Editor’s Choice

Disentangling the process of epistemic change: The role of epistemic volition

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Background. Many interventions on epistemic beliefs (i.e., individual beliefs about knowledge and knowing) are based on Bendixen and Rule’s Integrative Model for Personal Epistemology Development. Empirically, however, the model is still insufficiently validated. This is especially true for its epistemic volition component – a will or desire to actively change one’s beliefs.

Aims. To experimentally scrutinize the role of epistemic volition, we investigated (incremental) effects on epistemic change of an epistemic volition intervention.

Sample. 412 psychology students enrolled at German universities completed the study.

Methods. We employed a randomized pre–post design with three experimental groups that differed in the administered epistemic volition and resolvable controversies interventions. The purpose of the latter was to initiate an epistemic change process, thereby laying the foundation for the epistemic volition intervention. Both data collection and interventions were conducted online. In addition to self-report measures, we applied a complementary source evaluation task to analyse epistemic change.

Results. Even though we found small- to medium-sized changes in epistemic beliefs, these changes did not differ between experimental conditions. Exploratory analyses suggested, however, that source evaluation task performance might have been promoted by the epistemic volition intervention and that – across experimental groups – manipulation check measures on both interventions interacted positively.

Conclusion. Ultimately, we failed to separate the effects that our epistemic volition intervention had on epistemic change from these of the resolvable controversies intervention. Nonetheless, our study makes some strong contributions to – and interconnects – the growing bodies of research on epistemic change and multiple source use.

Introduction

A growing body of research suggests that individual epistemic beliefs (i.e., beliefs about the nature of knowledge and knowing) influence learning and knowledge acquisition (cf. Hofer, 2016; Hofer & Bendixen, 2012). Moreover, the impact these beliefs have on...
everyday life will likely further increase in knowledge-based societies (Sinatra, Kienhues, & Hofer, 2014), as prior research has revealed their relevance for processing and extracting knowledge from the Internet (cf. Strømsø & Kammerer, 2016) or dealing with textual sources in general (Braten, Strømsø, & Ferguson, 2016). In particular, research on the intertwined relationship between multiple source use and mental processes related to epistemic beliefs (i.e., epistemic cognition) has proven to be very fruitful in the last decades (see Barzilai and Strømsø (2018) and Braten, Britt, Strømsø, and Rouet (2011) for a review on how epistemic cognition affects multiple source use, but also Kienhues, Ferguson, and Stahl (2016) on how multiple source use in turn influences epistemic cognition). In accordance with these findings, Greene, Cartiff, and Duke (2018) showed in a recent meta-analysis that advanced epistemic beliefs and academic achievement are interrelated.

We concede that the normative conceptualization of ‘advanced’ or ‘sophisticated’ beliefs is an ongoing issue that has not yet been fully resolved. We argue, however, that the design of interventions requires a certain amount of normativity – if we do not know which intervention goal we should actually aim for, the whole task of designing an intervention becomes futile. Nonetheless, it depends on many context-specific aspects which kind of belief best fits situational needs (e.g., Chinn, Buckland, & Samarapungavan, 2011; Elby & Hammer, 2001). Since the lack of such a contextually adaptive view is exactly what most ‘traditional’ approaches (e.g., Hofer & Pintrich, 1997) have been criticized for, we chose Kuhn, Cheney and Weinstock’s (2000) framework as a normative underpinning of our efforts. In their model, Kuhn et al. (2000) characterized epistemic beliefs along developmental levels that entail different views on assertions, reality, knowledge and critical thinking. More specifically, individuals are thought to start as absolutists, believing that an objective truth exists and is knowable, continue to multiplicism, characterized by a view of knowledge claims as mere ‘opinions’, and – at least some – end up as evaluativists who integrate both perspectives (Kuhn et al., 2000; Peter, Rosman, Mayer, Leichner, & Krampen, 2016). Despite its age, this framework is still very state of the art since it suggests a contextually adaptive view on knowledge and knowing – evaluativism – as the most advanced belief type – and thus explicitly addresses many of the problems that have been outlined in the ‘naïve-sophisticated’ debate.

**The integrative model for personal epistemology development**

As the benefits of advanced epistemic beliefs have become increasingly apparent, research programmes attempting to induce epistemic change are on the rise (Barzilai & Chinn, 2018; Muis, Trevors, & Chevrier, 2016). Up to now, the vast majority of epistemic change interventions (e.g., Kienhues, Bromme, & Stahl, 2008) has been based on the Integrative Model for Personal Epistemology Development (Bendixen & Rule, 2004), which breaks down the epistemic change process into three sequential components – epistemic doubt, epistemic volition, and resolution strategies. In their model, *epistemic doubt* describes a cognitive dissonance that is expressed by ‘questioning one’s beliefs about knowledge and knowing’ (Rule & Bendixen, 2010, p. 99), while Ferguson and colleagues defined *epistemic volition* as a ‘will or a desire to resolve [epistemic] doubt and reduce the cognitive dissonance created by the challenging and ill-structured problem space’ (2012, p. 111). According to the model, epistemic volition enables individuals to be aware of their own epistemic beliefs (and of their epistemic doubt), which should lead to goal-directed behaviour when facing information that is misaligned to their current beliefs (Rule & Bendixen, 2010). To actually resolve the dissonance that caused epistemic doubt, individuals are thought to apply resolution strategies, with *social interaction* and
reflection being most frequently mentioned (Bendixen, 2016; Bendixen & Rule, 2004; Rule & Bendixen, 2010). However, since the model suggests that all three process components are part of a higher order mechanism of change, none of them may guarantee epistemic change on its own (Rule & Bendixen, 2010). For example, according to the model, no change should occur without epistemic doubt as it is seen as the impetus for change. Epistemic volition, in turn, should be required to initiate the change process when facing epistemic doubt. Figure 1 briefly illustrates the model based on a fictitious example.

