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# Presenting a socio-scientific issue in a science and technology museum: Effects on interest, knowledge and argument repertoire

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## Abstract

Many museums deal with socio-scientific issues—meaning topics with multiple perspectives and ongoing research, such as climate change, vaccinations, or livestock farming. As important and trusted sources of science education, museums can play a critical role in raising awareness about such issues. They tend to highlight the various perspectives on the topic and thereby are able to provide a balanced and impartial information presentation. Visitors are therefore confronted both with views that correspond to their own beliefs and with views that contradict their beliefs and are supported in developing an informed opinion on the respective topic. In our study, we used an experimental exhibition on the topic "animal husbandry" to investigate the extent to which, first, an exhibition visit in general and, second, how different picture captions affect knowledge acquisition and interest. We chose a between-subjects design with the factor conflict framing through picture captions. Whereas one group visited an exhibition in which the picture captions were formulated neutrally, another group read picture

captions that emphasized the existing conflict. A control group, which did not visit the exhibition at all, allowed us to examine the general effect of the exhibition. As dependent variables, we chose interest and knowledge acquisition as common instruments of educational visitor research. However, we went one step further and used an innovative instrument: visitors' argument repertoire. We found that visiting the exhibition led to higher interest, knowledge acquisition, and a more balanced argument repertoire. Varying the captions had no significant effect. Implications and limitations are discussed.

**KEYWORDS**

argument formation, interest, knowledge acquisition, museum, socio-scientific issues

## 1 | INTRODUCTION

When attempting to solve complex socio-scientific problems, such as climate change, the COVID-19 pandemic, or the dilemma of global food security and livestock welfare, scientific claims and arguments play a central role (Zeidler & Newton, 2017; Zeidler et al., 2019). Interpreting and assessing scientific claims and arguments, however, is a challenging task for most laypersons (Lobato & Zimmerman, 2018). Due to the nature of scientific research, findings are often uncertain and fragile. For example, in some cases, methodological limitations do not allow for sufficient generalization and thus no concrete statement can be made regarding the problem (Rubin, 2008; Shavelson & Towne, 2002). Moreover, available scientific evidence can be interpreted differently in the scientific community, leading to consensus uncertainty that often plays a central role in public controversies about important societal problems (Gustafson & Rice, 2020).

It is therefore important to support laypersons to be able to assess science-related claims and arguments in terms of their credibility and reliability (Kienhues et al., 2011; Petty & Briñol, 2010). In particular, civic science education (CSE) activities that enable individuals to engage in science-based public affairs have been identified as a core task for future education (Levy et al., 2021). Levy et al. (2021) outline three distinct categories of CSE, including foundational CSE experiences, defined as "exposure to, discussion of, and/or peer interactions around science-related public matters, with a focus on the development of related knowledge, skills, and values." (Levy et al., 2021, p. 1057). This is where museums and exhibitions can play a critical role. Empirical surveys confirm that museums and exhibitions are one of the most important and most trusted sources of information on scientific facts for adults, and this is equally true for children's and adolescents' extracurricular engagement with scientific topics (Bell et al., 2009; Bonnette et al., 2019; Dilenschneider, 2022; Falk et al., 2007). Museums can be safe settings for laypersons to engage with socio-scientific issues (Cameron, 2005).

Such issues (Pedretti & Iannini, 2020b; Zeidler & Nichols, 2009) and conflicting information resulting from current, ongoing research are increasingly addressed in exhibitions (Chittenden et al., 2004; Meyer, 2010; Yaneva et al., 2009). The objective to display such topics is to raise visitor awareness, to support visitors in forming a more differentiated mental representation, and to support them in forming their own (well-founded) opinions on the

respective topic (Delicado, 2009; Macdonald & Silverstone, 1992). According to Pedretti (2004), exhibitions that contain conflicting information and present multiple perspectives have the potential "to enhance learning by personalizing subject matter, evoking emotion, stimulating dialogue and debate, and promoting reflexivity" (p. 34). In 2020, Pedretti and Iannini (2020b) describe today's science museums as "fourth generation" museums oriented toward the promotion of responsible citizenship and of "agency" in terms of challenging science research agendas and lobbying for political and social change for example. They refer to Cameron (2005), among others, who in her paper concludes: "By raising awareness of issues and empowering people to educate themselves on important topics to determine their own position around these subjects and become socially active, museums can have a role in social transformation." (p. 229).

The challenge for museums in presenting conflicting information is to create a balanced, unbiased, or impartial exhibition without losing the stimulating content and thus the attention of the visitors. It has been shown, however, that far from being neutral institutions of information presentation and dissemination many museums show strong biases related to gender and ethnicity (Dancstep & Sindorf, 2018). Moreover, they tend to present issues in ways that privilege the perspective of their own dominant culture and nation (Ang, 2019). Yet despite these biases, museums are still viewed as neutral and reliable information sources that are highly trusted by the public (Dilenschneider, 2022). As museums have become more sensitive to these problems in the last decades, they have increasingly south to provide their audience with a multifaceted, informed, and balanced view of socio-scientific issues.

