Text-Belief Consistency Effects in the Comprehension of Multiple Texts with Conflicting Information

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Abstract

When reading multiple texts about controversial scientific issues, learners must construct a coherent mental representation of the issue based on conflicting information that can be more or less belief-consistent. The present experiment investigated the effects of text-belief consistency on the situation model and memory for text. Students read four texts about a scientific controversy. Learners' situation model was biased towards their beliefs when belief-consistent and belief-inconsistent texts were presented block-by-block. When the texts were presented alternatingly, situation models for belief-consistent and belief-inconsistent texts were equally strong. Moreover, the text base was better for belief-inconsistent texts. These results support the idea that prior beliefs influence the processing of conflicting information in multiple texts differently on the level of the situation model and on the propositional text base. A more balanced situation model of scientific controversies can be promoted by presenting belief-consistent and belief-inconsistent texts in an alternating sequence.

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Lay people, students, and scientists alike usually turn to web-based sources when they want to learn more about a scientific issue currently debated in public (such as global warming, renewable energies, or health issues). More often than not, they will study several texts that argue for different positions in the controversy (multiple texts, Perfetti, Rouet, & Britt, 1999). For example, learners researching information on the risks and benefits of vaccinations will encounter texts arguing for the benefits of regular vaccinations as well as texts arguing that vaccinations bear health risks that outweigh their benefits. In addition, most learners will not be fully impartial when they read about a topic but will come equipped with beliefs that may be closer to some positions in the controversy than to others. The scenario just described raises the question central to the research reported here: How do previously held beliefs affect the mental representation of science-related texts with conflicting information?

Research in the areas of text comprehension and social information processing indicates that the memory representation of controversial issues is biased towards belief-consistent information whereas belief-inconsistent information tends to be represented to a lesser extent (congeniality hypothesis, Eagly & Chaiken, 1993). For example, Levine and Murphy (1943) presented procommunist and anticommunist messages to participants who held procommunist or anticommunist views. In a later recall task, participants who held beliefs consistent with the arguments presented in a message showed better memory for exactly this message.

Schema theory provides a framework for understanding such text-belief consistency effects. According to a schema-theoretic explanation, prior beliefs might serve as a knowledge structure that guides the interpretation and the selection of information for encoding and also

facilitates the integration of information (Pratkanis, 1989). All of these processes can contribute to a memory advantage for belief-consistent information. Thus, the effects of prior beliefs on reading recall might be similar to perspective effects on reading recall (e.g., reading a story from the perspective of a burglar or a buyer of a house; Anderson & Pichert, 1978). In this research, perspective not only affected recall but also the allocation of attention during comprehension, with sentences relevant to the current perspective receiving longer reading and fixation times (Goetz, Schallert, Reynolds, & Radin, 1983; Kaakinen & Hyönä, 2005; Kaakinen, Hyönä, & Keenan, 2002).

In addition to recall tasks, recognition tasks are frequently used to investigate the influence of text-belief consistency on memory of texts. Recognition tasks require participants to make a judgment about whether the critical information has been encountered in the text. For such tasks, the particular type of items used to test recognition memory is critical for knowledge-based biases to occur. When information from the text is to be recognized, the target information can serve as a direct retrieval cue. Several studies have even found the recognition memory for atypical information (which does not confirm to a schema or script) to exceed recognition memory for schema-congruent information even at longer intervals between learning and test (e.g., Davidson, 1994; Smith & Graesser, 1981). Atypical information is often unexpected, surprising, and cannot be integrated easily into existing knowledge structures, all of which may lead to a privileged memory representation. However, when schema-congruent foils are presented, these are often falsely recognized as information that has been presented in the text (Maki, 1990; Smith & Graesser, 1981). These findings can be explained with a schema-pointer-plus-tag model in which information from the text is integrated with the schema but schema-incongruent information receives a prominent (*tagged*) status in the memory representation of

the text (Graesser, 1981; Schank & Abelson, 1977). Provided that learners' prior beliefs may serve as a schema in the comprehension and retrieval of multiple texts on controversial issues, it seems plausible to assume that text-belief consistency effects in this type of learning situation follow a similar pattern.

In text comprehension research, there is a common distinction made between two representational outcomes of comprehension processes: (a) the propositional text base and (b) the situation model or mental model of the text content (Johnson-Laird, 1983; Kintsch, 1988; van Dijk & Kintsch, 1983). The text base is usually conceived of as a representation of the semantic structure of a text. Its construction requires interpretive processes such as assigning meaning to words, identifying and extracting propositions, and connecting these propositions to a coherent network. As a result, the propositional text base reflects memory for text and can be used, for example, to recognize or recall information explicitly stated in the text. However, in order to gain a deep understanding of a text, learners have to go beyond the propositional text base by integrating text information with their prior knowledge by way of knowledge-based inferences. The representational outcome of such integrative processing is called a situation model (van Dijk & Kintsch, 1983) or mental model (Johnson-Laird, 1983) because it is a representation of the state of affairs (the situation) described in a text rather than a representation of the text itself.

For assessing the strengths of the text base and the situation model, Schmalhofer and Glavanov (1986) have proposed a technique that is based on bias-corrected recognition scores (similar to the signal detection measure *d'*). According to this proposal, the estimate of text base strength is based on the (bias-corrected) proportion of correctly recognized paraphrases from the text whereas the estimate of situation model strength is based on the (bias-corrected) proportion of inferences (falsely) recognized as coming from the text. Thus, the method proposed by

Schmalhofer and Glavanov (1986) for assessing text base strength resembles essentially a recognition task where information from the text—the meaning of the text rather than direct quotes—is to be recognized. In contrast, given that the inference items represent knowledge-based inferences, they largely correspond to schema-based foils used in studies on the schema-pointer-plus-tag hypothesis (e.g., Smith & Graesser, 1981). These items can activate available knowledge and beliefs, which, in turn, may lead to false-positive recognition responses because the inferences fit well with what participants know and believe about the topic (Reder, 1982).

In sum, if prior beliefs on controversial scientific issues serve as schema-like knowledge structures, text-belief consistency effects (i.e., a memory advantage for texts consistent with learners' prior beliefs) may be expected to occur on the level of the situation model. In contrast, on the level of the text base representation, a reverse text-belief consistency effect (i.e., a memory advantage for texts inconsistent with learners' prior beliefs) may be expected. At first glance, assuming opposite belief effects on the levels of the text base and the situation model may seem a little far-fetched because the propositional text base provides the textual input for constructing the situation model (Kintsch, 1988). Thus, learners are unlikely to build a strong situation model from a poor text base. However, this basic relationship notwithstanding, the pattern of opposite effects on the two types of representations can occur whenever an intervention increases the impact of knowledge-based processes which strengthens the situation model but, at the same time, weakens the propositional text base (see, for example, the reverse coherence effect; McNamara, Kintsch, Songer, & Kintsch, 1996).

Text-Belief Consistency Effects and Text Order

Apart from the type of text representation that is addressed by a memory task, the way in which multiple texts on controversial scientific issues are presented might also play a moderating

role for text-belief consistency effects. In particular, presenting belief-consistent and belief-inconsistent texts in an alternating order rather than block-by-block might be a way to create more balanced situation models for belief-consistent and belief-inconsistent information. Theoretically, this assumption can be justified by considering that alternating and block-by-block presentations differ in the relative memory strength that has been established for the belief-consistent position at the time that a learner reads a belief-inconsistent text. In most cases, the relative strength of the belief-consistent position is likely to be weaker in the alternating compared to the block-by-block presentation. As a consequence, it may be less likely overall that information from belief-inconsistent texts is ignored.

