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PESQUISA EMPÍRICA

Influence of source expertise on the detection and regulation of comprehension difficulties in reading science texts: failing to understand the world vs. failing to understand the text

Influência da expertise da fonte na detecção e regulação das dificuldades de compreensão na leitura de textos científicos: falha na compreensão do mundo *versus* falha na compreensão do texto

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Abstract. This study investigates how source expertise influence readers' reporting of comprehension difficulties in science texts, their assessment of text comprehensibility, and the attribution of causes for the reported problems. Secondary school students were presented with challenging science paragraphs supposedly taken from textbooks or from other students' science reports. The participants had to explicitly point out comprehension difficulties and provide a quantitative assessment of the difficulty of each paragraph. Expertise conditions did not present significant differences regarding the total number of reported problems or text comprehensibility scores. However, the source of low expertise was significantly associated with students attributing comprehension difficulties to an external cause: the linguistic representation and the author. The difference in the attribution of these difficulties suggests that future research should consider a different influence of source expertise on the detection and regulation stages.

Keywords: Difficulty detection, Regulation, Attribution, Source expertise.

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Resumo. O estudo investiga a influência da expertise atribuída à fonte de um texto na identificação de dificuldades de compreensão, na avaliação da compreensibilidade e na atribuição das causas dessas dificuldades por estudantes do Ensino Médio. Para isso, os participantes analisaram parágrafos de textos científicos considerados complexos, supostamente extraídos de livros didáticos ou de relatórios científicos de outros estudantes. Os participantes deveriam identificar explicitamente possíveis dificuldades de compreensão e avaliar quantitativamente o grau de dificuldade de cada parágrafo. Os resultados não evidenciaram diferenças significativas entre as condições de expertise quanto ao número total de problemas identificados e às pontuações de compreensibilidade do texto. No entanto, quando a fonte era apresentada como de baixa expertise, os estudantes atribuíram significativamente mais as dificuldades de compreensão a uma causa externa: à forma de representação linguística e ao autor do texto. Esses resultados indicam que a expertise atribuída à fonte pode exercer influência distinta sobre o processo de detecção e regulação das dificuldades de compreensão, aspecto que merece maior investigação em estudos futuros.

Palavras-chave: Detecção de dificuldades, Regulação, Atribuição, Expertise da fonte.

Introdução

Readers who attempt to understand a text may find difficulties because of information that is inconsistent with their knowledge or inconsistent with previous text. In this situation, the reader's mental representation may not reach the appropriate standard of coherence, prompting reader-initiated actions (Van den Broek et al., 2011; Van den Broek & Helder,

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2017). This entire process has received considerable attention in research on the monitoring and regulation of comprehension, *i.e.*, on noticing and repairing comprehension difficulties (see for example Hacker, 2014); Kienhues & Bromme, 2011; Otero, 2002; Rapp, 2008; Tapiero & Otero, 1999) and also on studies focusing on sourcing and the validation of information especially when originating from multiple documents (Braasch & Bråten, 2017; Braasch & Scharrer, 2020; Isberner & Richter, 2014; Richter & Rapp, 2014; Richter & Maier, 2017; Stadtler & Bromme, 2014).

This study examines the effect of source expertise, i.e., the competence in providing accurate information, on secondary school students' reporting and attribution of difficulties in understanding relatively complex science texts. Text difficulties were expected in this study because text complexity was created by manipulating text features such as causal cohesion, the linguistic relationships indicating causality, or degree of elaboration, the extent to which additional information is included in a text to improve its readability (Mesmer et al., 2012).

Analyzing how students cope with difficulties in texts is important in science education. In natural school settings, difficulties are not deliberately introduced in science texts, as is the case in this study. However, students are expected to encounter obstacles when reading the relatively complex content of their school manuals. As demonstrated by numerous studies, metacognitive skills are essential for students to identify these obstacles and implement suitable solutions. For example, in an ambitious and extensive study, Wang et al. (1993) showed the relevance of metacognitive variables for school learning in general. They used content analysis of 179 articles and book chapters, ratings of 61 experts, and 91 meta-analyses to study the effect of a wide range of educational, psychological, and social variables on school learning. They grouped the numerous variables into 28 categories, such as "Motivation and Affect", "Curriculum and Instruction", and "Home Environment and Parental Support". According to the combined score from the three methods, metacognitive variables ranked second in importance for school learning, after the "Classroom Management" category. Subsequent studies have documented the importance of metacognitive variables for learning, specifically in science [for reviews see Thomas (2011) and Zohar & Barzilai (2013)] and in mathematics and problem solving (De Corte et al., 2000; Desoete & De Craene, 2019). This study analyzes how the perceived expertise of a source of information, such as a textbook or a student's report, affects the metacognitive processes involved in processing comprehension difficulties. The analysis is conducted within the framework of Stadtler and Bromme's (2014) model of processing conflicting information.