From a psychological point of view, forming opinions about socio-scientific issues are based on considering arguments in favor of a certain position together with arguments speaking against that position (and in favor of the opposite position; Cappella et al., 2002). Argumentation is a central part of scientific progress and an important tool in science education (Erduran et al., 2004). In science education, Toulmin's argument pattern (Toulmin, 1958) is often used to study argumentation. According to Toulmin (1958), arguments consist of a specific pattern of elements that include at least one claim, for example, in favor of a particular position on a controversial scientific issue and data to support that claim. Based on Toulmin's argument pattern, Erduran et al. (2004) proposed five levels of argumentation that reflect differences in the quality of argumentation. At the most basic level, only claims are exchanged without further support. From Erduran et al.'s next level on the claims are linked to additional elements from Toulmin's pattern, including supporting data. These levels are helpful "to express quality of argumentation discourse in the classroom in an extended timeframe through instructional support" (Erduran et al., 2004, p. 920). For studying argumentation in informal learning settings however, and more specifically for a one-off, self-determined exploration of an exhibition (i.e., without interaction with an educator or instructor), a detailed distinction between different quality levels would be too elaborate. For our present purposes, we define an individual's argument as a particular claim about a socio-scientific issue combined with supporting data and use this as the basis for our assessment of visitors' arguments. This ensures a certain quality of argument that moves beyond Erduran et al.'s basic level, without a detailed analysis of quality levels as would be appropriate in the context of science discourse in a formal learning setting.

In a self-directed museum visit, it would be more suitable to assess visitors' argument repertoire, which allows for an evaluation of argumentation without the need for it to be dialogic and focuses on number of available arguments (Cappella et al., 2002). More specifically, the notion of argument repertoire implies that individuals know, to some extent, both arguments for (own argument repertoire) and against (oppositional argument repertoire) a particular opinion on an issue (Cappella et al., 2002; Chen et al., 2020). Ideally, the argument repertoire should be balanced, that is, an individual should not only know of arguments for his or her own position on a socio-scientific issue, but also arguments of the opposite stance (Chen, 2018).

Museum exhibitions dealing with socio-scientific issues tend to include multiple viewpoints (Pedretti, 2004) and in doing so, inevitably present visitors with views that correspond to their position and views that contradict their position. However, museum visitors are free to select information. Visitors' personal interests and visit motivation, situational interest, and attention allocation all play a role in the selection and processing of exhibition pieces and content (Schwan et al., 2014). In other words, based on their pre-existing interests, views, and beliefs, visitors can

be biased in both their selection and processing of the information presented to them. Cognitive biases, including confirmation bias, motivated reasoning, and myside bias can get in the way of visitors' developing a more balanced repertoire of arguments. Confirmation bias implies that people selectively attend to information that is consistent with their beliefs and tend to ignore inconsistent information (Knobloch-Westerwick et al., 2015). In addition, people engage in motivated reasoning when they evaluate and interpret scientific evidence in such a way that it best fits their own goals and motives (Kunda, 1990; Rothmund et al., 2017). Moreover, recipients often tend to suffer from a myside bias in that they generate more arguments that are consistent with their own beliefs than arguments that are inconsistent with their own beliefs (Baron, 1995; Stanovich et al., 2013). Still, to build an informed opinion (and decision) on socio-scientific issues, it is important to deal with information that is inconsistent with one's own beliefs and to process opposite view arguments in an elaborative manner, thus becoming aware of arguments both for and against one's own beliefs (Cappella et al., 2002; Chen, 2018).

Research on science communication indicates that the uncertainty of claims and its controversial character should be clearly stated to be recognized by recipients (Jensen, 2008; Kimmerle et al., 2015). In museum galleries, this could be done by highlighting the controversial nature of an item on the corresponding label. Recent research has shown that visitors not only pay attention to labels (Reitstätter et al., 2022; Schwan et al., 2019), but also that appropriate label wording can have positive effects on visitors' behavior (Gutwill & Dancstep née Dancu, 2017; Land-Zandstra et al., 2020). Therefore, formulating labels in terms of a controversy can raise visitors' awareness of that conflict and lead them to reflect on arguments that support or oppose a particular position on a socio-scientific issue. In addition, the controversial topic should be presented in a consensus-oriented way by taking a two-sided perspective (Mayweg-Paus & Jucks, 2018).

Against this background, several dimensions of visitor behavior would indicate that a museum exhibition presenting a socio-scientific issue succeeds in raising awareness and supporting opinion formation. It should raise the visitors' topic interest, make them aware of the controversial character of the issue, and have them learn some important facts. In addition, it should help them generate a more balanced repertoire of arguments, including arguments both for and against the various alternatives. Whereas topic interest and knowledge acquisition build the standard repertoire of learning-related visitor research, argument repertoire has not often been applied as a measure of scientific reasoning in an informal learning setting, although it should be well suited for determining the visitor-related effects of exhibiting socio-scientific or controversial topics in museums (Cappella et al., 2002; Stanovich et al., 2013; Toplak & Stanovich, 2003).

