Mechanismen epistemischen Wandels

Kumulative Dissertationsschrift zur Erlangung des akademischen Grades des Doktors der Naturwissenschaften des Fachbereichs I der Universität Trier

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Artikel I

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Artikel III

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Abstract

Die Relevanz epistemischer (individueller wissensbezogener) Überzeugungen in unserer modernen Wissensgesellschaft ist nahezu unbestritten. Trotzdem ist vergleichsweise wenig dazu bekannt, wie die Entwicklung hin zu fortgeschrittenen epistemischen Überzeugungen – welche zum Beispiel die Kontextspezifität von Wissensansprüchen (d. h. Behauptungen) anerkennen – gefördert werden kann. Erschwerend hinzu kommt, dass aktuelle theoretische Modelle, welche Forschende in diesem Unterfangen unterstützen könnten, bislang nur unzureichend empirisch validiert sind. Die Arbeiten der vorliegenden Dissertation widmeten sich aus diesem Grund der Erforschung der Mechanismen epistemischen Wandels und unterzogen das derzeit wohl prominenteste Prozessmodell epistemischen Wandels von Bendixen und Rule (2004) einer empirischen Prüfung. Diese Prüfung fand in drei paradigmatisch aufeinander aufbauenden Forschungsartikeln statt. Zentrale Forschungsfragen, die in diesen Artikeln adressiert wurden, betrafen die Rolle der zentralen Prozesskomponenten des Bendixen und Rule (2004) Modells – epistemischer Zweifel, epistemischer Volition und Lösungsstrategien – sowie Rahmenbedingungen epistemischen Wandels. Spezifisch betrachtete Rahmenbedingungen waren hierbei die (Un)Auflösbarkeit divergierender (d. h. widersprüchlicher) Evidenz, welche zur Initiation des Prozesses des epistemischen Wandels genutzt wurde, epistemische Ausgangsüberzeugungen sowie die Domänenspezifität epistemischer Überzeugungen. In den drei Forschungsartikeln konnte die zentrale Rolle epistemischer Zweifel bestätigt werden. Überraschenderweise hatte die Auflösbarkeit widersprüchlicher Evidenz allerdings keinen nachweisbaren Einfluss auf epistemischen Wandel. Hinsichtlich der Rolle epistemischer Ausgangsüberzeugungen zeigte sich, dass naive Ausgangsüberzeugungen, welche mit einem stärkeren Erleben kognitiver Dissonanz in Verbindung stehen sollten, epistemischen Wandel begünstigten. Auch die Domänenspezifität epistemischen Wandels konnte als wesentliche Rahmenbedingung des Wandels bestätigt werden. Für epistemische Volition und Lösungsstrategien zeigte sich allerdings kein eindeutiges Ergebnismuster. In konfirmativen Analysen wurden hier nicht die erwarteten Effekte gefunden, während explorative Analysen teilweise doch modellkonforme Evidenz zu liefern schienen. Insgesamt leistet die vorliegende Dissertationsschrift damit einen wesentlichen Beitrag zur Klärung der Mechanismen epistemischen Wandels und erlaubt eine Ausdifferenzierung des Bendixen und Rule (2004) Modells. Darüber hinaus erweitert diese Dissertationsschrift auch das Methodenrepertoire der Erforschung epistemischen Wandels durch die Übertragung bestehender Interventionsansätze auf Online-Formate und illustriert die praktische Relevanz dieses Forschungsstrangs durch den Nachweis von Interventionseffekten auf Verhaltensmaßen.

1 Einleitung

In unserer modernen Gesellschaft ist wissenschaftliches Wissen nahezu allgegenwärtig und der Zugang zu wissenschaftlicher Evidenz meist nur noch eine Suchanfrage entfernt (vgl. Baram-Tsabari & Schejter, 2019). Diese breite Verfügbarkeit wissenschaftlichen Wissens kann – ganz im Sinne des Francis Bacon zugeschriebenen Aphorismus, dass (wissenschaftliches) Wissen Macht sei – nicht zuletzt zu einer mündigeren Demokratie beitragen (Kidron, Tirosh, Kali & Schejter, 2019). Im Internet-Zeitalter ist diese Freiheit des Wissens aber nicht nur auf den Zugriff zu qualitätsgesicherter Evidenz beschränkt, sie erstreckt sich vielmehr auch auf die Möglichkeit, selbst ohne Schranken – und damit ohne jegliche Qualitätskontrolle – Informationen aller Art bereitzustellen und als sichere Evidenz zu präsentieren (vgl. Barzilai & Chinn, 2019). Auch wenn *Fake News* sicherlich keine neue Erfindung dieses Zeitalterns sind, erleichtert das Internet damit doch die Verbreitung solcher Falschinformationen (Martens, Aguiar, Gómez-Herrera & Mueller-Langer, 2018). Der Umgang mit (scheinbar) wissenschaftlicher Evidenz sowie deren Bewertung kristallisiert sich in der Folge als eine zentrale Herausforderung an Individuen in unserer modernen Gesellschaft heraus (Barzilai & Chinn, 2019; Sinatra, Kienhues & Hofer, 2014). Man könnte auch sagen, dass Wissen an und für sich nicht mehr dem Einzelnen oder der Einzelnen Macht verleiht, sondern vielmehr die Fähigkeit Wissen oder Wissensansprüche (d. h. Behauptungen) auf ihre Gültigkeit hin zu bewerten und adäquat einzuordnen (vgl. Bromme, Kienhues & Porsch, 2010). Individuen müssen verstärkt herausfinden, was sie unter Wissen verstehen und unter welchen Umständen sie Behauptungen als Wissen akzeptieren, mit anderen Worten, wie es um ihre *epistemischen* Überzeugungen bestellt ist (Hofer, 2016). Diese Bedeutung epistemischer Überzeugungen konnte im letzten Jahrzehnt in mehreren Überblicksarbeiten belegt werden, welche unter anderem Verbindungen zwischen epistemischen Überzeugungen und akademischer Leistung (Greene, Cartiff & Duke, 2018), konzeptuellem Wandel (Sinatra & Mason, 2013), Umgang mit webbasierter Evidenz (Strømsø & Kammerer, 2016) sowie dem Umgang mit multiplen Quellen oder Dokumenten generell (Barzilai & Strømsø, 2018) fanden. Epistemische Überzeugungen und das Bestreben, die Entwicklung solcher Überzeugungen zu fördern, rückten in der Folge stärker in den Fokus der Bildungswissenschaften (Sinatra et al., 2014). Die durch diese Dissertationsschrift vorgenommene Untersuchung der Mechanismen epistemischen Wandels mit dem Ziel einer solchen Förderung epistemischer Überzeugungen lässt sich damit als folgerichtige Fortsetzung dieser Forschungstradition begreifen.

Dass epistemische Überzeugungen sich über die Lebensspanne sowie in Abhängigkeit des Bildungsniveaus entwickeln, ist nahezu unbestritten (vgl. Hofer, 2016). So sollen Individuen beispielsweise innerhalb dieses Entwicklungsprozesses erkennen, dass die Gültigkeit von Behauptungen von ihrem Bezugsrahmen, wie der Stärke der sie stützenden Evidenz oder ihrer Quelle, abhängt. *Wie* genau und *unter welchen Umständen* epistemische Entwicklung stattfindet, ist hingegen noch eher unklar (Bråten, 2016). Eine Vielzahl von Studien griff in der Vergangenheit zur Förderung epistemischer Überzeugungen auf eher lang andauernde und inhaltlich eher diverse Interventionsprogramme zurück (Muis, Trevors & Chevrier, 2016). Diese Art von Interventionsprogramm ist allerdings meist zu breit gefächert in seinen Interventionsinhalten, um Rückschlüsse auf die Wirksamkeit einzelner Interventionskomponenten bezüglich epistemischer Veränderungen zu erlauben. Beispielsweise nutzten Muis und Duffy (2013) in ihrer ein Semester andauernden Intervention zur Förderung epistemischer Überzeugungen im Laufe eines Statistikseminars eine Fülle von Konzepten, welche sich dem Spektrum konstruktivistischer Lehrpraktiken zuordnen lassen. Welche Rolle hier dem reinen *Aufzeigen* divergierender (konfligierender) Evidenz innerhalb dieses Kurses im Vergleich zu dessen begleiteter *Reflektion* oder der *Motivation* der Studierenden sich diesen Prozessen zu stellen einnahm, lässt sich im Kontext einer solchen Intervention nicht eruieren. Ein zweiter Forschungsstrang besteht in zeitlich eng beschränkten Kurzzeitinterventionen, welche vergleichsweise kurzfristige Veränderungen epistemischer Überzeugungen, sogenannten epistemischen Wandel, unter kontrollierten experimentellen Bedingungen untersuchen (Kerwer & Rosman, 2020b; Muis et al., 2016). Die hieraus resultierende empirische Evidenzbasis bedarf allerdings auch (noch) rigoroserer experimenteller Kontrolle. Existierende Studien deuten beispielsweise darauf hin, dass die Präsentation divergierender Evidenz epistemischen Wandel beeinflussen könnte, entbehren aber, wie in Kapitel 2.2.2 näher beleuchtet werden wird, adäquater passiver Kontrollinterventionen. Die Auswirkungen dieser Limitation sind umso gravierender, da theoretische Modelle, welche zur Fundierung aktueller Interventionsansätze bisher genutzt werden, selbst auch unzureichend empirisch abgesichert sind (Bråten, 2016). Solange diese Wissenslücke besteht, können Interventionsprogramme zur Förderung epistemischer Überzeugungen, welche sich zur Wahl ihrer Interventionskomponenten auf solche theoretischen Modelle stützen, nahezu zwangsläufig nicht ihr volles Potenzial entfalten. Die in dieser kumulativen Dissertation vorgestellte Forschung versucht deshalb durch drei aufeinander aufbauende präregistrierte Experimentalstudien, diese Forschungslücke zu schließen und hierdurch die Forschung zu Mechanismen epistemischen Wandels voranzutreiben. Anhand einer Untersuchung der (inkrementellen) Effekte verschiedener Interventionskomponenten wird eine empirische Prüfung des Bendixen und Rule (2004)

Modells, des derzeit wohl meistgenutzten Rahmenmodells epistemischen Wandels, vorgenommen und basierend auf den Ergebnissen dieser empirischen Testung eine Erweiterung des Bendixen und Rule (2004) Modells vorgeschlagen.

2 Theoretischer Hintergrund

In diesem Abschnitt wird das publikationsübergreifende theoretische Rahmenwerk eingeführt, welches dieser Dissertationsschrift zugrunde liegt. Hierzu findet zunächst eine Darlegung der in dieser Arbeit verwendeten Auffassung epistemischer Überzeugungen statt. Anschließend wird die zu Beginn der Dissertation vorliegende Forschungslandschaft (zur Förderung) epistemischen Wandels skizziert. Basierend auf dieser Darstellung wird schließlich das Forschungsprogramm der Dissertation in Form von publikationsübergreifenden zentralen Forschungsfragen abgeleitet.

2.1 Epistemische Überzeugungen

2.1.1 Kuhns Stufenmodell epistemischer Entwicklung

Traditionell existieren diverse Wege epistemische Überzeugungen (d. h. individuelle Überzeugungen über die Natur von Wissen und den Prozess des Wissens) zu konzeptualisieren (Hofer & Pintrich, 1997). Frühe Arbeiten in diesem Forschungsfeld gingen in der Regel von einer Piagetschen Abfolge von Entwicklungsstufen aus. Die Entwicklung epistemischer Überzeugungen über die Lebensspanne hinweg wurde in solchen Modellen konsequenterweise als eine Abfolge qualitativ unterschiedlicher Entwicklungsstadien dargestellt (Hofer & Pintrich, 1997). Relativer Konsens bestand in diesen Modellen bezüglich der allgemeinen Entwicklungsrichtung epistemischer Überzeugungen über diese Entwicklungsstadien hinweg (Hofer, 2016). Ausgehend von einer Betonung der Objektivität des Wissens im Kindesalter (Wissen als unveränderliche, externe Entität), über eine sich hieran anschließende Entdeckung der Subjektivität von Wissensansprüchen (Wissen als variable individuelle Meinungen), sollten Individuen schließlich die beiden vorausgehenden Positionen integrieren (Kuhn & Weinstock, 2002). Die Anzahl der in diesen Modellen postulierten Entwicklungsstadien war allerdings recht hoch, was den praktischen Nutzen dieser Modelle limitierte (vgl. Kuhn & Weinstock, 2002). Mit dem Ziel der leichteren Handhabbarmachung, entwickelten Kuhn und Weinstock (2002) in der Folge deshalb das wohl populärste Modell dieser Tradition, welches drei Entwicklungsstufen vorsieht: *Absolutismus* (Wissen wird als einfach und sicher angesehen), *Multiplismus* (Wissensansprüche werden als reine Meinungen der Quelle betrachtet, Wissen als komplex und unsicher) und *Evaluativismus* (Wissen werden subjektive und objektive Komponenten zugeschrieben,

eine Annäherung an die Wahrheit aber trotzdem als möglich erachtet). Wichtig ist hierbei, sich vor Augen zu halten, dass diese Integration der subjektiven und objektiven Dimension des Wissens auf der letzten Stufe des Kuhnschen Modells Individuen nicht davon abhält im Einzelfall eindeutige Schlussfolgerungen zu ziehen. Nach Kuhn und Weinstock (2002) geht es auf dieser Entwicklungsstufe vielmehr um eine Anerkennung von Unsicherheit ohne Verzicht auf Bewertung („acknowledging uncertainty without forsaking evaluation“, S. 124). Die Spezifikation „ohne Verzicht auf Bewertung“ impliziert, dass Absolutisten, Multiplisten und Evaluativisten zwar unterschiedliche Ansichten oder Positionen zur Natur des Wissens haben können, aber dennoch zu derselben Schlussfolgerung über die Gültigkeit bestimmter Wissensansprüche kommen können. So sollten Evaluativisten beispielsweise Wissensansprüchen, die auf stärkerer Evidenz fußen (z. B. metaanalytischen Studien), Vorrang gegenüber schwächerer Evidenz (z. B. anekdotischer Evidenz) einräumen.

Empirische Forschungsarbeiten von Kuhn und Kollegen (z. B. Kuhn, Cheney & Weinstock, 2000) beinhalteten in der Regel eine Zuweisung von Individuen zu den qualitativ verschiedenen Stufen der epistemischen Entwicklung ihres Modells (vgl. Barzilai & Weinstock, 2015). Dies mag verwunderlich erscheinen, da die Koordination der subjektiven und objektiven Dimensionen des Wissens von Kuhn und Weinstock in den Ausführungen zu ihrem Modell als eher *fortdauernde* Entwicklungsaufgabe begriffen zu werden scheint („the developmental task […] is the coordination of the subjective and objective dimensions of knowing“, Kuhn & Weinstock, 2002, S. 123) – welche zu keinem Zeitpunkt als vollkommen abgeschlossen angesehen werden kann. Basierend auf diesem Gedanken der epistemischen Entwicklung als einem fortwährenden *Kampf konkurrierender Ansichten* („struggle with competing views“) über die Subjektivität und Objektivität des Wissens (Barzilai & Weinstock, 2015, S. 156, siehe auch Kerwer und Rosman, 2020b), stellten Barzilai und Weinstock (2015) diese Annahme qualitativ distinkter Stadien folgerichtig in Frage. Sie plädierten dafür Absolutismus, Multiplismus und Evaluativismus als drei verschiedene epistemische Positionen zu betrachten und die individuelle Zustimmung zu diesen Positionen simultan auf separaten Skalen zu messen (Barzilai & Weinstock, 2015). Beispielsweise können Personen in diesem Rahmenwerk evaluativistischen Aussagen stark zustimmen, aber dennoch weiterhin bis zu einem gewissen Grad absolute und multiplistische Ansichten vertreten. Eine solche Operationalisierung epistemischer Entwicklung scheint der komplexen Natur epistemischer Überzeugungen eher gerecht zu werden als die Annahme qualitativ abgrenzbarer Entwicklungsstufen (Kerwer & Rosman, 2020b, aber vgl. auch Schommer-Aikins, 2002). Auch Krettenauer entwickelte bereits 2005 mit dem deutschsprachigen *Fragebogen*

zur Erfassung des Entwicklungsniveaus epistemologischer Überzeugungen (FREE) ein Messinstrument, welches prinzipiell eine solche simultane Erfassung von Kuhns Stufen als epistemische Positionen ermöglicht. Dieses Verfahren wurde in der Folge von Rosman, Mayer, Merk & Kerwer (2019) für den themenspezifischen (FREE-GST zum Thema „Geschlechterstereotypisierung an Gymnasien“) und domänenspezifischen (FREE-EDPSY zur Domäne „Pädagogische Psychologie“) Einsatz adaptiert (siehe Kapitel 2.1.2 zur Domänen- und Themenspezifität epistemischer Überzeugungen). Aus dieser Annahme simultan zustimmungsfähiger Positionen heraus ergibt sich darüber hinaus auch weiteres Potenzial zur Bildung von Aggregatmaßen zur Erfassung fortgeschrittener epistemischer Überzeugungen. So schlug Krettenauer (2005) die Bildung eines sogenannten D-Index vor, welcher die individuelle Zustimmung zur fortgeschrittenen Position, Evaluativismus, gegen die Zustimmung zu den beiden naiveren Positionen, Absolutismus und Multiplismus, gewichtet.

2.1.2 Die Theory of Integrated Domain in Personal Epistemology

Epistemische Überzeugungen sollten aber natürlich nicht losgelöst von ihrem Gegenstand betrachtet werden. So stellt sich selbstverständlich die Frage, auf welches konkrete Wissen (d. h. welche [Wissens-]Domäne) Individuen denn Bezug nehmen, wenn sie von ihren epistemischen Überzeugungen berichten. Rosman, Mayer, Kerwer & Krampen (2017) zeigten beispielsweise, dass sich studienfachbezogene Entwicklungsverläufe epistemischer Überzeugungen zwischen Informatikstudierenden und Psychologiestudierenden unterschieden. Unter Anderem waren absolute Überzeugungen von Psychologiestudierenden in Bezug auf ihr Studienfach zu Beginn der Studie bereits weniger stark ausgeprägt und änderten sich kaum während des Bachelorstudiums, während absolute Überzeugungen bei Informatikstudierenden sogar in den ersten Semestern ihres Studiums zunahmen. Auch wenn diese Studie zunächst „nur“ nahelegt, dass sich die Individuen in ihren epistemischen Überzeugungen bezüglich ihres *jeweiligen* Studienfachs unterschieden – also *inter*individuelle Unterschiede zwischen solchen Bereichen oder Wissens*domänen* bestehen, so illustriert dies doch die Notwendigkeit, die Domäne epistemischer Überzeugungen mit zu betrachten. In Übereinstimmung hiermit legt tatsächlich eine Vielzahl empirischer Befunde nahe, dass erhebliche *intra*individuelle Unterschiede in epistemischen Überzeugungen je nach Gegenstandsbereich vorliegen (siehe Buehl, Alexander & Murphy, 2002; Greene, Torney-Purta & Azevedo, 2010; Rosman, Seifried & Merk, 2020; Stahl & Bromme, 2007). Aufbauend auf solchen Befunden entwickelten Muis, Bendixen und Haerle (2006) die einflussreiche *Theory of Integrated Domain in Personal Epistemology* (TIDE). Die TIDE nimmt an, dass interdependente Ebenen epistemischer Überzeugungen existieren. Das heißt

beispielsweise, Individuen können innerhalb der Domäne *akademisches psychologisches Wissen* divergierende Überzeugungen in den Subdomänen *pädagogisch psychologisches Wissen* sowie *neuropsychologisches Wissen* haben. Diese Überzeugungen auf Ebene der Subdomänen beeinflussen wiederum die individuelle Wahrnehmung des Wissens der psychologischen Wissenschaft als Ganzes, während gleichzeitig Überzeugungen zur Psychologie als Ganzes auch die individuelle Wahrnehmung des Wissens der Subdomänen beeinflusst. Hieraus folgt auch, dass epistemische Entwicklung, die auf einer hierarchisch niedrigeren Ebene epistemischer Überzeugungen stattfindet, die Entwicklung auf hierarchisch höheren Ebenen beeinflussen sollte (Muis et al., 2006). Wie jüngst gezeigt wurde, lassen sich diese Grundgedanken der TIDE auch auf Themen (z. B. Forschung zu Geschlechterstereotypisierung im Bildungssystem) innerhalb von Subdomänen (z. B. pädagogische Psychologie) übertragen (Merk, Rosman, Muis, Kelava & Bohl, 2018).

2.2 Epistemischer Wandel

Kuhns in Kapitel 2.1.1 eingeführtes Modell beschreibt idealtypisch die über die Lebensspanne stattfindende „natürliche“ Entwicklung epistemischer Überzeugungen. Dies entspricht gewissermaßen einer „Makro“-Perspektive epistemischer Entwicklung. Nicht behandelt wird in Kuhns Modell hingegen, wie und unter welchen situativen Umständen sich Veränderungen epistemischer Überzeugungen *konkret* vollziehen. Diese prozessorientierte „Mikro“-Perspektive auf die Veränderung epistemischer Überzeugungen wird auch als *epistemischer Wandel* bezeichnet (Bråten, 2016; Kerwer & Rosman, 2020b; Muis et al., 2016). Im Folgenden wird mit dem Bendixen und Rule (2004) Modell das derzeit bedeutendste theoretische Rahmenwerk epistemischen Wandels vorgestellt (vgl. Bråten, 2016; Muis et al., 2016). Basierend auf dieser Vorstellung werden Forschungslücken und Konkretisierungsbedarfe hinsichtlich des dort vorgeschlagenen Mechanismus epistemischen Wandels identifiziert, die für die wissenschaftlichen Publikationen dieser Dissertationsschrift handlungsleitend waren.

2.2.1 Das Bendixen und Rule Modell epistemischen Wandels

Inspiriert von Modellen des konzeptuellen Wandels (z. B. Dole & Sinatra, 1998), ist das Herzstück von Bendixen und Rules *Integrative Personal Epistemology Model* (Bendixen, 2002; Bendixen & Rule, 2004; Bendixen, 2016; Rule & Bendixen, 2010) ein Mechanismus des epistemischen Wandels, der sich aus drei zentralen Prozesskomponenten zusammensetzt: *Epistemischen Zweifeln* (epistemic doubt), *epistemischer Volition* (epistemic volition) und *Lösungsstrategien* (resolution strategies). Epistemischer Zweifel wird hierbei definiert als das evidenzbasierte Hinterfragen der eigenen epistemischen Ausgangsüberzeugungen (Bendixen & Rule,

2004). Unter der zweiten Prozesskomponente, epistemischer Volition, wird hingegen der Wille, diese Zweifel aktiv anzugehen und sich mit etwaigen aufkommenden negativen Emotionen zielorientiert auseinanderzusetzen, verstanden (Rule & Bendixen, 2010). Die letzte Komponente, Lösungsstrategien, wiederum zielt auf den Einsatz effektiver Strategien zur Reduktion und Auflösung dieser Zweifel ab (Bendixen & Rule, 2004). Effektiv meint hierbei, dass die Auseinandersetzung mit epistemischen Zweifeln in einer Art und Weise geschieht, die ein Voranschreiten in Richtung fortgeschrittener epistemischer Überzeugungen ermöglicht (siehe Kapitel 2.1.1). Beispielhafte von Bendixen und Rule (2004) genannte Lösungsstrategien sind die Reflektion eigener Zweifel sowie der Zweifel auslösenden Evidenz oder die diesbezügliche soziale Interaktion mit Anderen. Abbildung 1 in Artikel III (Appendix C) veranschaulicht anhand eines fiktiven Fallbeispiels die Abfolge dieser Prozesskomponenten.

Der Mechanismus des epistemischen Wandels, wie er in diesem Modell konzeptualisiert wird, ist aber keineswegs als zwangsläufige und geradlinige Abfolge dieser Prozesskomponenten zu verstehen (Bendixen & Rule, 2004). Vielmehr ist eine Rückkehr zu den eigenen epistemischen Ausgangsüberzeugungen zu jedem Zeitpunkt möglich und keine der Prozesskomponenten garantiert für sich allein genommen epistemischen Wandel hin zu fortgeschrittenen Überzeugungen (Bendixen & Rule, 2004). Beispielsweise können Individuen aufkommende epistemische Zweifel schlicht ignorieren, wenn sie nur über ein unzureichendes Ausmaß epistemischer Volition verfügen (vgl. Rule & Bendixen, 2010).

Modellkomponenten des Bendixen und Rule Modells gehen aber über diese drei zentralen Prozesskomponenten hinaus (Bendixen & Rule, 2004; Rule & Bendixen, 2010). Das Modell umschließt zusätzlich diverse periphere Modellkomponenten, welche epistemischen Wandel potenziell beeinflussen können, wie Metakognitionen, Affekt oder kognitive Fertigkeiten (Bendixen & Rule, 2004). Schließlich findet innerhalb des Modells auch eine Diskussion der *Bedingungen des Wandels* (conditions for change) sowie eine Betrachtung *epistemischer Ausgangsüberzeugungen* (current beliefs) statt. Diese beiden Aspekte des Modells werden in den Kapiteln 2.2.3 und 2.2.4 detaillierter beleuchtet.

2.2.2 Empirische Testung der Prozesskomponenten des Bendixen und Rule Modells

Es mag überraschen, dass das Bendixen und Rule (2004) Modell trotz seiner Beliebtheit in der aktuellen Forschungspraxis derzeit nur mangelhaft empirisch validiert ist (Bråten, 2016). Maßgebliche empirische Vorarbeiten von Lisa Bendixen (2002), die zur Bildung ihres Modells führten, lassen sich ferner einer nicht-experimentellen qualitativen Forschungstradition zuordnen. Auch neuere qualitative Studien liefern allerdings nur teilweise modellkonforme (Lahtinen &

Pehkonen, 2013) und auch kontroverse Evidenz (Ferguson, Bråten & Strømsø, 2012). Insbesondere der zentrale Mechanismus epistemischen Wandels erscheint insgesamt noch unzureichend empirisch abgesichert zu sein (Bråten, 2016; Ferguson et al., 2012). Ein möglicher Grund hierfür könnte sein, dass, wie in Kapitel 1 dargelegt wurde, Interventionsprogramme traditionell häufig eher allgemein an einer Förderung der Entwicklung epistemischer Überzeugungen interessiert sind und hierfür simultan auf eine Vielzahl von Interventionskomponenten zurückgreifen. Eine isolierte Betrachtung einzelner Interventionsbestandteile mit direktem Bezug zu Bendixen und Rules (2004) Modellkomponenten und eine derart gestaltete „indirekte" Validierung des Modells über eine Analyse der in dieser Literatur bestehenden Evidenzbasis ist in der Konsequenz kaum möglich.

Experimentelle Kurzzeitintervention könnten hingegen ein potenziell mächtiges Werkzeug sein, um das Verständnis der Mechanismen epistemischen Wandels zu verbessern. Solche zeitlich eng umgrenzten und meist im Laborsetting stattfindenden Interventionen erlauben eine starke experimentelle Kontrolle und damit eine gezielte Manipulation einzelner Faktoren, die mit epistemischem Wandel in Verbindung gebracht werden (siehe aber auch Kerwer und Rosman, 2020b, zur Frage, ob epistemischem Wandel in Kurzzeitintervention und epistemischer Entwicklung dieselben Mechanismen zugrunde liegen). So analysierten beispielsweise Kienhues, Ferguson und Stahl (2016) bestehende aus Kurzzeitinterventionen stammende Evidenz zum Einfluss der Präsentation divergierender Informationen auf epistemischen Wandel und kamen zum Schluss, dass die Präsentation divergierende Evidenz epistemischen Wandel auszulösen scheint. Da divergierende Informationen das evidenzbasierte Hinterfragen naiver Überzeugungen, also epistemische Zweifel, durch eine Illustration der Subjektivität wissenschaftlichen Wissens in besonderem Maße induzieren sollten, wurde dies als bestätigende Evidenz für eine zentrale Rolle epistemischer Zweifel im Prozess epistemischen Wandels im Sinne des Bendixen und Rules (2004) Modells gewertet (Kienhues et al., 2016). Betrachtet man die von Kienhues und Kollegen (2016) analysierten Studien allerdings genauer, wird deutlich, dass der Großteil dieser Studien keine experimentelle Kontrolle über Scheininterventionen vornahm, wodurch die Aussagekraft dieser Studien geschmälert wird. So wurden Kontrollgruppen häufig als reine Wartebedingungen operationalisiert (z. B. Kienhues, Stadtler & Bromme, 2011). Zusätzlich wurde in den von Kienhues und Kollegen (2016) betrachteten Interventionen in der Regel die reine Präsentation divergierender Informationen, welche tatsächlich besonders stark mit der Prozesskomponente epistemischer Zweifel assoziiert sein sollte, mit reflektionsanregenden Instruktionen zur Integration präsentierter konfligierender Evidenz vermischt. Solche reflektionsanregenden Instruktion sollten allerdings nach Bendixen und Rules (2004) Modell

eher mit der Prozesskomponente der Lösungsstrategien eng in Verbindung stehen, da hier schon eine Auflösung epistemischer Zweifel durch deren Reflektion aktiv unterstützt wird. So wurden Teilnehmende in diesen Untersuchungen beispielsweise aufgefordert, einen fiktiven Freund zu beraten (Kienhues et al., 2011), ein Essay zu dem gegebenen kontroversen Thema zu verfassen (Ferguson, Bråten, Strømsø & Anmarkrud, 2013) oder die Inhalte in Kleingruppen zu diskutieren (Rosman, Mayer, Peter & Krampen, 2016). Rückschlüsse auf einzelne Prozesskomponenten sind auch in solchen Kurzzeitinterventionen damit derzeit leider nicht möglich, da nicht ausreichend zwischen Effekten einzelner Interventionskomponenten getrennt werden kann.

Ein zentrales Anliegen der Forschungsartikel dieser Dissertationsschrift war deshalb die Untersuchung der inkrementellen Effekte von Interventionskomponenten, die jeweils spezifisch auf eine der drei zentralen Prozesskomponenten des Bendixen und Rule (2004) Modells zugeschnitten waren, unter strikter experimenteller Kontrolle dieser inkrementellen Effekte durch die Nutzung von Scheininterventionen. Weitere Aspekte des Mechanismus epistemischen Wandels, welche in diesem Kontext betrachtet wurden, werden in den folgenden Kapiteln behandelt.

2.2.3 Die Art divergierender Evidenz als Bedingung epistemischen Wandels

Auch wenn in Bendixen und Rules (2004) Modell derzeit bereits Bedingungen des Wandels vorgesehen sind, werden diese eher auf einer generellen Ebene als *Dissonanz* (Dissonance) und *persönliche Relevanz* (Personal Relevance) beschrieben. Eine Diskussion spezifischer externer Auslöser des epistemischen Wandels fehlt hingegen komplett oder bleibt sehr vage (z. B. „individuals must feel that current beliefs are no longer working satisfactorily“, Bendixen & Rule, 2004, S. 74). Implizit geht allerdings aus der Definition von *Dissonanz* als einer der Bedingungen des Wandels hervor, dass die Wahrnehmung konfligierender Evidenz, welche nicht der eigenen Erwartungshaltung entspricht, ein Auslöser epistemischen Wandels sein kann. Auch die im vorrangegangen Kapitel vorgestellte Forschungslage zu Effekten divergierender Evidenz auf epistemischen Wandel deutet in diese Richtung (vgl. Kienhues et al., 2016). Eine spezifischere Klärung, wie verschiedene Arten konfligierender Evidenz sich konkret auf den resultierenden epistemischen Wandel niederschlagen könnten, wäre damit eine wünschenswerte Ausdifferenzierung des Modells und könnte zukünftige Forschungsarbeiten in der Operationalisierung der eher grob definierten Modellkomponente der Bedingungen epistemischen Wandels unterstützen. Dass sich die Entwicklung epistemischer Überzeugungen je nach Art der erhaltenen Information unterscheidet, ist augenscheinlich. So wurde im Kontext der Einführung der

Domänenspezifität epistemischer Überzeugungen in Kapitel 2.1.2 bereits eine Studie von Rosman et al. (2017) vorgestellt, welche divergierende Entwicklungsverläufe für Informatik- und Psychologiestudierende im Laufe ihres Bachelorstudiums nachwies. Die aufgefundenen disziplinspezifischen Unterschiede lassen sich nicht nur im Hinblick auf die Domänenspezifität epistemischer Überzeugungen interpretieren, sondern auch dahingehend, dass die epistemische Entwicklung der Studierenden davon abhing, ob sie Informationen (curriculare Inhalte) der Psychologie (einer im Vergleich zur Informatik eher weichen Sozialwissenschaft) oder der Informatik (einer im Vergleich zur Psychologie eher härteren stärker mathematisch-orientierten Wissenschaft) erhielten.

Basierend auf der Idee, dass verschiedene Arten divergierender Evidenz epistemischen Wandel in unterschiedlichem Ausmaß unterstützen sollten und damit eine wichtige Bedingung epistemischen Wandels bilden, entwickelten Rosman und Kollegen ein Interventionskonzept, das auf der Präsentation auflösbarer Widersprüche beruht, sogenannter *Resolvable Controversies* (Rosman et al., 2016; Rosman & Mayer, 2018; Rosman et al., 2019). Die Grundidee von Resolvable Controversies ist nach der Terminologie von Kuhns Modell (siehe Kapitel 2.1.1), dass auflösbare Widersprüche sowohl naive absolute Positionen (da Widersprüche existieren), als auch naive multiplistische Positionen (da Widersprüche integrierbar sind) hinterfragen sollten, während sie gleichzeitig Prinzipien fortgeschrittenen evaluativistischen Denkens illustrieren (Rosman et al., 2019). Zur Umsetzung dieser Interventionsidee wurde auf das Thema „Geschlechterstereotypisierung an Gymnasien“ zurückgegriffen (Rosman et al., 2019). Durch die Präsentation verschiedener Kurztexte wurde beispielsweise (wahrheitsgetreu) suggeriert, dass wissenschaftliche Evidenz auf eine fächerabhängige Diskriminierung von Jungen (in sprachlichen Fächern wie Deutsch) und Mädchen (in naturwissenschaftlichen Fächern wie Mathematik) hinweise, während in anderen Fächern (wie Geschichte) keinerlei Diskriminierung stattfinde. Zur Umsetzung dieses Interventionsansatzes administrierten Rosman et al. (2019) zunächst solche auflösbaren Widersprüche in einer Leseaufgabe, während die Reflektion und Integration der Widersprüche anschließend durch eine Schreibaufgabe unterstützt wurde. Diese Unterstützung war derart gestaltet, dass in einer Schreibaufgabe die Integration der widersprüchlichen Evidenz über die explizite Identifikation der Bedingungen, unter denen eine etwaige Diskriminierung stattfand, erleichtert wurde. Obwohl die Gesamtwirksamkeit dieser Intervention von Rosman et al. (2019) etabliert wurde, wurde der unterstellte Wirkmechanismus (dass eben die Auflösbarkeit der präsentierten Widersprüche ein entscheidender Faktor sei) aber in keiner der hierzu durchgeführten Studien unter kontrollierten experimentellen Bedingungen empirisch getestet.

