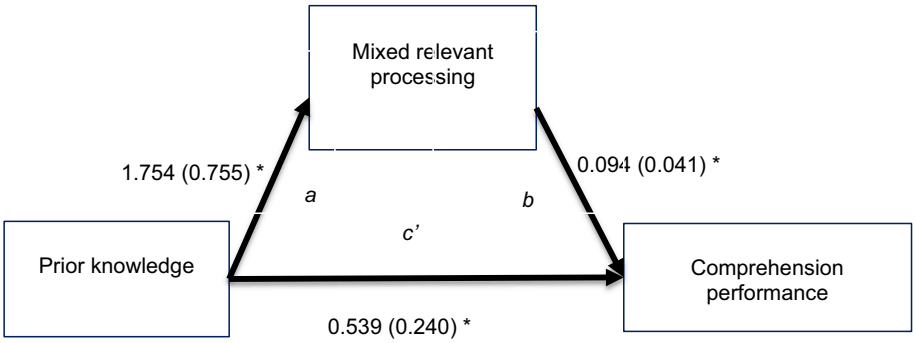

Fig. 1. Mediation model for the effect of prior knowledge on comprehension performance via mixed relevant processing.

were significantly correlated with performance. At the same time, however, this analysis revealed that readers' expression of thoughts that were inconducive to comprehension (i.e., irrelevant processing) was negatively correlated with our performance measure. This finding is in accordance with research on the relationship between mind wandering (i.e., task unrelated thoughts) and reading comprehension (e.g., Unsworth & McMillan, 2013), suggesting that it is not only a broad repertoire of relevant processing strategies that matters but also avoiding being derailed by irrelevant thoughts during reading.

This potential importance of irrelevant processing was also apparent in the multiple regression analysis that we conducted. Thus, while we had expected that mixed processing would contribute to comprehension performance over and above both reading comprehension skills and prior topic knowledge, only irrelevant processing emerged as a unique (negative) predictor of performance in this analysis. As suggested previously, this difference in the predictability of irrelevant and mixed processing was likely due to the latter category being positively correlated with both reading comprehension skills and prior knowledge. The fact that irrelevant processing was only weakly (and negatively) correlated with reading comprehension skills and prior knowledge also highlights that potentially detrimental irrelevant processing during reading may occur among readers at different levels of comprehension skills and different levels of prior knowledge about the topic of the text.

In our final analysis, we took the possibility that irrelevant processing might work in the opposite direction of mixed processing (which was suggested by our data) into consideration and created a strategy measure capturing readers' use of a combination of surface- and deeper-level strategies without being derailed by irrelevant thoughts during reading. Using a bootstrap estimation approach, we were able to show that participants' scores on this measure of mixed relevant processing were predicted by their prior knowledge and, in turn, predicted their comprehension performance, consistent with a partial mediation of prior knowledge effects on comprehension performance via mixed relevant processing. Thus, even readers who lack competence or expertise in an area may possess different degrees of knowledge about the topic that they can channel into a form of strategic processing that is adaptive in terms of their level of knowledge as well as the reading task. Of note is that this form of strategic processing seems to include superficial as well as deeper strategies in the absence of comprehension irrelevant processing.

One limitation of the present study is, of course, that we used only correlational data collected at one particular point of time, which makes it impossible to draw any firm conclusions regarding causality. Still, the fact that our findings were consistent with the assumption that a combination of surface- and deeper-level strategies may be particularly valuable to readers who lack competence or expertise in a domain, may be the starting point for further experimental work to clarify causal relationships. Preferably, such research should also include readers with greater variation in prior topic knowledge, which could make it possible to discern at which level of competence or expertise solely deeper-level strategies would suffice. Relatedly, because our sample was limited to college undergraduates, we cannot say with any degree of certainty whether our findings would hold for students at lower levels of ability, and future research including students at different levels of ability is therefore needed. Other individual difference variables, for example related to reading motivation and engagement (e.g., Guthrie & Klauda, 2016), could also be included in this line of research. Finally, the generalizability of our findings should be probed in future research by including students reading about other topics for other purposes in other types of texts.

Despite such limitations, and the need for much future research to address them, we believe that our modest contribution may have not only theoretical but also educational implications. In educational contexts, students commonly read about relatively unfamiliar topics of which they have limited background knowledge. Based on the assumption that deeper-level strategies are always better, educators may easily disregard that in such contexts, deeper-level strategies may have to be supplemented with strategies that help readers establish a rudimentary knowledge base from which extended strategic actions can be launched. Without such a knowledge base, attempts to use deeper-level strategies may potentially do more harm than good because students come to draw incorrect inferences. By highlighting the potentially adaptive role of mixed relevant processing, the current study may serve as a reminder that an exclusive instructional focus on deeper strategies may sometimes fail to achieve the goal of facilitating deep, coherent understanding of textual content. As a viable alternative, strategy instruction may be adapted to students' developmental trajectory within a domain by progressing from a focus on surface-level strategies via mixed processing to deeper-level strategies.