To sum up, museums as trusted sources of information play an important role in displaying socio-scientific issues, in supporting laypersons in forming a differentiated mental representation of the topic, and in building their own (well-founded) opinion on the topic. They tend to do so by presenting such topics from various perspectives in a balanced and (often) impartial way. By confronting visitors both with views that correspond to their own beliefs and with views that contradict their beliefs, they are triggered to generate a more balanced repertoire of arguments on the topic and a more differentiated mental representation. However, museum visitors are free to select information. Based on their pre-existing interests, views, and beliefs, they can be biased in both their selection and processing of the information presented to them. While museums increasingly include socio-scientific issues in their repertoire of exhibition topics (Pedretti & Iannini, 2020b), to the best of our knowledge, no empirical research has yet empirically investigated the impact of such exhibitions on visitors' argument repertoire aside from its effects on interest and knowledge acquisition.

To address this issue, an experimental field study was conducted on the socio-scientific issue of animal farming at a large German museum on science and technology, regarding the following research questions:

1. Do visitors of an exhibition on the socio-scientific topic of animal farming develop more interest, acquire more knowledge, and generate more arguments compared to a control group that does not visit the exhibition?
2. Does explicitly emphasizing the controversial nature of the exhibition topic in the picture captions lead to more situational interest, more topic interest, more knowledge, and to the generation of more arguments compared to

picture captions that do not explicitly point out the controversial nature of the topic? Is there an effect of picture captions on visitors' perceived conflictuality (i.e., the extent to which visitors perceive the exhibition topic to be controversial)?

## 2 | METHODS

### 2.1 | Participants

The study took place at the Deutsches Museum München. Museum visitors were recruited as participants before entering the museum while in line to buy tickets. Participants had to be over 18 years of age and fluent in German. The 194 participants ranged in age between 18 and 79 years with an average age of $M = 37.43$ (SD = 16.43); 89 of them (45.9%) were female. Overall, the participants had a relatively high level of education: 9.3% had completed a lower secondary education (Hauptschule/Mittelschule/Volksschule), 16.0% an "intermediate level" of secondary education (Realschule/Mittlere Reife), and 71.1% a higher level of secondary education (Allgemeine Hochschulreife/Fachhochschulreife). All participants provided written informed consent before participating in this study and received a free ticket for the Deutsches Museum for taking part in the study. The study was approved by two independent ethics committees.

### 2.2 | Design

We used a one-factorial between-subjects design with the factor conflict framing. We systematically varied whether the picture captions used were neutrally worded or whether they emphasized the existing conflict (see Figure 1 for an example). To investigate the general effect of the exhibition, we included a control group that did not visit the exhibition at all.

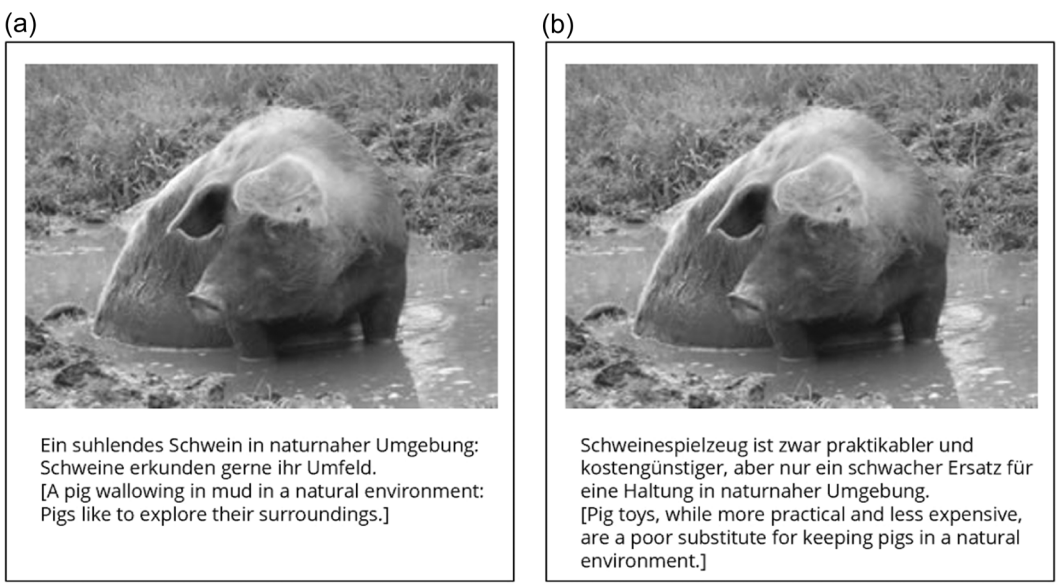


**FIGURE 1** (a) Picture with the neutral caption. (b) Photo with the conflict-emphasizing caption.

The participants were randomly assigned to one of the three conditions: neutral captions ($n = 64$), conflict-emphasizing captions ($n = 66$), and control group ($n = 64$). The participants were not informed that there were different experimental conditions.

