education sciences

MDPI

*Article*

# Epistemological Sensitization as a Short-Term Intervention to Change Epistemological Beliefs—Is It Effective or Not?

**Eric Klopp [1,*], Johanna Gathen [2] and Robin Stark [1]**

[1] Department of Education, Saarland University, 66123 Saarbrücken, Germany
[2] Department of Psychology, Saarland University, 66123 Sarbrücken, Germany
* Correspondence: e.klopp@mx.uni-saarland.de

**Abstract**

This study investigates the effects of an epistemological sensitization on domain-specific epistemological beliefs. An epistemological sensitization is a short-term intervention that presents a domain's epistemological features to elicit epistemological doubt when these features are dissonant with a person's current epistemological beliefs. In a pre–post-test design, two sensitization interventions (argumentative vs. informative) were compared with a control condition in their ability to reduce absolutist and multiplicist beliefs and foster evaluativist beliefs with a sample of psychology students. Two different measures of domain-specific epistemological beliefs were used as dependent variables. The results show that while there is evidence for a reduction in either absolutism or multiplicism, there are, at the same time, backfire effects. There was no evidence for an increase in evaluativism. However, these effects depend on the epistemological belief measure. We finally discuss possible reasons for the findings and present the study's limitations.

**Keywords:** epistemological belief; epistemological belief change; sensitization; short-term-intervention

## 1. Introduction

Epistemological beliefs refer to the subjective assumptions concerning the nature of knowledge and the process of knowledge acquisition (cf., Hofer & Pintrich, 1997)[1]. They are essential for engaging in scientific reasoning and constitute a prerequisite for developing advanced scientific argumentation skills (cf., Fischer et al., 2014). In particular, evaluativist epistemological beliefs, i.e., the beliefs that knowledge is based on weighted evidence or justified decisions concerning theories or paradigms, are favorable for competent scientific reasoning and serve as a basis for the skilled application of argumentation strategies (Kuhn, 2001). This applies, in particular, to domains like psychology.

Knowledge in psychology is characterized by two epistemological features. Firstly, there is an ill-defined knowledge structure (cf., Rosman et al., 2017) consisting of seemingly inconsistent definitions, theories, paradigms, or empirical results that, secondly, often result in controversies over certain topics. Therefore, evaluativist epistemological beliefs are adequate for advanced scientific argumentation in this domain and a crucial factor of scientific competence (cf. Rosman et al., 2017). Additionally, however, these two epistemological features may foster the development of multiplicist epistemological beliefs, i.e., the belief that knowledge is arbitrary and mere opinion, which counteracts the development of advanced scientific argumentation skills. Rosman et al. (2017) investigated the development of psychology students' epistemological beliefs over their first four semesters. Their



Academic Editor: Luca Tateo

Received: 2 February 2026
Revised: 9 June 2026
Accepted: 12 June 2026
Published: 17 June 2026

results indicate an overall high level of multiplicist epistemological beliefs and, particularly, an increase in multiplicist epistemological beliefs during the first semester. As a consequence, the enculturation in the domain may indeed counteract the necessary acquisition of adequate argumentation skills.

Thus, there is a need for interventions that aim to develop favorable epistemological beliefs. Several interventions based on the presentation of scientific controversies were developed (e.g., Klopp & Stark, 2022a, 2022b; Rosman et al., 2017). These interventions range from a duration of about one hour to several weeks. However, from a practical perspective, a short-term intervention that could be easily integrated in, e.g., lectures, is more desirable. Such short-term interventions are known to have effects on epistemological beliefs (Kienhues et al., 2008). Porsch and Bromme (2011) used an epistemological sensitization, which is a short-term intervention highlighting a domain's epistemological features, to alter students' source choices. Klopp and Stark (2022a, 2022b) used the idea of epistemological sensitization consisting of a short text to highlight the epistemological features of psychology before they presented their scientific controversies interventions to change domain-specific epistemological beliefs. However, these authors only considered the effects of the epistemological sensitization in combination with the controversy-type intervention. Thus, the question arises if the epistemological sensitization could be used as an intervention on its own. Such a short-term intervention would have the benefit of being easy to integrate into a curriculum in order to counteract the unfavorable development of multiplicist epistemological beliefs in domains like psychology. A short-term intervention to address students' epistemological beliefs would also be useful in other domains as a possible curricular element to foster adequate epistemological beliefs.

However, evidence regarding the effectiveness of epistemological sensitization as an isolated intervention is still needed. Therefore, this study aims to investigate the effectiveness of epistemological sensitizations as an isolated intervention to foster the development of psychology students' epistemological beliefs.

## 2. Theoretical Background

### *2.1. The Developmental Model of Epistemological Beliefs, the Process of Epistemological Belief Change, and a Sensitization Intervention*

One of the most prominent approaches in epistemological beliefs research is the developmental approach (cf., Hofer & Bendixen, 2012; Kuhn, 2001), which describes the development of epistemological beliefs as the succession of three qualitatively different levels: absolutism, multiplicism, and evaluativism. In the integrative approach to epistemological beliefs, Weinstock (2006) characterizes the levels based on their account of knowledge, reasons for different accounts, and justification for knowledge claims. At the absolutism stage, only one correct account can exist, while other accounts are deemed incorrect due to errors or bias, and justification occurs by judgment of which account is correct. At the multiplicism stage, multiple subjective accounts exist that are incommensurable and are merely personal opinions. At the evaluativism level, evidence-based knowledge is constructed, and different accounts are attributed to emphases in different contextual aspects such as justification of claims through critical evaluation and weighing of evidence and expert opinions. Usually, an individual should develop through these levels from absolutism, over multiplicism to evaluativism.

The development of epistemological beliefs is described in the Process Model of Personal Epistemology Development (Bendixen, 2002; Bendixen & Rule, 2004). The model combines three mechanisms: epistemological doubt, epistemological volition, and resolution strategies. Epistemological doubt represents the first phase of the process of epistemological change and is defined as an evidence-based questioning of one's initial epistemological

beliefs. Doubt occurs when a discrepancy exists between an individual's current epistemological beliefs and the newly experienced information, leading to a cognitive imbalance in the form of cognitive dissonance (Festinger, 1957). The elements of the newly experienced information and the individual's epistemological beliefs are dissonant cognitions. However, the newly experienced information must be of personal relevance. Epistemological doubt elicits epistemological volition, i.e., the motivation to reduce cognitive dissonance. Lastly, the resolution strategies are the means to resolve epistemological doubt in that the individual's epistemological beliefs are altered in a way that they constitute consonant cognitions with respect to the newly experienced information.

Epistemological beliefs usually develop during the enculturation within a certain domain and its respective scientific community (cf., Klopp & Stark, 2016), and the development process can be described in the sense of Bendixen's process model. The process model also provides the basis for interventions aiming at epistemological belief change toward evaluativism. The intervention drawing on the presentation of scientific controversies developed by Rosman et al. (2016) also rests on the process model. In this intervention type, in the first step, individuals are confronted with scientific controversies that aim to induce epistemological doubt. In the second step, they receive the controversy's resolution. Klopp and Stark (2022b) describe this process of belief revision as follows: Absolutists would deny the possibility of resolving scientific controversies because only one account can be correct, and the other is necessarily false. The controversy's resolution provides cognitions that are consonant with evaluativist epistemological beliefs. These are added so that the individual's epistemological beliefs change towards evaluativism. Multiplicists would deny that controversies exist because scientific claims are incommensurable against each other and are merely scientists' personal opinions. The mere existence of a controversy is dissonant with multiplicist beliefs. Therefore, subtracting these cognitions and adding the cognitions from the controversy's resolution should change the individual's epistemological beliefs from multiplicist to evaluativist. In sum, an intervention of this kind should push absolutists and multiplicists toward evaluativism. Rosman et al. (2016) provide evidence for the effectiveness of this intervention concept, demonstrating its ability to reduce absolutism and multiplicism.