Vor allem ein Vergleich zu „normalen“, nicht innerhalb derselben Materialien anhand von Kontextfaktoren auflösbaren Widersprüchen, scheint notwendig zu sein, um den von Rosman et al. (2019) angenommenen Wirkmechanismus zu validieren. Über die Validierung dieses spezifischen Wirkmechanismus hinaus könnte so auch allgemein unser Verständnis davon verbessert werden, welche konkreten Rahmenbedingungen epistemischen Wandel in besonderem Ausmaß begünstigen und welche nicht.

2.2.4 Epistemische Ausgangsüberzeugungen als Bedingung epistemischen Wandels

Wie oben beschrieben wurde, stellt die Wahrnehmung einer Dissonanz, welche zu epistemischen Zweifeln führt, eine zentrale Bedingung epistemischen Wandels in Bendixen und Rules (2004) Modell dar. Ausgehend von Festingers klassischen Werken zur kognitiven Dissonanz (z. B. Festinger, Riecken & Schachter, 1956) lässt sich ableiten, dass die Wahrnehmung kognitiver Dissonanz wesentlich von den aktuellen epistemischen Überzeugungen eines Individuums abhängt. Individuen, die beispielsweise bereits evaluativistische Positionen vertreten sowie absolute und multiplistische Positionen ablehnen, werden kaum ihre bisherigen Überzeugungen hinterfragen, wenn sie mit auflösbaren Widersprüchen konfrontiert werden, da diese bereits mit ihrem bestehenden Überzeugungsmuster in Einklang sind. In Bendixen und Rules (2004) Modell wurde die Verbindung zwischen Bedingungen des Wandels und Ausgangsüberzeugungen allerdings nur einseitig in Richtung der Ausgangsüberzeugungen konzipiert, um anzuzeigen, dass in jeder Phase des epistemischen Veränderungsprozesses eine Rückkehr zu bisherigen epistemischen Überzeugungen möglich ist. Die hierdurch implizierte Einseitigkeit der Beziehung zwischen Ausgangsüberzeugungen und Bedingungen des Wandels lässt allerdings den oben skizzierten Einfluss der Ausgangsüberzeugungen als Determinante kognitiver Dissonanz, welche wiederum eine wesentliche Bedingung des Wandels darstellt, außer Acht. Um der Komplexität dieser Beziehung zwischen Ausgangsüberzeugungen und Bedingungen des Wandels gerecht zu werden, erscheint deswegen die Annahme einer bidirektionalen Beziehung zwischen beiden Modellkomponenten sinnvoll: Je nach Bedingungen des Wandels kann zwar eine Rückkehr zu Ausgangsüberzeugungen stattfinden (z. B. wenn keine Dissonanz auftritt), die Ausgangsüberzeugungen selbst sollten darüber hinaus aber auch eine wesentliche Determinante der Bedingungen des Wandels sein, da das Ausmaß kognitiver Dissonanz von ihnen maßgeblich mitbestimmt wird.

2.2.5 Domänenspezifität epistemischen Wandels

Die Domänenspezifität epistemischer Überzeugungen (siehe Kapitel 2.1.2) spielt tatsächlich in der 2004 von Bendixen und Rule vorgenommenen Konzeptualisierung der Mechanismen epistemischen Wandels kaum eine Rolle. Da Bendixen und Rules (2004) Modell explizit den Anspruch erhebt ein integratives Modell epistemischen Wandels zu sein und Lisa Bendixen auch selbst mit an der Entwicklung der TIDE beteiligt war, ist diese Nichtberücksichtigung der Domänenspezifität überraschend. Darüber hinaus argumentierten Bråten und Strømsø (2010) im Hinblick auf Lernerfolg, dass Zusammenhänge zwischen Interventionseffekten und epistemischen Überzeugungen am stärksten zu Tage treten sollten, wenn Intervention und epistemische Überzeugungen eine starke themenspezifische Korrespondenz aufweisen. Ausgehend hiervon ist es durchaus plausibel anzunehmen, dass das Ausmaß epistemischen Wandels auch von der Themen- oder Domänenspezifität etwaiger epistemischer Zweifel auslösender Informationen abhängen könnte. Die Nichtbetrachtung von Domänenspezifität im Prozess epistemischen Wandels des Bendixen und Rule (2004) Modells könnte auch schlicht darauf zurückzuführen sein, dass die TIDE zeitlich jünger als Bendixen und Rules (2004) Modell ist. Spätere Ausführungen von Lisa Bendixen zur Rolle der Argumentation für epistemischen Wandel könnten diese Annahme stützen (Bendixen, 2016). So schlägt Lisa Bendixen dort beispielsweise vor, dass das Erlernen wissenschaftlicher Argumentation in besonderem Maße über den fachspezifischen Kontext hinaus epistemischen Wandel in verschiedenen akademischen Kontexten fördern sollte (Bendixen, 2016). Zumindest implizit scheint hier also von ihr eine Domänenspezifität epistemischen Wandels im Sinne einer unterschiedlichen Generalisierung von Interventionseffekten angenommen zu werden. Eine Untersuchung der Domänen- und Kontextspezifität epistemischen Wandels sowie gegebenenfalls eine diesbezügliche Erweiterung des Bendixen und Rule (2004) Modells erscheint demzufolge angeraten zu sein.

2.3 Forschungsfragen

Basierend auf dem vorgestellten Forschungsstand wurden in den Forschungsartikeln der vorliegenden Dissertationsschrift folgende Forschungsfragen adressiert, die auf die empirische Prüfung der Rolle der drei zentralen Prozesskomponenten des Mechanismus epistemischen Wandels in Bendixen und Rules (2004) Modell abzielten:

Forschungsfrage 1: Führt die reine Präsentation divergierender Informationen, welche mit der Prozesskomponente epistemischer Zweifel assoziiert sein sollte, zu mehr epistemischem Wandel als eine Kontrollintervention?

Forschungsfrage 2: Führt die Administration einer Intervention, die epistemische Volition stärkt, zu inkrementellen Effekten auf epistemischen Wandel im Vergleich zur reinen Induktion epistemischer Zweifel über die Präsentation divergierender Evidenz?

Forschungsfrage 3: Führt die Reflektion zu divergierender Evidenz, welche mit der Lösungsstrategie-Prozesskomponente assoziiert sein sollte, zu inkrementellen Effekten auf epistemischen Wandel im Vergleich zur reinen Induktion epistemischer Zweifel über die Präsentation divergierender Evidenz?

Darüber hinaus wurde in diesem Kontext auch untersucht, inwiefern die (Un-)Auflösbarkeit widersprüchlicher Evidenz sowie epistemische Ausgangsüberzeugungen wichtige Bedingungen epistemischen Wandels darstellen.

Forschungsfrage 4: Führt die Konfrontation mit integrierbarer divergierender Evidenz (auflösbaren Widersprüchen) zu einem stärkeren epistemischen Wandel als die Konfrontation mit nicht-integrierbarer divergierender Evidenz (unauflösbaren Widersprüchen)?

Forschungsfrage 5: Welche Rolle spielen epistemische Ausgangsüberzeugungen für den Prozess epistemischen Wandels?

Die letzte Forschungsfrage dieser Dissertationsschrift beschäftigte sich schließlich mit der Domänenspezifität epistemischen Wandels:

Forschungsfrage 6: Welche Rolle spielt die Domänenspezifität epistemischer Überzeugungen für den Prozess epistemischen Wandels?

Im Folgenden findet eine Zusammenfassung und Diskussion der drei empirischen Forschungsartikel statt, welche dieses Forschungsprogramm bearbeiteten.

3 Mechanisms of epistemic change – Under which circumstances does diverging information support epistemic development? (Kerwer & Rosman, 2018)

Der in diesem Kapitel vorgestellte erste Forschungsartikel behandelte vorrangig Forschungsfragen 1, 3, 4 und 6 des in Abschnitt 2.3 eingeführten Forschungsprogramms der Dissertation. Der Artikel wurde in der Zeitschrift *Frontiers in Psychology* am 22.11.2018 publiziert und ist als Open Access Publikation auf der Website des Verlags frei zugänglich. Als Teil des Research Topics *Development of Student Understanding: Focus on Science Education* ist er darüber hinaus auch Teil eines im Januar 2020 veröffentlichten eBooks. Die Originalfassung des Artikels findet sich in Appendix A.

3.1 Zusammenfassung

Um die Auswirkungen der Präsentation (un)auflösbarer Widersprüche, sowie einer reflektionsunterstützenden Schreibaufgabe auf epistemischen Wandel zu untersuchen, wurden innerhalb einer präregistrierten Studie vier experimentelle Bedingungen realisiert: Zur Testung von Forschungsfrage 1 (Effekte des reinen Lesens divergierender Information) wurde epistemischer Wandel in einer Kontrollgruppe, in der Individuen nicht-divergierende Informationen zum Thema „Lernstrategien im Studium“ erhielten, mit dem Wandel in einer Experimentalgruppe verglichen. Diese Experimentalgruppe erhielt divergierende Informationen mit auflösbaren Widersprüchen zum Thema „Geschlechterstereotypisierung an Gymnasien“ (d. h. die Leseaufgabe der Resolvable Controversies Intervention, siehe Kapitel 2.2.3 sowie Rosman et al., 2019). Inkrementelle Effekte der Lösungsstrategie *Reflektion* (Forschungsfrage 3) wurden wiederum über einen Vergleich dieser Gruppe, die auflösbaren Widersprüche las, zu einer dritten Gruppe, die zusätzlich die reflektionsanregende Schreibaufgabe der Resolvable Controversies Intervention erhielt, realisiert (siehe Kapitel 2.2.3 sowie Rosman et al., 2019). Um Forschungsfrage 4 zu untersuchen, wurde eine alternative Version von Resolvable Controversies entwickelt, mit dem Ziel unauflösbare divergierende Informationen darbieten zu können. Hierzu wurde der Einfluss der Kontextfaktoren, die eine Integration der präsentierten Widersprüche zu Geschlechterstereotypisierung ermöglichen, maskiert. Im in Kapitel 2.2.3 eingeführten Beispiel der fächerabhängigen Diskriminierung von Jungen beziehungsweise Mädchen hieß es nun beispielsweise nicht mehr, dass Jungen in Deutsch und Mädchen in Mathematik diskriminiert wurden, während in Geschichte keine Diskriminierung vorlag. Stattdessen wurde nun suggeriert, dass in Deutsch und Mathematik scheinbar zufällig durch manche Studien eine Diskriminierung von Mädchen gefunden wurde und durch andere eine Diskriminierung von Jungen (das Muster

in Geschichte blieb hiervon unbeeinflusst). Um zusätzlich Forschungsfrage 6 untersuchen zu können, wurden epistemische Überzeugungen nach Kuhn (vgl. Kapitel 2.1.1) per Selbstbericht auf themenspezifischer Ebene (epistemische Überzeugungen zum Thema „Forschung zu Geschlechterstereotypisierung an Gymnasien“) und auf domänenspezifischer Ebene (epistemische Überzeugungen zur Domäne „Pädagogische Psychologie“) erfasst. Ausgehend von Bråten und Strømsø (2010) sowie den Annahmen der (erweiterten) TIDE (Merk et al., 2018; Muis et al., 2006) wurde in diesem Kontext angenommen, dass Effekte der themenspezifischen Intervention signifikant höher auf themenspezifischen Maßen im Vergleich zu domänenspezifischen Maßen sein sollten. Methodisch wurde epistemischer Wandel in einem Prä-Post-Studiendesign als Zu- beziehungsweise Abnahme der Zustimmung zu den epistemischen Positionen nach Kuhn, welche als Skalen auf diesen Messinstrumenten erfasst wurden, operationalisiert. Eine Analyse dieser Veränderungen fand über Strukturgleichungsmodelle als *Latent Difference Scores* (McArdle, 2009) statt. Die Prämessung epistemischer Überzeugungen wurde online mindestens eine Woche vor der Intervention durchgeführt und die Postmessung als Gruppen-Präsenzerhebung in den PC-Pools der Psychologie der Universität Trier unmittelbar nach der Intervention. Vor der Datenerhebung wurde die Studie auf dem Open Science Framework präregistriert (https://osf.io/te7wk).

Insgesamt konnten N = 185 Psychologiestudierende für die Studie rekrutiert werden. Auf deskriptiver Ebene wurde das bezüglich Forschungsfrage 1 und 3 erwartete Wirkungsmuster größtenteils aufgefunden: Mit anderen Worten, die größte Veränderung in Richtung fortgeschrittener epistemischer Überzeugungen[1] wurde bei Teilnehmenden beobachtet, die eine zusätzliche reflektionsunterstützende Schreibaufgabe erhielten (b = 0.688, p < .001), während Effekte des reinen Lesens aufklärbarer Widersprüche (b = 0.477, p < .001) deskriptiv stärker waren, als Veränderungen in der Kontrollbedingung (b = 0.256, p = .026). Veränderungen, die durch das Lesen *un*auflösbarer Widersprüche ausgelöst wurden, waren aber überraschenderweise sogar deskriptiv leicht größer (b = 0.546, p < .001) als solche Veränderungen, die durch das Lesen auflösbarer Widersprüche ausgelöst wurden. In konfirmativen inferenzstatistischen Analysen wurde allerdings das präregistrierte Kriterium für einen signifikanten Gruppenunterschied im epistemischen Wandel nicht erreicht (alle $\Delta\chi^2 < 6.233$, df = 3, alle p > .100). Explorative Analysen deuteten jedoch darauf hin, dass dies auf Powerprobleme beziehungsweise eine

[1]Berichtet werden hier zur besseren Vergleichbarkeit der Befunde über die drei Forschungsartikel hinweg, standardisierte Ergebnisse auf dem D-Index, einem Aggregatmaß fortgeschrittener Überzeugungen. Die entsprechenden gruppenspezifischen Regressionskoeffizienten wurden in Artikel I aufgrund der Nichtsignifikanz des konfirmativen Tests auf Gruppenunterschiede nicht berichtet.

sehr restriktive statistische Methodik in konfirmativen Analysen zurückzuführen sein könnte. So konnte beispielsweise gezeigt werden, dass auf dem D-Index, einem Aggregatmaß fortgeschrittener Überzeugungen, konsistente Unterschiede im epistemischen Wandel in den Interventionsgruppen verglichen mit dem epistemischen Wandel in der Kontrollgruppe vorlagen (b = 0.304[2], p = .018), wobei epistemischer Wandel in der Kontrollgruppe überraschenderweise auch in dieser Analyse signifikant blieb (b = 0.256[2], p = .027). Über alle Interventionsgruppen hinweg zeigte sich außerdem in explorativen Analysen ein signifikant größeres Ausmaß epistemischer Veränderungen in Richtung fortgeschrittener Überzeugungen im Vergleich zur Kontrollgruppe für themenspezifischen Multiplismus (b = - 0.313[2], p = .045), und Evaluativismus (b = 0.289[2], p = .035). In Bezug auf Forschungsfrage 6 waren in explorativen Analysen aufgefundene Interventionseffekte ferner auf themenspezifischen Maßen, außer für Evaluativismus ($\Delta\chi^2$ = 2.973, df = 2, p = .226), stets signifikant größer als auf domänenspezifischen Maßen (alle $\Delta\chi^2$ > 6.329, df = 2, alle p < .042).

3.2 Diskussion

Bezüglich Forschungsfrage 1, der Effekte einer reinen Präsentation divergierender Informationen auf epistemischen Wandel, bleiben die Ergebnisse des ersten Forschungsartikels leider unschlüssig. Konfirmative Analysen konnten die Existenz solch inkrementeller Effekte für sich genommen, zumindest im Vergleich zu einer Kontrollgruppe, nicht nachweisen. Explorative Analysen bestätigen zwar die Gesamtwirksamkeit der Präsentation divergierender Evidenz, auch im Vergleich zu einer Kontrollgruppe. Es kann aber nicht ausgeschlossen werden, dass dieser Effekt vor allem durch die reflektionsunterstützende Schreibaufgabe (die in diese Analyse mit einging) verursacht wurde und damit nicht auf die reine Präsentation divergierender Evidenz zurückzuführen sein könnte. Dass allerdings auch eine Gruppe, die eine Scheinintervention erhielt, beträchtlichen epistemischen Wandel erlebte, könnte darauf hindeuten, dass das Ausbleiben von signifikanten Gruppenunterschieden in den konfirmativen Analysen unter anderem auf erhebliche Kontrollgruppeneffekte zurückzuführen sein könnte. Zur abschließenden Bewertung von Forschungsfrage 1 war es deshalb unter anderem notwendig, diese Kontrollgruppeneffekte näher zu beleuchten. Eine plausible Erklärung für diese Kontrollgruppeneffekte schien zu sein, dass die Art der Darbietung der Informationen in der Kontrollgruppe (eine vergleichende Bewertung von Lernstrategien anhand diverser Kriterien) dafür sorgte, dass die

[2]Zur besseren Vergleichbarkeit der Befunde über die Forschungsartikel hinweg wurden diese Effektschätzer standardisiert. In Artikel I wurden Befunde nicht standardisiert, wodurch es zu geringfügigen Abweichungen in den berichteten absoluten Werten zwischen Dissertationsschrift und Forschungsartikel kommt.

Kontrollintervention von den Probanden als Präsentation divergierender Evidenz zum Thema „Lernstrategien“ betrachtet wurde. Sollte dies zutreffen, hätte auch die Kontrollaufgabe epistemische Zweifel in der Domäne „Pädagogische Psychologie“ induzieren können, die sich nach der TIDE auch auf andere Themen (z. B. Forschung zu Geschlechterstereotypisierung) in dieser Domäne übertragen sollten. Um eine finale Bewertung von Forschungsfrage 1 zu erlauben, wurde deshalb in Artikel II innerhalb einer Folgestudie eine entsprechende Modifikation der Kontrollaufgabe durchgeführt.

Obwohl hinsichtlich der Rolle der Reflektion divergierender Evidenz (Forschungsfrage 3) ähnliche Probleme bestehen, lässt sich die Befundlage des Forschungsartikels dahingehend doch etwas leichter einordnen. Ungeachtet etwaiger Kontrollgruppeneffekte sollten sich inkrementelle Effekte der Reflektion auf epistemischen Wandel nämlich trotzdem im Vergleich zu den anderen drei Experimentalbedingungen der Studie zeigen, in denen die Reflektion der Befunde nicht gezielt unterstützt wurde. Da kein Unterschied im epistemischen Wandel zwischen den Interventionsbedingungen festgestellt werden konnte, scheint in der Konsequenz kein allzu großer inkrementeller Effekt der reflektionsunterstützenden Schreibaufgabe vorzuliegen. Allerdings sind solche Schlussfolgerungen auf Grundlage nicht signifikanter Befunde in ihrer Aussagekraft selbstredend eher begrenzt und spekulativ – auch wenn sie auf präregistrierten Studien mit Stichprobenumfangsplanung beruhen. Ferner deuten deskriptive Befunde dieses Artikels sowie eine Reanalyse der Daten dieses Artikels in Rosman et al. (2019) darauf hin, dass inkrementelle Effekte der Reflektion divergierender Evidenz durch eine reflektionsunterstützende Schreibaufgabe im Vergleich zum reinen Lesen auflösbarer divergierender Evidenz durchaus vorliegen könnten.

Bezüglich Forschungsfrage 4, dem Vergleich der Effekte auflösbarer und unauflösbarer divergierender Informationen, wurde in Artikel I kein signifikanter Unterschied gefunden. Dies könnte als Evidenz gegen den unterstellten Wirkmechanismus der Resolvable Controversies Intervention – dass die Auflösbarkeit präsentierter Widersprüche epistemischen Wandel fördere – gewertet werden. Eine mögliche Alternativerklärung für das Ausbleiben solcher Unterschiede könnte aber auch sein, dass die Modifikation der Texte der Resolvable Controversies Intervention zur Schaffung unauflösbarer Widersprüche nicht weit genug ging. Die Studierenden könnten beispielsweise gelernt haben, dass Evidenz zur Geschlechterdiskriminierung in bestimmten Fächern (z. B. Deutsch und Mathematik) scheinbar widersprüchlich ist, während in anderen Fächern, wie Geschichte, Konsens dazu besteht, dass keine Diskriminierung existiert. Dies käme durchaus auch einer Illustration evaluativistischen Denkens im Sinne der Grundidee von

Resolvable Controversies gleich. Auch Forschungsfrage 4 wurde deshalb in Artikel II weiter untersucht, um diesbezüglich zu einer klaren Konklusion zu kommen.

Hinsichtlich Forschungsfrage 6, der Domänenspezifität epistemischen Wandels, zeigte sich hingegen in den meisten Fällen, in denen signifikante Interventionseffekte gefunden wurden, dass die Präsentation themenspezifischer divergierender Informationen sich signifikant stärker auf themenspezifischen epistemischen Wandel auswirkte als auf den Wandel auf domänenspezifischen Maßen. Darüber hinaus könnten – in Abhängigkeit der Ergebnisse der Folgearbeiten – auch die unerwarteten Kontrollgruppeneffekte dieses Artikels potenziell als Evidenz für das erweiterte TIDE Modell (Merk et al., 2018) interpretiert werden, da hier möglicherweise Effekte von einem Thema „Lernstrategien“ zu einem anderen Thema „Geschlechterstereotypisierung“ innerhalb derselben Subdomäne „Pädagogische Psychologie“ übertragen wurden.

4 Epistemic change and diverging information: How do prior epistemic beliefs affect the efficacy of short-term interventions? (Kerwer & Rosman, 2020a)

Der zweite Forschungsartikel dieser Dissertationsschrift wurde als direkte Folgestudie basierend auf den Befunden von Artikel I konzipiert. Um Forschungsfragen 1 und 4 abschließend beantworten zu können, wurden fortführende Analysen zu den Auswirkungen der Präsentation divergierender Informationen auf epistemische Veränderungen sowie zu differenziellen Effekten auflösbarer und unauflösbarer divergierender Informationen durchgeführt. Auch die Effekte epistemischer Ausgangsüberzeugungen auf epistemischen Wandel (Forschungsfrage 5) konnten mit einem vergleichsweise großen Stichprobenumfang in diesem Forschungsartikel untersucht werden. Der Artikel wurde am 24.05.2020 als *Advance Online Publication* der Zeitschrift *Learning and Individual Differences* veröffentlicht und ist auf den Seiten des Verlags frei zugänglich. Die Originalfassung des Artikels findet sich in Appendix B.

4.1 Zusammenfassung

Artikel II nutzte erneut ein einfaches Prä-Post-Design zur Untersuchung epistemischen Wandels. Hierbei wurde allerdings auf einen Einschluss der Schreibaufgabe aus Artikel I verzichtet, weswegen es nur drei Experimentalbedingungen gab. Die erste Experimentalgruppe erhielt auflösbare divergierende Evidenz, welche identisch mit der Evidenz war, die der Gruppe präsentiert wurde, welche auflösbare divergierende Evidenz in Artikel I las. In einer zweiten Experimentalgruppe wurden unauflösbare Widersprüche präsentiert. Die in Artikel I eingesetzten Interventionsmaterialien wurden hierzu modifiziert, um den in der Diskussion dieses Artikels beschriebenen möglichen Integrationsmechanismus zu maskieren. Zum Beispiel wurde in den präsentierten Informationen nun suggeriert, dass die Evidenz zu Geschlechterdiskriminierung an Gymnasien ohne Ausnahme in allen Fächern widersprüchlich sei. In einer dritten Experimentalgruppe wurde schließlich auch die in Artikel I genutzte Kontrollaufgabe zu nicht-divergierender Evidenz überarbeitet, um die oben beschriebene mögliche Wahrnehmung dieser Informationen als divergierende Evidenz zum Thema Lernstrategien zu unterbinden. Zu diesem Zweck fand eine separate Präsentation der Lernstrategie-Texte und eine Verschiebung des Aufgabenfokus weg von einer vergleichenden Bewertung der Lernstrategien hin zu einer Einschätzung der persönlichen Präferenz einzelner Strategien statt. Ferner wurde epistemischer Wandel in diesem Artikel nicht mehr in einer reinen Population von Psychologiestudierenden untersucht, sondern in einer fächerübergreifenden studentischen Population. Um diesem Fakt Rechnung zu tragen, wurde der epistemische Wandel nicht nur auf einer themenspezifischen Ebene

(über den FREE-GST, Rosman et al., 2019), sondern auch auf einer domänenübergreifenden Ebene (über den FREE, Krettenauer, 2005), erfasst. Die Studie wurde vor ihrer Durchführung auf PsychArchives präregistriert (http://dx.doi.org/10.23668/psycharchives.937).

Prämessung, Intervention und Postmessung fanden online an einem einzigen Messzeitpunkt statt, wobei die Probandenrekrutierung über den Paneldienstleister Respondi (https://www.respondi.com/) realisiert wurde. Insgesamt N = 509 Universitätsstudierende verschiedenster Disziplinen nahmen an der Studie teil. Im Hinblick auf Forschungsfrage 1 der Dissertationsschrift zeigte sich hierbei, dass sowohl auflösbare (b = 0.138, p = .038) als auch unauflösbare (b = 0.135, p = .042) divergierende Evidenz den themenspezifischen Wandel hin zu fortgeschrittenen epistemischen Überzeugungen im Vergleich zu einer Kontrollgruppe (b = - 0.011, p = .848) begünstigte. Keinerlei Effekte zeigten sich allerdings für domänenübergreifende epistemische Überzeugungen sowohl in Bezug auf Gruppenunterschiede als auch in Bezug auf Änderungen insgesamt (alle p > .057). Darüber hinaus lagen auch keinerlei signifikante Gruppenunterschiede im epistemischen Wandel zwischen auflösbarer und unauflösbarer divergierender Evidenz vor (b = - 0.003, p = .972, Forschungsfrage 4). Hinsichtlich Forschungsfrage 5, der Rolle epistemischer Ausgangsüberzeugungen im epistemischen Wandel, konnte in konfirmativen und explorativen Analysen ferner gezeigt werden, dass themenspezifischer epistemischer Wandel hin zu fortgeschrittenen Überzeugungen in beiden Experimentalgruppen, die divergierende Evidenz erhielten, für Teilnehmende mit naiven Ausgangsüberzeugungen stärker ausgeprägt war als für Teilnehmende, die fortgeschrittene epistemische Ausgangsüberzeugungen aufwiesen (alle b < - 0.237, alle p < .001). Weitere explorative Analysen zeigten ferner, dass dieses Muster für auflösbare divergierende Evidenz durch einen quadratischen Trend ergänzt wurde (b = 0.103, p = .005). Diesem Trend zufolge waren Veränderungen hin zu fortgeschrittenen Überzeugungen in Individuen mit stark naiven aber auch stark fortgeschrittenen Überzeugungen besonders ausgeprägt. Derselbe Trend zeigte sich – allerdings nur auf deskriptiver Ebene – auch für domänenübergreifende Überzeugungen sowie für unauflösbare divergierende Evidenz.

4.2 Diskussion

Die in Artikel II aufgefundene Befundlage ermöglicht tiefere Einsichten hinsichtlich Forschungsfrage 1. Divergierende Informationen förderten in dieser Studie epistemischen Wandel, auch wenn auf die Administration einer reflektionsunterstützenden Schreibaufgabe verzichtet wurde. Da diese divergierende Evidenz explizit auf die Induktion epistemischer Zweifel ausgerichtet war, bestätigt dies Bendixen und Rules (2004) Modell im Hinblick auf eine zentrale

Rolle epistemischer Zweifel im Prozess des epistemischen Wandels. Ein höheres Ausmaß epistemischen Wandels lag aber – verglichen mit nicht-divergierender Evidenz – sowohl für auflösbare als auch für unauflösbare divergierende Evidenz vor. Wie in Artikel I konnten damit auch in Artikel II keinerlei Unterschiede im epistemischen Wandel für diese beiden Typen divergierender Evidenz gefunden werden. In der Zusammenschau mit Artikel I zeigt sich damit bezüglich Forschungsfrage 4 vergleichsweise eindeutig, dass auflösbare Widersprüche und unauflösbare Widersprüche epistemischen Wandel in vergleichbarem Ausmaß zu fördern scheinen.

Hinsichtlich Forschungsfrage 5 lässt sich festhalten, dass in Artikel II eindeutig Evidenz für die Rolle epistemischer Ausgangsüberzeugungen als wesentliche Determinante epistemischen Wandels gefunden wurde. In Einklang mit den Annahmen der kognitiven Dissonanztheorie (Festinger, 1957) profitieren Individuen mit naiveren epistemischen Überzeugungen eher von der Präsentation divergierender Informationen. Eine Stärke des zweiten Forschungsartikels ist hierbei, dass anders als bei früheren Studien (z. B. Kienhues, Bromme & Stahl, 2008) auch durchschnittliche (und nicht nur fortgeschrittene und naive) epistemische Überzeugungen analysiert wurden sowie eine passive Kontrollgruppe verwendet wurde. So kann in der vorliegenden Arbeit ausgeschlossen werden, dass es sich bei den beobachteten Effekten epistemischer Ausgangsüberzeugungen um artifizielle durch Regression zur Mitte (Zwingmann & Wirtz, 2005) verursachte Effekte handelt. Dass das Ausmaß der zu erwartenden kognitiven Dissonanz das Ausmaß epistemischen Wandels mitbestimmt, kann ferner auch als Evidenz für Dissonanz als Bedingung epistemischen Wandels interpretiert werden (Bendixen & Rule, 2004). In den explorativen Analysen von Artikel II wurde außerdem ein quadratischer Effekt epistemischer Ausgangsüberzeugungen gefunden. Dieser Effekt deutete darauf hin, dass epistemischer Wandel bei Individuen mit weit fortgeschrittenen Ausgangsüberzeugungen verstärkt ausgeprägt war. Dies stützt wiederum Rule und Bendixens (2010) Annahme, dass epistemische Überzeugungen selbst Schemata zur Verarbeitung von (divergierender) Evidenz darstellen, welche im Fall einer Übereinstimmung zwischen epistemischen Überzeugungen und der Natur der präsentierten Evidenz die Verarbeitung ebendieser Evidenz erleichtern (vgl. auch consistency hypothesis, Muis & Franco, 2010; Muis, Kendeou & Franco, 2011). Im Fall von Artikel II drückt sich dies darin aus, dass Individuen mit fortgeschrittenen epistemischen Überzeugungen stärker von der Präsentation auflösbarer divergierender Evidenz profitieren, welche im Einklang mit solchem fortgeschrittenen epistemischen Denken ist.

Schließlich erlaubt die in diesem Artikel aufgefundene Effektlage aber natürlich auch Rückschlüsse auf die Domänenspezifität epistemischen Wandels (Forschungsfrage 6). Dass sich keine (Transfer)Effekte der themenspezifischen Intervention auf domänenübergreifenden epistemischen Wandel (gemessen durch den FREE) zeigen, mag ausgehend von der TIDE (Merk et al., 2018; Muis et al., 2006) zunächst überraschen. Auch wenn eine Auslegung von Nullbefunden natürlich immer spekulativ ist, sollte eine vorsichtige Interpretation dieses Nullbefunds vor dem Hintergrund einer präregistrierten Stichprobenumfangsplanung, welche eine Power von über .95 für die Detektion selbst kleiner Effekte anzeigt, in diesem Fall möglich sein. So ist es durchaus plausibel, dieses Effektmuster innerhalb der TIDE dahingehend zu interpretieren, dass der Transfer themenspezifischen Wandels zu „Forschung zu Geschlechterstereotypisierung an Gymnasien“ auf die darüber liegende Domäne „Psychologie als Wissenschaft“ bis hin zu einer noch höheren weiter generalisierten Ebene epistemischer Überzeugungen „allgemein“, welche durch den FREE erfasst wird, schlicht zu weit ist (siehe auch Kapitel 6 für eine zusammenfassende Bewertung der Evidenz zu dieser Forschungsfrage).

5 Disentangling the process of epistemic change: The role of epistemic volition (Kerwer, Rosman, Wedderhoff & Chasiotis, 2020)

Der dritte Fachartikel dieser Dissertationsschrift adressierte vorrangig die Rolle epistemischer Volition im Prozess epistemischen Wandels (Forschungsfrage 2). Gleichzeitig erlauben die in diesem Artikel verwendeten Kontrollbedingungen und Maße epistemischer Überzeugungen aber auch Rückschlüsse hinsichtlich der Rolle epistemischer Zweifel und der Domänenspezifität epistemischen Wandels (Forschungsfragen 1 und 6). Der Artikel wurde am 07.11.2018 als Registered Report bei der Zeitschrift *British Journal of Educational Psychology* eingereicht und erhielt am 01.04.2019 „in-principle acceptance“ Status. Das akzeptierte Stage 1 Protokoll des Registered Reports wurde vor der Durchführung der Studie auf dem Open Science Framework verfügbar gemacht (https://doi.org/10.17605/OSF.IO/N6WFK). Nach Abschluss des Stage 2-Begutachtungsprozesses wurde der Artikel am 29.07.2020 als *Advance Online Publication* der Zeitschrift *British Journal of Educational Psychology* veröffentlicht und ist auf den Seiten des Verlags frei zugänglich. Die Originalfassung des Artikels findet sich in Appendix C.

5.1 Zusammenfassung

Epistemische Volition ist in Bendixen und Rules (2004) Modell epistemischen Wandels als zweite nachgelagerte Prozesskomponente konzipiert, welche Individuen dazu in die Lage versetzt, auftretende epistemische Zweifel bewusst anzugehen (Rule & Bendixen, 2010). In Artikel III wurde deshalb divergierende Evidenz präsentiert, um epistemische Zweifel zu induzieren und den Prozess epistemischen Wandels in Gang zu bringen, und getestet, ob eine experimentelle Steigerung der epistemischen Volition in diesem Kontext zu stärkerem epistemischen Wandel führte oder nicht. Zur Erstellung der hierfür benötigten epistemischen Volitionsintervention wurden ausgehend von Rule und Bendixen (2010) sowie Bendixen (2002) relevante Grundlagen dieser Prozesskomponente identifiziert, wie zum Beispiel Forschung von Corno (1993, Boekaerts & Corno, 2005) zum Konzept der Volition oder aber auch Forschung zu *Intentional Conceptual Change* (Sinatra & Pintrich, 2003). Darauf basierend wurde ein Erweiterungsmodul zu epistemischer Volition entwickelt, welches die in Artikel II beschriebene Version der Resolvable Controversies Intervention (d. h. auflösbarer divergierender Evidenz) ergänzen sollte. Bestandteile dieser Volitionsintervention waren unter anderem Komponenten zur Steigerung der *Awareness* (der Bewusstheit eigener epistemischer Überzeugungen, Rule & Bendixen, 2010), zu *Compassion* (beispielsweise das Aufzeigen, dass die Revision epistemischer Überzeugungen mit negativen Emotionen einhergehen kann, Rule & Bendixen, 2010), zu

fiktivem Feedback (Podsakoff & Farh, 1989) sowie zur Setzung von *Implementation Intentions* (Armitage, 2009; Bayer & Gollwitzer, 2007).