## 2.3 | Materials

For the present study, we set up a mock-up exhibition on the topic of animal husbandry and animal welfare, which will be part of a new permanent exhibition at the Deutsches Museum in Munich. The exhibition involved a selection of the final exhibition contents. It included three taxidermic animals (sheep, pig, and rooster) as eye-catchers, two introductory texts (one on animal husbandry, 107 words; the other on the co-dependency between consumer, farmer, and animals, 127 words), a poster presenting visions for the future, a chart showing information on product labels and underlying guidelines on animal husbandry, and a shelving unit displaying three devices used in animal husbandry: a castration forceps, a pig toy (i.e., a toy for pigs), and a dehorning device. Each device had an object label, that is, accompanying text naming the device and describing its use, the potential consequences for the farmer and the animal, and the conflicts that it might cause (each approximately 85 words). A representative animal photo was also provided for each device. Depending on the experimental condition, the picture caption of this animal photo was either formulated neutrally or emphasized the existing conflict that comes with the use of the corresponding device (Figure 1).

## 2.4 | Measures

The participants were asked to fill out a questionnaire before and after visiting the experimental exhibition. Because the present study is part of a large project with different collaborators, we used a broad range of different scales on visitor characteristics. We will not report all of them here because some of them lie outside the focus of this paper.

### 2.4.1 | Prior knowledge, interest, and attitude

*Self-evaluated prior knowledge*

Eleven items that were answered on a 5-point Likert-type scale (1 “not at all,” 2 “hardly,” 3 “somewhat,” 4 “fairly,” and 5 “very”) measured the participants' self-evaluated knowledge of specific aspects relating to the exhibition's topic. The main question “How familiar are you with the following topics?” was followed by 11 specific topics, for example, livestock, slaughter, and so forth. An average prior knowledge score was calculated from the sum of all responses divided by the total number of items (Cronbach's $\alpha = 0.91$).

*(Prior) topic interest*

Thematic interest in the topic of the exhibition was measured by four items on a 5-point Likert-type scale (1 “not at all” to 5 “strongly” in agreement with the four statements: e.g., “I am interested in the topic of livestock husbandry” and “I like gaining new knowledge of the topic of animal husbandry.”). An average interest score was calculated by the sum of all responses divided by the total number of items. The scale was used two times—before and after the exhibition—in the two exhibition conditions and once in the control group (Cronbach's $\alpha_{pre} = 0.86$, Cronbach's $\alpha_{post} = 0.83$).

*Attitudes toward livestock farming and meat consumption*

We used eight items to measure the attitude towards livestock farming and meat consumption (−2 “disagree completely” to 2 “agree completely”). An average attitude score was calculated by the sum of all responses divided by the total number of items (Cronbach's $\alpha = 0.81$).

### 2.4.2 | Visited-related measures

*Duration of stay*

A neutral observer was present in the experimental exhibition and wrote down when each participant entered and left the exhibition. This way, we were able to calculate the duration of stay.

*Intensity of exploration*

After visiting the experimental exhibition, we asked the participants to indicate on an exhibition plan what they had engaged themselves with. They marked the intensity of their engagement with each of the texts, objects, and pictures on a 5-point Likert-type scale (0 "not at all" to 4 "very"). An average engagement score was calculated by the sum of all responses divided by the total number of items (Cronbach's $\alpha = 0.84$).

*Situational interest*

We used an adapted German scale for situational interest (Knogler et al., 2015; Lewalter, 2020) with 12 items on a 5-point Likert-type scale (1 "not at all" to 5 "strongly") that was developed in the context of science learning in formal and informal settings (e.g., "The exhibition contents captured my attention"; Cronbach's $\alpha = 0.89$).

*Perceived conflictuality*

As a manipulation check, perceived conflictuality was assessed with five self-developed items on a 5-point Likert-type scale (1 "not at all" to 5 "very"). The main question "In your view, to what extent is the following topic controversial?" was followed by five specific topics, for example, castration of piglets or dehorning of cattle, and so forth. An average score was calculated from the sum of all responses divided by the total number of items (Cronbach's $\alpha = 0.64$).

### 2.4.3 | Knowledge acquisition and argument repertoire

*Knowledge test*

Our knowledge acquisition test consisted of 11 self-developed open-ended questions (e.g., "Why are male piglets castrated?") regarding content that was addressed in the texts that were presented in the exhibition. The participants were instructed to give short answers (keywords only). They earned one point for each correct answer. A total of 11 points could be achieved. Two raters, blind to the experimental conditions, evaluated the participants' answers.

*Argument repertoire*

With the measure repertoire of arguments, we wanted to find out which arguments the participants could think of regarding different aspects of industrial animal husbandry. Study participants in the control group had to draw their own prior knowledge of the topic, whereas participants in the two exhibition conditions could draw on their prior knowledge as well as any additional knowledge gained during the exhibition visit. Similar to Toplak and Stanovich (2003), the participants were asked to list all arguments they could think of. In addition, they subsequently indicated for each argument whether it was in favor of or against conventional animal husbandry (pro-contra assessment). Two independent raters judged whether the arguments were valid or not. Nonvalid arguments were those that did not fit the task (e.g., "questionnaires are too long"), that did not represent real arguments (e.g., "pay attention to what you eat"—this is an appeal to the consumer rather than an advantage or disadvantage of conventional livestock farming—or e.g., "that's just the way it is" as an "empty" statement) as well as arguments for which no pro-contra-assessment was given. In addition, in the case of repetitions or paraphrasing (e.g., "animal quality of life" and "animal welfare"), only the first mentioned was counted. This way, we could determine the number of valid arguments each participant could think of. The agreement of the raters was 94.54%. A third rater decided in case of disagreement.