A framework to examine detection and regulation of comprehension difficulties

Stadtler and Bromme (2014) developed the content-source integration model (CSI) to describe the processes underlying readers' attempts to comprehend conflicting information. Its basic elements are coincident with other analyses of comprehension difficulties arising from conflicts and inconsistencies in single and multiple documents (Braasch & Scharrer, 2020; Otero, 2002). The model includes three basic stages: conflict detection, conflict

regulation, and conflict resolution. As the conflict resolution stage in this model especially applies to the processing of multiple documents, it will be jointly addressed with the regulation component to deal with the case of a single source.

The first stage, conflict detection in texts, a monitoring process in Nelson and Narens' (1990) model of metacognition, consists of noticing inconsistencies by comparing incoming information versus readers' knowledge or versus previous text. Noticing these inconsistencies depends on several individual text and task variables that have been examined in numerous studies (for example, Hacker, 2014; Marsh & Umanath, 2014; Mills, 2013; Myers & O'Brien, 1998; Otero & Kintsch, 1992; Tapiero & Otero, 1999; Van den Broek & Kendeou, 2008).

The second stage in the CSI model, conflict regulation, falls within Nelson and Narens' (1990) control component of metacognitive processes. It consists of deliberate attempts to repair the inconsistencies detected in the previous stage to restore coherence in the memory representation of discourse (coherence is the property that results from the relationship between the elements of meaning in a text.) Analyses of verbal protocols (Black et al., 1979; Blanc et al., 2008; Chinn & Brewer, 1993, 1998; Hakala & O'Brien, 1995; Mosenthal, 1979; Otero & Kintsch, 1992) as well as eye movement measures while reading inconsistent information (Frazier & Rayner, 1982; Hyönä et al., 2003; Rayner, 1998; Vauras et al., 1992; Wiley & Rayner, 2000), indicate that readers seek to restore coherence when an inconsistency is detected. Several paths can be followed to achieve this (Kienhues & Bromme, 2011; Otero, 2002; Otero & Campanario, 1990; Stadtler & Bromme, 2014), and three of them are distinguished in the CSI model: ignoring the conflict, reconciling conflicting information, and attributing the conflict to different sources in the event that information is obtained from different documents or provided by different sources within a single document. In fact, regarding the latter option, according to the discrepancy-induced source comprehension (D-ISC) assumption (Braasch et al., 2012) conflicting information prompts readers to pay particular attention to content-source links. Finally, in addition to the three aforementioned possibilities, one more option may be considered: when readers do not ignore or reconcile inconsistent claims, they can explicitly acknowledge the existence of a problem (Otero, 2002). Then, external support from an expert source, such as a teacher, may be sought to resolve the conflict.

The third stage in the CSI model, conflict resolution, implies that attempts to restore coherence in the previous stage fail. At this point, readers must decide on the validity of inconsistent claims originating from different documents. This can be made by "first hand" or "second hand" evaluation (Bromme et al., 2010) i.e., validating one of the claims in terms of one's knowledge and reasoning, or in terms of source features such as credibility--how believable a source is perceived to be.

Detection and regulation of comprehension difficulties and source expertise

Extensive research has been conducted on the role of sources in the detection and regulation of inconsistent information, as well as in its validation (for reviews see Bråten et al., 2018; Scharrer & Salmerón, 2016). Several studies have examined the effect of source expertise on the detection and regulation of inconsistencies and consequent comprehension difficulties,

yielding different results. A positive effect hypothesis would predict a better detection of inconsistencies coming from a high expertise source. This is expected because such a source would increase the likelihood of more attentive reading and deeper processing. The results of several studies showing enhanced processing of information coming from a high expertise source are consistent with this hypothesis. Heesacker et al. (1983) found a positive effect of source expertise on information processing by field-dependent subjects, that is, those that tend to be passive and intuitive in contrast to those that are active and hypothesis-testing. The former students assessed and elaborated more on a message's content when this was provided by a high credibility and expertise source (a comprehensive study by a competent commission), compared to a low expertise source such as a high school student. This enhanced processing should be associated with improved detection of text inconsistencies. Also, García-Arista et al. (1996) studied the effect of two sources of different expertise, along with two different academic settings, on the comprehension difficulties reported in inconsistent science texts. Secondary school students read texts that included explicit contradictions in a science setting where the source was a textbook. Alternatively, they read the texts in a language setting where the source was a newspaper. The results showed that both the contradictions detected and reported and the appropriate regulatory processes were more frequent for the high expertise source in the science setting than for the low expertise source in the language setting.