Computational modeling work based on the construction integration model allows a more precise formulation of these assumptions (Goldman, Varma, & Coté, 1996). From this perspective, reading belief-consistent and belief-inconsistent texts block-by-block would lead to a strong network of interrelated propositions from the belief-consistent texts. If this network stays active in working memory, less activation is available for processing new information from the belief-inconsistent texts and connecting it to prior knowledge. In contrast, reading belief-consistent and belief-inconsistent texts in an alternating sequence increases the activation of propositions from belief-inconsistent texts and the prior knowledge activated during processing of these texts, leading to a stronger situation model. However, due to the fact that an alternating presentation should also decrease the activation for propositions from belief-consistent texts, the situation model for these texts should also be weakened.

To the best of our knowledge, there are no experiments on order effects in the comprehension of multiple texts with conflicting information. However, in a series of careful experiments, Wiley (2005) investigated the recall of belief-consistent and belief-inconsistent

arguments on controversial topics. She found a memory advantage for arguments consistent with one's own position only when supporting and opposing arguments were presented block-by-block. When the arguments were presented in an alternating fashion, participants were able to recall belief-consistent and belief-inconsistent arguments equally well. For comprehension of multiple texts on controversial scientific topics, these results suggest that presenting belief-consistent and belief-inconsistent texts in an alternating sequence rather than block-by-block might have a similar effect by reducing the text-belief consistency effect, leading to equally strong situation models for belief-consistent and belief-inconsistent texts.

Rationale of the Present Experiment

The aim of the present experiment was to investigate how learners studying multiple texts about a scientific controversy remember information from texts that are consistent or inconsistent with their own stance on the issue. To this end, participants read four texts that represented opposing positions on an issue currently debated in public (causes of global warming or risks/benefits of vaccinations). The texts were designed in such a way that the broad majority of participants strongly favored one position in the controversy over the other. For example, concerning global warming, all participants held the view that the current trend in global warming is the result of man-made rather than natural causes. Likewise, concerning vaccinations, all participants endorsed the view that the individual and social benefits of vaccinations by far exceed their risks. As a consequence, two of the four texts that each participant received were consistent or inconsistent with their prior beliefs concerning the issue. In addition to text-belief consistency, we also varied the order in which the texts were read. Thus, the experiment created a scenario which more or less resembled situations in which learners use the World Wide Web to research information about scientific issues.

For this scenario, the assumption that learners' prior beliefs on the controversial issue can serve as a schema-like knowledge structure for encoding and retrieval of text information implies a number of predictions. First, information from belief-consistent texts should be integrated with learners' prior beliefs. In contrast, for belief-inconsistent texts, fewer and possibly less accessible beliefs are available to integrate information from these texts. As a result, the situation model for texts communicating belief-consistent information should be stronger overall compared to texts communicating belief-inconsistent information (Hypothesis 1). However, the activation available for processing belief-inconsistent information might be increased when texts taking opposite stances are presented in an alternating fashion. Research on memory for arguments on controversial topics (Wiley, 2005) suggests that presenting belief-consistent and belief-inconsistent information in an alternating order might be a way to foster comprehension and memory for belief-inconsistent information. Against this background, we assume that the predicted advantage for belief-consistent compared to belief-inconsistent texts for the situation model should be reduced by an alternating presentation of belief-consistent and belief-inconsistent texts (Hypothesis 2).

The hypothesized memory advantage of belief-consistent over belief-inconsistent information should hold for the situation model representation only. For the memory for the text itself (i.e., the text base representation) we make the reverse prediction: texts with belief-inconsistent information will have an advantage over texts with belief-consistent information (Hypothesis 3). This hypothesis can be justified by research on memory for schema-inconsistent information. Despite the fact that information from belief-inconsistent texts is less likely to be integrated into the situation model, it may nevertheless be remembered as part of the text that has been read. Moreover, belief-inconsistent information might receive a privileged (tagged) status

in the memory representation of the text (cf. the schema-pointer-plus-tag model; Graesser, 1981; Schank & Abelson, 1977). One variant of Hypothesis 3 is that the source memory (i.e., memory for the particular text from which a piece of information is taken or can be inferred) will be better for belief-inconsistent information compared to belief-consistent information (Hypothesis 4). This hypothesis is also motivated by research on multiple text comprehension for which the representation of source information is an important issue (cf. the notion of the intertext model in Perfetti et al., 1999). Belief-inconsistent information might increase attention for the source of the information and, hence, the encoding of source information along with the text information.

In order to get an idea of the cognitive processes behind the hypothesized effects of text-belief consistency on the situation model and memory for text, we also analyzed the reading times for belief-consistent and belief-inconsistent texts. Reading times can be regarded as a gross measure of the amount of cognitive effort during reading (e.g., Graesser, 1981)—in this case, participants' cognitive effort to process belief-consistent and belief-inconsistent texts. The analyses of the reading times were guided by the question of whether and to what extent the magnitude of the text-belief consistency effect would be associated with differences in the reading times for belief-consistent vs. belief-inconsistent texts. Theoretically, two basic patterns of effects may occur. First, text-belief consistency effects might be associated with longer reading times for belief-inconsistent compared to belief-consistent texts. This pattern would be expected from the perspective of schema theory: belief-inconsistent texts should be more difficult to process than belief-consistent texts. Alternatively, it seems possible that text-belief consistency effects occur if participants invest less cognitive effort (i.e., spend less time when reading belief-inconsistent texts). This pattern would hint at a strategic process of information selection that favors belief-consistent information over belief-inconsistent information (selective

exposure; see, for example, the theory of cognitive dissonance; Festinger, 1957).

Method

Participants

Participants were 79 psychology undergraduates (59 women and 20 men) with an average age of 24.7 years (*SD* = 5.86).

Text Material

Eight generally accessible texts about currently debated scientific issues were used as experimental texts. Four of the texts referred to causes of global warming whereas the other four texts discussed the risks and benefits of vaccinations. These controversies were selected because participants of the target population (*N* = 18) had rated them as interesting in a pilot study with 18 topics (global warming: *M* = 4.22, *SD* = .73; vaccination: *M* = 3.83, *SD* = 1.02; ratings on a scale from 1, *not interesting at all*, to 5, *very interesting*). In addition, for these two topics the vast majority of the German population strongly agrees with one argumentative position and at the same time disagrees with the contrary argumentative position. Thus, concerning global warming, large parts of the general public in Germany hold the view that the current acceleration in global warming results from man-made rather than natural causes. Likewise, concerning vaccinations, most people hold the view that vaccinations are more beneficial than risky. Based on this preference for one argumentative position in these two controversies, we constructed two texts for each topic that were clearly consistent with the beliefs of the vast majority of the general public and two texts that were clearly inconsistent with the beliefs of the vast majority of the general public.

Accordingly, two of the texts on global warming claimed that mankind is responsible for global warming (belief-consistent stance) whereas the other two texts took the opposite stance

that natural phenomena are the causes of global warming (belief-inconsistent stance). Likewise, two of the texts on vaccinations argued for the claim that vaccinations are necessary and beneficial (belief-consistent stance) whereas the other two texts claimed that they are unnecessary and harmful (belief-inconsistent stance). The texts were constructed on the basis of science-related journal articles 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). These websites are typical sources used by the general public for informal learning about science topics. To ensure the comparability of the texts, writing style, structure, and length of all texts were held strictly parallel (see Table 1 for a synopsis of text characteristics).

----INSERT TABLE 1 ABOUT HERE----

All texts started with a short statement of the text's major claim and key arguments. In the body of each text, the four key arguments were presented separately, with each key argument under a subheading. The arguments that were presented in each text supported the text's major claim and were unique to this text (for an overview of the arguments for each text see Table 2). As a consequence, all texts contained new information that was not presented in any of the other texts. Four arguments for each text were used to provide sufficient arguments and evidence for the text's major claim. In each text, each argument consisted of a claim that was followed by supporting evidence. At the end of each text a short summary of the arguments and a conclusion reflecting the text's major claim were presented (an example of the text materials is available in the Appendix).