Even though Bendixen and Rule’s (2004) model seems plausible and has proven to be fruitful in qualitative studies for analysing epistemic change (e.g., Lahtinen & Pehkonen, 2013), empirical evidence substantiating its postulated mechanisms of change is scarce. Regarding the epistemic doubt, several studies evoked epistemic change through the presentation of diverging information (conflicting knowledge claims) – probably by creating a dissonance (Kienhues et al., 2016). This indirectly corroborates the role of epistemic doubt as a driving force of epistemic development. Moreover, recent research started to address at least one resolution strategy, reflection, similar to the conception of Bendixen and Rule’s (2004) model – albeit under the name of reflexivity (see Feucht, Lunn Brownlee, & Schraw, 2017; Lunn Brownlee, Ferguson, & Ryan, 2017), and in prior studies, explicit reflection promoted epistemic change (see Lunn Brownlee, Schraw, Walker, & Ryan, 2016). Ferguson et al. (2012) also found evidence for epistemic doubt and for reflection using think-aloud protocols but – like Bendixen (2002) – not for epistemic volition.1 As a consequence, calls to further inspect Bendixen and Rule’s (2004) model

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**Figure 1.** Case study Julia. Exemplary case study (grey boxes) of a psychology student whose epistemic beliefs develop according to Bendixen and Rule’s (2004) Integrative Model for Personal Epistemology Development from absolute to multiplicitic beliefs. Further information on specific process components (blue boxes) is based on Bendixen and Rule’s (2004) model. [Colour figure can be viewed at wileyonlinelibrary.com]

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1 But see also Hofer and Bendixen (2012) for evidence connecting epistemic volition to learning outcomes.
have become louder (e.g., Braten, 2016; Ferguson et al., 2012), and we see this as especially true for the volition component.

The current study
In the present study, we will heed this call by scrutinizing the role of epistemic volition for epistemic change. To investigate its effects on epistemic change, we designed an intervention that explicitly targets epistemic volition, which, together with an epistemic doubt intervention, allows to single out the effects of these two components of Bendixen and Rule’s (2004) model.

Epistemic volition intervention
In the various works on epistemic volition, it remained unclear whether epistemic volition was thought to be purely volitional or to also encompass motivational aspects. We tend to assume that the concept of epistemic volition pertains to both volitional and motivational processes. In fact, motivation is generally seen as a precursor of volition (e.g., Heckhausen & Gollwitzer, 1987); individuals who are not motivated to resolve their epistemic doubt (motivational component) will not think about how and when to act in order to do so (volitional component). As a consequence, our epistemic volition intervention has to target both the motivational component and the volitional component of epistemic volition.

When introducing their model, Bendixen and Rule repeatedly (2004; Rule & Bendixen, 2010) referred to research on (intentional) conceptual change (see Sinatra & Pintrich, 2003) and Corno’s (1993) work on how to promote volition as theoretical foundations for understanding epistemic volition. Thus, in addition to Bendixen and Rule’s (2004) model, we drew upon these frameworks – and their applications to epistemic change (e.g., Sinatra & Chinn, 2012) – when designing our epistemic volition intervention. For instance, Rule and Bendixen (2010) argued that recognizing a discrepancy between actual and target state is a crucial prerequisite for epistemic volition, which is why it is important to convince students that their beliefs are not fully developed yet. Moreover, the model posits that taking charge of one’s own beliefs is a central component of epistemic volition (Rule & Bendixen, 2010), which also implies fostering self-efficacy for epistemic change. Finally, change in (epistemic) beliefs should also depend on the personal relevance of those beliefs (Bendixen & Rule, 2004; Dole & Sinatra, 1998). Thus, when designing interventions in a higher education setting, one might highlight study-related benefits of advanced epistemic beliefs, both on a cognitive level (more advanced beliefs have positive effects on learning; Greene et al., 2018) and on an affective level (more advanced beliefs lead to less frustration when dealing with inconsistent and contradictory findings; Rosman & Mayer, 2018). Based on these considerations, our intervention is structured as follows (more details and examples are provided in Table 1).

Introduction. In the first intervention component, students are given a written definition of epistemic beliefs and a short summary on the cognitive and affective benefits of more advanced epistemic beliefs. The goal of this component is to raise students' awareness for the concept in question and to lay the groundwork for the other components.
| Component                        | Content                                    | Example/Excerpt                                                                                                                                                                                                 |
|----------------------------------|--------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Introduction                     | Concept introduction (100 words)           | [...] In the course of your studies, you certainly noticed that conflicting findings and theories exist in psychological research. [...] Educational research revealed that so-called epistemic beliefs are vital when dealing with such inconsistencies. Epistemic beliefs are [...] |
| Exemplify benefits (110 words)   |                                             | [...] Advanced epistemic beliefs have been shown to support individuals in dealing with ostensibly ill-structured knowledge domains, such as psychology, and in regulating their knowledge acquisition. [...] |
| Monitoring of learning results    |                                             | Advanced epistemic beliefs... • facilitate knowledge acquisition. [right] • increase memory capacity. [wrong] • [...] |
|                                  | (multiple-choice task)                     |                                                                                       |
| Awareness                        | 3 problems (60 to 100 words)               | There is still some debate in developmental psychology on whether childhood development is predetermined by genetic factors or due to environmental influences. Three students are preparing a presentation on this issue and are therefore debating on these conflicting findings in order to phrase their take-home message: [...] |
| 3 case studies for each problem   |                                             | Armin [...] is strongly convinced that the controversy will be ultimately resolved. In a few years’ time, research will hopefully be able to draw on better methods and reveal what is right and what is wrong. [...] |
| illustrating absolute, multiplistic, and evaluativistic views (70 to 100 words) | [Case Study Absolutism]                     |                                                                                       |
| 5 Items for each case study       |                                             | Armin’s view on knowledge in psychology... • facilitates Armin’s acquisition of psychological knowledge. • is common among psychological researchers. • is helpful for the advancement of psychological science. • corresponds to my personal opinion. • corresponds to the opinion of my lecturers. |
| (6-point Likert scale on agreement)|                                             |                                                                                       |
| Component          | Content                                                                 | Example/Excerpt                                                                                                                                 |
|--------------------|-------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------|
| Fictitious feedback| Illustration of discrepancies between actual and target beliefs (50 words) | We evaluated the data you provided so far (today and during the first measurement) in order to give you feedback on the current developmental level of your epistemic beliefs. The personalised result for code X is: You achieved a z-standardised index score of 0.026. The developmental level of your epistemic beliefs is therefore just about average. [...] |
| Self-efficacy      | Fictitious change prognosis (50 words)                                  | Based on your previous answers, we also computed a change prediction. The personalised result for code X is: Your developmental prospects are very good. [...] |
|                    | Presentation of encouraging findings (80 words)                         | Scientists working on epistemic change assume that...                                                                                                                                                     |
|                    |                                                                         | • ...epistemic cognitions usually change slowly,                                                                                                                                                            |
|                    |                                                                         | • ...but can also change in shorter periods of time when learners are confronted with complex problems (Ferguson et al., 2012; King & Kitchener 2002).                  |
|                    |                                                                         | • [...]                                                                                                                                                                                                   |
| Goal striving      | Setting of implementation intentions for the resolvable controversies task/control task (50 words) | Instruction: • I will try to become aware of my own epistemic beliefs regarding psychological research while working on the tasks.                                                                 |
|                    |                                                                         | • If doubts concerning my current epistemic beliefs arise, then I will consciously address these doubts.                                                                                                    |
|                    |                                                                         | • If I notice that my motivation declines, then I will focus on the beneficial effects advanced epistemic beliefs will have on my studies.                                                                 |