However, some results do not conform to this positive effect hypothesis. Stadtler et al. (2013) examined the effect of a single text or multiple text presentations of information authored by medical doctors (a high expertise source) or by secondary school students (low expertise source). No significant differences due to source expertise were found in students' memory of conflicting information in any of the presentation formats. Also, the results of Werner da Rosa and Otero (2018) failed to support a positive effect of expertise on reporting comprehension difficulties in manipulated science texts. The study examined the effect of expertise on reporting comprehension difficulties in science information originating from sources similar to those in Stadtler et al.'s (2013) study. Secondary school students read challenging science paragraphs, with poor cohesion and elaboration, under two expertise conditions. The paragraphs were presented either as taken from a textbook authored by an expert, or as taken from reports authored by their peers. No significant difference was found between the number of comprehension difficulties reported in the high expertise condition and the low expertise condition. Finally, Keck et al. (2015) found mixed results regarding the effect of expertise on the identification of contradictions in online science texts. Secondary school students had to report about online conflicting information found in sources of different authoritativeness and expertise: a university website vs. a forum website. In each case, the information was presented as written either by an expert author, a professor, or a less expert author, a student. The study showed that conflicting information was more frequently reported in the conditions corresponding to matched authoritativeness and expertise of the sources. The authors interpret the result as consistent with both the positive effect hypothesis and a negative effect hypothesis. According to the former, both the authoritativeness of the source and expertise of the author encourage deeper processing of information, including a comparison of the conflicting propositions. In turn, a low

authoritativeness and expertise of the source lead students to anticipate difficulties increasing their recognition. Ambiguous cues about authoritativeness and expertise result in poorer performance because they neither result in the deep processing strategies stimulated by a high expertise source nor in expectations of difficulties in the information provided by a low expertise source.

According to the models of conflict detection and regulation (Braasch & Scharrer, 2020; Otero, 2002; Stadtler & Bromme, 2014) explicitly reporting an inconsistency in information is a step that readers take after failing to restore coherence by regulation measures such as downplaying the difficulty, or attempting warranted or unwarranted inferences. In some research, the distinction between detecting an inconsistency and explicitly reporting it has not been clearly made, although differences in readers' behavior in the detection and regulation stages are well recognized (García-Rodicio & Sánchez, 2014; Helder et al., 2016; Otero & Campanario, 1990). Therefore, the particular effect of source expertise on the regulation stage, in particular on the causal attribution of inconsistencies and comprehension difficulties, merits some attention.

Attribution of comprehension difficulties and source expertise

As pointed out above, readers who do not overlook or repair a detected inconsistency may explicitly state it as a comprehension difficulty with different causal attributions. This regulatory action is especially encouraged in experimental situations such as the one in this study, where readers are instructed to report comprehension difficulties.

Several analyses of the regulation process include a basic distinction depending on readers' attribution or perceived locus of causality of a detected inconsistency (Braasch & Scharrer, 2020; Otero, 2002). An internal attribution occurs when readers believe that a conflict stems from their lack of understanding of a complex situation due to their own limited knowledge of the topic. For instance, in the study of Otero and Campanario (1990) students had to detect and underline inconsistencies in manipulated science texts. Some of the participants explained that their insufficient knowledge led to their failure to report an explicit contradiction "…it seemed to me a bit queer that they should contradict themselves; but as I didn't understand anything about the subject, I didn't underline it…perhaps it [the contradiction] was like that" (Otero & Campanario, 1990, p. 452).

In contrast, an external attribution occurs when the conflict is attributed to external actors or situations. This occurs when an inconsistency is attributed to the knowledge itself because it may be fragmentary or controversial, as reflected by disagreements among experts (Deroover et al., 2023). This extrenal attribution necessitates appropriate "epistemic beliefs" as noted by Kienhues and Bromme (2011) along whit a sufficient level of knowledge to determine that the knowledge itself is controversial. In cases where knowledge is not fragmentary or controversial, readers may still perceive inconsistencies in the information provided. In such cases, they may rely on another type of external attribution: the perceived deficiencies are ascribed to semantic or syntactic inadequacies within the text. These deficiencies ultimately stem from shortcomings in the source, such as an author's limited knowledge or writing

abilities, rather than from world complexity. This type of external attribution is examined in this study, along with the aforementioned internal attribution.