### 2.2. Epistemological Sensitization as a Short Intervention

Porsch and Bromme (2011) introduced the concept of an epistemological sensitization to alter students' source choices. An epistemological sensitization explains and exemplifies a domain's epistemological features as a short text. Porsch and Bromme (2011) demonstrated that an epistemological sensitization causes an increased use of sources to evaluate content according to the content of the epistemological sensitization. Klopp and Stark (2022a, 2022b) used the notion of an epistemological sensitization to enrich Rosman et al.'s (2016) intervention concepts. They presented an epistemological sensitization describing psychology's epistemological features before they presented five controversies. This procedure aimed to induce epistemological doubt within this particular domain by highlighting its epistemological features before presenting the controversy that refers to a certain topic within a domain. Thus, the sensitization was intended to work as an amplifier for the controversy intervention. Their sensitization text described and explained psychology's epistemological features, in particular with regard to the reasons for the ill-defined knowledge structure. Thus, the sensitization should induce epistemological doubt according to the same process as in the controversy intervention: Absolutists would feel dissonant cognitions in the reasons why an ill-defined knowledge structure exists, and multiplicists would feel dissonant cognitions because of their belief that an ill-defined knowledge structure is the result of different opinions on the same issue. Therefore, epistemological sensitization

itself is an intervention on its own. However, Klopp and Stark (2022b) only used their sensitization intervention in combination with their controversy intervention, not as a stand-alone short-term intervention and therefore, there is no evidence that epistemological sensitizations alone can act as an intervention to alter epistemological beliefs.

Despite the fact that there is currently no evidence for epistemological sensitizations as a stand-alone short-term intervention, there is evidence that short-term interventions of this kind have the potential to alter epistemological beliefs. Kienhues et al. (2008) found that a short intervention consisting of either a refutational epistemological instruction or an informative text altered participants' epistemological beliefs regarding DNA fingerprinting. Refutational texts have an argumentative structure. They begin by presenting a prevalent belief and challenge and disprove it by proposing an alternative, more compelling belief, such as refutation. Kienhues et al.'s (2008) refutational epistemological instruction contrasted the viewpoint that DNA fingerprinting is a reliable technique with a viewpoint about the uncertainties of DNA fingerprinting. The informative text about DNA fingerprinting was in a textbook style without highlighting any controversy. The participants took a pre-test on topic-specific epistemological beliefs towards DNA fingerprinting and were grouped as either showing naïve or sophisticated beliefs regarding DNA fingerprinting. After the intervention, the naïve group in the refutational epistemological instruction condition changed toward more sophisticated epistemological beliefs. In contrast, the sophisticated participants in the informative text condition changed unexpectedly toward more naïve epistemological beliefs.

Thus, such an epistemological sensitization, particularly in the form of a refutation text, would be a possible candidate for a short-term intervention to alter epistemological beliefs, however, with the constraints to avoid unwanted effects such as changing from sophisticated to naïve epistemological beliefs. As refutation texts refer to a certain misconception, they cannot be directly applied to multifaceted constructs like absolutist and multiplicist epistemological beliefs. However, the argumentative structure of a refutational text can be applied to the sensitization text used in Klopp and Stark (2022b)—describing the epistemological features of psychology, like inconsistent definitions, theories, paradigms, or empirical results. A sensitization text can be structured according to the basic form of an argument, i.e., a claim followed by its justification. This argumentative sensitization first describes a certain epistemological feature of a particular domain, followed by the reason why the feature exists. The justification typically consists of an explanation of the respective characteristic. This characteristic may be inconsistent with absolutist or multiplicist beliefs or congruent with evaluativist beliefs. In the first two cases, the characteristic's description would induce epistemological doubt, further driving the belief revision process outlined above because the epistemological features of psychology are more in line with evaluativist beliefs than with the other ones. In the latter case, the description and reasons would be congruent with evaluativist beliefs, so no epistemological belief change should happen. Similar considerations could also be put forward for texts presenting only the epistemological features without any explanation, which may be considered informative texts. However, as informative texts lack explanations for the presented epistemological features, fewer dissonant cognitions potentially result in a lower amount of epistemological doubt and, therefore, also a lower amount of motivation to change the current beliefs toward evaluativism compared to an argumentative text. A common feature of both text types is that they lack a resolution strategy, i.e., they do not explain how beliefs could be changed towards evaluativism.

In sum, argumentative and informative texts may have the potential to alter epistemological beliefs toward evaluativism as they may induce epistemological doubt. However, as both lack the induced doubt's resolution, the effects on belief change may be less pro-

nounced than with a full-fledged intervention. Additionally, because of the potentially lower amount of induced epistemological doubt, purely informative texts should exert less pressure to change one's beliefs toward evaluativism.

Investigating the effects of the two sensitization interventions also requires methodological considerations. The argumentative sensitization explains the epistemological features that give raise to possible controversies, whereas the informative sensitization text only mentions them, and is therefore shorter. However, this may require the methodological consequence of keeping both texts at a constant length to hold the potential amount of reading time constant.

## 3. Hypotheses and Research Questions

This study aims to investigate the effectiveness of an epistemological sensitization as a stand-alone intervention for inducing epistemological change among psychology students. Two different versions of the epistemological sensitization, i.e., an argumentative and an informative text, were used to induce changes in psychology students' domain-specific epistemological beliefs. The study was conducted via a prepost-test design. Drawing on the above-mentioned reasoning, we hypothesized that (1) an epistemological sensitization reduces absolutism and multiplicism, and (2) fosters evaluativism. Additionally, due to the potentially lower amount of induced epistemological doubt, we expect the effects of the informative text to be smaller than the argumentative effects. Because there is no prior research with regard to this issue, possible differences between the effects of an argumentative and informative sensitization were tested exploratively.

## 4. Methods

### *4.1. Sample, Design, and Procedure*

The initial sample consisted of 317 psychology students. The subjects were recruited through social networks and billboard postings on the campus of a university in the southwest of Germany and the study was implemented as a computer-based intervention. They received a 45 min time credit for their obligatory participation in psychological experiments. According to the examination regulations, participation in psychological studies is a prerequisite for subsequent approval to write the bachelor's thesis.

Out of the 317 initial participants, 69 did not reach the end of the experiment and were therefore excluded. Of the remaining 248 participants, we excluded all participants whose reading time of the sensitization text was below 30 s, indicating only a superficial reading of the text, which left 214 participants. We also excluded participants with a reading time longer than 10 min, indicating that these participants got distracted. We set the lower bound to account for very fast readers, although there is still a possibility that these participants read the text only superficially. As the study was computer-based (see below), the lower bound excluded those participants who "clicked on the Continue button." The upper bound was based on the Flesch index of the sensitization intervention, which is around 30 for all sensitization interventions, and the highest number of words for a sensitization intervention, which is 933 (see Section 4.2 for details for all texts). Because the Flesch index indicated a difficult text, we assumed a conservative reading speed of 100 words per minute for slow readers, giving an approximately 10 min upper bound for reading time. After setting those bounds on the reading time, the final sample consisted of 195 (152 female) psychology students. The gender distribution resembles the typical German distribution in psychology (German Federal Statistical Office, 2020, 2024), thus representing the target population of the study's intervention. The mean was 23.46 age ($SD$ = 6.88), and the median semester was 3 (range 1–8).

The study had a pre–post-test design with the three experimental conditions: One experimental condition (EC1) in which the participants received the argumentative sensitization and two other experimental conditions (EC2 and EC3) where the participants received different versions of the informative sensitization (see Section 4.2 for details). The subjects were randomly assigned to one of the three experimental conditions ($N_{EC1}$ = 43, $N_{EC2}$ = 52, $N_{EC3}$ = 50) and a control condition ($N_{CC}$ = 50). The participants in one of the three epistemological sensitizations received the sensitization intervention, whereas those in the control condition received a text about learning strategies.

The experiment was conducted online, and the participants completed the experiment from their home computers. Firstly, all participants gave informed consent to participate in the study, answered a short demographic questionnaire, and then took pre-tests on the epistemological belief measures. After that, the participants in the experimental conditions received the epistemological sensitization, and those in the control condition received the text on learning strategies. Lastly, they took the post-test on the epistemological belief measures.

