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Text-belief consistency effect in adolescents´ comprehension of multiple documents from the

Web

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## Abstract

Readers comprehend belief-consistent information from multiple texts often better compared to belief-inconsistent information (text-belief consistency effect). The aim of the present study was to investigate whether adolescents' comprehension of multiple texts is similarly impact by their beliefs. Moreover, readers' prior knowledge and an alternating (compared to a blocked) mode of presenting multiple texts were expected to attenuate the text-belief consistency effect. High school students read two belief-consistent and two belief-inconsistent texts on one of two scientific issues in different modes of presentation (blocked vs. alternating). A recognition task was used to assess situation model strength for each text and prior beliefs and prior knowledge were measured before the main experiment. As expected, in the blocked mode of presentation high school students had a stronger situation model for belief-consistent texts. In the alternating mode of presentation, participants had similar situation model strengths for the different texts. Moreover, high knowledge participants experienced a text-belief consistency effect, whereas low knowledge participants had weaker and similar situation models for the texts.

*Keywords*: beliefs, validation, multiple texts, prior knowledge, mode of presentation

**Introduction**

Adolescents commonly rely on texts as sources of information when preparing for school work or assignments. In our digital age, this activity often includes searching the World Wide Web for information and reading several web-based texts with different and often opposing views, standpoints and arguments on the same issue. For example, reliable but opposing arguments for the causes and consequences of global warming can be found on the Web, more precisely arguments for the natural and the man-made greenhouse effect. Scientific topics are not only relevant to individuals and societies, but are also part of the school curriculum in formal education in upper secondary high school (e.g., climate change as a global challenge is discussed in Grade 10 of German academic-track high schools, Staatsinstitut für Schulqualität und Bildungsforschung, 2018). In an ideal case, students would learn about the causes of global warming from different points of views and would be able to identify and combine competing as well as overlapping information from the texts. In such a reading situation, students should ideally be able to construct a coherent documents model of the situation that contains divergent perspectives from multiple texts and their argumentative interrelations (Perfetti, Rouet, & Britt, 1999). Such a complete and balanced understanding of multiple texts would also require the construction of a sound and comprehensive situation model for each text, i.e. a good representation of the state of affairs described in the text (Johnson-Laird, 1983; van Dijk & Kintsch, 1983).

However, research has shown that readers' prior beliefs impact the comprehension of multiple texts in such a way that readers have a rather one-sided representation of controversial issues, which is characterized by a stronger situation model for belief-consistent compared to belief-inconsistent information (*text-belief consistency effect*; e.g., Eagly & Chaiken, 1993; Maier & Richter, 2013, 2014; Wiley, 2005). Text-belief consistency effects hamper readers'

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understanding of scientific controversies because only one argumentative position is well understood whereas the contrary (but often also valid and sound argumentative position) is not well comprehended.

Most studies on text-belief consistency effects have examined multiple text comprehension in university students (for an overview, see Richter & Maier, 2017) and research on text-belief consistency effects in adolescents is still sparse. This is surprising because adolescents, who often lack relevant background knowledge for complex scientific controversies, might be especially prone to the biasing influence of prior beliefs. Moreover, an additional difference between adolescents in secondary high school and university undergraduates is the way in which they are used to handle uncertainty in scientific topics. The school curriculum provides high-school students with some knowledge about concepts and mechanism of action on science-related topics but scientific information is most often not discussed as being partial or even conflicting. Rather, school text books resolve conflicts for scientific topics and provide a valid solution for the "right" side. During university training, dealing with uncertainty and handling partial or even conflicting information on the same issue can be viewed as essential component of academic training. Hence, university students, but not necessarily high school students, should acknowledge and understand better why science-related information and evidence provided on the World Wide Web may be fragile or even conflicting. Given these considerations, we assumed that high school students should have more difficulty comprehending conflicting science-related texts and thus, might be more affected by their prior beliefs in terms of text-belief consistency effect in comprehension. With the present study, we intend to contribute to closing this research gap by investigating the impact of prior beliefs on the comprehension of multiple web-based texts in high-school students. Moreover, we investigated if an alternating mode of presenting belief-consistent and belief-inconsistent texts as situational factor and high

prior knowledge as personal factor can reduce the text-belief consistency effects in adolescents, as it has been shown in previous research with university student samples. A moderating influence of these factors on the text-belief consistency effect is predicted by the Two-step model of Validation (Richter & Maier, 2017). In addition to the more general MD-TRACE model (Rouet & Britt, 2011) of multiple document comprehension, the Two-step model of Validation will guide our discussion of potential effects of prior beliefs on multiple text comprehension and the moderating roles of presentation mode and prior knowledge.

**Multiple Text Comprehension and Prior Beliefs**

The Multiple-Document Task-based Relevance Assessment and Content Extraction (MD-TRACE) model (Rouet & Britt, 2011) describes the processes and steps that readers undergo while processing multiple texts. The MD-TRACE model assumes that readers construct a task model before they read multiple documents based on their individual interpretations of the reading task, such as preparing for an exam. The task model also includes readers' plans how to achieve their reading goal and a selection of information that is based on the perceived relevance of the information to achieve the established reading goal. Besides such a task model, readers are also expected to construct a context model as mental model of the social and physical environment, in our case the experimental situation (Rouet, Britt, & Durik, 2017). During reading, readers then update their task product and evaluate this as their reading outcome after reading. If the reading outcome, such as readers' understanding of the issue, is perceived as satisfactory, reading will stop. If the reading outcome is not satisfactory, readers may continue searching for additional information. Hence, the MD-TRACE model assumes that not only the task model, but also the evaluation of the task product is prone to subjective influences.