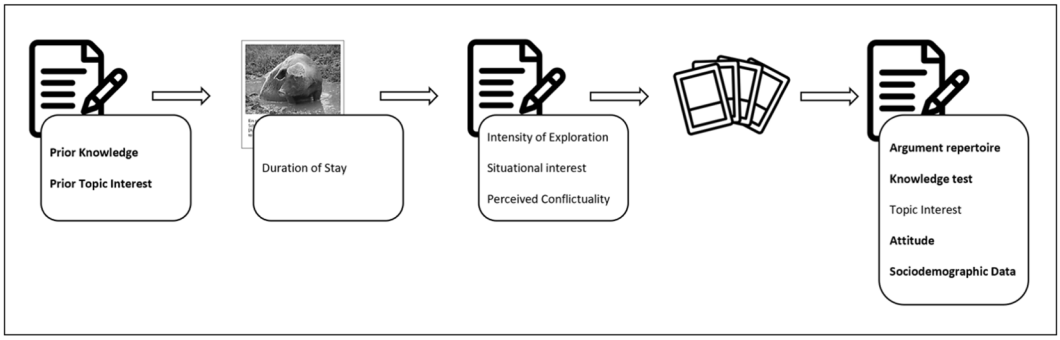


**FIGURE 2** Procedure of the study in the treatment groups. Variables in bold were also collected in the control group in one questionnaire.

## 2.5 | Procedure

After reading the information about the study and signing the informed consent, the participants in the two treatment groups (the two exhibition conditions) were asked to fill out the pretest questionnaire. The pretest consisted of a self-evaluation of prior knowledge and a prior topic interest scale. Once completed, the participants were asked to explore the mock-up exhibition just like a regular exhibition, at their own pace and according to their own interests. The exhibition contents were the same for both conditions, except for the picture captions. A neutral observer noted the time of arrival and departure of the visitors so that we could calculate the time spent in the exhibition

Following the visit, the participants were asked to fill out the first part of the posttest questionnaire. They were asked to report how thoroughly they had explored each aspect of the exhibition. After that, they filled out a questionnaire which included a scale on situational interest, and questions about the perceived conflictual character of the exhibition's topic. Next, for approximately 10 min, the participants were asked to play a card game as a filler task. The card game served as an additional delay and distraction between the exhibition visit and the cognitive assessments in the second part of the posttest.

The second part of the posttest questionnaire contained the argument repertoire, the knowledge acquisition test, a scale on attitude towards livestock farming and meat consumption, a scale on topic interest, and questions on their sociodemographic data. The study lasted 30–45 min for each participant, depending on the time they had spent in the exhibition (Figure 2 gives an overview of the study).

The control group completed only one questionnaire that contained the following survey elements: a self-evaluation of knowledge, a scale on topic interest, the argument repertoire, knowledge test, attitude, and questions on their sociodemographic data.

# 3 | RESULTS

## 3.1 | Prior knowledge, prior interest, and attitude

According to one-factorial analysis of variances (ANOVAs), no significant differences between the three conditions "control" (without visiting the exhibition), "neutral captions", and "conflicting captions" were found for participants' self-rated prior knowledge of livestock farming and meat production, $F(2,191) = 1.65$, $p = 0.195$, $\eta^2 = 0.02$. The one-factorial ANOVA on prior interest in livestock farming showed a significant effect of condition, $F(2,191) = 4.33$, $p = 0.015$, $\eta^2 = 0.04$. According to Bonferroni corrected $t$ tests, the participants in the control condition reported

significantly lower interest in livestock farming than participants in the neutral condition, whereas no differences were found between these conditions and the conflict condition. We therefore included prior interest as a covariate in subsequent ANOVAs containing the control condition.

Regarding attitudes toward livestock farming and meat consumption, no differences between the conditions were found, $F(2,190) = 1.77$, $p = 0.173$, $\eta^2 = 0.02$. Overall, participants showed a strong attitude toward industrial livestock farming. All means and standard deviations are shown in Table 1.

## 3.2 | Visit-related measures

Since the control group did not visit the exhibition, only group comparisons between the experimental groups (neutral vs. conflict) were calculated with regard to the visit-related measures on time spent in the exhibition, intensity of exploration, conflict perception, and situational interest. An overview of the mean values and standard deviations are found in Table 2.

On average, the participants spent 6.47 min (SD = 2.67) in the exhibition with no significant difference between the two groups, $t(218) = 0.20$, $p = 0.843$, $d = 0.03$. According to Serrell (2020), the sweep rate index (SRI), which indicates how slowly visitors move through an exhibition, is calculated by relating the duration of the visit to the size of the exhibition (323 $ft^2$). In the present study, the SRI is 50, which indicates that visitors took their time to look at the exhibits and moved slowly through the exhibition.

This is also reflected in the self-reported intensity of the exploration of the various exhibition elements, which was on average relatively high, again with no significant difference between the two groups, $t(218) = 0.83$, $p = 0.408$, $d = 0.16$.