The latter attribution can be explained by referring to a basic distinction in discourse processing models: the difference between the representation of a situation to which a text refers and the representation of the text itself (Kintsch, 1998; Van Dijk & Kintsch, 1983). Readers may explicitly declare the existence of a personal difficulty in understanding a situation in the world with little reference to the text as the cause of the detected difficulty. This would correspond to an internal attribution, as explained above. Alternatively, readers may explicitly point to deficiencies in a text, an external representation of a situation, as the cause of comprehension difficulty. For instance, lack of cohesion (cues that facilitate connections between ideas in a text) and lack of elaboration (relevant information that aids readers in understanding) are two of the linguistic characteristics of writing which influence perceptions of text quality (Crossley & McNamara, 2016). Therefore, a mention of these characteristics, among other problematic features that could be found in texts depending on reading level (McNamara et al., 2008), should be expected in the reports of readers who attribute the inconsistencies and consequent comprehension difficulties to an external factor, such as text features.

Some studies point to a possible influence of expertise on readers' causal attributions of inconsistencies in information. Stadtler et al. (2013) investigated the influence of source expertise, together with presentation format, i.e., single document vs. multiple documents, on the explanation of conflicts about a health topic. Secondary school students were asked to provide explanations for conflicting information that they had read. The conflicts were more frequently attributed to deficits in source expertise when the information was produced by lay authors (high school students) than when it was produced by experts (medical doctors). In contrast, explanations focusing on the nature of the presented scientific content and its production were more frequent for information supposedly produced by experts. Gottschling et al. (2020) studied the combined influence of source trustworthiness and source expertise on the attribution of conflicting scientific claims from two documents. A higher proportion of conflicts was attributed to source expertise in cases where this was different, as compared to cases where the sources were equally expert.

Converging, albeit indirect evidence about the effect of expertise on students' causal attribution of their own comprehension difficulties was found in the study of Werner da Rosa and Otero (2018) mentioned above. In this study, the participants had the additional task of assessing the comprehensibility of the experimental texts after having reported comprehension difficulties. The students judged that a text presented as written by an expert author was more comprehensible than the same text presented as it originated from a fellow student. This was interpreted as a manifestation of Kruglanski et al.'s (2005) "reverence effect" whereby a reader may refrain from attributing a detected comprehension problem to an information source high in expertise and epistemic authority.

According to the above, the influence of source expertise may result in two basic kinds of attributions made by science students. An internal attribution would occur when a reader acknowledges difficulties in constructing an appropriate situation model due to his or her

knowledge limitations. Regarding external attributions, readers with limited knowledge of the subject matter may not be able to attribute an inconsistency to incomplete or fragmentary knowledge. However, they may attribute the inconsistency to flaws in the text itself or ultimately to the author.

Aims of the study and experimental design

Based on the previous analysis, this study examines the effect of source expertise on, a) the number of reported comprehension difficulties in a sample of science texts, b) the comprehensibility ratings given to the texts, c) the locus (internal vs. external) of causal attribution of the reported difficulties. Both quantitative and qualitative methods are used in the study.

The research has two aims. First, it attempts to replicate the results of Werner da Rosa and Otero's (2018) study using similar materials, a similar setting, and a greater number of participants. In that study, no difference was found between the high- and low-expertise conditions regarding the number of reported comprehension difficulties. However, there was a positive difference between the high- and low-expertise conditions in the comprehensibility ratings given to science texts.

Second, this study aims to examine possible differences in the internal versus external attributions of difficulties in texts supposedly written by authors with low and high expertise.

For this, secondary school, 12th-grade students were provided with relatively complex scientific information supposedly originating from sources of different expertise: textbooks or, alternately, fellow students' reports. Textbook characteristics and the institutional setting in which they are used make them sources of greater expertise and authority for students than their peers' writings (Luke et al., 1983). The source was varied between subjects through the presentation of different information about the authors, as in the previous Werner da Rosa and Otero's (2018) experiment. This information was included on the front page of the experimental booklets, in the written instructions to carry out the reading task, and in the headings of each of the experimental texts. The two presentations, identical to those in the study by Werner da Rosa and Otero (2018), were found credible by the participants in that study, as evidenced by their written comments.