Of importance for the present study is the assumption by Rouet and Britt (2011) that readers' internal resources such as their prior knowledge and beliefs influence the task model as

well as the evaluation of the task product. Especially when readers strongly favor one argumentative position in a controversy, prior beliefs may determine the relevance of textual information and which information is processed with higher cognitive effort. In line with this idea, research has established many findings of text-belief consistency effects that can be considered as outcome of such a preference for belief-consistent information in comprehension. For example, after reading belief-consistent and belief-inconsistent texts (or belief-consistent and belief inconsistent arguments in a text), high school and university students provided biased essays (Anmarkrud, Bråten, & Strømsø, 2014; van Strien, Brand-Gruwel, & Boshuizen, 2014), showed a better recognition memory for belief-consistent arguments or texts (Maier & Richter, 2013; Wiley, 2005), and evaluated belief-consistent arguments more positively (McCrudden & Barnes, 2016). In the study by van Strien and colleagues, for example, 11th graders read six pro and six contra texts on the link between violent videogames and aggression. In the essays that students wrote after reading, the authors found a text-belief consistency effect, i.e. participants were far more likely to take a belief-consistent position in the essays. Other studies have shown that individuals are resistant to change their beliefs if faced with new information that explicitly corrects or discredits their beliefs (e.g., Chinn & Brewer, 1993; Limon & Mason, 2002; Johnson & Seifert, 1994; Ross, Lepper, & Hubbard, 1975). Such text-belief consistency effects reduce readers' ability to fully understand controversial issues and to come to an informed own point of view.

For prior beliefs to influence comprehension, readers must notice belief-inconsistent information in a text. In fact, eye-tracking data suggest that readers' multiple text comprehension includes an immediate monitoring process that takes the consistency of textual information with their beliefs into account (Maier, Richter & Britt, 2018). This eye-tracking study found slow-downs in participants first-pass re-reading times for belief-inconsistent information even when

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readers are not instructed to verify or scrutinize the consistency or plausibility of information during reading (for similar results, see Wolfe, Tanner & Taylor, 2013). Likewise, research on language and text comprehension suggest that memory content (such as prior knowledge or beliefs) activated at a given moment during comprehension is used to assess the validity of new incoming text information in a passive and involuntarily way (Richter, 2015; Singer, 2013). This process has been termed validation (Singer, 2013). Validation refers to a routine assessment of the consistency of text information with readers' prior knowledge and beliefs that occurs when the latter are activated and retrieved through concepts and propositions of the text. As a non-strategic process, validation does not require readers' active control (for a review of studies supporting this claim, see Isberner & Richter, 2014). In this context, it is important to note that even upper elementary school children have been shown to detect cross-textual inconsistencies in a multiple text context (Beker, van den Broek & Jolles, 2018).

The Two-step Model of Validation (Richter & Maier, 2017) uses the concept of a non-strategic validation process to explain text-belief consistency effects in the comprehension of multiple texts. The model makes clear and testable predictions how prior beliefs should affect the comprehension of belief-relevant multiple texts. In detail, the model proposes that per default, readers rely solely on non-strategic validation (the first of the two steps of validation), which means that their prior beliefs serve as kind of epistemic gatekeeper. One implication of this assumption is that in normal reading situations belief-inconsistency leads to immediate disruptions of comprehension (sensu Maier et al., 2018). Another implication is that this initial disruption is typically not followed by readers' attempt to repair the inconsistency with strategic and resource-intensive comprehension. Rather, the model predicts that readers' simply continue reading without integrating the inconsistent information into their evolving mental model of the controversy. Put differently, belief-inconsistent information initially receives greater immediate

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and non-strategic attention during reading because a cognitive conflict is evoked by such information, but readers usually allocate greater subsequent and strategic attention to belief-consistent information. Hence, readers are assumed to make more cognitive resources available for the comprehension of information they perceive as belief-consistent and less resources for information that is inconsistent or implausible from their point of view (Schroeder, Richter & Hoever, 2008). Such a conception of the effects of prior beliefs is reminiscent of research on effects of reading perspectives (e.g., Anderson & Pichert, 1978) that show that information perceived as relevant for a reading perspective receives more attention during reading and is better comprehended. Moreover, the proposed text-belief consistency effect as result of non-strategic validation may be considered a variant of the classical notions of selective exposure (Festinger, 1957) or confirmation bias (Nickerson, 1998). These theories have in common that they assume that people deliberately seek and favor belief-confirming information. By contrast, the text-belief consistency effect is supposed to be due to a non-strategic validation process that is viewed as independently from a specific reading goal or motivational state. In addition, the involuntary and passive effects of non-strategic validation occur during comprehension, and not, for example, in the stage of selecting information as assumed by selective exposure theory.