----INSERT TABLE 2 ABOUT HERE----

The average length of each text was 899 words. The average readability score (determined with the German adaptation of the Flesch`s Reading Ease Index; Amstad, 1978) was 48.8, indicating that the texts were of moderate difficulty. To further ensure the comparability of the text content, the texts were pilot-tested with an independent sample of 106 university students. Each of the participants in the pilot study read two of the four texts on the same topic. Participants perceived all eight texts as easily understandable and providing high-quality arguments that represented a clear stance toward the issue (see Table 1 for results of these students' ratings during the pilot study). In order to detect possible differences between the texts, we performed 60 paired samples *t*-tests (all 6 possible pairs of texts for each of the two issues: 12 text combinations x 5 text characteristics; Holm-Bonferroni correction for multiple tests; Holm, 1979). None of these tests revealed a significant difference between the texts.

Dependent Variables

Situation model strength and memory for text. Memory was measured on the levels of the situation model and memory for text (propositional text base) with a recognition task modified after Schmalhofer and Glavanov (1986). Situation model strength and memory for text were assessed with 24 test items (sentences) per text (examples of the item materials are available in the Appendix). Participants had to judge whether the information expressed in the test item was explicitly provided in the text or not. More specifically, they were told that for a positive response, the test item was required to correspond in content (but not verbatim) to one sentence in the text. Eight of the sentences were paraphrases of sentences from the text, eight were inferences from the text, and eight were distracters. For paraphrase items, a sentence from

the text was altered by varying the word order and replacing key content words with synonyms. As a consequence, the similarity of the sentence to the text surface was reduced while leaving the explicit content of the sentence (i.e., its semantic structure) intact.

In contrast, inference items contained information not explicitly mentioned in the text. Rather, the information needed to be inferred by the participants to build an adequate mental representation of the state of affairs described in the text. The items required four different types of inferences: explanations, associations, predictions, and superordinate goal associations (Graesser, Singer, & Trabasso, 1994; Narvaez, van den Broek, & Ruiz, 1999). Explanations or backward inferences include causes—such as motives or conditions—that explain why events or circumstances mentioned in the texts might have occurred. Associations or concurrent inferences provide additional information about specific functions or characteristics of concepts and objects discussed in the texts. Together, explanations and associations accounted for two thirds of the inference items. Predictions or forward inferences state consequences that might occur in the future as results of circumstances mentioned in the texts. Finally, superordinate goal associations are statements about motives and goals that caused specific behavior of agents mentioned in the texts. These last two types of inference items accounted for approximately one third of the inference items. The inference items never required the integration of information across different texts.

Finally, the distracter items communicated information that was loosely related to the topic described in the text but was neither explicitly mentioned in the text nor a sensible inference from the text. Thus, the information communicated by distracter items was not part of the memory for text or the situation model. Rather, it shared some superficial content aspects with the text.

The idea behind using a recognition task adapted from Schmalhofer and Glavanov (1986) is that it allows for assessing the strength of memory for text (the propositional text base) as well as the situation model with one single task. Participants can provide a yes-response to a paraphrase item simply by retrieving information from the propositional text base and determining that this information matches the content of the test item. In contrast, yes-responses to inference items must be based on a different mechanism. They are likely to be based on a consistency check of the information in the test item with the situation model constructed by the text. Following this logic, we constructed measures of situation model strength and memory for text (the propositional text base) based on the recognition responses to the three sets of items that were corrected for response tendencies (similar to the signal detection measure *d'*; see Schmalhofer & Glavanov, 1986, for details).

The measure for situation model strength was based on the proportions of yes-responses to inference items and distracter items. These proportions were probit-transformed to normalize their distributions. Based on the assumption that the proportion reflects the cumulative proportion of a normally distributed variable, the proportion is transformed by determining the corresponding *z*-value to which 5 is added to avoid negative values (e.g., Cohen, Cohen, West, & Aiken, 2003, p. 241). The probit-transformed proportions of yes-responses to the distracter items (false alarms) were subtracted from the probit-transformed proportions of yes-responses to the inference items (hits).

Likewise, the measure for memory of text was based on the proportions of yes-responses to paraphrase items and distracter items. This measure was computed by subtracting the probit-transformed proportions of yes-responses to the distracter items (false alarms) from the probit-transformed proportions of yes-responses to the paraphrase items (hits). In contrast to the

original method proposed by Schmalhofer and Glavanov (1986), yes-responses to the distracter items rather than to the inference items were used for bias-correction of the memory for text measure. This modification was applied to avoid the artificial negative dependency between this measure and situation model strength that would arise if yes-responses to the inference items were counted as hits on the situation model level but as false alarms on the level of the propositional text base.

Source memory. As an additional indicator of memory for text in the context of multiple text comprehension, we used a source memory task. In this task, participants were provided with the title of the text and had to indicate by pressing the appropriate key (number key 1 to 4) to which text the paraphrase and inference items belonged. The number did not indicate the order in which participants read the texts but was randomly assigned to each of the texts. As indicator of the strength of source memory we measured the proportion of correctly assigned paraphrases for each text.

Reading times. Participants read the texts paragraph-by-paragraph in a self-paced fashion on a computer screen (20-24 paragraphs per text). For exploratory analyses, we recorded the reading times for each paragraph. This measure was standardized by dividing the raw reading time by the number of syllables in the paragraph. The standardized reading times per paragraph were inspected for outliers. Reading times deviating more than two standard deviations from the mean of the experimental condition (3.7% of all reading times) were discarded (Ratcliff, 1993). Finally, the mean outlier-corrected standardized reading time was computed for each text and each participant.

Learner Characteristics

Prior beliefs. Participants' prior beliefs about the two issues discussed in the

experimental texts were assessed by asking them to judge their agreement with ten statements per issue (response categories ranging from 1, *totally disagree*, to 6, *totally agree*). Five statements claimed that mankind is responsible for global warming (e.g., “I believe that humans are the cause of the global warming”) whereas another five statements claimed that 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 has existed”). Likewise, five statements claimed that vaccinations are necessary and beneficial (e.g., “I think that vaccinations are the most important and most effective method against infectious diseases”) whereas another five statements represented the position that vaccinations are unnecessary and harmful (e.g., “I am against vaccinations because they might overstrain my immune system”). The internal consistency of the scales (Cronbach's α) were .79 (global warming) and .90 (vaccination).

Prior knowledge. Prior knowledge concerning the two issues was measured by multiple choice tests (one correct answer, two distracters) that referred to knowledge about basic concepts and technical terms mentioned (but not explained) in the texts (e.g., “Why is it necessary to renew vaccinations?”; “Where is the ozonosphere located?”). The scales consisted of nine (global warming) and seven items (vaccination). In the present sample, they reached rather poor internal consistencies of .50 (global warming) and .42 (vaccination). The mean item difficulty was .22 (global warming) and .19 (vaccination), indicating an overall low prior knowledge on the issues discussed in the texts. Given the low overall level and the resulting low variance of prior knowledge, the measure was not included in the analyses.

Procedure

Learner characteristics were measured on a separate occasion four weeks prior to the experiment in order to minimize carry-over effects. In the experiment proper, participants read

either the four texts on global warming or the four texts on vaccinations in a self-paced fashion. The texts were presented paragraph by paragraph on a computer screen. Participants were instructed to read the texts carefully. After the presentation of each text, the corresponding test items of the recognition task were presented one-by-one in black letters (font type Arial, average height 0.56 cm, bold) on a white background and in random order. Participants were asked to indicate whether or not the information expressed in the test item was explicitly provided in the text by pressing one of two response keys (marked green and red for *yes* and *no*, respectively). After all four texts, source memory was assessed with the same set of paraphrase and inference items. Participants gave their responses by pressing one of the four response keys. Finally, participants received an argument generation task and a reading strategy questionnaire (data for these tasks are not reported here). At the end of the experiment, participants were thanked and debriefed.