Table 1. (Continued)
Awareness. To make students recognize a discrepancy between actual and target beliefs (i.e., evaluativism) and to increase awareness for their own epistemic beliefs (Rule & Bendixen, 2010), they receive case studies for each of the three developmental levels (absolutism, multiplicity, and evaluativism). Awareness of their own beliefs and the developmental perspectives of those beliefs may become more visible to students when contrasting their own epistemic beliefs to those of experts – similar to the notions underlying apprenticeship instruction (and other interventions grounded on socioculturalism that draw on exemplifying expert-thinking; see Boekaerts & Corno, 2005). Upon reading each text, students therefore separately state, on a Likert scale, whether they think that the position presented in the case study is consistent with their own position, the position of psychological researchers, or their lecturers’ position. Moreover, they are asked to indicate whether this view facilitates acquiring knowledge (both with regard to an individual level and for science as a whole).

Feedback. Providing students with feedback on their performance has been shown to be a powerful predictor of learning (Hattie & Timperley, 2007). To further strengthen students’ awareness for potential discrepancies between actual and target beliefs, participants therefore receive fictitious written feedback on their beliefs, stating that based on their prior responses (during both sessions), their epistemic beliefs still need development (i.e., that they achieved a z-score which is just about average). We chose this normative comparison based on the assumption that providing a z-score, a statistical figure well established in psychological curricula, will make the feedback more credible to psychology students, which will increase feedback efficacy (e.g., Podsakoff & Farh, 1989). Moreover, using such a normative approach by providing comparative feedback, we draw on an established means to stimulate profound intraindividual attitudinal and behavioural changes in various contexts. For example, Hawkins, Kreuter, Resnicow, Fishbein, and Dijkstra (2008) pointed out that comparative feedback may constitute an effective way of tailoring health-promoting information to specific information consumers, and likewise, Dixon, Deline, McComas, Chambliss, and Hoffmann (2014) found effects on energy conservation behaviour. We argue that comparative feedback may similarly promote epistemic volition in the context of epistemic change.

Self-efficacy. According to Rule and Bendixen (2010), it is crucial to ‘convince students that they are, indeed, in charge of their own epistemic views’ (p. 115). In order to do this, we combine our normative comparison feedback with a self-efficacy feedback that serves as a motivational boost. More precisely, students receive – immediately after the normative comparison feedback – a fictitious individual change prognosis stating that, even though their beliefs still need development, they are moving in the right direction. They then are presented scientific findings showing that epistemic change can come about quickly, but are also reminded that it requires active and deliberate action. Once more, potential positive effects of more advanced epistemic beliefs are summarized (e.g., that such beliefs are beneficial for all research-related study activities such as writing a thesis).

Goal striving. In the last intervention component, students are supported in planning out goal striving during the following task by setting implementation intentions (Bayer, Gollwitzer, & Achtziger, 2010). Providing individuals with this kind of prompt
successfully promoted change in various areas of research, such as health psychology (e.g., Armitage, 2009) or academic achievement research (e.g., Bayer & Gollwitzer, 2007). We derived the specific statements directly from Bendixen and Rule’s (2004) model. For example, students are made aware that they might experience doubt regarding their existing beliefs and that this is a desirable effect – corresponding to Rule and Bendixen’s (2010) notion of modelling and compassion.²

**Resolvable controversies intervention**

Since epistemic volition is conceptualized as part of a higher order mechanism (Bendixen & Rule, 2004), we need to observe epistemic change ‘in action’ to determine whether our epistemic volition intervention has the intended effects. In other words, we have to ensure that the change process is initiated and that individuals experience a dissonance, which can be addressed by their epistemic volition. To achieve this, a diverging information intervention is administered after the manipulation check of the epistemic volition intervention.³ Based on our prior considerations, this intervention has to meet two criteria: First, as we strive to disentangle the process of epistemic change, it is important that the intervention targets neither epistemic volition nor resolution strategies but preferably epistemic doubt only. Second, its intervention concept must be in line with our epistemic volition intervention’s aim of reducing absolute and multiplistic beliefs (i.e., and not absolute beliefs only) while strengthening evaluativism. For this endeavour, we built upon prior efforts by Rosman and colleagues (Rosman & Mayer, 2018; Rosman, Mayer, Merk, & Kerwer, 2019; Rosman, Mayer, Peter, & Krampen, 2016) and refined their resolvable controversies approach to fit our needs. This approach confronts students with apparently conflicting information on a socioscientific issue (gender stereotyping and discrimination in secondary schools). In contrast to similar approaches, it is thought to evoke epistemic doubt regarding both absolutism (since inconsistent knowledge claims are presented) and multiplism (since apparently contradictory claims can be integrated). While the apparent controversies were initially introduced and discussed by an instructor (Rosman et al., 2016), Rosman and Mayer (2018) modified the procedure by including a reading task (i.e., reading conflicting texts and answering adjunct questions) and a writing task (i.e., writing a summary that identifies contextual factors), which could be administered without an instructor. Recent work by Kerwer and Rosman (2018) indicates that this paradigm still triggers epistemic change when the writing task is omitted. In other words, it produces effects that are solely attributable to presenting conflicting knowledge claims and therefore most likely closely connected to epistemic doubt (see Figure 2 for exemplary resolvable controversies texts).