The Two-step Model of Validation (Richter & Maier, 2017) further proposes that readers sometimes actively resolve inconsistencies and contradictions and describes the conditions that increase the likelihood that readers engage in this second (optional) step of validation. One condition that probably affects whether readers engage in this second (optional) step of validation is whether they are satisfied with their understanding of a science-related debate. This assumption coheres well with research on the standards of coherence (van den Broek, Beker, & Oudega, 2015). In general, if readers set themselves a higher standard of coherence, they should invest more cognitive effort to strategically search, retrieve, and validate

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information from multiple texts. For example, in a study by Blanc, Kendeou, van den Broek, and Brouillet (2008), participants were able to integrate two (initially conflicting) causal explanations for one event by generating logical connections between the two causes. However, such strategic elaboration processes should only be initiated if students are motivated and able to come to a justified and defensible point of view. During the comprehension of belief-relevant information, resolving inconsistencies should include various knowledge-based comprehension processes that focus especially on information that was perceived as implausible or belief-inconsistent at first sight. Elaborative processes might include a search for reasons supporting inconsistent information, elaborative and bridging inferences to establish hypothetical truth conditions or establishing relationships between competing information to better understand dubious information. Such elaborative processes also include the strategic processes of comparing, contrasting, and corroborating across texts that are proposed to be of importance for successful multiple text comprehension by the MD-TRACE model (Rouet & Britt, 2011). All of these processes are likely to benefit comprehension in such a way that especially belief-inconsistent information receives more cognitive resources during processing and comprehension. This interpretation is supported by results from eye-tracking and comprehension data (Maier et al., 2018). In this study, readers had longer first-pass rereading times for belief-inconsistent reasons and a higher likelihood of lookbacks to belief-inconsistent information if multiple texts where presented alternatingly. Such a mode of presentation is a reading situation that had been shown to reduce the text-belief consistency effect (Maier & Richter, 2013; Maier et al., 2018; Wiley, 2005). In the next sections, we will elaborate on the effects of different modes of text presentation and the role of reader's prior knowledge in the strategic elaboration of belief-inconsistent information.

**Mode of Text Presentation**

While searching the web, adolescents can read multiple belief-consistent and belief-inconsistent texts in different sequences. For example, they might read texts that argue for the same position successively or blocked, i.e. they might start reading a belief-consistent text followed by another belief-consistent text before they come across two belief-inconsistent texts in a row. However, they might also encounter texts of different belief types alternatingly, that is they might start reading a belief-consistent text, followed by a belief-inconsistent text before they again read a belief-consistent text etc. An alternating mode of presentation has been shown to reduce the memory advantage for belief-consistent arguments (Wiley, 2005) and multiple texts (Maier & Richter, 2013). Moreover, the eye-tracking study by Maier and colleagues (2018) suggests that an alternating mode of presentation especially benefits the strategic comprehension of belief-inconsistent information. In particular, an alternating mode of presentation led to longer immediate reading times for belief-inconsistent reasons and more lookbacks while reading belief-inconsistent texts. Moreover, the text-belief consistency effect was attenuated when belief-consistent and belief-inconsistent texts were read in an alternating mode of presentation (see also Maier & Richter, 2013).

In sum, an alternating mode of presentation seems to increase the attention to and comprehension of belief-inconsistent information. Such an increased attention to belief-inconsistent information, in turn, might result in readers being more consciously aware of inconsistencies and conflicts between the texts as well as textual information and their prior beliefs. This explanation has strong resemblance to the concept of co-activation in research on misconceptions (Kendeou & O'Brien, 2014). According to this concept, two (competing) pieces of information must be activated at the same time in readers' working memory for conflicts to be consciously noted and to initiate processes needed to (re-)establish a level of coherence that matches reader's standard of coherence (van den Broek, et al., 2015). In line, upper elementary

school children had a higher level of integration in recall after reading two short texts, if the reading situation made co-activation of information easier (Beker et al., 2018). An alternating mode of text presentation might be a contextual factor that leads to such an increased amount of co-activation and hence, increases readers' need for coherence establishing processes such as strategic elaboration of inconsistencies. In terms of the MD-TRACE model, an alternating mode of presentation might lead to a situation in which readers evaluate their understanding of the issue not as satisfactory and hence, start another reading and processing cycle.

### Prior Knowledge

Prior topic knowledge is a personal characteristic that is crucial for text comprehension in general and multiple text comprehension in particular (Braasch & Bråten, 2017). In general, prior knowledge related to the topic of a text is necessary to establish a coherent and adequate situation model of the text content (Kintsch, 1988, 1998). Kintsch's (1998) construction-integration (CI) model describes how prior knowledge is used during the construction of a texts' situation model. Most important, during text processing, the situation model continually develops with new textual information being integrated with readers' existing situation model, earlier read text information and relevant background knowledge. In this process, new information and prior knowledge become connected to form a structured episodic memory representation of the text and its contents.

In addition to adding information to the explicit content provided by a text, prior knowledge has been shown to be relevant to integrate and solve inconsistencies between multiple texts. For example, Bråten and colleagues used path analyses to establish direct and indirect influences of prior topic knowledge on multiple text comprehension (Bråten, Anmarkrud, Brandmo & Strømsø, 2014). This study assessed prior knowledge with a multiple-choice measure that focused on concepts and information discussed in five multiple texts read by the participants.

The authors found that prior knowledge directly positively influenced multiple text comprehension (assessed with three essay questions) and indirectly impacted multiple text comprehension through a positive link on participants self-reported deeper strategy use. In contrast, a study by Wolfe and Goldman (2005) found no relationship between prior knowledge and text processing in young adolescents at the age of 11 and 13 (Wolfe & Goldman, 2005). Nevertheless, this study showed that students did use prior knowledge for elaboration and were able to integrate information across texts if they used their prior knowledge for self-explanations.