There was also no significant difference between the experimental groups in perceived conflictuality of the exhibition's topics, $t(218) = 0.71$, $p = 0.481$, $d = 0.12$. This suggests that the manipulation of the captions was too minor to actually influence the perception of the conflictual nature of the exhibition's topic.

The participants in both experimental groups reported a relatively high situational interest. There were no significant differences between groups, $t(218) = 0.24$, $p = 0.814$, $d = 0.04$.

## 3.3 | Changes in topic interest in the experimental conditions

A two-factorial mixed ANOVA with the two experimental conditions (neutral vs. conflict) as the between-subjects factor and time of test (before or after the visit of the exhibition) as the within-subjects factor was conducted to show if the exhibition visit had an effect on topic interest. It showed no significant effect of condition and no interaction of condition and time of test, both $F < 1$, but a significant effect of time of test, $F(1,127) = 9.24$,

**TABLE 1** Group differences in prior knowledge, prior interest, and attitude.

| | Control (no exhibition visit), *M* (SD) | Neutral captions, *M* (SD) | Conflict emphasizing captions, *M* (SD) |
|---|---|---|---|
| Prior knowledge of livestock farming and meat production | 2.70 (0.65) | 2.91 (0.79) | 2.74 (0.59) |
| Attitudes toward livestock farming and meat production | 1.00 (0.61) | 0.93 (0.76) | 1.14 (0.53) |
| Prior topic interest | 3.05 (0.79) | 3.47 (0.86) | 3.36 (0.87) |

Abbreviations: M, mean; SD, standard deviation.

**TABLE 2** Group differences in visit-related measures.

| | Neutral captions,*M* (SD) | Conflict emphasizing captions, *M* (SD) |
|---|---|---|
| Time spent in exhibition (in min) | 6.42 (2.72) | 6.52 (2.65) |
| Intensity of exhibition exploration | 2.92 (0.59) | 2.83 (0.56) |
| Perceived conflictuality | 3.50 (0.70) | 3.58 (0.68) |
| Situational interest | 3.85 (0.58) | 2.83 (0.63) |

Abbreviations: M, mean; SD, standard deviation.

**TABLE 3** Interest development.

| | Neutral captions, *M* (SD) | Conflict emphasizing captions, *M* (SD) |
|---|---|---|
| Prior topic interest | 3.47 (0.86) | 3.36 (0.87) |
| Topic interest after visit | 3.63 (0.81) | 3.50 (0.85) |

Abbreviations: M, mean; SD, standard deviation.

$p = 0.003$, $\eta_p^2 = 0.07$. For both experimental groups, visiting the exhibition led to an increase in topic interest. Means and standard deviations are shown in Table 3.

## 3.4 | Knowledge test and argument repertoire

We conducted an ANCOVA with the three conditions (control, neutral, and conflict) as factor and prior interest as the covariate to examine differences in the knowledge test scores. There was a significant effect of condition, $F(2,180) = 124.69$, $p < 0.001$, $\eta^2 = 0.58$. According to Bonferroni corrected $t$ tests, the participants in the control condition had significantly lower test scores than the participants in the neutral condition and the participants in the conflict condition, whereas no differences were found between the neutral and conflict conditions. Means and standard deviations are shown in Table 4.

The analyses of the argument repertoire showed that, on average, the participants listed $M = 4.92$ (SD = 2.42) valid arguments. Of these arguments, on average, $M = 2.14$ (SD = 1.81) pro-arguments and $M = 2.79$ (SD = 1.98) contra-arguments. Most of the arguments were related to animal welfare ("animals are exploited"—contra-argument), the consumer ("quality of product"—contra-argument; "low prices"—pro-argument), and profitability ("high yield"—pro-argument). In a 3 × 2 mixed ANCOVA with conditions (control vs. neutral vs. conflict) as the between-subjects factor, type of argument (arguments for industrial livestock farming vs. arguments against industrial livestock farming) as the within-subjects factor and prior interest as the covariate, differences in the number of arguments were analyzed. There was a significant main effect of condition, $F(2,180) = 7.03$, $p = 0.001$, $\eta_p^2 = 0.07$, a significant interaction of condition with type of argument, $F(2,180) = 5.52$, $p = 0.005$, $\eta_p^2 = 0.06$, a significant effect of prior interest, $F(1,180) = 12.73$, $p < 0.001$, $\eta_p^2 = 0.07$ and a significant interaction of prior interest and argument type, $F(1,180) = 5.71$, $p = 0.018$, $\eta_p^2 = 0.03$, whereas the main effect of type of argument was not significant, $F(1,180) = 2.45$, $p = 0.119$, $\eta_p^2 = 0.01$. Post hoc contrast showed no significant differences between the conditions regarding the number of arguments *against* industrial livestock farming. However, there was a difference in the number of arguments for industrial livestock farming between the control condition and both experimental conditions, regarding the number of arguments in favor of industrial livestock farming. Means and standard deviations are shown in Table 4.