The students in the two conditions were instructed to report any comprehension difficulty that they may find and to point out anything in the text in need of improvement. Two types of obstacles involving cohesion and elaboration (Crossley & McNamara, 2016), were explicitly introduced in the texts, as explained in detail in the "Materials" section: unclear causal relations and incomplete information about the entities described in the texts. These obstacles were introduced to affect both the quality of the text and the construction of a situation model, that is to say, comprehension. The intent was to produce a relatively complex text to assess the extent to which difficulties were internally or externally attributed. Also, given previous results, it was anticipated that the participants would report unplanned difficulties (Werner da Rosa & Otero, 2018).

Method

Participants

One hundred and six students from two 12th-grade classes in two public schools in a medium-sized city of southern Brazil participated in the study (49.1 percent female). These students, in the last year of secondary education, were in an age range of 16 to 17 years old. All of the students had taken Biology, Chemistry, and Physics courses in the 10th grade, 11th grade, and 12th grade. One uncooperative student (zero difficulties reported and maximum comprehensibility score in all of the paragraphs), was removed from the sample.

Materials

Seven-paged booklets (in Portuguese) were prepared for the two expertise conditions. The layout of the front pages, and headings of the texts followed the presentation in the Werner da Rosa and Otero's (2018) study. It proved to be sufficiently credible for students to differentiate between the two expertise conditions, according to the written comments in that study. The front page in the high expertise, textbook condition included a reproduction of three science textbook covers and the title "COMPREHENSION OF TEXTS IN COURSEBOOKS" [COMPREENSÃO DE TEXTOS EM LIVROS DIDÁTICOS, in Portuguese]. In the low expertise condition, the front page included a reproduction of a hand holding a pencil, a sample of handwriting taken from a student's exercise, and the title "COMPREHENSION OF TEXTS WRITTEN BY STUDENTS" [COMPREENSÃO DE TEXTOS ESCRITOS POR ALUNOS, in Portuguese]. The next page of the booklets included instructions explaining that the study aimed to examine how school science textbooks or, alternately, students' reports describe and explain natural phenomena and technology:

> This study is an inquiry about how [science textbooks/high school students; depending on expertise condition] explain scientific phenomena and technology and how they could be improved. The following are some explanations written in [textbooks/students' reports] that seek to explain phenomena like rain or the problems involving power consumption. Our goal is to know if you understand what is written by these [authors of textbooks/students]. For this, we ask for your help to read and note everything you do not understand and judge to be not properly explained and in need of improvement. For that, we ask you to underline what you do not understand. Please explain in the blank box on the right the difficulties found and underlined in the text. Finally, below each text, there is a scale from 1 to 5 to rate the text as difficult or easy to understand (1 for very difficult and 5 for very easy).
>
> Following is an example of what you should do in this work.

A 64-word long sample text with highlighted comprehension obstacles suggested as an example was presented immediately after the instructions. Five target texts between 61 and 70 words followed on each of the next pages of the booklet. Two of them described natural phenomena: sparks and clouds. The other three described energy sources, water pollution, and features of submarine navigation. All of the texts were exactly the same in the two expertise conditions except for different headings. Each of the texts in the high expertise condition had information about the textbook from which it was supposedly taken, such as "Taken from the textbook 'Science. Understanding Nature' C. Cesar et al., 2009". Similarly,

texts in the low expertise condition had headings providing information about student authorship, such as “Taken from a report made by a 9th-grade student from Simões Neto School in Caxias do Sul, RS”.

The texts were made more complex by the implementation of two types of obstacles to comprehension, as in the Werner da Rosa and Otero’s (2018) study. They were based on the two main factors affecting text quality mentioned above: cohesion and elaboration. First, cohesion was manipulated by presenting an unclear causal relation that was nonetheless explicitly signaled by the connective “therefore”. This would normally encourage the generation of a causal inference (Millis et al., 1995), but it was hardly achievable in these cases because the necessary knowledge was out of the participating students’ reach. For instance, generating the enabling link between the existence of dust particles and the building of drops that may result in rain, as described in the text on clouds in Table 1, requires relatively advanced knowledge not available to the participant secondary students.

The second expected difficulty was based on insufficient elaboration, withdrawing critical information necessary to adequately represent a situation. The inferences necessary to fill out these gaps – “associative inferences” in the categorization by Trabasso and Magliano (1996) – were difficult to generate as they required relatively advanced scientific knowledge, beyond the students’ expected capabilities. For instance, a text on energy sources included the following content: “In some [power plants] magnetism is used to keep very high temperatures”. According to the teachers’ advice and our review of curricular materials in Brazilian secondary education, we expected the students not to be familiar with the operation of fusion devices for energy generation. Therefore, they were expected not to have the required knowledge to adequately represent the process linking magnetism and the sustained high temperature necessary for the operation of these devices.