The combined effects of prior beliefs and prior topic knowledge were directly investigated by Wiley (2005). In this study, low-knowledge participants showed a text-belief consistency effect in comprehension, that is recalled more arguments that were consistent with their beliefs. In contrast, high-knowledge participants recalled belief-consistent and belief-inconsistent arguments equally well. Hence, Wiley's (2005) study suggests that higher prior topic knowledge protects against text-belief-consistency effects.

In terms of the Two-Step Model of Validation (Richter & Maier, 2017), prior knowledge is an important pre-requisite for elaborative processing to resolve inconsistencies between multiple texts and to successfully comprehend belief-inconsistent information. Elaborative processing consist of various knowledge-based comprehension processes such as elaborative and bridging inferences to reason about belief-inconsistent information. All of these processes require prior knowledge.

## Rationale of the Present Experiment

Our research builds on recent research on text-belief consistency effects and the Two-Step Model of Validation to understand how adolescents approach the comprehension of multiple belief-relevant texts. There is already some evidence that not only university students' but also high-school students' comprehension of multiple texts may be biased by prior beliefs in terms of

a text-belief consistency effect (e.g., van Strien, et al., 2014; McCrudden & Barnes, 2016). However, to the best of our knowledge, studies investigating the comprehension of multiple texts for adolescents to date focused on essay-writing tasks to assess comprehension outcomes (van Strien, et al., 2014), evaluations of arguments as dependent variable (McCrudden & Barnes, 2016) or belief change (Mason & Boscolo, 2004; McCrudden & Sparks, 2014). The aim of the present experiment was to investigate how upper high school students remember information from multiple texts that are consistent or inconsistent with their beliefs about the controversy. Upper high school students read four digital texts on one of two socio-scientific debates (global warming vs. vaccinations) in a self-paced reading scenario. Two of the texts were inconsistent with participants' prior beliefs and two were consistent with participants' prior beliefs. In the attempt to interrelate our study to earlier research on text-belief effects in comprehension outcomes, we used a recognition task (adapted from Schmalhofer & Glavanov, 1986) to measure participants' comprehension of each text after reading (see Maier & Richter, 2013).

Given the text-belief consistency effects that have been found in previous research on multiple text comprehension (see Richter & Maier, 2017, for an overview), we predicted a text-belief consistency effect in adolescents' comprehension of multiple texts: Adolescents should comprehend texts that are belief-consistent better compared to texts that are belief-inconsistent (Hypothesis 1). Moreover, an alternating compared to a blocked mode of presenting belief-consistent and belief-inconsistent arguments/ texts has been shown to be beneficial for comprehension as it seems to reduce the text-belief consistency effect (Maire & Richter, 2013; Wiley, 2005). Hence, Hypothesis 2 predicted that the text-belief consistency effect should be attenuated if belief-consistent and belief-inconsistent texts are presented alternatingly, compared to a blocked presentation mode. A similar positive and beneficial effect on the comprehension outcome was assumed to occur if readers possess a higher amount of prior knowledge. Prior

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knowledge can not only be used to fill coherence gaps in the texts during situation model construction, but it also fosters deeper strategy use (Bråten, et al. 2014) and reduces the impact of readers' prior beliefs during multiple text comprehension (Wiley, 2005). Thus, we expected participants with stronger prior knowledge to be less affected by their prior beliefs, that is, the text-belief consistency effect for such participants should be weaker. Participants with weaker prior knowledge, in contrast, should have a stronger situation model for belief-consistent texts compared to the situation model of the belief-inconsistent texts.

## Method

### Participants and Check of Text-Belief Consistency

Seventy-nine high school students (29 males, 50 females) from 13 different academic-track high schools in Cologne and Kassel (Germany) participated in the experiment.[1] Four weeks prior to the experiment proper, participants' prior beliefs were assessed with belief scales that consisted of eight items for each topic (see section "prior beliefs"). For the topic of global warming, participants strongly agreed with the stance of the two pro texts that attributed global warming to man-made causes (agreement to argumentative stance: $M = 4.62$, $SD = 1.05$, ratings on a scale from 0 = *do not agree* to 6 = *fully agree*). Mean agreement to the stance of the two contra global warming texts (i.e., that natural phenomena are the causes of global warming) was weaker ($M = 2.29$, $SD = 1.05$, ratings on a scale from 0 = *do not agree* to 6 = *fully agree*). In the same fashion, participants strongly agreed to the stance of the two pro texts on vaccinations that argued for the necessity and utility of vaccinations (agreement to argumentative stance: $M = 4.44$, $SD = 0.99$, ratings on a scale from 0 = *do not agree* to 6 = *fully agree*). They agreed less strongly with the stance of the contra texts that argued for the opposite claim that vaccinations are unnecessary and harmful (agreement to argumentative stance: $M = 2.34$, $SD = 0.91$, ratings on a scale from 0 = *do not agree* to 6 = *fully agree*). A closer look at the data, however, revealed that 6

out of 41 participants that received the topic global warming preferred the contra-text stance that natural phenomena are the causes of global warming. For the text topic vaccination 1 out of 38 participants that received this topic believed that vaccinations are more harmful than beneficial. In order to align data analysis to existing research (e.g., Maier et al., 2018) and because of the impossibility to balance out belief-consistency given these uneven cell sizes for both topics, only the data from participants favoring the stance of the pro texts were used in further analyses. In the following, the argumentative stance of the pro text for both texts topics is referred to as *belief-consistent position*, whereas the argumentative stance of the contra text is referred to as *belief-inconsistent position*.