Design

The core experimental design was a 2 (text-belief consistency: consistent vs. inconsistent) X 2 (order of presentation: block-by-block vs. alternating) design. The first variable was varied within subjects and the latter was varied between subjects. In addition, the topic of the texts (global warming vs. vaccination, varied between subjects) and the text order (consistent-inconsistent vs. inconsistent-consistent, varied within subjects) were included as control factors.

Results

The hypotheses concerning effects of text-belief consistency and order of presentation were tested with an ANOVA for designs with between- and within-subjects factors. The order of belief-consistent vs. belief-inconsistent texts, the text topic (global warming vs. vaccinations), and the texts itself were included as control factors in the analysis. The between-subject factors

were entered into the model as contrast-coded predictors (-1 vs. 1). All hypothesis tests were tested based on type-I-error probability of .05. Descriptive statistics and intercorrelations of all variables are provided in Table 3. The means of the recognition scores, which were used to compute the dependent variables, are provided in Table 4. Text topic as well as the texts itself were controlled for as independent variables in the ANOVAs but did not exert any significant effects that would alter the interpretation of hypothesis-relevant effects. Hence, effects of these variables are not reported here. Under the assumption of a medium effect size (f = .25 according to Cohen, 1988) and medium correlations (ρ = .5) between the levels of the independent variables in the population, the design and sample size of the experiment yielded a power (1-β) of .99 for detecting the focal interaction of text-belief consistency and order of presentation (power was computed with the software G*Power 3; Faul, Erdfelder, Lang, & Buchner, 2007).

----INSERT TABLE 3 ABOUT HERE---

----INSERT TABLE 4 ABOUT HERE----

Manipulation Check of Text-Belief Consistency

Prior to investigating the effects of text-belief consistency on situation model strength and memory for text, we checked whether or not participants' initial beliefs conformed to the text-belief consistency definition used in this experiment. Paired sample *t*-test revealed that for participants reading texts about global warming, they strongly agreed with the idea that mankind is responsible for global warming (M = 4.85, SD = 0.91), but they tended to reject the idea that natural phenomena are the causes of global warming (M = 2.64, SD = 0.77, $t(78) = 13.32$, $p <$

.001, d = 2.62). Both belief scores differed significantly from the theoretical midpoint (3.5) of the response scale (mankind responsible for global warming: $t(78) = 13.14$, $p < .001$, $d = 2.01$; natural phenomena cause global warming: $t(78) = -9.93$, $p < .001$, $d = -1.58$). Similarly, for the vaccination issue, participants favored the position that vaccinations are necessary and beneficial ($M = 3.81$, $SD = 1.18$) and at the same time disagreed with the position that vaccinations are unnecessary and harmful ($M = 2.64$, $SD = 1.10$, $t(78) = 4.89$, $p < .001$, $d = 1.03$). Again, both belief scores differed significantly from the theoretical midpoint of the response scale (vaccinations are necessary and beneficial: $t(78) = 2.33$, $p < .05$, $d = 0.37$; vaccinations are unnecessary and harmful: $t(78) = -6.97$, $p < .001$, $d = -1.01$).

Effects of Text-Belief Consistency on Situation Model Strength

Hypothesis 1 predicted that the situation model for texts communicating belief-consistent information should be stronger than the situation model for texts communicating belief-inconsistent information. An ANOVA on the signal-detection measure of situation model strength revealed a main effect of text-belief consistency, $F(1, 71) = 11.3$, $p < .01$, $\eta_p^2 = .14$. In line with Hypothesis 1, the situation model for belief-consistent texts was stronger ($M = 2.29$, $SE_M = 0.06$) than the situation model for belief-inconsistent texts ($M = 2.09$, $SE_M = 0.06$). However, the main effect of text-belief consistency was qualified by an interaction with the order of presentation, $F(1, 71) = 4.3$, $p < .05$, $\eta_p^2 = .06$ (Figure 1). When the texts were presented block-by-block, there was a strong advantage for belief-consistent texts ($M = 2.37$, $SE_M = 0.09$) over belief-inconsistent texts ($M = 2.05$, $SE_M = 0.08$), $F(1, 71) = 13.5$, $p < .001$, $\eta_p^2 = .16$. When the text were presented in an alternating order, the advantage of belief-consistent texts ($M = 2.20$, $SE_M = 0.08$) over belief-inconsistent texts ($M = 2.13$, $SE_M = 0.07$) was smaller and no longer significant, $F(1, 71) = .92$, $p = .34$. In sum, the order of presentation moderated the effects of

text-belief consistency as predicted by Hypothesis 2.

----INSERT FIGURE 1 ABOUT HERE----

Effects of Text-Belief Consistency on Memory for Text

Memory for text (propositional text base). Hypothesis 3 predicted that memory for belief-inconsistent texts will be better than memory for belief-consistent texts. In an ANOVA on the signal-detection measure of text memory, there was a large main effect of text-belief consistency, $F(1, 71) = 13.4$, $p < .001$, $\eta_p^2 = .16$. In line with Hypothesis 3, the memory for belief-inconsistent texts was considerably stronger ($M = 2.41$, $SE_M = 0.05$) than the memory for belief-consistent texts ($M = 2.22$, $SE_M = 0.05$).

The interaction between text-belief consistency and order of presentation (block-by-block vs. alternating) failed to reach significance, $F(1, 71) < 1$, $p = .68$. Instead, there was an interaction with whether the belief-consistent or the belief-inconsistent text was presented first, $F(1, 71) = 7.8$, $p < .01$, $\eta_p^2 = .10$ (Figure 2). This interaction was due to the fact that the memory advantage of belief-inconsistent texts over belief-consistent texts was particularly pronounced when belief-inconsistent texts were presented first ($M = 2.55$, $SE_M = 0.07$ vs. $M = 2.22$, $SE_M = 0.07$), $F(1, 71) = 21.9$, $p < .001$.

----INSERT FIGURE 2 ABOUT HERE----

Source memory. In an ANOVA with source memory (proportion of correctly assigned paraphrase items) as dependent variable, there was a large main effect for text-belief consistency,

$F(1, 71) = 30.0$, $p < .001$, $\eta_p^2 = .30$. As predicted by Hypothesis 4, the source memory for belief-inconsistent texts ($M = .65$, $SE_M = 0.02$) was stronger than the source memory for texts with belief-consistent information ($M = .51$, $SE_M = 0.02$). There was no interaction of text-belief consistency and presentation order, $F(1, 71) = 0.1$, $p = .75$.

Exploratory Analyses of Reading Times

In order to explore how effects of text-belief consistency covaried with the amount of cognitive effort in reading belief-consistent and belief-inconsistent texts, we took a closer look at the relationships of the differences in the reading times for belief-consistent vs. belief-inconsistent texts with the magnitude of the belief-consistency effect in the individual participants' memory scores. Separate correlations were computed for block-by-block and alternating presentation.

Situation model strength. The magnitude of the text-belief consistency effect is reflected in the difference score of the situation model strengths for the belief-consistent vs. belief-inconsistent texts (*belief-consistent – belief-inconsistent*). Under the block-by-block presentation, the difference in situation model strength was correlated negatively with the reading time difference between belief-consistent and belief-inconsistent texts ($r = -.33$, $p < .05$, two-tailed). In contrast, under the alternating presentation, there was no significant relationship between the difference in situation model strength and the reading time difference ($r = .18$, $p = .24$, two-tailed). In sum, the text-belief consistency effect became stronger the less time participants devoted to processing the belief-inconsistent compared to the belief consistent texts, but this relationship occurred only under the block-by-block presentation of belief-consistent and belief-inconsistent texts.