One obstacle due to an unclear causal relation and one obstacle due to insufficient elaboration were introduced in every text. Table 1 shows one of the experimental texts, “Clouds”, with the unclear causal relation mentioned above. The second obstacle, based on under-elaborated information, concerns the existence of water below 0º C in clouds. Building an adequate mental representation of this situation is difficult when information about supercooling is withdrawn and a reader is not familiar with the phenomenon. Additionally, as shown in Table 1, there was a scale from 1 to 5 to rate the paragraph’s comprehensibility.

Table 1. Example of experimental text (translated from Portuguese).

Taken from the textbook “Os Fundamentos de Física” (E. Ramalho et al., 2011). [*or alternatively, depending on expertise condition*]. Taken from a report written by a 10th grade student from Rui Barbosa School in Santa Maria, RS.
Clouds are an important constituent of the atmosphere. Clouds are made up of small drops of water. In the atmosphere there are particles of dust or other materials. Therefore, drops may be formed in the atmosphere. There are clouds in which temperatures can reach below 0ºC. These clouds contain ice and water, although water cannot exist below 0°C.
How would you assess the comprehensibility of this text? (circle the appropriate score). 1 Very difficult 2 Difficult 3 Medium 4 Easy 5 Very Easy

Procedure

The experiment was carried out in the classrooms during a regular class hour. The teachers introduced one of the researchers, who briefly explained the purpose of the study: to understand how natural phenomena and technology should be explained in school. She requested the help of students to identify comprehension difficulties and to assess the comprehensibility of the information provided. The two versions of the seven-paged booklets were randomly provided to the participants to ensure a random distribution of students in the two expertise conditions. Then, the students were instructed to carefully read the instructions in the materials. After reading the instructions and the sample text, the students proceeded to read the five target texts at their own pace. The session lasted approximately 20 minutes. In the end, the students were debriefed about the purpose of the experiment and thanked for their participation.

Measurements

Students had to explicitly point out comprehension difficulties and make a quantitative judgment of the difficulty of each paragraph. The number and type of comprehension difficulties underlined and/or described in the blank space to the right of each of the four texts were recorded, along with the comprehensibility score given to each paragraph. Any underlined sentence, along with a description of the comprehension difficulty counted as a reported difficulty. Explicit statements such as “It was not easy to understand what a cloud of metal dust is” (Student #110) were also identified as difficulties, even if they did not correspond to content underlined in the text.

Two main types of attributions of reported difficulties were distinguished according to the previously mentioned distinction. One type, corresponding to internal attributions, includes difficulties in understanding the situation in the world described or explained in the text (“W[orld] difficulties” for short) articulated through questions such as “How do these copper plates prevent the occurrence of sparks” (Student #14), “How do they detect sound waves underwater?” (Student #44), or “How are drops formed?” (Student #55). The other type, external attributions, corresponded to difficulties related to the text as well as to the author (“T[ext] or A[uthor] difficulties” in the following). Text related difficulties include indications of text inadequacy and specific reports of insufficient elaboration or cohesion: notices of information incompleteness, notices of inadequate explanations, and warnings of cohesion gaps. These difficulties were expressed through questions and statements such as “A connection between ideas in the sentences is lacking” (Student #33), “These two sentences are not coherent between them, they do not complete each other” (Student #49) or “A text that raises doubts and requires correction by a teacher” (Student #82). The terms 'text', 'paragraph' or 'sentence', appearing in 88.3% of these difficulties, were used as indicators of a text related difficulty. Finally, difficulties attributed to the author were expressed through the indication of inadequate knowledge or lack of writing ability, frequently using the words “author” or “student”. Examples of these difficulties were “The way the author introduces why droplets form in the atmosphere is unclear” (Student #41), "The student writes confusing information" (Student #101), or "Who wrote the text did not understand about fish" (Student

#103). The difficulties attributed to the author could overlap with those attributed to the text, but they were counted separately.

To compare the students' science and language background across the conditions of the study, scores for mid-term exams of three main courses (Physics, Chemistry, and Portuguese Language) were taken as proxies for science and language competence.