The remaining sample consisted of 72 high school students (26 males, 46 females) from twelve different schools in Kassel and Cologne. Participants average age was 17.4 years ($SD$ = 1.35, range:15-19). They received a small monetary reward (8 Euros per hour) for their participation.

**Material**

**Text material.** Four texts debating the causes of global warming and four texts discussing the risks and benefits of vaccinations were used as experimental texts. The text material had been constructed, tested and used in an earlier study with university students (Maier & Richter, 2013). Evidence and arguments presented in the texts were based on texts from reputable German magazines that are freely accessible over the Internet (e.g., Spiegel Online, http://www.spiegel.de; Deutsches Ärzteblatt, http://www.aerzteblatt.de). Each text started with a short statement of the text's major claim. Subsequently, four key arguments separated through sub headlines were presented, which consisted of a claim that was followed by supporting evidence. All texts ended with a short summary of the arguments and a conclusion that reflected the text's major claim (one sample text translated into English is provided in the Appendix). The

texts provided some sources within the individual arguments, but no source information was attached to the full texts. The average length of the texts was 899 words and the average readability score (determined with the German adaption of the Flesch`s Reading Ease Index, Amstad, 1978) was 48.8. To ensure the comparability of the text content for adolescents, a pilot study with an independent sample of 48 students in upper secondary high school was conducted. Students rated all eight texts as well understandable, providing high-quality arguments, and representing a clear stance toward the issue (Table 1). In order to detect possible differences between the texts, we performed paired samples *t*-tests that revealed no significant difference between the texts.

**Comprehension measure.** Comprehension for each text was measured with 24 test items (sentences) per text in a modified version of the recognition task proposed by Schmalhofer and Glavanov (1986). For each text, eight paraphrases of text information, eight inferences matching the text content and eight distracters were constructed. For the construction of paraphrases the word order of text sentences was varied and their key content words were replaced with synonyms. In contrast, inferences contained information that was not explicitly provided by the text. Instead, participants needed to infer this information to build an adequate mental representation of the text content. Finally, distracters communicated new information about the text topic that was neither an explicit content of the text nor a sensible inference from the text. Thus, distracters shared some superficial content aspects with the texts.

**Prior beliefs.** Prior beliefs scales were based on the belief scales that had been constructed, tested and used in earlier studies on multiple text comprehension (Maier & Richter, 2013).[2] Eight statement assessed participants' beliefs about the cause of global warming and eight statements their beliefs about vaccinations (response categories ranging from 1 = *totally disagree* to 6 = *totally agree*). Four statements were used to measure participants' agreement to

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the argumentative pro stance of each controversy, that is, mankind is responsible for global warming (e.g., "I believe that humans are the cause of global warming", Cronbach's $\alpha$ = .77) and vaccinations are more beneficial than harmful (e.g., "I think that vaccinations are the most important and most effective method against infectious diseases", Cronbach's $\alpha$ = .71). Four statements were used to measure participants' agreement to the argumentative contra stance of global warming, that is natural phenomena are the causes of global warming (e.g., "I believe that the climate on earth has always changed from time to time as long as the earth exists", Cronbach's $\alpha$ = .74) and four statements were used to measure that vaccinations are unnecessary and harmful (e.g., "I am against vaccinations because they might overstrain my immune system", Cronbach's $\alpha$ = .75).

**Prior knowledge**. Prior knowledge about global warming and vaccinations was assessed with single choice tests (one correct answer, two distracters, and the possibility to indicate lack of knowledge). These tests included questions about basic concepts and technical terms mentioned in the texts (for example: "Why is it necessary to renew vaccinations?", "Where is the ozonosphere located?"). The scales reached internal consistencies (Cronbach's $\alpha$) of .59 (global warming, 13 items) and .57 (vaccination, 8 items). To compute a prior knowledge score, each correct answer given by participants was coded with 1, false answers or lack of knowledge were coded with 0. Afterwards, mean scores were computed for prior topic knowledge (ranging from .00 to 1.00). For both topics, participants' prior knowledge was rather low (global warming: $M$ = .54, $SD$ = .22, *range:* .15 – .85, vaccination: $M$ = .53, $SD$ = .22, *range:* .13 – 1.00).

**Procedure**

Participant's prior knowledge and their beliefs about the two topics global warming and vaccination were measured four weeks prior to the experiment proper in order to minimize carry-

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over effects. In the experimental proper, participants read either the four texts on global warming or the four texts on vaccinations paragraph by paragraph on a computer screen in self-paced fashion. Participants were instructed to read the texts carefully and to respond to the questions after each text. After each text presentation the corresponding test items of the recognition task were presented. In this task, participants indicated whether or not the sentence was explicitly stated in the text by pressing on of two response keys (marked green and red for *yes* and *no*, respectively). The sentences were presented one-by-one in black letters (font type Arial, average height 0.56cm, bold) on a white background and in random order. At the end of the experiment, participants were thanked and debriefed. The first session (assessment of prior knowledge and beliefs) took about 30 minutes. The main experimental session during which the texts were read and dependent variables were assessed took about one and a half hours.

**Design**

The experimental design was a 2 (text-belief consistency: consistent vs. inconsistent, varied within subjects) X 2 (mode of presentation: blocked vs. alternating, varied between subjects) design. Prior knowledge ($z$-standardized) was included as covariate. In addition, we controlled for procedural artifacts (e.g., counter-balancing) by including the topic of the texts (global warming vs. vaccination, varied between subjects) and the text order (consistent-inconsistent vs. inconsistent-consistent, varied between subjects) as control factors into the analyses.