Zur Untersuchung der inkrementellen Effekte dieser neuen Volitionsintervention wurde, wie in den vorausgehenden Forschungsartikeln, ein Prä-Post-Design mit mehreren Experimentalgruppen realisiert. Die erste Kontrollbedingung, welche als Vergleichsbedingung im Kontext der Untersuchung inkrementeller Effekte epistemischer Volition diente, erhielt nicht die neue Volitionsintervention, sondern eine Kombination aus den nicht-divergierenden Informationen (der Kontrollbedingung) und den auflösbaren divergierenden Informationen aus Artikel II. Diese Bedingung sollte Effekte der reinen Präsentation divergierender Evidenz abbilden. Eine weitere Kontrollbedingung erhielt die neue Volitionsintervention zusammen mit nicht-divergierender Evidenz. Durch diese Gruppe sollte getestet werden, ob Haupteffekte epistemischer Volition unabhängig von der Induktion epistemischer Zweifel existierten. In diesen beiden Kontrollbedingungen wurden – ausgehend von der Konzeption des Prozesses epistemischen Wandels als voneinander abhängiger linearer Abfolge dreier Prozesskomponenten (vgl. Bendixen & Rule, 2004; Rule & Bendixen, 2010) – eher niedrige Effekte auf epistemischen Wandel erwartet, da jeweils nur einzelne Prozesskomponenten (epistemische Zweifel *oder* epistemische Volition) adressiert wurden. In einer letzten Bedingung wurde schließlich auflösbare divergierende Evidenz, welche sich in Artikel II als effektiver Initiator epistemischen Wandels erwiesen hatte, mit der Volitionsintervention kombiniert. Nach Bendixen und Rules (2004) Modell wurde hier das größte Ausmaß epistemischen Wandels erwartet, da durch diese Intervention zwei der drei interdependenten Prozesskomponenten angesprochen wurden.

Im Rahmen eines Registered Reports wurden Theorie, Datenerhebung, Datenaufbereitung sowie Hypothesen und statistische Methoden vor der Studiendurchführung begutachtet und registriert. Innerhalb der Datenerhebung wurden anschließend deutschlandweit N = 412 Psychologiestudierende über Mailinglisten deutscher Universitäten und Fachschaften rekrutiert. Alle Messungen sowie die Intervention fanden hierbei wie in Artikel II rein online statt, wobei im Gegensatz zu Artikel II nun die Prämessung mindestens eine Woche vor der Postmessung stattfand. Des Weiteren wurde epistemischer Wandel erneut auf themen- (FREE-GST) und domänenspezifischer (FREE-EDPSY) Ebene erfasst und nicht mehr auf domänenübergreifender Ebene, wie in Artikel II. Überraschenderweise zeigten sich in statistischen Analysen allerdings keinerlei Gruppenunterschiede im epistemischen Wandel auf themen- und domänenspezifischer Ebene (alle $p > .300$). Vielmehr gab es in allen Gruppen beachtliche Veränderungen hin zu fortgeschrittenen epistemischen Überzeugungen – sowohl auf themenspezifischer als auch

auf domänenspezifischer Ebene (alle $b > 0.339$[3]). In explorativen Analysen, welche auf einer Analyse der im Artikel genutzten Manipulation-Check-Maße zur selbstberichteten Integration präsentierter widersprüchlicher Evidenz sowie zu selbstberichteter epistemischer Volition beruhten, zeigte sich allerdings auf themenspezifischer Ebene, dass diese beiden Manipulation-Check-Maße im Hinblick auf epistemischen Wandel interagierten ($b_{\text{Interaktion}} = 0.260$, $p < .001$). Ferner lag auch ein Haupteffekt für das betreffende Integrationsmaß ($b_{\text{Integration}} = 0.176$, $p < .001$), aber nicht für das Volitionsmaß vor ($b_{\text{Volition}} = -0.026$, $p = .603$). Mit anderen Worten, auf intraindividueller Ebene lag die in Bendixen und Rules (2004) Modell erwartete Wechselwirkung zweier Prozesskomponenten vor, während diese Wechselwirkung auf Gruppenebene nicht auftrat.

Um der häufigen Kritik an der derzeitigen Forschung zu epistemischen Überzeugungen zu begegnen, dass sie in zu starkem Ausmaß auf Selbstberichtsverfahren zur Erfassung dieser Überzeugungen fokussiere (Greene & Yu, 2014; Mason, 2016), wurde für Artikel III zusätzlich eine Quellenwahlaufgabe zum Thema Gesundheitsinformationsverhalten entwickelt. Basierend auf einer breiten Evidenzbasis zur engen Verbindung zwischen Quellenwahlverhalten und epistemischer Kognition (Barzilai, Tzadok & Eshet-Alkalai, 2015; Bråten, Ferguson, Strømsø & Anmarkrud, 2014; Pieschl, Stahl & Bromme, 2008), wurde das Verhalten in dieser Aufgabe als Proxy im Sinne eines nachgelagerten Maßes epistemischen Wandels genutzt (vgl. auch Greene, Muis & Pieschl, 2010). Im Speziellen wurden die Teilnehmenden in dieser Aufgabe innerhalb eines Szenarios („Sie wollen herausfinden, ob zwischen Leistungsmotivation und Herzinfarktrisiko ein positiver oder negativer Zusammenhang besteht.“) dazu aufgefordert zwischen verschiedenen Suchergebnissen in einer an Internetsuchmaschinen wie Google angelehnten Umgebung zu wählen. Diese Suchergebnisse unterschieden sich unter anderem in der suggerierten Qualität der präsentierten Quelle (zum Beispiel Forenbeiträge im Vergleich zu Zusammenfassungen wissenschaftlicher Studien). Es zeigte sich in explorativen Analysen, dass beide Gruppen, die die Volitionsintervention erhalten hatten, ein signifikant höheres Ausmaß qualitativ hochwertiger Quellen wählten im Vergleich zu der Gruppe, die keine Volitionsintervention erhalten hatte (Odds Ratio > 1.80). Ferner zeigte sich hierbei auch, dass fortgeschrittene epistemische Überzeugungen (Evaluativismus, Odds Ratio = 2.00) mit einer höheren Wahrschein-

[3]Die Angabe des standardisierten Regressionsgewichts findet sich nicht in Artikel III selbst und wurde hier statt der im Artikel genutzten Effektstärken berichtet, um einen besseren Vergleich der Befunde über die Forschungsartikel hinweg zu erlauben.

lichkeit mit der Wahl qualitativ hochwertiger Quellen einhergingen, während naive Überzeugungen (Multiplismus, Odds Ratio = 0.68) zu einer niedrigeren Wahrscheinlichkeit der Wahl solcher Quellen führten.

5.2 Diskussion

Zunächst lässt sich zur Rolle epistemischer Zweifel (Forschungsfrage 1) festhalten, dass in Artikel III die reine Präsentation divergierender Evidenz (diesmal in Kombination mit nicht-divergierender Evidenz) erneut in der Lage war, beträchtlichen epistemischen Wandel hin zu fortgeschrittenen Überzeugungen hervorzurufen. Warum der Effekt der gemeinsamen Präsentation divergierender und nicht-divergierender Evidenz in Artikel III größer ausfiel, als ausgehend von den Effekten der hier genutzten Interventionskomponenten in Artikel II zu erwarten gewesen wäre, bleibt allerdings fraglich. Mögliche Erklärungsansätze dieses Phänomens werden in Kapitel 6 diskutiert.

Hinsichtlich der Rolle epistemischer Volition, der vorrangig in Artikel III behandelten Forschungsfrage 2, erscheint das gefundene Effektmuster kontrovers. Ein Haupteffekt epistemischer Volition scheint einerseits vorzuliegen, da Prä-Post-Veränderungen hin zu fortgeschrittenen Überzeugungen in einer Gruppe existierten, die die Volitionsintervention zusammen mit einer Kontrollaufgabe erhielt, welche in Artikel II keinen epistemischen Wandel induzierte. Dass das Ausmaß epistemischen Wandels in dieser Gruppe sogar genauso groß war, wie in der Gruppe, die zusätzlich divergierende Evidenz zur Induktion epistemischer Zweifel erhielt, mag überraschen, da Bendixen und Rules (2004) Modell von einer linearen schrittweisen Abfolge und Abhängigkeit der einzelnen Prozesskomponenten ausgeht. Entsprechend wäre ein größeres Ausmaß epistemischen Wandels in dieser Gruppe, die zusätzlich divergierende Evidenz erhielt, zu erwarten gewesen. Eine mögliche Erklärung für diese vergleichbaren Effekte in beiden Gruppen wäre, dass epistemische Volition nicht induziert werden kann ohne gleichzeitig epistemische Zweifel hervorzurufen.[4] Beispielsweise könnten Komponenten der Volitionsintervention zur Steigerung der Bewusstheit eigener Überzeugungen zu entsprechenden Effekten geführt haben. Da die Komponenten der Volitionsintervention allerdings strikt aus Bendixen und Rules (2004) Modell abgeleitet wurden, könnte dies damit auf eine mangelnde konzeptuelle Trennung der beiden Prozesskomponenten im theoretischen Rahmenwerk selbst hinweisen. Dass sich Abhängigkeiten zwischen Prozesskomponenten durchaus in explorativen Analysen

[4] Nicht außer Acht gelassen werden sollte allerdings, dass sich ein vergleichbares Ausmaß epistemischen Wandels auch in der Gruppe zeigte, die auflösbare divergierende und nicht-divergierende Evidenz in Kombination erhielt. Eine ausführliche Diskussion und Einordnung dieses Phänomens findet in Kapitel 6 statt.

zeigten, welche direkt auf Manipulation-Check-Maße (und damit auf Maße intraindividueller Kognitionen) zurückgriffen, stützt diese Argumentation und könnte gleichzeitig als Evidenz im Sinne der angenommenen Interdependenz der Prozesskomponenten des Bendixen und Rule (2004) Modells gewertet werden. Da mit dem Manipulation Check-Maß der Resolvable Controversies Intervention aber die Integration von Widersprüchen, welche der Lösungsstrategien-Komponente des Bendixen und Rule Modells nahestehen sollte, erfasst wurde, könnte der hier in explorativen Analysen gefundene Haupteffekt auch als indirekter Beleg der Rolle von Lösungsstrategien (Forschungsfrage 3) betrachtet werden.

Interessant erscheint in Bezug auf die Effekte epistemischer Volition auch, dass sich in explorativen Analysen eine Tendenz zur Wahl qualitativ höherwertiger Quellen in beiden Gruppen zeigte, die die Volitionsintervention durchliefen, im Vergleich zu der Gruppe, die nur auflösbare Widersprüche erhielt. Ein Rückgriff auch das einflussreiche von Chinn, Buckland und Samarapungavans (2011) eingeführte erweiterte Rahmenwerk epistemischer Kognitionen ermöglicht den Versuch einer theoretischen Einordnung dieser Befunde. So nehmen Chinn, Buckland und Samarapungavans (2011) an, dass (1) Individuen in unterschiedlichem Ausmaß über *epistemische Tugenden* (epistemic virtues, z. B. Gewissenhaftigkeit oder die Bereitschaft eigene Überzeugungen zu hinterfragen) verfügen und diese ihr Verhalten in relevanten Situationen prägen, (2) dass trotz zeitinvarianter Anteile dieser Tugenden die Ausprägung dieser epistemischen Tugenden durchaus kontext- und situationsspezifisch sein kann. Das in dieser Studie gefundene Effektmuster könnte damit potentiell darauf zurückführbar sein, dass die verwendete epistemische Volitionsintervention in einer situationsspezifischen Anregung epistemischer Tugenden resultierte. Im konkreten Fall könnte sich dies durch eine gewissenhaftere und kritischere Lektüre präsentierter Quellen ausgedrückt haben. Diese situationsspezifische Anregung epistemischer Tugenden könnte in der Folge ein verändertes Quellenwahlverhalten erklären, was alleine anhand der Konzepts epistemischer Volition nicht möglich zu sein scheint. Sollte sich diese Spekulation bewahrheiten, könnte eine solche Verknüpfung zwischen epistemischer Volition und epistemischen Tugenden nicht zuletzt eine aussichtsreiche Perspektive zur Integration des Bendixen und Rule (2004) Modells und des Rahmenwerks von Chinn und Kollegen (2011) darstellen.

Bezogen auf die Domänenspezifität epistemischen Wandels (Forschungsfrage 6) könnte man die Befunde konfirmativer und explorativer Analysen auch dahingehend interpretieren, dass epistemische Volition stärker auf domänenübergreifenden Wandel einzuwirken scheint als

epistemische Zweifel, die durch die Präsentation rein themenspezifischer Evidenz hervorgerufen werden. Bemerkenswert ist hierbei, dass die Experimentalgruppe, welche keinerlei divergierende Evidenz zum Thema Geschlechterstereotypisierung erhielt, trotzdem ein vergleichbares Ausmaß themenspezifischen Wandels hierzu erfuhr, wie Gruppen, die solche themenspezifische divergierende Evidenz erhielten. In diesem Fall sollte also ein erheblicher Transfer epistemischen Wandels stattgefunden haben. Die Volitionsintervention scheint darüber hinaus auch in der Lage zu sein, das Quellenwahlverhalten zu themenspezifischen Gesundheitsinformationen – also in einer deutlich von Geschlechterstereotypisierung und pädagogischer Psychologie verschiedenen Domäne – zu beeinflussen. Dies könnte suggerieren, dass eine Induktion epistemischer Volition (beziehungsweise gegebenenfalls die Anregung entsprechender epistemischer Tugenden, siehe oben) die domänenübergreifende Generalisierung epistemischen Wandels stärker begünstigen könnte, als dies themenspezifischer epistemischer Zweifel alleine zu tun vermag.

6 Gesamtdiskussion

Forschungsfrage 1 beschäftigte sich damit, inwiefern epistemische Zweifel, welche über die Präsentation divergierender Evidenz induziert wurden, epistemischen Wandel förderten. Über alle drei Artikel hinweg zeigte sich bezüglich Forschungsfrage 1, dass die reine Präsentation divergierender Informationen epistemischen Wandel induzierte – auch ohne eine Darbietung reflektionsanregender Instruktionen. Befunde aus Artikel II zeigen darüber hinaus, dass diese Effekte der Präsentation divergierender Informationen auch rigoroser experimenteller Kontrolle standhielten. Insgesamt wird durch die Befunde dieser Dissertation damit eine zentrale Rolle epistemischer Zweifel im Prozess epistemischen Wandels bestätigt sowie die Präsentation widersprüchlicher wissenschaftlicher Evidenz als probates Mittel zur Initiation des Prozesses epistemischen Wandels belegt. Ob die in den experimentellen Kurzzeitinterventionen dieser Dissertation gewonnenen Erkenntnisse zu epistemischem Wandel auf die langfristige epistemische Entwicklung übertragen werden können, bleibt allerdings eine offene Forschungsfrage (vgl. Bråten, 2016; Kerwer & Rosman, 2020b). Bemerkenswert ist jedoch, dass zu einem gewissen Ausmaß epistemischer Wandel auch durch die Kontrollaufgaben in Artikel I sowie Artikel III initiiert wurde, obwohl in diesen Fällen keine Präsentation divergierender Evidenz intendiert war. Vor allem die Kontrollgruppeneffekte in Artikel I könnten möglicherweise darauf zurückzuführen sein, dass Individuen situationsbezogen in ein „evaluativistisches Denkmuster“ durch die Darbietung einer vergleichenden Bewertungsaufgabe hineingelangt sein könnten. Dieser Kontrollgruppeneffekt könnte im Sinne von Elby, Macrander und Hammer (2016) damit als kurzzeitiges „cuing“ einer „epistemological stance“ verstanden werden. Diese Auffassung wird dadurch gestützt, dass Effekte der Kontrollaufgabe in Artikel II verschwanden, wenn keine vergleichende Bewertung derselben Materialien mehr vorgenommen werden sollte, sondern nur noch die individuelle Präferenz bezüglich Lernstrategien berichtet werden sollte.

Insgesamt bilden die Befunde zur Rolle epistemischer Volition (Forschungsfrage 2), welche in Artikel III generiert wurden, für sich genommen leider kein eindeutiges Effektmuster. Sowohl in einer kombinierten Experimentalbedingung zu epistemischem Zweifel *und* epistemischer Volition als auch in zwei Experimentalbedingungen, die nur eine dieser Prozesskomponenten ansprachen, lag dort ein vergleichbares Ausmaß epistemischen Wandels vor. Eine mögliche Erklärung dafür, warum eine Kombination divergierender und nicht-divergierender Evidenz effizienter sein könnte als die separate Präsentation dieser Informationstypen, wird weiter unten in den Ausführungen zu Forschungsfrage 4 diskutiert. Eine gemeinsame Betrachtung der Befunde von Artikel II und III zeigt ferner aber auch, dass epistemische Volition durchaus für sich

genommen epistemischen Wandel (im Vergleich zur reinen Administration der Kontrollaufgabe in Artikel II) zu induzieren scheint. Ergebnisse explorativer Analysen suggerieren darüber hinaus, dass auf intraindividueller Ebene tatsächlich die in Bendixen und Rules (2004) Modell angenommene Wechselwirkung zwischen verschiedenen Prozesskomponenten den Wandel hin zu fortgeschrittenen Überzeugungen zu begünstigen scheint. Vor dem Hintergrund einer mangelnden abgrenzbaren Nachweisbarkeit epistemischer Volition beispielsweise bei Ferguson et al. (2012) scheint es damit fraglich, ob überhaupt eine experimentelle Induktion epistemischer Volition möglich ist, ohne gleichzeitig epistemische Zweifel anzuregen, oder ob beide Prozesskomponenten (derzeit noch) konzeptuell zu stark in Bendixen und Rules (2004) Modell verwoben sind (siehe Kapitel 5.2). Wie in Kapitel 5.2 argumentiert wurde, könnte eine gemeinsame konzeptuelle Betrachtung des Konstrukts epistemischer Volition und des Konstrukts epistemischer Tugenden des Rahmenwerks von Chinn und Kollegen (2011) unter anderem zur Erklärung der unterschiedlichen Generalisierbarkeit der Effekte epistemischer Zweifel beziehungsweise epistemischer Volition sinnvoll sein. Eine finale Antwort auf Forschungsfrage 2 steht damit aber, bis diese verschiedenen theoretischen Erklärungsmodelle in zukünftigen Studien getestet wurden, noch aus.

Analysen zur Prozesskomponente der Lösungsstrategien (Forschungsfrage 3) zeigen insgesamt leider auch kein vollkommen eindeutiges Bild. Wie eine tiefergehende Reflektion divergierender Evidenz interventionsbasiert angeregt werden kann, wurde in Artikel I ausgehend von Vorarbeiten von Rosman und Kollegen (Rosman & Mayer, 2018; Rosman et al., 2019) gezeigt. Eine Schreibaufgabe forderte Individuen hier zur Anregung solcher Reflektionsprozesse dazu auf, Kontextfaktoren zu identifizieren und erleichterte damit anhand dieser Kontextfaktoren die Auflösung vermeintlicher Widersprüche. Hinsichtlich der inkrementellen Effekte der Lösungsstrategie *Reflektion* ließ sich innerhalb des dazu vorgestellten ersten Forschungsartikels allerdings keine klare Schlussfolgerung ziehen (siehe Kapitel 3). Eine Reanalyse der Daten aus Artikel I durch Rosman et al. (2019) weist jedoch auf mögliche inkrementelle Effekte der in diesem Forschungsartikel genutzten reflektionsanregenden Aufgabe hin. Genauso könnten auch explorative Befunde aus Artikel III, welche zeigen, dass eine retrospektiv berichtete Integration divergierender Evidenz epistemischen Wandel begünstigte, als Anzeichen für die Relevanz der Anwendung von Lösungsstrategien im epistemischen Wandel interpretiert werden.

Auch wenn in Analysen zu Forschungsfrage 1 demonstriert werden konnte, dass die reine Darbietung divergierender Evidenz tatsächlich epistemischen Wandel zu initiieren vermag, so

zeigte sich doch im Gegensatz zur ursprünglichen Erwartung kein Effekt der Auflösbarkeit präsentierter widersprüchlicher Evidenz (Forschungsfrage 4). Mit anderen Worten, der von Rosman et al. (2019) ausgehend von Kuhns Modell epistemischer Entwicklung angenommene „Wirkmechanismus“ der Resolvable Controversies Intervention, konnte in den empirischen Arbeiten dieser Dissertationsschrift nicht bestätigt werden. Auflösbare und unauflösbare divergierende Evidenz begünstigten vielmehr epistemischen Wandel in vergleichbarem Ausmaß. Eine Aufgabe künftiger Forschung könnte es sein, mögliche Erklärungen dieses Phänomens zu testen. So könnte es sein, dass Individuen in ihre Urteilsbildung miteinbeziehen, dass es sich bei den innerhalb der Studienmaterialien dargebotenen Informationen immer nur um eine Teilmenge eines breiteren Literaturkorpus beziehungsweise allgemein einer größeren Evidenzbasis handelte. Auch wenn die vorliegende divergierende Evidenz im konkreten Fall der dargebotenen Teilmenge keine Integration von Befunden anhand der präsentierten Kontextfaktoren (z. B. Schulfach) erlaubt, könnten Individuen so doch aus den dargebotenen Informationen auf die *mögliche Existenz* relevanter Kontextfaktoren in der gesamten Evidenzbasis schließen. Wie sich hier andeutet, scheint es angebracht zu sein, in zukünftigen Forschungsarbeiten individuelle epistemische Kognitionen, die mit der Rezeption auflösbarer beziehungsweise unauflösbarer Widersprüche einhergehen, qualitativ beispielsweise über die Methode des lauten Denkens zu erforschen (vgl. Ferguson et al., 2012; Mason, 2016).

Betrachtet man die Ergebnisse von Artikel II und III in der Zusammenschau, erscheint auch interessant, dass sich hier Hinweise auf Wechselwirkungen in den Effekten der Präsentation verschiedener Typen divergierender Evidenz finden. So war der Effekt einer Kombination auflösbarer divergierender und nicht-divergierender Evidenz in Artikel III deutlich größer, als anhand der separaten Effekte der einzelnen Evidenztypen in Artikel II zu erwarten gewesen wäre. Dies könnte möglicherweise darauf hindeuten, dass die gleichzeitige Präsentation verschiedener Typen divergierender Evidenz die epistemische Natur der einzelnen Typen divergierender Evidenz besonders hervorzuheben und ihre Implikationen für den epistemischen Wandel zu akzentuieren vermag. Zum Beispiel könnten Teilnehmende im konkreten Fall gelernt haben, dass für das Thema „Geschlechterstereotypisierung an Gymnasien“ nicht aber für das Thema „Lernstrategien im Studium“ Kontextfaktoren existieren, welche eine Integration widersprüchlicher Evidenz erlauben. Eine weitere Erforschung solcher Wechselwirkungen verschiedener Typen divergierender Evidenz erscheint in jedem Fall empfehlenswert.

Forschungsfrage 5, welche sich mit der Rolle epistemischer Ausgangsüberzeugungen als möglicher Determinante epistemischen Wandels beschäftigte, wurde vor allem durch Artikel II

adressiert. In diesem Artikel zeigte sich in Einklang mit den Annahmen der kognitiven Dissonanztheorie, dass epistemischer Wandel in den dort verwendeten Interventionsgruppen – und nicht in der Kontrollgruppe – für naivere Ausgangsüberzeugungen stärker ausgeprägt war als für fortgeschrittene Ausgangsüberzeugungen. Dies könnte nicht zuletzt auch als Indiz für eine wesentliche Rolle epistemischer Zweifel im Prozess epistemischen Wandels gewertet werden, da das zu erwartende Ausmaß epistemischer Zweifel ein Prädiktor epistemischen Wandels zu sein scheint. Eine Erweiterung des Bendixen und Rule (2004) Modells um epistemische Ausgangsüberzeugungen als wesentliche Determinante der Bedingungen epistemischen Wandels ist folglich angeraten. Der praktische Wert einer solchen Betrachtung epistemischer Ausgangsüberzeugungen als Prädiktor epistemischen Wandels wurde unter anderem jüngst von Kerwer und Rosman (2020b) illustriert, die epistemischen Wandel innerhalb der Resolvable Controversies Intervention analysierten. Sie konnten unter anderem zeigen, dass absolute Überzeugungen den Wandel hin zu evaluativistischen Überzeugungen während dieser Intervention begünstigten, wohingegen multiplistische Überzeugungen diesen Wandel sogar behinderten (Kerwer & Rosman, 2020b). Die Implikationen der Befunde dieser Dissertationsschrift zu Forschungsfrage 5 reichen darüber hinaus aber auch in die pädagogische Praxis hinein. Beispielsweise suggeriert die bedeutende Rolle epistemischer Ausgangsüberzeugungen, dass eine zielgruppenorientierte Anpassung von Interventionsmaterialien zur Förderung epistemischen Wandels an die jeweiligen individuellen Eigenschaften der Lernenden vorgenommen werden sollte.

Bezüglich der Domänenspezifität epistemischen Wandels (Forschungsfrage 6) zeigte sich in Artikel I und II dieser Arbeit wiederum ein vergleichsweise klares Effektmuster. Themenspezifische divergierende Evidenz scheint in stärkerem Ausmaß themenspezifischen epistemischen Wandel zu induzieren und in schwächerem Ausmaß domänenspezifischen oder domänenübergreifenden Wandel. Ferner deutet Artikel III darauf hin, dass eine Induktion epistemischer Volition oder eine Kopplung verschiedener Typen divergierender Evidenz zu einer größeren Generalisierung epistemischen Wandels führen könnte. Zukünftige Forschungsarbeiten könnten beispielsweise in stärkerem Ausmaß untersuchen, inwiefern je nach betrachteter Prozesskomponente des Bendixen und Rule (2004) Modells in unterschiedlichem Ausmaß eine Generalisierung epistemischen Wandels stattfindet. Eine Erweiterung des Bendixen und Rule (2004) Modells um die Domänenspezifität der betrachteten epistemischen Überzeugungen sowie der Domänenspezifität der den Prozess epistemischen Wandels auslösenden Evidenz scheint aber in jedem Fall aufgrund der Befunde dieser Dissertationsschrift angebracht zu sein.

Über die Beleuchtung dieser konkreten Forschungsfragen hinaus trägt diese Dissertation aber auch zur Erweiterung des Methodenrepertoires klassischer Interventionsstudien zum epistemischen Wandel bei. Traditionell fanden Interventionen zu epistemischem Wandel, auch wenn sie computerbasiert durchgeführt wurden, bisher meist in Präsenzsettings vor Ort (d. h. im Labor) statt. Die Studien, und auch Interventionen, in Artikel II und Artikel III wurden im Gegensatz hierzu rein online auf den privaten Geräten der Teilnehmenden administriert. Zum einen eröffnet dies neue fruchtbare Perspektiven zur Untersuchung epistemischen Wandels. So könnten in Online-Formaten beispielsweise leichter Populationen jenseits von Studierenden oder Schülern beziehungsweise Schülerinnen erreicht werden, womit einer häufigen Limitation aktueller Studien zu epistemischen Überzeugungen begegnet werden kann (vgl. Mason, 2016; Muis et al., 2016). Beispielsweise ließ sich so demonstrieren, dass die ursprünglich auf Psychologiestudierende ausgerichteten Interventionsmaterialien und Interventionskonzepte der Resolvable Controversies Intervention auch auf andere Populationen (Universitätsstudierende allgemein) übertragen werden können. Zum anderen kann durch eine Darbietung der Studieninhalte in einer Online-Umgebung auf den Geräten der Teilnehmenden der Kontextspezifität epistemischer Kognitionen (vgl. Chinn et al., 2011; Elby & Hammer, 2001) vor allem in Bezug auf Internetrecherchen – in gewissem Ausmaß – Rechnung getragen werden. Zum Beispiel in Artikel III konnte das Quellenwahlverhalten im Internet so genauso untersucht werden, wie es Studierenden meist in ihrem Alltag begegnen wird: Zuhause oder unterwegs an ihrem eigenen internetfähigen Gerät – und nicht in der Universität in einem künstlichen akademischen Laborsetting, welches möglicherweise Erwartungseffekte hervorruft. Die praktische Relevanz solcher Befunde sollte damit als vergleichsweise hoch einzuschätzen sein und eine solche Untersuchung epistemischer Kognitionen in Online-Umgebungen erhebliches Potenzial für die zukünftige Erforschung epistemischer Kognitionen und epistemischen Wandels bieten.

Dass jede der in dieser Dissertationsschrift eingeschlossenen Studien gemäß des Open Science Gedankens (vgl. Banks et al., 2019) vor ihrer Durchführung präregistriert oder sogar als Publikation im Registered Report Format realisiert wurde, sollte im Hinblick auf eine Bewertung der bezüglich einiger Forschungsfragen vielleicht in Teilen etwas unschlüssigen Befundlage dieser Dissertationsschrift nicht außer Acht gelassen werden. So sollten im Rahmen der angestrebten Wende hin zu Open Science in der Psychologie fragwürdige Forschungspraktiken abnehmen, was nahezu zwangsläufig zu einer Reduktion des Anteils signifikanter veröffentlichter Befunde führen sollte (vgl. Banks et al., 2019; Nosek, Spies & Motyl, 2012; Open Science Collaboration, 2015). Die vorliegende Dissertationsschrift könnte damit auch im Zeichen der Realität einer

neuen transparenteren Wissenschaft darauf hindeuten, dass „Geschichten“, die wissenschaftliche Publikationen erzählen, als Preis für diese größere Offenheit psychologischer Forschung zukünftig in ihrer Geradlinigkeit abnehmen könnten.

Abschließend lässt sich im Hinblick auf die in dieser Dissertationsschrift angestrebte Untersuchung der Mechanismen epistemischen Wandels über eine Validierung des Bendixen und Rule (2004) Modells festhalten, dass ein Großteil der Annahmen dieses Modells durch die Analysen der Arbeit eher bestätigt als widerlegt werden konnte. So steht eine zentrale Rolle epistemischer Zweifel im Prozess epistemischen Wandels wohl nahezu außer Frage, während weitere Forschung zu epistemischer Volition und Lösungsstrategien angeraten zu sein scheint. Die empirischen Befunde dieser Arbeit weisen allerdings auch auf wesentliche Bedarfe zur Erweiterung (z. B. bezüglich der Domänenspezifität epistemischer Überzeugungen) und Konkretisierung (z. B. bezüglich der Rolle epistemischer Ausgangsüberzeugungen) des Rahmenwerks von Bendixen und Rule (2004) hin. Frei nach Karl Popper möchte man folglich sagen, dass wir durch die vorliegende Arbeit zwar „eine ganze Menge [Neues zu Bendixen und Rules (2004) Modell] wissen“ und hoffentlich auch „tiefe Einsichten vermitteln“ konnten, wir aber in Teilen „mit jedem Schritt, den wir vorwärts mach[t]en, mit jedem Problem, das wir lös[t]en, […] neue und ungelöste Probleme [entdeckten]“ (Popper, 1997, S. VII). Die Fortführung dieses Zitats „wir entdecken auch, daß dort, wo wir auf festem und sicherem Boden zu stehen glaubten, in Wahrheit alles unsicher und im Schwanken begriffen ist.“ (Popper, 1997, S. VII) trifft wohl aber nicht gänzlich auf die in dieser Dissertationsschrift präsentierte Forschung zu Mechanismen epistemischen Wandels zu. Die vorliegende Arbeit leistet vielmehr einen Beitrag zur Absicherung des Fundaments dieser Forschung, da die Anzahl ungelöster Probleme und Forschungsfragen insgesamt gesehen durch sie reduziert wird. Ferner konnte die vorliegende Arbeit auch zeigen, dass epistemische Überzeugungen und Verhalten in relevanten Situationen über Kurzzeitinterventionen gefördert werden können. Diese Ergebnisse können vor dem Hintergrund des einleitenden Gedankens dieser Dissertation, dass der Umgang mit wissenschaftlicher Evidenz und damit epistemisches Denken in der heutigen Wissensgesellschaft Macht geleichkommen könne, schließlich als höchst ermutigend angesehen werden.

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Appendix A

Artikel I

Kerwer, M., & Rosman, T. (2018). Mechanisms of epistemic change—Under which circumstances does diverging information support epistemic development? *Frontiers in Psychology*. *9*:2278. https://doi.org/10.3389/fpsyg.2018.02278

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Mechanisms of Epistemic Change—Under Which Circumstances Does Diverging Information Support Epistemic Development?

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Background: The number of studies on how to foster change toward advanced epistemic beliefs (i.e., beliefs about the nature of knowledge and knowing) is continuously growing because these beliefs are an important predictor of learning outcomes. In past intervention studies, presenting diverging information (e.g., descriptions of studies yielding contradictory results) reliably led to epistemic change. However, prior research insufficiently examined which aspects of diverging information affect these changes.

Aims: We investigated (1) if epistemic change differs depending on the (un)resolvability of contradictory information, (2) to what extent explicitly reflecting on diverging information supports epistemic change and (3) how topic-specific diverging information affects topic–and domain-specific epistemic beliefs. All confirmatory hypotheses were preregistered at OSF. Additionally, several exploratory analyses were conducted.

Method: To examine the research questions, we employed a simple randomized pre-post design with four experimental groups. $N = 185$ psychology students participated in the study. Experimental groups differed in the kind of diverging information included: Students either read (1) information on students applying learning strategies (control), (2) unresolvable, or (3a) resolvable controversial information on gender stereotyping. In the latter condition (3b), an additional group of participants deliberately resolved apparent contradictions in a writing task.

Results: Confirmatory latent change analyses revealed no significant group differences in epistemic change (i.e., beliefs in the control group also changed toward advanced epistemic beliefs). Using a different methodological approach, subsequent exploratory analyses nevertheless showed that presenting diverging information on gender stereotypes produced stronger topic-specific epistemic change and change in justification beliefs in the treatment groups in contrast to the control group. However, effects in the treatment groups did not differ significantly depending on the resolvability of presented controversies or for the group which was instructed explicitly to integrate controversial findings.

Conclusion: Contrary to our expectations, diverging information seems to foster epistemic change toward advanced beliefs regardless of the resolvability of presented

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information, while no final conclusion concerning effects of reflection could be drawn. Moreover, our findings indicate that effects of topic-specific interventions are more pronounced on topic-specific measures. However, this relationship may vary depending on the epistemic belief dimension (e.g., justification beliefs) under investigation.

Keywords: epistemic beliefs, epistemic change, psychology, diverging information, experimental study, gender stereotypes, higher education

INTRODUCTION

Epistemic beliefs are conceptualized as an individual's beliefs about the nature of knowledge and knowing (Hofer and Pintrich, 1997). Even though a long tradition of interdisciplinary research on the predictors and effects of epistemic beliefs exists (Hofer and Pintrich, 1997; Greene et al., 2008, 2018; Chinn et al., 2011), interventions that aim to promote epistemic change are relatively rare (cf. Muis et al., 2016). Recently, however, interest in epistemic change surged (Kienhues et al., 2016; Muis et al., 2016; Barzilai and Chinn, 2017). This may, at least partially, be due to the fact that these beliefs have been repeatedly shown to affect how individuals deal with crucial requirements of a modern knowledge-based society, such as acquiring and evaluating knowledge (Kienhues et al., 2016; Strømsø and Kammerer, 2016). Accordingly, quasi-experimental and correlational studies point toward beneficial effects of advanced epistemic beliefs (e.g., beliefs that knowledge claims have to be weighed and evaluated) for information integration (Barzilai and Ka'adan, 2017) and sourcing (Bråten et al., 2014), while more naive types of beliefs tend to impair the performance in such tasks (e.g., Kammerer et al., 2015; Rosman et al., 2016b). In this context, the term *naive beliefs* embraces views that (1) knowledge claims can only be either true or false, or (2) the conception of knowledge as purely tentative and subjective (Kuhn et al., 2000). In line with these ideas, a recent meta-analysis by Greene et al. (2018) confirmed that epistemic beliefs are positively correlated with academic achievement, which further corroborates the importance of (fostering) those beliefs.