Memory for text (propositional text base). The reverse text-belief consistency effect

(i.e., the stronger memory for belief-inconsistent texts) is reflected in a (negative) difference score of the memory for the belief-consistent and belief-inconsistent texts. Under the block-by-block presentation, the difference in memory for text was correlated positively with the reading time difference between belief-consistent and belief-inconsistent texts (r = .34, p < .05, two-tailed). In contrast, under the alternating presentation, there was again no significant relationship between the difference in memory for text and the reading time difference (r = -.05, p = .24, two-tailed). Thus, similar to the text-belief consistency effect for the situation model, the reverse text-belief consistency effect became stronger the less time participants devoted to processing the belief-inconsistent compared to the belief consistent texts, but this relationship occurred only under the block-by-block presentation of belief-consistent and belief-inconsistent texts.[1]

Overall, this pattern of results fits well with a schema-theoretic interpretation in which prolonged reading times for belief-inconsistent texts indicate difficulties in the comprehension and integration of the information conveyed by these texts. Both the text-belief consistency effect for situation model strength and the reverse text-belief consistency effect were associated with longer reading times for belief-inconsistent compared to belief-consistent texts. In other words, the more time participants devoted to reading the belief-consistent compared to the belief-inconsistent texts, the more likely it was that they achieved a balanced situation model and memory for texts. However, it is important to note that an alternating presentation leveled out these relationships.

Discussion

[1] Moderated regression analyses (Cohen et al., 2003) revealed the same pattern of differential effects. Importantly, these analyses revealed significant interactions of the reading time difference with presentation order both with the differences in situation model strength (B = 0.14, SE = 0.06, $t(71)$ = 2.1, p < .05, ΔR^2 = .05) and with the differences in memory for text (B = -0.15, SE = 0.06, $t(71)$ = -2.7, p < .01, ΔR^2 = .08) as dependent variables. Presentation order and all other independent variables varied between-subjects were entered as contrast-coded predictors in the regression models.

This study was conducted to investigate the role of learners' initial beliefs on the situation model strength and the memory for text (propositional text base) in the processing of multiple science texts with conflicting information on two controversial topics (causes of global warming and risks vs. benefits of vaccinations). Results revealed that learners' situation model of the controversy was biased towards belief-consistent texts (text-belief consistency effect) whereas their memory for information explicitly mentioned in the text was better for belief-inconsistent texts (reverse text-belief consistency effect). However, the situation model bias towards belief-consistent texts disappeared when learners read belief-consistent and belief-inconsistent texts in an alternating manner. Exploratory analyses examining the relationships of the memory data with reading times revealed that both the text-belief consistency effect for the situation model and the reverse text-belief consistency effect for memory of text disappeared when participants spent more time reading the belief-consistent compared to the belief-inconsistent texts.

These findings are in line with the idea that the general stance a learner takes in a scientific controversy operates like a schematic knowledge structure, possibly guiding encoding. According to our results, the pattern of memory for belief-consistent vs. belief-inconsistent texts bears a striking resemblance to the results of earlier experiments on recognition memory for typical (schema-congruent) and atypical (schema-incongruent) information (e.g., Smith & Graesser, 1981). Compared to belief-inconsistent information, information from texts that argue for a position consistent with learners' beliefs is more likely to be integrated into a situation model of the text content. As one consequence, inferences that are based on learners' prior beliefs but are not part of the text are falsely recognized as information coming from the text. The reading time data for a block-by-block presentation of belief-consistent and belief-inconsistent texts indicate that the better situation model for belief-consistent texts is associated with less cognitive effort in

reading these texts. Accordingly, the advantage of belief-consistent texts in terms of situation model strength disappears when participants have to spend more cognitive effort—as indicated by longer reading times—to process these texts compared to belief-inconsistent texts.

In contrast, recognition memory for information from the text itself (i.e., the text base representation) was better for belief-inconsistent compared to belief-consistent texts. This reverse text-belief consistency effect coheres well with research that demonstrated an enhanced memory for schema-inconsistent information (Davidson, 1994; Smith & Graesser, 1981). According to schema-theoretic explanations (the schema/script-pointer-plus-tag hypothesis, Graesser, 1981; Schank & Abelson, 1977), recognition memory for schema-inconsistent information is better than that for schema-consistent information because information that cannot be integrated into the schema is stored separately from the schema and receives a privileged representation in memory. Similar to the text-belief consistency effect for the situation model data, the reverse text-belief consistency effect was associated with longer reading times for belief-inconsistent compared to belief-consistent texts, suggesting that the tagging of schema-inconsistent information requires cognitive effort. Thus, belief-inconsistent information is by no means ignored. It is less likely to have an influence on the situation model of the scientific controversy, but seems to be more likely to be included in the text base representation.

A bias towards belief-consistent information, similar to the one reported here for situation model strength, was found by Wiley (2005) who investigated how well participants can recall controversial arguments presented in a single text. In her study, high-knowledge learners were able to recall conflicting arguments on both sides of the issue whereas low-knowledge learners recalled more arguments in line with their own beliefs. According to these results, prior knowledge seems to moderate the effect of text-belief consistency. In the present experiment,

participants' level of prior knowledge was low overall (despite the fact that participants had strong beliefs), suggesting that most learners had problems elaborating on belief-inconsistent information in order to form an integrated model of the controversial issue. However, future studies should explore this issue further by comparing low-knowledge and high-knowledge learners. Presumably, the text-belief consistency effect found in the present experiment would be weaker or even disappear for learners with high prior knowledge.

Presenting belief-consistent and belief-inconsistent texts in an alternating order enabled learners to construct a situation model for the belief-inconsistent texts that was on par with that for the belief-consistent texts. Notably, the association between prolonged reading times and the text-belief consistency effect, which we found for a block-by-block presentation of belief-consistent and belief-inconsistent texts, disappeared under an alternating presentation of these texts. The moderating role of a block-by-block vs. alternating presentation of conflicting arguments is in line with previous research on the memory for controversial arguments (Wiley, 2005). One possible mechanism behind this effect is that an alternating presentation of belief-inconsistent texts leads to a weaker memory strength of the belief-consistent position than the block-by-block presentation. This, in turn, increases the activation available for processing the information from belief-inconsistent texts, leading to a more balanced representation.

The moderating effects of the block-by-block vs. alternating presentation did not occur for the memory for text. One interpretation of this finding is that the knowledge-based processes that might have been facilitated by the alternation presentation were relevant for the situation model representation but not as much for memory for text. However, the reverse text-belief consistency effect on memory for text was especially marked if a belief-inconsistent text was presented first. This pattern of effects might be due to the fact that information provided by the belief-inconsistent

texts was perceived as novel and surprising when it was presented at the beginning of the experiment.

In the present study, a specific method was used for assessing comprehension outcomes (i.e., a variant of the recognition method proposed by Schmalhofer and Glavanov, 1986). One particular asset of this method is that it allows estimating the strength of the propositional text base and the situation model with one single task. As a result, hypotheses concerning both levels of representation can be tested in a methodologically stringent way because differences in the results for measures of the situation model and measures of memory for text cannot be attributed to methodological factors. However, it must be noted that the recognition method assesses situation model strength only indirectly through false positive responses to inference items. Thus, despite its advantages, this method is likely to miss certain aspects of situation model strength that may be captured by some of the numerous other tasks which have been proposed to assess comprehension on the situation model level (for example, inference questions, recall tasks, essay tasks, or sorting tasks; McNamara et al., 1996; Wiley, 2005). In particular, the recognition method is not suitable to assess the integration of information across texts (at least not with the test items used in this study), which is one of the major challenges of multiple text comprehension (Perfetti et al., 1999).