### 4.2. Intervention

The intervention consisted of an epistemological sensitization text. In the first experimental condition (EC1), the participants received the argumentative sensitization. This text was based on Klopp and Stark's (2022b) sensitization intervention and discussed the issue of conflicting empirical results or theories in psychology. The reasons for conflicting claims are presented and explained afterward. The argumentative sensitization covered five topics about the reasons for conflicting claims. The first topic dealt with the possible revisability of scientific knowledge. Because knowledge depends on a consensus in the scientific community, there is a body of knowledge for which consensus is given and a body of knowledge under investigation in continuing research; therefore, conflicting claims are common. The second topic discussed scientific methods as a potential source of conflicting claims. In particular, the theoretical assumptions underlying various methods were mentioned as a source of potential conflicting claims. The third topic dealt with the difference between the knowledge required to explain psychological phenomena and the knowledge required to conceptualize interventions. Theories that explain behavior may not contain any clues to change behavior, and vice versa. Thus, these different kinds of theories may potentially provide conflicting claims on the same issue. The fourth topic dealt with different research paradigms as a reason for conflicting claims. The fifth and last topic discussed the difference between scientific claims that target a lay audience, e.g., science journalism, and scientific claims that target the scientific community that may result in seemingly conflicting claims due to simplification. The argumentative sensitization had 933 words with a Flesch index of 30.

The participants in the second experimental condition (EC2) received the informative sensitization. To account for the issue mentioned above and hold the text length constant compared to the argumentative sensitization, a filler text covering the difference in text length between both interventions was introduced. The filler text was designed not to induce epistemological doubt to avoid confounding with the intervention content. The filler text first presented an introduction to the science of psychology and a juxtaposition between scientific and everyday psychology. Afterward, the text presented a short overview of psychology's historical development before the actual informative sensitization followed (hereafter: informative sensitization with filler text). Concerning the placement of the filler text, the text part containing the informative sensitization was placed after the filler text because of a potential recency effect. The text in this experimental condition had 742 words with a Flesch index of 29.

The participants in the third experimental condition (EC3) received only the informative part from the text in the second experimental condition. This text had 376 words with a Flesch index of 31 (hereafter: informative sensitization).

The text about learning strategies in the control condition (CC) covered a description of control, regulation, and planning strategies for learning processes and a description of the SQ3R method. This text had 786 words with a Flesch index of 30.

### 4.3. Epistemological Belief Measures

Concerning the measurement of epistemological beliefs, two different measures assessing psychology-specific epistemological beliefs were included because there is evidence that the results of interventions may differ depending on the particular measure (cf., Kerwer & Rosman, 2018; Klopp & Stark, 2022a, 2022b). The first measure was the EBI-AM questionnaire (Peter et al., 2016). The EBI-AM measures domain-specific absolutism with 12 items and multiplicism with 11 items. The items refer to the domain of psychology, and the participants are asked to give their ratings of psychology's epistemological features. The items were administered in conjunction with a six-point rating scale. An item analysis indicated a potential problem with the tenth multiplicism item in the post-test measure. Therefore, this item was excluded from the further analysis for both measurements. The EBI-AM scales' internal consistencies (Cronbach's $\alpha$) are sufficient and shown in Table 1.

A drawback of the EBI-AM is that it does not provide a scale to measure evaluativism. The ETA questionnaire (Barzilai & Weinstock, 2015), however, provides such a scale. The ETA is a scenario-based questionnaire combining domain- and topic-specific absolutism, multiplicism, and evaluativism. The ETA's items refer to a scenario, i.e., a conflicting knowledge claim on a certain topic. The items are formulated to prompt the participants to reason about the scenario. Consequently, the ETA captures the expression of domain-specific epistemological beliefs with a certain proportion of topic-specific epistemological beliefs (Barzilai & Weinstock, 2015). We adopted the scenarios used in the ETA to the domain of psychology (cf., Klopp & Stark, 2022b). To avoid memory effects due to the shortness of the intervention, we used different scenarios in the pre- and post-test. The scenario of the pre-test referred to the processing of emotional stimuli and presented conflicting evidence stemming from two different paradigms, showing that either positive or negative emotional stimuli have advantages in cognitive processing. The pre-test scenario consisted of 337 words with a Flesch index of 26. The post-test scenario addressed whether violent video games cause violent behavior and presented two conflicting statements concerning experimental and longitudinal research designs that provided conflicting answers to this question. It consisted of 325 words, and its Flesch index was 34. The ETA scales' internal consistencies (Cronbach's $\alpha$) are sufficient and shown in Table 1.

### 4.4. Statistical Analysis and Sample Size Considerations

For all statistical analyses, R (R Core Team, 2020, version 4.02) was used in combination with the packages Revelle (2016, version 2.0.9), lavaan (Rosseel, 2012, version 0.6.13), and pwr (Champely, 2020, version 1.3.0). We used latent change regression score models (LCRS; McArdle, 2009). We used a multiple-group LCRS model with the groups representing the experimental conditions. LCRS models capture the difference between the pre- and post-test using a latent variable that also regresses on the pre-test to account for possible effects of the pre-test. Because reading time could vary within the bounds described in the Section 4.1, design, and procedure, we included reading time as another relevant covariate; see Figure 1 for an exemplary depiction of the LCRS model for the EBI-AM in a given group. The model is saturated, i.e., it has zero degrees of freedom. The mean of the latent change regression score was calculated using estimated marginal means (EMM) using

defined parameters. The EMM in each condition represents the respective epistemological belief change.

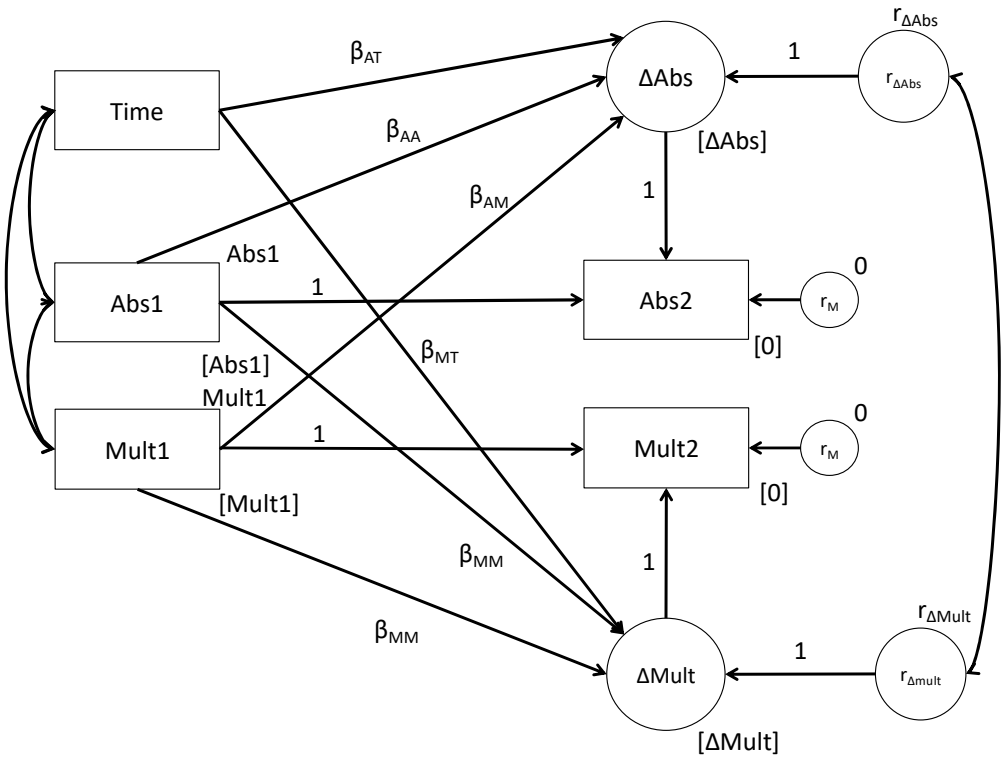


**Figure 1.** LCRS model for the EBI-AM in one experimental condition.

The analysis strategy is as follows: Firstly, we investigated if the EMM of the LCRS provides evidence of epistemological belief changes in each experimental condition; secondly, we compared the experimental conditions with the control condition for cases where there was evidence of epistemological belief change. Thirdly, if there was an epistemological change in more than one of the experimental conditions, we also compared the change in these conditions. The nominal significance level was $\alpha$ =.05. Cohen's d was used as an effect size measure.