Appendix A. Coding system for scoring the verbal protocols

Processing	Definition	Examples
Associations	Comments made in response to text content that referred to prior knowledge or experience without facilitating understanding or creating coherence.	It is not easy to be young. I'm not sure how difficult it will be to be young in the future, for my children and their children, because we have quite another, quite another view of what is private and not today than earlier. So we'll see. Soon privacy will be gone (paragraph 3). … I was thinking about my cousin, because she has phonophobia, so she has stopped visiting our house, so she just keeps to herself, it's so funny (paragraph 4).
Paraphrases	Comments that repeated or reworded text content.	And then, there are two forms of phobias, social phobia and specific phobia (paragraph 3). That it is two to three times more common for women to have phobias than it is for men (paragraph 8).
Backward inferences	Comments that connected content in the current paragraph with content in one or more preceding paragraphs.	I was thinking that this paragraph was about, about phobias, so it's building on the first paragraph, because in the first paragraph fear was explained (referring back to content in paragraph 1 after reading paragraph 2) … boys might be a bit more, like, fight mode, whereas girls are a bit more flight mode, it seems like there is such a relationship (referring back to content in paragraph 1 after reading paragraph 8)
Elaborative inferences	Comments that connected text content with relevant prior knowledge and experience that facilitated understanding and increased coherence.	I am thinking that struggling with social phobias must be the worst, because if you need treatment you kind of have to see a human being, so then you must break a barrier you have inside (paragraph 3). This gave me a kind of flashback to when I took psychology in high school and we learned about mice, for example, that was given a shock each time it tried to take food and then it learned that it couldn't go there, so then it started to stay away from it. I was, like, imagining that mouse and that psychology class (paragraph 6).

(*continued on next page*)

(*continued*)

Processing	Definition	Examples
Predictive inferences	Comments that anticipated content in one or more forthcoming paragraphs based on content in the current paragraph.	… but I reckon that what I'm going to read later is that phobias are not necessarily that rational (paragraph 1). … but what it didn't mention at all, was exposing oneself to the phobia in a way, which I find a little interesting. It is possible that it is described somewhere else in the text (paragraph 9).
Monitoring	Comments that involved reflections on one's own thinking about text content or one's own (lack of) understanding or knowledge of text content.	I didn't realize that one could have a phobia of speaking in public places or of how others will perceive you, so that was a bit, I didn't know that in advance. I thought it was only, «only» in quotation marks, something that people regarded as anxiety, that those were not the same, but they actually are in a way (paragraph 3). I haven't really understood this text, but it has something to do with genes, I think. (paragraph 7).
Evaluation	Comments that were opinions about or affective responses to the text content.	It was interesting what they said about some people being more vulnerable to phobias in relation to their nervous system (paragraph 5). Yes, it makes sense that people in a way can fear things that have been dangerous before, but I still think it was a bit strange (paragraph 7).
Other	Comments that did not fit into any of the categories above and did not facilitate understanding or contribute to coherence.	And the last one was something about animals (paragraph 3). I don't have that many thoughts about that, the only thing I'm thinking is that it's quite good for those struggling with fear of the phobias (paragraph 9).

Appendix B. Main idea and elaboration in each text paragraph

Paragraph 1

Main idea: Fear is a natural reaction to danger.
Elaboration: A fear reaction can involve either fight or flight.

Paragraph 2

Main idea: Phobias involve rational fear.
Elaboration: Phobias interfere with adaptive functioning.

Paragraph 3

Main idea: The main types of phobias are social phobias and specific phobias.
Elaboration: Description of both social and specific phobias and mentioning at least one category of specific phobias.

Paragraph 4

Main idea: Some less familiar phobias are phonophobia and trypophobia.
Elaboration: Description of both phonophobia and trypophobia.

Paragraph 5

Main idea: Phobias may have genetic causes.
Elaboration: The genetic explanation is related to the (autonomous) nervous system/a chemical substance in the brain/GABA.

Paragraph 6

Main idea: Phobias may be learned.
Elaboration: Learning of phobias may occur by means of classical conditioning and by means of observational learning (at least one form must be explained).

Paragraph 7

Main idea: Phobias may be caused by an innate tendency to fear things that were dangerous in the distant past (i.e., have an evolutionary origin).
Elaboration: Fear enhanced our chances of survival.

Paragraph 8

Main idea: Phobias are more common among women than among men.
Elaboration: This may be associated with typical gender role patterns, with boys confronting dangers and girls avoiding dangers and/or being better at identifying emotional states in others.

Paragraph 9

Main idea: Phobias may be treated with medicines.
Elaboration: These medicines are anxiety reducing and/or cortisol (i.e., a stress hormone that inhibits another stress hormone, adrenaline).

Paragraph 10

Main idea: Phobias may be treated with exposure therapy.
Elaboration: Exposure therapy involves gradually exposing persons to what they fear in a safe environment.

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