In our study, we continued this work by transferring the intervention to an online setting, thereby ruling out any instructor effects in favour of the intervention. However, Kerwer and Rosman’s (2018) results were also a bit ambiguous, especially concerning the mechanism of change ascribed to the intervention, since a change towards advanced

² Even though one could argue that in our specific setting, self-generated implementation intentions might lead to superior effects compared to researcher-generated prompts (see Adriaanse, Ridder, & Wit, 2009), the Synergy Expert Group (Hagger et al., 2016) concluded that preferring one of these options to the other is still ‘speculative’ as no clear evidence exists in this regard. For example, Armitage (2009) found that researcher-generated implementation intentions were as efficient as self-generated ones.

³ Considering the postulated sequence in Bendixen and Rule’s (2004) model, including the diverging information intervention after the volition intervention might seem counter-intuitive. However, Rule and Bendixen (2010) suggested that epistemic volition needs to be already in place when students experience epistemic doubt, which in turn implies that this choice is indeed theoretically well grounded.
beliefs in their control group was observed. In this control group, participants read twelve text pairs on students employing different learning strategies and compared properties of the strategies presented in each text pair based on some predefined criteria. Kerwer and Rosman (2018) argued that participants probably interpreted this information as conflicting knowledge claims, which they putatively had to integrate, and that observed changes in the control group might be due to this issue. To resolve the issue and thwart any integration of information in our study, we aimed to present learning strategies randomly (i.e., not in pairs) and modified the adjunct questions by changing their focus to participants’ personal approval of each strategy (instead of an objective evaluation, see Figure 2).4

Hypotheses
In line with Bendixen and Rule’s (2004) model, we expect our epistemic volition intervention to promote epistemic change, and therefore suggest the following hypothesis:

Figure 2. Resolvable controversies intervention and control task. The first exemplary text of the resolvable controversies intervention (left column) presented here indicates that girls are discriminated against in physics while the second text states that boys are discriminated against in languages and literature. No discrimination occurs in history (third text). Identifying this pattern allows participants to resolve apparent inconsistencies between the snippets by concluding that gender discrimination depends, among others, on the respective subject area. No such pattern exists in the control task (right column) whose texts provide information on students applying different learning strategies. The complete German version of the texts is available on request. Please note that this figure builds upon a graphic that was initially published in Rosman and Mayer (2018).

results of Kerwer and Rosman (2020) suggest that these modifications worked out as intended and that the resolvable controversies approach still elicits changes in epistemic beliefs when it is administered in a purely online setting.
**Hypothesis 1** An epistemic belief intervention that includes the resolvable controversies intervention and a component specifically targeting epistemic volition has (incremental) beneficial effects on epistemic change (i.e., an increase in advanced epistemic beliefs as indicated by a reduction of both absolutism and multiplicity and an increase in evaluativism) compared to a control group that receives the resolvable controversies intervention but not the epistemic volition component.

Moreover, based on Bendixen and Rule's (2004) idea of the epistemic change process as higher order mechanism with process components that 'are dependent on one another' (p. 73), we propose that the combined effect of both interventions (resolvable controversies and volition) will be larger than the sum of respective effects when subjects receive only one of them.

**Hypothesis 2** Change towards advanced epistemic beliefs will be more pronounced when the resolvable controversies and the epistemic volition intervention are administered together – compared to the addition of their separate effects (i.e., we expect the effects of both interventions to interact positively).

A common drawback of past studies on epistemic change – and epistemic beliefs in general – has been that they often solely relied on self-report questionnaires and failed to investigate epistemic cognition in action (e.g., Bråten, 2016). In the present study, we address this limitation by examining whether our intervention also affects task performance when subjects choose between multiple sources. We opted to employ this specific kind of task as prior studies found close connections between epistemic cognition and accessing multiple sources (Pieschl, Stahl, & Bromme, 2008) or sourcing (Barzilai, Tzadok, & Eshet-Alkalai, 2015; Bråten, Ferguson, Stømsø, & Amnarkrud, 2014), respectively. For example, Pieschl et al. (2008) showed that students who held more advanced epistemic beliefs accessed more diverse information when using hypertexts, which, as a consequence, resulted in better learning outcomes. Thus, we propose that performance in a source evaluation task (when subjects are forced to choose between multiple sources based on provenance information) can be regarded as a ‘proxy’ of epistemic cognition (i.e., a more downstream measure influenced by epistemic cognition; see also Greene, Muis, & Pieschl, 2010). Based on H2, we therefore introduce the following task performance-related hypothesis:

**Hypothesis 3** A combined resolvable controversies and epistemic volition intervention will promote performance in a source evaluation task, which aims at knowledge acquisition (i.e., a more balanced choice of high-quality information) – compared to two interventions including either one of these two separate components.

**Method**

The approved Stage 1 protocol of this registered report is available at the Open Science Framework (https://doi.org/10.17605/OSF.IO/N6WFK), while data and code used in our analyses can be retrieved from the corresponding Open Science Framework project page (osf.io/suhy7).
**Design**

To test our hypotheses, we used a $2 \times 3$ design with measurement occasion (pre- and post-intervention) and intervention (epistemic volition intervention together with resolvable controversies intervention [VR], epistemic volition intervention and control task [VC], resolvable controversies intervention and control task [RC]) as factors. Figure 3 provides more details on the study design.

**Procedures and materials**

*Participants and procedure*

474 psychology students (major and minor) were recruited by means of psychology student mailing lists of ten German universities. Data were collected by the survey software Unipark. Upon giving their informed consent, students participated in the online pre-intervention measurement. One week later, they obtained a link for the second measurement occasion (intervention and post-intervention) via email and were randomly assigned to an intervention group by the respective Unipark function upon logging in. Finally, 412 participants (91.15% females), who were on average $M = 23.39$ ($SD = 3.99$) years old and studying for $M = 5.78$ ($SD = 3.54$) semesters, completed the study, were debriefed, and received a compensation of 15 Euro. All study procedures were approved by the Ethics Committee of the German Psychological Association (DGPs).

**Measures**

*Epistemic beliefs.* Epistemic beliefs according to Kuhn’s model were assessed by the FREE-GST and the FREE-EDPSY at each measurement occasion. Both instruments were derived from the scenario-based German FREE questionnaire (Krettenauer, 2005) where the FREE-GST takes a topic-specific perspective (i.e., gender-stereotype discrimination in secondary schools), while the FREE-EDPSY focuses on the domain of educational psychology (Rosman et al., 2019). To define the scope of each questionnaire, controversial positions on the topic or domain under investigation are introduced, and

![Figure 3](image_url)

**Figure 3.** Study design. Schedule of data collection procedures for the first (T1) and the second (T2) measurement occasion with planned duration in minutes (min).