To allow for future intervention studies to shape individuals' epistemic development in a more efficient way, our research aims to contribute to a better understanding of the underlying mechanisms of change. In this article, we start by briefly introducing popular developmental models for epistemic beliefs, as well as established models on epistemic change and models on the domain-specificity of epistemic beliefs. Thereafter, we review recent approaches for changing epistemic beliefs in (quasi-) experimental settings, focusing on the presentation of diverging information as an especially promising method. Bringing together these theoretical perspectives, we identify three essential and unsettled research questions that relate to properties of diverging information and the domain-specificity of both the presented information and the beliefs under investigation. Subsequently, we introduce an experimental study that addresses these research questions by examining psychology students' epistemic beliefs on gender stereotyping in secondary schools. Finally, after presenting the study's results, we discuss its implications for both future research on epistemic change and for the design of interventions that target epistemic change.

Developmental Models on Epistemic Beliefs

How are changes in epistemic beliefs thought to take place in non-experimental settings throughout an individual's lifespan? Most developmental models for describing epistemic change strongly rely on Piagetian ideas introducing *cognitive disequilibrium* as the driving force behind epistemic development (Hofer and Pintrich, 1997). More specifically, these models assume that cognitive disequilibria occur if new information contradicts previously acquired beliefs. For example, belief change may occur when math students realize that there is more than one way to solve problems in mathematics. Again typically Piagetian, almost all established developmental models postulate that epistemic development unfolds in distinct stages. In this study, we draw on the popular model of Kuhn et al. (2000), who propose a stage model that differentiates three stages of epistemic beliefs: Individuals start as *absolutists,* believing that knowledge is certain and that an objective truth exists. They then proceed to *multiplism*, whose characteristic aspect is that knowledge is seen as inherently subjective. The final and most advanced stage is called *evaluativism,* where individuals acknowledge the importance of weighing evidence and integrating contradictory knowledge claims. In our opinion, this does not imply that evaluativists deny the existence of certain knowledge. For example, an evaluativist may argue strictly in favor of vaccination if there is sufficient evidence to support its efficacy. Additionally, in a modern society with divided knowledge, advanced beliefs may also involve acknowledging one's knowledge gaps, identifying trustworthy external authorities that address these gaps (e.g., the World Health Organization for health issues), and relying on the information provided by them (Bromme et al., 2010). According to Kuhn et al. (2000), individuals successively progress from absolutism over multiplism to evaluativism in their epistemic development (although not all individuals reach the last stage). On a more fine-grained level, one may additionally characterize these rather broad stages on a set of dimensions so-called integrative models (e.g., Bendixen and Rule, 2004; Merk et al., 2018) with *certainty*, *simplicity*, *justification* and *source* of knowledge being the most prominent ones (Hofer and Pintrich, 1997). However, it should be of note that Greene et al. (2008) challenge this view by arguing that some of those dimensions, such as *simplicity* of knowledge, relate to an individual's ontological beliefs and not to their epistemic beliefs. Therefore, they suggest focusing on justification beliefs as "truly"

epistemic beliefs that determine under which circumstances individuals obtain knowledge. For this purpose, Greene et al. (2008) introduced two dimensions of justification beliefs – *justification by authority* (e.g., individuals justify knowledge claims based on experts) and *personal justification* (e.g., justification of knowledge claims based on personal experience). Subsequently, Ferguson et al. (2012) extended this framework by adding a third scale, *justification by multiple sources*, whose importance was confirmed by ensuing studies (e.g., Bråten et al., 2013).

Mechanisms of Epistemic Change—The Bendixen-Rule Model

Bendixen and Rule's (2004) *process model for personal epistemology development* describes more precisely how cognitive disequilibria presumably cause epistemic change in a certain situation. It introduces three central prerequisites of epistemic change (i.e., epistemic doubt, epistemic volition and resolution strategies), which are parts of a higher order mechanism (Bendixen, 2016). An idealized description of the proposed mechanism of change in Bendixen and Rule's model is as follows: As a starting point of epistemic change, an individual experiences epistemic doubt, a cognitive dissonance. This dissonance leads to questioning one's epistemic beliefs and may occur as a response to new information that contradicts an individual's existing beliefs (Rule and Bendixen, 2010). In order to deliberately tackle this epistemic doubt, it requires a certain amount of epistemic volition (i.e., the "will" or motivation for epistemic change), the second central component of the model (Rule and Bendixen, 2010). Thereafter, epistemic doubt is resolved by applying resolution strategies, such as reflection or social interaction, and individuals eventually adopt more advanced beliefs (Bendixen and Rule, 2004). However, proceeding to advanced beliefs is not guaranteed, even if all of these components are activated. Indeed, individuals may even regress to more naive beliefs under specific circumstances (Bendixen and Rule, 2004), which are, unfortunately, only vaguely specified in the original model. However, the notion that *epistemic doubt* may occur at any stage of an individual's epistemic development (i.e., even evaluativists are expected to question their beliefs from time to time) entails some important implications when designing intervention programs. To name only one, the interplay between prior beliefs and intervention contents has to be carefully considered (cf. Rule and Bendixen, 2010). Thus, the same instructional approach may be fruitful for absolutists, while it at the same time unintentionally evokes doubt on evaluativists' advanced beliefs. Nonetheless, this model is not uncontested, and, as Bråten (2016) stressed, the empirical validation of many assumptions of Bendixen's model, including its proposed mechanism of change, is still largely unsatisfactory.

Domain-Specificity of Epistemic Beliefs and Epistemic Change

So far, we treated epistemic beliefs in a universal way, thereby implying that beliefs on knowledge and knowing do not differ depending on the content domain they relate to. Indeed, epistemic development was initially considered to be consistent across fields or domains, and earlier research (e.g., Schommer, 1993) almost exclusively used this domain-general approach (i.e., it was assumed that individuals possess similar epistemic beliefs across content domains). Recent research has challenged this assumption by showing that epistemic beliefs encompass both domain-specific and domain-general aspects that are shared across domains (Buehl and Alexander, 2005; Muis et al., 2006). Moreover, Bråten and Strømsø (2010) argue that the same principle may also apply to specific topics, such as gender stereotyping, within certain domains or subdomains, for instance educational psychology. They further argue that the impact of epistemic beliefs on educational outcomes (such as academic achievement) should be particularly strong if beliefs and outcomes are measured on the same level of specificity. Drawing upon this thought, intervention-induced epistemic change should be particularly strong in epistemic belief measures whose specificity corresponds to the specificity of the information used to evoke epistemic doubt and subsequent changes in epistemic beliefs. Even though this assumption may sound highly plausible—especially as it is in line with findings from social psychology on the role that relevant exemplars play in behavior change (e.g., Lockwood and Kunda, 1997; Han et al., 2017), its empirical backing is certainly extendable.

Experimentally Inducing Epistemic Change

After providing this overview of the framework in which epistemic change is thought to occur, the question of how to efficiently influence individuals' epistemic development remains. As the number of research programs dedicated to achieve this aim is constantly growing, a variety of intervention approaches has been developed (see Bendixen, 2016; Muis et al., 2016). Naturally, it is theoretically sound and intuitive to evoke enduring belief change in long-term intervention programs, for example by using constructivist teaching methods (e.g., Muis and Duffy, 2013). However, short-term experimental interventions have recently become more prominent (Kienhues et al., 2016). A major advantage of this study type is that it allows for a better control of experimental circumstances and for a more specific investigation of the psychological mechanisms involved in epistemic change (even though far from all short-term interventions make use of this advantage). Moreover, those interventions have been shown to be surprisingly effective in inducing epistemic change—at least in the short term (Kienhues et al., 2008, 2011; Ferguson and Bråten, 2013). Most prominently, the presentation of *diverging information* (i.e., information that includes contradictory knowledge claims) has been shown to reliably evoke epistemic change (Kienhues et al., 2016), indicating that cognitive disequilibria (and subsequent epistemic doubt) are likely to be a driving force of epistemic development. Several interventions have been designed on this basis (Kienhues et al., 2016). For example, Kienhues et al. (2011) confronted students with conflicting knowledge claims concerning medication use for the control of cholesterol and showed that topic-specific epistemic change was more pronounced under these circumstances when compared to students that received consistent information on this topic.

Regrettably, however, most of these intervention studies fail to specify the kind of change in epistemic beliefs that is desired (Bråten, 2016); such as if they intend to reduce naive beliefs or

foster advanced beliefs. Especially studies that are not strongly based on Kuhn's framework often seem to strive to simply reduce absolute beliefs and tend to neglect possible adverse effects of strong multiplistic beliefs. More precisely, frequently proposed adverse effects of multiplism encompass impaired viewpoint and text comprehension (Bråten et al., 2013; Barzilai and Eshet-Alkalai, 2015) as well as impeded sourcing (Barzilai et al., 2015). Thus, even though the mere presentation of conflicting (or diverging) information has been shown to efficiently reduce absolutism, such interventions do not ensure that evaluativistic beliefs prosper. In fact, it is much more likely that an individual will simply "replace" absolute beliefs with multiplistic beliefs or that already existing multiplistic views are strengthened when he or she is confronted with inconsistent evidence on a specific topic. Furthermore, from a theoretical point of view, one may suggest that backward transitions from evaluativism to multiplism might occur if individuals are repeatedly confronted with diverging information including controversies that are more difficult to integrate (e.g., the conflicting intervention condition of Kienhues et al., 2011). As outlined above, this kind of epistemic change is, in our view, not worth striving for. Therefore, we need interventions that make individuals avert both absolute and multiplistic beliefs, while at the same time supporting a change toward evaluativistic beliefs.

The Resolvable Controversies Intervention

To address this need, Rosman et al. (2016a) developed an intervention approach, which—by drawing on so-called *resolvable controversies*—aims to reduce both absolutism *and* multiplism simultaneously, as well as to foster evaluativism. On a global level, it illustrates, based on apparently conflicting findings of studies on gender stereotyping at secondary schools, how to identify contextual factors that help to explain controversies when evidence seems to be ill-structured—or, more strictly speaking, it exemplifies how to weigh knowledge claims (Rosman et al., 2016a).

Recently, Rosman and Mayer (2018) used the following procedures for implementing the intervention: First, 18 short abstracts of conflicting studies on gender stereotyping and gender-specific discrimination in schools are presented. A crucial component of the resolvable controversies intervention is that apparent contradictions in these texts can be resolved (or integrated) by identifying the context in which a certain type of discrimination (favoring either boys or girls) occurs. To support this process, participants are additionally asked in adjunct questions who is discriminated against according to the present study. For example, intervention contents imply that girls are discriminated against in physics while boys are discriminated against in languages and literature. In this case, participants are thought to identify the factor "subject matter" as a contextual factor that explains apparent inconsistencies between the studies. This resolvability of apparent contradictions is thought to induce epistemic doubt concerning both absolutism and multiplism because a variation in findings exists but is explainable (Rosman et al., 2016a). According to Rosman, Mayer and Merk (under review), this insight should subsequently be generalized to higher-level domains (e.g., educational psychology). Unfortunately, on an empirical level, prior studies did not explicitly confirm this assumption—for example, by introducing a control condition drawing on inexplicable discrepancies in findings (i.e., "unresolvable" controversies)—but focused on the overall efficacy of the intervention instead.

In the second part of Rosman and Mayer's (2018) intervention, subjects proceeded by integrating conflicting findings in a writing task. In the resolution instruction of this writing task (i.e., the most prolific instruction for eliciting epistemic change), subjects were required to complete a scientific essay which illustrates conditions of gender-specific discrimination based on the presented studies. Because of the didactical properties of the presented controversies, subjects are expected to identify the aforementioned contextual factors under these circumstances. As the effects of both parts of the intervention (i.e., the reading and writing tasks) have never been disentangled, it remains unclear to what extent the intervention's efficacy can be attributed to either one of both of those distinct intervention contents. Examining these reading and writing tasks separately would be particularly insightful for clarifying how deeply diverging information has to be processed in order to affect epistemic beliefs. For example, drawing upon Bendixen and Rule's model of epistemic change, the writing task might trigger the resolution of epistemic doubt that was evoked by the presentation of diverging information. The underlying mechanism would be that a reflection on conflicting information in presented texts (during the writing task) prompts a reflection on one's own epistemic doubt that has been evoked by the respective texts. Although some studies investigated links between explicit reflection on epistemic beliefs and subsequent changes in those beliefs (see Lunn Brownlee et al., 2016), prior research failed to address the distinct relationship between receiving diverging information, reflecting on it, and epistemic change.

Research Questions

Based on these considerations, the purpose of our study is to shed some light onto how exactly diverging information may foster change toward advanced epistemic beliefs. Our first research question aims at identifying specific circumstances and characteristics of diverging information that trigger change toward certain types of epistemic beliefs.

(1) Under which circumstances does diverging information evoke epistemic change toward advanced belief types (i.e., no simple reduction of absolutism at the cost of rising multiplistic beliefs, but a reduction of both absolutism and multiplism, and a simultaneous change toward evaluativism)?

Moreover, we want to examine the effects of a deep processing of diverging information by separating effects of the *presentation* of diverging information (which should be closely related to the occurrence of epistemic doubt) from effects of *reflecting* on this information (which is possibly connected to the resolution of this doubt). Thus, our second research question is:

(2) Will interventions based on resolvable controversies still be able to induce epistemic change toward advanced epistemic

beliefs after removing all components that are linked to reflecting on how to integrate conflicting information?

As described above, it is plausible to assume that changes in epistemic beliefs depend on the level of specificity of both the administered intervention (i.e., presented diverging information) and the epistemic belief measure used. More specifically, intervention effects may be stronger if both levels of specificity correspond to each other. In our last research question, we will empirically scrutinize this assumption and examine to what extent changes in topic-specific beliefs (e.g., beliefs regarding the topic of gender stereotypes) carry over to higher-level domains (e.g., beliefs regarding educational psychology).

(3) Are the effects of topic-specific epistemic change interventions more pronounced in topic-specific epistemic belief measures?

In the next section, materials and methods of our study designed specifically to answer these questions are described.

MATERIALS AND METHODS

All planned procedures and hypotheses of our confirmatory analyses have been preregistered at the Open Science Framework (https://osf.io/te7wk/). For the reader's convenience, they are re-iterated here. Moreover, this section also includes information on actually collected data, exploratory outcomes and exploratory analyses. All study measures and methods were in compliance with the Declaration of Helsinki and the APA Ethics Code (American Psychological Association, 2002). Ethical approval was obtained from the Ethics Committee of the German Psychological Association and prior to their participation, all students gave their informed consent. Since study inclusion and pre-intervention measurements were conducted online, no written informed consent could be obtained at study inclusion. However, we provided an information sheet and consent form (for download) and subjects were only allowed to enter the study if they confirmed (by checking a box) that they agreed to the conditions specified in these documents. As all other study measures, these procedures for online data collection and study inclusion were approved by the Ethics Committee of the German Psychological Association.

Participants and Study Timeline

Our research questions were investigated with data from an experimental study employing a 4 × 2 pre-post design with one between-subjects factor (intervention type with four levels) and one within-subjects factor (repeated measurement factor with two levels). In total, $N = 201$ psychology students (minor and major), who were recruited at Trier University by means of flyers and mailing lists, partook in the online pre-intervention measurement. At least 1 week after this measurement, the second measurement occasion took place in group sessions at a university lab. In the second measurement occasion—that included the intervention as well as the post-intervention measurement—$N = 185$ students participated (92.04% of participants who had enrolled at the first measurement occasion) and received 20 Euro upon study completion. For one participant, pre-intervention and post-intervention data could not be matched and, thus, data of the first measurement occasion had to be treated as missing data. Thus, our dataset contains $N = 184$ students whose demographical data is known. These participants (89.67% females) had a mean age of $M = 23.21$ ($SD = 3.13$). 95.65% of our participants studied psychology as their major subject (59.78% Bachelor and 35.87% Master students), while 4.35% took a minor in psychology. The median study duration was six semesters ($M = 5.85$, $SD = 2.97$).

Procedures and Materials

Intervention

We modified Rosman and Mayer's (2018) resolvable controversies intervention that has been described above to address our research questions. We pursued two aims with this modification: (1) to inspect how the resolvable nature of presented controversies affects epistemic change, and (2) to examine the distinct effects of presenting diverging information (i.e., evoking epistemic doubt) on epistemic change by separating effects of doubt from effects that are possibly related to deeper level processing (i.e., the resolution strategy *reflection*).

To clarify if epistemic advancement does indeed depend on the resolvability of the controversies, we "masked" the resolvable nature of these controversies by distorting the effects of contextual factors that explain diverging findings (see **Figure 1** for an illustrative example). For example, if the original intervention text states that boys are consistently discriminated against in languages and literature, the modified version stated that some studies find that boys are discriminated against in languages and literature while others find that girls are disadvantaged in these subjects. Thus, we eliminated the pattern that underlies the presented conflicting information and, hence, the intervention should induce doubt concerning absolutism only because diverging findings cannot be integrated anymore. Multiplism, in contrast, might even be fostered since the abundance of conflicting information is likely to convey views of the knowledge body in question as extremely tentative and inconsistent.

Considering the second aim, that is singling out effects of epistemic doubt, we shortened the original resolvable controversies intervention of Rosman and Mayer (2018). The original paradigm uses both reading and writing about resolvable controversies. By means of specific writing instructions, participants are invited to integrate conflicting information and, thus, reflect on this information. It cannot be finally ruled out that this higher level processing of diverging information also causes reflection on participants' epistemic doubt. Thus, we separated effects of inducing epistemic doubt by the mere presentation of diverging information from effects of reflecting on this information by comparing a shortened version of the intervention, where the writing task is left out, to the original intervention that includes this writing task.

In order to test the overall efficacy of our intervention, we compared changes in epistemic beliefs in these three treatment conditions[1] to changes in a control group. Participants in

[1]In the following, we will refer to all experimental groups that received any kind of diverging information on gender stereotyping as *treatment groups* or *treatment*

Picault et al. (2003) compared grades in German of 113 high school students to their results in a standardized reading comprehension test (the so-called ELFE 1-6). Although boys/girls scored slightly higher than girls/boys in the reading comprehension test, the average grade boys/girls received was significantly lower. Consequently, boys/girls got poorer grades than girls/boys despite similar aptitude.

☐	☐	☐	☐
Boys are disadvantaged in secondary schools.	**Girls** are disadvantaged in secondary schools.	**Neither boys nor girls are disadvantaged** in secondary schools.	The study is **not related** to gender stereotyping in secondary schools.

In their study, Klerus et al. (2005) had 132 secondary school students take a standardized physics test. Moreover, students were also asked to state their grade in physics. Even though boys and girls did not show any differences in the standardized test, girls/boys had significantly poorer grades in physics. Thus, girls/boys received worse grades than boys/girls despite similar aptitude.

☐	☐	☐	☐
Boys are disadvantaged in secondary schools.	**Girls** are disadvantaged in secondary schools.	**Neither boys nor girls are disadvantaged** in secondary schools.	The study is **not related** to gender stereotyping in secondary schools.

Sperber et al. (2001) compared 126 secondary school students' grades in history to their results in a standardized school performance test (the so-called 'Hamburger Schulleistungstest'). Grades were assessed by means of self-reports. Analyses revealed no gender differences, neither with regard to the school performance test nor with regard to grades in history.

☐	☐	☐	☐
Boys are disadvantaged in secondary schools.	**Girls** are disadvantaged in secondary schools.	**Neither boys nor girls are disadvantaged** in secondary schools.	The study is **not related** to gender stereotyping in secondary schools.

FIGURE 1 | Three resolvable controversies sample texts. Cues allowing to resolve the controversies are underlined and red marks illustrate how texts were modified in the "Unresolvable Read" group (please note that only half of the cues were changed resulting in an overall random pattern of discrimination). The complete German version of the texts is available on request.

the control group read texts on students employing learning strategies. To design this task as similar as possible to the gender stereotypes reading task—which required participants to rate for each presented study if boys or girls were discriminated against (adjunct questions)—each text snippet of the control task contained two descriptions of students employing different learning strategies that were compared to each other. For example, participants learned that two students applied different approaches concerning the length and distribution of their learning units. While one student learned from 9 a.m. to 6 p.m. and only took a short lunch break of 20 min, the other student only learned for 2 h at a time and took extensive breaks in between. After reading both descriptions, participants were asked to assess the characteristics of these learning strategies on a set of scales, such as required effort or generation of detailed knowledge.

To sum up, intervention conditions or "experimental groups" in our study differed in the kind of intervention that participants received:

- *Control (learning strategies).* Group 1 read texts on students employing different learning strategies,
- *Unresolvable Read.* Group 2 read conflicting materials which cannot be resolved by identifying moderator variables (i.e., a modified version of the conflicting materials that are used in groups 3a and 3b),
- *Resolvable Read.* Group 3a read conflicting materials whose contradictions could be resolved (i.e., the original reading task of the resolvable controversies intervention),
- *Resolvable Read and Write.* Group 3b read conflicting materials whose contradictions could be resolved (the same task that group 3a received) and was additionally subjected

conditions (i.e., irrespectively of the (un)resolvable nature of these information or if subjects had to write an integrating text on these controversies).

to the resolution writing task of the resolvable controversies intervention.

The following time limits applied to respective tasks: Participants were allowed a maximum of 15 min for the reading task and 45 min for the writing task (in group 3b).

Assignment to Groups

Upon the start of the second measurement occasion, randomized assignment of participants to experimental groups was carried out using the respective function of the survey software Unipark. The study was single-blind (i.e., study staff could become aware of the assigned experimental group during the intervention). However, since all instructions that differed between groups and that were related to experimental manipulations were given in computerized form, this could not affect data quality. As expected, experimental groups did not differ significantly (all $p > 0.10$) in any demographic variables we assessed (i.e., age, gender, study semester, study subject, secondary school grades), nor in any pre-test scores on our dependent variables.

Manipulation Check

To evaluate whether our manipulation worked as intended, we checked if presented information on gender stereotypes were perceived as more controversial and contradictory in the "Unresolvable Read" group when compared to the "Resolvable Read" and "Resolvable Read and Write" groups. The underlying rationale is that—since we intended to thwart the integration of conflicting results by our modification of Rosman's intervention—higher scores on perceived contradictoriness indicate that diverging information has been recognized as non-resolvable in this group.

In order to test whether the expected differences occurred, we employed a self-report questionnaire that assessed to what extent subjects perceived presented information on gender stereotyping to be controversial or conflicting. A sample item is "Upon reading the texts…findings seemed to be very contradictory." The reliability on this scale was good (Omega total ranging from 0.80 to 0.81 in the three treatment groups). As a statistical technique, we used multiple regression analyses with the "Unresolvable Read" group as reference category and dummy-coded variables for group membership as predictors. It should be of note that the contradictoriness was only assessed for the "Unresolvable Read," "Resolvable Read" and "Resolvable Read and Write" group because of its topic-specific focus. Assessment took place after the intervention was finished in respective groups (i.e., after reading the controversies in the "Unresolvable Read" and "Resolvable Read" group and after writing a text on these controversies in the "Resolvable Read and Write" group). **Figure 2** provides a graphical overview of reported contradictoriness' mean scores separated by intervention group.

Results of these multiple regression analyses revealed that the perceived overall contradictoriness of presented information differed significantly between groups, $R^2 = 0.13$, $F_{(2, 136)} = 10.61$, $p < 0.001$. More precisely, estimates for dummy-coded regression coefficients indicate that subjects in the "Unresolvable Read" group rated presented information to be more inconsistent than subjects in both the "Resolvable Read" group ($b = -0.77$, $t_{(136)} = -3.213$, $p < 0.01$) and the "Resolvable Read and Write" group ($b = -1.06$, $t_{(136)} = -4.468$, $p < 0.001$).

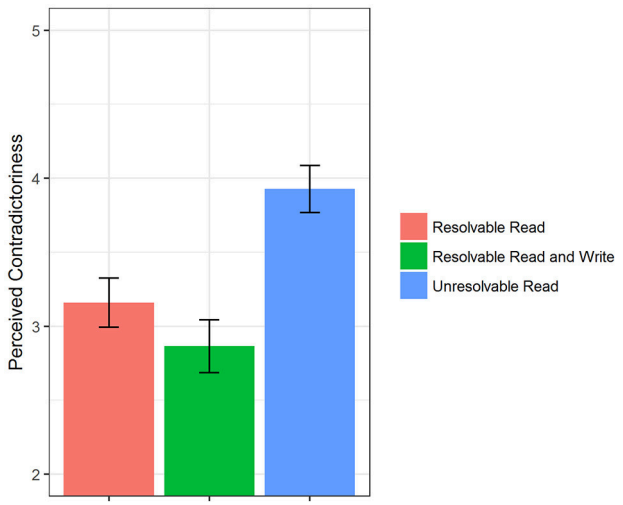

FIGURE 2 | Manipulation Check. Descriptive differences (means and standard errors) in perceived contradictoriness between groups that received controversial information on gender stereotyping.

Thus, our manipulation succeeded in "masking" the resolvability of inconsistent findings which is an integral part of the original intervention. Participants in the "Unresolvable Read group judged information concerning gender stereotypes to be more controversial than subjects in the "Resolvable Read" and "Resolvable Read and Write" groups.

Dependent Variables

Confirmatory dependent measures are the FREE-GST, a topic-specific measure of epistemic beliefs and the FREE-EDPSY, a domain-specific measure of epistemic beliefs. Both measures are based on Kuhn et al. (2000) framework and were initially developed and validated in a recent study of Rosman, Mayer and Merk (under review).

Primary outcome: topic-specific epistemic beliefs (FREE-GST)

The FREE-GST measures topic-specific epistemic beliefs on gender-stereotype discrimination in secondary schools. The questionnaire starts with the presentation of three controversial positions on gender stereotype discrimination (i.e., boys are disadvantaged, girls are disadvantaged, neither boys nor girls are disadvantaged). Thereafter, 15 statements on this controversy, which represent either absolute, multiplistic, or evaluativistic beliefs, are to be rated on a 6-point Likert scale (5 statements per belief type). A sample item for evaluativism is "Gender specific discrimination can be diverse. Accordingly, depending on certain contextual factors, rather one or the other view is correct."

Secondary outcome: domain-specific epistemic beliefs (FREE-EDPSY)

The FREE-EDPSY applies the same procedure to domain-specific epistemic beliefs in educational psychology. It introduces controversial scientific positions relating to the domain of educational psychology (i.e., an argument about the efficacy of an unspecified method of this field, such as a learning strategy or a teaching method). Subsequently, just like in the FREE-GST, 15 statements relating to either absolute, multiplistic, or evaluativistic beliefs are presented. A sample item for multiplism is "In educational research, scientists interpret their findings based on their personal opinion. Actually, nobody can know for sure whether specific methods are beneficial for learning or not."

Computation of scales and indices for the FREE-GST and FREE-EDPSY

Absolutism, multiplism and evaluativism scores were computed as mean scores of the respective items for the FREE-GST and FREE-EDPSY, exactly as has been done in prior research (e.g., Rosman and Mayer, 2018). After inspecting psychometric properties of these scales, we decided to drop one item of the multiplism scale because reliabilities increased for both the FREE-GST and the FREE-EDPSY if this item was excluded.

Furthermore, we combined absolutism, multiplism and evaluativism scores to the so-called D-index, which Krettenauer (2005) proposed as an overall measure of advanced epistemic beliefs. Applying Krettenauer's formula to our questionnaires, the D-index was computed as *Evaluativism –.5 x (Absolutism + Multiplism)* for the FREE-GST and the FREE-EDPSY. Because the D-Index condenses changes across absolutism, multiplism and evaluativism, we expected the power to detect such overall changes toward advanced beliefs to be higher in analyses using the D-Index. However, as the D-index was not part of our preregistration, analyses including this index are exploratory.

Exploratory outcome: psychology-specific justification beliefs

We assessed psychology-specific justification beliefs by a domain-specific adaptation of a domain-general German questionnaire (Klopp and Stark, 2016). Klopp and Stark's questionnaire builds on items originally developed by Ferguson et al. (e.g., Bråten et al., 2013; Ferguson and Bråten, 2013). The questionnaire differentiates the three types of justification beliefs that were introduced above: (1) personal justification, (2) justification by authority, (3) justification by multiple sources. All scores were computed as mean scores.

Covariates

To control for influences of third variables, we measured a set of potential covariates. Need for cognitive closure was assessed by Schlink and Walther's (2007) questionnaire as connections to epistemic change have already been empirically shown for this construct (Rosman et al., 2016a). Additionally, (Bendixen and Rule, 2004) repeatedly emphasized the (theoretical) importance of environmental factors. In order to account for this, we employed Schiefele and Jacob-Ebbinghaus (2006) study satisfaction questionnaire. Moreover, as Bendixen and Rule's model on epistemic change is closely connected to conceptual change theory (Bendixen and Rule, 2004), covariates that are proposed in the conceptual change literature, i.e. need for cognition, task value, prior topic interest and self-reported prior knowledge (Dole and Sinatra, 1998; Sinatra and Mason, 2013), were included as well. Therefore, we employed an established measurement instrument by Bless et al. (1994) for need for cognition and a questionnaire that proved to reliably assess task value dimensions in prior research (Gaspard et al., 2017). Since these variables were only included in exploratory analyses if they differed at least marginally significantly between groups (see below), further details are only provided for control variables that are relevant for the present paper in **Tables 2**, **3**.

Hypotheses

Based on the research questions that were introduced above, we derived the following hypotheses:

H1. Epistemic belief change can be induced by text-based interventions that evoke epistemic doubt. The predicted patterns of epistemic change regarding the three developmental stages of epistemic beliefs (absolutism, multiplism, evaluativism) can be found in **Table 1**.

More specifically, we expect small to moderate effects for the following differences between intervention conditions:

- *H1a.* Reading multiple texts presenting conflicting scientific evidence will induce epistemic change, whereas reading texts on students employing different learning strategies will not induce epistemic change.
- *H1b.* Evaluativism 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.
- *H1c.* The 'resolvable controversies' intervention reliably induces epistemic change even if it is shortened by leaving out the writing task. Incremental effects of the writing task will be small to moderate.

H2. All effects on epistemic change will be more pronounced in the topic-specific measure FREE-GST compared to the domain-specific FREE-EDPSY questionnaire.

In the following, statistical procedures for testing these hypotheses are described.

Statistical Analyses

All statistical analyses were conducted in R 3.5.0 (R Core Team, 2018). The package lavaan 0.6-1 (Rosseel, 2012) was used for latent variable analyses.

TABLE 1 | Predicted pattern of effects (FREE-GST, FREE-EDPSY).

	Absolutism	Multiplism	Evaluativism
Resolvable read and write	−	−	++
Resolvable read	−	−	+
Unresolvable read	−	+	0
Control (learning strategies)	0	0	0

+, increase in epistemic beliefs; –, decrease in epistemic beliefs; 0, no change in epistemic beliefs.

TABLE 2 | Intercorrelations and reliabilities of study variables at the pre-intervention measurement occasion (t1).

	Correlation \ *p*-values	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
1	Absolutism (topic-specific)	**0.73**	0.047	< 0.001	< 0.001	0.017	< 0.001	0.014	0.007	0.327	0.132	0.479	< 0.001	< 0.001
2	Multiplism (topic-specific)	0.147	**0.69**	0.004	0.764	< 0.001	0.014	< 0.001	0.605	0.707	0.088	0.338	< 0.001	< 0.001
3	Evaluativism (topic-specific)	−0.313	−0.212	**0.71**	0.002	0.007	< 0.001	< 0.001	0.845	0.019	0.002	0.056	< 0.001	< 0.001
4	Absolutism (domain-specific)	0.662	0.022	−0.224	**0.76**	0.512	0.001	0.167	< 0.001	0.554	0.390	0.922	< 0.001	< 0.001
5	Multiplism (domain-specific)	0.176	0.701	−0.199	0.049	**0.79**	0.017	< 0.001	0.184	0.504	0.793	0.710	< 0.001	< 0.001
6	Evaluativism (domain-specific)	−0.274	−0.180	0.757	−0.253	−0.176	**0.69**	0.002	0.738	0.036	0.019	0.299	< 0.001	< 0.001
7	Personal Justification	0.181	0.623	−0.262	0.102	0.711	−0.229	**0.77**	0.198	0.131	0.953	0.714	< 0.001	< 0.001
8	Justification by Authority	0.198	−0.038	−0.014	0.254	−0.098	−0.025	−0.095	**0.76**	0.056	0.364	0.505	0.336	0.324
9	Justification by Multiple Sources	−0.073	−0.028	0.172	−0.044	0.050	0.154	0.112	−0.141	**0.73**	0.604	0.404	0.043	0.201
10	Task Value	−0.112	−0.126	0.226	−0.064	−0.020	0.173	0.004	0.068	0.039	**0.90**	0.053	0.001	0.051
11	Prior Interest Gender Stereotypes	0.053	−0.071	0.141	0.007	0.028	0.077	−0.027	−0.050	0.062	0.143	**0.77**	0.188	0.641
12	D–Index (topic–specific)	−0.641	−0.562	0.845	−0.407	−0.455	0.661	−0.469	−0.071	0.150	0.236	0.098	–	< 0.001
13	D–Index (domain–specific)	−0.514	−0.430	0.661	−0.577	−0.568	0.818	−0.497	−0.073	0.095	0.145	0.035	0.783	–

N = 184 and 183 (for correlations involving prior interest in gender stereotypes or task value); values in bold on the diagonal = Omega Total; the lower triangle contains correlation estimates while the upper triangle represents corresponding p-values (two-tailed tests).

Statistical Model

Confirmatory analyses

We used latent difference score modeling (McArdle, 2009) to analyze our data. The main outcome variables of our analyses were changes in epistemic beliefs (i.e., absolutism, multiplism and evaluativism scores of the FREE-GST and FREE-EDPSY), which were operationalized as latent change scores (see **Figure 3** for more details). These latent change scores were predicted by dummy-coded intervention group variables. In order to investigate group differences not related to the reference group, we defined these effects as new parameters of the structural equation model. The same procedure holds for comparisons between topic–and domain-related measures (H2). Analyses concerning H1 were conducted separately for absolutism, multiplism and evaluativism (for FREE-GST and FREE-EDPSY, respectively) resulting in a total number of six target models. A logical precondition of H2 (more pronounced effects on epistemic change for the topic-specific FREE-GST) is that group differences in epistemic change exist. Therefore, H2 was only to be tested if any significant group differences were found in analyses that are related to H1. However, H2-analyses were performed even if the revealed pattern of effects contradicted the hypothesized pattern of effects. H2-analyses were conducted separately for absolutism, multiplism and evaluativism resulting in a maximum possible number of three target models.