**Results**

All hypothesis tests were based on type-I-error probability of .05. Descriptive statistics and intercorrelations of all variables are provided in Table 2. The means of the recognition scores, which were used to compute the dependent variables, are provided in Table 3. Participants' overall accuracy in the comprehension measure, that is, the percentage of correct responses to inferences and distracters in the recognition task, was 61 percent ($SD = 0.09$).

Text topic and text order did not exert any significant effects that would alter the interpretation of hypothesis-relevant effects and effects of these variables are not reported here.

Assuming a medium effect size ($f = .25$ according to Cohen, 1988) and medium correlations ($\rho = .5$) between the levels of the independent variables in the population, the design and sample size of the experiment yielded a power ($1-\beta$) of .99 for detecting the focal interaction of text-belief consistency and mode of presentation (power was computed with the software G*Power 3; Faul, Erdfelder, Lang, & Buchner, 2007).

Hypothesis 1 predicted a text-belief consistency effect in adolescents' comprehension of multiple belief-relevant texts. We expected the situation model for texts communicating belief-consistent information to be stronger than the situation model for texts communicating belief-inconsistent information. In addition, Hypothesis 2 predicted that the text-belief consistency effect should be stronger if texts were read block-by-block, but should be attenuated if the texts were presented alternatingly. Finally, Hypothesis 3 predicted that the text-belief consistency effect should be stronger for participants with weaker prior knowledge and weaker for participants with stronger prior knowledge.

In line with Hypothesis 1, results of the ANCOVA revealed a main effect of text-belief consistency, $F(1, 63) = 8.4$, $p < .05$, $\eta_p^2 = .12$. As expected, participants' situation model for the belief-consistent texts was overall better ($M = 2.03$, $SE_M = 0.08$) compared to the situation model for the belief-inconsistent texts ($M = 1.84$, $SE_M = 0.09$). Moreover, we also found an interaction of text-belief consistency and mode of presentation, $F(1, 63) = 4.3$, $p < .05$, $\eta_p^2 = .06$ (Figure 1). Participants that received the texts in a blocked mode of presentation had a stronger situation model for belief-consistent texts ($M = 2.07$, $SE_M = 0.11$) compared to belief-inconsistent texts ($M = 1.72$, $SE_M = 0.12$), $F(1, 63) = 13.7$, $p < .05$, $\eta_p^2 = .18$. In contrast and as predicted by

Hypothesis 2, participants reading belief-consistent and belief-inconsistent texts alternatingly had similar situation model strengths for the belief-consistent ($M$ = 2.00, $SE_M$ = 0.13) and the belief-inconsistent texts ($M$ = 1.95, $SE_M$ = 0.13), $F(1, 63)$ < 1.0, $n.s.$.

Results further revealed a main effect of prior topic knowledge, $F(1, 63)$ = 4.3, $p$ < .05, $\eta_p^2$ = .06. Conditional effects of belief-consistency were computed for participants with higher prior knowledge (1 $SD$ above the sample mean) and for participants with lower prior knowledge (1 $SD$ below the sample mean) to interpret the interaction of text-belief consistency and prior knowledge (Aiken & West, 1991). Participants with higher prior knowledge (1 $SD$ above the sample mean of prior knowledge) had overall stronger situation models ($M$ = 2.11, $SE_M$ = 0.11) compared to participants with lower prior knowledge (1 $SD$ below the sample mean), $M$ = 1.76, $SE_M$ = 0.12. Moreover, we found an interaction of prior knowledge and text belief-consistency, $F(1, 63)$ = 4.1, $p$ < .05, $\eta_p^2$ = .06. Participants with higher prior knowledge had a better situation model for the belief-consistent texts ($M$ = 2.28, $SE_M$ = 0.12) compared to the situation model for the belief-inconsistent texts ($M$ = 1.93, $SE_M$ = 0.12), $F(1, 63)$ =12.6, $p$ < .05, $\eta_p^2$ = .17. In contrast, participants with lower prior knowledge had weaker and similar situation models for the belief-consistent ($M$ = 1.79, $SE_M$ = 0.13) and the belief-inconsistent texts ($M$ = 1.74, $SE_M$ = 0.13), $F(1, 63)$ < 1.0, $n.s.$. In sum, the results for prior knowledge were at variance with Hypothesis 3.

## Discussion

The present study investigated adolescents' situation model for belief-consistent and belief-inconsistent multiple texts from the Web. Moreover, we examined whether an alternating (compared to a blocked) mode of presentation and high (compared to low) prior knowledge can reduce the text-belief consistency effect in the comprehension outcome. The results of our experiment indicated that high school students experience similar difficulties as university

students in the comprehension of multiple belief-consistent and belief-inconsistent texts from the Web. In line with our expectations and with earlier research (e.g., Maier & Richter, 2013; Maier et al., 2018), we found that adolescents had a better situation model for belief-consistent compared to belief-inconsistent texts. In addition, an alternating mode of presentation eliminated the text-belief consistency effect in the comprehension outcome. These results fully replicate the findings from Maier and Richter (2013) who investigated the text belief-consistency effect in the comprehension outcome for university students.