The present experiment concentrated on a thorough investigation of how text-belief consistency affects the construction of situation models for individual texts. The strength of the individual situation models are likely to be a major determinant of the contribution of each text to the documents model (in particular, its situational components; Perfetti et al., 1999) which learners construct in comprehending texts on controversial scientific issues. However, future research should investigate effects of text-belief consistency on the integration of information across texts

more directly. For this purpose, tasks that require inferences across different texts (belief-consistent and belief-inconsistent) seem to be well suited (such as the intertextual inference verification task proposed by Strømsø, Bråten, & Britt, 2010).

A second and more general limitation of the present study is that it offers no direct insight into the cognitive processes involved in the comprehension and retrieval of conflicting information from multiple science-related texts. Rather than investigating the moment-by-moment processes involved in situation model construction and updating, this study conceptualized and assessed readers' situation model as a memory structure that is the cumulative outcome of numerous cognitive processes taking place during reading. It is conceivable that additional mechanisms apart from the schema-driven encoding and retrieval processes contribute to the text-belief consistency effect in learning with multiple texts. For example, readers can use their prior beliefs not only to interpret, enrich, and encode the presented text information but also to validate incoming text information (i.e., assess its truth or plausibility; Isberner & Richter, 2013; Richter, Schroeder, & Wöhrmann, 2009; Singer, 2006). In the text comprehension literature, the role of such validation processes has been investigated primarily as one aspect of (metacognitive) comprehension monitoring (cf. the standards of internal and external consistency proposed by Baker, 1985, 1989). Previous research on the role of the credibility of document sources and the perceived plausibility of the information communicated by these sources suggests that these variables might also mediate the impact of text-belief consistency on comprehension (e.g., Bråten, Strømsø, & Salmerón, 2011; Maier & Richter, in press).

In order to clarify the mechanisms underlying text-belief consistency effects, further experiments should use on-line methods such as eye-tracking and think-aloud protocols to capture the cognitive processes that underlie the comprehension of conflicting information from multiple

texts (Hyönä, Lorch & Rinck, 2003; Kaakinen & Hyönä, 2005). Such experiments should also vary text-belief consistency on a trial-by-trial basis, with more fine-grained belief measures directed at the level of individual arguments or assertions rather than at learners' global stances toward an issue.

Despite the fact that the underlying cognitive processes are still in need of clarification, the results of the present study make clear that learners' prior beliefs can have a considerable impact on the comprehension and memory of multiple texts on controversial issues. The present study goes beyond existing research in two ways. First, it was demonstrated that learning with multiple texts on publicly debated scientific controversies can be subject to a belief bias which is similar to biases found in the processing of social information (Levine & Murphy, 1943). Second, the belief bias seems to depend on the memory task: When the memory task taps into a learners' situation model, there is an overall memory advantage for belief-consistent texts. In contrast, when information provided in the text simply needs to be recognized, belief-inconsistent texts show an advantage. The possibility of these two counter-directional types of belief biases should be kept in mind when multiple texts are to be used in instructional contexts to inform students about different views on controversial scientific issues.

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Table 1:

Text Characteristics of the Eight Experimental Texts

Text Topic	Argumentative Stance	Length[a]	Readability[b]	Plausibility Scale[c]	Understandability Scale[c]	Number of Arguments[c]	Clarity of Stance[c]	Interesting-ness[c]
				M (SE_M)	*M* (SE_M)	*M* (SE_M)	*M* (SE_M)	*M* (SE_M)
Global warming	Belief-consistent 1	898	48	4.17 (.15)	4.29 (.13)	4.48 (.31)	4.79 (.31)	3.61 (.23)
	Belief-consistent 2	927	46	3.87 (.19)	4.01 (.15)	3.96 (.20)	4.65 (.31)	3.92 (.27)
	Belief-inconsistent 1	894	47	3.28 (.19)	4.12 (.16)	3.50 (.22)	4.67 (.36)	4.25 (.23)
	Belief-inconsistent 2	903	49	3.02 (.22)	3.96 (.23)	3.54 (.27)	3.50 (.40)	3.54 (.33)
Vaccination	Belief-consistent 1	905	49	4.00 (.17)	4.42 (.15)	4.17 (.30)	5.19 (.26)	4.04 (.24)
	Belief-consistent 2	854	49	4.40 (.18)	4.59 (.13)	3.55 (.23)	5.46 (.21)	4.23 (.19)
	Belief-inconsistent 1	894	52	3.80 (.16)	4.20 (.13)	4.44 (.24)	5.52 (.22)	4.24 (.24)
	Belief-inconsistent 2	921	50	4.09 (.17)	4.27 (.15)	3.85 (.17)	4.86 (.22)	4.29 (.23)

[a]Number of words per text. [b]Determined with the German adaptation of the Flesch`s Reading Ease Index (Amstad, 1978). [c]Results of the pilot-testing with ratings of 106 university students (response categories ranging from 0, *not at all*, to 6 ,*totally*; the plausibility scale consists of five items (Cronbach's α = .83), the understandability scale consists of nine items (Cronbach's α = .80). Each entry represents the average judgments across all participants).

Table 2:

Summary of the Arguments Presented in the Eight Texts

Text	Argument Number			
	1	2	3	4
Global warming				
Belief-consistent 1	The IPCC[a] estimates the percentage of human influences on the global warming at over 90 percent.	Greenhouse gases wreck the natural thermic climate balance.	Human behaviors increase the amount of greenhouse gases.	Cirrus clouds created by aviation lead to local and global warming.
Belief-consistent 2	Carbon dioxide is not the effect of global warming but its cause.	The natural carbon dioxide cycle is destroyed.	Brightness of the sun and temperature on the earth develop asynchronously.	Simulations only fit actual climate change when man-made causes are included.
Belief-inconsistent 1	The climate has been changing as long as the earth has existed.	Short-term fluctuations of climate are meaningless.	Cyclical changes in sun activity are the main cause of climate change.	There is an interplay of sun activity and water temperature.
Belief-inconsistent 2	The Hockey Stick curve (global climate reconstruction) is inaccurate.	There are methodological errors in the NOAA[b] study.	There is a one-sided coverage of global warming in science journals.	Global warming satisfies the need for recognition of some researchers.
Vaccination				

Belief-consistent 1	No relationship between autism and vaccinations.	Permanent improvement of vaccines.	Advantages of polyvalent vaccines.	Dangers for unvaccinated children.
Belief-consistent 2	Failed extermination of infectious diseases.	Increased amount of outbreaks of infectious epidemics.	Prevention of epidemic outbreaks with a high vaccination rate.	Protection of un-inoculable individual through herd immunity.
Belief-inconsistent 1	Interference of vaccinations with the immune system.	Differences between vaccinations and natural infections.	Dangers in the production of vaccines.	Noxious consequences of combined vaccines.
Belief-inconsistent 2	Effects of vaccines cannot be examined in experimental field studies.	Cooperation between researchers and the pharmaceutical industry.	Long-term consequences are unknown at the time of market authorization.	Fading immunization from vaccines.

Note. The belief-consistent texts argued that humans caused global warming and that vaccinations are more beneficial than risky; the belief-inconsistent texts argued that the global warming is based on natural phenomena and that vaccinations are more risky than beneficial.

[a]Intergovernmental Panel on Climate Change. [b]National Oceanic and Atmospheric Administration.

