# Mechanisms of epistemic change – Exploring the role of (non-)resolvable diverging information in epistemic change

Martin Kerwer*[1], and Tom Rosman[1]

[1]Leibniz Institute for Psychology Information

The structure of this protocol is based on the template of the OSF's preregistration challenge (https://cos.io/prereg/).

**Introduction**

Research on how to influence individuals' (and especially higher education students') epistemic beliefs (i.e., beliefs about the nature of knowledge and knowing) is thriving because these beliefs have been shown to affect how individuals acquire and evaluate knowledge. While simpler belief types like absolutism (i.e., a view that knowledge claims are either true or false) and multiplism (i.e., a view that knowledge claims consist of purely subjective "opinions") impair learning and information processing (Kardash & Howell, 2000; Rosman, Peter, Mayer, & Krampen, 2016), evaluativism – defined as a belief that the relative "correctness" of knowledge claims varies depending on their argumentative quality, evidence, and context – has positive effects on such outcomes (Barzilai & Zohar, 2012).

Out of a growing body of research, presenting diverging information (i.e., conflicting knowledge claims) emerged as an especially promising method for promoting epistemic change (Kienhues, Ferguson, & Stahl, 2016). Based on this finding, Rosman and colleagues (Rosman & Mayer, 2018; Rosman, Mayer, Peter, & Krampen, 2016) developed 18 conflicting texts (around 50-90 words each) on a socio-scientific issue (gender stereotyping and discrimination in schools) to promote epistemic change. As described in previous studies (e.g., Rosman & Mayer, 2018) on this so-called 'resolvable controversies' intervention, apparent contradictions in these texts can be resolved (or integrated) by identifying the contextual factors that a certain type of discrimination (favoring either boys or girls) occurs in. For example, some texts include cues relating to the contextual factor 'subject matter'. Identifying this factor allows students to derive that girls are more likely to be discriminated against in natural sciences (e.g., physics), whereas boys are more often discriminated against in languages and literature (e.g., German language education). In the second part of this intervention, students are required to resolve the apparent contradictions in a writing task.

**Research Questions**

Although the resolvable controversies intervention's overall efficacy is well established, recent results by Kerwer and Rosman (in press), who scrutinized its theoretical underpinnings, are ambiguous. In this study, we tested the intervention's assumptions by introducing control

conditions that presented (1) presumably non-conflicting evidence or (2) unresolvable conflicts.

To our surprise, advanced epistemic beliefs prospered when subjects received non-resolvable information on gender stereotyping, and also when they worked on a control task (non-conflicting information on learning strategies). We discuss several issues in the design of the intervention materials as possible explanations for these unexpected findings in the corresponding article (Kerwer & Rosman, in press). In the present study, we will empirically address these issues and test if our initially proposed hypotheses (see below) hold true if they are resolved. More specifically, we will:

- Revise the 'unresolvable task': Possibly, subjects found an alternative way to integrate conflicting findings in our prior study because gender stereotyping was not completely at random. Therefore, we revised our materials in order to make them even more conflicting or unresolvable in this study.
- Revise the 'learning strategies task': Subjects in the control group might have interpreted the information on learning strategies as conflicting diverging information because of the way they were presented in Kerwer and Rosman (in press). Thus, we reduced their contradictoriness by presenting them separately (and not in pairs) and by modifying adjunct questions.
- Test if effects are replicable in a different sample: In Kerwer and Rosman (in press), we included only psychology students (as our materials are tailored to the domain of psychology). Now we want to test if our results are replicable in a sample of university students of all disciplines.
- Perform subgroup analyses on the role of prior beliefs. Analyzing the role that prior beliefs play in epistemic change (depending on the instruction subjects received) is an intriguing task for improving our understanding of epistemic change. Descriptively, some interesting differences emerged in our previous study, but failed to reach significance (likely because cell sizes were too small). In the present study, we want to further examine this issue by recruiting a larger sample allowing for meaningful multi-group analyses on the interaction between prior beliefs and intervention efficacy.

**Hypotheses**

H1. Epistemic belief change can be induced by text-based interventions that use resolvable controversies.

More specifically, we expect the following differences between the experimental conditions:

- H1a. Reading multiple texts presenting conflicting scientific evidence will induce epistemic change towards advanced beliefs whereas reading texts on students employing different learning strategies will not induce epistemic change towards advanced beliefs.
- H1b. Advanced beliefs will increase if the conflicts between the texts may be resolved by identifying moderator variables ('resolvable controversies') compared to a condition including texts in which the conflicts cannot be resolved.

H2. Change towards advanced beliefs will be more pronounced for subjects whose beliefs were naïve prior to the intervention when compared to subjects who already held advanced beliefs.