The present study also extends prior research as it sheds light on the role of students' prior knowledge on the text-belief consistency effect. Based on earlier research and the Two-Step model of Validation discussed in the introduction, we had expected prior knowledge to be a learner characteristic that reduces the text-belief consistency effect. In line with earlier research, we found that the comprehension of multiple texts was overall better for students with higher prior topic knowledge (Bråten et al., 2014). However, unexpectedly, results revealed that the text-belief consistency effect in the situation model was not reduced by higher knowledge. To the contrary, it occurred only for participants with higher prior topic knowledge in our sample (1 *SD* above the mean). At first sight, this result seems to be at variance with research by Wiley (2005), who found that low-knowledge readers experienced a text-belief consistency effect in argument recall, whereas high-knowledge readers recalled belief-consistent and belief-inconsistent arguments to a similar extent. To make sense of these seemingly inconsistent findings, three additional remarks are necessary. First, in contrast to the approach of using prior knowledge as continuous covariate in the present study, Wiley (2005) used specific groups of participants to vary domain knowledge (for example political science graduate students and law students for a texts on abortion (legal topic) and the Persian gulf war (political topic)) or a median split to compute two knowledge groups (for difficulties with this approach, see Richter, 2007). Second, a

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close look at our continuous prior knowledge measure revealed that students' prior knowledge was rather low and fragmentary in our sample as the point estimate of 1 *SD* above the mean is 76 percent correct answers for global warming and 75 percent correct answer for vaccination (global warming: *M* = .54, *SD* = .22, *range:* .15 – .85, vaccination: *M* = .53, *SD* = .22, *range:* .13 – 1.00, see section *"prior knowledge"*). Third, concepts assessed by the prior knowledge measure referred to general knowledge about the topics (e.g., "Why is it necessary to renew vaccinations?", "Where is the ozonosphere located?") that non-experts on the topic should have to understand the texts. The prior knowledge test did not assess discipline specific terms or deep-level domain knowledge. Hence, very low scores on our prior topic knowledge might indicate that such participants had difficulty to even understand the texts, whereas our higher knowledge participants had sufficient – but not deep-level – domain specific knowledge to comprehend the texts. For such participants, topic knowledge might have still been fragmentary so that they used their beliefs on the topic as a basis for comprehension of the texts (similar to Wiley's well-educated low knowledge participants). Put differently, higher knowledge participants in our sample cannot be considered domain specific experts that possess the necessary deep-level background knowledge to make strategic evaluations about the arguments and claims made in the texts. From this point of view, it is not surprising that we found a text-belief consistency effect in the situation models for high school students with a better general understanding of the texts, but none for our low-knowledge participants. Validation is tied to comprehension; if comprehension fails, effects of non-strategic validation should not be found in the comprehension outcome (Richter, 2015).

The present study focused on the effects of text-belief consistency on the comprehension outcome for each text. Integration of information across texts was not investigated as we wanted to align the research findings to existing results (e.g., Maier & Richter,

2013). Future studies should nevertheless also assess integration of information across texts and how it is affected by text-belief consistency. Moreover, the texts were presented in a digital environment, but without typical features of web-based information such as hyperlinks or the ability to freely navigate between the texts. This approach was necessary to vary the mode of text presentation. Nevertheless, it might have made it more difficult for participants to integrate information across texts as looking back to inconsistent or contrary information was not possible. In addition, comprehension questions for each text were directly provided after a text was read as we expected that participants will forget to much information if the comprehension task for all texts would have been provided after all texts had been read. Nevertheless, comprehension of the first and the following texts might be different from each other as participants get more used to the experimental procedure during the course of the experiment. However, it is important to note that participants were told that they should answer questions after each text at the beginning of the experiment. Moreover, reading order was counterbalanced and no order effects were found in the analyses.

A further shortcoming of the present study is the low internal consistency of the prior knowledge measures. Even if the prior knowledge measures focused on broad concepts relevant to understand the topics vaccinations and global warming, the low internal consistencies suggest that the aspects assessed by these measures are rather heterogeneous. Moreover, the low consistency score for the prior knowledge measure might be due to the fact that high school students' prior knowledge on the topics was fragmented, that is, participants might knew some basic knowledge, while they remain unaware of other pieces of knowledge. Guessing might have played an additional role in students' response to the multiple choice measures, even if participants were able to indicate lack of knowledge for each item. It might be more fruitful to

use open ended knowledge questions in subsequent research as they are influenced by guessing to a lower extent.

In the present study, two science-related topics, i.e., vaccinations and global warming, were used for the experimental texts. Despite the fact that the carefully conducted pilot study with an independent sample of 48 students in upper secondary high school found no differences between the belief-consistent and belief-inconsistent texts in their perceived plausibility (Table 1), the choice of topics for the experimental texts might have affected reading and reading outcomes. For example, comprehension of texts might have not only be stronger for texts that were consistent with readers' beliefs, but also for texts that seemed more reliable or at least compatible with scientific consensus on the topic. Further research should investigate the text-belief consistency effect for additional science-related topics that allow balancing out belief-consistency for the texts' topics.

The Word Wide Web makes scientific information and multiple texts easily available for adolescents. The present study implies that comprehending multiple belief-relevant texts from the Web is a challenging task for high school students as their comprehension of belief-inconsistent information might be hampered. In these cases, a rational metacognitive insight might be to acknowledge ones' inability to make valid judgment about the debate and rely on expert opinion instead (Scharrer, Rupieper, Stadtler & Bromme, 2017). Adolescents – similar as university students – fail to do so and rather rely on their prior beliefs as special kind of gatekeeper that determines the extent that they engage in the comprehension of belief-relevant information. An alternating – compared to a blocked – mode of presentation was one factor identified in the present research that seems to be able to reduce the impact of prior beliefs. Future research should be conduted to identify additional means that might prevent text-belief consistency effects in comprehension outcomes.