Results

Students' science and language background

The combined score in Physics+Chemistry (Sci) and the score in Portuguese Language (Lang), all of them ranging from 0 to 10, were not significantly different for students in the high expertise condition (HE) compared to the low expertise condition (LE) (SciHE= 6.86, SD=1.39; SciLE=6.68, SD=1.49, t=.64, p=.520; LangHE=7.19, SD=1.58, LangLE=6.92, SD=1.66, t=.87, p=.383).

W and T&A difficulties

A total of 870 comprehension difficulties were recorded and classified by one of the researchers into the main categories: 759 W difficulties and 111 T&A difficulties.

A trained graduate student classified a sample of 106 out of the 870 difficulties, yielding good agreement with the original categorization (Cohen's kappa = .85). Any disagreements in categorization were resolved through discussion.

Given the two planned obstacles in each text, it was to be expected that each participant would encounter at least 10 comprehension difficulties. However, some of these difficulties were not identified by some of the learners, while unanticipated difficulties were also found. Table 2 shows the mean number of W difficulties ("elaborative", "causal", and "other", *i.e.* unplanned) and mean comprehensibility scores in the two conditions.

Mann-Whitney nonparametric tests failed to show significant differences between conditions in the elaborative difficulties reported (U=1190.50, p=.213), causal difficulties (U=1192.50, p=.224), and other difficulties (U=1220.50, p=.278), as well as between the total number of W difficulties (U=1251.000, p=.411).

Additionally, there was no statistically significant difference in the total number of reported difficulties across the two conditions. (U=1115.00, p=.090), as well as in comprehensibility scores (U=1219.00, p=.305). W difficulties were more frequently reported than T&A difficulties (Wilcoxon matched-pairs signed-ranks test Z=8.813, p=.000).

There were significant positive differences in attributing difficulties to both the text (U = 796.50, p= .000) and the author (U = 928.00, p = .000) in the low expertise condition compared to the high expertise condition.

Table 2. Mean number of difficulties reported per student and comprehensibility scores (standard deviations in parentheses).

Condition	Number of students	World difficulties				Text & Author difficulties		TOTAL	Comprehensibility
		Elab	Causal	Other	Total W	Text*	Author*		
High expertise	52	.23 (1.20)	.92 (1.34)	.21 (1.49)	7.37 (2.48)	0,29 (.57)	0,04 (.19)	7.69 (2.53)	3.33 (.71)
Low expertise	53	.53 (1.14)	.62 (1.32)	.94 (1.36)	7.09 (2.71)	1,17 (1.28)	0,60 (.97)	8.87 (3.31	3.16 (.70)

(*) Significant differences between conditions (p<.001).

Discussion

The aim of this study consisted in ascertaining the relation between the expertise of a source of information and the participants' reporting of comprehension difficulties in science texts, the assessment of comprehensibility of these texts, and the attribution of the difficulties to internal or external causes. Three main findings are discussed next: first, there were no significant differences between the expertise conditions in the total number of difficulties detected and in the comprehensibility scores of the texts. Second, there was a majority of internal attributions of the difficulties reported. Third, there was a positive association between reading from a low expertise source and the attribution of difficulties to external factors, namely the text or the author.

Firstly, the study failed to show significant differences between expertise conditions in the number of W difficulties, as well as in the total number of difficulties reported as in the study of Werner da Rosa and Otero (2018). This absence of difference, in conjunction with other inconsistent results in the studies described above, suggests that source expertise may not primarily influence the detection stage but the regulation stage, in particular the causal attribution of the difficulties. Therefore, separate analyses of the effect of source expertise on the detection and regulation stages would be recommended. Research by Helder et al. (2016) supports this approach. Their findings indicate that children's challenges with coherence monitoring stem from the regulation phase rather than the initial detection phase. Also, the influence of expertise on the regulation stage was shown in the study by Gottschling et al. (2020) where the inconsistency resulted from conflictive claims made by two scientific sources.

Regarding comprehensibility ratings, the difference between the high expertise and low expertise conditions was positive, as in the Werner da Rosa and Otero's (2018) study, but it was non-significant here. However, the consistent direction of this difference suggests that source expertise may be associated with higher student comprehension ratings of science texts: students may find texts more comprehensible when they are attributed to an authoritative source, such as an expert author, as opposed to a low-authority source, such as a student peer. Further research is needed to clarify this relationship and to overcome the possible effect of low statistical power in the present study.

The second main finding was the overwhelming majority of reported difficulties involving internal attributions, i.e., one's own limitations in understanding situations in the world.