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5 Since the resolvable controversies intervention materials (Rosman, Mayer et al., 2016; Rosman & Mayer, 2018), and the volition intervention materials are tailored to the domain of psychology, only psychology students were recruited.

6 A Unipark function ensuring that the sample size was balanced across the three experimental groups was used.
subsequently, 15 statements are presented to which agreement is assessed on a 6-point Likert scale. Each of those statements either belongs to absolutism, multiplism, or evaluativism (sample item for multiplism: ‘In educational research, scientists interpret their findings based on their personal opinion’; cf. Rosman et al., 2019). Advanced beliefs can be directly assessed by the D-Index (Krettenauer, 2005). It is computed as

\[ D = \text{Evaluativism} - 0.5(\text{Absolutism} + \text{Multiplism}) \]

Higher values therefore indicate more advanced beliefs.

Source evaluation task. In order to preclude any unintentional transfer effects from previous intervention tasks (e.g., because of topic similarity), the source evaluation task dealt with knowledge claims that stem from a different domain (health psychology). Before the task was administered, participants received the following instruction ‘A fellow psychology student just told you that there is a connection between achievement motivation and heart diseases. After coming home, you want to know more about this topic and you start searching on the internet’. Thereafter, participants were presented with four different search engine mockup outputs (see Figure 4). Each of these four outputs contained four fictitious results – two high-quality and two low-quality sites, while the valence (i.e., the supposed direction of the relationship – achievement motivation increases or decreases the risk of heart diseases) differs within each pair (e.g., within high-quality sites). For each output, subjects chose which site they would like to inspect in more detail during a later stage of the study (since the task focused on source selection only, this follow-up task was never administered). Moreover, participants were asked to explain, using a free-text field, why they selected the respective site. Based on Braten et al. (2011), adaptive epistemic (justification) beliefs should result in high attention to source characteristics, whereas individuals who assume that knowledge is simple and certain – naive beliefs in our framework – should be more likely to choose one-sided information or overly simplistic sources. Accordingly, only subjects with advanced beliefs should select high-quality sources that differ in their valence, as these offer the highest potential for acquiring unbiased knowledge and for potentially integrating contradictions. Thus, to measure task performance, two scores were produced: one on the quality of chosen information (i.e., how many high-quality links subjects choose, 0–4), and one on its diversity (i.e., highly unbalanced, slightly unbalanced, balanced\(^7\)). Credibility and quality search engine texts were validated in a pilot study (\(N = 54\)).\(^8\)

\(^7\) With four links to be selected and only two directions available, all possible outcomes can be described exhaustively within this framework: highly unbalanced = All chosen links imply the same direction. Slightly unbalanced = Three of the four links imply the same direction. Balanced = Two links are chosen for each direction.

\(^8\) All statements were measured on a 5-point Likert scale (1 = ‘totally disagree’, 5 = ‘totally agree’). With regard to the perceived credibility, participants were asked to evaluate the following statement: ‘It is conceivable that this text can be found in a Google search output’. Mean perceived credibility ranged from \(M = 3.50\) (SD = 1.16) to \(M = 3.87\) (SD = 0.95). Quality was measured by asking participants to rate the following statement: ‘The search result points to a high-quality web site’. Mean perceived quality in the ‘high-quality’ texts ranged from \(M = 3.67\) (SD = 1.10) to \(M = 4.31\) (SD = 0.67); mean perceived quality in the ‘low-quality’ texts ranged from \(M = 1.20\) (SD = 0.49) to \(M = 2.24\) (SD = 0.89). For pointing out the assumed direction of association between achievement motivation and risk of heart disease that was suggested in the respective text, participants had to choose between four options: ‘positive’ (high achievement motivation increases risk of heart disease), ‘negative’ (low achievement motivation increases risk of heart disease), ‘ambiguous’ (association unclear), and ‘don’t know’. The positive association texts resulted in the following statistics: negative = 1.9 %, positive = 92.6 %, ambiguous = 3.7 %, and don’t know = 1.9 %. The negative association texts yielded the following results: negative = 90.7 %, positive = 1.9 %, ambiguous = 5.6%, and don’t know = 1.9 %.
**Covariates.** Based on Sinatra and Mason’s (2013) overview on learner characteristics that influence conceptual change, we measured need for cognitive closure at the pre-intervention measurement using Schlink and Walther’s (2007) German short-scale. During the intervention, we assessed epistemic emotions by the *Epistemically Related Emotion Scales* (Pekrun, Vogl, Muis, & Sinatra, 2017). Both scales have already been employed in similar samples (i.e., German university students) and have repeatedly proven to be reliable and valid. In addition, we assessed self-reported personal relevance of intervention tasks (1-item, 6-point Likert scale) and feedback credibility (1-item, 6-point Likert scale).

**Statistical analysis**

**Statistical model**

For H1 and H2, we used latent difference score modelling (McArdle, 2009) to analyse our data in R (R Core Team, 2019) using the lavaan package (Rosseel, 2012). Our dependent variable – epistemic change – was operationalized as latent change score with dummy-coded intervention group variables as independent variables (using the VR group as reference category, see Figure 5). Based on this model, we applied the following criteria for testing H1 and H2: H1 is confirmed if a significant detrimental effect of leaving out the volition intervention \( (b_1) \) is observed, and H2 is confirmed if the intervention effect in the VR group is significantly larger than the sum of the overall intervention effects in the other groups \( (b_0 + b_1 + b_2 < 0) \). Our main outcome was an increase in advanced beliefs as

\[
(b_0 + b_1 + b_2 < 0)
\]
measured by the D-Index of the FREE-GST, and our secondary outcome was an increase in the D-Index of the FREE-EDPSY.

We analysed source evaluation task performance using the Kruskal–Wallis test (since its level of measurement is ordinal), where H3 is confirmed if the VR group performed best. As we pre-specified the expected direction of change for all our hypotheses, one-sided hypothesis testing was performed. For confirmatory analyses, we applied no correction for multiple testing. Additional exploratory analyses (e.g., investigating the role of prior beliefs, personal relevance) were conducted.
Analysis pipeline
Prior to statistical analyses, we removed all data of subjects that participated in the pre-intervention measurements only (62 cases), failed to complete the intervention in less than three times the median response time (26 cases), or showed highly implausible response patterns (e.g., no variation in answers; one case) resulting in a sample size of 385. Thereafter, epistemic beliefs scales (including the D-Index) were computed as mean scores and extreme outliers on those scales were removed based on z-scores with $p(z) < .001$ as criterion (three cases). Finally, if ANOVAs comparing pre-intervention scores on covariates indicated that at least marginally significant group differences exist; we controlled for these covariates by including them as predictors of epistemic change in our statistical model.