We set up a multiple-group LCRS model for the EBI-AM and ETA, respectively. The conceptual LCRS model for the EBI-AM is depicted in Figure 1. We used the MLM estimator that provides robust standard errors because some of the variables in the model did not follow a normal distribution (cf., Finney & DiStefano, 2013).

Concerning statistical power, a minimum level is .50, with an ideal level of .80 (Kyriazos, 2018). Drawing on Klopp and Stark (2022b), we consider a power of .65 sufficient. Concerning the sample size planning, there is no analytical solution for the combined LCRS and EMM approach. Thus, we conducted a power analysis for a conceptually analogous two-sample t-test assuming an effect size of d = 0.50, a nominal significance level of $\alpha$ = .05, and a power of .65, which provides a sample size of 45 per group. We aimed at recruiting 55 participants for each condition to account for possible dropouts. We also computed the post hoc power, i.e., the power that would have been expected if the sample statistical parameters were the population parameters. Post hoc power was calculated using a Monte Carlo simulation with 1000 replications.

**Table 1.** Correlations and internal consistencies.

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. EBI-AM Absolutism Pre-test | .76 | | | | | | | | | |
| 2. EBI-AM Absolutism Post-test | .81 ($p < .001$) | .78 | | | | | | | | |
| 3. EBI-AM Multiplicism Pre-test | −.12 ($p = .084$) | −.14 ($p = .056$) | .73 | | | | | | | |
| 4. EBI-AM Multiplicism Post-test | −.02 ($p = .747$) | −.10 ($p = .146$) | .84 ($p < .001$) | .76 | | | | | | |
| 5. ETA Absolutism Pre-test | .33 ($p < .001$) | .39 ($p < .001$) | −.07 ($p = .316$) | −.05 ($p = .478$) | .79 | | | | | |
| 6. ETA Absolutism Post-test | .30 ($p < .001$) | .39 ($p < .001$) | −.01 ($p = .934$) | .01 ($p = .864$) | .72 ($p < .001$) | .85 | | | | |
| 7. ETA Multiplicism Pre-test | .20 ($p = .006$) | .22 ($p = .002$) | .23 ($p = .001$) | .20 ($p = .005$) | −.33 ($p < .001$) | −.27 ($p < .001$) | .73 | | | |
| 8. ETA Multiplicism Post-test | .25 ($p < .001$) | .26 ($p < .001$) | .17 ($p = .016$) | .22 ($p = .002$) | −.30 ($p < .001$) | −.35 ($p < .001$) | .79 ($p < .001$) | .80 | | |
| 9. ETA Evaluativism Pre-test | −.04 ($p = .605$) | .04 ($p = .571$) | .27 ($p < .001$) | .25 ($p < .001$) | .07 ($p = .310$) | .05 ($p = .497$) | .08 ($p = .265$) | .02 ($p = .788$) | .64 | |
| 10. ETA Evaluativism Post-test | .03 ($p = .633$) | .08 ($p = .283$) | .31 ($p < .001$) | .33 ($p < .001$) | .05 ($p = .507$) | .01 ($p = .879$) | .14 ($p = .051$) | .11 ($p = .126$) | .70 ($p < .001$) | .79 |
| 11. Reading time | .06 ($p = .403$) | .03 ($p = .693$) | .03 ($p = .642$) | −.02 ($p = .765$) | .12 ($p = .086$) | .12 ($p = .082$) | .01 ($p = .908$) | .05 ($p = .488$) | .01 ($p = .936$) | .02 ($p = .765$) |

*Note.* The main diagonal contains the scales' internal consistencies (Cronbachs $\alpha$).

## 5. Results

### *5.1. Descriptive Analysis and Internal Validity*

For epistemological beliefs, the pre-test and post-test showed the correlation depicted in Table 1. In particular, for the ETA, the other epistemological belief levels also correlate with the post-test, justifying their inclusion as covariates for the LCRS. However, reading time did not correlate with the post-test but was a significant covariate for some experimental conditions for the LCRS (see the regression tables). The means and standard deviations per condition are shown in Table 2. Concerning internal validity, there are no significant mean differences for epistemological pre-test variables between the conditions (all ANOVAs non-significant, $0.02 < F(3,191) < 2.51$, $.060 < p < .997$). The reading time differed significantly between the conditions ($F(3,191) = 12.17$, $p < .001$), with the informative intervention in EC3 having a significantly shorter reading time than the other conditions. However, this is expected due to the differences in text length. Overall, there is no evidence against the internal validity of the study.

**Table 2.** Descriptive statistics of epistemological belief scales for pre- and post-test in each experimental condition.

| | | EBI Absolutism | | EBI Multiplicism | | ETA Absolutism | | ETA Multiplicism | | ETA Evaluatism | | Reading Time | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Condition** | ***M*** | ***SD*** | ***M*** | ***SD*** | ***M*** | ***SD*** | ***M*** | ***SD*** | ***M*** | ***SD*** | ***M*** | ***SD*** |
| Pre-test | Overall | 2.50 | 0.56 | 3.95 | 0.59 | 4.03 | 0.64 | 2.46 | 0.63 | 4.45 | 0.47 | 3.56 | 2.00 |
| | EC1 | 2.51 | 0.57 | 3.82 | 0.49 | 4.03 | 0.67 | 2.53 | 0.65 | 4.43 | 0.51 | 4.07 | 2.06 |
| | EC2 | 2.51 | 0.58 | 4.06 | 0.58 | 4.16 | 0.52 | 2.48 | 0.58 | 4.52 | 0.45 | 4.01 | 1.80 |
| | EC3 | 2.49 | 0.54 | 4.05 | 0.62 | 3.96 | 0.66 | 2.49 | 0.57 | 4.53 | 0.40 | 2.20 | 1.28 |
| | CC | 2.51 | 0.56 | 3.83 | 0.62 | 3.99 | 0.71 | 2.37 | 0.70 | 4.32 | 0.51 | 4.01 | 2.15 |
| Post-test | Overall | 2.46 | 0.57 | 3.99 | 0.61 | 4.13 | 0.69 | 2.30 | 0.67 | 4.41 | 0.56 | | |
| | EC1 | 2.51 | 0.56 | 3.96 | 0.54 | 4.16 | 0.67 | 2.46 | 0.60 | 4.37 | 0.59 | | |
| | EC2 | 2.41 | 0.59 | 4.05 | 0.67 | 4.25 | 0.58 | 2.21 | 0.68 | 4.44 | 0.57 | | |
| | EC3 | 2.41 | 0.56 | 4.14 | 0.54 | 4.01 | 0.73 | 2.34 | 0.66 | 4.59 | 0.43 | | |
| | CC | 2.54 | 0.57 | 3.80 | 0.62 | 4.11 | 0.74 | 2.23 | 0.72 | 4.24 | 0.61 | | |

### *5.2. Results for the EBI-AM*

The results for the changes in each condition and comparisons between the conditions are shown in Table 3. With regard to absolutism, there is only a significant decrease in EC2, i.e., for the informative sensitization with filler text, but no belief changes in the other conditions. The decrease in EC2 is also significantly different from the control condition. However, the effect sizes are small, and the post hoc power is only at the minimum level.