The following procedure was employed for testing our hypotheses: First, intervention group was dummy-coded with the control group as reference category[2]. Thereafter, we estimated a null model that fixed differences in epistemic change between groups ($b_1 = b_2 = b_3 = 0$) [H1] or between topic-specific and domain-specific measures ($b_{0GST} = b_{0EDPSY}$, $b_{1GST} = b_{1EDPSY}$, $b_{2GST} = b_{2EDPSY}$, $b_{3GST} = b_{3EDPSY}$) [H2] to zero. Subsequently, we compared this null model to a target model that imposed no restrictions on differences in epistemic change between groups ($b_1 = x_1$, $b_2 = x_2$, $b_3 = x_3$) [H1] or topic–and domain-specific measures ($b_{0GST} = x_4$, $b_{0EDPSY} = x_5$, $b_{1GST} = x_6$, $b_{1EDPSY} = x_7$, $b_{2GST} = x_8$, $b_{2EDPSY} = x_9$, $b_{3GST} = x_{10}$, $b_{3EDPSY} = x_{11}$) [H2]. If the corresponding likelihood ratio test (LRT) revealed that epistemic change differed significantly between groups [H1] or measures [H2], we inspected the estimated model parameters in order to examine group [H1] or measure differences [H2] in epistemic change. We used the standard $p < 0.05$ criteria for likelihood ratio tests and for determining if the estimated effects of (dummy-coded) intervention group variables were significantly different from those expected if the null hypothesis was correct. As the expected direction of effects as well as the expected order of effects is explicitly predicted, we used one-tailed tests whenever appropriate.

[2]This is a minor modification to the planned procedure in our preregistration which suggested using the "Resolvable Read and Write" group as reference. However, this modification does not substantially affect our confirmatory analyses as it only changes how the model is parameterized (and not if effects become significant or not). We chose this procedure as it allowed us a more convenient interpretation of results (i.e., in terms of consistency with exploratory analyses).

TABLE 3 | Means and standard deviations of all study variables separated by intervention group.

	Pre-intervention (t1)								Post-intervention (t2)							
	M_{LS}	SD_{LS}	M_{UR}	SD_{UR}	M_{RR}	SD_{RR}	M_{RW}	SD_{RW}	M_{LS}	SD_{LS}	M_{UR}	SD_{UR}	M_{RR}	SD_{RR}	M_{RW}	SD_{RW}
Absolutism (topic-specific)	2.671	0.850	2.813	0.751	2.822	0.694	2.847	0.740	2.383	0.832	2.396	0.777	2.509	0.714	2.238	0.884
Multiplism (topic-specific)	2.978	0.738	3.076	0.758	2.924	0.673	3.059	0.747	2.924	0.859	2.777	0.738	2.614	0.737	2.777	0.911
Evaluativism (topic-specific)	4.871	0.606	4.870	0.558	4.813	0.666	4.749	0.720	4.891	0.682	5.048	0.530	4.935	0.595	5.026	0.673
Absolutism (domain-specific)	2.636	0.739	2.752	0.683	2.891	0.802	2.872	0.696	2.474	0.784	2.522	0.762	2.652	0.756	2.481	0.881
Multiplism (domain-specific)	3.083	0.885	3.011	0.756	2.832	0.825	3.229	0.746	2.799	0.843	2.777	0.834	2.614	0.881	2.899	0.817
Evaluativism(domain-specific)	4.987	0.602	4.922	0.537	4.917	0.563	4.877	0.687	5.052	0.583	5.074	0.534	4.991	0.537	5.111	0.575
D-Index (topic-specific)	2.047	1.082	1.925	0.908	1.940	0.932	1.796	1.030	2.238	1.141	2.461	0.895	2.373	0.738	2.518	0.953
D-Index (domain-specific)	2.127	0.936	2.040	0.886	2.056	0.930	1.826	0.968	2.416	0.919	2.424	0.814	2.358	0.804	2.421	0.917
Personal Justification	2.607	1.035	2.630	1.012	2.420	0.765	2.901	0.914	2.341	0.868	2.457	0.898	2.326	0.899	2.660	0.936
Justification by Authority	3.785	0.838	3.543	0.946	3.543	0.884	3.418	0.844	3.761	0.746	3.370	0.856	3.580	0.859	3.156	1.056
Justification by Multiple Sources	5.022	0.796	5.080	0.689	4.935	0.848	5.043	0.680	5.043	0.729	5.203	0.638	5.203	0.573	5.262	0.637
Task Value	2.920	0.675	2.707	0.618	2.549	0.680	2.660	0.681	–	–	–	–	–	–	–	–
Prior Interest Gender Stereotypes	4.341	1.131	4.399	1.104	4.072	0.883	4.809	1.056	–	–	–	–	–	–	–	–
Perceived Contradictoriness	–	–	–	–	–	–	–	–	–	–	3.928	1.082	3.159	1.133	2.865	1.219
N	45*	45*	46	46	46	46	47	47	46	46	46	46	46	46	47	47

*M, arithmetic mean; SD, standard deviation; indices specify the intervention group LS, Learning Strategies (Control); UR, Unresolvable Read; RR, Resolvable Read; RW, Resolvable Read and Write. *Due to missing values the sample size for prior interest in gender stereotypes and task value was 44.*

Exploratory analyses

In addition to this preregistered procedure, we introduced an alternating model which proposed that the presentation of topic-specific diverging information had an overall effect on epistemic beliefs that was invariant across treatment groups (i.e., in the "Resolvable Read," "Resolvable Read and Write" and the "Unresolvable Read" group). Strictly speaking, this "equal group effects" model thereby suggests that neither the writing task nor the resolvable or unresolvable nature of the intervention materials mattered, but that the mere presentation of diverging information may trigger epistemic change. In order to specify this model, we restricted effects of dummy-coded variables to be equal across treatment conditions ($b_1 = b_2 = b_3$) and repeated our analyses for the FREE-GST and FREE-EDPSY. Furthermore, we analyzed the five additional exploratory outcomes introduced above: justification beliefs (personal justification, justification by authority, justification by multiple sources), and the D-Indices of the FREE-GST respectively the FREE-EDPSY.

As a consequence, we extended our model comparison procedure for choosing a target model as follows: In a first step, we compared the equal group effects model ($b_1 = b_2 = b_3$) to the null model ($b_1 = b_2 = b_3 = 0$) based on a likelihood ratio test. The selected model of the first step was subsequently compared to our target model from the confirmatory analyses ($b_1 = x_1$, $b_2 = x_2$, $b_3 = x_3$). Otherwise, we applied the same procedures as for confirmatory hypothesis testing.

We also checked for pre-test differences on covariates that were measured before group assignment took place by means of ANOVAs with group as factor. If any marginally significant or significant differences between groups on covariates existed, we conducted additional analyses that introduced these covariates as predictors of both pre-intervention beliefs and epistemic change in our latent change model.

Finally, we investigated if the intervention was especially beneficial for subjects that held more naive epistemic beliefs (i.e., prior beliefs as indicated by pre-intervention values). For this purpose, we divided our sample into groups with more naive or more advanced epistemic beliefs—as has been done in prior research on epistemic change (e.g., Kienhues et al., 2008). More precisely, we repeated all prior exploratory analyses that yielded significant intervention effects and used multiple group modeling to test if these intervention effects differed between naive and advanced groups. For each multiple group model, we split our sample into a naive and an advanced group based on the median

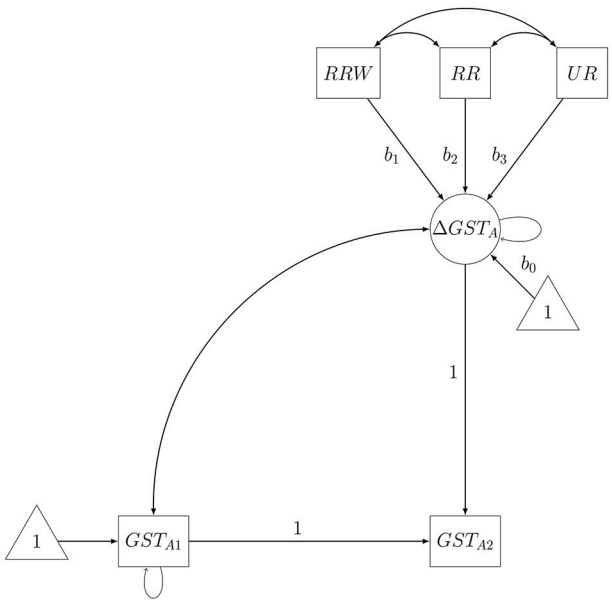

FIGURE 3 | Exemplary latent change model for testing H1. Latent change in epistemic beliefs Δ GST_A (i.e., latent change in absolutism on the FREE-GST) is predicted by dummy-coded variables indicating group membership (i.e., *RRW* for "Resolvable Read and Write", *RR* for "Resolvable Read" and *UR* for "Unresolvable Read"). Latent change itself is operationalized as the part of an observed outcome variable GST_{A2} (i.e., absolutism on the FREE-GST post-intervention) that differs from its pre-intervention measurement GST_{A1} (i.e., absolutism on the FREE-GST pre-intervention).

score of pre-intervention values of the outcome variable under investigation and tested if intervention effects differed between these groups based on LRTs.

Statistical Power and Sample Size Calculation

Our a priori determined target sample size was 212 participants (i.e., 53 for each experimental group). In order to calculate this target sample size, we conducted a simulation study in R. For each condition of this simulation study (i.e., tested sample size), we generated 1,000 datasets and, subsequently, analyzed the data using the statistical model described above. The expected effect size in the population model of this simulation study was derived from a previous study by Rosman, Mayer and Merk (under review), who examined epistemic change using the resolvable controversies intervention and employed a similar design to our current study. In this study, the authors showed that modifying the resolvable controversies intervention by introducing alternating writing tasks caused significant differences in epistemic change between conditions (i.e., a standardized regression coefficient of 0.276 for change in evaluativism). As we assumed that dropping the writing task or changing the resolvable nature of the presented controversies were much stronger modifications of the established resolvable controversies intervention, we expected larger effects in the current study. Our simulation study revealed that such effects would be detectable for a sample size of $n = 53$ subjects per group: The power for detecting small to moderate effects (i.e., beta $= 0.40$), which range above the practical significance criterion introduced by Ferguson (2009), surpassed 85%. Moreover, the power for detecting moderate effects (i.e., beta $= 0.50$) was above 96% for this sample size. A reanalysis with our actual sample size (46 subjects per group) showed that the power for detecting small to moderate effects still approximated 80% and was therefore acceptable.

RESULTS

Reliabilities and intercorrelations of all study variables for the first measurement occasion are given in **Table 2**, while means and standard deviations (separated by group) are given in **Table 3**. Moreover, considerable ceiling effects existed for the *justification by multiple sources* scale (pre 15.22% and post 20.00% of all subjects showed values at the upper limit of the scale), as well as small ceiling effects for *evaluativism* on both the FREE-GST (2.72% pre and 8.11% post) and the FREE-EDPSY (6.52% pre and 7.57% post). Floor effects for all other measures were neglectable (<5.00% pre respectively 6.50% post), while the D-Index was completely unaffected by ceiling effects. There were no univariate or multivariate outliers on dependent variables according to the criteria of our preregistration (i.e., based on z-scores with $p(z) < 0.001$ for univariate outliers and a mahalanobis distance with $p(\chi^2, df = 6) < 0.001$ for multivariate outliers). Thus, no outlier-corrected analyses were performed.

Confirmatory Analyses

A graphical overview of mean changes in epistemic beliefs on primary and secondary outcomes divided by experimental groups is given in **Figure 4**.

Hypothesis 1

None of the likelihood ratio tests that were planned in our preregistration reached significance (all $p > 0.05$ see **Tables 4**, **5** for more details). Thus, we found no significant group differences in epistemic change according to the preregistered criterion. For topic-specific beliefs, as measured by the FREE-GST, we observed, across experimental groups, significant declines in absolutism ($b_0 = -0.407$, $p < 0.001$) and multiplism ($b_0 = -0.242$, $p < 0.001$), while evaluativism increased significantly ($b_0 = 0.153$, $p < 0.01$). The same pattern was observed for domain-specific beliefs that were assessed by the FREE-EDPSY with regard to absolutism ($b_0 = -0.254$, $p < 0.001$) and multiplism ($b_0 = -0.271$, $p < 0.001$) and evaluativism ($b_0 = 0.134$, $p < 0.001$, see **Table 6** for more details).

Hypothesis 2

As prespecified in our statistical analysis plan, Hypothesis 2 was not tested because confirmatory analyses concerning Hypothesis 1 revealed no significant differences between groups.

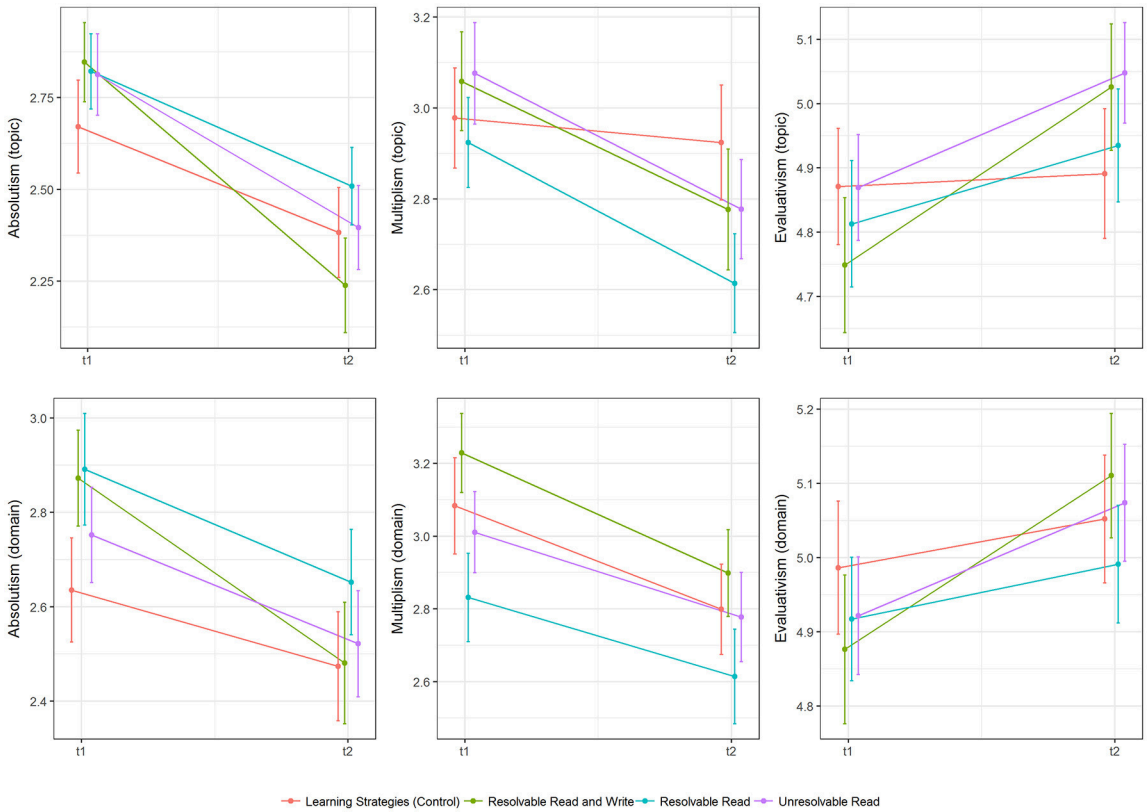

FIGURE 4 | Descriptive differences (means and standard errors) in epistemic change in topic-specific (FREE-GST) and domain-specific (FREE-EDPSY) epistemic beliefs for absolutism, multiplism and evaluativism.

Exploratory Analyses

Equal Group Effects Model

When repeating our analyses with the equal group effects model ($b_1 = b_2 = b_3$), all likelihood ratio tests on primary and secondary outcomes still failed to reach statistical significance when comparing the equal group effects model to the null model (all $p > 0.05$ see **Tables 4**, **5** for more details).

D-Index

Descriptive changes in the D-Index are depicted in **Figure 5**, while more information on descriptive statistics is available in **Table 3**.

For topic-specific advanced epistemic beliefs, LRTs indicated that the equal group effects model fitted our data best. In other words, effects on epistemic change for the control group and the three topic-specific intervention groups (i.e., the "Resolvable Read and Write," "Resolvable Read," "Unresolvable Read" groups) differed significantly ($\Delta\ \chi^2 = 6.413$, $df = 1$, $p < 0.05$), while differences in effect estimates between experimental conditions did not reach statistical significance ($\Delta\ \chi^2 = 2.830$, $df = 2$, $p = 0.243$). When analyzing parameter estimates of the model, we obtained the following pattern of effects: Even though D-index scores (an indicator of advanced epistemic beliefs) increased significantly in the control group ($b_0 = 0.253$, $p < 0.05$), this increase was significantly larger across topic-specific intervention groups ($b_1 = 0.300$, $p < 0.05$).

For the respective measure on domain-specific beliefs, LRTs indicated that neither for the equal group effects model, nor for a model with unrestricted group effects, model fit improved significantly. Across groups, we observed a significant increase in the D-Index for domain-specific beliefs ($b_0 = 0.397$, $p < 0.001$). **Tables 4**, **5** provide more details on model fit difference tests and overall model fit, while **Table 6** presents parameter estimates.

As epistemic change differed between groups, we tested Hypothesis 2 for the D-Index. Concerning Hypothesis 2, we selected (again based on LRTs) a model that restricted effects on topic-specific and domain-specific measures to be equal across topic-specific intervention groups ($b_1 = b_2 = b_3$) but allowed these effects (and the intercept in the control group) to differ between topic- and domain-specific measures (see **Table 7** for more details on model difference tests). Model inspection showed that intervention effects on epistemic change were indeed significantly more pronounced in the topic-specific D-Index than in the domain-specific D-index (b_{1GST}-$b_{1EDPSY} = 0.237$, $p < 0.05$), while effects in the control group did not differ significantly (b_{0GST}-$b_{0EDPSY} = -0.100$, $p = 0.396$). Again, **Table 6** provides further details on parameter estimates.

TABLE 4 | Fit indices and model difference tests for the FREE-GST.

	Without covariates							With covariates						
	χ^2	*df*	*p*		$\Delta\chi^2$	Δdf	*p*	χ^2	*df*	*p*		$\Delta\chi^2$	Δdf	*p*
ABSOLUTISM														
M0. No intervention effect	**7.905**	**6**	**0.245**	M0 vs. M1	1.096	1	0.295	**7.062**	**6**	**0.315**	M0 vs. M1	1.015	1	0.314
M1. Equal group effects	6.809	5	0.235	M1 vs. M2	–	–	–	6.047	5	0.302	M1 vs. M2	–	–	–
M2: Varying intervention effects	1.673	3	0.643	M0 vs. M2	6.232	3	0.101	0.944	3	0.815	M0 vs. M2	6.118	3	0.106
MULTIPLISM														
M0. No intervention effect	**5.197**	**6**	**0.519**	M0 vs. M1	3.597	1	0.058	6.403	6	0.380	M0 vs. M1	3.854	1	0.0496
M1. Equal group effects	1.600	5	0.901	M1 vs. M2	–	–	–	**2.549**	**5**	**0.769**	M1 vs. M2	0.508	2	0.776
M2: Varying intervention effects	1.242	3	0.743	M0 vs. M2	3.955	3	0.266	2.041	3	0.564	M0 vs. M2	–	–	–
EVALUATIVISM														
M0. No intervention effect	**4.904**	**6**	**0.556**	M0 vs. M1	2.440	1	0.118	6.219	6	0.399	M0 vs. M1	4.143	1	0.042
M1. Equal group effects	2.464	5	0.782	M1 vs. M2	–	–	–	**2.076**	**5**	**0.839**	M1 vs. M2	0.455	2	0.797
M2: Varying intervention effects	1.047	3	0.790	M0 vs. M2	3.856	3	0.277	1.621	3	0.655	M0 vs. M2	–	–	–
D-INDEX														
M0. No intervention effect	10.502	6	0.105	M0 vs. M1	6.413	1	0.011	11.405	6	0.077	M0 vs. M1	8.079	1	0.004
M1. Equal group effects	**4.088**	**5**	**0.537**	M1 vs. M2	2.830	2	0.243	**3.326**	**5**	**0.650**	M1 vs. M2	1.800	2	0.407
M2: Varying intervention effects	1.259	3	0.739	M0 vs. M2	–	–	–	1.526	3	0.676	M0 vs. M2	–	–	–

Boldface = target model.

TABLE 5 | Fit indices and model difference tests for the FREE-EDPSY.

	Without covariates							With covariates						
	χ^2	*df*	*p*		$\Delta\chi^2$	Δdf	*p*	χ^2	*df*	*p*		$\Delta\chi^2$	Δdf	*p*
ABSOLUTISM														
M0. No intervention effect	**6.004**	**6**	**0.423**	M0 vs. M1	0.375	1	0.540	**5.430**	**6**	**0.490**	M0 vs. M1	0.235	1	0.628
M1. Equal group effects	5.629	5	0.344	M1 vs. M2	–	–	–	5.195	5	0.393	M1 vs. M2	–	–	–
M2: Varying intervention effects	3.968	3	0.265	M0 vs. M2	2.037	3	0.565	3.457	3	0.326	M0 vs. M2	1.973	3	0.578
MULTIPLISM														
M0. No intervention effect	**6.141**	**6**	**0.408**	M0 vs. M1	0.033	1	0.855	**6.335**	**6**	**0.387**	M0 vs. M1	0.176	1	0.675
M1. Equal group effects	6.108	5	0.296	M1 vs. M2	–	–	–	6.159	5	0.291	M1 vs. M2	–	–	–
M2: Varying intervention effects	6.010	3	0.111	M0 vs. M2	0.131	3	0.988	6.046	3	0.109	M0 vs. M2	0.289	3	0.962
EVALUATIVISM														
M0. No intervention effect	**3.859**	**6**	**0.696**	M0 vs. M1	0.486	1	0.486	**3.138**	**6**	**0.791**	M0 vs. M1	1.165	1	0.280
M1. Equal group effects	3.374	5	0.643	M1 vs. M2	–	–	–	1.973	5	0.853	M1 vs. M2	–	–	–
M2: Varying intervention effects	0.704	3	0.872	M0 vs. M2	3.156	3	0.368	0.606	3	0.895	M0 vs. M2	2.532	3	0.470
D-INDEX														
M0. No intervention effect	**5.637**	**6**	**0.465**	M0 vs. M1	0.467	1	0.494	**4.634**	**6**	**0.592**	M0 vs. M1	0.571	1	0.450
M1. Equal group effects	5.170	5	0.396	M1 vs. M2	–	–	–	4.063	5	0.540	M1 vs. M2	–	–	–
M2: Varying intervention effects	2.640	3	0.450	M0 vs. M2	2.996	3	0.392	2.646	3	0.449	M0 vs. M2	1.988	3	0.575

Boldface = target model.

Justification Beliefs

Observed changes in justification beliefs are depicted in **Figure 6**, while **Table 8** details overall model fit and model difference tests. Finally, information on parameter estimates of the target models can be retrieved from **Table 9**.

Personal justification

For *personal justification*, we found no group differences in epistemic change ($p > 0.05$ for all LRTs). Overall, personal justification beliefs decreased significantly ($b_0 = -0.201$, $p < 0.001$) across groups.

Justification by authority

Regarding the next scale of the justification beliefs questionnaire, *justification by authority*, LRTs indicated that a model with varying (freely estimated) effects between experimental conditions fitted our data best ($\Delta\ \chi^2 = 9.708$, $df = 3$, $p < 0.05$, see **Table 8** for more details). According to this model, beliefs in justification by authority decreased significantly in the "Resolvable Read and Write" group ($b_1 = -0.378$, $p < 0.05$) and the "Unresolvable Read" group ($b_3 = -0.247$, $p < 0.05$) when compared to epistemic change in the control group. The corresponding effect in the "Resolvable Read"

TABLE 6 | Regression coefficients of target models predicting epistemic change in absolutism, multiplism, evaluativism and the D-Index (measured by FREE-GST and FREE-EDPSY).

	Absolutism				Multiplism				Evaluativism				D-Index			
	No covariates		Covariates		No covariates		Covariates		No covariates		Covariates		No covariates		Covariates	
	EST	SE	EST	SE	EST	SE	EST	SE	EST	SE	EST	SE	EST	SE	EST	SE
FREE-GST																
Intercept	**−0.407****	0.050	**−0.407****	0.049	**−0.242****	0.053	−0.072	0.099	**0.153****	0.044	0.019	0.072	**0.253***	0.114	**0.225***	0.113
Intervention	0.000	–	0.000	–	0.000	–	**−0.226***	0.113	0.000	–	**0.178***	0.085	**0.300***	0.127	**0.337****	0.125
Task Value		–	−0.091	0.057			0.001	0.058			0.045	0.045			0.027	0.061
Prior Interest			0.053	0.060			0.006	0.052			0.016	0.047			0.029	0.057
FREE–EDPSY																
Intercept	**−0.254****	0.049	**−0.254****	0.049	**−0.271****	0.048	**−0.271****	0.048	**0.134****	0.036	**0.134****	0.036	**0.397****	0.054	**0.397****	0.053
Intervention	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–
Task Value			0.050	0.054			0.049	0.053			0.031	0.037			−0.018	0.058
Prior Interest			−0.013	0.051			−0.061	0.054			0.035	0.035			0.072	0.061
FREE–GST and FREE-EDPSY																
Intercept_{GST}							−0.097	0.097			0.053	0.051	**0.224***	0.107	**0.199**$^{+}$	0.105
Intercept_{EDPSY}							**−0.298****	0.096			0.053	0.051	**0.323****	0.091	**0.334****	0.092
$\text{Intervention}_{GST}$							**−0.192**$^{+}$	0.106			**0.117**$^{+}$	0.062	**0.337****	0.118	**0.370****	0.114
$\text{Intervention}_{EDPSY}$							0.035	0.105			**0.117**$^{+}$	0.062	0.099	0.102	0.085	0.102
Task Value_{GST}							0.004	0.057			0.040	0.045			0.030	0.061
$\text{Prior Interest}_{GST}$							0.005	0.052			0.018	0.047			0.028	0.057
$\text{Task Value}_{EDPSY}$							0.051	0.053			0.040	0.038			0.069	0.060
$\text{Prior Interest}_{EDPSY}$							−0.062	0.053			0.032	0.035			−0.012	0.058
ΔControl							**0.201***	0.093					−0.100	0.117	−0.135	0.117
ΔIntervention							**−0.227***	0.094					**0.237***	0.118	**0.284***	0.116

N = 185; reference group (0/0/0 dummy coding) = control (learning strategies); EST, unstandardized regression weight; SE, standard error; boldface scores = two-tailed significance test; $^{+}p < 0.10$; $^{*}p < 0.05$; $^{**}p < 0.01$.

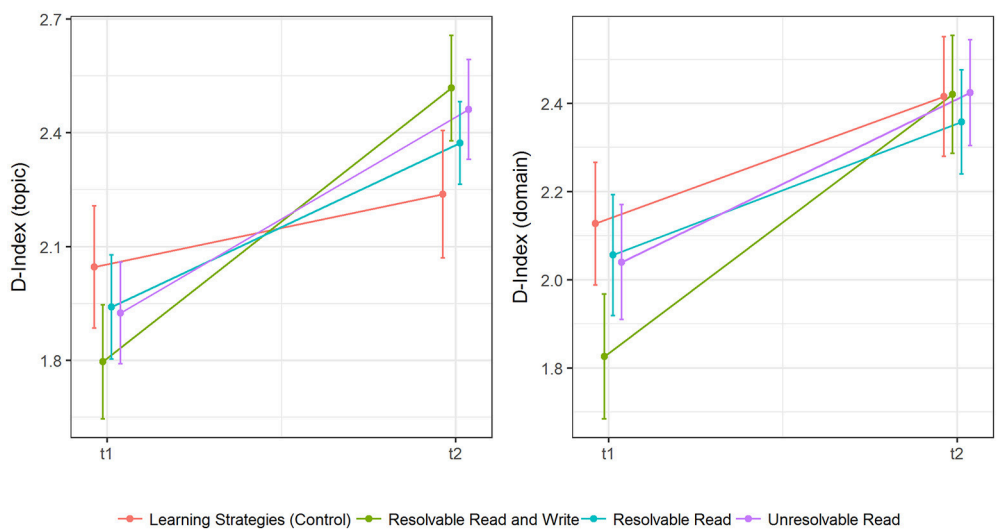

FIGURE 5 | Descriptive differences (means and standard errors) in epistemic change in topic-specific (FREE-GST) and domain-specific epistemic beliefs (FREE-EDPSY) for the D-index.

group ($b_2 = -0.037$, $p = 0.771$) and overall change in the control group ($b_0 = 0.066$, $p = 0.477$) did not reach statistical significance.

Justification by multiple sources

Finally, we selected a model with effects that were fixed to be equal for all groups that received a topic-specific intervention on

TABLE 7 | Fit indices and model difference tests for Hypothesis 2.

	Without covariates							With covariates						
	χ^2	*df*	*p*		$\Delta\chi^2$	Δdf	*p*	χ^2	*df*	*p*		$\Delta\chi^2$	Δ*df*	*p*
ABSOLUTISM														
M0. No difference between measures	–	–	–		–	–	–	–	–	–		–	–	–
M1. Equal group effects for each measure	–	–	–		–	–	–	–	–	–		–	–	–
MULTIPLISM														
M0. No difference between measures	–	–	–		–	–	–	20.849	14	0.106	M0 vs. M1	6.329	2	0.042
M1. Equal group effects for each measure	–	–	–		–	–	–	**14.520**	**12**	**0.269**				
EVALUATIVISM														
M0. No difference between measures	–	–	–		–	–	–	**31.567**	**14**	**0.005**	M0 vs. M1	2.973	2	0.226
M1. Equal group effects for each measure	–	–	–		–	–	–	28.594	12	0.005				
D-INDEX														
M0. No difference between measures	26.781	14	0.021	M0 vs. M1	6.405	2	0.041	28.844	14	0.011	M0 vs. M1	8.550	2	0.014
M1. Equal group effects for each measure	**20.376**	**12**	**0.060**					**20.293**	**12**	**0.062**				

Boldface = target model.

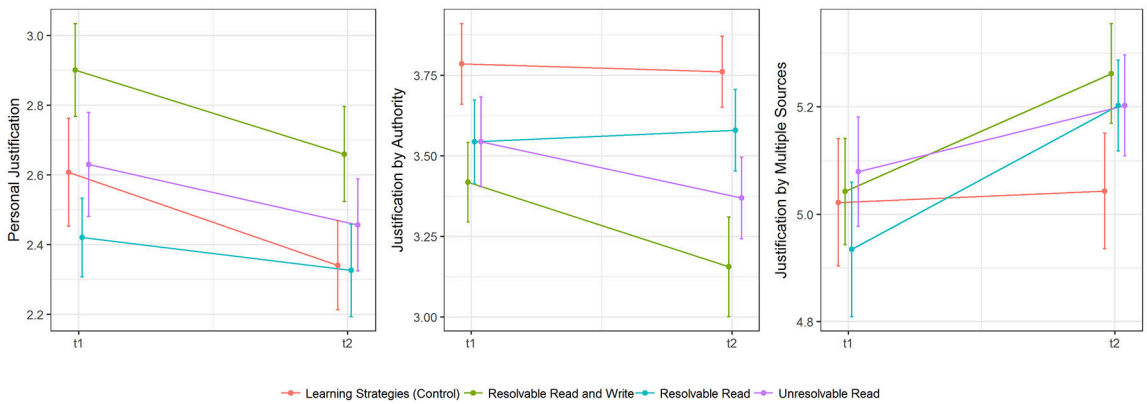

FIGURE 6 | Descriptive differences (means and standard errors) in epistemic change in psychology-specific justification beliefs.

gender-stereotypes for *justification by multiple sources* ($\Delta\ \chi^2 = 4.010$, $df = 1$, $p < 0.05$, see **Table 8** for more details). Participants of the treatment groups showed a change toward stronger beliefs in *justification by multiple sources* ($b_1 = 0.185$, $p < 0.05$) when compared to participants in the control group whose beliefs remained unchanged ($b_0 = 0.017$, $p = 0.836$).

Controlling for Pre-test Differences on Covariates

Analyses on pre-intervention differences on covariates revealed that groups differed at least marginally significant on self-reported intrinsic task value, i.e. a positive attitude toward dealing with psychological science, $F_{(3,179)} = 2.47$, $p < 0.10$, $\eta^2 = 0.04$, and prior topic interest, i.e. self-reported interest in the topic gender stereotyping, $F_{(3,179)} = 3.93$, $p < 0.01$, $\eta^2 = 0.06$, at the first measurement occasion (and therefore prior to group assignment). More specifically, Tukey-*post-hoc*-tests indicated that participants who were later assigned to the "Resolvable Read" group had significantly lower values ($p < 0.05$) on the intrinsic task value scale when compared to the control group and on prior topic interest when compared to the "Resolvable Read and Write" group. Apart from that, no *post-hoc* comparisons yielded significant results. Due to the randomized assignment of participants to intervention conditions, these differences can only be attributed to mere chance. To deal with the issue, however, we included these variables as covariates that predicted pre-intervention differences in epistemic beliefs and epistemic

TABLE 8 | Fit indices and model difference tests for psychology-specific justification beliefs.

	Without covariates							With covariates						
	χ^2	*df*	*p*		$\Delta\chi^2$	Δdf	*p*	χ^2	*df*	*p*		$\Delta\chi^2$	Δdf	*p*
PERSONAL JUSTIFICATION														
M0. No intervention effect	**7.572**	**6**	**0.271**	M0 vs. M1	1.386	1	0.239	**8.204**	**6**	**0.224**	M0 vs. M1	1.108	1	0.293
M1. Equal group effects	6.187	5	0.288	M1 vs. M2	–	–	–	7.096	5	0.214	M1 vs. M2	–	–	–
M2: Varying intervention effects	6.154	3	0.104	M0 vs. M2	1.418	3	0.701	7.085	3	0.069	M0 vs. M2	1.119	3	0.772
JUSTIFICATION BY AUTHORITY														
M0. No intervention effect	13.431	6	0.037	M0 vs. M1	3.563	1	0.059	13.301	6	0.038	M0 vs. M1	2.168	1	0.141
M1. Equal group effects	9.868	5	0.079	M1 vs. M2	–	–	–	11.133	5	0.049	M1 vs. M2	–	–	–
M2: Varying intervention effects	**3.723**	**3**	**0.293**	M0 vs. M2	9.708	3	0.021	**2.940**	**3**	**0.401**	M0 vs. M2	10.361	3	0.016
JUSTIFICATION BY MULTIPLE SOURCES														
M0. No intervention effect	5.507	6	0.481	M0 vs. M1	4.010	1	0.045	7.050	6	0.316	M0 vs. M1	5.564	1	0.018
M1. Equal group effects	**1.497**	**5**	**0.913**	M1 vs. M2	0.557	2	0.757	**1.487**	**5**	**0.915**	M1 vs. M2	0.808	2	0.668
M2: Varying intervention effects	0.940	3	0.816	M0 vs. M2	–	–	–	0.679	3	0.878	M0 vs. M2	–	–	–

Boldface = target model.

TABLE 9 | Regression coefficients of target models predicting epistemic change in justification beliefs.