Table 3:

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

Measure	*M*	*SD*	1	2	3	4	5	6	7	8
1 Order of presentation (contrast-coded, -1 = block-by-block vs. 1 = alternating)	0.09	1.00	1							
2 Situation model strength (belief-consistent texts)	2.28	0.52	-.16	1						
3 Situation model strength (belief-inconsistent texts)	2.10	0.50	.08	.45*	1					
4 Memory for text (belief-consistent texts)	2.22	0.47	-.13	.52*	.48*	1				
5 Memory for text (belief-inconsistent texts)	2.41	0.49	-.09	.45*	.57*	.48*	1			
6 Source memory (belief-consistent texts)	0.52	0.22	.11	.26*	.47*	.27*	.11	1		
7 Source memory (belief-inconsistent texts)	0.65	0.21	.14	.17	.20	.28*	-.05	.34*	1	
8 Reading times (belief-consistent texts)	164	40	.11	-.03	.26*	.13	.05	.15	.02	1
9 Reading times (belief-inconsistent texts)	170	42	.13	.03	.28*	.09	.09	.18	-.01	.85*

Note. $N = 79$. Situation model strength: biased-corrected proportion of yes-responses to inference items. Memory for text: biased-corrected proportion of yes-responses to paraphrase items. Source memory: proportion of correctly assigned paraphrases. Reading times = reading times per syllable in milliseconds averaged over text paragraphs and corrected for outliers by removing all paragraph reading times deviating more than two standard deviations from the condition mean.

* $p < .05$ (two-tailed).

Table 4:

Mean Proportions of Yes-Responses in the Recognition Task for Paraphrase, Inference, and Distracter Items and Mean Reading Times per Syllable (with Standard Errors) by Experimental Condition

Measure	Paraphrases	Inferences	Distracters	Reading Times (ms)
Belief-consistent texts				
Block-by-block presentation	.74 (.02)	.77 (.03)	.02 (.01)	158 (7)
Alternating presentation	.72 (.02)	.73 (.02)	.03 (.01)	168 (6)
Belief-inconsistent texts				
Block-by-block presentation	.80 (.02)	.68 (.02)	.03 (.02)	168 (6)
Alternating presentation	.79 (.02)	.71 (.02)	.03 (.02)	175 (6)
Total	.76 (.01)	.72 (.01)	.03 (.00)	167 (4)

Note. $N = 79$. Reading times = reading times per syllable in milliseconds averaged over text paragraphs and corrected for outliers by removing all paragraph reading times deviating more than two standard deviations from the condition mean.

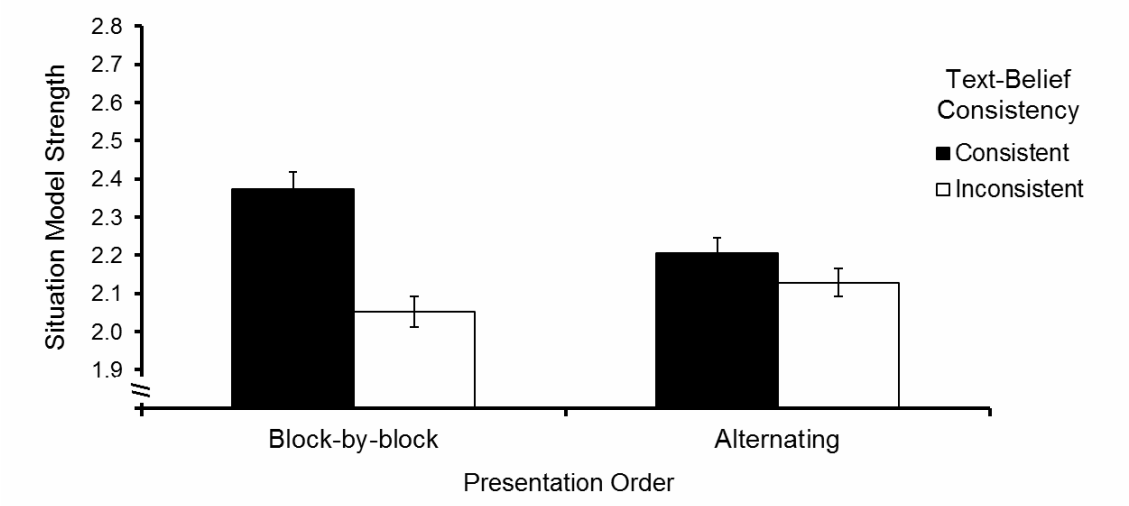

Figure 1. Strength of the situation model (signal-detection measure): Interaction of text-belief consistency with order of presentation (block-by-block vs. alternating). Error bars represent the standard error of the mean.

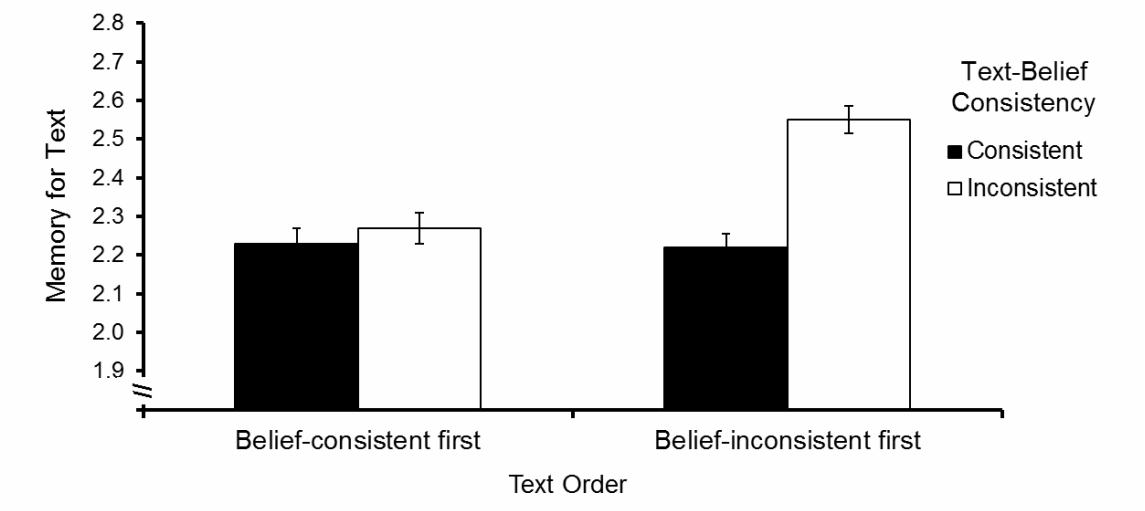

Figure 2. Strength of the memory for text (signal-detection measure): Interaction of text-belief consistency with text order (belief-consistent vs. belief-inconsistent text first). (Error bars represent the standard error of the mean).

Appendix

Text and Item Material for one Belief-consistent Text of the Topic Vaccination

Two belief-consistent and two belief-inconsistent texts about the question of whether or not vaccinations are beneficial (belief-consistent stance) or harmful (belief-inconsistent stance) were used as experimental texts. One belief-consistent text (translated into English) is presented below as an example of the text material. Table A1 contains the corresponding test items for the text. The complete text and item material for both topics (vaccination, climate change) is available from the authors upon request.

The Nearly Forgotten Horrors of the Past Will Appear Again Without Vaccinations

Until the 19th century, physicians were powerless against the widespread and continuously reoccurring epidemic diseases. But with the systematic development of numerous vaccines, the prevention of various epidemic diseases is made possible.