Concerning multiplicism, there is a significant increase in the argumentative sensitization in EC1 and informative sensitization in EC3 but no change in the other conditions. Again, there is no epistemological belief change in the control condition. Regarding the effect sizes, this change is more pronounced in EC1 than in EC3. In addition, in EC1, the post hoc power is at the desired level, whereas it is just below the minimum in EC3. The belief changes in EC1 and EC3 differ significantly from the control condition. For these differences, the comparison between EC1 and CC has a large effect size, and the post hoc power for this comparison is just below the ideal level. In contrast, the comparison between EC3 and CC has a small effect, and its post hoc power is slightly below the minimum.

In summary, there is slight evidence that the informative sensitization with filler text may reduce absolutism. However, in line with the results from Klopp and Stark (2022b), the sensitization may have a backfire effect on multiplicism. This backfire effect occurs for the argumentative sensitization, and there is slight evidence that the informative sensitization also backfires.

**Table 3.** Results of the latent change regression score models.

| | **EBI Absolutism** | | | | **EBI Multiplicism** | | | | **ETA Absolutism** | | | | **ETA Multiplicism** | | | | **ETA Evaluatism** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Epistemological belief change (EMM of the LCRS) | | | | | | | | | | | | | | | | | | | | |
| | *M* | *SE* | *p* | *Power* | *M* | *SE* | *p* | *Power* | *M* | *SE* | *p* | *Power* | *M* | *SE* | *p* | *Power* | *M* | *SE* | *p* | *Power* |
| EC1 | 0.01 | 0.06 | .946 | .07 | **0.14** | **0.05** | **.005** | .80 | 0.13 | 0.07 | .051 | .52 | −0.07 | 0.08 | .375 | .16 | −0.06 | 0.06 | .347 | .17 |
| EC2 | **−0.10** | **0.05** | **.048** | **.50** | −0.01 | 0.05 | .874 | .07 | 0.09 | 0.07 | .174 | .30 | **−0.27** | **0.05** | **<.001** | .99 | −0.08 | 0.05 | .137 | .38 |
| EC3 | −0.07 | 0.04 | .066 | .46 | 0.09 | 0.05 | .046 | .53 | 0.06 | 0.08 | .454 | .12 | **−0.15** | **0.07** | **.031** | .58 | 0.05 | 0.05 | .304 | .19 |
| CC | 0.03 | 0.04 | .445 | .14 | −0.03 | 0.04 | .425 | .16 | 0.12 | 0.08 | .105 | .38 | **−0.13** | **0.05** | **.007** | .75 | −0.08 | 0.07 | .231 | .26 |
| Pairwise comparisons | | | | | | | | | | | | | | | | | | | | |
| | *M* | *SE* | *p* | *Power* | *M* | *SE* | *p* | *Power* | *M* | *SE* | *p* | *Power* | *M* | *SE* | *p* | *Power* | *M* | *SE* | *p* | *Power* |
| EC1-CC | −0.03 | 0.07 | .683 | .08 | **0.18** | **0.07** | **.007** | .77 | 0.01 | 0.10 | .911 | .06 | 0.07 | 0.09 | .456 | .11 | 0.03 | 0.09 | .753 | .09 |
| EC2-CC | −0.14 | 0.07 | .045 | .51 | 0.03 | 0.06 | .683 | .09 | −0.03 | 0.10 | .759 | .06 | **−0.14** | **0.07** | **.046** | .54 | 0.01 | 0.09 | .922 | .05 |
| EC3-CC | **−0.11** | **0.06** | **.007** | **.47** | **0.13** | **0.06** | **.045** | .52 | −0.07 | 0.11 | .538 | .12 | −0.01 | 0.08 | .887 | .07 | 0.14 | 0.09 | .116 | .36 |
| EC1-EC2 | 0.11 | 0.08 | .169 | .29 | **0.15** | **0.07** | **.031** | .56 | 0.04 | 0.10 | .658 | .06 | **0.20** | **0.09** | **.002** | .63 | 0.02 | 0.08 | .794 | .06 |
| EC1-EC3 | 0.08 | 0.07 | .257 | .19 | 0.05 | 0.07 | .427 | .13 | 0.08 | 0.10 | .449 | .13 | **0.08** | **0.10** | **.044** | .13 | −0.11 | 0.08 | .166 | .29 |
| EC2-EC3 | −0.03 | 0.06 | .697 | .07 | −0.10 | 0.07 | .139 | .33 | 0.04 | 0.10 | .731 | .07 | −0.12 | 0.08 | .131 | .63 | −0.13 | 0.07 | .076 | .48 |
| Effect sizes | | | | | | | | | | | | | | | | | | | | |
| | *d* | | | | *d* | | | | *d* | | | | *d* | | | | *d* | | | |
| EC1 | 0.01 | | | | 0.43 | | | | 0.30 | | | | 0.14 | | | | 0.13 | | | |
| EC2 | 0.27 | | | | 0.02 | | | | 0.19 | | | | 0.62 | | | | 0.17 | | | |
| EC3 | 0.26 | | | | 0.28 | | | | 0.11 | | | | 0.27 | | | | 0.10 | | | |
| CC | 0.11 | | | | 0.12 | | | | 0.23 | | | | 0.27 | | | | 0.16 | | | |
| EC1-CC | 0.09 | | | | **0.57** | | | | 0.02 | | | | 0.14 | | | | 0.06 | | | |
| EC2-CC | 0.40 | | | | 0.08 | | | | 0.06 | | | | **0.29** | | | | 0.02 | | | |
| EC3-CC | **0.36** | | | | **0.40** | | | | 0.12 | | | | 0.02 | | | | 0.26 | | | |
| EC1-EC2 | 0.28 | | | | **0.44** | | | | 0.09 | | | | **0.44** | | | | 0.05 | | | |
| EC1-EC3 | 0.24 | | | | 0.17 | | | | 0.16 | | | | **0.15** | | | | 0.22 | | | |
| EC2-EC3 | 0.07 | | | | 0.29 | | | | 0.07 | | | | 0.25 | | | | 0.26 | | | |

*Note.* Significant results are printed in bold.

### 5.3. Results for the ETA

For the absolutism scale, there is no significant epistemological belief change. However, the argumentative sensitization narrowly missed the nominal significance level.

Concerning multiplicism, there is a significant decrease for the informative sensitization with filler text in EC2, showing a large effect size and almost perfect post hoc power. There is also a significant decrease for the informative sensitization in EC3, showing a small effect size and a post hoc power slightly below the minimum. However, there is also a significant decrease in the control condition CC, showing a small effect size and a post hoc power slightly below the ideal level. The belief change in EC2 significantly differs from the control condition CC. However, there was no significant difference between EC2 and EC3. Comparing the control condition with the other experimental condition shows that there is only a significant difference for the informative sensitization with filler text, indicating that in this condition, the decrease in multiplicism is stronger than in the control condition.

For evaluativism, there is no epistemological belief change, neither in the experimental conditions nor in the control condition.

In sum, no statistical evidence exists for a change in absolutism and evaluativism. The evidence for the decline in multiplicism for both informative sensitizations is overshadowed by the decline in multiplicism in the control condition.

## 6. Discussion

The results show that epistemological sensitizations may alter epistemological beliefs, but the results depend on the epistemological belief measure. In addition, there may be unwanted effects like backfiring. We discuss the results separately for the EBI-AM and the ETA because, as outlined in the methods section, the EBI-AM is a purely domain-specific measure, whereas the ETA is a measure that assesses a combination of domain-specific epistemological beliefs with a certain proportion of topic-specific epistemological beliefs.

Firstly, there is a desired decrease in absolutism for the EBI-AM scale, but only for the informative sensitization with the filler text. It is unclear why this decrease only occurs in this condition. A reason may be the content of the filler text: placing the informative sensitization in the context of psychology as a science, in particular with information about the historical development of the discipline, may lessen the belief that there is an objective truth by creating an evolving impression of the discipline and consequently causing epistemological doubt concerning absolutist beliefs. However, this interpretation does not explain why the argumentative sensitization did not lessen absolutism as expected. Perhaps the participants, who were mostly in the early semesters, could not comprehend the methodological arguments because of a lack of domain-specific prior knowledge. Possibly, they could understand the topic from a historical perspective because it is a view that does not require methodological prior knowledge.