## Notes

[1] Three high-school students that were 20 years old participated in the study. These participants were excluded from the analyses to align the study sample to the target of the Special Issue. Excluding these participants did not change the pattern of results.

[2] The original belief scales that had been constructed, tested and used in earlier studies on multiple text comprehension (Maier & Richter, 2013) consisted of five items each. However, one item for each scale was excluded from the analyses to improve the internal consistency of the scales.

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Table 1:

*Text Characteristics of the Eight Experimental Texts*

| Text Topic | Argumentative Stance | Length[a] | Readability[b] | Plausibility Scale[c] $M\ (SE_M)$ | Understandability Scale[c] $M(SE_M)$ | Number of Arguments[c] $M(SE_M)$ | Clarity of Stance[c] $M(SE_M)$ | Interesting-ness[c] $M(SE_M)$ |
|---|---|---|---|---|---|---|---|---|
| Global warming | Belief-consistent 1 | 898 | 48 | 4.02(.29) | 4.51(.23) | 5.20(.77) | 5.36(.43) | 3.36(.49) |
| | Belief-consistent 2 | 927 | 46 | 3.71(.43) | 4.31(.34) | 4.17(.55) | 5.00(.37) | 4.25(.43) |
| | Belief-inconsistent 1 | 894 | 47 | 3.54(.23) | 4.67(.28) | 3.50(.40) | 4.27(.51) | 4.00(.49) |
| | Belief-inconsistent 2 | 903 | 49 | 3.48(.29) | 4.53(.27) | 3.83(.42) | 5.17(.27) | 4.17(.32) |
| Vaccinations | Belief-consistent 1 | 905 | 49 | 4.19(.17) | 4,86(.11) | 5.25(.73) | 5.25(.35) | 4.50(.29) |
| | Belief-consistent 2 | 854 | 49 | 3.61(.24) | 4.19(.27) | 5.10(.67) | 4.27(.51) | 3.00(.42) |
| | Belief-inconsistent 1 | 894 | 52 | 3.96(.26) | 4.78(.17) | 4.71(.37) | 5.36(.23) | 4.14(.40) |
| | Belief-inconsistent 2 | 921 | 50 | 3.24(.30) | 4.58(.21) | 4.67(.33) | 5.77(.17) | 3.27(.60) |

*Note*. [a]Number of words per text. [b]Determined with the German adaption of the Flesch`s Reading Ease Index (Amstad, 1978). [c]Results of the pilot-testing with

ratings of 48 upper secondary high school students (response categories ranging from 0 = *not at all* to 6 = *totally;* The plausibility scale consists of five items

(Cronbach's α = .88), the understandability scale consists of nine items (Cronbach's α = .80). Each entry represents the average judgments across all participants).

Table 2:

*Means, Standard Deviations and Intercorrelations of Independent Variable (Varied Between-Subjects) and Dependent Variables*

| Measure | *M* | *SD* | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|
| 1 Mode of presentation (contrast-coded, -1 = blocked vs. 1 = alternating) | -0.08 | 1.00 | 1.00 | | | | |
| 2 Reading order (contrast-coded, -1 = belief-inconsistent text first, 1 = belief-consistent text first) | -0.08 | 1.00 | -.01 | 1.00 | | | |
| 3 Prior knowledge (z-standardized)[a] | 0.53 | 0.22 | .29* | .12 | 1 | | |
| 4 Situation model strength (belief-consistent texts) | 2.04 | 0.75 | .04 | -.01 | .29* | 1 | |
| 5 Situation model strength (belief-inconsistent texts) | 1.82 | 0.79 | .14 | .01 | .14 | .68** | 1 |

*Note. N* = 72. Situation model strength: biased-corrected proportion of yes-responses to inference items. [a] *M* and *SD* are provided for the raw prior knowledge scores.

* *p* < .05 (two-tailed), *p* < .01 (two-tailed).

Table3:

*Mean Proportions of Yes-Responses in the Comprehension Task for Inference and Distracter Items by Experimental Condition*

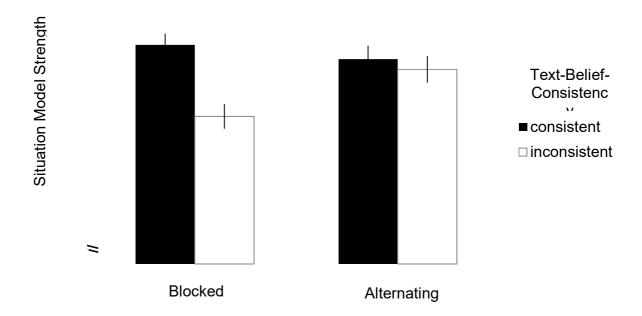| Measure | Inferences | Distracters |
|---|---|---|
| Block-by-block presentation | | |
| Belief-consistent texts | .74 (.02) | .10 (.03) |
| Belief-inconsistent texts | .66 (.02) | .12 (.03) |
| Alternating presentation | | |
| Belief-consistent texts | .69 (.03) | .04 (.01) |
| Belief-inconsistent texts | .67 (.03) | .04 (.01) |

*Note*. $N = 72$.

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*Figure 1.* Effects of text-belief consistency and mode of presentation on situation model strength. Error bars represent the standard error of the mean.