Increasing Amount of Infections

Thanks to high vaccination rates, numerous infectious diseases have been eradicated and the number of infected patients has been minimized. This decline is due to the fact that high vaccination rates offer the possibility to first eliminate infectious diseases in one region and then exterminate them throughout the whole world. Because of a high vaccination rate, the World Health Organization (WHO) was able to claim in 1980 that the world was free of smallpox. Moreover, the goal of also eradicating poliomyelitis throughout the world is nearly accomplished. Unfortunately, eliminating every epidemic disease has not yet been possible. For example, the goal to eliminate measles before 2005 was not met. This failure was due to the fact that numerous parents refused to vaccinate their children. Most children receive the combined

inoculation for Measles, Mumps and Rubella at the age of 13 months. However, the important secondary vaccination one year later is often omitted. Without this second vaccination, the lifelong protection is not provided, as acknowledged by the Ständige Impfkommission of the Robert-Koch-Institut (STIKO). The STIKO provides guidance on frequently asked questions about both vaccinations and epidemic diseases. In addition, they offer recommendations for and against important vaccinations in Germany based on scientific findings. The basis of their decision-making is the epidemiological cost-benefit ratio. Additional factors considered during this process are effectiveness indices and information about the side-effects and other risks of vaccinations. In addition, the STIKO develops criteria to distinguish between normal vaccination reactions and atypical harmful reactions. Consequently, only vaccinations clinically shown to be medically compatible and harmless are recommended.

Devastating Consequences of Vaccine Fatigue

The behavior of individuals prevents the eradication of diseases. As a result, the measles vaccination rate in Germany is disastrous according to Ursel Lindlbauer-Eisenach from the professional association of pediatrics in Bavaria. One reason for the vaccine fatigue is based on the high efficiency of vaccinations. As a result, diseases that were once feared and widespread in the past have lost their perception of danger in the public eye. This phenomenon can explain why local disease outbreaks and measles epidemics occur time and again. Numerous examples for this perception can be found between 2005 and 2007 in Bavaria, Baden-Württemberg, Hessen and North Rhine-Westphalia. The infection rate was around 6,000 patients per year. Furthermore, the symptoms of infection cannot be reduced to harmless childhood diseases with red pustules. Instead, 15 percent of infected patients suffer from typical complications such as an inflammation of the middle ear. This disease causes deafness and pneumonia. And these

complications are not even the worst outcomes. Much worse is that annually approximately 10 children die because of a generalized inflammation of the brain induced by a measles infection. These long-term consequences that were nearly forgotten are reoccurring because of vaccine fatigue, which in turn causes unnecessary suffering and the death of many children.

Epidemics Can Be Prevented

Dr. Stephan Arenz from the Bavarian State Office for Health verified that the measles epidemics from 2005 until 2007 could have been prevented. To have avoided the epidemic, more people should have been vaccinated. The lack of protection normally offered by high vaccination rates was strikingly demonstrated in Coburg where a measles epidemic occurred. The epidemic occurred because only 77 percent of the Coburg population was vaccinated. In every other aspect, this city is typical of many other regions in Germany. The city did not differ in terms of nutritional, educational, or health provisions. Therefore, these factors cannot be the cause of the epidemic outbreak. The only objective difference between Coburg and the neighboring regions was the vaccination rate. In the neighboring regions, 90 percent of the population was vaccinated. This high vaccination rate kept the epidemic outburst from spreading. This incidence demonstrates that epidemic diseases can easily return to Europe if the vaccination coverage were to fade. Even if the standard of living increased in the last century throughout Europe, epidemic diseases are able to reoccur in the same magnitude as they had centuries ago. Therefore, it is desirable that as many people as possible become vaccinated.

Double Protection

Additionally, a high vaccination rate offers the benefit of double protection. First, vaccinations provide direct protection against an epidemic infection. Second, herd immunity also protects those who could not be vaccinated such as infants or immune-compromised people, as

emphasized by Prof. Battegay, chief physician of the Department of Infectiology at the University of Basel. Herd immunity is defined as the protection of the whole population through the presence of vaccinated individuals. In an unvaccinated population, the epidemic has a snowball effect. However, with a large number of vaccinated people, the chance of avoiding widespread epidemic outbreaks is negligible. This protection is possible because vaccinated people do not excrete causative organisms, which in essence protects nonvaccinated people and in turn prevents the distribution of epidemics.

In sum, inoculation serves not only to protect individuals but also to protect communities. To avoid the nearly forgotten scares of the past from reoccurring, it is critical that everybody, including children, get vaccinated.

Table A1

Test Items for the Above Presented Belief-Consistent Text for the Topic of Vaccinations

Item type	**Test item**	**Original sentences from the text for the paraphrase test items**
Paraphrase	Fifteen percent of patients experience complications with measles, such as inflammation of the middle ear.	Instead, 15 percent of infected patients suffer from typical complications such as an inflammation of the middle ear.
Paraphrase	As a result of strict controls, only compatible and harmless vaccines are recommended.	Consequently, only vaccinations clinically shown to be medically compatible and harmless are recommended.
Paraphrase	Epidemiological cost-benefit analyses are the basis for decisions for or against certain vaccines.	The basis of their decision-making is the epidemiological cost-benefit ratio.
Paraphrase	Ursel Lindlbauer-Eisenach, member of the professional association of pediatrician in Bavaria, confirmed that Germans are insufficiently protected against measles.	As a result, the measles vaccination rate in Germany is disastrous according to Ursel Lindlbauer-Eisenach from the professional association of pediatrics in Bavaria.
Paraphrase	A low vaccination rate of 77 percent caused an outbreak of measles in the city of Coburg.	The epidemic occurred because only 77 percent of the Coburg population was vaccinated.

Paraphrase	The possibility of suffering any infection is just as high as centuries ago, even though living standards in Europe have increased steadily during the last centuries.	Even if the standard of living increased in the last century throughout Europe, epidemic diseases are able to reoccur in the same magnitude as they had centuries ago.
Paraphrase	The probability of preventing an epidemic increases with the number of immunized individuals in the population.	However, with a large number of vaccinated people, the chance of avoiding widespread epidemic outbreaks is negligible.
Paraphrase	Research results from Dr. Stephan Arenz from the Bavarian State Office for Health showed that a prevention of the infectious diseases from 2005 to 2007 would have been possible.	Dr. Stephan Arenz from the Bavarian State Office for Health verified that the measles epidemics from 2005 until 2007 could have been prevented.
Inference	Measles cannot yet be eradicated because many parents have not had their children fully immunized against measles, mumps, and rubella.	
Inference	A decrease in the vaccination rate can be explained by a reduced fear of infectious diseases.	
Inference	A low vaccination rate is sufficient to cause	

	an epidemic outbreak.
Inference	Prof. Battegay stated that herd immunity is an effective method to stop the distribution of infectious diseases and to reduce the amount of people that suffer from an infection.
Inference	If the proportion of vaccinated people in the neighboring towns of Coburg had been lower, the infection would have also spread there.
Inference	The World Health Organization aims to diminish all types of infectious diseases from the planet.
Inference	Many people are not aware of the serious long-term consequences of infections like measles; consequently, they view measles as a harmless childhood disease.
Inference	People who choose not to be vaccinated risk not only their own health but also contribute to the spreading of viruses and thus endangering the health of others.
Distracter	In contrast to human vaccinations, most vaccinations for animals are administered under the skin.

Distracter	In the case of a congenital immune deficiency, the decision for or against a vaccination with a live vaccine must be made individually.
Distracter	The causative organism of rabies is a virus that can infect all mammals.
Distracter	Wolf-Dieter Ludwig is chairman of the pharmacological committee of the German medical profession.
Distracter	The swine influenza virus was proven to not be the extensive pandemic that had been predicted after the outbreak in South America.
Distracter	The vaccination committee of the Robert-Koch Institute in Germany approved two vaccines that offer protection against the human papilloma virus.
Distracter	People who vaccinate themselves against seasonal influenza have a higher risk of becoming infected by the swine influenza virus.
Distracter	Vaccinations with live vaccines, such as yellow fever or hepatitis A, can be administered simultaneously; otherwise, a

minimum period of four weeks must be followed.