Concerning the purely domain-specific multiplicism measured with the EBI-AM, there is an unwanted increase in multiplicist beliefs for the argumentative and informative sensitization. The argumentative sensitization that explains the reasons for conflicting claims in psychology may have fostered an impression of arbitrariness typical for multiplicism (cf., Klopp & Stark, 2022b). In particular, regarding the above-mentioned issue that the students were mostly beginners, they perhaps could not handle these complex arguments requiring a certain amount of prior knowledge. The same may apply to the informative sensitization, but to a lesser degree, as evidenced by the smaller effect size, possibly due to the lack of explanations for why conflicting claims are possible. This lack of explanation lessened a possible impression of arbitrariness. Additionally, for the informative sensitization with the filler text, the embedding in the historical context may have lessened the impression of arbitrariness by supporting the view that the scientific results in psychology

emerge from systematic consideration, preventing the increase in multiplicism in this experimental condition.

A very different picture emerged for the results concerning ETA scales. There was no change for absolutism. For the argumentative text, a potential increase in absolutism narrowly missed the threshold for statistical significance. This may indicate a potential backfiring increase for the argumentative sensitization, presumably because of the same reason and the unwanted increase for EBI-AM absolutism. But, as this is a statistically non-significant result, we refrain from drawing further conclusions.

For ETA multiplicism, there was evidence of a reduction in multiplicist beliefs. However, this evidence is overshadowed by a reduction in multiplicism in the control condition. It is implausible to attribute this reduction to the text about learning strategies which the participants read in this condition. As mentioned in Klopp and Stark (2022b), a plausible explanation is that the change in multiplicism did not result from the intervention but came from lower amount of topic-specific multiplicist epistemological beliefs about the pre-test scenario compared to the topic-specific multiplicist epistemological beliefs about the post-test scenario. This would result from confounding epistemological change with differences in the topic-specific proportion of the measure. The decline in the control condition may indicate a generally lower amount of the topic-specific proportion of multiplicism for the post-test scenario. However, the decline in the control condition may serve as a benchmark for comparing the other conditions. From this perspective, there is only a true decline for the informative sensitization with filler text but not for the informative sensitization. The reason for a possible true decline in this condition may be the same that prevented the unwanted backfire effect in this condition for the EBI-AM multiplicism scale; the embedding in the historical context may have lessened the impression of the arbitrariness of scientific results in psychology yielding the possible and desired decline of multiplicism. Additionally, from this perspective, it is possible that the decline in multiplicism due to the decline in topic-specific multiplicism in the post-test prevents a possible backfiring (an increase in multiplicism) for the argumentative sensitization. Given the backfire effect for EBI-AM absolutism, it is likely that similar considerations may apply to the ETA multiplicism scale, but that is a very speculative view.

The ETA did not provide any evidence for the assumed increase in evaluativism. Also, even if it is not directly comparable, Klopp and Stark (2022b) reported a change in evaluativism only in their condition in which epistemological sensitization was paired with the main epistemological change intervention but not the epistemological change intervention alone. In addition, the descriptive statistics of the current study and the descriptive statistics in Klopp and Stark (2022b) indicate that the participants in all conditions already had a high level of evaluativism in the pre-test. Possibly, neither the sensitization alone nor a more comprehensive epistemological change intervention is powerful enough to foster an increase in evaluativism if the base level is already high.

Another topic concerns the effect sizes. All but one of the effect sizes had to be classified as small. Only the decrease in ETA multiplicism with the informative sensitization with filler text has a medium effect. However, as this decline is likely to be caused by a declining level of multiplicism in the post-test, the true effect size may lie in the small range, too. Thus, if there are effects of an epistemological sensitization, they are not pronounced. This is in line with the theoretical reasoning that the epistemological sensitization only induces epistemic doubt but does not provide a resolution for a more pronounced belief change. Concerning our explorative research question, only the unwanted increase in EBI-AM multiplicism may allow a comparison of the effect sizes of the different sensitization interventions. The comparison of the effect sizes in this condition indicates that the unwanted increase is smaller for the informative sensitization than for the argumentative

sensitization. Thus, as theorized, due to the presence of the epistemological feature's explanation in this condition, the possible effects may be potentially stronger than for the pure presentation of the epistemological features in the informative sensitization. But due to the absence of systematic effects and the associated lack of systematic comparisons between the sensitization interventions, this interpretation is once again rather speculative.

The final issue deserving to be discussed is the fact that a number of participants dropped out of the study, either because they skipped and did not reach the end of the experiment or because their reading times were beyond the preset limits. Both may be indicative of motivational issues. As the participants were obliged to participate in experiments, it is likely that most were externally motivated to earn a time credit instead of being internally motivated because they were interested in the topic of the study. As noted by McGonagle (2015), lacking effort may result in unsystematic errors and systematic forms of variance that might yield biases in the estimated parameters. Thus, the low and missing effects in the study may be attributed to the lack of participant effort, e.g., careless item responding or careless reading of the instructions or contents. From the perspective of self-determination theory (Deci & Ryan, 2012), external motivation reduces autonomy leaving a risk of disinterest and low persistence. In contrast, internally motivated behavior is considered autonomous and generally leads to more engagement, more persistence, and deeper information processing (e.g., Vansteenkiste et al., 2004). Thus, a possible lack of internal motivation stemming from the requirement of obligatory participation in psychological studies may yield shallower task processing.

Lack of motivation may affect the quality of the collected data. Braitman et al. (2022) explicitly relate motivation to data quality by arguing that lower participant motivation can increase satisficing, i.e., insufficient processing of survey items, which may result in poorer-quality data. This argumentation is slightly related to the situation in the present study. Braitman et al. (2022) conducted an experimental investigation into data quality and compared a pool of psychology students with a pool of students from the general student population. The psychology students pool consisted of students enrolled in psychology courses who could participate in research studies for research credit that counted toward a course or as extra credit. Participation in research was not the only way to earn credit; students could alternatively complete scientific article critiques. The general student population pool consisted of students enrolled at the university who received monetary compensation for participation. Braitman et al. (2022) found that the recruitment source was associated with participant compliance: participants recruited from the psychology participation pool were more likely to fail attention checks, indicating lower data quality, and also showed lower motivation to take part in consequent measurements than students recruited from the general student body. Regarding the relations among variables, excluding participants who failed attention checks altered some associations among study variables, whereas other associations remained unaffected. This suggests that inattentive responding may bias substantive results, whereas the effects on internal consistency estimates were negligible. This situation is loosely related to the situation in our study. As mentioned above, students are obliged to take part in psychological studies as a prerequisite to their admission to the bachelor's thesis. This situation may be comparable to Braitman et al.'s (2022) study. Filtering out participants with very short or very long reading times may adversely affect some variables but not others. However, it is unclear which variables are potentially affected. Additionally, although the boundaries for the exclusion of cases were drawn after substantial consideration, different boundaries may have led to divergent results. Thus, motivational issues might have caused some data quality issues, but it is unknown which variables are affected, and the results therefore should be interpreted cautiously.

Additionally, the question of internal motivation also relates to the participants' domain- and topic-specific interests. Domain-specific interest leads to a greater task effort, and topic-specific interest also yields a deeper task engagement and increased attention (e.g., Krapp, 1999). However, psychology is a broad discipline, and many students have more interest in applied psychology, e.g., psychotherapy or industrial psychology. Participants with such interests may not be as motivated to think deeply about the reasons for controversies as participants with the goal of becoming scientists. Thus, it should be fruitful to study such groups separately.

Considering subgroups of students would also refer to further exploration of the backfire effect. The current conceptualization of the backfire effect relies on the mean across all participants but leaves open the possibility that at the boundaries, some participants may show no or an extreme backfire effect. In the context of analyzing these subgroups, participants could be grouped into those showing a backfire effect and those showing no backfire effect, and the investigation could examine which other variables these groups differ on. Again, potentially relevant variables would be students' interests and other motivational constructs.