	Personal justification				Justification by authority				Justification by multiple sources			
	No covariates		Covariates		No covariates		Covariates		No covariates		Covariates	
	EST	SE	EST	SE	EST	SE	EST	SE	EST	SE	EST	SE
Intercept	**–0.201****	0.053	**–0.201****	0.053	0.066	0.092	0.029	0.089	0.017	0.084	0.010	0.085
Resolvable read and write	0.000	–	0.000	–	**–0.378***	0.146	**–0.352***	0.148	**0.185***	0.093	**0.220***	0.095
Resolvable read	0.000	–	0.000	–	–0.037	0.128	0.044	0.123	**0.185***	0.093	**0.220***	0.095
Unresolvable read	0.000	–	0.000	–	**–0.247***	0.126	**–0.211**$^+$	0.119	**0.185***	0.093	**0.220***	0.095
Task value			–0.037	0.053			**0.107***	0.050			0.064	0.050
Prior interest			0.035	0.050			0.066	0.051			–0.051	0.059

N = 185; reference group (0/0/0 dummy coding) = control (learning strategies); EST, unstandardized regression weight; SE, standard error; boldface scores = two-tailed significance test; $^+p < 0.10$; *$p < 0.05$; **$p < 0.01$.

change in our analyses and repeated all analyses specified above. To facilitate interpreting results of these analyses, both covariates were *z*-standardized prior to inclusion.

Results of the controlled analyses differed for topic-specific beliefs on multiplism and evaluativism. For both multiplism and evaluativism, as measured by the FREE-GST, we chose an equal group effects model ($b_1 = b_2 = b_3$) based on LRTs (see **Table 4** for more details). Parameter estimates of these models indicate that epistemic beliefs in the control group did not change significantly (multiplism: $b_0 = -0.072$, evaluativism: $b_0 = 0.019$, both $p > 0.05$). When compared to these effects, we observed a significantly more pronounced decline in multiplism ($b_1 = -0.226$, $p < 0.05$) and increase in evaluativism ($b_1 = 0.178$, $p < 0.05$) across topic-specific intervention groups.

Subsequently, we also tested Hypothesis 2 on multiplism and evaluativism while controlling for pre-test differences. For multiplism, an equal group effects model was chosen based on LRTs (see **Table 7** for more details). Inspection of parameter estimates revealed that treatment effects were significantly more pronounced in topic-specific measures (b_{1GST}–$b_{1EDPSY} = -0.227$, $p < 0.05$) while epistemic change toward advanced beliefs in the control group was significantly more prominent in domain-specific measures (b_{0GST}–$b_{0EDPSY} = 0.201$, $p < 0.05$). For evaluativism, model fit did not significantly increase upon allowing effects to differ between domain-specific and topic-specific measures (see **Table 7** for more details) and therefore, a model that restricted intercept and slope to be equal across topic– and domain-specific measures was chosen. Parameter estimates for this model imply that evaluativism scores in the control group did not change significantly over time ($b_0 = 0.053$, $p = 0.298$) while in comparison a significant increase of evaluativism was detected across measures for the treatment groups ($b_1 = 0.117$, $p < 0.05$; one-tailed). In other words, epistemic change in evaluativism does not differ between topic–and domain-specific beliefs (and H2 is therefore rejected), while an overall increase

in topic–and domain-specific evaluativistic beliefs is observed for the treatment groups. Apart from these findings, results did not differ for any other previously reported analyses with respect to the significance of results or selected target model (see **Tables 4–9** for further details).

Prior Beliefs and Epistemic Change

Exploring the relationship between pre-intervention values, instruction (i.e., treatment groups) and latent change scores, we found that treatment effects were descriptively stronger in the more naive group but that these differences failed to reach significance for all outcome measures (all $p > 0.05$).

DISCUSSION

Effects of Diverging Information on Epistemic Change

Hypothesis 1

Surprisingly, confirmatory analyses revealed no significant group differences between experimental groups. Results suggest that this lack of significant findings is largely due to a profound decrease in topic-specific and domain-specific absolutism and multiplism that takes place in our control group. Overall, this trend toward advanced beliefs in the control group and a decrease in multiplism as well as an increase in evaluativism in the "Unresolvable Read" group are the most important deviations from our a priori expected pattern of results concerning Hypothesis 1 (see **Table 1**). Applying these results to our specific hypotheses H1a, H1b, and H1c, we draw the following conclusions.

Hypothesis 1a

The second part of H1a assumed that the learning strategies task in the control group would not induce epistemic change. As stated above, our data clearly point toward a rejection of this hypothesis as advanced beliefs concerning absolutism and multiplism thrive in the control group. How can we explain this unexpected trajectory? After re-inspecting the materials from our control group, we tend to reframe the learning strategies task, i.e., reading texts on students employing different learning strategies, as a presentation of diverging information on the topic of learning strategies. More specifically, participants may interpret each description of a student employing a learning strategy as a "case study" that introduces a new knowledge claim regarding the efficacy of a certain learning strategy. Hence, this presentation of conflicting knowledge claims might engender a decline of absolute beliefs, while the subsequent task that requires participants to compare these knowledge claims on a set of predefined criteria (the adjunct questions) may trigger an integration of diverging information and, therefore, thwart a change toward multiplistic beliefs. Along these lines, selecting the topic "learning strategies" and this kind of control task may have been ill-fated choices with regard to obtaining significant differences between treatment and control groups because both the gender stereotypes interventions and the learning strategies task are settled in the educational psychology domain. Possibly, our subjects perceived learning strategies to be even more prototypical for this domain. Therefore, crossover-effects may exist for beliefs on different topics that are settled within the same domain (i.e., learning strategies and gender stereotyping within educational psychology). On the other hand, these "ill-fated choices" opened up a highly interesting new perspective for examining the diverging information paradigm. Based on our control group, we are actually able to compare effects of the mere presentation of any kind of diverging information, to science-based diverging information that was explicitly designed to evoke epistemic doubt and change toward advanced beliefs.

Nonetheless, as a consequence, the actual effect size of examined effects (and thus the power of our tests) that compared effects of gender stereotype interventions to control groups might be lower than expected for H1a. At least the non-significant effects in confirmatory analyses substantiate this theory. In spite of this fact, exploratory analyses introduce some evidence in favor of H1a as they revealed that topic-specific interventions fostered topic-specific epistemic change toward advanced beliefs when compared to the control group (an increase in the D-Index, a decrease in multiplism and an increase in evaluativism). Interestingly, this finding also holds for psychology-specific justification beliefs (a decreased belief in justification by authority in the "Resolvable Read and Write" and the "Unresolvable Read" group, as well as an increased belief in justification by multiple sources across treatment groups).

In conclusion, H1a can be partially confirmed as we observed some kind of treatment effect on five out of eleven outcome variables. Unexpectedly, the control task induced epistemic change toward advanced beliefs but exploratory analyses revealed that change toward advanced beliefs was more prominent for the treatment groups (in particular, evaluativism did only change in these groups). Additionally, treatment group interventions promoted the development of advanced justification beliefs more efficiently, which indicates that the mere presentation of any kind of diverging information does not equally affect all dimensions of epistemic beliefs.

Hypothesis 1b

Contrary to our expectations, changes in evaluativism in the "Unresolvable Read" group were similar to changes in the "Resolvable Read and Write" and "Resolvable Read" groups. Therefore, no significant differences were found for evaluativism between treatment groups. Even more importantly, non-significant effects do not seem to be due to power issues as the "Unresolvable Read" tended to outperform the "Resolvable Read" group—at least on a descriptive level. In a nutshell, our results indicated that epistemic change differed between treatment groups only on one out of eleven outcomes and in this case the observed effect even contradicted the expected pattern of effects (i.e., beneficial effects occurred in the "Unresolvable Read" group). Thus, H1b is completely rejected; the consequences of this will be discussed in the implications section.

Hypothesis 1c

The first part of this hypothesis (efficacy in the "Resolvable Read" group) is strongly connected to H1a and, thus, can be regarded as partially confirmed. A precondition for testing the

second part of this hypothesis ("difference in effects in the "Resolvable Read" and "Resolvable Read and Write" group is small to moderate") in a statistically sound way was that the corresponding target model would have been chosen by LRTs. Unfortunately, this was not the case as chosen target models restricted effects to be equal across groups. Therefore, they did not allow to introduce model constraints on effect parameters of dummy-coded intervention groups or to include differences between those effects as additional parameters in our model (i.e., for testing the hypothesis "difference smaller than value x").

On the other hand, the fact that differences between groups did not become significant based on LRTs implies that overall differences in efficacy cannot be very large because otherwise they would have been detected (as our power analyses indicate). Still, these LRT did not explicitly test the null hypothesis for H1c and descriptive statistics indicate that (small) differences might exist for some outcome measures. In other words, we cannot say for sure if the writing instruction supported epistemic change in our study but we can rule out with some certainty that it was a prerequisite for change. In conclusion, our data tend to confirm the first part of H1c (overall efficacy of the reading task), but are not able to fully test the second part of H1c that pertains to incremental effects of reflecting on diverging information.

Hypothesis 2

Our statistical analysis plan prescribed that H2 (i.e., differences in the efficacy concerning domain–and topic-specific measures) was only examined if differences between experimental groups occurred. Due to the fact that no differences between experimental groups (H1) were found in confirmatory analyses, Hypothesis 2 was not tested in our confirmatory analyses.

However, evidence in favor of this hypothesis stems from exploratory analyses, where significantly stronger effects in topic-specific measures were found for the D-Index and for multiplism (when controlling for covariates). Although findings for evaluativism descriptively confirmed this trend, the corresponding effects failed to reach significance. All in all, we found the hypothesized relationship between effects on topic– and domain-specific measures in two out of three cases, in which it could be meaningfully tested, and, therefore, Hypotheses 2 can be regarded as partially confirmed.

Then again, extrapolating from this notion, we would expect to find even weaker differences between effects in our topic-specific intervention groups and our control group for justification beliefs in psychological science, as this is the highest level-domain investigated by our study (i.e., gender stereotypes are a topic within educational psychology, which represents a subdomain of psychological science). Interestingly, this was not the case. On the contrary, we found effects for justification beliefs that would have been significant according to the criteria of our confirmatory analyses. Hence, different dimensions of epistemic beliefs seem to respond in very distinct ways to various aspects of administered interventions. Possibly, the learning strategies control task is only generalized to educational psychology (as a method within this domain), while the resolvable controversies intervention is generalized to both the topic of gender stereotyping and psychological science as a whole (because it deals with research findings on gender stereotypes).

Implications and Further Directions

With our first research question, we aimed to create a better understanding of how exactly diverging information affect epistemic change. The findings that we obtained for subjects that received unresolvable controversial information tell a very interesting story in this regard and offer promising starting points for future research. To our surprise, advanced epistemic beliefs (especially justification beliefs) prospered under these circumstances. This is even more remarkable as manipulation check analyses indicated that subjects actually perceived the presented information to be more inconsistent than subjects in the other groups. Why do subjects not regress to simpler multiplistic beliefs when facing this entirely inconsistent information but instead progress to advanced beliefs? Various explanations are conceivable: Possibly, our subjects found some way to integrate conflicting findings and went to great lengths in order to integrate conflicting findings (e.g., by identifying an alternating pattern). Alternatively, they may attribute inconsistencies of presented information solely on the limited amount of information that was offered by our intervention. Especially evaluativists could readily align new information to their existing beliefs by arguing that contextual factors exist but that prior research has, up to now, failed to identify those factors. In accordance with this notion, Rule and Bendixen (2010) argued that schema theory (Anderson et al., 1977) might offer a fruitful framework for understanding the role of prior beliefs in epistemic change. Furthermore, applying our findings to the current situation in psychology (e.g., the replication crisis), one could suggest that ill-structured knowledge does not necessarily hinder individuals' epistemic development after all. Indeed, our results suggest that advanced justification beliefs might prosper under this "climate of contradictoriness." On the other hand, this also implies that our population's prior competence in integrating conflicting knowledge claims might have been distinctively high. Therefore, it may be questionable if our results can be generalized beyond higher education students in psychology—even though existing research on beneficial effects of "standard" diverging information interventions (Kienhues et al., 2016) possibly corroborates our findings. This body of research also includes quasi-experimental studies from other disciplines whose findings are consistent with our observations in the "Unresolvable Read" group. For example, Han and Jeong (2014) showed that epistemic beliefs of (gifted) high school students who planned to major or majored in science and engineering prospered when they attended a Science-Technology-Society education program. In this education program, they were (among others) confronted with dilemmas in engineering and natural science that—just like the unresolvable controversies in our study—could not be resolved within the course. Nevertheless, these unresolvable dilemmas fostered advanced beliefs and moral judgment (Han and Jeong, 2014). As a consequence, future research should examine, which degree of inconsistency fosters epistemic development and from when on it hinders

progress, while paying close attention to the role of prior beliefs and educational background. Conceptual change research on "dissonance producing approaches" (e.g., contrasting common misconceptions to scientists' views) for teaching and their limitations (c.f. Clement, 2013) should provide some valuable input for this purpose.

Concerning our second research question, which aimed at investigating effects of reflecting on diverging information, results are harder to interpret. However, the concept of "epistemic reflexivity" that was introduced by Feucht et al. (2017) as an internal dialog that is focused on "personal epistemologies leading to action for transformative practices in the classroom" (p. 234) might be able to shed some light on the observed pattern of effects. The effects of *reflection* may not be very large because reflecting on diverging information lacks goal-orientation (i.e., the goal of epistemic change was not explicitly given in the writing task instructions). Hence, Lunn Brownlee et al.'s (2017) framework for epistemic reflexivity might be applied when designing future epistemic change interventions in order to ensure that reflection leads to reflexive thinking. Framing the same argument in Bendixen and Rule's model (Bendixen and Rule, 2004; Rule and Bendixen, 2010), one could also reason that subjects' "will" to resolve epistemic doubt (i.e., epistemic volition) may have been insufficient. Since epistemic doubt, epistemic volition and resolution strategies are thought to be part of higher order mechanisms in their model (Rule and Bendixen, 2010), larger effects of reflecting on diverging information might become apparent if subjects' epistemic volition is simultaneously targeted by interventions. Therefore, even though this is somewhat speculative, our results could point to the importance of epistemic volition in epistemic change, an aspect that should be investigated in future research. One way to do so would be the design of intervention components that are tailored specifically to affect *epistemic doubt*, *epistemic volition* or *reflection* and to investigate their incremental effects on epistemic change.

Moreover, our study gave some interesting insights into how effects of topic-specific interventions are generalized—a pressing issue in epistemic change research (cf. Bråten, 2016). In fact, experimental studies often possess a narrow topic-specific scope (cf. Muis et al., 2016) and, therefore, their overall impact on an individual's more general epistemic development may be questionable (cf. Bråten, 2016). With regard to this concern, Kienhues et al. (2008) have argued that topic-related epistemic cognitions can be used to exemplify notions beyond this topic. Thus, their so-called *exemplary principle* predicts that a certain way of dealing with epistemic problems can be transferred when approaching problems in related areas. Our research corroborates to this notion. As could have been predicted by the *exemplary principle*, we found carry over effects within the domain of educational psychology: Topic-specific intervention effects of our gender stereotyping intervention were transferred to domain-specific beliefs and even to higher-level justification beliefs.

Furthermore, the presentation of diverging information on the topic of learning strategies caused an unexpected decrease in absolute beliefs regarding another topic within the same domain (i.e., gender stereotyping within educational psychology). However, not all topic-specific beliefs were equally affected. More specifically, diverging information on learning strategies did not result in significant changes in evaluativism (topic–or domain-specific) nor in justification beliefs. This yields two important implications which pertain to both our first and last research question: First, the generalization of epistemic beliefs seems to depend on the dimension of epistemic beliefs under investigation. Possibly, it is comparatively easy to change beliefs on the structure of knowledge (i.e., certainty and simplicity) by presenting (any kind of) diverging information that is settled within a certain domain. In contrast, changing other belief dimensions (e.g., justification beliefs) might require interventions that are specifically tailored to modify epistemic beliefs. Future research should address this question, where Greene et al. (2008, 2010) distinction between ontological beliefs and epistemic beliefs may prove to be a valuable starting point for this endeavor. Secondly, we saw that evoking doubt regarding absolute beliefs was comparatively easy as we required no didactical concept in order to change those beliefs. Our learning strategies task efficiently reduced topic–and domain-specific absolute beliefs—at least in the short term—even though it was actually designed as a control task. Drawing upon this thought, epistemic change interventions that aim at a simple reduction of absolutism might lack in ambition because individuals are likely to encounter a vast amount of diverging information in their everyday life (in particular in softer disciplines and/or in higher education). Additionally, our findings suggest that these insights might be readily conferred to adjacent domains. However, once more, specific characteristics of our sample have to be taken into account when interpreting these findings and future research should examine if our observed pattern of effects holds in confirmatory studies for other populations.

Limitations

First, one may criticize that findings and conclusions of our study are largely based on exploratory analyses. However, our exploratory analyses modified confirmatory analyses in no substantial way as we derived exploratory analyses and outcomes from our prespecified theory and did not alter our research questions or hypotheses. Instead, we investigated the same questions on a more basic level in order to meaningfully examine if the overall paradigm had worked as intended. Nonetheless, as for all exploratory research, it is the task of future confirmatory studies to validate our findings. Until then, these findings should be cautiously interpreted.

Secondly, the duration of our intervention was rather short. This is particularly true considering the mismatch between intervention duration and length of normative development process that the intervention aims at. However, this is not uncommon for this kind of intervention (cf. Muis et al., 2016) and is indeed well-founded, as this experimental setting allows to disentangle the mechanism of change in the first place. Moreover, to settle the issue of targeting a long-term process by short-term interventions, Ferguson et al. (2012) referred to Vygotsky (1978). Based on his framework, they argued that short-term interventions in an experimental setting might be able

to accelerate or compress development processes that normally require longer periods of time. Nonetheless, long-term effects of those short-term interventions should be investigated in future studies by including follow-up measurements.

Concerning the power of our analyses, the significance criteria might have been chosen too restrictive for some exploratory analyses. We used the standard $p < 0.05$ criteria for likelihood ratio tests although we wanted to inspect one-sided effects in some cases. This procedure was designed to avoid an increased Type I error rate because of multiple testing when comparing effects for multiple treatment groups simultaneously. Unfortunately, the power in the equal group effects model of our exploratory analyses may have been diminished because only one intervention effect is estimated within this model and, thus, multiple testing is not an issue here. As a consequence, in some analyses, we obtained no significant LRT while the (single) parameter estimate would have been significant according to our criteria. Ceiling effects may further contribute to these power issues. However, exploratory analyses revealed that the intervention efficacy did not vary depending on the developmental level of epistemic beliefs. This possibly indicates that all groups were equally affected by ceiling effects (if at all). On the other hand, the existence of those ceiling effects further justifies our choice of the D-Index as exploratory outcome which does not suffer from this issue.

Conclusion

In sum, this study illustrates that many questions remain unanswered when it comes to understanding the relationship between (properties of) diverging information, epistemic doubt and subsequent changes on different dimensions of epistemic beliefs. It shows that evoking doubt regarding absolute beliefs is relatively easy because individuals seem to be skillful in recognizing varying knowledge claims and subsequently averting absolute beliefs. Additionally, we found evidence for the existence of carry-over effects from topic-specific interventions for both higher-level domain-specific beliefs (i.e., beliefs regarding educational psychology and psychological science as a whole) and beliefs pertaining to other topics within the same domain (i.e., effects of the learning strategies task on beliefs on gender stereotyping). In this context and for epistemic change in general, the role of reflecting on presented conflicting information should be thoroughly addressed by future research. Finally, we may need to reconsider our understanding on how individuals acquire and retain evaluativistic beliefs and the role that non-resolvable controversial information play in this development.

DATA AVAILABILITY STATEMENT

The data generated and analyzed for this study can be found in PsychArchives: doi: 10.23668/psycharchives.930.

AUTHOR CONTRIBUTIONS

TR and MK conceived, planned and preregistered the experiment based on a project proposal written by TR. MK conducted the study, analyzed the data and prepared the first draft of the manuscript. TR reviewed critically, revised the article and supervised the project.

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Appendix B

Artikel II

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Epistemic change and diverging information: How do prior epistemic beliefs affect the efficacy of short-term interventions?

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ABSTRACT

Changing epistemic beliefs (beliefs about knowledge and knowing) requires individuals to experience epistemic doubt (a specific type of cognitive dissonance). To evoke epistemic doubt, many studies rely on presenting diverging information (conflicting evidence). However, not much is known about how different types of diverging information and individual differences affect epistemic change. In a preregistered study (N = 509), we investigated how interventions based on resolvable/unresolvable diverging information influenced epistemic change compared to non-diverging information. Moreover, we examined the role of prior epistemic beliefs in this regard. Multiple-group latent change analyses showed that topic-specific epistemic beliefs prospered in the two diverging information groups but not for non-diverging information, while domain-general beliefs remained largely unchanged. Although epistemic change was—as expected—more pronounced for individuals with naive prior beliefs in diverging information groups, detrimental effects existed for advanced prior beliefs. These findings point to the important role of prior beliefs in epistemic change.

1. Introduction

Conflict drives change. In spite of the fact that this statement might not apply to each and every situation, developmental and educational psychologists are certainly familiar with the underlying notion. In fact, the terms *disequilibria* in Piagetian models and *cognitive dissonance* in conceptual change models are (more or less) just another way to describe specific kinds of conflict which are supposed to initiate transition processes. In accordance with this reasoning, Bendixen and Rule (2004) developed their *Integrative Model for Personal Epistemology Development*, which delineates how epistemic beliefs (i.e., individual beliefs about knowledge and knowing) are thought to evolve.

Within this model, the conflict between prior epistemic beliefs and newly encountered information is seen as the impetus for change—a notion that has been supported by several empirical studies which used diverging (i.e., conflicting) information to initiate the change process (see Kienhues, Ferguson, & Stahl, 2016 for a review). Not much is known, however, about interactions between specific types of diverging information and individual differences. If such interactions exist, some learners will almost inevitably receive interventions that are not well-tailored to their specific needs. Consequently, intervention programs, which administer diverging information in order to foster epistemic change, might not be as efficient as they could be. To close this knowledge gap, we present an empirical study that investigates connections between epistemic change, different types of diverging information, and prior epistemic beliefs of information recipients.

1.1. Epistemic beliefs, epistemic development and epistemic change

More and more studies investigate the circumstances under which epistemic beliefs develop (cf. Bråten, 2016). One line of research examines specific intervention programs' suitability for fostering students' long-term epistemic development—in other words, such studies aim to accelerate naturally occurring (lifelong) developmental processes. For example, Muis and Duffy (2013) investigated how constructivist instruction affected epistemic development during a social science statistic class. A second research track mainly draws on experimental studies which aim at isolating and manipulating single factors in order to inspect their role in epistemic change. Kienhues and Bromme (2012) created, for example, two versions of a newspaper article—one version described a scientific debate as fair and rational while the other version described the same debate as contentious and emotional. They then experimentally examined how reading one or the other version influenced their subjects' epistemic beliefs. In this context, epistemic change may be regarded as a more transient and short-lived change in epistemic beliefs which is clearly attributable to a short-term intervention.

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Such experimental studies are of theoretical and practical relevance as they lay foundations for new intervention programs and serve as starting points for future process-based research examining thought patterns underlying experimentally-induced changes. Furthermore, topic-specific short-term interventions may also affect the long-term development of epistemic beliefs on related topics and even on higher-level domains for two reasons: (1) Insights gained in experimental settings might be subsequently applied to related problems ("exemplary principle", Kienhues, Bromme, & Stahl, 2008), and, (2) drawing on Muis and colleagues' TIDE model (e.g., Merk, Rosman, Muis, Kelava, & Bohl, 2018; Muis, Bendixen, & Haerle, 2006), changes in topic-specific epistemic beliefs might be transferred to higher-level domains (e.g., discipline-specific epistemic beliefs). Especially Muis et al.'s (2006) notion of "reciprocally influential" layers of epistemic beliefs implies that such feedback loops between layers may exist.

When developing an epistemic beliefs intervention (or any other intervention), a precise goal definition constitutes the first step. Researchers, therefore, need to have some kind of normative goal in mind (Kerwer, Rosman, Wedderhoff, & Chasiotis, 2019)—in spite of the fact that valid objections on the adequacy of describing epistemic beliefs along a continuum from 'naive' beliefs (views of knowledge as fixed 'truths') to 'advanced' beliefs (views of knowledge as tentative and evolving) exist (Barzilai & Chinn, 2018; Chinn, Buckland, & Samarapungavan, 2011; Elby & Hammer, 2001). Alternative conceptualizations of epistemic beliefs, such as Chinn et al.'s (2011) AIR framework, unfortunately do not (yet) provide researchers with tangible normative or educational goals (cf. Barzilai & Chinn, 2018), which is why Barzilai and Chinn (2018) aimed to close this gap by introducing the concept of *apt epistemic performance*. The field, however, still lacks consensus on what exactly apt epistemic performance is in different contexts, and there are no validated instruments to assess it. For this reason, we argue that there may be some merit in still using the advanced-naive-distinction, especially since prior research has shown that advanced epistemic beliefs, among others, promote information integration across multiple documents (e.g., websites; Barzilai & Strømsø, 2018), facilitate conceptual change (Sinatra & Mason, 2013) and correlate with academic achievement (Greene, Cartiff, & Duke, 2018). Against this background, we chose Kuhn, Cheney, and Weinstock's (2000) framework of epistemic development as theoretical underpinning of our intervention since the model itself and corresponding measurement instruments are (in comparison to the aforementioned models) well-established. This model suggests that individuals progress from absolute (i.e., knowledge claims can be either true or false) via multiplistic (i.e., knowledge claims are mere opinions) to evaluativistic beliefs (i.e., conclusions can be drawn by weighing knowledge claims; Kuhn et al., 2000). It has been empirically shown that this latter stage, evaluativism, depicts a more advanced view of knowledge compared to the earlier 'naive' stages (e.g., Barzilai & Eshet-Alkalai, 2015; Barzilai & Zohar, 2012). Furthermore, from a theoretical perspective, one might also argue that evaluativists should achieve higher levels of apt epistemic performance as, in our view, coordinating subjectivity and objectivity includes a reliance on expert judgments if one's own knowledge is limited, for example.

1.2. Diverging information and epistemic change

The notion of conflict as a driving force of development is well-established for epistemic change. To introduce conflict, short-term interventions often present some kind of diverging information (i.e., conflicting knowledge claims) on a specific topic (e.g., on the causes of climate change, Kienhues et al., 2016). Correspondingly, in the current article, we refer to diverging information as "all types of information that present different, apparently conflicting, viewpoints to the information consumer" (Kienhues et al., 2016, p.319). In this framework, the 'divergingness' of information is regarded as an information-inherent characteristic (cf. Kienhues et al., 2016). Thus, whether information is diverging or not is *independent* from whether individuals experience a cognitive dissonance (see Section 1.3)—divergingness only depends on the information itself, while experiencing cognitive dissonance depends on an interaction between individual differences and information-inherent characteristics.

Even though a rather strong body of evidence suggests that diverging information foster epistemic change (Kienhues et al., 2016), studies that examine how exactly different types of diverging information affect epistemic beliefs are rare. In this study, we will follow up on recent work by Kerwer and Rosman (2018) which is based on the so-called *resolvable controversies* approach (Rosman & Mayer, 2018; Rosman, Mayer, Merk, & Kerwer, 2019). A central assumption of this approach is that presenting apparent contradictions that can be easily integrated (i.e., a special form of diverging information) supports progress along Kuhn's stages by exemplifying the principles underlying evaluativistic thinking while refuting absolute and multiplistic positions (Rosman et al., 2019). Kerwer and Rosman (2018) compared effects of these resolvable controversies on epistemic change to effects of presumably *un*resolvable diverging information (i.e., that should not allow an integration of findings) and non-diverging information (i.e., non-conflicting evidence). Unexpectedly, however, advanced epistemic beliefs prospered not only when their participants were subjected to resolvable diverging information, but also when presented with unresolvable diverging or—to a smaller extent—non-diverging information. Kerwer and Rosman (2018) argued that these surprising findings were possibly due to participants finding an alternative way to resolve allegedly 'unresolvable' contradictions, thereby creating another type of resolvable diverging information. Furthermore, they found that certain task characteristics in their non-diverging information condition might have unintendedly suggested that this evidence would be another type of diverging information (Kerwer & Rosman, 2018). As these limitations prevail, more research is required to clarify the role that the (non-)resolvability of diverging information plays in the context of epistemic change.

We will therefore investigate if epistemic change depends on the (non-)resolvability of diverging information. Assuming that one fixes the above-mentioned issues in Kerwer and Rosman's (2018) materials, we expect that any kind of diverging information (regardless of their resolvability) will induce epistemic change towards advanced beliefs—whereas presenting non-diverging information (i.e., a description of varying but non-conflicting viewpoints) will not (*Hypothesis 1a*). Furthermore, we suggest that epistemic change will be larger when diverging information are resolvable compared to when they are unresolvable (*Hypothesis 1b*), as only the first type of diverging information exemplifies principles of evaluativistic thinking.

1.3. Prior beliefs and epistemic change

Focusing on the characteristics of diverging information while neglecting how individual differences affect epistemic change, however, is a futile endeavor—especially as the specific type of cognitive dissonance that we want to inspect arises if *individual* beliefs and newly encountered information are misaligned (cf. Festinger, Riecken, & Schachter, 1956). For example, in Festinger et al.'s (1956) classical study, this new information was that the apocalyptic flood Mrs. Keech 'foresaw' failed to occur—thereby contradicting the belief system of the members of her 'cult'. Transferring this reasoning (i.e., that cognitive dissonances result from interactions between prior beliefs and external stimuli) to epistemic change, we need to focus on the current state of an individual's epistemic beliefs as these will determine to what extent individuals experience cognitive dissonance when facing diverging information. Individuals who deny the existence of an objective truth, will, for example, be unlikely to doubt these beliefs when receiving unresolvable diverging information (that also suggest that there is no objective truth). In other words, to shed more light onto how exactly diverging information engender changes in epistemic beliefs, we need

to investigate the role of prior (epistemic) beliefs in epistemic change—a connection that has been neglected in the past and that "is still wide open for future research" (Bråten, 2016, p.364).

Reviewing the literature on epistemic change, there are good reasons why epistemic change should be more pronounced in individuals with 'naive' prior beliefs. For a start, Bendixen and Rule (2004) argue that individuals have to experience a cognitive dissonance that results in epistemic doubt (i.e., questioning one's current epistemic beliefs) to initiate the change process. Obviously, individuals with naive (prior) beliefs should be more likely to sense this kind of dissonance since (resolvable) diverging information are thought to exemplify principles underlying advanced (and not naive) epistemic reasoning. Hence, in terms of Bendixen and Rule's (2004) model, resolvable controversies should evoke epistemic doubt regarding both absolute and multiplistic thinking, while unresolvable controversies cast doubt on absolute beliefs only. In line with this notion, Kienhues et al. (2008) found a greater change towards advanced epistemic beliefs in a group of epistemologically naive students compared to a sophisticated group when they were confronted with diverging information in an experimental study.

We therefore assume that the pattern of epistemic change towards advanced beliefs described in Hypothesis 1a and 1b is more pronounced for individuals that hold more naive prior epistemic beliefs compared to individuals holding more advanced beliefs (*Hypothesis 2*). To put it differently, we propose that the effects of presenting diverging information will decrease for individuals with higher levels of prior epistemic beliefs and, thus, that prior beliefs moderate the intervention's effects on epistemic change. To ensure a strictly confirmatory approach, Hypotheses 1 and 2 (as well as study procedures, methods and statistical techniques for testing them) were preregistered at http://dx.doi.org/10.23668/psycharchives.937.

On the other hand, Rule and Bendixen (2010) also argued that current epistemic beliefs provide individuals with schemata for interpreting new information and therefore influence how efficiently they react to and deal with (diverging) information, where schema-consistent information should be more readily processed. In accordance with this notion, Franco et al. (2012) found that their participants' learning improved when task characteristics and epistemic beliefs were in alignment (consistency hypothesis, Muis & Franco, 2010). Thus, a good argument can be made that the premises for efficiently processing diverging information should be *better* (and not worse, as suggested by Hypothesis 2) for subjects with advanced beliefs.

Combining the two delineated viewpoints, one might thus assume that the linear trend, which is suggested in Hypothesis 2, is complemented by a quadratic relationship. For example, it seems reasonable that overall change due to resolvable diverging information decreases as a function of prior beliefs (since the cognitive dissonance becomes smaller for advanced beliefs), while change might again increase for individuals with above average beliefs (since prior beliefs and information are well-aligned and information are more readily processed). This expectation of a quadratic effect was not preregistered and should therefore be treated as exploratory in nature.

2. Method

2.1. Design

To test our hypotheses, we used a 2 × 3 design with *diverging information type* as between-subjects factor (non-/resolvable diverging information and non-diverging information) and *time* as within-subjects factor (pre-intervention and post-intervention).

2.2. Participants

We recruited $N = 509$ participants through an external panel service (i.e., Respondi, https://www.respondi.com/). Only German native speakers currently enrolled at German universities and aged 18 to 70 were eligible for study participation. In our actual sample, age ranged from 18 to 62 ($M = 26.65$, $SD = 7.43$) and academic subjects of participants were as diverse as computer science, law, or languages and literature. Since the intervention materials deal with a gender-sensitive topic (i.e., gender discrimination at secondary schools, see Section 2.4), we obtained a sample whose gender distribution (48.72% male) corresponded closely to the general gender distribution at German universities (i.e., 49.30% male students, Statistisches Bundesamt Deutschland [Federal Statistical Office of Germany], 2018).

2.3. Procedure

Pre-intervention measurements, the intervention and post-intervention measurements took place during the same measurement occasion. Data were collected on participants' own devices (smartphone, tablet, computer, etc.) in an online environment created by the authors using the survey software Unipark. Prior to data collection, the panel provider invited participants to our online survey, where we screened out all individuals that did not fulfill our eligibility criteria or whose gender quotas were already closed. Before data collection started, participants were informed of the expected study duration (30–40 min), and were instructed to complete the survey in a quiet place of their own choice. Thereafter, participants were randomly assigned[1] to one of three intervention groups that differed in the type of diverging information presented (see Table 1). Subsequently, they completed the pre-intervention measurement (i.e., epistemic beliefs questionnaires) as well as the intervention and post-intervention measurements (i.e., manipulation check and epistemic beliefs questionnaires[2]). Having finished the data collection, participants obtained a link which redirected them to Respondi's sites where they received their financial compensation. The study complied with APA ethical standards and was part of the MEPIC project, which was approved by the Ethics Committee of the German Psychological Association.

2.4. Intervention

Intervention groups differed on the presented type of diverging information (i.e., resolvable, unresolvable or non-diverging information). Detailed descriptions of intervention conditions and tasks are given in Table 1, whereas exemplary intervention materials are provided in Appendix A.

2.5. Dependent variables

Limitations of traditional self-report questionnaires have been widely discussed in the field (cf. Greene & Yu, 2014). To better capture the multidimensionality and context-specificity of epistemic beliefs in an adequate manner, scenario-based instruments have been suggested (Barzilai & Weinstock, 2015; Mason, 2016). By providing a specific 'context' (i.e., the scenario) which is the same for participants, these instruments control—at least to some extent—for the context-specificity of epistemic beliefs by keeping it constant. Moreover, it should be noted that while the multidimensional assessment of Kuhn et al.'s (2000) developmental *stages* in these instruments may seem inconsistent at first, Barzilai and Weinstock (2015) have argued convincingly in favor of this operationalization because it allows to capture individuals' model-inherent "struggle with competing views" (p.156) on the objectivity and subjectivity of knowledge. For these reasons, our study employed multidimensional scenario-based instruments to assess

[1] This assignment was stratified for sex (i.e., to ensure that the gender distribution did not differ across intervention groups).