Power analysis
Sample size calculation was based on recent data from Kerwer and Rosman (2018), who employed a design that was similar to the present study. As no out-of-the-box power calculation procedures for latent difference score modelling exist, we employed the respective routines for repeated-measures ANOVAs (as a comparable standard technique). Using R, we applied the ezANOVA function of package ez to estimate a repeated-measures ANOVA and inserted the obtained results (Cohen’s $f = .094$; $r = .66$) into GPower (Faul, Erdfelder, Buchner, & Lang, 2009) while setting power to .90 and $\alpha$ to .05 in a repeated-measures design with three groups. The resulting total sample size was 249. In order to account for data cleaning procedures, publication bias, and reduced compliance in a purely online setting (when compared to the group setting of Kerwer and Rosman (2018)), we aimed to recruit 400 subjects for our study (corresponding to a power of .90 for $f = .074$ and .987 for $f = .094$).

Manipulation check
To test whether the epistemic volition intervention (H1) worked out as intended, a self-report state measure on epistemic volition was administered before the resolvable controversies intervention respectively the control task (sample item: ‘I am feeling highly motivated to reconsider my current understanding of psychological knowledge’; 6-point Likert scale). By means of a self-report questionnaire on the integration of conflicting information, we additionally assessed whether participants in the resolvable controversies intervention actually realized that contradictions could be integrated (sample item: ‘Upon reading the texts... I figured out how to explain contradictions between the short texts’; 6-point Likert scale). Higher scores on these measures in the intervention groups indicate that the respective interventions were successful.

Results
Manipulation check
Table 2 provides descriptive statistics and Tukey’s post-hoc comparisons on manipulation check variables. In line with our expectations, ANOVA results indicate that group

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10 In five cases, we were unable to match intervention and post-intervention data to pre-intervention data, the corresponding values are therefore treated as missing values.
means on our epistemic volition state measure differed significantly ($F[2,382] = 11.38, p < .001, \eta^2 = .056$), while post-hoc tests revealed that epistemic volition was higher in the VC and VR conditions compared to the RC condition. Moreover, as anticipated, we found significant group differences on self-reported integration of conflicting information ($F[2,382] = 9.685, p < .001, \eta^2 = .048$). Subjects in the VR condition reported more integrations of conflicting knowledge claims compared to subjects in the VC and RC conditions. We did, however, not find higher scores on the integration measure in the RC compared to the VC condition. In order to find out how this might affect epistemic change, we performed an additional exploratory analysis with manipulation check measures as predictor variables (see Exploratory analyses). Taken together, these findings nevertheless suggest that both interventions (i.e., manipulations) were successful in the VR condition and that the volition intervention was successful altogether.

**Confirmatory analyses**

As no significant pre-intervention differences between groups existed, we conducted confirmatory analyses without covariates.

**Hypothesis 1 and Hypothesis 2 – epistemic change**

Descriptive statistics on topic- and domain-specific epistemic beliefs are provided in Table 3. Making use of the flexibility of latent difference score modelling, we simultaneously analysed topic-specific and domain-specific beliefs in one model. Figure 5 illustrates the univariate model underlying these analyses. To facilitate the interpretation of results, we generated $\gamma$-standardized regression coefficients through centring primary and secondary outcome variables with respect to their pre-intervention means and standard deviations.

**Topic-specific epistemic beliefs.** Conforming to our expectations, we found significant changes towards advanced beliefs in the VR condition ($b_0 = 0.361, p < .001$). These did, however, not significantly differ from changes in the VC condition ($b_2 = -0.022, p = .859$) or the RC condition ($b_1 = 0.004, p = .971$). In other words, there was no detrimental effect of leaving out the volition intervention on epistemic change (H1). Instead, small- to medium-sized changes towards advanced epistemic beliefs were observed in all conditions (see Table 3). Unexpectedly, our statistical test on H2 revealed that the sum of intervention effects in the VC and RC conditions was significantly larger.
Table 3. Topic- and domain-specific epistemic beliefs: Descriptive statistics and effect sizes for primary and secondary outcomes by intervention condition

| Intervention condition       | D-Index topic-specific | D-Index domain-specific |
|-----------------------------|------------------------|-------------------------|
|                             | $M_{\text{Pre}}$ | $SD_{\text{Pre}}$ | $n_{\text{Pre}}$ | $M_{\text{Post}}$ | $SD_{\text{Post}}$ | $n_{\text{Post}}$ | $\text{Cor}$ | $d$ | $M_{\text{Pre}}$ | $SD_{\text{Pre}}$ | $n_{\text{Pre}}$ | $M_{\text{Post}}$ | $SD_{\text{Post}}$ | $n_{\text{Post}}$ | $\text{Cor}$ | $d$ |
| Volition and resolvable     | 1.82       | 0.87       | 129       | 2.13       | 0.97       | 131       | .59       | 0.39 | 1.87       | 0.79       | 128       | 2.13       | 0.92       | 130       | .66       | 0.40 |
| Volition and control        | 1.90       | 0.71       | 130       | 2.15       | 0.85       | 130       | .51       | 0.36 | 1.86       | 0.76       | 130       | 2.23       | 0.75       | 130       | .58       | 0.53 |
| Control and resolvable      | 1.87       | 0.88       | 121       | 2.17       | 0.97       | 124       | .56       | 0.36 | 1.96       | 0.76       | 120       | 2.20       | 0.83       | 122       | .62       | 0.36 |

Note. $M =$ arithmetic mean; $SD =$ standard deviation; $Pre =$ pre-intervention measurement, $Post =$ post-intervention measurement, $Cor =$ pre–post correlation, $d =$ repeated-measures effect size estimate based on Morris and DeShon (2002), McDonald’s $\omega$ was .68 and .70 for topic-specific and domain-specific beliefs, respectively.

As no strict rule exists for assigning items to triplets when building difference score items, we computed reliability estimates for 14,359 possible ways of doing so. For the sake of simplicity, only the means of those estimates are reported here.
than the effect in the VR condition ($b_0 + b_1 + b_2 = 0.343, p = .013$; see Statistical analysis and Footnote 9) – instead of smaller. In conclusion, results on our primary outcome support neither H1 nor H2.