**TABLE 4** Group differences in knowledge test and argument repertoire.

| | Control (no exhibition visit), *M* (SD) | Neutral captions, *M* (SD) | Conflict emphasizing captions, *M* (SD) |
|---|---|---|---|
| Knowledge test (possible scores 0–11) | 3.43 (1.70) | 8.02 (2.35) | 8.62 (1.90) |
| Argument repertoire *against* industrial livestock farming | 2.56 (2.02) | 2.69 (2.0) | 3.12 (1.90) |
| Argument repertoire *for* industrial livestock farming | 1.27 (1.38) | 2.85 (2.01) | 2.28 (1.64) |

Abbreviations: M, mean; SD, standard deviation.

## 4 | DISCUSSION

Museums increasingly include socio-scientific issues in their repertoire of exhibition topics (Pedretti & Iannini, 2020b). Exhibitions presenting socio-scientific topics have the capacity to stimulate learning through reflection and discourse (Pedretti, 2004), but also to promote responsible citizenship and social action (Cameron, 2005; Pedretti & Iannini, 2020b). As places for informal learning, museums remain trusted sources of information (Dilenschneider, 2022) and can be "trusted incubators for social change" by presenting socio-scientific topics from various perspectives in a balanced and impartial way and leaving visitors to engage with the exhibition's content on their own terms (Cameron, 2005, p. 229). In doing so, they support laypersons in forming a differentiated mental representation of socio-scientific topics and in building their own opinion. Building an informed opinion and determining one's position requires a consideration of the different arguments for and against that position (Cappella et al., 2002), yet argumentation has so far received very little attention in empirical educational visitor research.

With this study, we investigated whether a visit to a mock-up exhibition on animal husbandry as a prototypical socio-scientific issue leads to changes in several dimensions of visitor behavior and cognitive outcomes including topic interest, awareness of the controversial character of the topic, knowledge acquisition, and argument repertoire. The aim of the study was twofold. First, we examined whether visitors to the exhibition develop more interest, acquire more knowledge, and generate more arguments compared to a control group that does not visit the exhibition. Secondly, we investigated whether emphasizing the controversial nature of the exhibition topic via picture captions leads to a higher awareness of the controversial nature of the topic, to differences in situational interest, in topic interest, and in knowledge, and to the generation of more arguments compared to picture captions that do not explicitly state the controversial nature of the topic.

In designing the study, care was taken to minimize the potential influence of the study on the exhibition visit. While the low SRI (Serrell, 2020) in our study indicates a slow movement of the visitors through the exhibition, visitors' self-reported "medium" intensity of engagement with the various exhibition elements indicate a rather "normal" visit behavior despite visitors' participation in a study (Serrell, 2020). Also, in both conditions, situational interest was at a relatively high level, showing that even this small exhibition was able to arouse the curiosity and attention of visitors.

Starting with the second research question, our findings show no differences between the neutral and conflict-emphasizing caption conditions for situational interest, knowledge acquisition, and number of arguments. Findings also show that the conflict-emphasizing captions perception did not influence the visitors' perceptions of conflict, that is, the extent to which visitors perceive the exhibition topic to be controversial. Despite previous research showing that visitors pay attention to captions and that captions may trigger elaborative processing of the exhibits content (Reitstätter et al., 2022; Schwan et al., 2019), the results suggest that our caption condition may have been too subtle and that other means of presentation or a combination of different presentation features, such as textual

and visual emphases, are needed to influence visitors' perception of the conflictual or controversial nature of an exhibition, which in turn may influence various visit outcomes. Additional research is needed to establish the effects of emphasizing the controversial nature of a socio-scientific exhibition topic on visit outcomes.

Regarding the first research question, the study confirms a frequently found result that exhibition visits are able to promote topic interest in the exhibited content (Schwan et al., 2014); that is, the exhibition visit led to an increase in the topic interest and not to its saturation. Furthermore, we found that the visitors to the exhibition (independent of the variation in caption wording) had a significantly higher level of topic-related knowledge as measured by a "conventional" knowledge test than those who did not visit the exhibition. It is not surprising that participants that visited the exhibition scored higher on a knowledge test with questions directly related to the exhibition's content compared to study participants that did not visit the exhibition. However, it is interesting to find such a clear learning effect after a brief visit to an exhibition (app. 6.5 min on average) and a subsequent work on a filler task.

At least as interesting is that visitors seem to have drawn on their newly acquired knowledge for their argument repertoire. When examining the effect of the visit on visitors' argument repertoire, we found no significant differences between the three experimental groups (two caption conditions and one control group) with regard to the number of arguments *against* industrial animal farming, however, visitors' argument repertoire *in favor of* industrial animal farming was significantly more extensive in the two experimental groups compared to the control group. As the three comparison groups do not differ significantly in their personal characteristics, except for topic interest, which we controlled for, it is reasonable to assume that this significant difference is related to the exhibition visit. As the vast majority of the visitors reported a strong attitude against industrial livestock farming and meat consumption, this finding contradicts assumptions about myside bias (Baron, 1995; Stanovich et al., 2013), according to which a higher expression was to be expected for the attitude-conforming arguments. It seems the exhibition visit provided visitors with new information (in this case, arguments for industrial livestock farming) and contributed to a more balanced argument repertoire. Although providing visitors with additional arguments for industrial livestock farming may not have been the curator's aim, this is an important first finding on the effect of exhibition visits on visitors' argument repertoire. Since museums are often committed to the goal of informing their audience comprehensively and neutrally and, on this basis, to promote evidence-based civic participation, it is exciting to find indications that an exhibition visit can not only lead to a higher number of arguments but can also have a "balancing effect" on visitors' argument repertoire. Whether museums can indeed overcome myside bias and lead visitors to increase their knowledge of attitude-opposing arguments would need to be further confirmed by future studies with participants that have varying attitudes towards the topic at hand.