This predominance of internal attributions is consistent with the nature of science texts, generally demanding on reader's knowledge. Especially in regard to the inferences necessary to achieve a coherent mental representation of the situation the text is about (Best et al., 2005; Britt et al., 2014). In contrast to the inference demands of genres such as narratives, non-expert readers may judge inferences necessary to understand science texts to be beyond their capabilities (Otero, 2002), thereby attributing comprehension problems to their own limited knowledge. Besides, textbook language, involving a reduction of personal pronouns and the use of an impersonal voice, separates speaker and speech (Luke et al., 1983). This, together with the presentation of authoritative statements that are epistemic ally warranted by the scientific community (Snow, 2010) may induce in secondary school students, such as the ones participating in this experiment, what Phillips and Norris (1999) in their study with similar subjects, described as a "deferential stance". The students recognize the expertise of the source and defer to its credibility and authority (Bromme & Goldman, 2014; Hendriks et al., 2016) resorting to an ability explanation for the inconsistencies found.

Evidence for this internal attribution of problems in understanding science texts may be found in other research also. In a qualitative study on persuasion and refutational science texts, Hynd (2001) provided several types of explanations of projectile motion to secondary school students. The reactions of some students after reading the texts exemplify Phillips and Norris' (1999, p. 706) deferential stance: "I have no reason not to believe this", "It's in a science book", "It doesn't seem right to be, but because it's a text, it has to be true". Also, in the study of Otero and Campanario (1990) about comprehension monitoring of manipulated science texts, the participants had to explain why having instructions to report any comprehension problem found, and having detected contradictory statements, they failed to report them: "Yes, I saw one [contradiction] at the beginning and another at the end…maybe I didn´t underline them because I didn't understand the text well and I thought that it was like that…" (Otero & Campanario, 1990, p. 452-453). Results such as these document novices' recourses to internal attributions when failing to understand science texts.

Thirdly, in contrast with a no-difference result regarding the number of internal attribution of difficulties depending on expertise condition, the low expertise source was associated with a significantly more frequent external attribution of difficulties to the text and the author. The result is consistent with the findings of the study of Gottschling et al. (2020) reported above, where differences in source expertise prompt readers to attribute detected inconsistencies to source competence.

This attribution would not be expected when novices read science texts written by expert authors. A separation between speaker and speech has been pointed out as one of the reasons for the authority of textbooks as sources of information "providing an impression of textual objectivity and neutral validity" (Luke et al., 1983, p. 113). The responses in the low expertise condition show that the students did not separate the author from the text to such an extent as the students who believed that they were reading textbook paragraphs. Viewing the author as a source of less epistemic trust, and therefore a source of less reliance on matters unknown to the reader (Mills, 2013), prompted students to treat the information in the paragraphs as a construct that could be criticized, rather than viewing it as an unchallenged, hard-to-

understand truth. Thus, in the low expertise condition of this experiment, students naturally followed the approach advocated by Beck and McKeon (2001) in their "Questioning the author" (QtA) scheme for text understanding: "...QtA addresses text as the product of a fallible author, as someone's ideas are written down...What we were attempting to do was to shift the reason for needing active effort from a reader's inadequacies to an author's vulnerability" (Beck & McKeown, 2001, p. 229-230).

From an educational perspective, enhancing processes such as inquiry-based learning and question generation entails comprehending the mechanisms through which students become aware of their own deficiencies in knowledge and understanding (Otero & Werner da Rosa, 2019, 2023). The aforementioned findings can contribute to our understanding of the role of variables, such as source expertise, in these mechanisms.

Limitations and future directions

Some limitations of the study should be noted. First, no individual variables, such as reading ability were taken into account in the study. For instance, Kammerer et al. (2019) showed that secondary school students' reading skills moderated the effectiveness of an intervention to improve the detection of contradictions in physics texts. In our study, care was taken to randomize the participants in the two conditions, but academic competence in science and language was the only controlled individual variable. Further analyses may consider how readers' characteristics interact with source expertise specifically in the attribution of difficulties. However, the relationship between individual variables and sourcing, including the evaluation of source credibility, is not always clear (Anmarkrud et al., 2022; for an example regarding self-efficacy beliefs see Anttonen et al., 2024).

Second, as pointed out above, the results of this study suggest further analyses of the separate processes of detection and regulation under different expertise conditions. Regarding the latter process, additional studies may elucidate the disposition of students' in a low expertise condition, *i.e.*, their possible distrust mindset (Mayo, 2015) that results in criticisms of the texts and their authors. It could reveal components that may be transferred to classroom settings to improve the processing of naturally occurring text difficulties.

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