From a methodological perspective, an advanced approach to tackle such issues would be a combination of the usual variable-oriented analysis with a person-oriented analysis. This perspective was recently brought into the research in epistemological beliefs (e.g., Schiefer et al., 2022). The main goal of the person-oriented approach is to find subgroups of persons with homogenous characteristics. Klopp et al. (2023) suggested that this approach can also be used in experimental research. By doing so, the participants could be divided according to their interests or motivation, and the relation between the intervention and epistemological beliefs change can be analyzed separately for each group. However, the drawback of such an analysis would be that the number of required participants increases, as in each of the subgroups, a minimum amount is required depending on the expected effect size. A classical approach would introduce variables like interests or motivation as covariates. As with reading time in this study, the latent change regression score could be regressed on those covariates so that they are considered in the change score.

## 7. Limitations

The first three limitations refer to more methodological issues. From a methodological perspective, the issues mentioned here are not only limitations but, at the same time, also considerations for future research.

The diverging results of the two epistemological beliefs questionnaires are a primary and rather large limitation. Although there are commonalities, both measures seem to refer to different constructs of epistemological beliefs. For instance, the pre-test measures for absolutism and multiplicism correlate positively between the EBI-AM and ETA. But the correlations only indicate amounts of shared variance between 4% and 9%. Such a low variance share cannot solely be attributed to the topic-specific epistemological belief component inherent in the ETA. Thus, although both measures refer to epistemological beliefs, the specific constructs that they measure seem to be different. Consequently, it is an open question if the results transfer from one measure to another. The different scenarios used with the ETA questionnaire, yielding a potential confounding between epistemological beliefs change, and varying levels of topic-specific epistemological beliefs are a second limitation.

Another limitation refers to the informative sensitization with filler text. Firstly, drawing on the recency effect, the filler text was placed before the informative sensitization text. However, due to a possible primacy effect, it is possible that different effects may have emerged when the informative sensitization text would have been placed before the filler

text. Secondly, apart from the placement, the content of the filler text may be responsible for some of the effects found in this study. Thus, the content of the filler text may limit the generalizability of the results as it may be responsible for the mitigation or amplification of the informative sensitization.

The last methodological limitation concerns the choice of a relatively low power level in the sample size planning. This was a deliberate choice, but it came with some disadvantages. A first disadvantage is the elevated risk of obtaining a statistically nonsignificant result even if the assumed effect exists. In consequence, a failure to reject the null hypothesis does not strongly suggest that the effect is absent because of a possibly underpowered statistical test. In addition, when a priori power is low, even when statistical significance is achieved, the estimated effect size may be upwardly biased because only unusually strong sample results that pass the nominal significance threshold are included. In consequence, a missing effect does not necessarily imply a lack of effectiveness of the epistemological sensitization. However, the effect sizes of the statistically significant effects may be exaggerated, implying that the true effect of sensitization is smaller than indicated in the current sample. Overall, these considerations suggest, on the one hand, not to overinterpret a non-statistical result as indicating that sensitization is not apt to change epistemological beliefs, but, on the other hand, that the resulting epistemological changes may be smaller than indicated by the results.

Apart from such methodological limitations, the sensitization text's difficulty is a substantial limitation, expressed by the rather low Flesch indices. Thus, the text may have been hard to understand for the participants, especially since they were mostly in the early phases of their studies and, therefore, had a possible lack of sufficient methodological prior knowledge. From this perspective, the text difficulty may have caused the observed small or non-existent effects. The text difficulty may also have played a role in the observation that there are participants with extraordinarily short reading times. Possibly, these participants simply opted to go to the next site to continue the experiment after becoming aware of the high text difficulty. Thus, the difficult intervention text may have caused motivational problems, which, in turn, may have diminished the participants' reading efforts so that no epistemological doubt arose to induce epistemological change. However, an analysis of two random text samples with comparable mean word count to the intervention texts indicated Flesch indices of 41 (text sample from Becker-Carus & Wendt, 2017) and 23 (text sample from Asendorpf & Neyer, 2012). Thus, the intervention texts fall within the range of difficulty that the typical student is used to reading.

Lastly, the results so far only refer to the domain of psychology. The focus on psychology resulted from the reference to Klopp and Stark (2022b), who also related their sensitization intervention to psychology. However, this focus limits the generalizability of the results. Since many of the effects seem to depend on the presentation of a domain's epistemological features and their contextual embedding, against the background that epistemological beliefs are domain-specific, a systematic consideration of other domains is justified. In particular, not all domains share the ill-defined knowledge structure of psychology, e.g., information science and mathematics (Klopp & Stark, 2022b; Rosman et al., 2017).

## 8. Conclusions

Taken together, there is only slight evidence for the hypothesized effects of the epistemological sensitizations, and there is more evidence for unwanted backfire effects. Thus, epistemological sensitizations as short interventions seem to have the potential to alter the domain-specific epistemological beliefs but not as indicated by the theoretical expectations. In particular, the conditions under which an epistemological sensitization provides the desired reduction in absolutism and multiplicism and fosters evaluativism must be investi-

gated. However, there may be no "one-size-fits-all solution," i.e., no type of sensitization that simultaneously reduces absolutism and multiplicism (cf., Klopp & Stark, 2022a). This is further complicated because all the effects differ between the various methods to assess epistemological beliefs.

In consequence, before the effects of an epistemological sensitization are thoroughly investigated, it should not be used in combination with other epistemological change interventions, e.g., as in Klopp and Stark (2022b), to avoid confounding effects of both interventions. Alternatively, the experimental design should be constructed in such a way that the effects can be clearly separated.

From an educational perspective, the epistemological sensitization as applied in this study is not apt to serve as a handy tool to change epistemological beliefs in the desired direction. Given the evidence for possible backfire effects due to the design of such an intervention, there is the risk of fostering either absolutist or multiplicist beliefs. Additionally, the current results refer only to the domain of psychology, so there is no evidence for the possible effectiveness of epistemological sensitization in other domains.

**Author Contributions:** E.K.: Project administration, conceptualization, investigation, data curation, methodology, formal analysis, resources, software, supervision, visualization, writing—original draft, writing—review & editing. J.G.: Conceptualization, investigation, data curation, methodology, formal analysis, writing—original draft. R.S.: Project administration, conceptualization, resources, validation, supervision, writing—original draft. All authors have read and agreed to the published version of the manuscript.

**Funding:** This research received no funding. We acknowledge support by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) and Saarland University within the funding program Open Access Publishing.

**Institutional Review Board Statement:** The study was conducted in accordance with the ethical guidelines of the German Psychological Association. No institutional approval was necessary in accordance with local law and departmental requirements.

**Informed Consent Statement:** Written informed consent was obtained from all subjects involved in the study.

**Data Availability Statement:** The data presented in this study are available on request from the corresponding author due to data protection issues.

**Conflicts of Interest:** The authors declare no conflicts of interest.

## Notes

[1] In alignment with Klopp and Stark (2022b), we opted to use the term epistemological beliefs, notwithstanding the frequent usage of the term epistemic beliefs. As mentioned by these authors, a lexical perspective suggests that the term epistemological pertains to the theoretical framework of knowledge, particularly its methodology, validity, and breadth. In contrast, the term epistemic is associated with the extent to which knowledge is validated. Richter and Schmid (2010) advocate the limitation of the term epistemic to cognitive processes that pertain specifically to the validation of knowledge, such as epistemic strategies. However, as this study does not aim at cognitive processes but instead at measures that assess an individual's personal framework regarding knowledge and the mechanisms of knowledge acquisition (cf., Hofer & Pintrich, 1997) in terms of interindividual differences (cf., Hammer & Elby, 2002, pp. 171–173), we favor the term epistemological beliefs. Additionally, again following Klopp and Stark (2022b), we utilize the term epistemological beliefs as an overarching term for the various concepts referenced in this study, such as epistemological understanding (Kuhn, 2001), epistemological position (Weinstock, 2006), or epistemic thinking (Barzilai & Weinstock, 2015).