[2] Some additional covariates (e.g., epistemic emotions) were also included (cf. preregistration; http://dx.doi.org/10.23668/psycharchives.937).

Table 1
Intervention conditions.

Diverging information type	Intervention topic	Intervention materials	Intervention task
Non-diverging information –different but non-conflicting viewpoints on a topic	Learning strategies in higher education	• Revised version of Kerwer and Rosman's (2018) control task. • 18 examples of students applying learning strategies Subjects might have interpreted the presented information in Kerwer and Rosman (2018) as conflicting knowledge claims on learning strategies due to the presentation mode (pairs of two snippets on "students employing different learning strategies that were compared to each other"; Kerwer & Rosman, 2018, p.6). Thus, we reduced the task's contradictoriness by presenting snippets separately (and not in pairs) and discarding the comparison task.	Participants were instructed to indicate their personal appraisal of presented learning strategies. 3 pages with 6 texts on learning strategies per page were presented. Participants had to select for each learning strategy one of the following answers (a) I am already applying this learning strategy, (b) I am not applying this learning strategy, but I want to do so in the future, (c) I am not applying this learning strategy, and I do not want to do so in the future, (d) This is no learning strategy. Participants were allowed to continue after 3 min on each page. The median duration of the intervention was 12 min.
Resolvable diverging information – information that introduces apparent contradictions that can be integrated	Gender stereotyping at secondary schools	• Reading task of Kerwer and Rosman (2018) • 18 description of studies on gender stereotyping at secondary schools Some study descriptions suggest that boys, and others that girls are discriminated against. To exemplify principles of evaluativistic thinking, each text includes a specific cue (e.g., subject matter). Taking these clues together, a pattern emerges (e.g., that discrimination depends on subject matter), and subjects are thought to realize that valid conclusions can be drawn even if contradicting knowledge claims exist (Rosman et al., 2019).	Participants were instructed to decide which conclusion on gender stereotyping was supported by the texts. 3 pages with 6 studies per page were presented. Participants had to select for each study one of the following answers (a) Boys are disadvantaged in secondary schools, (b) Girls are disadvantaged in secondary schools, (c) Neither boys nor girls are disadvantaged in secondary schools, (d) The study is not related to gender stereotyping in secondary schools. Participants were allowed to continue after 3 min on each page. The median duration of the intervention was 13 min.
Unresolvable diverging information - information that introduces contradictions that cannot be integrated	Gender stereotyping at secondary schools	• Revised version of Kerwer and Rosman's (2018) unresolvable controversies task • 18 description of studies on gender stereotyping at secondary schools Kerwer and Rosman (2018) tried to create unresolvable diverging information by masking the pattern that allows an integration of conflicting findings in the resolvable controversies approach. They argued that their attempt to create unresolvable diverging information may have failed because an alternative way for integrating conflicting findings existed. Based on the suggestions they made in their paper, we revised this task to create a completely random pattern of discrimination.	The intervention task was exactly the same as in the resolvable diverging information group. The median duration of the intervention was 13 min.

domain-general and topic-specific epistemic beliefs.

2.5.1. Domain-general epistemic beliefs: FREE

Domain-general beliefs were measured by the FREE questionnaire, an established instrument for assessing epistemic beliefs in university students (Krettenauer, 2005a). This questionnaire introduces twelve scenarios (i.e., controversies from varying domains of knowledge, such as different positions on the risks of genetically modified foods). For each scenario, agreement to three statements that relate to either absolute, multiplistic or evaluativistic beliefs was to be indicated on a 6-point Likert scale (sample items for this questionnaire are provided in Krettenauer, 2005b).

2.5.2. Topic-specific epistemic beliefs: FREE-GST

The FREE-GST, a topic-specific adaption of the FREE (Rosman et al., 2019), presents, as a scenario, three conflicting positions on the existence and direction of gender-stereotyping in secondary schools. Five topic-specific items were administered for each of Kuhn's stages. Just as for the FREE, agreement to these items was measured on a 6-point Likert scale. More details on item wordings and psychometric properties of this instrument are included in Rosman et al. (2019).

2.5.3. Outcome measure: D-index

For both questionnaires, we operationalized our main outcome, a multidimensional change towards advanced beliefs, as pre-post changes in the so-called D-Index (Krettenauer, 2005a). The D-Index is computed as $Evaluativism - 0.5 * (Absolutism + Multiplism)$,[3] with high scores indicating advanced beliefs in the sense of preferring evaluativistic positions over absolute or multiplistic positions (Krettenauer, 2005a). Reliabilities and descriptive statistics are given in Table 2.

2.6. Statistical analysis

2.6.1. Hypothesis 1: confirmatory analyses on effects of diverging information

Using the R package "lavaan" (Rosseel, 2012), we operationalized epistemic change as latent change scores (McArdle, 2009), which were predicted by dummy-coded diverging information type variables. One combined analysis of epistemic change on the D-Index of the FREE-GST and the FREE, respectively, was performed (see Fig. 1a).

2.6.2. Hypothesis 2: confirmatory analyses on effects of prior epistemic beliefs

To test Hypothesis 2, we created a categorical prior beliefs variable by assigning subjects to three groups based on the tertiles to which their pre-intervention scores on the respective outcome variable belonged

[3] To be in line with Krettenauer (2005a), we used this formula instead of the preregistered formula ($2*Evaluativism - [Absolutism + Multiplism]$) to compute the D-Index. Both formulas yield, however, identical inferential results since they differ exactly by a factor of two and variables were standardized prior to statistical analyses (see Section 2.6.4).

Table 2
Means, standard deviations and reliabilities of study variables.

Measure	Pre-intervention (t1)							Post-intervention (t2)					
	ω	M_{ND}	SD_{ND}	M_U	SD_U	M_R	SD_R	M_{ND}	SD_{ND}	M_U	SD_U	M_R	SD_R
D-Index (topic-specific epistemic beliefs)	0.73[a]	1.12	0.92	0.91	0.87	1.06	0.94	1.10	1.11	1.03	0.93	1.17	1.00
Absolutism (topic-specific epistemic beliefs)	0.75	3.19	0.94	3.23	0.88	3.10	0.82	3.08	1.04	3.14	0.85	3.08	0.93
Multiplism (topic-specific epistemic beliefs)	0.75	3.55	0.90	3.70	0.76	3.60	0.80	3.54	0.93	3.77	0.80	3.56	0.82
Evaluativism (topic-specific epistemic beliefs)	0.70	4.49	0.67	4.38	0.66	4.41	0.73	4.41	0.70	4.49	0.73	4.49	0.66
D-Index (domain-general epistemic beliefs)	0.70	0.84	0.65	0.68	0.64	0.82	0.70	0.84	0.74	0.67	0.66	0.74	0.79
Absolutism (domain-general epistemic beliefs)	0.73	3.43	0.70	3.52	0.60	3.46	0.65	3.45	0.79	3.49	0.72	3.48	0.76
Multiplism (domain-general epistemic beliefs)	0.68	3.48	0.63	3.58	0.62	3.49	0.59	3.50	0.74	3.67	0.73	3.54	0.68
Evaluativism (domain-general epistemic beliefs)	0.71	4.29	0.50	4.23	0.55	4.30	0.55	4.31	0.61	4.26	0.58	4.26	0.64
Spontaneous integration	0.81	–	–	–	–	–	–	3.08	1.12	3.56	0.97	3.76	1.03
Perceived contradictoriness	0.73	–	–	–	–	–	–	2.76	0.99	3.64	0.90	3.25	0.99
N	482	168[b]	168[b]	154[c]	154[c]	160[d]	160[d]	168[b]	168[b]	154[c]	154[c]	160[d]	160[d]

Note: M = arithmetic mean; SD = standard deviation; ω = McDonald's ω at the first occasion of measurement, indices specify intervention groups: ND = Non-diverging information, U = Unresolvable diverging information, R = Resolvable diverging information.

[a] For the topic-specific D-Index of the FREE-GST, assigning items to triplets in order to build the difference variable *Evaluativism* − *0.5* ∗ (*Absolutism* + *Multiplism*) is arbitrary (compared to the FREE which structures triplets by sub-topic). We therefore computed the mean reliability of the D-Index for 14,359 possible single item to triplet assignments. The 14,359 reliability estimates ranged from 0.71 to 0.76.

[b] As outliers were corrected on domain-general epistemic beliefs, sample size was 167 for these variables.

[c] As outliers were corrected on topic-specific and domain-general epistemic beliefs, sample size was 153 for these variables.

[d] As outliers were corrected on topic-specific and domain-general epistemic beliefs, sample size was 157 for topic-specific and 158 for domain-general beliefs.

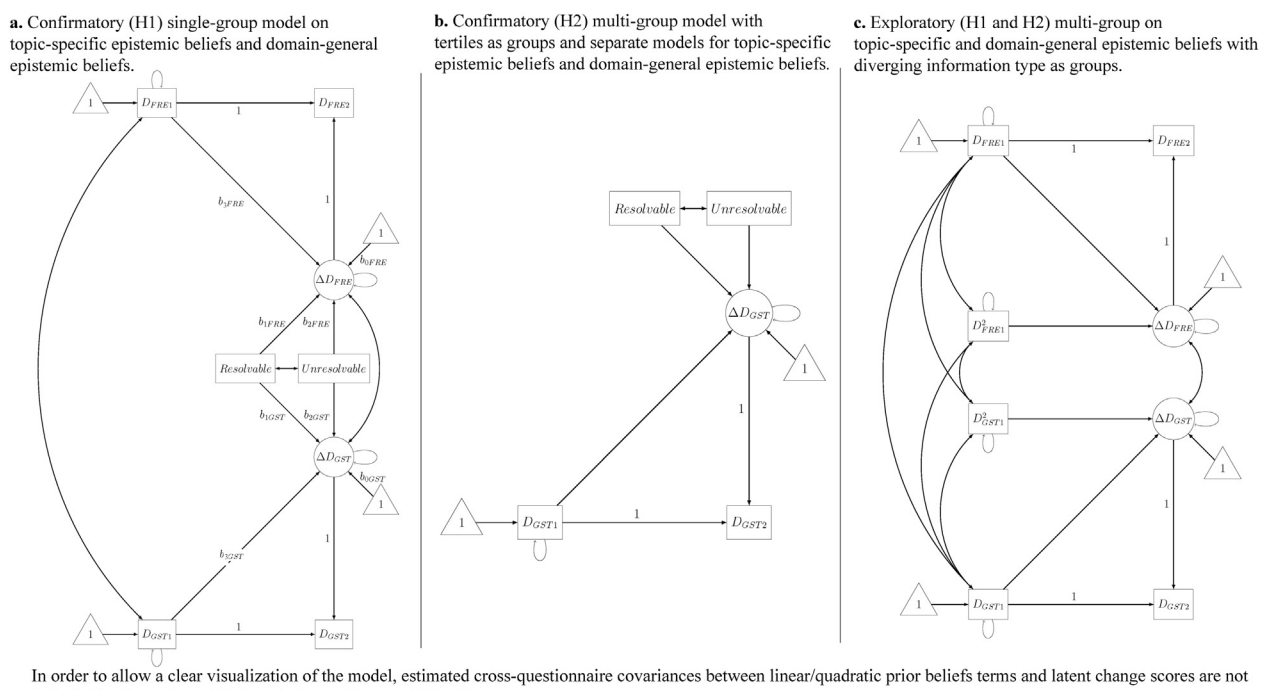

Fig. 1. Latent change models. In panel a, latent change of topic-specific Δ D_{GST} and domain-general Δ D_{FRE} epistemic beliefs is predicted by dummy-coded diverging information type variables. In panel b, a univariate version of the model depicted in panel a is used, but as a multi-group model with prior beliefs tertile as group variable. In panel c, latent change in topic-specific and domain-general epistemic beliefs is inspected—once more in a combined model. Moreover, quadratic effects of prior epistemic beliefs are included and diverging information type is used as group variable in a multi-group analysis.

(i.e., tertiles were computed across and not within intervention groups). Multi-group latent difference score analyses were subsequently performed separately for the FREE-GST and FREE (since tertiles were computed for each outcome individually) and the level of model invariance was determined. Apart from the inclusion of this grouping variable, these multi-group models corresponded to the statistical model for Hypothesis 1 (see Fig. 1b).

2.6.3. Hypothesis 1 and 2: exploratory analyses on linear and quadratic effects of prior epistemic beliefs

After preregistering our study, we realized that the analysis plans for Hypothesis 1 and Hypothesis 2 described above were in some regards limited. In fact, the latent difference score model we employed for testing Hypothesis 1 estimates *one* effect of prior beliefs on epistemic change (i.e., b_{3GST}/b_{3FRE} in Fig. 1a), thereby (implicitly) assuming that effects of prior beliefs do not vary across diverging information types. To test this assumption empirically, multi-group modeling can be used with diverging information type as grouping variable (see Fig. 1c). Using this technique, further benefits emerge for our statistical analysis regarding Hypothesis 2. First, we can treat prior beliefs as a continuous predictor—and not as an artificially created categorical variable (i.e., based on a tertile split). Second, the FREE and FREE-GST can be

analyzed simultaneously. Model invariance testing was used to determine if means of latent change variables (Hypothesis 1) and effects of prior beliefs (Hypothesis 2) differed between diverging information types. This procedure is therefore superior to the procedure originally proposed in our preregistration and a more meaningful and faithful—albeit exploratory—test of Hypothesis 1 and Hypothesis 2.

2.6.4. Hypothesis testing

As we preregistered the expected direction of effects, one-tailed tests were conducted whenever appropriate. Confirmatory analyses concerning Hypothesis 2 were conducted by comparing confidence intervals. Moreover, to obtain easily interpretable regression coefficients, we standardized pre- and post-intervention measures of outcome variables using their pre-intervention mean and standard deviation.

2.6.5. Sample size calculation

Based on the above-mentioned study by Kerwer and Rosman (2018), who found a small effect on the D-Index (Cohen's $f = 0.094$) when comparing different types of diverging information, we expected our effect size to be around $f = 0.080$ (due to a reduced intervention efficacy in an online environment). Setting $r = 0.66$ in G*Power (Faul, Erdfelder, Buchner, & Lang, 2009), the required sample size to achieve a power of 96.50% was $N = 450$ for this effect size and a pre-post-design with three groups.

2.6.6. Data cleaning

13 participants were excluded because their responses during the study indicated that they did not actually fulfill the inclusion criteria (e.g., because they stated 'none' when asked to indicate their university), and data of 14 participants were discarded because they showed highly implausible response patterns (e.g., no variation in the answers on a 15-items Likert scale questionnaire) or responses that indicated they did not engage with the intervention materials in the intended manner (e.g., by stating that all intervention texts in the resolvable/unresolvable diverging information group were not related to gender stereotyping).[4] Finally, we also excluded seven outliers on the FREE-GST and FREE[5] (based on z-scores; criterion: $p(z) < .001$).

3. Results

3.1. Manipulation check

To evaluate subjects' perceptions regarding the resolvability of diverging information (in the resolvable diverging information group compared to the other groups), we administered a self-report measure on the spontaneous integration of conflicting information. The corresponding ANOVA was significant ($F[2, 479] = 18.66$, $p < .001$, $\eta^2 = 0.072$) and the expected pattern of mean values emerged on a descriptive level (see Fig. 2 and Table 2). More specifically, the lowest scores on the spontaneous integration measure were found for non-diverging information and the highest scores for resolvable diverging information. All differences reached statistical significance in non-adjusted t-tests (all $p < .050$), while differences between resolvable and unresolvable diverging information did not do so in Tukey-adjusted post-hoc-tests. We argue, however, that Tukey-post-hoc corrections should be overly restrictive in our case, since they do not take the prespecified direction of effects into account. This means that two-sided instead of one-tailed tests are performed even though using one-tailed tests would be justified.

We also tested if participants actually perceived the presented information as more contradictory for unresolvable diverging information compared to resolvable diverging or non-diverging information (based on the same questionnaire that Kerwer & Rosman, 2018 employed).[6] Our analyses showed that perceived contradictoriness decreased from unresolvable diverging information to resolvable diverging and non-diverging information. All group differences were significant as indicated by an ANOVA ($F[2, 479] = 33.59$, $p < .001$, $\eta^2 = 0.123$) and Tukey-adjusted post-hoc-tests (all $p < .001$). Item texts of manipulation check measures are provided in Appendix B.

3.2. Hypothesis 1: confirmatory analyses on effects of diverging information

3.2.1. Topic-specific epistemic beliefs: FREE-GST

On a descriptive level, the increase in advanced topic-specific epistemic beliefs was stronger for unresolvable and resolvable diverging information than for non-diverging information (see Fig. 3 and Table 2). These observed differences in epistemic change between the diverging information groups (i.e., the resolvable and the unresolvable group) and the non-diverging information group were significant for both unresolvable ($b_{2GST} = 0.135$, $SE = 0.078$ $p = .042$) and resolvable diverging information ($b_{1GST} = 0.138$, $SE = 0.078$, $p = .038$), while effects in the diverging information groups did not differ significantly (b_{1GST}-$b_{2GST} = -0.003$, $SE = 0.079$, $p = .972$). Moreover, the overall increase in advanced beliefs reached statistical significance for resolvable ($b_{0GST} + b_{1GST} = 0.127$, $SE = 0.057$, $p = .025$) and unresolvable ($b_{0GST} + b_{2GST} = 0.124$, $SE = 0.057$, $p = .030$) diverging information, while overall change for non-diverging information was non-significant ($b_{0GST} = -0.011$, $SE = 0.055$, $p = .848$). Thus, diverging information engendered a change towards advanced beliefs regardless of their resolvability.

3.2.2. Domain-general epistemic beliefs: FREE

To our surprise, we observed, on a descriptive level, decreases (instead of increases) in domain-general epistemic beliefs across all groups (i.e., subjects' beliefs became more naive over time, see Fig. 3 and Table 2). Inferential analyses revealed, however, that these changes in epistemic beliefs were far from significant for unresolvable diverging information ($b_{2FRE} + b_{0FRE} = -0.022$, $SE = 0.048$, $p = .650$) and non-diverging information ($b_{0FRE} = -0.005$, $SE = 0.046$, $p = .905$), and closely missed statistical significance for resolvable diverging information ($b_{1FRE} + b_{0FRE} = -0.090$, $SE = 0.048$, $p = .058$). This observed pattern of group differences contradicted our hypothesized pattern of effects (i.e., as we expected change towards advanced beliefs to be fostered and not impaired for resolvable and unresolvable diverging information compared to non-diverging information), which is why no one-tailed hypothesis tests on group differences were conducted.

3.3. Hypothesis 2: confirmatory analyses on effects of prior epistemic beliefs

Results of model invariance tests indicated that every imposed restriction significantly impaired model fit (see Table 3 for model difference tests and Table 4 for overall model fit of target models). Among others, this confirms that substantial mean differences between tertiles in prior epistemic beliefs exist (see Table 5).

3.3.1. Topic-specific epistemic beliefs: FREE-GST

On a descriptive level, epistemic change was—as expected—more

[4] We acknowledge that these criteria were not preregistered (as we have never observed these response patterns before). However, controlling for them was required in order to ensure a minimum of data quality.

[5] One participant was classified as outlier on the evaluativism scales of the FREE and FREE-GST. Six participants were classified as outliers on either D-Index, absolutism scale or evaluativism scale (three on the FREE-GST and three on the FREE).

[6] Since perceived contradictoriness was labelled as 'covariate' in our preregistration, corresponding analyses should be regarded as a complement to preregistered manipulation checks.

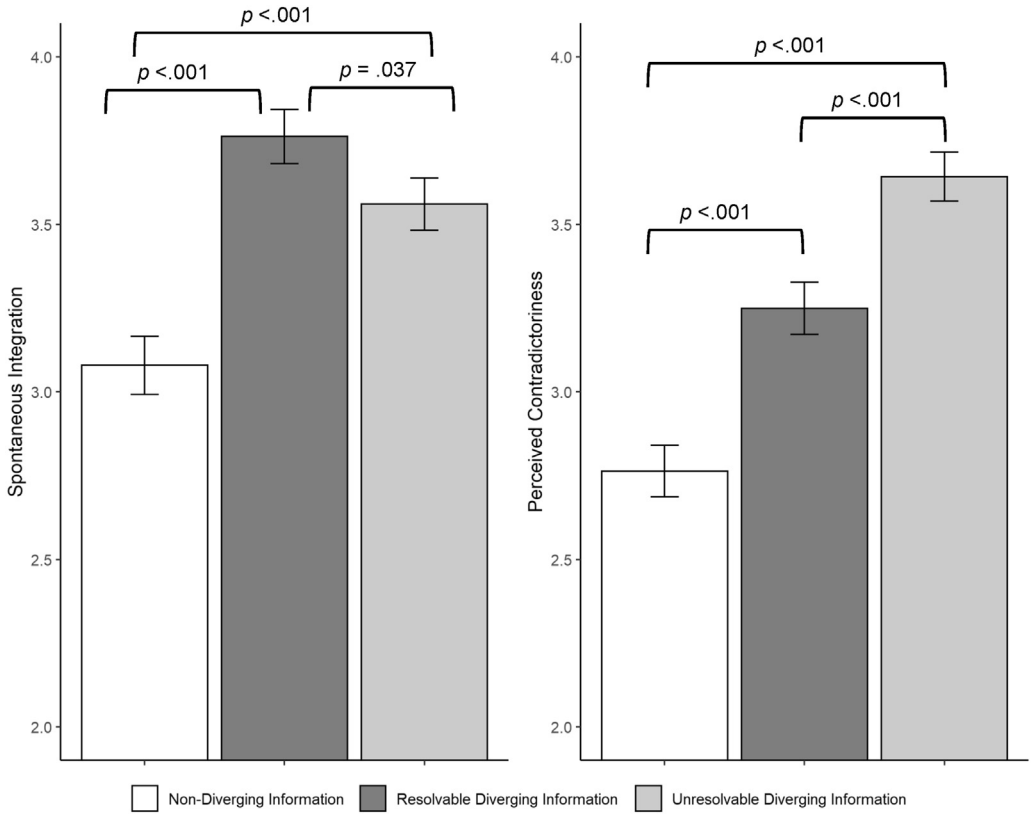

Fig. 2. Manipulation Check. Descriptive group differences (means and standard errors) in spontaneous integration efforts and perceived contradictoriness. The reported *p* value for differences in spontaneous integration efforts between resolvable and unresolvable diverging information is based on a non-adjusted *t*-test and was non-significant for Tukey-adjusted tests (p = .200). The level of significance did not differ between adjusted and non-adjusted tests for all other *p* values.

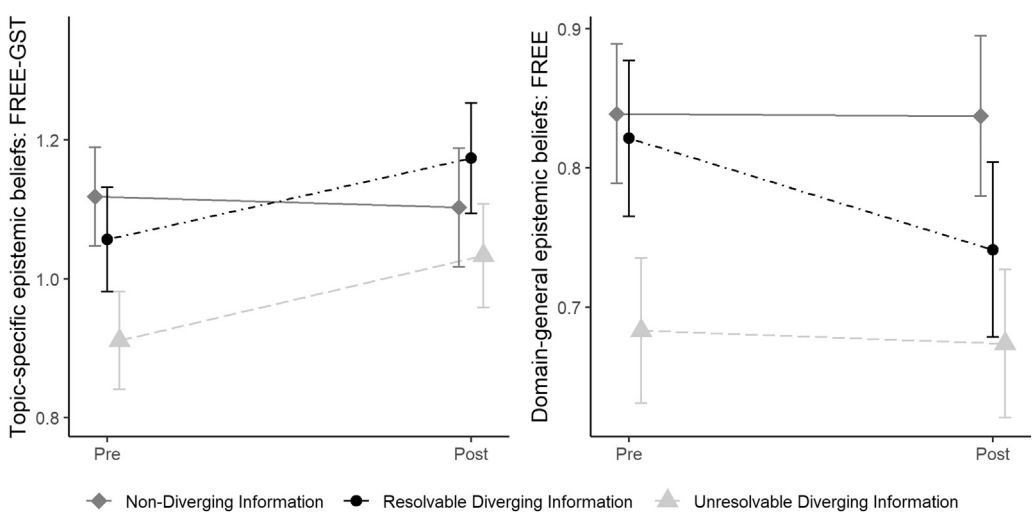

Fig. 3. Descriptive differences (means and standard errors) in epistemic change in topic-specific (FREE-GST) and domain-general epistemic beliefs (FREE) for the D-Index.

pronounced in the 'naive' prior beliefs group compared to the 'advanced' group for all types of diverging information (see Table 5). According to our preregistration criteria (no overlap in confidence intervals), this difference was, however, only significant in the diverging information groups but not for non-diverging information (see Table 5). In other words, individuals with 'naive' beliefs benefitted to a larger extent from both diverging information interventions (when compared to individuals in the 'advanced' group). In line with our assumptions, overall intervention efficacy in the diverging information groups also decreased descriptively from the 'naive' to the 'average' to the 'advanced' groups (see Table 5), but comparisons involving the 'average' beliefs group yielded only one significant result—a more pronounced change for 'average' compared to 'advanced' beliefs for resolvable diverging information. Moreover, for non-diverging information, the corresponding pattern differed, as no linear increase in epistemic change from the 'naive' group to the 'average' and 'advanced' groups occurred (see Table 5). Taken together, these findings imply that diverging information type and prior epistemic beliefs might interact—however, this interaction did not consistently reach significance.

Finally, variances in epistemic change differed significantly between groups (see Table 3). They were higher in the 'advanced' (σ_Δ^2 = 0.53) and 'average' (σ_Δ^2 = 0.58) prior beliefs group compared to the 'naive' group (σ_Δ^2 = 0.38), which suggests that trajectories in epistemic change were more homogeneous for naive prior beliefs.

Table 3
Model difference tests.

Model restriction	H2: Confirmatory multi-group models						H1 and H2: Exploratory multi-group model		
	Topic-specific epistemic beliefs: Tertiles as groups			Domain-general epistemic beliefs: Tertiles as groups			Combined model with topic-specific and domain-general epistemic beliefs: Diverging information type as groups		
	$\Delta\chi^2$	Δdf	p	$\Delta\chi^2$	Δdf	p	$\Delta\chi^2$	Δdf	p
Step 1: Intercepts fixed across groups	**568.93**	**2**	**< 0.001**	**531.08**	**2**	**< 0.001**	8.43	8	0.393
Step 2: Residual variances fixed across groups	**84.13**	**2**	**< 0.001**	**126.97**	**2**	**< 0.001**	**40.14**	**8**	**< 0.001**
Step 3: Residual covariances fixed across groups	–	–	–	–	–	–	**41.15**	**12**	**< 0.001**
Step 4: Latent variances fixed across groups	**7.19**	**2**	**0.027**	**30.05**	**2**	**< 0.001**	5.46	4	0.243
Step 5: Latent covariances fixed across groups	–	–	–	–	–	–	**18.43**	**10**	**0.048**
Step 6: Latent means fixed across groups	**8.72**	**2**	**0.013**	**7.97**	**2**	**0.019**	3.95	4	0.412
Step 7: Regressions fixed across groups	**32.95**	**6**	**< 0.001**	**12.79**	**6**	**0.046**	**23.12**	**8**	**0.003**
Step 8: Quadratic effect fixed to zero	–	–	–	–	–	–	**21.96**	**6**	**0.001**

Note. Values in bold = significant likelihood ratio tests.

Table 4
Fit indices of target models.

Model	Epistemic beliefs	Model restrictions imposed	χ^2	*df*	*p*	*CFI*	*RMSEA*	*SRMR*
H1: Confirmatory single-group model	Topic-specific epistemic beliefs and domain-general epistemic beliefs	None	6.435	4	0.169	0.998	0.036	0.038
H2: Confirmatory multi-group model with tertiles as groups	Topic-specific epistemic beliefs	None	12.959	6	0.044	0.938	0.085	0.043
H2: Confirmatory multi-group model with tertiles as groups	Domain-general epistemic beliefs	None	10.775	6	0.096	0.967	0.071	0.051
H1 and H2: Exploratory multi-group with diverging information type as groups	Topic-specific and domain-general epistemic beliefs	Intercepts, latent variances and latent means fixed across groups	17.848	16	0.333	0.999	0.027	0.042

Table 5
Overall intervention effects on epistemic change in confirmatory multi-group models with tertiles as groups.

Topic-specific epistemic beliefs				Domain-general epistemic beliefs			
Group	Parameter	EST	CI	Group	Parameter	EST	CI
Naive prior beliefs (N = 153)	Intercept (prior beliefs)	−1.114	[−1.171, −1.057]	Naive prior beliefs (N = 157)	Intercept (prior beliefs)	−1.083	[−1.141, −1.024]
	Prior beliefs	−0.694	[−0.886, −0.502]		Prior beliefs	−0.345	[−0.491, −0.200]
	Non-diverging	0.214	[0.067, 0.360]		Non-diverging	0.059	[−0.059, 0.177]
	Resolvable	0.320	[0.167, 0.474]		Resolvable	−0.066	[−0.187, 0.056]
	Unresolvable	0.346	[0.202, 0.490]		Unresolvable	0.190	[0.085, 0.295]
	R^2	0.193			R^2	0.125	
Average prior beliefs (N = 165)	Intercept (prior beliefs)	−0.044	[−0.078, −0.010]	Average prior beliefs (N = 160)	Intercept (prior beliefs)	−0.035	[−0.066, −0.004]
	Prior beliefs	0.204	[−0.165, 0.572]		Prior beliefs	0.000	[−0.316, 0.317]
	Non-diverging	−0.224	[−0.391, −0.057]		Non-diverging	−0.148	[−0.282, −0.014]
	Resolvable	0.180	[0.009, 0.352]		Resolvable	−0.082	[−0.203, 0.040]
	Unresolvable	0.106	[−0.061, 0.273]		Unresolvable	−0.098	[−0.238, 0.041]
	R^2	0.055			R^2	0.002	
Advanced prior beliefs (N = 160)	Intercept (prior beliefs)	1.111	[1.038, 1.183]	Advanced prior beliefs (N = 161)	Intercept (prior beliefs)	1.091	[1.011, 1.171]
	Prior beliefs	−0.029	[−0.199, 0.141]		Prior beliefs	−0.129	[−0.288, 0.031]
	Non-diverging	0.040	[−0.115, 0.195]		Non-diverging	0.057	[−0.095, 0.210]
	Resolvable	−0.151	[−0.310, 0.008]		Resolvable	−0.223	[−0.399, −0.046]
	Unresolvable	−0.090	[−0.273, 0.093]		Unresolvable	−0.195	[−0.383, −0.007]
	R^2	0.013			R^2	0.040	

Note: *EST* = regression weights of prior epistemic beliefs and overall effects in treatment conditions; *CI* = 90% confidence interval.

3.3.2. Domain-general epistemic beliefs: FREE

In line with our topic-specific results, we found significantly more pronounced epistemic change in domain-general epistemic beliefs for subjects in the 'naive' group compared to the 'advanced' and 'average' prior beliefs groups, but only for unresolvable diverging information (see Table 5). Nonetheless, the same pattern of effects that we observed for topic-specific beliefs—a decrease in intervention efficacy from advanced to average to naive beliefs for resolvable and unresolvable diverging information, but not for non-diverging information—also emerged on a descriptive level for domain-general beliefs (see Table 5).

Once more, variances of epistemic change differed significantly (see Table 3) and decreased from the 'advanced' ($\sigma_\Delta{}^2$ = 0.57) to the 'naive' prior beliefs group ($\sigma_\Delta{}^2$ = 0.24), while we also found more homogenous trajectories in the 'average' group ($\sigma_\Delta{}^2$ = 0.34).

3.4. Hypothesis 1 and 2: exploratory analyses on linear and quadratic effects of prior epistemic beliefs

Model invariance tests of our exploratory model, which included linear and quadratic effects of prior epistemic beliefs on epistemic change while treating diverging information type as group variable, showed that we had to consider a variation in residual (co)variances, latent covariances and regressions between groups (but not latent means, see Table 3). This implies that diverging information type does indeed moderate the relationship between prior beliefs and epistemic change, while *mean differences* between intervention conditions—which we found in our confirmatory analyses on Hypothesis 1—cease to exist if one accounts for the influence of prior beliefs. To explicitly test the significance of quadratic effects, we also compared a null model (target model with quadratic trend restricted to zero) to our actual target model after invariance testing. This test showed that including quadratic effects significantly improved model fit (see Table 3). Additionally, overall model fit of our target model was very good (see Table 4).

In both diverging information groups, we obtained significant, small to medium-sized, negative linear effects of prior beliefs on topic-specific change (see Table 6). Respective effects for domain-general change were smaller and only marginally significant for resolvable diverging information, while linear effects of prior beliefs on topic-specific and domain-general beliefs were non-significant for non-diverging information (see Table 6). This implies that (in accordance with our expectations) subjects in the diverging information groups who had below average prior beliefs experienced a more pronounced epistemic change towards advanced beliefs compared to subjects that received non-diverging information. For topic-specific epistemic beliefs, this is, however, to some extent counterbalanced by (marginally) significant positive quadratic effects of prior beliefs in the diverging information groups (see Table 6). For non-diverging information, significant quadratic effects also existed for domain-general beliefs.

Based on this model, Fig. 4 illustrates how predicted changes in epistemic beliefs and prior epistemic beliefs relate to each other within each diverging information type. With regard to topic-specific beliefs, our model predicts that diverging information outperform non-diverging information in terms of epistemic change for subjects with naive prior beliefs, while this trend reverses for advanced prior beliefs (see Fig. 4a). For domain-general beliefs, this pattern differs substantially (see Fig. 4b). For naive prior beliefs, individuals that receive non-diverging or unresolvable diverging information experience comparable levels of epistemic change. But, while the predicted change continues to decrease for advanced beliefs for unresolvable diverging information, it increases again for non-diverging information. In contrast, the change prognosis for resolvable diverging information is worse than in these groups for domain-general beliefs—irrespective of the level of prior beliefs. While almost no change is predicted for naive beliefs (compared to positive change in the other groups), predicted change declines for advanced prior beliefs, up to the point where the predicted trend for advanced beliefs becomes comparable to the trend in the unresolvable diverging information group (see Fig. 4b).

4. Discussion

4.1. Hypothesis 1: effects of diverging information

In Hypothesis 1a, we assumed that any kind of diverging information would promote epistemic change in self-report measures when compared to non-diverging information. Our results indicate that this is true for topic-specific beliefs but not for domain-general-beliefs. For domain-general beliefs, change towards advanced beliefs was, on a

Table 6
Regression coefficients of the exploratory target model predicting epistemic change in the D-Index (measured on a topic-specific and domain-general level).