**Domain-specific epistemic beliefs.** The pattern of change that emerged for our secondary outcome closely corresponded to findings on our primary outcome (see Table 3). Again, advanced epistemic beliefs significantly increased (on average) in the VR condition ($b_0 = 0.345, p < .001$), while differences between treatment conditions were non-significant ($b_1 = 0.008, p = .937; b_2 = 0.097, p = .331$). Accordingly, our test on H2 also suggested that the combined intervention’s effect was significantly smaller than the sum of its intervention components’ effects ($b_0 + b_1 + b_2 = 0.450, p < .001$). Thus, the results on our secondary outcome neither confirm H1 nor H2.

**Hypothesis 3 – source evaluation task performance**

To test whether the VR intervention promoted source evaluation task performance compared to the other groups, we examined group differences in diversity and quality scores (see Tables 4 and 5 for descriptive statistics). The Kruskal–Wallis tests were non-significant for the diversity score ($\chi^2 = 0.519, df = 2, p = .772$), as well as for the quality score ($\chi^2 = 4.826, df = 2, p = .090$). Thus, H3 was not confirmed. To follow up on this matter, exploratory ordinal regression analyses were performed (see Exploratory analyses).

**Table 4.** Source evaluation task – diversity score: Descriptive statistics on the diversity score by intervention group

| Diversity score      | Volition and resolvable | Volition and control | Control and resolvable |
|----------------------|-------------------------|----------------------|------------------------|
|                      | n    | %    | n    | %    | n    | %    |
| Highly unbalanced    | 16   | 12.21| 12   | 9.23 | 14   | 11.29|
| Slightly unbalanced  | 66   | 50.38| 72   | 55.38| 70   | 56.45|
| Balanced             | 49   | 37.40| 46   | 35.38| 40   | 32.26|

**Table 5.** Source evaluation task – quality score: Descriptive statistics on the quality score by intervention group

| Number of high-quality sources chosen | Volition and resolvable | Volition and control | Control and resolvable |
|--------------------------------------|-------------------------|----------------------|------------------------|
|                                      | n    | %    | n    | %    | n    | %    |
| 0                                    | 3    | 2.29 | 0    | 0.00 | 2    | 1.61 |
| 1                                    | 5    | 3.82 | 2    | 1.54 | 4    | 3.23 |
| 2                                    | 3    | 2.29 | 4    | 3.08 | 11   | 8.87 |
| 3                                    | 13   | 9.92 | 19   | 14.62| 18   | 14.52|
| 4                                    | 107  | 81.68| 105  | 80.77| 89   | 71.77|
**Exploratory analyses**

Once more making use of the flexibility of latent difference score modelling, we included manipulation check measures (i.e., the integration of conflicting information and epistemic volition state measures) and their interaction as predictor variables in our model of change, leaving out the intervention condition variables. For topic-specific epistemic change, these analyses revealed a linear effect of the integration ($b_{\text{Integration}} = .176, p < .001$) and no linear effect of the volition measure ($b_{\text{Volition}} = -.026, p = .603$), but a significant interaction between both variables ($b_{\text{Interaction}} = .260, p < .001$), suggesting that effects of the integration variable were smaller for lower levels of epistemic volition. For domain-specific change, the corresponding effects were considerably smaller and non-significant ($b_{\text{Integration}} = .089, p = .057$, $b_{\text{Volition}} = -.014, p = .765$, $b_{\text{Interaction}} = .062, p = .164$). Finally, a follow-up multigroup analysis showed that effects of manipulation check measures did not significantly differ between experimental conditions (see Table 6).

We also investigated whether group differences on the source evaluation task performance would become significant if we increased the corresponding analyses’ sensitivity by controlling for relevant covariates (cf. Tabachnick & Fidell, 2007, p. 195). Based on prior studies by Barzilai and colleagues (Barzilai & Eshet-Alkalai, 2015; Barzilai et al., 2015; Barzilai & Zohar, 2012), who found distinct effects of absolutism, multiplicism, and evaluativism on sourcing and related tasks (e.g., viewpoint comprehension), we considered post-intervention epistemic beliefs to be such relevant covariates and included them in an ordinal logistic regression analysis. To obtain a baseline model, which closely corresponded to the model of our confirmatory analyses, we predicted the diversity and quality score by dummy-coded intervention condition variables in a first step. In a second step, we included topic-specific epistemic beliefs as additional predictors. The corresponding likelihood-ratio test yielded significant results for the quality score ($\Delta \chi^2 = 17.417, df = 3, p < .001$) but not for the diversity score ($\Delta \chi^2 = 0.289, df = 3, p = .962$). More specifically, we found that the quality score increased for higher levels of evaluativistic beliefs, but was impaired by multiplicistic beliefs, while absolute beliefs had no effect (see Table 7). More importantly, differences between the VR/VC and RC condition became significant in this model, suggesting that

| Model difference test | $\Delta \chi^2$ | $\Delta df$ | $p$          |
|------------------------|-----------------|-------------|--------------|
| **Step 1: Intercepts** | 41.11           | 10          | <.001        |
| Step 2: Residual variances | 15.51         | 10          | .115         |
| Step 3: Residual covariances | 30.81         | 20          | .058         |
| Step 4: Latent variances | 1.77           | 4           | .778         |
| Step 5: Latent covariances | 16.94         | 10          | .076         |
| Step 6: Latent means    | 5.61            | 4           | .230         |
| Step 7: Regressions     | 12.12           | 12          | .436         |

| Overall fit target model | $\chi^2$ | $df$ | $p$ |
|--------------------------|----------|-----|-----|
| Intercepts unrestricted  | 82.77    | 60  | .027|

*Note. Values in bold = significant likelihood-ratio tests.*
subjects who received the volition intervention were more likely to choose high-quality sources.