## References


Asendorpf, J. B., & Neyer, F. (2012). *Psychologie der persönlichkeit* [Personality psychology]. Springer. [CrossRef]

Barzilai, S., & Weinstock, M. (2015). Measuring epistemic thinking within and across topics: A scenario-based approach. *Contemporary Educational Psychology*, *42*, 141–158. [CrossRef]

Becker-Carus, C., & Wendt, M. (2017). *Allgemeine psychologie: Eine einführung* [General psychology: An introduction]. Springer. [CrossRef]

Bendixen, L. D. (2002). A process model of epistemic belief change. In B. K. Hofer, & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 191–208). Lawrence Erlbaum.

Bendixen, L. D., & Rule, D. C. (2004). An integrative approach to personal epistemology: A guiding model. *Educational Psychologist*, *39*, 69–80. [CrossRef] [PubMed]

Braitman, A. L., Strowger, M., Shipley, J. L., Ortman, J., MacIntyre, R. I., & Bauer, E. A. (2022). Data quality and study compliance among college students across 2 recruitment sources: Two study investigation. *Journal of Medical Internet Research: Formative Research*, *6*(12), e39488. [CrossRef] [PubMed]

Champely, S. (2020). *pwr: Basic functions for power analysis*, R package version 1.3-0. Available online: https://cran.r-project.org/package=pwr (accessed on 1 February 2026).

Deci, E. L., & Ryan, R. M. (2012). Motivation, personality, and development within embedded social contexts: An overview of self-determination theory. In R. M. Ryan (Ed.), *Oxford handbook of human motivation* (pp. 85–107). Oxford University Press. [CrossRef]

Festinger, L. (1957). *A theory of cognitive dissonance*. Stanford University Press. [CrossRef]

Finney, C., & DiStefano, C. (2013). Nonnormal and categorical data in structural equation modeling. In G. R. Hancock, & R. O. Mueller (Eds.), *Structural equation modeling—A second course* (pp. 439–492). Information Age Publishing. [CrossRef]

Fischer, F., Kollar, I., Ufer, S., Sodian, B., Hussmann, H., Pekrun, R., Neuhaus, B., Dorner, B., Pankofer, S., Fischer, M., Strijbos, J. W., Heene, M., & Eberle, J. (2014). Scientific reasoning and argumentation: Advancing an interdisciplinary research agenda in education. *Frontline Learning Research*, *4*, 28–45. [CrossRef]

German Federal Statistical Office. (2020). *Studierende an hochschulen: Wintersemester 2019/2020 (Fachserie 11, reihe 4.1)* [Students at higher education institutions: Winter term 2019/2020 (Specialized series 11, series 4.1)]. Wiesbaden.

German Federal Statistical Office. (2024). *Bildung, forschung und kultur. Statistik der studierenden—Wintersemester 2023/2024* [Education, research, and culture—Student statistics]. Wiesbaden.

Hammer, D., & Elby, A. (2002). On the form of a personal epistemology. In B. K. Hofer, & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 169–190). Lawrence Earlbaum.

Hofer, B. K., & Bendixen, L. D. (2012). Personal epistemology: Theory, research, and future directions. In K. Harris (Ed.), *Handbook of educational psychology* (pp. 225–254). American Psychological Association. [CrossRef]

Hofer, B. K., & Pintrich, P. R. (1997). The development of epistemological theories: Beliefs about knowledge and knowing and their relation to learning. *Review of Educational Research*, *67*, 88–140. [CrossRef]

Kerwer, M., & Rosman, T. (2018). Mechanisms of epistemic change—Under which circumstances does diverging information support epistemic development? *Frontiers in Psychology*, *9*, 1060. [CrossRef] [PubMed]

Kienhues, D., Bromme, R., & Stahl, E. (2008). Changing epistemological beliefs: The unexpected impact of a short-term intervention. *British Journal of Educational Psychology*, *78*(4), 545–565. [CrossRef] [PubMed]

Klopp, E., Krause-Wichmann, T., & Stark, R. (2023). Profiles of epistemological beliefs, knowledge about explanation norms, and explanation skills: Changes after an intervention. *Frontiers in Psychology*, *14*, 1178129. [CrossRef] [PubMed]

Klopp, E., & Stark, R. (2016). Persönliche epistemologien—Elemente wissenschaftlicher kompetenz. In A.-K. Mayer, & T. Rosman (Eds.), *Denken über wissen und wissenschaft: Epistemologische überzeugungen als gegenstand psychologischer forschung* (pp. 39–69). Pabst Science Publishers.

Klopp, E., & Stark, R. (2022a). How to change epistemological beliefs? Effects of scientific controversies, epistemological sensitization, and critical thinking instructions on epistemological change. *Education Sciences*, *12*, 499. [CrossRef]

Klopp, E., & Stark, R. (2022b). Scientific controversies and epistemological sensitization—Effects of an intervention on psychology students' epistemological beliefs and argumentation skills. *Frontiers in Education*, *6*, 785241. [CrossRef]

Krapp, A. (1999). Interest, motivation and learning: An educational-psychological perspective. *European Journal of the Psychology of Education*, *14*, 23–40. [CrossRef]

Kuhn, D. (2001). How do people know? *Psychological Science*, *12*(1), 1–8. [CrossRef] [PubMed]

Kyriazos, T. A. (2018). Applied psychometrics: Sample size and sample power considerations in factor analysis (EFA, CFA) and SEM in general. *Psychology*, *9*, 2207–2230. [CrossRef]

McArdle, J. J. (2009). Latent variable modeling of differences and changes with longitudinal data. *Annual Review of Psychology*, *60*, 577–605. [CrossRef] [PubMed]

McGonagle, A. (2015). Participant motivation: A critical consideration. *Industrial and Organizational Psychology*, *8*, 208–214. [CrossRef]

Peter, J., Rosman, T., Mayer, A.-K., Leichner, N., & Krampen, G. (2016). Assessing epistemic sophistication by considering domain-specific absolute and multiplicistic beliefs separately. *British Journal of Educational Psychology*, *86*(2), 204–221. [CrossRef] [PubMed]

Porsch, T., & Bromme, R. (2011). Effects of epistemological sensitization on source choices. *Instructional Science*, *39*(6), 805–819. [CrossRef]

R Core Team. (2020). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing.

Revelle, W. (2016). *psych: Procedures for personality and psychological research*. Northwestern University. [CrossRef]

Richter, T., & Schmid, S. (2010). Epistemological beliefs and epistemic strategies in self-regulated learning. *Metacognition and Learning*, *5*, 47–65. [CrossRef]

Rosman, T., Mayer, A.-K., Kerwer, M., & Krampen, G. (2017). The differential development of epistemic beliefs in psychology and computer science students: A four-wave longitudinal study. *Learning and Instruction*, *49*, 166–177. [CrossRef]

Rosman, T., Mayer, A.-K., Peter, J., & Krampen, G. (2016). Need for cognitive closure may impede the effectiveness of epistemic belief instruction. *Learning and Individual Differences*, *49*, 406–413. [CrossRef]

Rosseel, Y. (2012). lavaan: An R package for structural equation modeling. *Journal of Statistical Software*, *48*(2), 1–36. [CrossRef]

Schiefer, J., Edelsbrunner, P. A., Bernholt, A., Kampa, N., & Nehring, A. (2022). Epistemic beliefs in science—A systematic integration of evidence from multiple studies. *Educational Psychology Review*, *34*, 1541–1575. [CrossRef] [PubMed]

Vansteenkiste, M., Simons, J., Lens, W., Sheldon, K., & Deci, E. (2004). Motivating learning, performance, and persistence: The synergistic effects of intrinsic goal contents and autonomy-supportive contexts. *Journal of Personality and Social Psychology*, *87*, 246–260. [CrossRef] [PubMed]

Weinstock, M. P. (2006). Psychological research and the epistemological approach to argumentation. *Informal Logic*, *26*(1), 103–120. [CrossRef]