## Sampling Plan

### *Data collection procedures*

Participants will be recruited through an external panel service (e.g., respondi) while data collection will be performed online using the survey software Unipark with a script built by the authors.

Pre-intervention measurements, the intervention and post-intervention measurements will take place at the same measurement occasion for each participant. Participants can complete the data collection independently (without instructor) using their own device (smartphone, tablet, computer, etc.).

The following eligibility criteria apply to our sample:

- Only students that are currently enrolled at a German university are eligible for study participation.
- Participants have to be German native speakers.

Moreover, the panel service will be instructed to obtain a sample whose gender distribution corresponds to the gender distribution at German universities.

### *Target Sample Size and Sample Size Calculation*

In our study, power issues are more likely to occur for H2 (when compared to H1), as H2 focuses on differences between treatment groups in epistemic change. To circumvent power issues, we will recruit at least 50 subjects for each of the 9 ‘cells’ of this multi-group design (high/medium/low prior beliefs crossed with treatment group with three levels) resulting in 450 subjects. Thus, we will attempt to recruit up to $N$ =501 participants ($n$ = 167) to control for dropouts and varying distributions in prior beliefs over the treatment groups.

Concerning H1, the estimated power is above 97.50% for this sample size – even if we assume that our effect size will be lower (e.g., due to a reduced intervention efficacy in an online setting) as in our recent study (Cohen’s $f$ = .094 in Kerwer and Rosman (in press)). More precisely, our specification in GPower (Faul, Erdfelder, Buchner, & Lang, 2009) was $r$ = .66 (based on Kerwer and Rosman [in press]), $\alpha$ = .05, $f$ = .08 in a pre-post-design with three groups.

## Variables

### *Manipulated variables*

Participants will be randomly assigned to an intervention condition after pretesting. These intervention conditions or 'groups' differ on the kind of intervention that participants receive. Thus, the independent variable ‘group’ is a between-participants variable with three levels that are described below:

- Resolvable: Group 1 reads resolvable controversies (same materials that were used by Kerwer and Rosman (in press) but in an online format).
- Unresolvable: Group 2 reads conflicting materials which cannot be resolved by identifying moderator variables (i.e., a modified version of the conflicting materials that were used by Kerwer and Rosman (in press)),

- Control (learning strategies): Group 3 reads non-conflicting texts on students employing different learning strategies (i.e., a modified version of the learning strategies task used by Kerwer and Rosman (in press)).

***Dependent variables***
The *topic-specific epistemic beliefs questionnaire* (FREE-GST) begins with the presentation of three controversial positions on the nature and extent of gender-stereotype discrimination in secondary schools. Subsequently, 15 statements that relate to either absolute, multiplistic, or evaluativistic beliefs regarding the controversy are to be rated on a 6-point Likert scale.

The *domain-general epistemic beliefs questionnaire* (FREE, Krettenauer, 2005) introduces twelve controversial issues from varying domains of knowledge (e.g., different interpretations of Holy Scripture) and for each issue three statements that relate to either absolute, multiplistic or evaluativistic beliefs are to be rated on a 6-point Likert scale. Additionally, subjects choose which statement fits their own beliefs best.

***Manipulation check***
To evaluate whether subjects realized that controversies existed and were resolvable (in the resolvable controversies group when compared to the other groups), a self-report measure on the spontaneous integration of conflicting information will be administered.

***Covariates***
Demographical variables (age, sex, study subject, study semester), epistemic emotions (Pekrun, Vogl, Muis, & Sinatra, 2017), as well as self-reported perceived contradictoriness of presented information and deliberate integration efforts will be assessed.

***Indices***
Absolutism, multiplism and evaluativism scores will be computed as mean scores of the respective items for the FREE (Krettenauer, 2005) and the FREE-GST, exactly as has been done in prior research (e.g., Rosman & Mayer, 2018). Primary outcome will be the D-Index which aggregates advanced beliefs (Krettenauer, 2005) and is computed as *2*Evaluativism – (Absolutism + Multiplism)*.

Epistemic change will be operationalized as a latent change score.

**Design Plan**

***Study type***
Experiment - A researcher randomly assigns treatments to study subjects, this includes field or lab experiments. This is also known as an intervention experiment and includes randomized controlled trials.

***Blinding***
Subjects will not know the treatment group to which they have been assigned.

***Study design***
We will use a 3x2 pre-post design with 1 within-subjects factor (repeated measurement factor with two levels) and 1 between-subjects factor (intervention type with 3 levels). Hypothesis 2 will be tested by splitting the prior belief variables into three groups (high/medium/low) after data collection.