**Discussion**

**Hypotheses**

In the present study, advanced beliefs prospered irrespectively of whether we combined the epistemic volition intervention with a control task or an epistemic doubt intervention. However, although these results were consistent with our assumptions, we also found that epistemic change remained largely unchanged if we dropped the volition intervention and solely administered the doubt intervention. Thus, H1 was not supported by our data. Moreover, regarding H2, we expected effects of the doubt and volition interventions to interact. Since we found no differences in epistemic change across experimental conditions, this assumption had to be rejected as well. The exploratory analyses on our manipulation check measures, however, allow a more nuanced view of this relationship as they suggest that across groups, an interaction between integrating conflicts and epistemic volition existed on an individual level for topic-specific beliefs – but not on the intervention condition level we used to specify H1 and H2. These exploratory findings support the rationale underlying H1 and H2 – epistemic change was indeed more pronounced if the epistemic change process was initiated (i.e., through the integration of conflicts, which should evoke doubt regarding absolutism and multiplism), and subjects experienced epistemic volition.

In H3, we proposed that a combined epistemic doubt and epistemic volition intervention would promote source evaluation task performance. Whereas H3 was not supported in confirmatory analyses, exploratory analyses indicated that the quality of chosen sources might have increased when the volition intervention was administered (with or without the doubt intervention).

**Theoretical issues and limitations**

What implications do our findings on H1 and H2 have for Bendixen and Rule (2004) model? As leaving out the doubt intervention had no detrimental effect, our results seem

| Diversity | Quality |
|-----------|---------|
| Predictor | EST     | CI       | OR       | Predictor | EST     | CI       | OR       |
| Volition and control | 0.154 | [−0.321, 0.630] | 1.17 | Volition and control | 0.611 | [0.023, 1.212] | 1.84 |
| Volition and resolvable | 0.150 | [−0.251, ∞] | 1.16 | Volition and resolvable | 0.586 | [0.086, ∞] | 1.80 |
| Absolutism | 0.095 | [−0.201, 0.400] | 1.10 | Multiplicity | −0.389 | [−0.715, −0.067] | 0.68 |
| Evaluativism | 0.695 | [0.312, 1.085] | 2.00 |

Nagelkerke $R^2$ .002

Note. EST = regression weight; CI = 95% confidence interval; OR = odds ratio, reference category is the ‘control and resolvable controversies’ condition.
to suggest that epistemic volition – but not epistemic doubt – is indispensable when it comes to epistemic change. While the opposite argument (i.e., that leaving out the volition intervention has no effect) can be made just as well, analyses on manipulation check measures suggest that the epistemic change process was initiated in all intervention conditions. Taken together, these results tentatively indicate that it is virtually impossible to foster the downstream component of the epistemic change process, epistemic volition, without simultaneously addressing the upstream component, epistemic doubt.

Why did we, however, fail to find superior effects for a combined doubt and volition intervention compared to the effects of its components even though manipulation check measures interacted? A possible explanation is that higher amounts of epistemic change are simply not attainable in short-term interventions (e.g., because memory effects might limit the capacity of change, cf. Contzen & Inauen, 2015) – a notion that is supported by comparably high effect sizes in all study conditions. In this context, it is especially surprising that effects in the RC condition were considerably larger than one would have expected based on Kerwer and Rosman (2020). This might indicate that the interplay of different types of diverging information is more complex than currently assumed. More specifically, the perceived ‘divergingness’ and resolvability of resolvable controversies might be accentuated if they are presented after a control task, since individuals contrast this new resolvable diverging information to the previous non-diverging and non-resolvable information. If this speculation holds true, it might explain non-significant findings on H1. Furthermore, as stated in our introduction section, epistemic volition is thought to allow individuals to address cognitive dissonances that are caused by ill-structured problems (Ferguson et al., 2012). Keeping this in mind, one might argue that resolvable controversies are too well structured (i.e., as the presented apparently conflicting positions were specifically designed to be easily reconcilable at second glance; Rosman et al., 2019) for the effects of epistemic volition to show. Lastly, Bendixen and Rule’s (2004) model encompasses one additional central component, resolution strategies, and several peripheral components, which might deserve closer attention.

**Practical implications**

From a theoretical perspective, our exploratory findings on H3 are intriguing as they link epistemic volition, a specific component of Bendixen and Rule’s (2004) model, with sourcing. Moreover, they have some interesting practical implications. Drawing on the distinction between *skill* and *will* for self-regulated learning (McCombs & Marzano, 1990) and the notion of context-specificity of epistemic virtues and vices (Chinn et al., 2011), students who are sufficiently skilled to distinguish high- from low-quality sources (i.e., in terms of information literacy) might still lack the will (i.e., epistemic volition) to apply this skill. Since we showed that epistemic volition is comparatively easy to enhance, this might offer promising starting points for instructional measures if confirmed in future studies. In this vein, the epistemic volition manipulation check might be regarded as an intervention itself since it forced individuals to reflect on their virtues and vices (i.e., their unwillingness to give up beliefs, cf. Chinn et al., 2011). Possibly, this even made subjects in the RC condition subsequently more amenable for change.

Admittedly, psychology students are a special population – even compared to other students (cf. Rosman, Mayer, Kerwer, & Krampen, 2017) – and this may cast doubt on the generalizability of our findings. However, Kerwer and Rosman (2020) recently showed that resolvable controversies also work in cross-disciplinary samples of students, which
indicates that our findings may be transferred beyond the domain of psychology – although our volition intervention encompassed several psychology-specific aspects that would certainly need to be adapted to the specific needs of other domains. Moreover, the generalizability beyond university students remains an open question.

**Conclusion**

In this registered report, we set out with the aim of scrutinizing the epistemic volition component of Bendixen and Rule (2004) model. Our newly developed epistemic volition intervention evoked pre–post changes in epistemic beliefs, and exploratory (but not confirmatory) findings indicate that this intervention was possibly connected to higher performance in a sourcing task. However, we only succeeded in differentiating effects related to epistemic doubt and volition in exploratory, and not in confirmatory, analyses. Ultimately, our troubles in disentangling these concepts’ roles are probably due to the difficulties of addressing the complex multilayered nature of Bendixen and Rule (2004) framework in one single study. Hence, much work on the role of epistemic volition – and on Bendixen and Rule (2004) model as a whole – still remains to be done. We hope, nonetheless, that our study provides a valuable starting point for this endeavour.

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**Author contributions**

Martin Kerwer: Conceptualization; Investigation; Methodology; Writing – original draft; Writing – review & editing. Tom Rosman: Conceptualization; Funding acquisition; Project administration; Supervision; Writing – review & editing. Oliver Wedderhoff: Conceptualization; Methodology; Writing – review & editing. Anita Chasiotis: Conceptualization; Methodology; Writing – review & editing.

**Conflicts of interest**

All authors declare no conflict of interest.

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