To the best of our knowledge, this is the first empirical study demonstrating the benefits of visiting an exhibition on a socio-scientific issue beyond interest and knowledge acquisition by expanding and balancing visitors' argument repertoire about a socio-scientific issue. In other words, the findings show that museum exhibitions may support visitors to develop an informed opinion on a socio-scientific issue, in this case, industrial livestock farming. According to recent models of opinion formation, confronting recipients with information that considers both sides of a controversial topic lead them to become aware of possible arguments in favor of a position that opposes their own, which in turn triggers elaborative reasoning about the pros and cons of both positions, resulting in an expanded and balanced argument repertoire that forms the basis for developing an informed opinion (Chen, 2018).

Two main conclusions can be drawn with regard to museum policy and exhibition design. First, the results show that museum exhibitions can contribute significantly to promote responsible citizenship (Pedretti & Iannini, 2020a) and to CSE activities (Levy et al., 2021). Previous research has highlighted the importance of participatory and dialogic activities that allow for an exchange of ideas, arguments, and critical reflections on equal footing between experts and laypersons, for example, by organizing dialogue events in the context of exhibitions (Davies et al., 2009). The present study adds to this field by showing that simply visiting an exhibition can also help promote responsible citizenship at the level of foundational CSE activities (Levy et al., 2021). The mock-up exhibition used in this study was carefully designed to promote critical, reflective thinking on the topic of livestock farming. However,

as we did not find any effect of changes in captions and did not include other variations in exhibit design, a systematical investigation of how exhibitions on controversial issues should be designed to promote informed opinion formation seems to be a fruitful perspective for future empirical research.

As a second conclusion, curators should be sensitive to biased, one-sided presentation of socio-scientific issues in favor of a privileged, culturally dominant perspective. Instead, given the underlying psychological mechanisms of information opinion formation described in the introduction, a multifaceted and multi-perspective presentation of the topic is an essential prerequisite for the successful mediation of a socio-scientific topic in an exhibition. This approach also seems to be in line with visitors' own expectations as shown in a study carried out by Cameron (2005): "our research revealed that for many a museum's role is to maintain an impartial stance and to inform opinion making, rather than overtly express strongly held beliefs and values, or engage in a partisan debate." (p. 226). In the present case, this was achieved by intensive discussion among all members of the project, including curators, museum educators, and researchers. To go one step further, the participation of different visitor groups in the development of an exhibition concept can help to further reduce possible biases in the presentation of the topic.

The presented study is associated with some limitations. First, the visitors' argument repertoire and attitude toward industrial livestock farming and meat production were only surveyed after the visit to the exhibition and not before. This procedure was chosen to minimize a prompting effect by the pre-questionnaire to investigate the effects of the different caption designs in the context of a visit with minimal influence. The control group allowed for an assessment of the attitudes and argument repertoires of subjects who had not visited the exhibition. In future studies, a pre-post design to determine attitude and argument repertoire will allow for a more direct, within-subjects measurement of the effects of an exhibition on opinion formation. Second, although the present study included a 10-min pause between the end of the visit and the argument repertoire query, no conclusions can be drawn about the medium- and long-term effects of the visit on argument repertoire. Future studies should therefore examine the stability of the findings over longer periods of time.

Third, the study was conducted in a relatively small, cabinet-like exhibition. While the average dwell time of about 6.5 min seems short at first glance, both the quotient of dwell time to exhibition area and respondents' self-reported average engagement indicate that visitors moved slowly and attentively through the exhibition. This supports Serrell's (2020, p. 11) observation that "smaller exhibitions seem to engage visitors for longer times per square foot than do larger exhibitions." On a positive note, this indicates that small exhibitions may be particularly well suited to present socio-scientific issues that require visitors to engage in depth with the content of the exhibition. It is also surprising that such a short experience, at least immediately after the visit, already led to a higher number of (pro) arguments compared to the control group. Whether the present findings can be generalized to larger galleries, however, is an open question. A replication of the study in a larger setting would certainly be informative here.

Overall, the study provides a first insight into the potential of exhibition visits in promoting the acquisition of a broad(er) repertoire of arguments. The findings make apparent that an exhibition visit can stimulate individual engagement with the presented content beyond the acquisition of knowledge, to applying that knowledge in generating topic-related arguments and forming an informed opinion. The findings also suggest that in the museum, which still enjoys a high level of trust and credibility compared to other public sources of information, reception-related effects of a myside bias are less pronounced than is known from studies in other contexts. As museums and exhibitions can play a critical role in raising awareness about controversial, socio-scientific issues, further research is needed on how museums can best support visitors in developing an informed opinion on such complex topics.

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## CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

## DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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