***Randomization***
Simple randomized assignment of participants to treatment conditions will be carried out using the respective function of the survey software Unipark.

**Analysis Plan**

***Statistical models***
We will use latent difference score modeling (McArdle, 2009) to analyze our data. Dependent variables are change in epistemic beliefs (FREE-GST, FREE) and independent variables are dummy coded intervention group variables.

One combined analysis of epistemic change will be conducted for H1 (one latent change model for the D-Index of the FREE-GST and FREE, respectively).

In order to test H2, multi-group latent difference score analyses will be conducted separately for the FREE-GST and FREE because the 'groups' (i.e., tertiles on outcome variables prior to the intervention) need to be generated for each outcome individually. Otherwise, these models correspond to the latent change model used for H1. Thus, two target models exist for H2.

***Transformations***
Intervention group will be dummy coded with group 3 ('learning strategies') as reference category.

We will create a prior beliefs variable for multiple group analyses by dividing subjects into three groups based on the tertiles to which their pre-intervention scores of the respective outcome variable belonged. Tertiles will be computed across and not within intervention groups.

Pre- and post-intervention measures of outcome variables will be standardized using their pre-intervention mean and standard deviation.

***Inference criteria***
We will use the standard $p < .05$ criterion for determining if the estimated effects of (dummy coded) intervention group variables are significantly different from those expected if the null hypothesis were correct. In order to further investigate group differences, which are not related to the reference group, we will define these effects as new model parameters (H1). For multi-group models, we will test if intervention effects differ significantly between sub-groups based on their confidence intervals (H2).

***Data exclusion***
Analyses will be performed without univariate outliers (based on $z$-scores; criterion: $p(z) < .001$).

***Missing data***
Full information maximum likelihood estimation, as provided by the lavaan package, will be used if the missing mechanism can be regarded as missing at random or missing completely at random.

## References

Barzilai, S., & Zohar, A. (2012). Epistemic thinking in action: Evaluating and integrating online sources. *Cognition and Instruction*, *30*(1), 39–85. https://doi.org/10.1080/07370008.2011.636495

Faul, F., Erdfelder, E., Buchner, A., & Lang, A.-G. (2009). Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods*, *41*(4), 1149–1160. https://doi.org/10.3758/BRM.41.4.1149

Kardash, C. M., & Howell, K. L. (2000). Effects of epistemological beliefs and topic-specific beliefs on undergraduates' cognitive and strategic processing of dual-positional text. *Journal of Educational Psychology*, *92*(3), 524–535. https://doi.org/10.1037//0022-0663.92.3.524

Kerwer, M., & Rosman, T. (in press). Mechanisms of Epistemic Change – Under which circumstances does diverging information support epistemic development? *Frontiers in Psychology.* Advance online publication. https://doi.org/10.3389/fpsyg.2018.02278

Kienhues, D., Ferguson, L. E., & Stahl, E. (2016). Diverging information and epistemic change. In J. A. Greene, W. A. Sandoval, & I. Bråten (Eds.), *Handbook of epistemic cognition* (pp. 318–330). London: Routledge.

Krettenauer, T. (2005). Die Erfassung des Entwicklungsniveaus epistemologischer Überzeugungen und das Problem der Übertragbarkeit von Interviewverfahren in standardisierte Fragebogenmethoden [Measuring the developmental level of epistemological beliefs and the problem of transfering interview procedures to standardized questionnaire methods]. *Zeitschrift Für Entwicklungspsychologie Und Pädagogische Psychologie*, *37*(2), 69–79. https://doi.org/10.1026/0049-8637.37.2.69

McArdle, J. J. (2009). Latent variable modeling of differences and changes with longitudinal data. *Annual Review of Psychology*, *60*, 577–605. https://doi.org/10.1146/annurev.psych.60.110707.163612

Pekrun, R., Vogl, E., Muis, K. R., & Sinatra, G. M. (2017). Measuring emotions during epistemic activities: The Epistemically-Related Emotion Scales. *Cognition & Emotion*, *31*(6), 1268–1276. https://doi.org/10.1080/02699931.2016.1204989

Rosman, T., & Mayer, A.-K. (2018). Epistemic beliefs as predictors of epistemic emotions: Extending a theoretical model. *British Journal of Educational Psychology*, *88*(3), 410–427. https://doi.org/10.1111/bjep.12191

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. https://doi.org/10.1016/j.lindif.2016.05.017

Rosman, T., Peter, J., Mayer, A.-K., & Krampen, G. (2016). Conceptions of scientific knowledge influence learning of academic skills: Epistemic beliefs and the efficacy of information literacy instruction. *Studies in Higher Education*, *43*(1), 96–113. https://doi.org/10.1080/03075079.2016.1156666