Group	Parameter	Topic-specific epistemic beliefs			Domain-general epistemic beliefs		
		EST	SE	*p*	EST	SE	*p*
Resolvable (*N* = 156)	Intercept (epistemic change)	0.005	0.041	0.908	−0.081	0.034	0.017
	Prior beliefs	−0.256	0.057	< 0.001	−0.078	0.047	0.098
	(Prior beliefs)^2	0.103	0.037	0.005	−0.023	0.027	0.381
	R^2	0.140			0.027		
Unresolvable (*N* = 152)	Intercept (epistemic change)	0.005	0.041	0.908	−0.081	0.034	0.017
	Prior beliefs	−0.238	0.061	< 0.001	−0.175	0.050	< 0.001
	(Prior beliefs)^2	0.072	0.042	0.083	0.035	0.029	0.217
	R^2	0.107			0.078		
Non-diverging (*N* = 167)	Intercept (epistemic change)	0.005	0.041	0.908	−0.081	0.034	0.017
	Prior beliefs	−0.041	0.060	0.488	−0.055	0.049	0.256
	(Prior beliefs)^2	0.039	0.038	0.298	0.103	0.035	0.003
	R^2	0.005			0.035		

Note: *EST* = standardized regression weight; *SE* = standard error, *p* = *p*-value of two-tailed significance test.

descriptive level, even impaired for resolvable diverging information. Hypothesis 1a is therefore only partially supported by our data.

This pattern of effects has some interesting implications: First, we can confirm corresponding findings by Kerwer and Rosman (2018); the sole reading of diverging information does indeed cause epistemic change. In other words, this type of small-scale intervention engenders epistemic change in experimental settings. Second, in contrast to the control intervention of Kerwer and Rosman (2018), our modified control intervention (non-diverging information) did not affect epistemic change. If their control intervention indeed did induce epistemic change because participants interpreted the corresponding snippets as diverging information (Kerwer & Rosman, 2018), this might indicate how readily subjects regard information as conflicting knowledge claims, which, in turn, induce changes in epistemic beliefs. Distinguishing those effects from these of intentionally set up contradictions (e.g., our diverging information interventions) will be a task for future research.

In Hypothesis 1b, we proposed that the effects of presenting resolvable diverging information would be superior to those of presenting unresolvable diverging information. This, however, did not show in our data. Consequently, Hypothesis 1b has to be rejected.

This outcome is in line with results of Kerwer and Rosman (2018), who already failed to observe a difference between resolvable and unresolvable diverging information. Even though one might argue that both studies assessed epistemic change only by means of self-report questionnaires, we nonetheless conclude that the theoretical framework underlying our assumptions should be revisited. Why do unresolvable diverging information, at least descriptively, outperform resolvable diverging information on a domain-general level? Why do they not impair epistemic change on a topic-specific level? These are intriguing questions for future research. However, in order to correctly interpret these findings on overall intervention efficacy, we also need to consider individual differences in prior epistemic beliefs—a factor our study revealed to play a decisive role when it comes to intervention efficacy on an individual level.

4.2. Hypothesis 2: effects of prior beliefs

When examining to which degree our interventions' effects depended on participants' prior epistemic beliefs, we found that intervention-related epistemic change was, as expected, more pronounced for subjects with naive beliefs compared to subjects with advanced beliefs. It is remarkable that—even though the diverging information interventions did not work out as intended for domain-general beliefs (see Section 4.1)—this pattern also emerged for domain-general beliefs. Of course, the observed pattern of effects in the diverging information groups could be explained (at least partially) by regression to the mean (e.g., Zwingmann & Wirtz, 2005). Regression to the mean should,

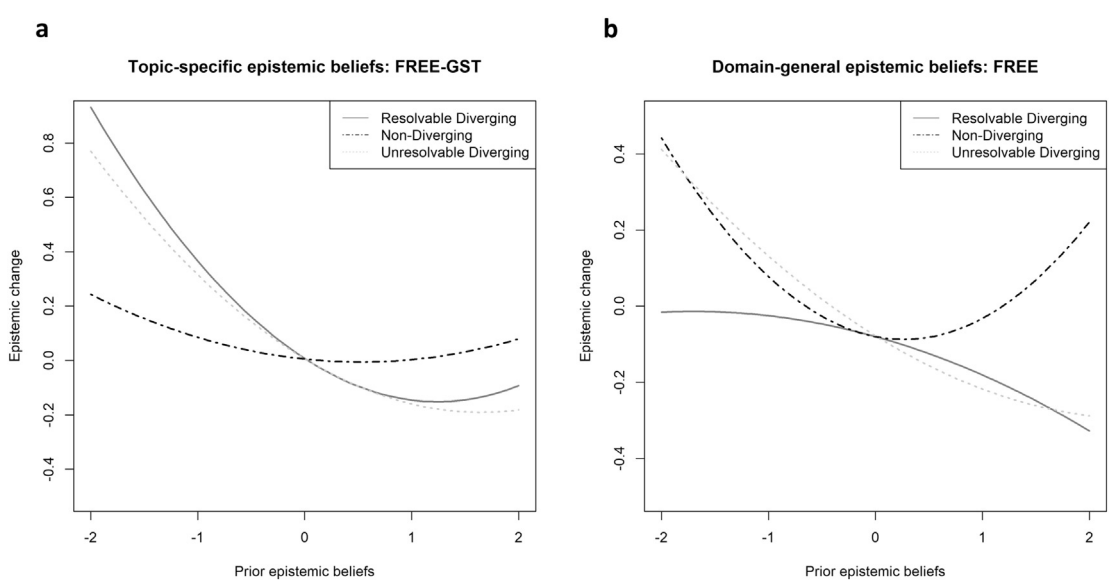

Fig. 4. Change in epistemic beliefs as predicted by prior epistemic beliefs.

however, equally affect all groups, including the non-diverging information group where no comparable pattern exists. For this reason, we regard Hypothesis 2 as confirmed by our data.

When it comes to defining the 'target audience' of diverging information interventions, the predicted change curves depicted in Fig. 4 provide some interesting insights. First, even though both types of diverging information outperformed non-diverging information for topic-specific beliefs on average (see Section 4.1), both types of diverging information might have detrimental effects in individuals with advanced prior beliefs. Second, the overall detrimental effects of (resolvable) diverging information on a domain-general level almost cease to exist for subjects with naive prior beliefs. Thus, drawbacks of diverging information interventions only take effect in subjects with advanced prior beliefs—a finding that is not unprecedented. In fact, Kienhues et al. (2008) reported a similar, at first sight counterintuitive, effect: Students with sophisticated beliefs viewed knowledge as more simple and certain after reading refutational texts. On the other hand, the quadratic trends, which we observed in the diverging information groups, indicate that detrimental effects are less pronounced for subjects with highly advanced beliefs. This could be possibly due to the fact that diverging information can be better aligned to the existing schemata of these individuals' advanced prior epistemic beliefs (cf. Rule & Bendixen, 2010).

4.3. Limitations and future directions

While our results allow some intriguing conclusions, our study is not without limitations. First, the longevity of our intervention effects remains an unresolved issue. However, it may be overly ambitious to expect a 10-minute epistemic change intervention to affect long-term epistemic development and the main objective of our study was not to cause long-term changes but to examine the processes underlying these changes on a more fine-grained level. Second, we assessed epistemic change only by means of self-report measures—a measurement approach that is not unchallenged in current literature (e.g., Mason, 2016). Our results should therefore be interpreted with some caution until they are verified in future studies which include process-related 'in action' measures of epistemic change. Third, this study aimed to confirm that prior epistemic beliefs and information characteristics *do* interact when it comes to epistemic change. Since we expected changes on all stages of Kuhn's model and Kerwer and Rosman (2018) found that small effects of short-term interventions may only emerge as multidimensional change, the best outcome choice for testing this hypothesis seemed to be the D-Index. The advanced-naive distinction which we consequently introduced to describe epistemic beliefs is almost certainly overly simplistic. *How exactly* different dimensions of epistemic beliefs interact with different types of diverging information was beyond the scope of the present study and should be inspected in future studies in more nuanced ways. Finally, only German university students were allowed to participate in our study. Since the development of epistemic beliefs has been shown to depend on age and education (e.g., Kuhn et al., 2000), effects of resolvable and unresolvable diverging information might differ for other populations.

Furthermore, our study revealed some promising starting points for future research. Examining the psychological mechanisms underlying the effects of prior beliefs on intervention efficacy might prove worthwhile. In fact, the non-linear relationship between prior beliefs and epistemic change we observed might be driven by mediating effects. Students with advanced beliefs, for instance, might experience less negative emotions, such as anxiety, when faced with diverging information, as they are less likely to doubt their current beliefs. Experiencing less negative emotions might then allow them to process the presented information more efficiently (see Muis, Chevrier, & Singh, 2018; Muis, Trevors, & Chevrier, 2016) and therefore to focus on the rational side of the cognitive dissonance that arises, and, subsequently, on the successful application of resolution strategies (cf. Bendixen & Rule, 2004). This, in turn, could foster epistemic change in subjects with advanced beliefs, thereby offering an explanation for the quadratic trend that we found in our study. Moreover, our research also illustrates the general need to examine how individual differences affect epistemic change. Future studies might investigate effects of individual differences in topic-related factors, such as prior topic-related knowledge and content-related beliefs (e.g., Kienhues et al., 2016), but also in situation-specific motivational factors, such as epistemic volition (the will to question one's beliefs, Rule & Bendixen, 2010), and in personality traits (e.g., need for cognitive closure; Rosman, Mayer, Peter, & Krampen, 2016). Controlling for epistemic volition should prove to be especially worthwhile in future short-term interventions, since reversions back to the prior beliefs might occur if individuals lack the will to address their epistemic doubt (cf. Bendixen & Rule, 2004).

Moreover, the topic of our intervention, gender stereotyping at secondary schools, is especially well-suited to illustrate principles of evaluativistic thinking (cf. Rosman et al., 2019). More specifically, there is evidence in the literature for a discrimination against both boys and girls, depending on the study in question. At first sight, this would support a naive view of the corresponding knowledge body as subjective. The same evidence, however, is also objective, since contextual factors (e.g., subject matter) exist, which is why evaluativistic reasoning helps individuals to weigh the apparently conflicting knowledge claims by identifying these contextual factors. We are confident that our findings also apply to other topics with similarly structured evidence. To what extent our findings can be transferred to topics or knowledge domains with evidence that is structured differently, remains, however, a question for future research.

Surprisingly, our results on topic-specific and on domain-general epistemic beliefs did not only differ in magnitude but also in direction. The deviations we observed cast doubt on the extent to which the effects of presenting diverging information are transferred to higher-level domains (cf. Rosman et al., 2019). More specifically, they suggest that beneficial effects of presenting unresolvable diverging information might not be generalized, while presenting resolvable diverging information even has unintended side effects on higher-level beliefs. These findings are, to some extent, inconsistent with the idea of *reciprocity* in the TIDE model (Muis et al., 2006). Possible explanations are manifold. First, topic-specific changes in epistemic beliefs might simply have been too small to cause any changes in domain-general beliefs. Another explanation would be that participants may have learned that weighing knowledge claims is the method of choice for the topic of gender discrimination at secondary schools. Instead of generalizing this finding, they may, however, have contrasted it to the other scenarios introduced in the FREE. More specifically, since our intervention offers no possibility of resolving the conflicting positions presented in the original FREE questionnaire, our participants may deem advanced beliefs only to be 'productive' in the specific intervention context.

Finally, some of our conclusions are mainly based on exploratory analyses. However, the results of these analyses did not contradict results of confirmatory analyses, and our preregistered hypotheses were left unchanged. Hence, we deem their results to be trustworthy.

4.4. Practical implications

Overall, intervention effects in our study were rather small. Since the whole study was conducted online, this should, however, not be overly surprising. In fact, our study is, to our knowledge, the first study showing effects of a pure online intervention on epistemic change. This implies that the rationale underlying diverging information interventions in laboratory settings can also be transferred to interventions in real world settings, and starting from this point, online interventions targeting epistemic beliefs could be developed.

What are the implications of our results for practitioners (e.g., lecturers at universities)? The (surprising) positive effects of unresolvable

diverging information are certainly good news for practitioners in higher education. Contents of scientific curricula often contain open-ended research questions, which is why lecturers will in many cases have no other choice but to provide their students with some kind of unresolvable diverging information. Based on our results, we would argue that this should not hamper, but even foster their students' epistemic development, especially in individuals with naive prior beliefs. A drawback in this regard are, however, potentially occurring detrimental effects for individuals already holding advanced beliefs—especially on a domain-general level. Instructional measures, which were outlined by Rule and Bendixen (2010) and their idea of teachers providing compassion and modeling in epistemic change, might counter these negative effects to some degree. More precisely, Rule and Bendixen (2010) argue that students might be more "willing to accept the challenges of epistemic change" if the change process is transparent for them (p.119). Hence, teachers might illustrate how unresolvable topic-specific diverging information affect their own epistemic thinking on a topic-specific as well as on a domain-general level and how they deal with the accompanying challenges to support their students. However, reliable statements on this issue certainly require studies that investigate long-term effects of repeated exposure to unresolvable diverging information. Inspecting this kind of long-term effect seems to be especially interesting as—drawing on Bendixen and Rule's (2004) notion of "overall epistemic movement as a […] spiral-like [progression]" (p.77)—the punctual detrimental effects that we observed, could also be the starting point of a new overall progression cycle. This idea of a spiral-like transfer of topic-specific changes to a domain-general level resembles Muis et al.'s (2006) idea that "educational contexts may serve as an impetus for such recursion" (p.40). We propose that the doubt caused by resolvable diverging information might be addressed in the short-term as this type of information is "well-structured" with regard to topic-specific beliefs (Muis et al., 2006, p.40). In this context, 'well-structured' would mean that these information's implications—the need to apply evaluativistic reasoning on knowledge claims which relate to the specific topic—are (comparatively) transparent. However, implications for domain-general beliefs are less obvious—as one never knows for sure if the topic at hand is the exception to the rule, or the rule rather than the exception—and this uncertainty "may trigger a regression back to an early stage of development" (Muis et al., 2006, p.40). Accordingly, being confronted with topic-specific diverging information may represent a 'small-scale educational context change'. If this speculation holds true, findings of our study that are seemingly inconsistent with the TIDE model (see Section 4.3) could be reconciled with its framework.

4.5. Conclusion

Drawing back on the allegory that we used to start this article, our data confirmed that conflict (i.e., diverging information) did indeed drive (epistemic) change. If this change in epistemic beliefs is for better or for worse, however, seems to depend on learner characteristics (i.e., prior epistemic beliefs), on the type of diverging information administered, and on the level of epistemic beliefs under investigation. This study showed that diverging information are a powerful tool when it comes to changing epistemic beliefs, but also that examining intervention efficacy without inspecting the role of individual differences may result in misleading interpretations of data. In our study, this caveat manifested itself in the role that prior beliefs play when it comes to dealing with diverging information, but it is virtually certain that it also applies to experimental educational psychology as a whole.

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Declaration of competing interest

The authors declare that they have no conflict of interest.

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Appendices

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Appendix C

Artikel III

Kerwer, M., Rosman, T., Wedderhoff, O., & Chasiotis, A. (2020). Disentangling the process of epistemic change: The role of epistemic volition. *British Journal of Educational Psychology*. https://doi.org/10.1111/bjep.12372

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Registered Report

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

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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 (Bråten, 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 Bråten, 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 *multiplism*, 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

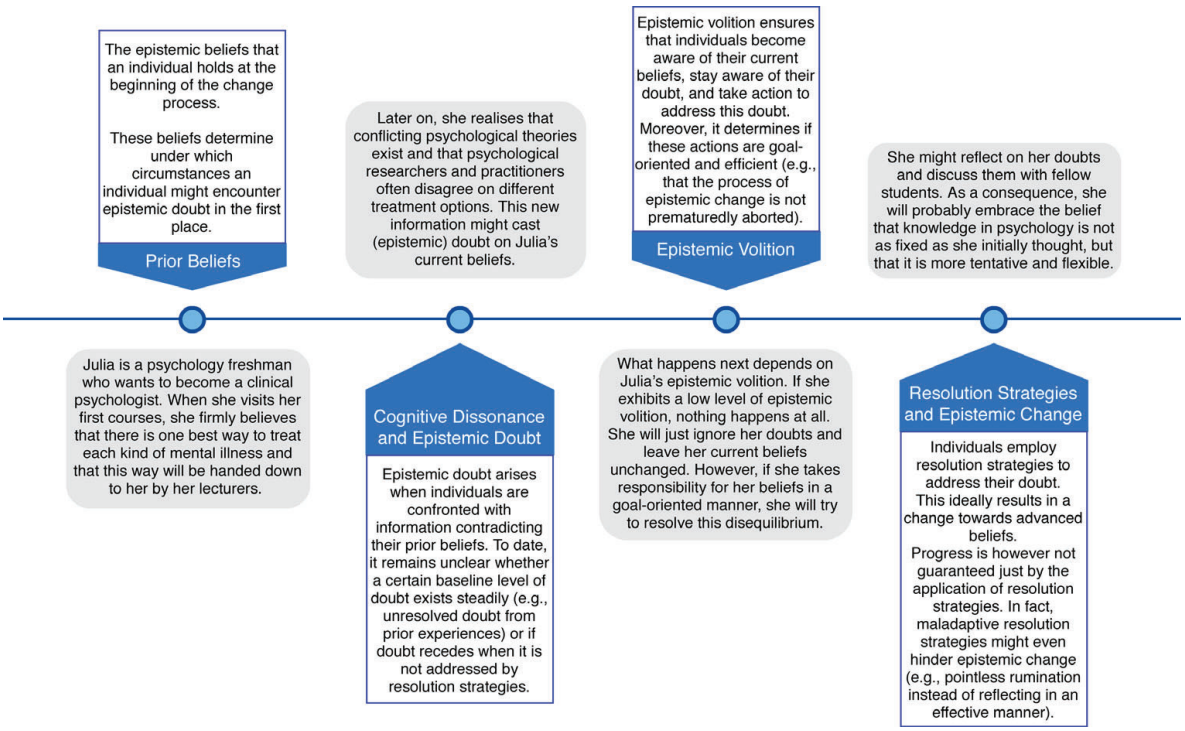

Figure 1. Case study Julia. Exemplary case study (grey boxes) of a psychology student whose epistemic beliefs develop according to Bendixen and Rule's (2004) Integrative Model for Personal Epistemology Development from absolute to multiplistic beliefs. Further information on specific process components (blue boxes) is based on Bendixen and Rule's (2004) model.

[1] *But see also Hofer and Bendixen (2012) for evidence connecting epistemic volition to learning outcomes.*

have become louder (e.g., Bråten, 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.

Table 1. Epistemic volition intervention. Content of all intervention components with (translated) exemplary text snippets: Word count is rounded to the nearest ten

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 (multiple-choice task)	Advanced epistemic beliefs. . . • facilitate knowledge acquisition. [right] • increase memory capacity. [wrong] • [. . .]
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 illustrating absolute, multiplistic, and evaluativistic views (70 to 100 words)	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. [. . .] [Case Study Absolutism]
	5 Items for each case study (6-point Likert scale on agreement)	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.

Continued

Table 1. (*Continued*)

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.

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, multiplism, 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 sociocul-turalism 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

[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.*

Resolvable Controversies

In a study by Meier et al. (2015), 250 physics teachers graded physics tests. Even though all tests had been completed by boys, half of the tests were tagged with girls' names. Independently of teachers' sex, tests allegedly completed by girls received significantly lower grades than tests allegedly completed by boys.

- ○ Boys are disadvantaged in secondary schools.
- ○ Girls are disadvantaged in secondary schools.
- ○ Neither boys nor girls are disadvantaged in secondary schools.
- ○ The study is not related to gender stereotyping in secondary schools.

Mertes et al. (2014) had 224 German teachers grade essays from secondary school students. Allegedly, the essays were written either by boys or girls. Even though all essays had been written by the researchers themselves, essays allegedly written by boys received significantly lower grades than those allegedly written by girls.

- ○ Boys are disadvantaged in secondary schools.
- ○ Girls are disadvantaged in secondary schools.
- ○ Neither boys nor girls are disadvantaged in secondary schools.
- ○ The study is not related to gender stereotyping in secondary schools.

Feldmann et al. (2016) instructed 240 history teachers to grade history exams (secondary school level). All exams were originally written by girls. However, the researchers tagged half of the exams with boys' names. Exams that were allegedly written by boys were neither graded better nor worse than those allegedly written by girls.

- ○ Boys are disadvantaged in secondary schools.
- ○ Girls are disadvantaged in secondary schools.
- ○ Neither boys nor girls are disadvantaged in secondary schools.
- ○ The study is not related to gender stereotyping in secondary schools.

Learning Strategies (Control Task)

Peter discovered that his lecturer likes to test detailed knowledge (e.g. listing all diagnostic criteria for a particular mental disorder). In order to be able to memorize all the criteria, he pays particular attention to them and repeats them three times a day (in the morning, in the afternoon and before going to bed) by reading and recalling them several times.

- ○ I am already applying this strategy.
- ○ I am not applying this strategy, but I want to do so in the future.
- ○ I am not applying this strategy, and I do not want to do so in the future.
- ○ This is no learning strategy.

Lukas assumes that learning as long as possible at a stretch is the quickest way to succeed. He studies every day from 9 am to 6 pm. He takes a short lunch break of 20 minutes. In order to regenerate, he does intensive sports in the evenings.

- ○ I am already applying this strategy.
- ○ I am not applying this strategy, but I want to do so in the future.
- ○ I am not applying this strategy, and I do not want to do so in the future.
- ○ This is no learning strategy.

When preparing for an exam, Marie reads the learning material section by section. She does not use a highlighter but however takes notes at the edge of the text with a pencil. She highlights enumerations in the text body by numbering them explicitly (1., 2., 3.) and links related sections with arrows. Moreover, she summarises more complicated text contents (studies, theories, etc.) on separate worksheets.

- ○ I am already applying this strategy.
- ○ I am not applying this strategy, but I want to do so in the future.
- ○ I am not applying this strategy, and I do not want to do so in the future.
- ○ This is no learning strategy.

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).

mechanism of change ascribed to the intervention, since a change towards advanced 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]

Hypothesis 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:

[4] *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 multiplism 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, Strømsø, & Anmarkrud, 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 × 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)[5] 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[6] 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

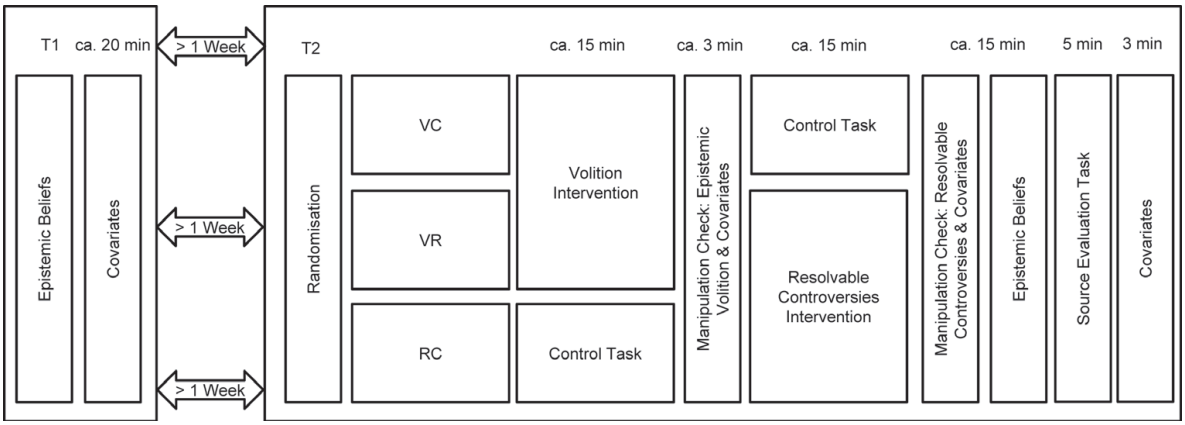

Figure 3. Study design. Schedule of data collection procedures for the first (T1) and the second (T2) measurement occasion with planned duration in minutes (min).

[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 $D = Evaluativism - 0.5(Absolutism + Multiplism)$. 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 Bråten *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 – naïve 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 %.*

Achievement motivation protects against heart diseases

deutsche-agentur-für-gesundheit.de/aktuelles.html

A long-term study by Ulm University shows that most patients suffering from heart diseases have a low motivation to achieve. This trait hinders them from becoming integrated into nowadays performance-driven society, which leads to social exclusion with health-damaging consequences.

When achievement is more important than the heart

schlau-gefragt-ama.de/gesundheit-herz-leistung.html

25.07.2018 - My friend Nora never manages to relax. She is 24/7 available for her job and always tells me how important a high motivation to achieve is in our society. She recently had a medical check-up. Her doctor told her that her risk of a heart attack had increased considera...

Figure 4. Exemplary mockup search engine output. The first result has a (comparably) high quality and implies that achievement motivation protects against the development of heart diseases, while the second result is of lower quality and suggests otherwise (i.e., that high achievement motivation actually promotes the development of heart diseases).

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 ($b_0 + b_1 + b_2 < 0$).[9] Our main outcome was an increase in advanced beliefs as

[9] *(Resolvable Controversies and Control Task) + (Volition Intervention and Control Task) < (Resolvable Controversies and Volition Intervention)* $b_0 + b_1 + b_0 + b_2 < b_0 b_0 + b_1 + b_2 < 0$

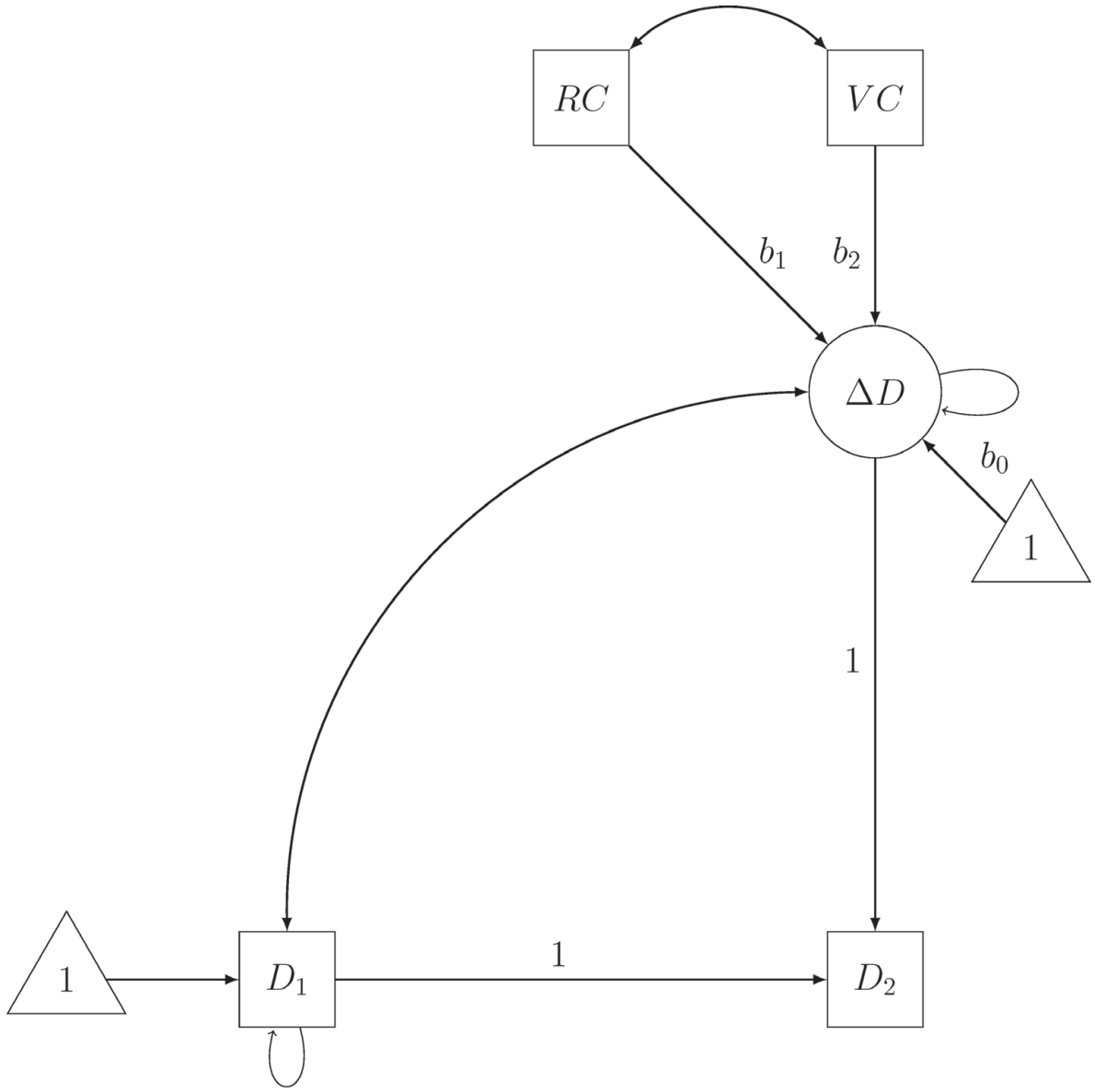

Figure 5. Latent change model for primary analyses. Latent change in epistemic beliefs ΔD (i.e., latent change on the D-Index of the FREE-GST) is measured by the corresponding pre-intervention (D_1) and post-intervention scores (D_2) as the part of the observed outcome variable D_2 that differs from its pre-intervention score D_1. Dummy-coded intervention variables – with the combined volition and resolvable controversies intervention as reference group (i.e., *VC* is coded as '1' for the group that receives the volition intervention in combination with the control task, while *RC* is coded as '1' for the group that receives the resolvable controversies intervention with the control task) – predict differences in the latent change variable.

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),[10] 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 α 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

[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.*

Table 2. Manipulation check: Means, standard deviations, and Tukey-adjusted post-hoc tests on group differences in manipulation check variables

		Volition and resolvable (1)		Volition and control (2)		Resolvable and control (3)		
Manipulation check measure	ω	*M*	*SD*	*M*	*SD*	*M*	*SD*	Post-hoc
Epistemic volition	.89	3.69	1.15	3.65	1.11	3.06	1.24	1,2> 3
Integration	.86	4.04	1.08	3.44	1.19	3.58	1.14	1> 2,3

Note. *M* = arithmetic mean; *SD* = standard deviation; ω = McDonald's ω.

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 y-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 ($b_2 = -0.022$, $p = .839$) 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

	D-Index topic-specific								D-Index domain-specific							
Intervention condition	M_{Pre}	SD_{Pre}	n_{Pre}	M_{Post}	SD_{Post}	n_{Post}	*Cor*	*d*	M_{Pre}	SD_{Pre}	n_{Pre}	M_{Post}	SD_{Post}	n_{Post}	*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 ω 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

	Volition and resolvable		Volition and control		Control and resolvable	
Diversity score	*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

	Volition and resolvable		Volition and control		Control and resolvable	
Number of high-quality sources chosen	*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, multiplism, 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 multiplistic 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

Table 6. Model difference tests: Likelihood-ratio tests on invariance restrictions that were imposed on a multiple-group latent difference score model, in which epistemic change was predicted by manipulation check variables

Model difference test	$\Delta\chi^2$	Δdf	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	χ^2	df	p
Intercepts unrestricted	82.77	60	.027

Note. Values in bold = significant likelihood-ratio tests.

Table 7. Ordinal logistic regression: Ordinal logistic regression of diversity and quality scores on dummy-coded intervention group variables and topic-specific epistemic beliefs (post-intervention)

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
				Multiplism	−0.389	[−0.715, −0.067]	0.68
				Evaluativism	0.695	[0.312, 1.085]	2.00
Nagelkerke R^2	.002			Nagelkerke R^2	0.072		

Note. EST = regression weight; CI = 95% confidence interval; OR = odds ratio, reference category is the 'control and resolvable controversies' condition.

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

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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ERKLÄRUNG

Ich erkläre hiermit, dass ich die vorliegende Arbeit ohne unzulässige Hilfe Dritter und ohne Benutzung anderer als der angegebenen Hilfsmittel angefertigt habe. Die aus anderen Quellen direkt oder indirekt übernommenen Daten und Konzepte sind unter Angabe der Quelle gekennzeichnet.

Bei der Auswahl und Auswertung der in dieser Dissertation dargestellten Methoden und Experimente haben mir die nachstehend aufgeführten Personen in der jeweils beschriebenen Weise entgeltlich/unentgeltlich geholfen:

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Weitere Personen waren an der inhaltlich-materiellen Erstellung der vorliegenden Arbeit nicht beteiligt. Insbesondere habe ich hierfür nicht die entgeltliche Hilfe von Vermittlungs- bzw. Beratungsdiensten (Promotionsberater oder andere Personen) in Anspruch genommen. Niemand hat von mir unmittelbar oder mittelbar geldwerte Leistungen für Arbeit erhalten, die im Zusammenhang mit dem Inhalt der vorliegenden Dissertation stehen.

Die Arbeit wurde bisher weder im In- noch im Ausland in gleicher oder ähnlicher Form einer anderen Prüfungsbehörde vorgelegt.

Ich versichere die Richtigkeit der vorangegangenen Erklärung und bin mir der strafrechtlichen Folgen einer Falschaussage bewusst.

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Stellungnahme zu den Arbeitsanteilen an den Inhalten der kumulativen Dissertation nach § 9 (3) der Promotionsordnung des Fachbereichs I der Universität Trier

Die Konzeptualisierung der der kumulativen Dissertation zugrundeliegenden Fragestellung erfolgte durch den Zweitgutachter Dr. Tom Rosman im Rahmen des Drittmittelantrages „Epistemischer Wandel im Hochschulkontext (MEPIC)“.

Die in der kumulativen Dissertation enthaltenen Studien wurden von Martin Kerwer unter Betreuung des Gutachters Dr. Tom Rosman durchgeführt.

Die Idee und Konzeptualisierung der einzelnen Artikel sowie der Interventionsbausteine zum epistemischen Wandel stammt teilweise aus dem oben genannten Drittmittelantrag zum epistemischen Wandel, wurde aber von Martin Kerwer ausgearbeitet, unterstützt durch Feedback von Dr. Tom Rosman. Die Materialien der Resolvable Controversies Aufgabe basieren zu großen Teilen auf Vorarbeiten von Dr. Tom Rosman und Dr. Anne-Kathrin Mayer. Die entsprechenden Datenauswertungen stammen von Martin Kerwer, wiederum unter Betreuung von Dr. Tom Rosman. Die Artikel wurden federführend von Martin Kerwer, mit Feedback von Dr. Tom Rosman, geschrieben.

Martin Kerwer reichte die einzelnen Artikel zur Begutachtung in den jeweiligen Fachzeitschriften ein, fungierte als korrespondierender Autor und sichtete die jeweiligen Reviews. Die Überarbeitung der Artikel auf Basis der Reviews wurde selbständig von Martin Kerwer, mit Feedback von Dr. Tom Rosman, sowie der weiteren Koautoren Anita Chasiotis und Oliver Wedderhoff für Artikel III, vorgenommen. Auch die Materialien der in Artikel III genutzten Quellenbewertungsaufgabe wurden aus einer Pilotstudie von Anita Chasiotis und Oliver Wedderhoff adaptiert.

Ich versichere die Richtigkeit der vorangegangenen Stellungnahme und bin mir der strafrechtlichen Folgen einer Falschaussage bewusst.

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